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Tallgrass Prairie Center's Native Seed Production Manual

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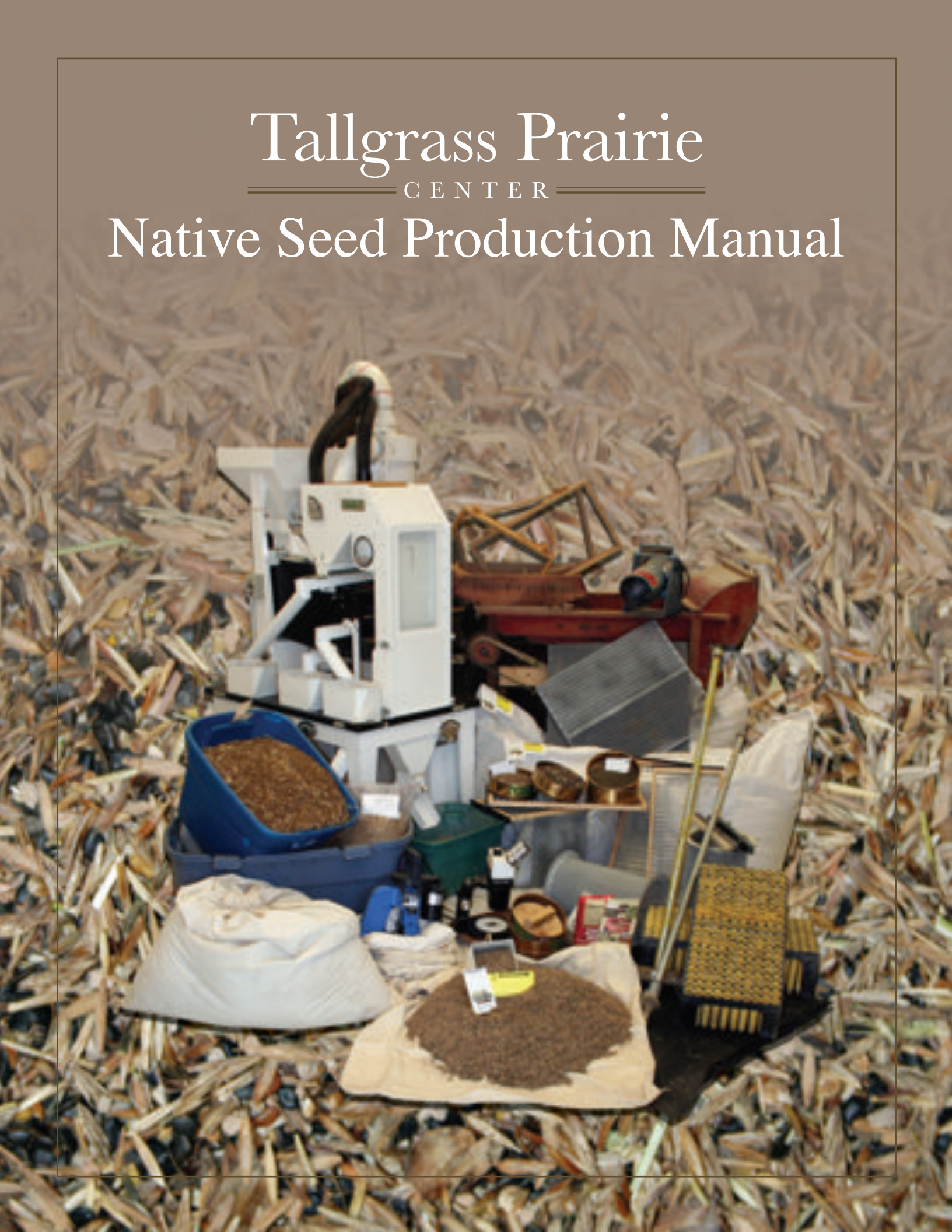
Tallgrass Prairie
CENTER

Native Seed Production Manual



Tallgrass Prairie
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Tallgrass Prairie Center's Native Seed Production Manual

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The Tallgrass Prairie Center develops research, techniques, education, and source identified seed for restoration and preservation of native vegetation in rights-of-way and other lands.

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INTRODUCTION

The intent of this manual is to provide basic information for native seed production of nearly 50 species of the tallgrass prairie flora of the upper Mid-west. The information presented is compiled from published accounts coupled with native seed production experience at the Tallgrass Prairie Center at the University of Northern Iowa. Critical to this effort were publications from the USDA-NRCS Plant Materials Program, published research articles and technical notes, and Internet resources. Botanical nomenclature follows USDA PLANTS Database (http://plants.usda.gov).

What's in the Manual

The manual has four main parts, described briefly as follows:

General Information - The first part of the manual consists of four chapters providing general information on greenhouse propagation, harvesting, seed processing, and issues of seed source and quality. Specific examples referencing native species are given to help illustrate the application of the techniques being described.

Species Reference Sheets - The next section consists of more in-depth seed production information for 32 selected species. Included are 15 species of wildflowers, 5 species of legumes, 8 species of C4 grasses, and 4 species of C3 grasses. These reference sheets include species' description, habitat preference and conservation status, as well as recommendations for stand establishment, management, and seed harvest and cleaning. In addition, an estimate of the range of seed yield expected is presented in the text, along with actual data derived from records kept for seed increase plots at the Tallgrass Prairie Center. A photograph of the seed is also presented to help illustrate seed size and shape and to highlight issues associated with seed cleaning.

Appendices - The third section provides extensive tables summarizing seed production information for nearly **50 native species**. Included are establishment recommendations, seed germination protocols, harvesting and seed cleaning information, sample seed test results, and seed counts per unit weight.

Supplemental Information – This last section includes reference material for native plant propagation, native and weed species identification, and research publications on seed germination. Also provided is an abbreviated list of purveyors of seed-related equipment and horticultural supplies.

Propagation of Native Species

Refer to Appendix A Table 1A for establishment recommendations for individual species.

Seed Dormancy

Dormancy is an adaptive trait, allowing germination to occur over time and in proper season. This vital trait prevents the germination of all seeds at a time that might be suboptimal, or even lethal, for seedling establishment. Staggered germination over time is normal, even with stratification, and should be expected when propagating native prairie species. The benefits of removing dormancy are twofold: First, more seeds germinate in a shorter period of time, which means limited and costly greenhouse space is used more efficiently. Second, increased germination means that more individual plants will potentially establish, flower, and reproduce, contributing their genetic diversity to the next generation.

There are two main categories of dormancy – primary and secondary. Primary dormancy occurs when seed is dormant upon dispersal, which is typical of many prairie species. Species with secondary dormancy produce seed with the ability to germinate readily upon dispersal (fresh); however, the seed may enter a dormant state if conditions aren't favorable. Many woodland spring ephemeral species belong to this category of dormancy.

Within the category of primary dormancy, there are several types of seed dormancy, and appropriate strategies are required to remove each type. One type is morphological dormancy (see Table 1.). The embryo within the seed is underdeveloped upon dispersal, and warm, moist conditions are generally necessary for maturation (55 to 65 °F, 13 to 18 °C). Species with this type of dormancy are found in the Parsley, Buttercup, Arum, Lily, and Iris families, among others (Baskin and Baskin 1998). Another type, physical dormancy, is due to a physical characteristic of the seed; for example, the seed coat may be hard or waxy or otherwise impermeable to water and gas exchange, thus inhibiting germination. Species in the Sumac, Legume, Geranium, and Buckthorn families have these characteristics. Seeds with physical dormancy require some type of scarification to remove these barriers. Biochemical compounds constitute a third type of dormancy. These compounds may be produced in the seed itself or translocated to the seed from the plant prior to dispersal. Abscisic acid, for example, prevents premature germination of mature seeds in the seed head, before dispersal from the parent plant. Concentrations of germination inhibitors, like abscisic acid, decline over time, allowing the seed to germinate. Many seeds may have a combination of dormancy types, which is sometimes called double dormancy.

Mechanisms of Dormancy	Cause	Removed by
Morphological	Underdeveloped embryo	Appropriate conditions for embryo development (usually warm moist conditions)
	Examples of Morphological Dormancy: *Apiaceae (Parsley), Ranunculaceae (Buttercup), Araceae (Arum), Iridaceae (Iris)*	
Physical	Seed coat impermeable to water/gases	Opening of specialized structures (scarification)
	Examples of Physical Dormancy: *Anacardiaceae (Sumac), Fabaceae (Legumes), Geraniaceae (Geranium), Rhamnaceae (Buckthorn) New Jersey tea - 100 °C water bath*	
Biochemical	Germination inhibitors (I.e. abscisic acid)	Warm and/or cold stratification, Special light/dark requirements, Treatment with giberellic acid (GA)
	Examples of Biochemical Dormancy: *Many other species*	

Table 1. Types of dormancy associated with family groups and strategies for breaking dormancy (Adapted from Baskin and Baskin 1998).

Seed Treatments

Scarification ***Appendix A, Table 2A***

Scarification is a technique that simulates the natural disintegration of the seed coat to initiate germination. A hard or waxy coat will not allow the seed to soak up (imbibe) the water needed for germination until the seed coat breaks down. Seed is scarified either through natural processes such as weathering, abrasion, or partial digestion, or through artificial techniques. Seeds have natural openings for water uptake and these weather or wear away first, especially in seeds with hard seed coats, allowing the seed to imbibe water so germination can occur. The trick of scarification, then, is to accelerate the process of weathering these natural openings so seeds can imbibe water, but stopping short of damaging the seed. Some simple scarification techniques are presented here.

Sandpaper wood blocks – These blocks can be constructed using rubber cement to glue a sheet of fine grain sandpaper to each of two flat plywood boards. Lay one sand block on a tray and use light pressure and a circular motion to move the other sand block on top of a quantity of seed sandwiched in between the two blocks. Adequate scarification is achieved after a minute or two, when seed begins to look dull.

Percussion scarification – Seeds are shaken vigorously inside a heavy glass bottle for a few minutes. Allow ample room for all of the seeds to impact the sides of the bottle. This technique is considered less aggressive and less likely to damage seeds than the sand block method. A variation of the percussion

scarification, a pneumatic paint shaker was modified by Khadduri and Harrington (2002) to scarify the very hard seeds of native locust tree species (*Robinia neomexicana, R. pseudoacacia*).

Wet heat – Pour boiling water (212 ˚F, 100 ˚C) over the seeds just enough to cover them all and allow to cool to room temperature, or immerse seeds in boiling hot water for five to twenty seconds and remove to rinse and cool. This technique is reserved for certain species and not broadly recommended. Some species will also require stratification after wet heat. This is effective for New Jersey tea (*Ceanothus americana*) and reportedly for false gromwell (*Onosmodium molle*).

Commercial scarifiers are also available from seed equipment manufacturers, such as a Forsberg scarifier, which is basically a sandpaper-lined cylinder with metal paddles that turn and agitate the seed. This is a very aggressive method and only a few seconds are generally needed. Precious seed can be reduced to flour if left on too long. Seed may already be scarified as part of the cleaning process (e.g., if scarifier/brush machine was used for dehulling legume seeds). Contact your seed vendor/producer to determine if the seed has been cleaned with a scarifier/brush type machine.

Various equipment for scarifying small quantities of seed. From left to right: Brass soil sieve with sandpaper covered wood paddle, Forsberg scarifier, sandpaper covered wood boards.

Stratification

Stratification is a process whereby seeds are placed in a moist medium, such as clean sand or vermiculite, at appropriate temperatures for a period of time. The idea is to mimic critical conditions necessary for germination that seeds are exposed to naturally in the environment after dispersal. Generally, if seeds are dispersed in autumn, they may require cold, moist stratification. If dispersed in late spring or early summer, they may require warm, moist conditions, or warm followed by cold stratification, as in Michigan lily (*Lilium michiganense*). Mix seed with an equal amount of moist, sterile sand; sawdust; or vermiculite and place in a Ziploc bag. Avoid excessive moisture; water should not be pooled anywhere in the bag. Use vermiculite if working with species adapted to drier conditions to minimize the risk of rot.

Effective temperatures for cold stratification are from 32 to 45 ˚F (0 to 10 ˚C), with 41 ˚F (5 ˚C) considered optimum for many species (Baskin and Baskin 1998). Some species require as little as ten days, others as long as ninety days. A few species, among them American vetch (*Vicia americana*) and butterfly milkweed (*Aesclepias tuberosa*), will germinate at these temperatures, so check bags weekly to look for emergence of the radicle and plant immediately if this occurs. Some species may germinate best when stratified under natural winter temperature fluctuations (for example, in an unheated building). If sowing seeds in flats for outdoor stratification, cover with screen mesh to protect seeds from being displaced by animals or heavy rains. Cold frames can be used for stratification and extending the growing season in the spring. Effective temperatures for warm stratification are from 68 to 94˚F (20 to 35˚C), with 68 to 76˚F (20 to 24˚C) optimum for many species with this requirement (Baskin and Baskin 1998).

Rhizobium Inoculation

Rhizobium are types of nitrogen-fixing bacteria that live symbiotically with the roots of many species, typically forming nodules on rootlets of the plant. They "fix" nitrogen by converting gaseous nitrogen from the air spaces in the soil into plant available ammonia nitrogen, which directly benefits the host plant. The plant, in turn, provides carbohydrates for the rhizobium. Strains of rhizobium have been isolated and are commercially available for groups of species, notably in the genera Amorpha, Lespedeza, and Dalea. Rhizobium comes as a black powder that is mixed with the seed just prior to planting. Greenhouse-grown seedlings of legumes benefit from rhizobium inoculation. Rhizobium bacteria inoculum does not readily adhere to seed. Use a sugar water solution as a sticking agent. Do not use carbonated beverages as the low pH of these products may harm the bacteria. It may be unnecessary to inoculate with rhizobium, however, if seedlings will be planted within a few weeks after germination into native soil where rhizobium naturally occurs.

Mycorrhizal Inoculation

Mycorrhiza means "fungus root," which implies a symbiotic relationship between plants and fungi. This is common in many, if not most, plant species. Mycorrhizal fungi are naturally occurring in healthy soil, but may need to be provided for soils that have been fallow, flooded, or eroded over long periods. Sites disturbed by extensive and long-term construction grading or altered by mining will also benefit from inoculation. Commercial

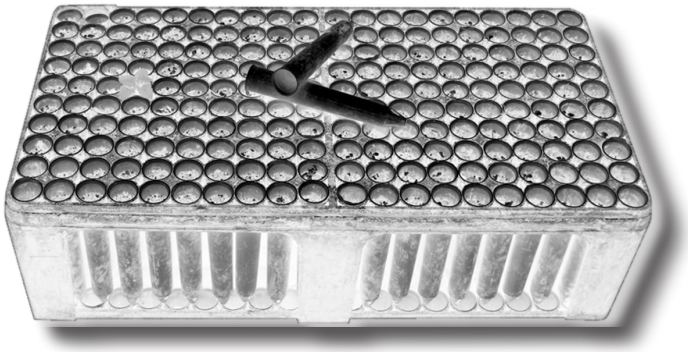
inoculum consisting of endomycorrhizal spores, host plant roots, and a sterilized medium is now available, and this can be incorporated into the soil at the time of seeding or transplanting. Inoculation of the site with healthy soil from a different location is another option.

Greenhouse Propagation

Once viable seed is obtained and pre-treated to remove dormancy, it's ready to plant in the greenhouse. Critical factors include a suitable container and potting medium, water, soil temperature, light, and air.

Containers

Containers should provide good drainage, space for root development, and yet be small enough to provide efficient use of potting medium and bench space. Nurseries interested in retail seedling/plant production will first germinate seeds in flats, which take up much less greenhouse space. Seedlings are



Ray leach "Conetainers"™ RLC4 Pine cell, UV stabilized, allow for 100 cells/ft² of bench space.

then transplanted into disposable trays with perforated pull-apart planting cells for retail marketing. Seedlings for transplant into seed production plots can be placed in a modular reusable "cone" tainer and tray system. These cone-tainers are designed for accommodating taproot growth in conifer tree seedlings. They work well for perennial prairie species – particularly those that put down tap roots, like compass plant (*Silphium laciniatum*), butterfly milkweed (*Aesclepias tuberosa*), and *Baptisia* spp. Various sizes of cone-tainers are available in yellow UV stabilized plastic for longer life. The so-called "fir" cells, approximately 6.5 in deep, with a 1-in. diameter at the top, work well for most native species. Each tray accommodates 200 cone-tainers, 100 cone-tainers per square foot, so it's also an efficient use of limited bench space. Planting "dibbles" are available that exactly match the size and shape of the various cone-tainers, so transplanting is highly efficient. The cone-tainers and dibble system allow the roots of seedlings to be planted deeply enough so that roots are able to tap into sub-soil moisture. Irrigation isn't necessary, especially with spring or fall transplanting when rains are more frequent.

Potting Medium

A good potting medium should be light enough to allow for good root development, provide adequate drainage, and have enough fertility for seedlings to grow quickly in the greenhouse environment to become large enough for transplanting in a reasonable amount of time. It should also be sterile, meaning weed seed- and disease-free. We recommend a soil-less mix (less than 20% soil) consisting of 10% sterile soil and 10% composted manure, about 50% milled peat moss, and the remainder equal parts perlite and vermiculite. To ensure fertility, use an encapsulated controlled release fertilizer (Osmocote®, *Scotts* brand) at the recommended medium rate (8 lb./cubic yard). Seedlings are susceptible to damage from over fertilization, particularly legumes. Controlled release fertilizer has the added benefit of continuing to provide fertility after transplantation of seedlings into production plots. For small-scale home plantings a pre-mixed and packaged sterile potting soil is suitable.

Peat moss (4 cu. ft/bag)	2 bags (8 cu. ft)
Vermiculite (medium 4 cu. ft/bag)	1/2 bag (2 cu. ft)
Perlite (4 cu. ft/bag)	1/2 bag (2 cu. ft)
Sterile soil	two 5-gal buckets
Composted (sterile) manure	40-lb bag
Osmocote® Plus fertilizer 15-9-12 (180 days)	8 lb

The recipe above makes approximately 1 cubic yard of soil-less mix (enough for 35 trays of 200-cell "fir" cone-tainers). If mixing on the floor, sweep and vacuum the area prior to mixing to remove seeds, debris, and other contaminants:

Screen peat moss, soil, and composted cow manure through a ½-in. mesh hardware cloth screen to break up or remove large pieces that would tend to clog and create air pockets as cone-tainers are being filled. Add remaining ingredients, mix with shovels on floor, and fill trays. A note of caution: All of these materials are extremely dusty in their dry form. Be sure to wear a high quality dust mask when handling and mixing materials. Materials should be moistened with water before mixing to reduce dust.

Strategy for Filling and Seeding Cone-tainers

When filling trays of cone-tainers, tamp the tray on the floor to firm potting medium and remove large air pockets. Avoid overfilling. Leave about ¾-in. unfilled space at the top of each cone-tainer. This space acts as a reservoir during watering, allowing the water to seep in slowly, helping to saturate the entire soil column. Water cone-tainers frequently for a day or two before planting to fully hydrate the potting medium. Refill any cone-tainers that may have settled excessively.

Attempt to sow several seeds per cone-tainer (cell). If seed has been mixed with damp sand or other medium for stratification, it may be impossible to distinguish small seeds from the medium. If this is the case, place the damp seed/medium mixture into a shallow dish and mix thoroughly to evenly distribute the seed within the medium. Use a small, flat implement (point of a knife or wood popsicle stick) to place a small amount of mixture in each cone-tainer. Getting an appropriate number of seeds per cell is guesswork with tiny seeds, but experience will improve efficiency. Thinning may be necessary if too many seeds germinate in each cell. Blank cells will result if no viable seeds were planted. For larger seeds with high purity and viability (90% or more), one to three seeds per container is adequate. Increase accordingly for seed of poor or unknown quality. Cover with no more than to 1/8 to 1/4 in. of soil for most species. **Caution:** Very tiny seeds should not be covered! Additional information and precautions on sowing seed of specific species can be found under the following sections on light, temperature, and water requirements for propagation.

Light

See Appendix A, Table 2A for recommended planting depth and light requirements

Natural light should be sufficient for seedling establishment in the greenhouse from mid-March through mid-September. Sow seeds in early February and expect germination and emergence to occur over a two- to six-week period. Greenhouse grown seedlings grow well with only natural light through March and April and into May, when transplanting into production plots begins. Keep in mind that some species require light for germination. These are typically small seeded species, including but not limited to Culver's root (*Veronicastrum virginicum*), mountain mints (*Pycnanthemum spp*.), grass-leaved goldenrod (*Euthamia graminifolia*), Joe-pye weeds (*Eupatorium maculatum*.), great blue lobelia (*Lobelia siphilitica*), and prairie sage (*Artemisia ludoviciana*). These do best if sprinkled on top of the soil surface and kept continually moist until the seed leaves (cotyledons) are evident.

Temperature

Germination will occur throughout a range of temperatures, but will be slower with less than optimal temperatures. The risk of fungal pathogens and rot increases if seed does not germinate and is non-dormant. Warm season grasses and legumes germinate best in warm soils greater than 70 ˚F (21 ˚C). Cool season grasses and many forb species will germinate more readily in cool soil temperatures 40 to 50 ˚F (5 to 10 ˚C) and may cease germination at temperatures above 77 ˚F (25 ˚C). Soil temperature in the cone-tainers fluctuates with greenhouse air temperature (72 ˚F, 22.2 ˚C daytime and 60 ˚F, 15.5 ˚C nighttime). Pulses of emergence occur on sunny days with some species, presumably because an optimum soil temperature has been reached from solar heating. Covering cone-tainers with translucent plastic will increase soil temperature and improve germination of species that require warm soil temperatures. Use this technique with **caution**. Lethal temperatures can occur quickly under the plastic with full summer sun. Plastic should be removed as soon as the first seedlings emerge to avoid over-heating new seedlings. Cooler soil temperatures can be achieved by setting trays of cone-tainers on the floor. If sowing seed in flats, precise regulation of soil temperature can be achieved with propagation mats. Propagation mats are placed under the flats and are plugged into an electrical temperature control box. Soil temperature in the flats is regulated by a soil temperature probe from the control box inserted into the potting soil of one of the flats. These are commercially available at reasonable cost from nursery or greenhouse supply companies.

Watering

Proper watering is critical to greenhouse propagation. It's important to keep the soil surface moist until germination has occurred, especially for small seeds that require light and are sown directly on the soil surface. An automated mist system is helpful

during this stage of propagation. If using a wand or watering can, use a sprinkler head that produces small gentle droplets and low pressure so that watering doesn't dislodge seed, forcing it deeper into the soil or splattering it out of the containers.

Once plants are established, they should be watered thoroughly at least once a day, ensuring that the entire soil column is moistened, but allowing the soil to drain and the surface soil to begin to dry slightly. More frequent watering (two to three times daily) is required on hot and sunny days and for larger plants with fibrous roots that fully occupy the container. Under watering will allow the lower portion of the soil to dry out and root growth will be stalled. Containers that are overfilled with soil are prone to under watering since the water can't pool on the surface and

Seedlings are ready for transplant when roots fully occupy conetainer, forming a 'plug'.

gradually soak in. Likewise, over watering saturates the soil, depriving the root zone of air and creating conditions conducive to decay. Containers and potting medium that allow for proper drainage will help prevent over watering.

Excessive watering can also damage shoots. Healthy looking plants will suddenly fall over, appearing to be cut off at soil level. This is known as "damping off" and is caused by a fungus. Legumes are particularly susceptible to this condition, but it can affect other species as well, especially if they are planted too densely. Sprinkling a layer of perlite over the top of the soil surface after seeding will help dry the soil surface and wick water away from the stems. Maintaining good air circulation will evaporate excess water from stems and soil surface and minimize the risk of damping off. Thinning may be necessary to improve air circulation. Watering pots/containers from below by setting them in a pan of water until soil wicks up moisture will also help. Washing and sterilizing containers, benches, and equipment and using sterile potting medium will also help reduce the risk of damping off.

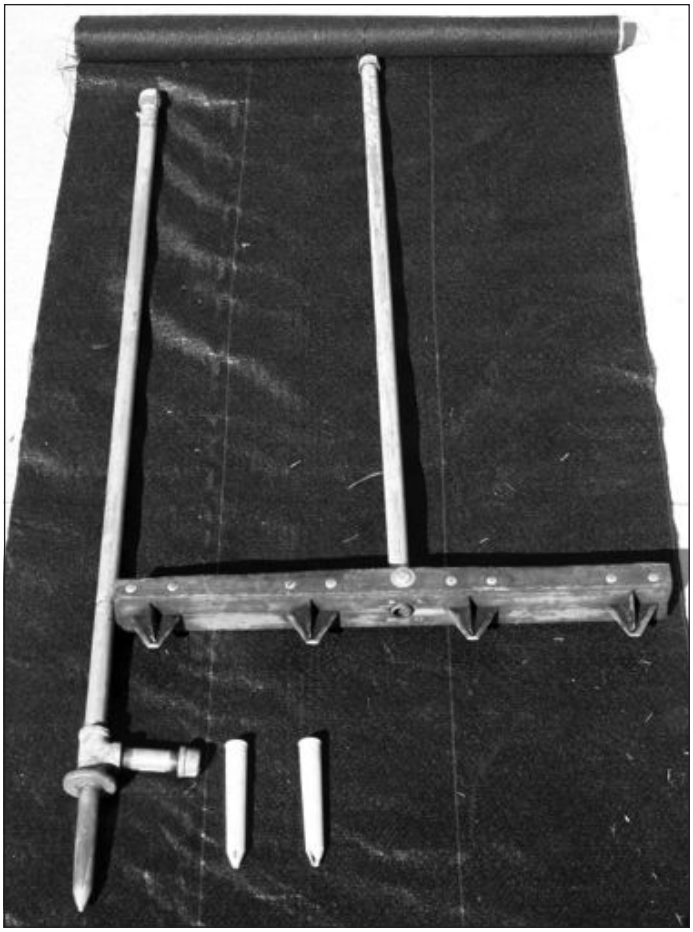
Transplanting Seedlings

Seedling Development/Timing

The key to successful transplanting of native perennial species is strong root development. Ideally roots should fully occupy the entire soil column so that when the plant is removed the soil and roots remain intact as a "plug" (i.e. retains the shape of the cone-tainer). Grasses and forbs with fibrous roots form beautiful plugs after a few weeks of growth and present little challenge in transplanting. Species with taproots (*Baptisia* spp., compass plant, *Desmodium* spp., butterfly milkweed) develop a thickened fleshy taproot within a few weeks after germination in a greenhouse, but the taproot itself may not be enough to hold the plug intact when transplanting. Allow growth to continue until the tap root reaches the bottom of the cone-tainer. The taproot will air-prune (can't grow further) and fine lateral root growth will be stimulated. These fine lateral roots will help considerably in holding the plug intact when the seedling is removed from the cone-tainer for transplanting. Slower growing forbs and shrubs require more time for roots to develop adequately for transplant.

Rigid goldenrod, *Solidago rigida*, direct seeded into rows and managed with cultivation and roguing.

Seedlings are prone to top-kill when transplanted directly from the greenhouse into the field. Greenhouse grown seedlings are pampered: they have been protected from drying wind, harsh sun, and herbivores. Robust greenhouse grown seedlings of many native species can tolerate the stress and will regrow quickly if they have strong root development and adequate soil moisture. A better approach, however, is to acclimate seedlings gradually to outdoor conditions with a process call "hardening off." A week before transplanting, set flats or trays outside for a few hours each day from mid-morning to mid-afternoon in a place sheltered from strong winds and full sun. The idea is to acclimate the plants gradually to outdoor conditions of wind and sun. Strong winds



Transplanting equipment pictured: Dibble on left, note the end of the dibble is the same size and shape as the two cone-tainers. The other tool is made of sickle bars welded into four 'X'-shaped cutters spaced 8-inches apart on-center and mounted on a 2x4 board (ripped down the middle, sickle bar base inserted and the assemblage bolted together).

and heavy rains should be avoided. Another option is to move flats/trays into a cold frame (unheated greenhouse) and roll up the sides or open side vents to allow natural airflow and some direct sun to the plants.

The ideal time for transplanting is in the spring after the last frost-free date for your region. Rains are more reliable at this time of year, the sun less intense, and plants have the entire growing season to establish and flourish. If transplanting during the summer months, check to insure adequate soil moisture. Be prepared to water regularly and deeply until plants are established. Transplanting in the fall (early to mid-September) may be another option as well, if strong root development is present to survive the winter months.

Bare Soil vs. Weed Barrier

To establish seed production plots, seedlings can be transplanted into weed-free bare soil or weed barrier. Transplanting into killed sod works well for natural landscaping with a mixed assemblage of prairie species but is not recommended for seed production plots. The dead sod interferes with cultivation and hoeing should weeds become a problem.

Aggressive clonal species like horsemint (*Monarda fistulosa*), prairie coreopsis (*Coreopsis palmata*), Culver's root (*Veronicastrum virginicum*), and cordgrass (*Spartina pectinata*) can be successfully established as seed production plots in bare soil. Good weed suppression, as always, is critical. Pre-emergent herbicide (Pendulum®, Prowl®) can be used on the site after transplanting to inhibit weed seed germination. Be sure to water in seedlings after transplanting to settle soil around the root zone before applying pre-emergent. Otherwise rain may concentrate run-off of herbicide into freshly dibbled holes containing the new transplants, damaging roots or killing the seedlings. Do a small test plot on species not listed as tolerant on product label. Read, understand, and follow all precautions and directions on product label. Planting 8 to 12 in. apart in well-space rows (32 to 36 in.) will permit cultivation later that season for weed control. Do not cultivate as long as pre-emergent herbicide remains effective in suppressing weed seed germination. These aggressive clonal species will spread and create solid rows in two to three years. Seed production begins to decline after the third year and may drop off sharply after the fourth year as plants become root-bound within the rows. Aerating the soil with a turf-type aerating implement in the fall or early spring may extend productivity of the plot.

Weed-barrier comes in a variety of materials. Plastic film is inexpensive but less durable than fabric type barriers. Plastic creates abnormally moist conditions that can cause disease problems, but may be suitable for short-term (one to three year) applications. As the name implies, weed-barrier suppresses weed growth by blocking light, physically obstructing shoot growth, and by solar heat sterilization of weed seeds in the soil. Weed-barrier also conserves soil moisture, and plants grow more vigorously in barrier than bare soil. For these reasons, weed barrier aids establishment the first year, and increases seed production the second year, for most species. By the third year, aggressive clonal species will send rhizomes in all directions and will be smothered by the barrier. For these species, plant in bare soil as described above, or use an inexpensive barrier that degrades or can be pulled up after the second season.

We use a durable, water- and gas-permeable weed barrier (DeWitt Pro woven landscape fabric) for long-term applications (up to ten years). This can be purchased in rolls 6' x 250' or 12' x 300' rolls. This type of weed-barrier provides long-term benefits of weed suppression and moisture retention for less-competitive species that establish slowly. It's also a good choice for species with taproots that remain where they are planted (non-clonal). Transplant seedling of these species 8 to 12 in. apart in blocks or rows to optimize use of costly weed-barrier. Slits are cut in fabric weed barrier using a tool made of modified sickle bar blades

Pinch soil over top of plug and around base of seedling.

mounted on a wooden 2x4 with attached handle. This device cuts four "x-shaped" 2-in. slits, 8 in. apart at one time. Cutting larger slits will permit more weeds to germinate and come up through the openings. Hand pull weeds that emerge through the slits while small, taking great care not to disturb new transplants. Pressing gently downward on the top of the newly transplanted plug while pulling adjacent weeds will protect it from being uprooted. A garden or dandelion knife can be used to carefully slice through taproots of larger weeds. Slice into taproot just below soil surface, again taking great care not to damage roots of transplants. Hand weeding periodically throughout the first growing season will be required to give transplants the best chance of establishing the first year and producing a good seed crop in subsequent years.

How to Transplant Seedlings

Soil should be firm in all cases. If dibbling into bare soil, soil should be rolled or packed to prevent dibbled holes from collapsing. Likewise, very dry soils resist dibbling. It may be necessary to sprinkle the area the day before, or wait a day or two after a soaking rain. Just prior to transplanting, liberally water seedlings in cone-tainers to fully saturate the root plugs. This will make it much easier to remove the plugs from the cone-tainers and provide extra moisture to the root zone after transplanting. Hold cone-tainer upside down firmly in one hand, and rap the rim of the cone-tainer sharply on the palm of other hand, using a flick of the wrist. The plug should slide out easily; repeat if necessary. (If plugs do not hold their shape upon removal, either the roots are not adequately developed or too much force is being used. Transplant success drops significantly if this happens!) Slide intact plug into dibbled hole – it should just fit, with the top of the root plug just at or slightly below the soil level. Pinch soil firmly around the top of the plug to seal in moisture, taking care not to bury the base of the shoot. The lighter soil-less mix can actually wick moisture away from the roots if left exposed. Be sure dibbled holes are deep enough to comfortably receive the full depth of the plug. Plugs forced into a too small/shallow hole will often "pop up" out of the ground after a good rain, exposing the root collar.

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Native Seed Production and Stand Longevity

Refer to Appendix B, Table 1B for yield potential and expected stand life.

Production of native seed is fundamentally different from traditional row-crop agriculture. The primary differences are related to the biology and life-cycle of the respective crops. Most tallgrass prairie species are perennial, meaning their roots persist year after year, and the above ground portion re-grows from the root each growing season. For a plant to persist in a prairie, or a seed production plot for that matter, seed production and viability are of secondary importance. Traditional row-crops, such as corn and beans, are annual plants, completing their life-cycle in a single year. This means they must be seeded each year, and are biologically programmed to produce abundant seed in that same year.

Most native species require two full growing seasons after establishment to grow adequate root systems and above ground parts to support flowering and seed development and maturation. This time period can be shortened to one growing season, for a few species at least, if propagated as seedlings in a greenhouse in advance of the natural growing season. This requires priming seed for efficient germination and providing proper fertility, moisture, and light for two to three months prior to transplanting into production beds at the beginning of the growing season. Direct seeded plots will generally require at least two growing seasons to establish and set seed, if good weed management is maintained.

Generally speaking, peak seed yields occur in the second or third year after establishment, and then decline as perennial plants grow to fully occupy the root zone. Also, because the individual plants or all of the same species, they are at the same growth stage and have the same nutrient and water requirements at the same point in time. This creates intense competition for resources critical to flowering and seed development. Plants may

persist long-term, but seed production will decline to a point that's no longer cost-effective, even with continued tillage between rows. In fact, tillage at this point can sever lateral roots At this stage of stand life, some species may respond to chisel plowing, plug-type soil-aeration, or aggressive tillage to reduce in-row width back to a single plant width. Other species will require transplanting into new production beds, or regenerating from seed. To conserve the initial genetic diversity of a seed source, replant seed from the original collection, if possible, or at least an earlier generation of that seed source. By conserving generations in this way, it will minimize genetic selection and genetic drift specific to production field soils, climate, and cultural practices that otherwise would tend to narrow genetic diversity over successive regenerations of the seed source.

HARVESTING

Refer to Appendix B, Table 1B for recommendation on harvesting methods and timing

General Indications of Seed Ripening

Grasses

Seed ripening and timing of harvest varies by species, source of parent material, and environmental conditions. For example, cool-season grasses begin growth early in the growing season and consequently ripen earlier, as compared to warm-season grasses. In grasses, there are roughly four stages of seed maturity: milk, soft dough, medium dough, and hard dough. Firm thumbnail pressure on the caryopsis, or germ, will help determine maturity. Grasses should be harvested at the hard dough stage, when firm thumbnail pressure slightly dents the caryopsis. Many grasses ripen about a month after flowering, and some do not hold seed long after maturity. Test ripeness by firmly striking the seed head against palm; if some shattering occurs, the seed is ready to harvested. If it shatters with only gentle striking, harvest immediately.

Forbs

Generally, the seed head itself or the stalk immediately below the seed head will begin to appear dry or discolored as the seed ripens. If the seed is easy to strip off or shatters out when the seed head is gently thrashed into the palm, seed ripening has begun. Notable exceptions are the spiderworts (*Tradescantia*), members of the day-flower family. These species will drop seed from individual flower heads as they ripen even while the bracts remain green and other flowers in the same cluster are in bud or blooming. Species with dispersal apparatus such as awns or hairs will appear dry and fluffy at maturity.

Environmental Factors Affecting Seed Maturity and Dispersal

Most species ripen gradually, so not all seed will be at the same stage of maturity at any given time. Seed maturity usually progresses from top to bottom of the seed head in grasses and many prairie forbs. Mature seeds may be quickly dispersed either by gravity, wind, water, or animals, so it's important not to delay harvesting. Immature seed stores poorly, losing viability more quickly than mature seed. Likewise, some species forcefully eject seed at maturity (phlox and violets, for example), and must be checked and harvested daily or bagged loosely with a tightly woven mesh or cloth bag. In terms of the plants' environment, cold, moist conditions will tend to delay seed maturity, while hot, dry conditions may hasten it. Latitude will also affect ripening since many plants flower and set seed in response to photoperiod. Flowering and seed set may be delayed if plants are grown northward from their origin, or hastened if moved southward. If moved a great enough distance north or south of their origin (greater than 300 mi) they may fail to set mature seed.

Plastic combs are inexpensive and efficient tools for stripping grass seed. Good quality scissors or pruning shears are handy for clipping seedheads of many forb species. Both hands are kept free for collecting by strapping plastic milk jugs around waist to hold and protect paper lunch-size collecting bags.

Use small-comb teeth Little bluestem, larger teeth for Big bluestem, Indian grass.

Harvesting Techniques

Hand harvest

Hand harvesting is time- and labor-intensive and not practical for large projects, but it is an important way to collect the seed of native species that otherwise are commercially unavailable and/or inaccessible through machine harvesting. Such species may be low or high growing species, early or late ripening species, or uncommon or patchy species in native prairie. Efficiency can be improved by keeping both hands free to harvest by fastening collection bags and containers around the waist.

Hand harvesting is also an important way to obtain a sample of seed from populations for use as foundation material for seed increase and seed production plots. Keep in mind, however, that a seed collection is only a sub-sample of the seed available in a population. How and when the seed is collected and propagated for increase can influence the genetic potential of the resulting population. Annual variation in rainfall and temperature can affect total seed production, quality, maturity, and dormancy. To optimize the capture of genetic diversity present in a population, approximately equal amounts of seed should be collected from several widely spaced individuals (minimum of 30) throughout the site and over multiple years. If collecting from multiple sites, attempt to equalize the contribution of seed from each site, particularly when planting a seed nursery production plot to generate seed for other reconstructions. To sample larger, evenly distributed populations, walk line transects at parallel intervals throughout the population, sampling seed at predetermined intervals (perhaps every 10 steps, for example). Populations grown and re-grown in a production field can become adapted to site conditions and nursery management practices. Therefore, it is important to save seed from the original collections or earlier generations for replanting production fields.

Mechanical Harvest

Refer to Appendix B, Table 2B for combine settings.

Combine harvest

As already established, not all seeds ripen at the same time; with any given species, a determination has to be made as to when **most** seeds present are at or nearing maturity (Figure 1). Grasses are generally harvested at maturity (hard dough stage) with some exceptions. Test ripeness by firmly striking the seed head against palm; if shattering occurs with only gentle striking, the stand should be combined **immediately**. Since most grasses ripen from the top down, some shattering of the tops of the seed heads may have already occurred. If a species' seed shatters very easily, harvest in the early morning when humidity is high and wind speeds are less, as a strong wind can reduce the harvest significantly in a single afternoon. Windrowing or swathing during the medium- to hard-dough stage – in grasses that otherwise shatter easily at maturity – can be effective, since seed will after-ripen for several days after cutting. For this method, however, it's important to be sure no rains are in the forecast for the next few days after cutting. Swaths can then be picked up with a combine after the material has dried at the site for a few days. Combines may require significant modifications to make them suitable for harvest of native grasses and forbs.

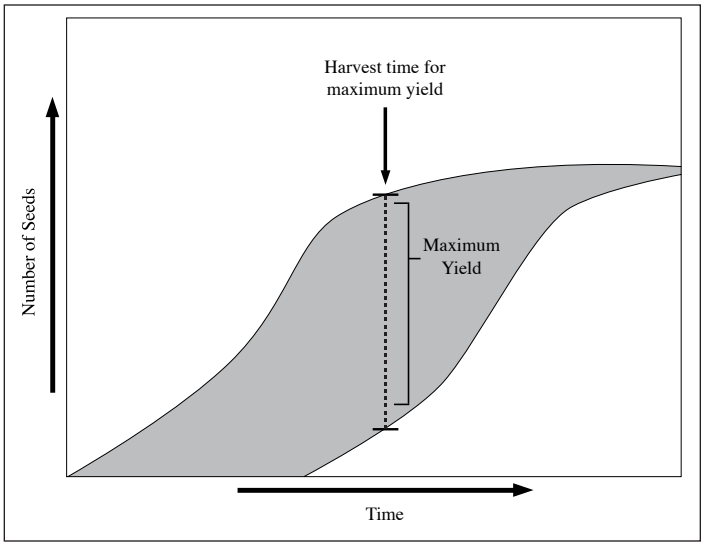


Figure 1. Conceptual diagram illustrating optimal harvest time for capturing maximum mature seed yield (single point in time mechanical harvest). As seed ripens, seed shattering soon follows, and the rate of both processes increases through time. Time of harvest is critical for capturing optimum mature seed yield.

Species with fluffy seed (asters, goldenrods, etc.) should be harvested when seed is mature, but just prior to the dry-fluff stage. If the seed is dry-fluffy, the combine will be come a super seed dispersal machine. Reducing or shutting off airflow in a combine is a must for native species with lightweight seeds. Plugging of shaker sieves and augers is a constant issue, particularly with fluffy seed or seed with long awns. The long twisty awns of Canada wildrye can be a combine's bane. Deawner bars can be installed into the cylinder surrounding the concaves to increase the threshing action of the concaves.

Seed strippers

Commercial seed strippers are available as handheld, implement pull-type, or tractor-mounted equipment. They all use a rotating brush or bristles to "strip" the seed from stems and stalks of plants. While perhaps not as efficient as combines, strippers can be used for the successive harvest of species that ripen gradually or at different times. Handheld strippers and pull-types light enough to be pulled with an ATV allow harvest of otherwise inaccessible native sites.

1977 Hege 125B plot combine modified for harvesting native species. Harvesting Rigid goldenrod in this photo.

Ethics of Harvesting from Remnant Sites

Repeated, annual harvesting of seed from remnant prairies for the commercial market is not encouraged. First, seed production and seed quality from 'wild' stands will never be as high as can be produced in nursery plots, and second, there is a temptation to then manage such remnants solely for maximal seed production. Manipulation of a remnant prairie to maximize seed production – such as whole-site, repeated annual burns, herbicide treatments, or fertilizing – is inappropriate and unethical. A remnant prairie is a diverse, biotic community (both above and below ground) of microbes, fungi, plants, and animals (vertebrate and invertebrate) interacting in complex relationships. Any management applied indiscriminately and repeatedly will be detrimental to some of these associations.

Burning should be limited to only a portion of a remnant any given year, and each portion should be burned on rotation and at different times of year, at varying intervals of time. Bulk harvest from remnants may be appropriate when the seed is intended for planting on adjacent or nearby land to buffer and expand the native prairie. Finally, any mechanical harvesting occurring in remnant sites should include a careful inspection and cleaning of equipment prior to use, including vehicles, to avoid introducing exotic/invasive species that may contaminate the equipment and lead to the degradation of the remnant or create long-term management issues.

Be mindful of other ethical considerations when collecting seed from prairie remnants. Federal and state endangered and threatened species cannot be collected without proper permits. Of course, it's essential to ask permission of the landowner before collecting seed on private property. Some seed growers will lease native prairie from the owners to exclude grazing over the summer so seed can be harvested from the site. Likewise, removal of any plant or plant part from preserves, natural areas, and parks may be restricted. Check with the proper agency before harvesting seed in these areas. Harvesting from roadsides may also be restricted in some states and counties. Contact the county engineer's office or state department of transportation before harvesting from county and state roadsides.

Seed Processing

Post-harvest processes include drying, pre-cleaning, cleaning, and proper seed storage. The extent of cleaning required after drying will depend on the species, storage conditions, and intended seeding method. Knowledge, skill, and access to specialized equipment are necessary for some of the cleaning steps described, and these factors will determine the quality of the finished product. Most commercial producers of native seed are cleaning seed to a very high quality of purity and germination.

Wooden drying bin with racks for drying bulk bags. Squirrel- cage blower provides ambient air flow.

Drying

Drying is a necessary step for proper seed cleaning and storage for most prairie species. Seed should be dried immediately after harvesting to prevent fungal growth and decomposition. Plastic bags or airtight containers can be used for storage **ONLY** after the seed is properly dried and cleaned. Larger quantities of material will require special bins with screened bottoms and a source of airflow up through the material for it to dry properly. Smaller quantities can be collected in large 100% cotton muslin bags made to fit inside a 30-gal plastic bin. Fill bags loosely with seed heads, tie closed, label, and place in the drying bins. If the material associated with the seed is very green, as is the case with spiderwort, or is damp from a recent shower, it's best to spread the material out on tarps and position several box fans overhead, turning the seed frequently with pitchforks or shovels. Drying may take several days to a few weeks, depending on quantity of material and drying conditions.

Pre-cleaning

Harvested material will require some degree of pre-cleaning to reduce bulk. The extent of pre-cleaning required will depend on the method of seed harvest, intended storage period, and method of planting. Threshing, debearding/deawning, and brushing are considered pre-cleaning methods because they are designed to prepare the seed for later cleaning processes by removing unnecessary appendages and improving seed flow.

Threshing

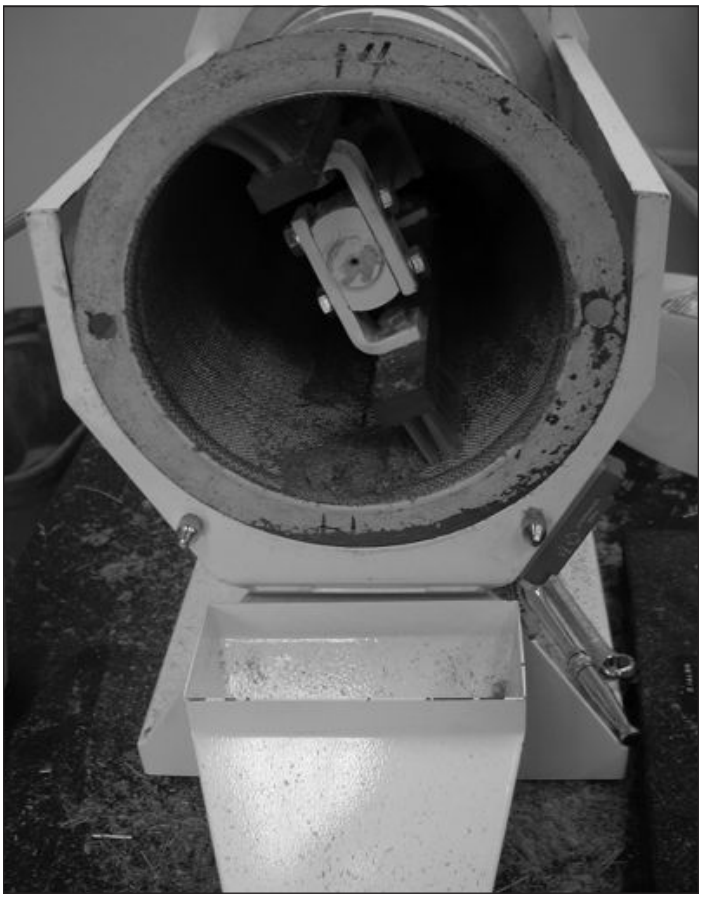
Threshing removes the seed from seed heads, one of the primary functions of a combine harvester. Hand-collected material can be threshed with a variety of machines, including hammer mills, huller/scarifiers, and brush machines. Some growers have adapted older combines (with cutter bars and reel removed for safety) for use as a stationary thresher of hand-collected material. A debearder (see next section) is effective for threshing the dried seed heads of compass plant and dried milkweed pods.

Non-mechanized threshing can be accomplished by stomping on seed heads. Using large plastic tubs, place about a 2-in. layer of bulk material in the bottom and stomp on it with waffle-type boots. Toe kicks to the corners of the tub help break up any stubborn seed heads. Stomped material is then screened through a coarse ½-in. or ¼-in. screen into a second tub. Continue in batches, returning any intact seed heads remaining to the stomping tub. This method is very effective on species of *Baptisia*, *Silphium*, *Helianthus*, *Veronicastrum*, and *Rudbeckia*. *Echinacea* tends to be stubborn and requires machine threshing, unless it's collected late in the season after seed heads naturally begin to break apart.

Big bluestem, *Andropogon gerardii*, discharging from debearder.

Deawning/Debearding

Many species have appendages, such as long awns or "beards" on grasses and pappus "parachutes" on seeds of asters, goldenrods, and other composites. Removing or minimizing these appendages further reduces bulk and improves seed flow for further cleaning. This step requires specialized and costly equipment. Debearding machines consist of a turning shaft with projecting metal teeth (bars) housed in a chamber. As the chamber fills with seed, the bars work the seed against itself, eventually breaking or rubbing the awns off. It's important, however, to fill the chamber with the proper amount of seed: too little and it's ineffective, too much and the seed can heat up and be damaged. A continuous flow-type debearder works well for larger quantities of seed, but batch-type debearders are also available for smaller quantities. A small gallon-size huller/scarifier is useful for deawning small individual accessions of seed. This type of machine is very aggressive and only a few seconds of treatment are typically needed.



Westrup Lab Scarifier/Brush machine with housing removed to show brushes and drum screen.

A laboratory scarifier/brush machine is useful for removing the pappus from asters, goldenrods, and blazingstars, but this versatile machine actually has many uses. Its basic action is to rub seeds/seed heads over a drum screen, or mantel, with rotating brushes. Mantels come in various screen sizes, and a variety of brushes is available. However, the machine can also be used as either a deawner or scarifier and is effective in removing the "cotton" from thimbleweed (*Anemone virginiana, A. cylindrica*), threshing seed from hand-collected mints, removing pods from purple prairie clover and leadplant, and deawning smaller quantities of grasses. Heavy canvas beater bars can be installed in place of brushes for a hammer-mill effect.

Cleaning Seed

Refer to Appendix C, Table 1C-4C for screen sizes and settings

Cleaning seed involves several techniques to remove plant fragments, particles, dust, and weed seeds. Proper cleaning will also remove empty, and therefore, non-viable, seed heads. Cleaning techniques involve various ways of sorting using screens, airflow, and specialized machines. The end goal is high quality, pure, filled seed, ready for an official seed test and precision planting.

Screening

Screens are used for sorting by shape and size. Screens are an integral part of fanning mills and air-screen cleaners and are commercially available in a wide range of pore sizes and shapes for these machines. Handheld pan-type screens are handy for small batches. Nested soil sieves are expensive but make excellent durable seed screens. Homemade screens of hardware cloth attached to wood frames are effective for rough cleaning. Depending on the application, screens are classified as scalping, grading or sizing, and sifting, as described below.

Rough screening combined material through 1/2" hardware cloth to remove large stems and leaves.

Scalping removes objects larger, longer, and wider than the desired crop seed. Screens used for scalping have pores larger than the seed. Scalping material through a much larger screen first, and then one closer to seed size is often more efficient, allowing material to flow more freely through each screen.

Grading sorts desired seed, or "crop" seed by size. Any given species' seed will contain a range of seed sizes. Avoid intentionally grading seed intended for restoration plantings, since selection for seed size can happen in one generation, (i.e. large seeds will give rise to plants with large seeds), and may reduce genetic variability. Likewise, sometimes seeds of a weed species are present that are equal in size and weight to the smaller or larger sizes of crop seed present. If this is the case, it may be a necessary trade-off to scalp off a small fraction of the smaller or larger sizes of crop seed in order to effectively remove the weed species.

Westrup Lab Air Screen Cleaner

Screen pulled out for viewing.

Sifting is the final screening step. Use a screen with pores just smaller than the seed to allow dust, broken seeds, etc. to fall through and yet retain desired seed on screen.

This series of screening processes is effective in concentrating desired seed and removing most other inert, or non-seed material. Empty, non-viable, but otherwise normal looking seed will not be removed by simple screening. This "light" seed is removed with airflow, either by winnowing or aspiration.

Winnowing

Winnowing is a process using horizontally moving air to separate heavy from light particles. Winnowing seed in a gentle breeze can be very effective in removing chaff and light seed. To achieve more control, place a tarp on the floor and an ordinary box fan at one end of the tarp. Pour seed gently in front of the fan. Heavier seed falls closer to the fan than light seed or empty seed. Fine-tune the process by experimenting with fan speed and distance from fan. Once you find the most effective combination, continue to pour the seed in front of the fan in a consistent manner. The seed should now be laying somewhat fanned out on the tarp, with the heavier seed nearer to the fan and light or empty seed further away. Using a thumbnail, push down on the seed coats closest to the fan at first, repeating this test as you gradually move away from the fan. Heavy seed will feel firm and resist being crushed with gentle, downward pressure; empty seeds, on the other hand, will offer little resistance and crush easily. Make a determination where the heavy seed ends and the light or empty seed begins, and draw a line through the pile of seed at this point. Clean, heavy seed can then be swept up and stored for planting, while the rest is discarded.

Aspirating

Aspirating uses vertically moving air to suspend particles in a column. Lighter seeds are either captured in a pocket of the column, as in a South Dakota seed blower, or blown completely out of the column. Heavier seeds drop out of the column. Desired separation is achieved by adjusting airflow in the column. Fanning mills and air/screen cleaners are machines designed to combine the screening and aspiration process and are very efficient once the proper screens and settings have been made.

Separating Seed by Length, Seed Coat, Specific Gravity

Proper weed control during the growing season – especially the removal of weeds from production fields prior to harvest – is the best way to assure a weed-free finished product. Invariably, weed seeds will find their way into the combine and into the crop seed. If weed seeds of the same size, weight, and shape as the crop seed are present, they cannot be removed by

simple screening and aspirating alone. Additional separating and sorting techniques will be required and may not always be successful. The following machines/techniques are indispensable for commercial seed cleaning and conditioning necessary to meet federal and state seed laws; however, they require a considerable investment and are not practical for non-commercial use.

• *Length*

Seeds can be separated by length in an indent cylinder. An indent cylinder consists of a dimpled drum rotating nearly horizontally. Seeds small enough to fit in a dimple are picked up and dropped by gravity into a trough suspended in the center of the rotating drum. Material too long to fit in the dimples dribbles out the end of the drum. Thus, two fractions are produced: seed/particles shorter than or equal to the dimples and seeds/particles longer than the dimples. This is a very effective way to sort foxtail, pigweed, lamb's quarters, etc. from longer grass seeds. Drums are available with different size dimples.

• *Shape/Seed coat texture*

Seeds can be sorted by seed coat texture with velvet rollers and belt sorters. As seed is dribbled onto an inclined rotating belt or cylinder, seeds with projections, hairs, or rough seed coats are pulled along on the belt or off over the cylinder, while smooth seeds slide off more quickly, creating a separation between smooth and rough seed types. Belt sorters are also effective in sorting seeds with flat shapes from those with rounded shapes. Flat seeds tend to stay on the inclined belt and are conveyed to a hopper at the end of the rotating belt, while rounded seeds tend to roll off the inclined belt and collect in a different hopper. An example of this would be sorting the rounded seeds of foxtail (*Setaria spp*.) from the flatter seeds of greyhead coneflower (*Ratibida pinnata*).

• *Specific gravity*

Gravity tables are used to sort particles of different size and same density, or particles of same size with different densities. Thus lighter, unfilled, and therefore less dense seeds are separated from heavy, filled seed. Gravity tables are most effective on seed that has been graded to a uniform size using grading screens. The gravity table was effective in sorting lamb's quarter (*Chenopodium spp*.) seed from horsemint (*Monarda fistulosa*).

Literature Cited

Deno, N.C. 1993. Seed germination theory and practice, based on experiments on 145 families, 805 genera, 4000 species. Second Ed. Penn State University. Address all inquiries and orders to Norman C. Deno, 139 Lenor Dr, State College, PA 16801, USA.

Storage

Proper storage of seed is essential to maintain viability (ability to germinate) and vigor (ability to successfully establish in the field). Generally, germination tends to increase slightly in some species stored up to a year after harvest as dormancy mechanisms break down. Germination then declines over the long term due to seed mortality during storage. Proper storage conditions will slow this decline. In controlled environment as defined below, seed with hard seed coats, such as legumes, tend to store longer than grass seeds and may remain viable for decades. However in an uncontrolled environment the reverse situation can occur. Oil based seeds, such as legumes, can quickly degrade within a few years, compared to starch based seeds that degrade more slowly over time *(Figure 2)*.

Seed should always be kept in a cool, dry, rodent-proof place. Seed stored at 60°F stays viable twice as long as seed stored at 70°F. Long-term storage requires a more stringent temperature- and humidity-controlled environment. A rule of thumb is that the sum of the temperature (degrees Fahrenheit) and relative humidity (RH) should not exceed 100. An examples would be storing seed at 50°F and 40% RH or 40°F and 50% RH, the addition of the two is less than 100. Relative humidity above 40% is especially detrimental to legume (oil based) seeds. As a general guideline, the longevity of seed is halved for each 10-degree increase in storage temperature or 1% increase in seed moisture content during storage. Once seed has been dried properly, moisture resistant containers, such as glass or plastic jars, or 4-mil plastic bags, will help protect it from collecting moisture.

There are other important factors, besides temperature and humidity, that can affect longevity of stored seed. Inert matter can harbor fungal and insect pathogens which might damage seed during storage. Cleaning seed properly and thoroughly will extend viability. Overly aggressive cleaning, however, can damage seed and shorten longevity of stored seed. Care should be taken with brushing/debearding/deawning processes not to excessively damage seed. Seed damaged by overly aggressive debearding may shorten shelf life over the long term, but the benefits include improved germination and seed flow. Improved seed flow facilitates cleaning and seed placement during planting.

Generally, germination tends to increase slightly in some species stored up to a year after harvest as dormancy mechanisms break down. Germination then declines over the long term due to seed mortality during storage. Proper storage conditions will slow this decline.

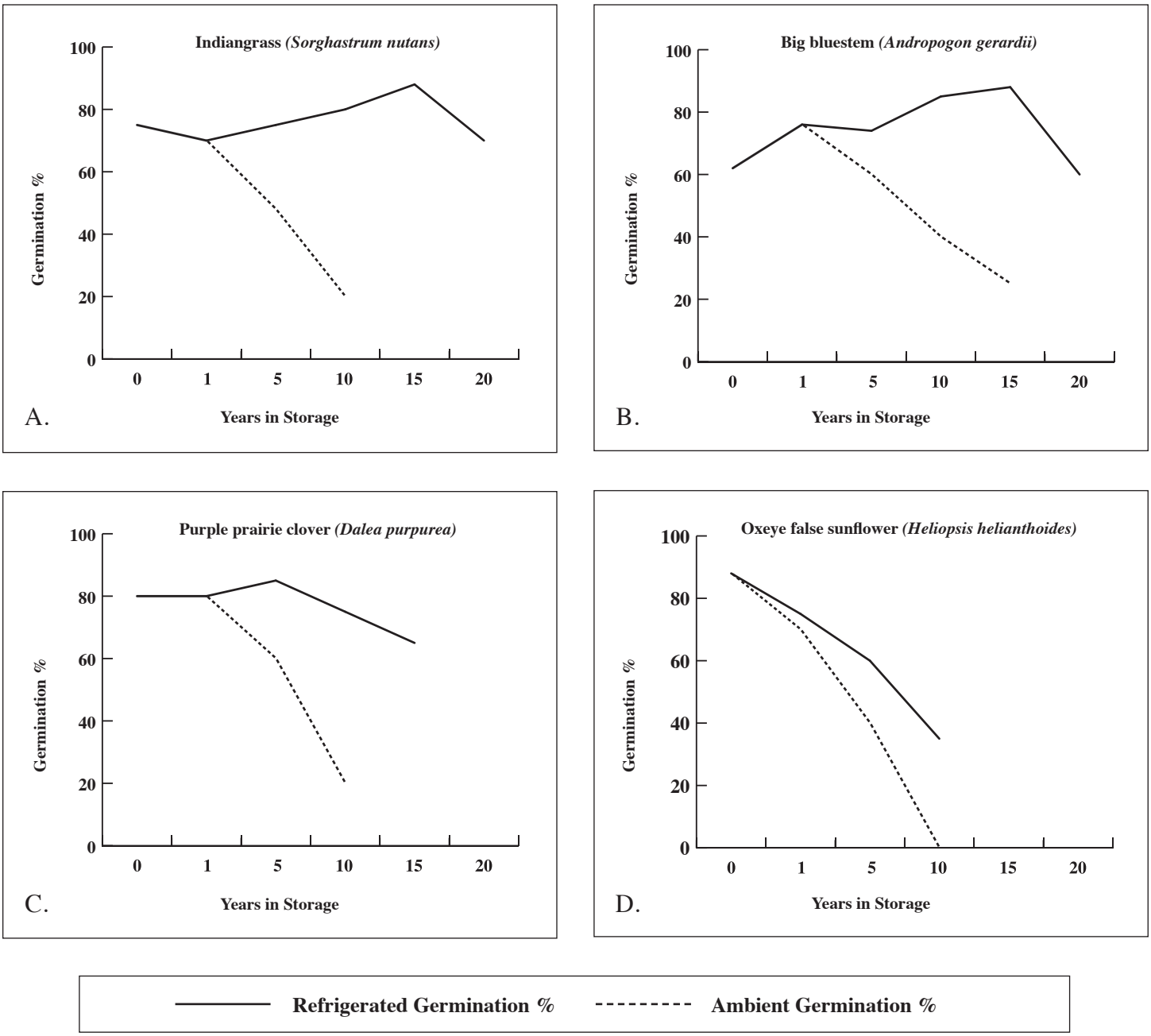


Figure 2. The above graphs illustrate the importance of proper storage conditions for preserving seed viability (germination %) over time. Solid line represents seed viability in controlled conditions of temperature and humidity (refrigerated). Dashed line represents seed viability at room temperature (ambient) conditions. Graph A) Indiangrass *(Sorghastrum nutans)*; B) Big bluestem *(Andropogon gerardii)*; C) Purple prairie clover *(Dalea purpurea)*; and D) Oxeye false sunflower *(Heliopsis helianthoides)*. Note that germination % may increase initially as dormancy mechanisms in the seed break down over time. Viability (germination %) diminishes over time, but much more rapidly when stored improperly. Starched-base grass seed store well over time (graphs A and B). Seed of forb species, such as oxeye, may not store as well long-term due to higher oil content (graph D). Forbs with hard seed coats, such as in legume species, help preserve viability (graph C). Data from a long term seed storage study at USDA NRCS Manhattan Plant Materials Center, Manhattan, KS. (Courtesy of Rich Wynia, Manager, Manhattan PMC).

Seed Source and Quality

Importance of Seed Source

In prairie restoration, seed source is of critical importance. Remnant prairie serves as a template for species composition and abundance, but also may have unique genetic composition. Many seek to use the most appropriate genetic source for restoration. In all cases, a seed's source should not be confused with where the seed is produced or sold (i.e., location of a production field, nursery, or seed dealer); rather, source refers to the original remnant source of the seed used to establish the production field or nursery.

Local Ecotype vs. Regional Sources

Prairie restorationists are often admonished to use "local ecotype" seed with little clarification as to what this means. The terms "local" and "ecotype" are commonly used to convey the idea that any remnant population may have specific genetic traits (genotypes) or adaptations that are unique to that population. Preserving this presumed inherent value of local gene pools of species in remnant communities is important. To help preserve this genetic material, using "local" seed (i.e., seed from the remnant itself or other very nearby remnants) is recommended for plantings adjacent to or within one-half mile of a remnant prairie (Reinartz 1997). The challenge of this approach is harvesting enough quality seed from a remnant in a single year to seed the new planting; therefore, the seeding may need to be done in phases over successive years.

There is an assumption that local seed is always best or better adapted to a proposed reconstruction site than "non-local" seed; however, this may not be true. A single local seed source may be adequate if a large, genetically diverse population is available and seed is collected from throughout the population. On the other hand, extremely small populations of only a few individuals may have lost genetic diversity over time with a loss of reproductive fitness and long-term survival.

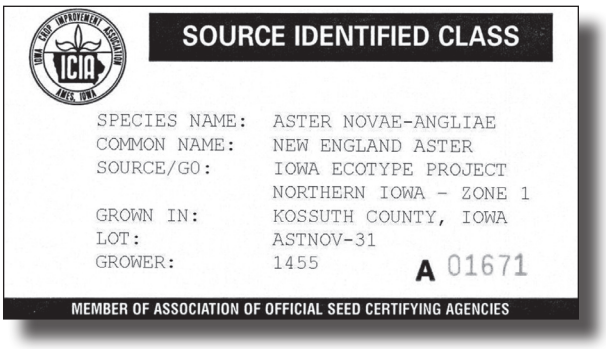
More important than using seed from a local source, then, is actually matching the conditions of the site of the donor seed source to those of the reconstruction site. For example, harvesting seed from a wet pothole prairie to use on a nearby upland is not as suitable – in terms of both species and "ecotypes" – as using seed from a more distant, but upland remnant source with similar soils and climate and a more appropriate species composition.

A regional source of seed pooled from several remnant populations is an appropriate source for most reconstructions. In the Midwest, remnant prairies are so scattered and isolated that there may be no "local" remnant sources of seed over large areas of the landscape. Various agencies have defined seed-source regions based on geography, landforms, watersheds, species distribution, and political boundaries. Pooling seed collected from different populations in a defined area or region is a reasonable strategy for increasing the genetic diversity of the donor seed, a way of hedging your bet that the right combination of genetic material will be present to best occupy the reconstruction site over the long term. This may be particularly important when donor populations are very small and isolated. Mixing populations from the extremes of a species geographic or habitat range, however, should be avoided.

An equal amount of seed, or seedling grown transplants, from each population should be planted in the nursery population so that all populations contribute roughly equal amounts to the next generation of seed. Admittedly, in the absence of species- and population-specific information on genetics and reproductive biology, the size and extent of a region and which populations should be mixed often becomes a matter of personal opinion for restoration practitioners.

Source-Identified Seed

Because plant materials of known genetic origin were in immediate demand for restoration on disturbed sites in the West, the need for third-party verification of source led to the development of the source-identified seed program. Standards for source-identified, or "Yellow Tag" seed, were developed by the Association of Official Seed Certifying Agencies (AOSCA). The program is administered by AOSCA's affiliate state crop improvement associations. AOSCA source-identified seed



standards provide a "fast-track" alternative release procedure when 1) there are inadequate existing commercial supplies for a species, 2) propagation material from specific ecotypes is needed for ecosystem restoration, 3) there is a high potential for immediate use, and 4) there is limited potential for commercial production beyond specific plant community sites (Young 1995).

Source-identified seed may be from either a single remnant source or from several sources pooled together as a regional source. No intentional selection or testing of traits occurs. Original

collection sites are documented, and nursery and production fields established from original collections are inspected and certified annually. Commercially produced seed is marketed with an official AOSCA yellow certification tag identifying the source and the producer of the material.

Several Midwest states have source-identified seed programs in place, administered by their respective crop improvement association per AOSCA guidelines. Individual states differ in their application of source-identified program guidelines regarding native species, so it's important to check specific policies for the particular state in question. Several states have reciprocal agreements regarding isolation distances and proprietary rights – among them Iowa, Minnesota, Wisconsin, and Missouri.

Cultivated Varieties of Native Species

The USDA Plant Materials Program has developed cultivated varieties, commonly known as cultivars, of several native grasses and some forb species. The traditional approach was to collect an entire plant, or seed from a plant, that exhibited a desired characteristic, such as vigor. These collections, or accessions, were propagated and evaluated in common gardens to further study their characteristics. A selection was made, often of only a few individuals or populations, for further breeding and increase. The goal was to select specific, desired traits such as good germination and establishment, high forage yield, height, vigor, and winter hardiness. However, while cultivars may be desirable in a pasture setting for forage production, they are not recommended for prairie restoration, particularly since they either 1) have been derived from distant, out-of-state sources, or 2) have been selectively bred for specific traits, often competitiveness and vigor, which has the effect of narrowing their genetic base. If cultivars must be used for reconstructions, two or three different varieties should be used to increase the genetic diversity of the planting.

More recently, USDA-PMC plant selections have reflected the trend toward broad-based regional genetic diversity. Badlands "ecotype" little bluestem, for example, is a composite of 68 accessions (collections) selected for disease resistance from an initial evaluation of 588 vegetative accessions collected from throughout North and South Dakota and Minnesota. This "selection" of a diverse assemblage of little bluestem populations may be a desirable and appropriate seed source for restorations in those states from which it was derived.

The USDA-NRCS has long recognized the limits of the successful transfer of plant materials to another location (Cooper 1957, McMillan 1959). Their recommendation has been to move cultivars (primarily in reference to warm-season grasses) not more than 300 miles north or 200 miles south of their origin. Plants moved northward more than 300 miles generally will not produce seed and are prone to winter injury (Olson 1986, Jacobson 1986). Plants moved southward further than 200 miles are more prone to disease.

Cultivar material exists for limited number of native species. Many native species that are in demand for restoration can only be obtained through direct harvest from native stands or through the source-identified seed program described above.

Seed Quality

Knowing the quality of the seed you purchase, produce or market, is critically important. Impure or trashy seed will not store as well as clean seed and can harbor the seed of noxious weeds or other undesirable species. Fortunately, seed quality has improved dramatically over the past few years as growers gain experience and acquire better equipment for producing, harvesting, and cleaning native species. Seed dispersal apparatus like awns on grass seed and hairy "parachutes" on forb seed are routinely removed. This means the seed lot can be cleaned to greater purity and viability and will flow more efficiently through the seeding equipment.

Quality native seed is sold on a pure live seed, or PLS basis. Three factors are used to calculate the percentage of pure live seed: purity, germination, and dormancy. These values must be determined by a certified seed analyst. Purity is a measure of pure, unbroken crop seed units as a percent by weight of the seed lot. Percent germination is determined by placing seed in a germination chamber for an approved time period. Many species,

Lab. Number	12-1641
Date	1/13/07
Kind and Variety	LITTLE BLUESTEM (*SCHIZACHYRIUM SCOPARIUM*)
Purity and Germination analysis of seed sample	
Pure seed	58.85 %
Inert matter	41.14 %
Other crop	0.01 %
Weed seeds	0.00 %
Germination	65.00 %
Hard seed	%
Total germ and hard seed	%
Dormant seed	30.00 %
Tetrazolium	%
Name and no. of noxious weed seeds per lb. (All states noxious count unless otherwise indicated.)	NONE

particularly forbs, have dormancy mechanisms that require several weeks of cold-moist stratification to "break" dormancy,

allowing germination to occur. For most native species, no standard protocols exist for breaking dormancy for germination testing purposes. Therefore, any remaining non-germinated seed is tested biochemically with tetrazolium chloride (TZ), a clear compound that stains living tissue cherry red. The analyst determines the potential viability of stained seed – non-germinated seed considered viable by a TZ test is counted as dormant. A seed test showing a high percentage of dormancy is common in many native forb species and some grasses. This should be expected of natives, particularly in seed lots harvested within the past year. A high percentage of dormancy means much of that seed won't germinate until dormancy is broken, either artificially or by natural environmental conditions.

Refer to Appendix D, Table 1D for sample seed test results for various species.

Calculating Pure Live Seed Amounts

Pure Live Seed (PLS) is a measure of the proportion of the viable seed of a species or variety per unit weight for a given lot of seed. PLS for forage crops and turf grass is normally calculated using percent purity and percent germination, only, as dormancy is not a significant issue for these types of species. Native species, however, may have a significant proportion of dormant, yet viable seed, particularly among forb species. The native seed trade recognizes this fact and uses three factors to calculate PLS. Therefore, purity, germination, and dormancy are used to calculate Pure Live Seed, or PLS, of any given native seed lot per below:

Pounds (#) PLS is calculated as:

#PLS= (#Bulk) x (%purity) x (%germination + % dormant)

Where % is expressed as a proportion, i.e. 98% = 0.98

For example, a 50# bulk bag of seed that is 98% pure seed, with 52% germination and 27% dormant seed, really contains only 38# of pure viable seed (seed that potentially will germinate):

#PLS = 50# bulk x 0.98 x (0.52 + 0.27) = 38# PLS or 50# bulk x 0.7742

If however, you request 50# PLS bag of that same seed, you would receive a bag weighing 64.58# bulk.

#bulk = #PLS/[(%purity) x (%germination + % dormant)] or 50#PLS/0.7742= 64.58# bulk

Literature Cited

Cooper, H.W. 1957. Some plant materials and improved techniques used in soil and water conservation in the Great Plains. J. *Soil Water Conserv*. 12:163-168.

Jacobson, E.T., D.A. Tober, R.J. Haas, and D.C. Darris. 1986. The performance of selected cultivars of warm season grasses in the northern prairie and plains states. Ed. G.K. Clambey and R.H. Pemble. *The prairie: past, present and future: Proceedings of the Ninth North American Prairie Conference*. Tri-College University Center for Envrionmental Studies, Moorhead, Minnesota.

McMillan, C. 1959. The role of ecotypic variation in the distribution of the central grassland of North America. *Ecol. Monogr*. 29:285-308.

Olson, W.W. 1986. Phenology of selected varieties of warm season native grasses. Ed. G.K. Clambey and R.H. Pemble. *The prairie: past, present and future: Proceedings of the Ninth North American Prairie Conference*. Tri-College University Center for Environmental Studies, Moorhead, Minnesota.

Young, S.A. 1995. Verification of germplasm origin and genetic status by seed certification agencies. B.A. Roundy, E.D. McArthur, J.S. Haley, D.K. Mann, comps. 1995. Proceedings*: Wildland Shrub and Arid Land Restoration Symposium*; 1993 October 19-21; Las Vegas, NV. Gen. Tech. Rep. INT-GTR-315. Ogden, UT; U.S. Department of Agriculture, Forest Service, Intermountain Research Station.

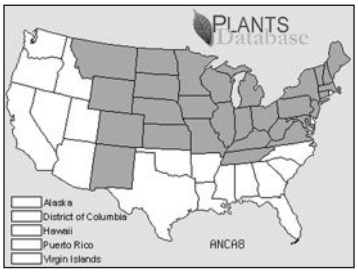
Canada Anemone
Anemone canadensis, L.

Genus *Anemone*, Greek 'wind', e.g. 'windflower'; species *canadensis* Latin 'of Canada'.

Family: Buttercup (Ranunculaceae)

Other Common Name(s): meadow anemone

Description: Native herbaceous perennial. 1-1 1/2' tall, sprawling. Large white flowers, 1 1/2" wide, borne above on stalk above leaves. Leaves basal with long (6") stalks, deeply 3-lobed, 2-3" wide. Seedhead somewhat mace-like, globular, often overtopped by foliage at maturity. Seedheads shatter by mid-summer. This plant is very clonal, spreading vegetatively from rhizomes, and is typically found in patches, sometimes large ones.



Adaptation/Habitat: Wet-mesic to mesic soil conditions, full sun to partial sun.

Threatened/Endangered Status: Endangered in CT, TN, MD; Historical in KY.

General Comments: This species is challenging to propagate from seed because of difficulties with germination, but once established it tends to spread prolifically and is relatively easy to manage, harvest, and clean.

Establishment for Seed Production (Appendix A)

Direct seeding:

Seeding rate: 4.5 PLS lbs/acre (40 seeds/linear foot)
Row Spacing: 30-36" rows
Seeding Depth: 1/4"
Seeding Methods: drill
Time of Seeding: Dormant
Weed Control: Prepare clean, firm, weed free seedbed prior to seeding

Greenhouse:

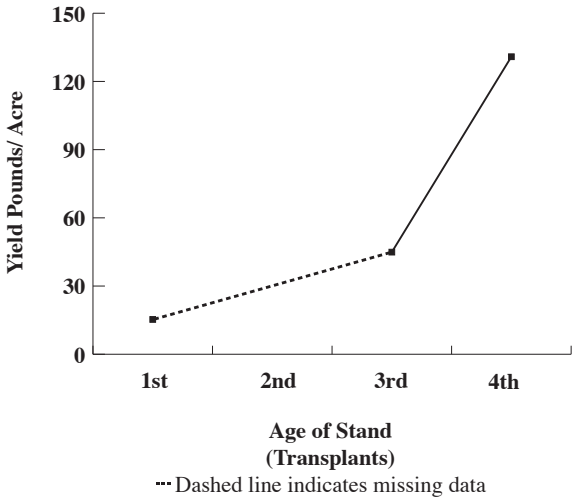
Seed pre-treatment: Moist stratify 12 weeks at 40º F, or alternatively in ambient winter conditions (unheated building). Sow seed in greenhouse two months before last frost free date. Typically this species exhibits very high dormancy (low germination) and may require two winter cycles to germinate. Transplant into bare soil in rows or weedbarrier at 8" intervals after all danger of frost is past. Once plants are established they spread prolifically by rhizomes, so weed barrier will need to be remove or slit open to accommodate growth and enhance seed production.

Stand Management

Weeds –Weed control is critical to successful establishment and seed production of this species. Control with post-emergent grass herbicide, tillage, hand roguing.
Pests – Blister beetles may forage voraciously on foliage
Diseases – No serious diseases known
Pollination: Insects. Plants will not self-pollinate within the same genetic clone (Douglas and Cruden, 1994). Easy to propagate by division of rhizomes, but more than one genotype needs to be present for effective seed production.

Seed Production (Appendix B)

- First Harvest: Some flowering and seed set end of 1st growing season from greenhouse grown transplants. Direct seed stands may take 3 years to become productive
- Yield/Acre: 50-150 bulk lbs/ac
- Stand Life: Peak harvest 4th year? Stand longevity unknown as of this writing.
- Flowering Date: Flowering occurs mid-May to late June.
- Seed Maturity: Mid- to late July
- Seed Retention: Shattering occurs soon after (and perhaps before) seed maturity.
- Harvest date range at TPC (2002-2006): July 17 – July 26
- Recommended Harvest Method: Combine near maturity, but before seed head breaks apart. (Refer to *Appendix B* for settings.) Plants will regrow new foliage after harvest.



Dashed line indicates missing data

Seed Cleaning (Appendix C)

Cleaning Process: Pre-clean air-dried material by scalping thru 1/2" and 1/4" mesh to remove large particles. Air-screen to clean.

Seed Characteristics (Appendix D)

Seed count: 8,000 seeds/oz (128,000/lb)

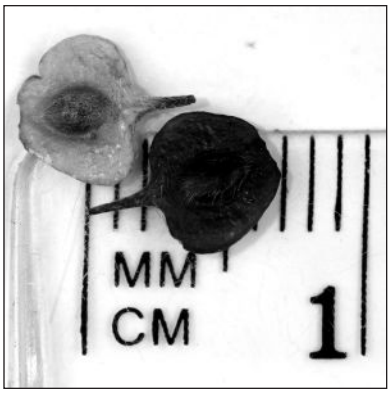


Photo credit: Dave Williams

Description: 'Seeds' are actually one-seeded flattened fruits, about 1/8" in diameter, arranged in a ball-shape head about 3/8" in diameter.

Seed Storage: Stores well in refrigerated conditions (50° F, 30% RH)

Typical Seed Test (%)

- Purity 90-99
- Germination: 20
- Dormancy: 70

Released Germplasm (Appendix E):

Source Identified Material: Southern Iowa *Natural Selections™*

Cultivated Varieties: None known

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 12 January 2007.

An Illustrated Guide to Iowa Prairie Plants, p. 148. Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

The Reproductive Biology of Anemone canadensis (Ranunculaceae): Breeding System and Facilitation of Sexual Selection. Douglas, K.L., R.W. Cruden. 1994. *American Journal of Botany*, Vol. 81, No. 3 (Mar., 1994), pp. 314-321

Notes:

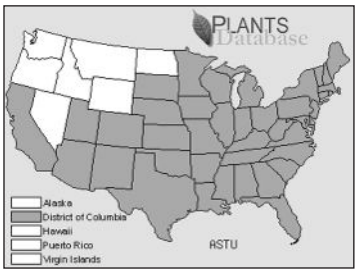
Butterfly Milkweed
Asclepias tuberosa L.

Genus *Asclepias*, Latin, named for *Aesculapius*, Roman god of medicine and healing in recognition of plants medicinal qualities; species *tuberosa,* Latin *tuberosus* 'knobby, tuberous', in reference to tuberous, knobby tap root.

Family: Milkweed family (Asclepiadaceae)

Other Common Name(s): Butterfly weed, Pleurisy-root.

Description: Native herbaceous perennial. 1.5-2.5' tall. Bright orange flowers 1/4" long borne in clusters (umbels) on stem tips. Alternate leaves, somewhat hairy. Seedpods (follicles) about 4" long, produced more abundantly on 2nd year plants, and tend to abort on older plants. Deep, somewhat woody tap root. Unlike other milkweeds, butterfly milkweed has no milky sap. Forms large clumps in preferred, well-drained soils.



Adaptation/Habitat: Mesic to dry, prefers well-drained soils; high quality prairie remnants. Full sun.

Threatened/Endangered Status: Endangered (NH); Threatened (VT, NY); Possibly extirpated (ME).

General Comments: The bright orange flowers make this a desirable species for horticultural displays as well as prairie reconstructions. Germinates readily in the greenhouse with proper stratification. Requires care in transplanting because of the taproot structure. Does best in very well-drained soils. Requires hand-harvesting as pods ripen.

Establishment for Seed Production (Appendix A)

Direct seeding:

NOT RECOMMENDED FOR THIS SPECIES

Seeding rate: 8.5 PLS lbs/acre (40 seeds/linear foot)
Row Spacing: 30-36" rows
Seeding Depth: 1/4"
Seeding Methods: drill
Time of Seeding: dormant
Weed Control: Prepare clean, firm, weed free seedbed prior to seeding.

Greenhouse:

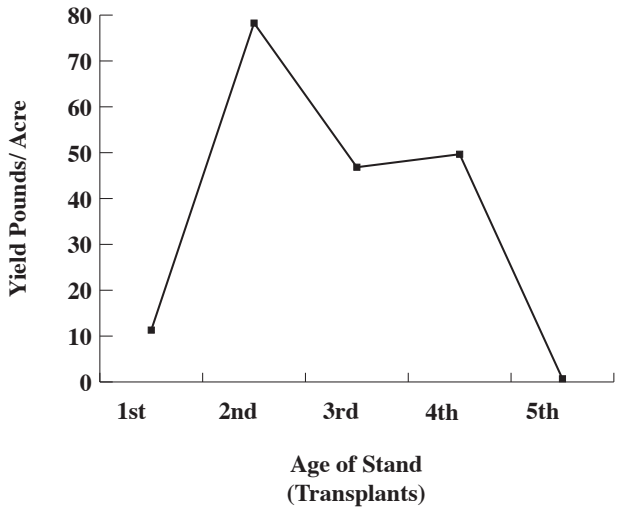
Seed pre-treatment: Wet stratify 8 weeks at 40º F.
Sow seed in greenhouse two months before last frost free date. Susceptible to damping off in greenhouse (See Greenhouse Propagation chapter). Plant into bare soil in 36" rows or weedbarrier at 12" intervals.

Stand Management

Weeds – Mow/cultivate between rows. Post emergence grass herbicide, tillage, roguing
Pests – Yellow milkweed aphids on upper portions of plant, including pods. Monarch larva eat foliage and pods, but not a serious problem on this milkweed species.
Diseases – Susceptible to Pythium root rot in field soils, contaminated potting soils, containers, etc. (Tsror et al. 1997).
Pollination: Insects, particularly butterflies, bees

Seed Production (Appendix B)

- First Harvest: Some flowering and minimal seed production first year with greenhouse transplants.
- Yield/Acre: 10-80 bulk lbs/ac
- Stand Life: Peak harvest 2nd year. Stand persists in well-drained soils if disease free, but seed production may decline significantly in subsequent years.
- Flowering Date: Flowering occurs from mid-June to mid-August
- Seed Maturity/Harvest Date: Mid-August to mid-October
- Seed Retention: Seed dispersed soon after ripening
- Harvest date range at TPC (2002-2006): Sept. 2-Oct. 17
- Recommended Harvest Method: Small plots - Hand harvest as pods ripen. Check daily. Ripe pods usually have a blush of yellow (somewhat like a ripe peach) and split readily with a gentle squeeze. Seeds are mature if they appear chocolate brown. If still creamy white, leave pod unpicked for another day or two.

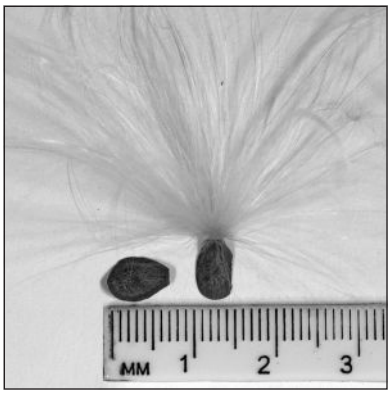


Seed Cleaning (Appendix C)

Cleaning Process: Seeds can be separated from freshly picked pods with a hammer mill, or from dried pods using a debearder. Brush seeds to remove winged margin, then air-screen.

Seed Characteristics (Appendix D)

Seed count: 4,300 seeds/oz (68,800/lb)



Description: Seeds are flat, brown about 1/4" by 3/16" with tuft of filaments (floss).

Seed Storage: Stores well in refrigerated conditions (50º F, 30% RH)

Typical Seed Test (%)

- Purity: 95+
- Germination: 50
- Dormancy: 40

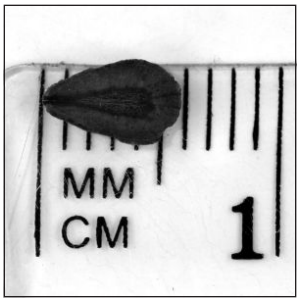


Photo credits: Dave Williams, Brent Butler

Released Germplasm (Appendix E)

Source Identified Material: Central, Southern Iowa *Natural Selections*™, 'Glacial Lake', (NY-Albany,PMC)

Other economics values of milkweeds in general: silk (floss) as hypo allergenic fibers; roots for pharmaceuticals; blooms as cut flowers; seed oil for soaps and personal care products.

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 4 January 2007.

Illinois Wildflowers, http://www.illinoiswildflowers.info/prairie/plantx/btf_milkweedx.htm. Accessed January 4, 2007.

Pythium root rot. http://www.ppath.cas.psu.edu/extension/plant_disease/pythrrot.html. Plant Pathology Department, Penn State College of Agriculture. Accessed 4 January 2007.

A Grower's Guide: Butterfly Milkweed/Pleurisy Root. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. MF-2623, Available at (http://www.oznet.ksu.edu) May 2004.

An Illustrated Guide to Iowa Prairie Plants, p. 25, Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

Wilt and Root Diseases of Asclepias tuberosa L. L. Tsror (Lahkim), M. Hazanovski, O. Erlich, and N. Dagityar, Department of Plant Pathology, Agricultural Research Organization, Gilat Experiment Station, 85280, M. P. Negev, Israel, Plant Disease, Vol. 81 No. 10, October 1997.

Notes:

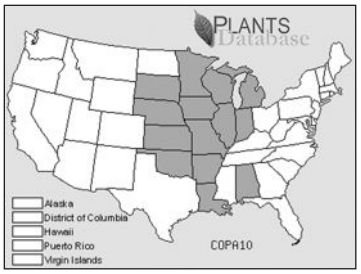
Prairie Coreopsis
Coreopsis palmata, Nutt.

from *koris*, Greek 'bedbug'; *opsis*, Greek 'appearance'; thus bug-like, referring to achenes. *palmata*, Latin 'palmate' (hand-shaped leaves).

Family: Daisy family (Asteraceae)

Other Common Name(s): Stiff coreopsis, Stiff tickseed

Description: Native perennial. 2- 2.5' tall. Composite yellow flowers with notched petals at ends of leafy flower stalks. Only marginal flowers produce 'seeds' (fruits). Opposite leaves divided into three elongate lobes. Spreads vegetatively (rhizomatous).



Adaptation/Habitat: Mesic to dry-mesic soils, medium to high quality prairies. Avoid wet and poorly drained soils. Threatened/Endangered Status: Threatened (MI)

General Comments: This species typically occurs in colonies (clonal) in native prairies, spreading from rhizomes. Flattened, inwardly curved, winged seeds makes effective air-screen separation challenging.

Establishment for Seed Production (Appendix A)

Direct seeding:

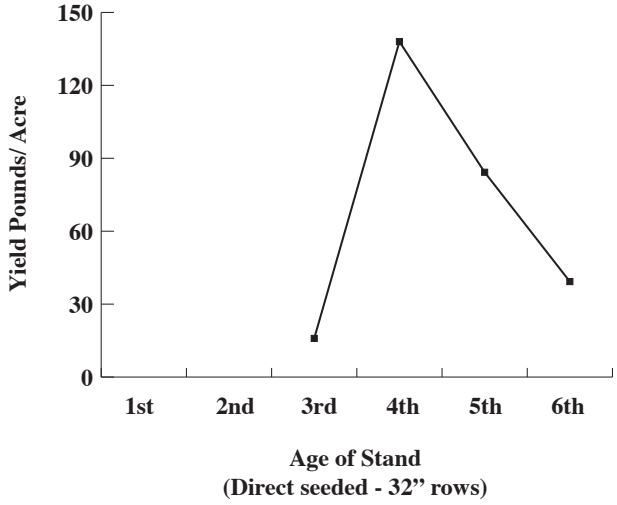
Seeding rate: 3.0 PLS lbs/acre (40 seeds/linear foot)
Row Spacing: 30-36" rows
Seeding Depth: 1/4"
Seeding Methods: native seed drill
Time of Seeding: dormant season
Weed Control: Prepare clean, firm, weed free seedbed prior to seeding.

Greenhouse:

Seed pre-treatment: Wet stratify 8-12 weeks at 40 F. Sow seed in greenhouse two months before last frost free date. Harden-off, transplant into bare soil in rows after all danger of frost. Weed barrier is NOT recommended since this species spreads vegetatively.

Stand Management

Weeds – Mow/cultivate between rows. Post emergence grass herbicide, tillage, roguing
Pests – No serious pests known
Diseases – Crown root rot if planted in too wet soils
Pollination: Insects



Seed Production (Appendix B)

- First Harvest: Some flowering first growing season from transplants, but minimal seed production. Flowering and seed production second year.
- Yield/Acre: 40-140? bulk lbs/ac Stand Life: Peak harvest 2-3rd year. Stand persists but seed production declines 4th year. Aerating the soil of the plot post-harvest 3rd season with a turf aerator may enhance seed set the following season.
- Flowering Date: Flowering occurs late June through mid July
- Seed Maturity/Harvest Date: October
- Seed Retention: Shattering occurs late October to early November
- Harvest date range at TPC (2002-2006): Oct.. 9 - 20
- Recommended Harvest Method: Combine

Seed Cleaning (Appendix C)

Cleaning Process: Pre-clean by scalping thru 1/2' and 1/4" mesh to remove large particles and make flowable, then air-screen repeatedly, indent if needed. Because seeds are flat, separation from leaf particle of similar size and weight requires repeated air-screen cleaning to improve purity.
(No awns or appendages to remove)

Seed Characteristics (Appendix D)

Seed count: 10,000 seeds/oz (160,000/lb)

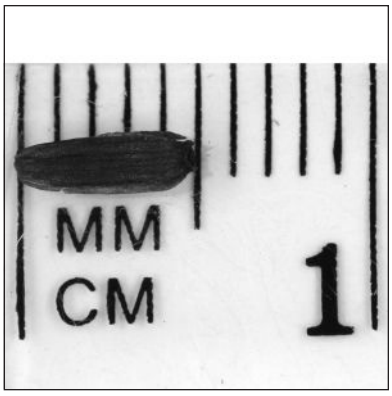


Photo credit: Dave Williams

Description: 'Seeds' are oblong, inwardly curved achene with winged margins
Seed Storage: Stores well in refrigerated conditions (32-40 F, 40-60% RH).

Typical Seed Test:
- Purities: 70+
- Germination: 42
- Dormancy: 47

Released Germplasm (Appendix E):

Northern, Southern Iowa *Natural Selections™* Source-Identified germplasm, Northern, and Western Missouri Source Identified germplasm.

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 21 December 2006.

Missouri Botanic Gardens. 2006. PlantFinder Database, Kemper Center for Home Gardening (http://www.mobot.org/GARDENINGHELP/PLANTFINDER/). Accessed 20 December 2006.

Notice of Release, Missouri Germplasm, Prairie Coreopsis. USDA-NRCS Elsberry Plant Materials Center. June 2001.

An Illustrated Guide to Iowa Prairie Plants, p. 42. Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

An Illustrated Flora of the Northern United States and Canada, Vol. III p. 492. Britton, N. and A. Brown. General Publishing Company, Ltd., Toronto, Ontario, Canada. 1970.

Notes:

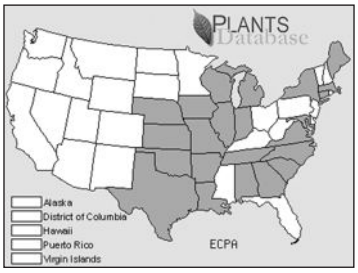
Pale Purple Coneflower
Echinacea pallida, (Nutt.) Nutt.

Genus *Echinacea*, Latin echinos 'sea urchin, hedgehog' presumably in reference to the spiny seedhead ; species *pallida* Latin 'pale, pallid', in reference to pale colored petals.

Family: Aster (Asteraceae)

Other Common Name(s):

Description: Native perennial. 2-3' tall. Flowers arranged as a single, composite head at top of flowering stalks. Leaves are mostly basal, long-tapered, coarsely hairy, with three prominent parallel veins. Flowerheads with pale pink-purple drooping ray petals about 1 ½" long. Central cone of disk flowers an inch or more in diameter. Seeds develop from disk flowers, which bloom from the outer ring of 'cone' inward.



Adaptation/Habitat: Mesic to dry-mesic soil conditions, prefers well-drained upland soils, full sun.

Endangered Status: Threatened (WI), (TN)

General Comments: This species is best propagated in the greenhouse for transplant into weed barrier or bare soil. Weed suppression is essential for good establishment and seed production. Combine harvest is fairly straight forward, since it retains seed well in the heads. All *Echinacea* species are known to hybridize, so proper isolation should be maintained between related species to prevent hybrid seed production (McGregor 1968).

Establishment for Seed Production (Appendix A)

Direct seeding:
Seeding rate: 3.0-5.0 PLS lbs/acre
(40 seeds/linear foot)
Row Spacing: 30-36" rows
Seeding Depth: 1/8"
Seeding Methods: drill
Time of Seeding: dormant season
Weed Control: Prepare clean, firm, weed free seedbed prior to seeding.

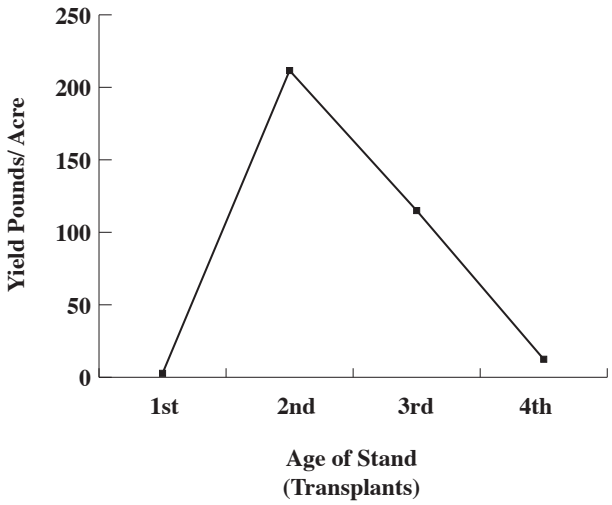
Greenhouse:
Seed pre-treatment: Wet stratify 12 weeks at 40º F.
Sow seed surface to 1/8" deep in greenhouse two months before last frost free date. Literature suggests this species needs light to germinate, but covering seed lightly to 1/8" does not inhibit germination. Harden-off, transplant into bare soil in rows or weedbarrier at 8" intervals after all danger of frost.

Stand Management

Weeds – Hand rogue weeds, being careful not to uproot seedlings.
Pests – No serious pests known
Diseases – No serious diseases known
Pollination: Insects, primarily bees, butterflies

Seed Production (Appendix B)

- First Harvest: Second year plants.
- Yield/Acre: 50-250 bulk lbs/ac
- Stand Life: Peak harvests 2nd year. Good harvest 3rd year. Stand persists but seed production declines significantly 4th year and after.
- Flowering Date: Flowering occurs mid-June to mid-July
- Seed Maturity: September
- Seed Retention: Generally holds seed well, some shattering may begin in late September, and extend throughout the winter months.
- Harvest date range at TPC (2002-2006): Sept... 1 – Sept... 23
- Recommended Harvest Method: Combine in the fall before significant shattering occurs. (Refer to *Appendix B* for settings.)



Seed Cleaning (Appendix C)

Cleaning Process: Combine does a superb job of threshing seedheads. Pre-clean combine run material by scalping thru 1/2" and 1/4" mesh to remove large particles and make flowable, then air-screen. If hand harvested, seedheads need to be threshed using a hammermill or brush machine, using care not to overclean and damage seed coat.

Seed Characteristics (Appendix D)

Seed count: 5,200 seeds/oz (83,200/lb)

Photo credit: Brent Butler

Description: 'Seeds' are achenes, about 1/8" long, square at one end and pointed at the other. No awns of appendages to remove.

Seed Storage: Stores well in refrigerated conditions (50º F, 30% RH)

Typical Seed Test (%)

- Purity: 90+
- Germination: 40-50
- Dormancy: 40-50

Released Germplasm (Appendix E):

Source Identified Material: Northern, Central, Southern Iowa *Natural Selections™*; Northern, Western Missouri Source Identified.

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 10 January 2007.

Plant Fact Sheet, Pale Purple Coneflower, Echinacea pallida (Nutt.) Nutt. USDA-NRCS Elsberry Plant Materials Center. October 2002.

An Illustrated Guide to Iowa Prairie Plants, p. 43. Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

The Taxonomy of the Genus *Echinacea* (Compositae). McGregor, R.L. The University of Kansas Sicence Bulletin, Vol. XLVIII, No. 4, pp. 113-142. 1968.

Notes:

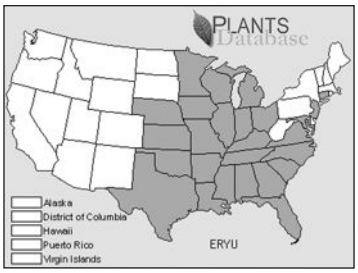
Rattlesnake Master
Eryngium yuccifolium, Michx.

(from *Eryngium*, Greek 'prickly plant'; *yuccifolium*, Greek 'yucca-like leaves')

Family: Carrot family (Apiaceae)

Other Common Name(s): Button Snakeroot, Button eryngo

Description: Native perennial. 2-3' tall. Spherical flower heads arranged on short branches on upper portion of plant. Seedheads with prickly bracts upon drying. Tough, fibrous yucca-like leaves, mostly basal.



Adaptation/Habitat: Dry-mesic to wet-mesic soils. Occurs in medium to high quality remnant prairie (full sun). Well-drained loamy soils preferred for seed production purposes.

Threatened/Endangered Status: Endangered (MD); Threatened (OH, MI)

General Comments: Greenhouse propagation is recommended for this species. It grows readily, and produces some seed the first year from transplants. Potentially high seed yield. Fairly straight forward to combine harvest and air-screen clean.

Establishment for Seed Production (Appendix A)

Direct seeding:
Seeding rate: 3.25 PLS lbs/acre (40 seeds/linear foot)
Row Spacing: 30-36" rows
Seeding Depth: 1/4"
Seeding Method: seed drill
Time of Seeding: dormant season
Site Preparation: Prepare clean, firm, weed free seed bed prior to seeding

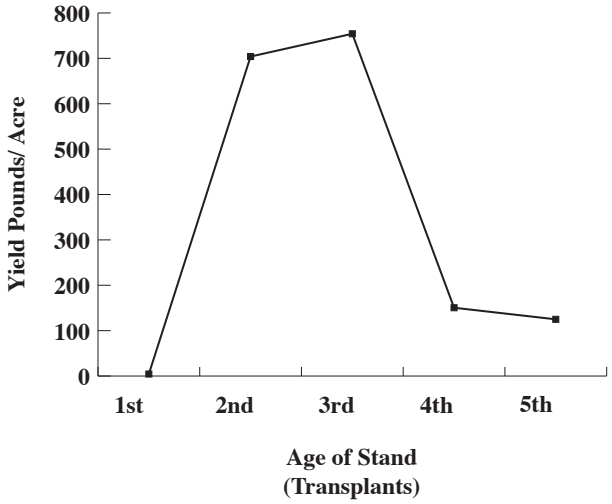
Greenhouse:
Seed pre-treatment: Wet stratify 8-12 weeks at 40° F. Sow seed in greenhouse two months before last frost free date. Harden-off, transplant into bare soil in rows or weedbarrier at 8" intervals after all danger of frost.

Stand Management

Weeds –Mow/cultivate between rows. Post emergence grass herbicide.tillage, hand roguing
Pests – No serious pests known
Diseases – Cucumber mosaic virus detected in populations in Ohio (Whitten and Nameth, 2004)
Pollination: Insects, predominantly bees and wasp, but also flies, butterflies, beetles, moths

Seed Production (Appendix B)

- First Harvest: Small harvest first growing season if greenhouse propagated in March and planted into weed-barrier in spring. Second year if direct seeded.
- Yield/Acre: 200-800 bulk lbs/ac
- Stand Life: Peak harvest 2nd-3rd year. Stand declines 4th year
- Flowering Date: Mid July-mid August
- Seed Maturity: Early October
- Seed Retention: Shattering occurs mid to late October
- Harvest date range at TPC (2002-2006): October 5-18
- Recommended Harvest Method: Combine (Refer to *Appendix B* for settings.)



Seed Cleaning (Appendix C)

Cleaning Process: Pre-clean by scalping thru 1/2" and 1/4" mesh to remove large particles and make flowable, then air-screen
(No awns or appendages to remove)

Seed Characteristics (Appendix D)

Seed Count: 7,500 seeds/oz (120,000/lbs)

Photo credit: Dave Williams

Description: 'Seeds' are one-seeded scaly fruits, 3/16" long

Seed Storage: Stores well in cool, dry conditions

Typical Seed Test (%)
- Purity: 90+
- Germination: 32
- Dormancy: 52

(50° F, 30% RH)

Released Germplasm (Appendix E):

Northern, Central, Southern Iowa *Natural Selections*™ Source-Identified germplasm.

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov, 28 November 2006). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

Whitten, K.R. and S.G.P. Nameth, First Report of Cucumber mosaic virus in Eryngium yuccifolium (Rattlesnake Master) in Ohio. Plant Dis. 88:1384, 2004

Planting Guide, Eryngium yuccifolium, Michx. USDA-NRCS Elsberry Plant Materials Center. 4/27/00.

An Illustrated Guide to Iowa Prairie Plants, p. 17. Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

Flora of Missouri, p. 1122. Steyermark, J.A. Iowa State University Press, Ames, IA. 1996.

Notes:

Oxeye Sunflower
Heliopsis helianthoides, (L.) Sweet var. *scabra* (Dunal) Fern.

(from *helios*, Greek 'sun'; *opsis*, Greek 'appearance'; and *helianthoides*, Latin 'like Helianthus' from the likeness to true sunflowers.)

Family: Daisy family (Asteraceae)

Other Common Name(s): Oxeye false sunflower, Sunflower Heliopsis

Description: Native perennial. 2 1/2' - 4' tall. Sunflower-like yellow flowers, 2" diameter on heads at ends of long stalks from stem tip and upper leaf axils. Opposite leaves, with sawtooth margins. Clump forming in cultivation.

Adaptation/Habitat: Dry mesic to wet mesic soils, low to high quality remnant prairies, disturbed areas, full sun.

Threatened /Endangered Status: Not Listed

General Comments: This species is fairly easy to establish by direct seeding, if good seedbed prearation and weed suppression are achieved. Extended flowering and seed-ripening period makes determining optimal combine harvesting time more difficult. Seed cleaning accomplished with air-screen cleaning.

Establishment for Seed Production (Appendix A)

Direct seeding:
Seeding rate: 4.0 PLS lbs/acre (40 seeds/linear foot)
Row Spacing: 30-36" rows (3x above rate for 7" rows or solid stand)
Seeding Depth: 1/4"
Seeding Methods: seed drill
Time of Seeding: dormant season
Weed Control: Prepare clean, firm, weed free seedbed prior to seeding.

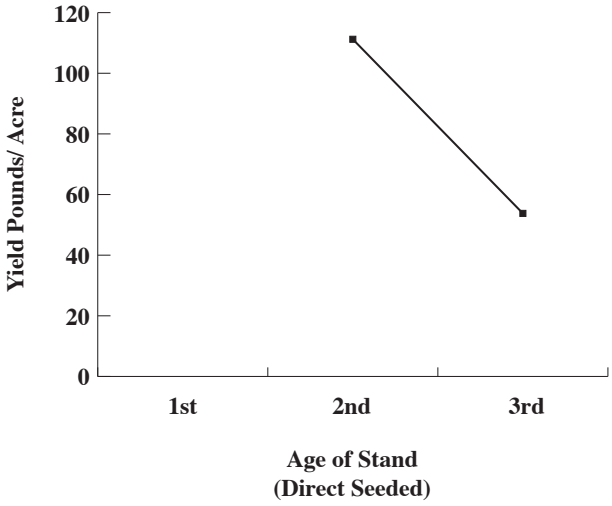
Greenhouse:
Seed pre-treatment: Wet stratify 8-12 weeks at 40° F.
Sow seed approx. two months before last frost free date. Harden-off, transplant into bare soil in rows or weedbarrier at 8" intervals after all danger of frost.

Stand Management

Weeds – Mow/cultivate between rows. Post emergence grass herbicide, tillage, roguing
Pests – No serious pests known
Diseases – Powdery mildew, some susceptibility to aphids
Pollination: Insects

Seed Production (Appendix B)

- First Harvest: Some flowering and seed produced first growing season from transplants and in well-managed direct seeded stand.
- Yield/Acre: 100-250 bulk lbs/ac
- Stand Life: Peak harvest 2nd- 4th year. Stand declines 5-7th year
- Flowering Date: Flowering occurs over an extended period from early June through late July.
- Seed Maturity: Mid-September to mid-October
- Seed Retention: Shattering occurs mid to late October
- Harvest date range at TPC (2002-2006): Sept.. 22 – Oct. 10
- Recommended Harvest Method: Combine (Refer to *Appendix B* for settings.)



Seed Cleaning (Appendix C)

Cleaning Process: Pre-clean by scalping thru 1/2" and 1/4" mesh to remove large particles and make flowable, then air-screen
(No awns or appendages to remove)

Seed Characteristics (Appendix D)

Seed Count: 6,300 seeds/oz (100,800/lbs)

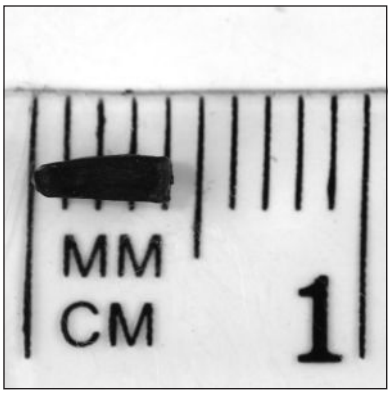


Photo credit: Dave Williams

Description: 'Seeds' are a smooth achene about 3/16" long.

Seed Storage: Stores well in refrigerated conditions. (50º F, 30% RH)

Typical Seed Test (%)

- Purity: 95+
- Germination: 71
- Dormancy: 19

Released Germplasm (Appendix E)

Northern, Central, Southern Iowa *Natural Selections*™ Source-Identified germplasm.

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov, 23 December 2006). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

Notice of Release: Oxeye False Sunflower, Iowa Germplasm. USDA-NRCS Elsberry Plant Materials Center. February 2000.

An Illustrated Guide to Iowa Prairie Plants, p. 50. Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

Flora of Missouri, p. 1553. Steyermark, J.A. Iowa State University Press, Ames, IA. 1996.

Notes:

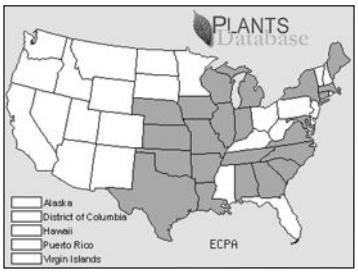
Rough Blazingstar
Liatris aspera, Michx.

Genus *Liatris*, derivation unknown; species *aspera* Latin 'rough'.

Family: Aster (Asteraceae)

Other Common Name(s): Button snakeroot, Rough gayfeather

Description: Native perennial. 2-3' tall. Rough blazingstar is similar in appearance to prairie blazingstar *(L. pycnostachya)*. Flower heads are larger and more widely spaced on the flowering stalk, giving it the 'button' appearance. Root is a corm, which can be divided.



Adaptation/Habitat: Occurs on dry-mesic to dry, even sandy or rocky soil conditions, full sun. Upland very well-drained loamy soils preferred for seed production. If soils are too dry or poor seed production will be curtailed.

Threatened/Endangered Status: Not listed

General Comments: This species is best propagated in the greenhouse, and transplanted in spring into weed-free planting bed or weedbarrier. Seedlings develop pea-size corms after two months in the greenhouse. Sometimes 1st year corms are exposed by frost-heaving over the winter, and may be eaten by voles. Species in the genus *Liatris* are known to hybridize, therefore proper isolation should be maintained between related species to avoid hybrid seed production (Levin 1968, Menhusen 1972). Liatris species are also being produced commercially for the cut-flower industry.

Establishment for Seed Production (Appendix A)

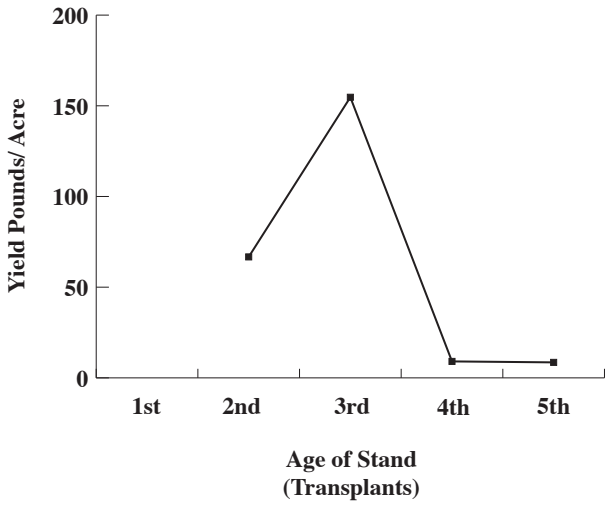
Direct seeding:
NOT RECOMMENDED FOR THIS SPECIES
Greenhouse:
Seed pre-treatment: Wet stratify 8-12 weeks at 40º F. Sow seed 1/4" in greenhouse two months before last frost free date. Harden off, transplant into bare soil in rows and mulch or into weedbarrier at 8" intervals after all danger of frost is past.

Stand Management

Weeds – Mow/cultivate between rows, mulch within rows. Post emergence grass herbicide, tillage, hoeing, hand roguing. Very sensitive to soil disturbance during bolting/flowering.
Pests – Voles will eat and/or cache corms, rabbits and deer eat young shoots
Diseases – powdery mildew, root-knot nematodes, stem rot, verticillium wilt.
Pollination: Insects, particularly bees and butterflies

Seed Production (Appendix B)

- First Harvest: Remain vegetative first year (seedlings), abundant flowering/seed production 2nd year. Fall corm division/transplanting results in abundant flowering the following growing season.
- Yield/Acre: 50-150 bulk lbs/ac
- Stand Life: Peak harvests 2nd or 3rd year. Stand declines significantly 4th year and after. Plants tend to lodge 2nd year when flowering.
- Flowering Date: Flowering occurs early August to early September
- Seed Maturity: Late September to mid-October
- Seed Retention: Wind dispersed soon after maturity
- Harvest date range at TPC (2002-2006): Oct. 1 to Oct. 13
- Recommended Harvest Method: Combine at maturity, but before plumes are dry and fluffy. (Refer to *Appendix B* for settings.)



Seed Harvest/Cleaning (Appendix C)

Cleaning Process: Pre-clean by scalping thru 1/2" mesh to remove large particles and make flowable, brush gently to remove 'plumes' (pappus) using care not to damage seed coat, then air screen.

Seed Characteristics (Appendix D)

Seed count: 16,000 seeds/oz (256,000/lb)

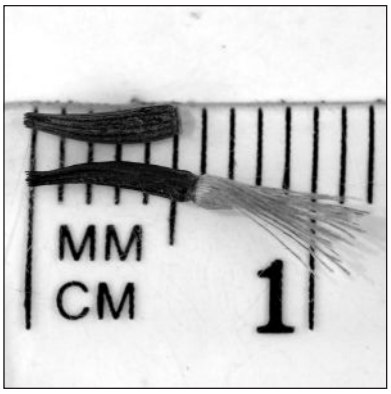


Photo credit: Dave Williams

Description: 'Seeds' are achenes, about 1/8" long or less, with tuft of hairs (plume).

Seed Storage: Stores well in controlled conditions of temperature and RH if seed is not damaged during cleaning. (50° F, 30% RH)

Typical Seed Test (%)

- Purity: 90-99
- Germination: 36
- Dormancy: 61

Released Germplasm (Appendix E):

Source Identified Material: Northern, Central, Southern Iowa *Natural Selections™*

Cultivated Varieties: No known cultivars

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 18 January 2007.

Plant Solutions, Missouri Germplasm Rough Gayfeather. USDA-NRCS Elsberry Plant Materials Center. October 2002.

An Illustrated Guide to Iowa Prairie Plants, p 57. Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

Liatris, Commercially Specialty Cut Flower Production. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. MF-1087, Available at (http://www.oznet.ksu.edu) Oct. 1993

Ecology of the Prairie Species of the Genus Liatris. Menhusen, B.R. Third Midwest Prairie Conference Proceedings. Kansas State University, Manhattan, KS Sept.. 22-23, 1972. Pp. 60-62.

The Structure of a Polyspecies Hybrid Swarm in Liatris. Levin, D.A. Evolution. 22:352-372. June 1968.

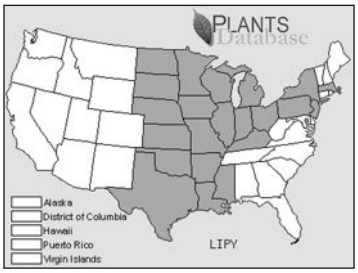
Notes:

Prairie Blazingstar
Liatris pycnostachya, Michx.

Genus *Liatris*, derivation unknown; species *pycnostachya* Greek *pycnos* 'close/compact', Gr. *stachys* "spike/ear of corn' reference to the compact flowering spike.

Family: Daisy family (Asteraceae)

Other Common Name(s): Prairie gayfeather, Cattail gayfeather, Kansas gayfeather



Description: Native perennial. 3-4' tall. Purplish-pink disc flowers, flower heads sessile arranged in a spike on upper portion of plant. Leaves alternate, grass-like (linear). Seeds are plumed and form in fertile disc flowers. Root is a corm, which can be divided.

Adaptation/Habitat: Wet-mesic to mesic soils, full sun. May be abundant in medium to high quality prairies. Moist but well-drained soils preferred for seed production.

Threatened/Endangered Status: Threatened (IN)

General Comments: Prairie blazingstar is best propagated in the greenhouse, where seedlings form small pea-sized corms after about 2 months. Seedling leaves are grass-like. Prolific seed production second growing season, then stand declines. Corms can be dug and divided for fall transplant, if disease free, for abundant flowering and seed set the following growing season. Species in the genus *Liatris* are known to hybridize, therefore proper isolation should be maintained between related species to avoid hybrid seed production (Levin 1968, Menhusen 1972). Liatris species are also being produced commercially for the cut-flower industry.

Establishment for Seed Production (Appendix A)

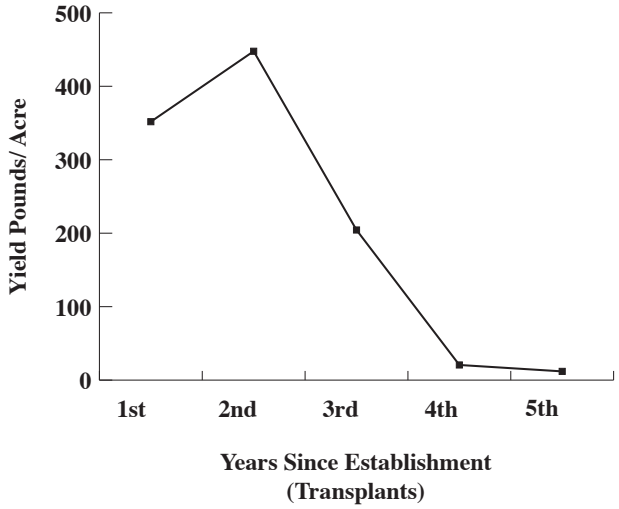
Direct seeding:
NOT RECOMMENDED FOR THIS SPECIES
Greenhouse:
Seed pre-treatment: Wet stratify 8-12 weeks at 40° F. Sow seed in greenhouse two months before last frost free date. Harden-off, transplant into bare soil in rows or weedbarrier at 8" intervals after all danger of frost.

Stand Management

Weeds – Mow/cultivate between rows, mulch within rows. Post emergence grass herbicide, tillage, hoeing, hand rouging. Very sensitive to soil disturbance during bolting/flowering.
Pests – Voles will eat and/or cache corms. Rabbits and deer eat young shoots.
Diseases – powdery mildew, root-knot nematodes, stem rot, verticillium wilt.
Pollination: Insects, particularly bees and butterflies

Seed Production (Appendix B)

- First Harvest: Remain vegetative first year (seedlings), abundant flowering/seed production 2nd year. Fall corm division/transplanting results in abundant flowering the following growing season.
- Yield/Acre: 150-450 bulk lbs/ac
- Stand Life: Peak harvests 2nd year. Good harvest 3rd year if proper soils. Stand declines significantly 4th year and after. Plants tend to lodge 2nd year when flowering
- Flowering Date: Flowering occurs late July to late August
- Seed Maturity: Early September to mid-October
- Seed Retention: Seed is wind dispersed shortly after ripening and 'parachutes' dry
- Harvest date range at TPC (2002-2006): Sept.. 9 - Oct. 9
- Recommended Harvest Method: Combine at maturity, but before plumes are dry and fluffy (Refer to *Appendix B* for settings.)



Seed Cleaning (Appendix C)

Cleaning Process: Pre-clean by scalping thru 1/2" mesh to remove large particles and make flowable, brush gently to remove 'parachutes' (pappus) using care not to damage seed coat, then air screen.

Seed Characteristics (Appendix D)

Seed count: 11,000 seeds/oz (176,000/lb)

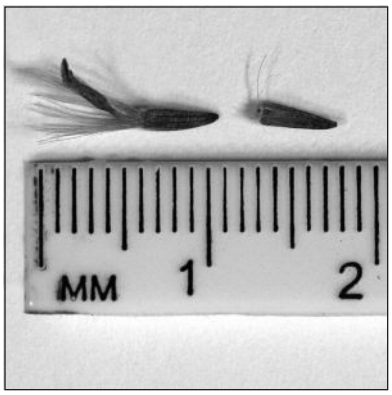


Photo credit: Brent Butler

Description: 'Seeds' are achenes, about 1/8" long, with tuft of hairs (plume).

Seed Storage: Stores well in controlled conditions of temperature and RH if seed is not damaged during cleaning. (50º F, 30% RH)

Typical Seed Test (%)

- Purity: 90-99
- Germination: 3.5
- Dormancy: 90+

Released Germplasm (Appendix E)

Source Identified Material: Northern, Central, Southern Iowa *Natural Selections™*; Northern, Western Missouri Source Identified.

Cultivated Varieties: 'Eureka' (developed for cut flower industry)

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 4 January 2007.

Planting Guide, Prairie blazingstar, Liatris pycnostachya Michx. USDA-NRCS Elsberry Plant Materials Center. April 2000.

An Illustrated Guide to Iowa Prairie Plants, p. 56. Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

Liatris, Commercially Specialty Cut Flower Production. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. MF-1087, Available at (http://www.oznet.ksu.edu) Oct. 1993

Ecology of the Prairie Species of the Genus Liatris. Menhusen, B.R. Third Midwest Prairie Conference Proceedings. Kansas State University, Manhattan, KS Sept.. 22-23, 1972. Pp. 60-62.

The Structure of a Polyspecies Hybrid Swarm in Liatris. Levin, D.A. Evolution. 22:352-372. June 1968.

Notes:

Rigid Goldenrod
Oligoneuron solidago (L.)
Small var. *rigidum*

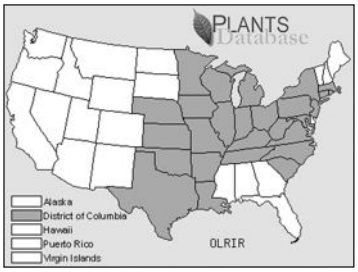
(Formerly as *Solidago rigida,* (L.)

Genus *Solidago*, Latin *solidare* 'to strengthen, unite' an allusion to reputed healing properties; species *rigida* Latin 'stiff, rigid, inflexible'.

Family: Aster (Asteraceae)

Other Common Name(s): Stiff goldenrod

Description: Native herbaceous perennial 3'- 4' tall. Stem usually unbranched, finely hairy. Yellow flowers borne in a branched flat-domed cluster at top of stem. Leaves alternate, lower leaves long-stalked, upper nearly clasping stem, with soft hairs. Seeds have fluffy plumes when ripe, seedhead at top of mature plant.



Adaptation/Habitat: Wet-mesic to dry-mesic soil conditions, full sun. Well-drained loamy soils preferred for seed production

Threatened/Endangered Status: Endangered in CT, MD, NJ, PA; Threatened (NY); Historical (RI)

General Comments: Rigid goldenrod establishes readily from direct seed or transplants, and will spread from short rhizomes to form clumps. Seed can be combined but is critical to harvest before plumes are dry and fluffy.

Establishment for Seed Production (Appendix A)

Direct seeding:
Seeding rate: 1.0 PLS lbs/acre (40 seeds/linear foot)
Row Spacing: 30-36" rows
Seeding Depth: 1/4"
Seeding Methods: drill
Time of Seeding: Dormant
Weed Control: Prepare clean, firm, weed free seedbed prior to seeding

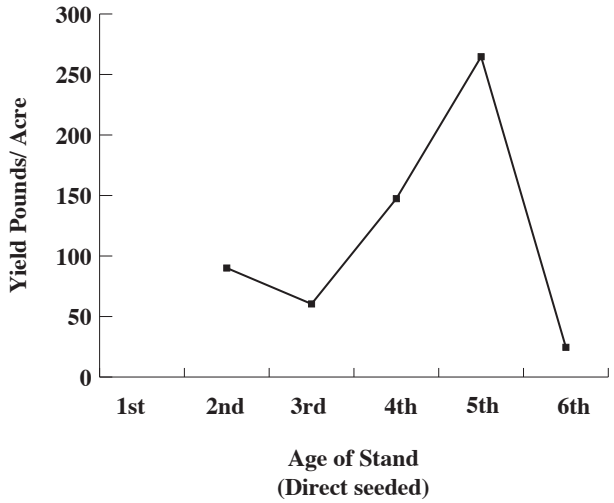
Greenhouse:
Seed pre-treatment: Wet stratify 8-12 weeks at 40° F. Sow seed in greenhouse two months before last frost free date. Transplant into bare soil in rows convenient for tillage, equipment, or weedbarrier at 8" intervals after all danger of frost is past.

Stand Management

Weeds – Post emergence grass herbicide, tillage, hand roguing
Pests – No serious pest known; powdery mildew on foliage
Diseases – No serious disease known, foliage may be affected by rust
Pollination: Insects, especially bees, wasps, butterflies, beetles

Seed Production (Appendix B)

- First Harvest: Flowering and seed set end of 2nd growing season from either greenhouse grown transplants or direct seeded, well-managed stand
- Yield/Acre: 100-250 bulk lbs/ac
- Stand Life: Peak harvests 2nd growing season. Seed production declines 3rd year and after.
- Flowering Date: Flowering occurs mid-August to mid-September
- Seed Maturity: October
- Seed Retention: Seed wind dispersed soon after maturity and drying of plumes.
- Harvest date range at TPC (2002-2006): Oct. 9 – Oct. 25
- Recommended Harvest Method: Combine after seed maturity but before more than 10% of the seedheads have turned white and fluffy. Otherwise, combining will simply contribute to dispersal of the seed crop. Harvested material will have to be forced-air dried and turned carefully to prevent mold and decay. (Refer to *Appendix B* for settings.)



Seed Cleaning (Appendix C)

Cleaning Process: Pre-clean air-dried material by scalping thru 1/2" and 1/4" mesh to remove large particles. Remove plumes with debearder or brush machine, then air-screen.

Seed Characteristics (Appendix D)

Seed count: 41,000 seeds/oz (656,000/lb)

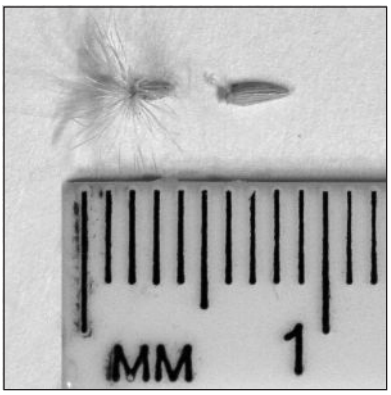


Photo credit: Brent Butler

Description: 'Seeds' (achenes) glabrous, bone white, about 1/16" long with long white plumes. Stores well in refrigerated conditions. (50° F, 30% RH)

Typical Seed Test (%)

- Purity: 90-99
- Germination: 60
- Dormancy: 22

Released Germplasm (Appendix E):

Source Identified Material: Northern, Central, Southern Iowa *Natural Selections™*

Cultivated Varieties: No known cultivars

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 16 January 2007.

Missouri Botanic Gardens. 2006. PlantFinder Database, Kemper Center for Home Gardening (http://www.mobot.org/GARDENINGHELP/PLANTFINDER/). Accessed 16 January 2007.

Plant Fact Sheet, Stiff goldenrod, *Oligoneuron rigidum* (L.) Small var. *rigidum*. USDA-NRCS Elsberry Plant Materials Center. October 2001.

An Illustrated Guide to Iowa Prairie Plants, p 74. Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

Notes:

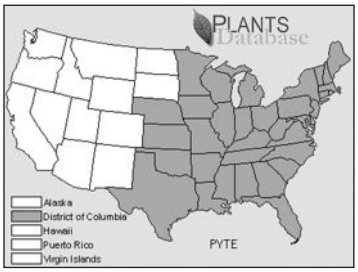
Narrowleaf Mountain Mint
Pycnanthemum tenuifolium
Schrader

Genus *Pycnanthemum*, Greek *pycn* 'compact', and *anthum* 'flowers', e.g. 'dense flower-clusters'; species *tenuifolium* Latin *tenuis* 'thin, slender' and *folius*, 'leaves'.

Family: Mint (Lamiaceae)

Other Common Name(s): Slender mountain mint

Description: Native perennial. 1-3' tall. Small white flowers (1/4") clustered at stem tips. Stems are four sided and are smooth. Leaves are opposite, very narrow (1/8" or less). Seeds (nutlets) develop within the calyx. Strong mint odor when crush. Seedheads light brown color when mature, in contrast to grey color of P. virginianum seedheads. Also spreads vegetatively by rhizomes.



Adaptation/Habitat: Mesic to dry-mesic soils in upland prairies, full sun.

Threatened/Endangered Status: Not a listed species

Establishment for Seed Production (Appendix A)

Direct seeding:

NOT RECOMMENDED FOR THIS SPECIES

Greenhouse:

Seed pre-treatment: Dry cold stratify 12 weeks at 40º F. Surface sow seed in greenhouse two months before last frost free date. Water carefully (fine mist) to prevent seed from splattering out of containers. Transplant into weedbarrier at 8" intervals. Plants spread clonally, so weed barrier can be remove by third season, but seed production typically declines by 4th season.

Stand Management

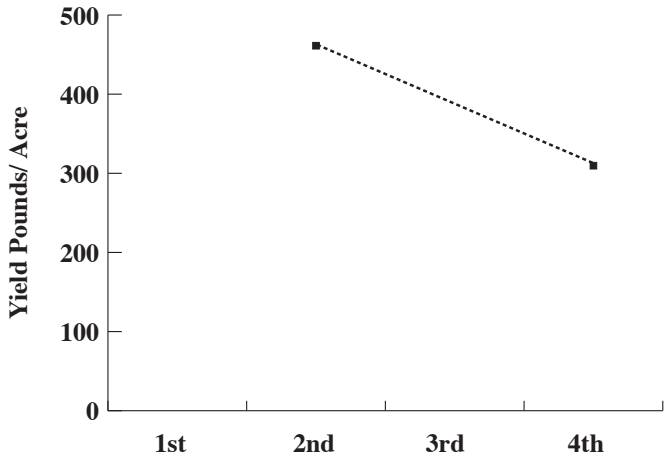
Weeds – Hand rogue weeds, being careful not to uproot seedlings.
Pests – No serious pest known
Diseases – No serious diseases known
Pollination: Insects, particularly bees, wasps, butterflies, flies, beetles

Seed Production (Appendix B)

- First Harvest: Some flowering and seed production first year from greenhouse grown transplants
- Yield/Acre: 10-80 bulk lbs/ac
- Stand Life: Peak harvests 2nd - 3rd year. Stand persists but seed production may decline significantly 4th year and after
- Flowering Date: Flowering occurs mid-July into August
- Seed Maturity: Mid September to early October
- Seed Retention: Holds seed well, shattering occurs mid to late October
- Harvest date range at TPC (2002-2006): Oct. 12-18
- Recommended Harvest Method: Combine, no air (Refer to *Appendix B* for settings.)

Seed Cleaning (Appendix C)

Cleaning Process: Pre-clean by scalping thru 1/2" and 1/4" mesh to remove large particles and make flowable, then air-screen.
(No awns or appendages to remove)



··· Dashed line indicates missing data

Seed Characteristics (Appendix D)

Seed count: 378,000 seeds/oz (6,048,000/lb)

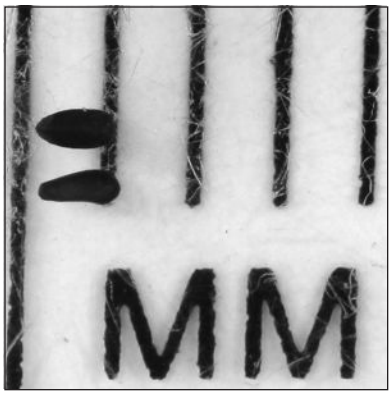


Photo credit: Dave Williams

Description: 'Seeds' are nutlets, about 1mm long, developing in tube-like calyx of inflorescence. Stores well in refrigerated conditions. (50º F, 30% RH)

Typical Seed Test (%)

- Purity: 90-99
- Germination: 75
- Dormancy: 11

Released Germplasm (Appendix E):

Source Identified Material: Southern Iowa *Natural Selections™*

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 8 January 2007.

Plant Fact Sheet, Narrowleaf mountainmint, Pycnanthemum tenuifolium Schrad. USDA-NRCS East Texas Plant Materials Center. Nacogdoches, TX. September 2004

An Illustrated Guide to Iowa Prairie Plants, p. 125, Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

Notes:

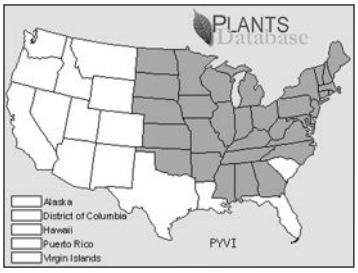
Virginia Mountain Mint
Pycnanthemum virginianum, (L.)

Genus *Pycnanthemum*, Greek *pycn* 'compact', and *anthum* 'flowers', e.g. 'dense flower-clusters'; species *virginianum* Latin 'of Virginia'.

Family: Mint (Lamiaceae)

Other Common Name(s): Mountain mint

Description: Native perennial, 1-3' tall. Small white flowers (1/4") clustered at stem tips. Stems are four sided, and smooth except for *hairs on the stem angles*. Leaves are opposite, at least 3/16" wide or more. Seeds (nutlets) develop within the calyx. Strong mint odor when crush. Mature seedheads grey color. Spreads vegetatively by rhizomes.



Adaptation/Habitat: Wet-mesic to mesic soils, low prairies, full sun. Moist, well-drained loamy soils preferred for seed production.

Threatened/Endangered Status: Endangered (NH)

General Comments: This species is typically encountered in patches or colonies in native prairie, spreading by rhizomes. Weed control is essential for good establishment and seed production. Can be combine harvested if plots are weed free.

Establishment for Seed Production (Appendix A)

Direct seeding:

NOT RECOMMENDED FOR THIS SPECIES

Greenhouse:

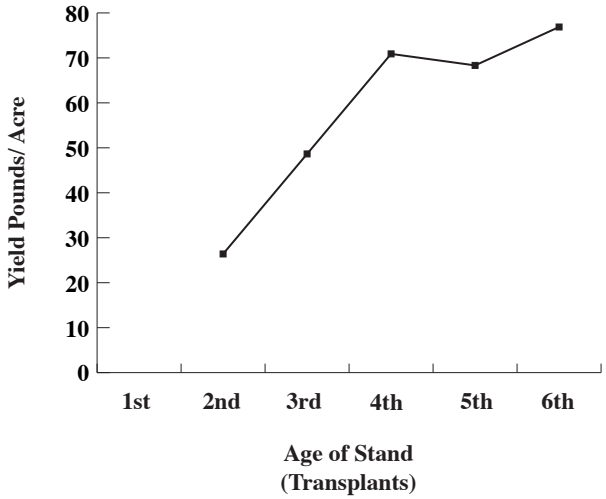
Seed pre-treatment: Dry cold stratify 12 weeks at 40° F. Surface sow seed in greenhouse two months before last frost free date. Water carefully (fine mist) to prevent seed from splattering out of containers. Transplant into weedbarrier at 8" intervals. Plants spread clonally, so weed barrier can be remove by third season.

Stand Management

Weeds – Hand rogue weeds, being careful not to uproot seedlings.
Pests – No serious pest known
Diseases – No serious diseases known
Pollination: Insects, particularly bees, wasps, butterflies, flies, beetles

Seed Production (Appendix B)

- First Harvest: Some flowering and seed production first year from greenhouse grown transplants
- Yield/Acre: 25-70 bulk lbs/ac in
- Stand Life: In proper soils with good management, stand and seed production persists at least into 4th year
- Flowering Date: Flowering occurs mid-July into August
- Seed Maturity: Mid September to early October
- Seed Retention: Holds seed well, shattering occurs mid to late October
- Harvest date range at TPC (2002-2006): Oct. 6- Oct.. 20
- Recommended Harvest Method: Combine at maturity (Refer to *Appendix B* for settings.)

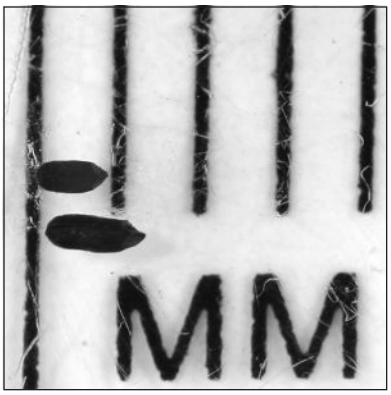


Seed Cleaning (Appendix C)

Cleaning Process: Pre-clean by scalping thru 1/2" and 1/4" mesh to remove large particles and make flowable, then air-screen.
(No awns or appendages to remove)

Seed Characteristics (Appendix D)

Seed count: 220,000 seeds/oz (3,520,000/lb)



Description: 'Seeds' are nutlets, developing in tube-like calyx of inflorescence. Stores well in refrigerated conditions. (50° F, 30% RH)

Typical Seed Test (%)

- Purity: 90-99
- Germination: 77
- Dormancy: 8

Photo credit: Dave Williams

Released Germplasm (Appendix E):

Source Identified Material: Northern, Central, Southern Iowa *Natural Selections™*;

Cultivated Varieties: None known

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 9 January 2007.

An Illustrated Guide to Iowa Prairie Plants, p. 124. Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

Notes:

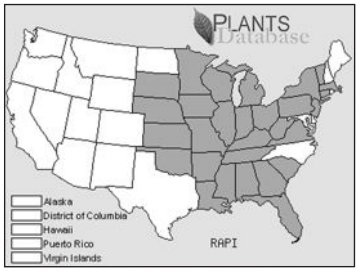
Greyhead Coneflower
Ratibida pinnata (Vent.) Barnhart

Genus *Ratibida*, definition unknown; *pinnata* Latin pinnatus 'feather', reference to the pinnately lobed leaves.

Family: Daisy family (Asteraceae)

Other Common Name(s): Drooping Yellow Coneflower, Prairie Coneflower

Description: Native perennial. 3 - 5' tall. Composite flowers with drooping 1" long yellow petals, surrounding egg-shaped dome of disc flowers. Disc gray, becoming brown as disc flowers open. Leaves alternate, pinnately lobed. Seedheads borne at the end of long flower stalks on upper portion of plant. Seedheads release an anise or citrus scent when crushed.



Adaptation/Habitat: Wet-mesic to dry-mesic loamy soils, usually common on medium to high quality prairies.

Threatened/Endangered Status: Extirpated (PA)

General Comments: Greyhead coneflower is typically common on mid-western prairies, and establishes readily in reconstructed prairies. Seed harvesting and cleaning are relatively straight forward if good weed control is maintained.

Establishment for Seed Production (Appendix A)

Direct seeding:
Seeding rate: 3.6-5.0 PLS lbs/acre
(40 seeds/linear foot)
Row Spacing: 30-36" rows
Seeding Depth: 1/4"
Seeding Methods: drill
Time of Seeding: dormant season
Weed Control: Prepare clean, firm, weed free seedbed prior to seeding.

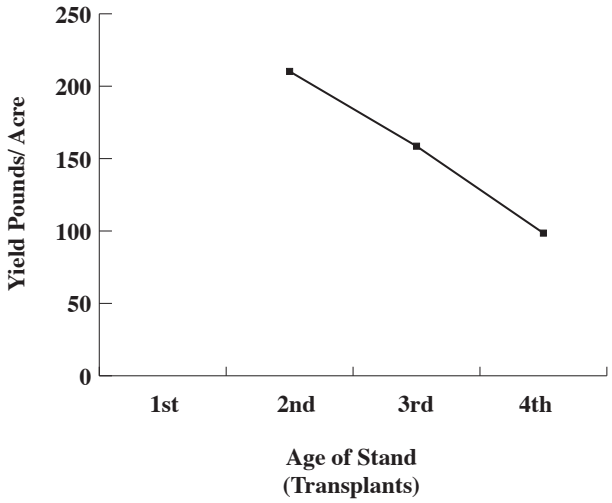
Greenhouse:
Seed pre-treatment: Wet stratify 8-12 weeks at 40° F. Sow seed in greenhouse two months before last frost free date. Harden-off, transplant into bare soil in rows or weedbarrier at 8" intervals after all danger of frost.

Stand Management

Weeds – Mow/cultivate between rows. Post emergence grass herbicide, tillage, roguing
Pests – No serious pest known
Diseases – No serious diseases known
Pollination: Insects, particularly bees

Seed Production (Appendix B)

- First Harvest: Remain vegetative the first year, abundant flowering and seed production second year.
- Yield/Acre: 100-250 bulk lbs/ac
- Stand Life: Peak harvests 2nd year. Good harvest 3rd year. Stand persists but seed production may decline significantly 4th year and after.
- Flowering Date: Flowering occurs early July to mid-August
- Seed Maturity: Late September
- Seed Retention: Shattering occurs mid to late October
- Harvest date range at TPC (2002-2006): Sept... 20 – Oct.. 12
- Recommended Harvest Method: Combine (Refer to *Appendix B* for settings.)



Seed Cleaning (Appendix C)

Cleaning Process: Pre-clean by scalping thru 1/2" and 1/4" mesh to remove large particles and make flowable, then air-screen. Foxtail can be removed from most of the seed with scalping screens, followed by a final cleaning with a belt-sorter or velvet roller of scalped material.
(No awns or appendages to remove)

Seed Characteristics (Appendix D)

Seed count: 30,000 seeds/oz (480,000/lb)

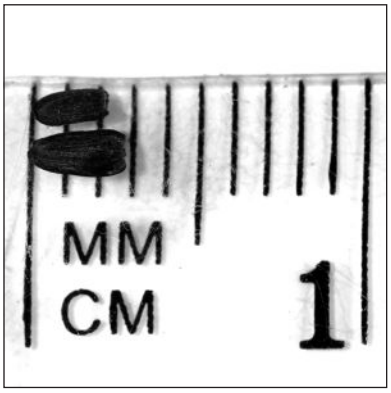


Photo credit: Dave Williams

Description: seeds (achenes) develop from fertile disc flowers. About 1/16" long. Stores well in refrigerated conditions (50° F, 30% RH)

Typical Seed Test (%)

- Purity: 90-99
- Germination: 80-90
- Dormancy: 0-10

Released Germplasm (Appendix E):

Source Identified Material: Northern, Central, Southern Iowa *Natural Selections™*; Northern Missouri Source Identified.

Cultivated Varieties: 'Sunglow' (Kansas)

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 3 January 2007.

http://www.usask.ca/agriculture/plantsci/classes/range/ratibida.html (Accessed 1/3/07). University of Saskatchewan, Dept. of Plant Sciences

Plant Fact Sheet, Grey-headed Coneflower, Ratibida pinnata (Vent.) Barnh. USDA-NRCS Elsberry Plant Materials Center. May 2003.

An Illustrated Guide to Iowa Prairie Plants, p. 64. Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

An Illustrated Flora of the Northern United States and Canada, Vol. III p. 474. Britton, N. and A. Brown. General Publishing Company, Ltd., Toronto, Ontario, Canada. 1970.

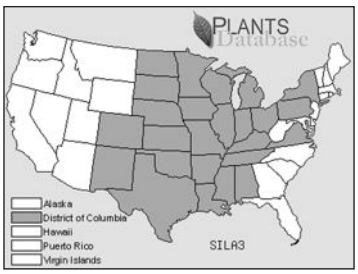
Notes:

Compass Plant
Silphium laciniatum, L.

Genus *Silphium*, Latin named after an extinct medicinal plant of ancient Cyrene; species *laciniatum* Latin 'deeply cut', in reference to the deeply loped irregular leaf shape of this plant. Common name refers to habit of basal leaves to be oriented perpendicular to the ground along a north-south axis.

Family: Aster (Asteraceae)

Other Common Name(s): Pilot-weed



Description: Native perennial. 4-6' tall (6'-9' tall in production). Stem rounded in cross-section, coarse hairs, somewhat woody late season. Composite yellow flower, 3-4" in diameter. Leaves alternate, deeply lobed, 12-24" long, coarsely hairy. Seeds formed only in outer fertile flowers of central disk. Flowering and seed ripening occurs first in flowers on ends of main stalks and branches, later on lateral flowers.

Adaptation/Habitat: Wet-mesic to dry-mesic soil conditions, typically on high quality prairie remnants, full sun. Preference is for moist, well-drained soils for seed production.

Threatened/Endangered Status: Threatened (MI, TN); Endangered (OH)

General Comments: Compass plants are a long-lived, tap-rooted species. An individual seedling may take 2-4 years to flower in production, and flower every year thereafter for a few years. In a prairie, an individual may take 5-10 years to flower from seed, and typically flowers every other year or so. Silphium species (congeners) will hybridize with one another in nature, so Silphiums should be properly isolated from related species for seed production purposes (i.e. cupplant, *Silphium perfoliatum*; rosinweed, *Silphium integrifolium*; prairie dock, *Silphium terebinthinaceum*; etc.) (Fisher 1966, Clevinger and Panero 2000)

Establishment for Seed Production (Appendix A)

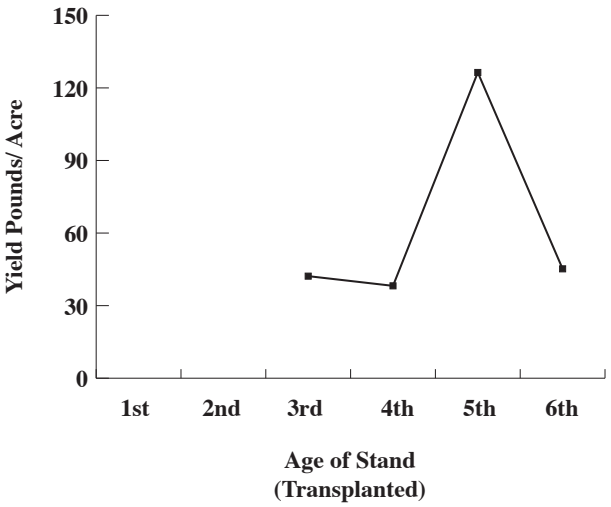
Direct seeding:
NOT RECOMMENDED FOR THIS SPECIES
Greenhouse:
Seed pre-treatment: Wet stratify 8-12 weeks at 40° F. Sow seed in greenhouse two months before last frost free date. Transplant into bare soil in rows or weedbarrier at 12" intervals after all danger of frost is past.

Stand Management

Weeds – Post emergence grass herbicide, tillage, hand roguing
Pests – No serious insect pest known
Diseases – No serious diseases known
Pollination: Insects, primarily bees

Seed Production (Appendix B)

- First Harvest: Some flowering and seed set end of 2nd year, most will flower during 3rd growing season from greenhouse grown transplants
- Yield/Acre: 40-130 bulk lbs/ac
- Stand Life: Peak harvests 3rd year. Plants are very long-lived, but seed production begins to decline significantly 5th year and after.
- Flowering Date: Flowering occurs early July to mid-August
- Seed Maturity: Mid-August to mid-September
- Seed Retention: Shattering occurs as seeds mature and dry, end of August into September
- Harvest date range at TPC (2002-2006): Aug. 30 – Sept.. 27
- Recommended Harvest Method: Hand collect as seed ripens for most efficient harvest of small plots, combine for larger stands when seed is mostly mature and before significant shattering (Refer to *Appendix B* for settings.)



Seed Cleaning (Appendix C)

Cleaning Process: Pre-clean air-dried material by scalping thru 1/2" and sifting through 1/4" mesh, if desired (most seed will be retained on top of 1/4" mesh). Repeated air-screening to clean.

Seed Characteristics (Appendix D)

Seed count: 660 seeds/oz (10,560/lb)

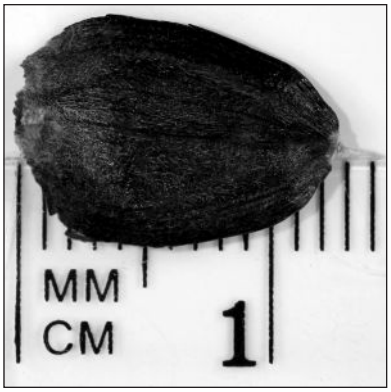


Photo credit: Dave Williams

Description: 'Seeds' are flat fruits (achenes), 3/8 – 1/2" long, with broad wing around margins, making it difficult to get a good separation between filled and unfilled seed. No plume.

Seed Storage: Stores well in refrigerated conditions (50º F, 30% RH)

Typical Seed Test (%)

- Purity: 85+
- Germination: 23
- Dormancy: 72

Released Germplasm (Appendix E)

Source Identified Material: Northern, Central, Southern Iowa *Natural Selections™*

Cultivated Varieties: No known cultivars

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 16 January 2007.

The Phylogenetic Analysis of *Silphium* and subtribe *Engelmanniinae* (Asteraceae: Heliantheae) Based on ITS and ETS Sequence Data. Clevinger, J.A. and J.L.Panero. 2000. American Journal of Botany 97(4): 565-572.

An Illustrated Guide to Iowa Prairie Plants, p. 69 Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

The Genus *Silphium* in Ohio. Fisher, T.R. 1966. The Ohio Journal of Science 66(3): pp 259-263.

Notes:

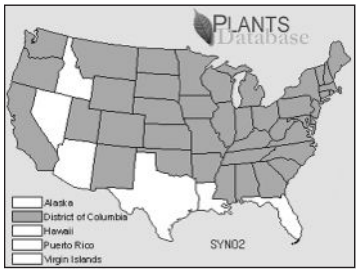
New England Aster
Symphyotrichum novae-angliae, (L.) Nelson

(Formerly classified as *Aster novae-angliae*(L.) Recently re-classified as *Symphyotrichum-angliae* based on G.L. Nesom, based on molecular analysis)

Genus *Aster*, Latin 'star'; species *novae-angliae* Latin 'of New England'.

Family: Aster (Asteraceae)

Other Common Name(s): Purple meadow aster
Description: Native herbaceous perennial. 3-4' tall. Stem hairy. Composite flowerheads 1" to 1 1/2" across, usually purple rays, but may occasionally be white or pink; with yellow disk flowers. Leaves opposite, base of each leaf clasps stem, hairy below. Seed is small and plumed, dispersing very soon after ripening.



Adaptation/Habitat: Wet-mesic soil conditions, prairie swales, wet meadows, full sun. Avoid poorly drained clay soils for seed production purposes.

Threatened/Endangered Status: Not listed

General Comments: This species is easy to propagate in the greenhouse. Though this species establishes readily in prairie reconstructions, weedy competition will severely curtail establishment and seed yield for seed production purposes. Plumes consist of fine hairs arising from nearly the entire surface of the seed, requiring thorough brushing/debearding to remove for good airscreen separation.

Establishment for Seed Production (Appendix A)

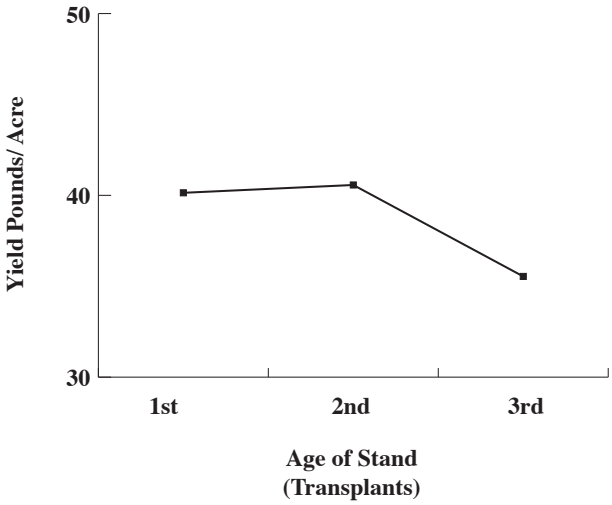
Direct seeding:
NOT RECOMMENDED FOR THIS SPECIES
Greenhouse:
Seed pre-treatment: Wet stratify 8 weeks at 40º F. Sow seed in greenhouse two months before last frost free date. Harden-off, transplant into bare soil in rows or weedbarrier at 8" intervals after all danger of frost.

Stand Management

Weeds – Post emergence grass herbicide, tillage, hand roguing. Weed pressure severely curtails establishment and seed production of this species.
Pests – Rabbits and groundhogs seem to favor eating foliage of this and other aster species, keeping plants pruned to 8" all growing season, particularly establishment year.
Diseases – Powdery mildew
Pollination: Insects, primarily bees and butterflies.

Seed Production (Appendix B)

- First Harvest: Flowering and seed set end of first growing season from greenhouse grown transplants
- Yield/Acre: 20-40 bulk lb/ac
- Stand Life: Peak harvests 1st and 2nd year. Seed production declines significantly 3rd year and after. For ornamental purposes, plants of this species are commonly pinched back through mid-summer to increase bushiness and flowering. Whether this would also increase seed production has not been demonstrated.
- Flowering Date: Flowering occurs late August to September
- Seed Maturity: Mid-September to October
- Seed Retention: Seeds wind dispersed very soon after maturity
- Harvest date range at TPC (2002-2006): Oct. 7- Oct.. 25
- Recommended Harvest Method: Combine after seed maturity but before more than 10% of the seedheads have turned brown and fluffy. Otherwise, combining will simply contribute to dispersal of the seed crop. Harvested material will have to be forced-air dried and turned carefully to prevent mold and decay. (Refer to *Appendix B* for settings.)



Seed Cleaning (Appendix C)

Cleaning Process: Pre-clean air-dried material by scalping thru 1/2" and 1/4" mesh to remove large particles. Remove plumes with debearder or brush machine, then air-screen.

Seed Characteristics (Appendix D)

Seed count: 66,000 seeds/oz (1,056,000/lb)

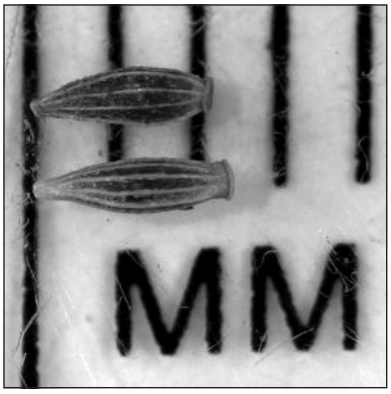


Photo credit: Dave Williams

Description: 'Seeds' are achenes 1/16" long, very hairy, with plume hairs attached to all parts of the achene.

Seed Storage: Stores well in refrigerated conditions (50º F, 30% RH)

Typical Seed Test (%)

- Purity: 80+
- Germination: 40-50
- Dormancy: 20-30

Released Germplasm (Appendix E):

Source Identified Material: Northern, Central, Southern Iowa *Natural Selections™*;

Cultivated Varieties: None

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 11 January 2007.

Plant Fact Sheet, New England aster, Symphyotrichum novae-angliae (L.). USDA-NRCS Elsberry Plant Materials Center. October 2002.

An Illustrated Guide to Iowa Prairie Plants, p. 37. Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

Notes:

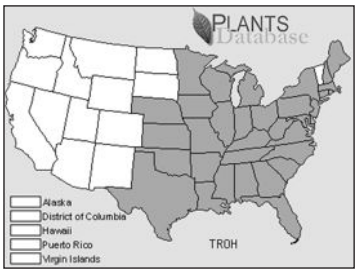
Ohio Spiderwort
Tradescantia ohioensis Raf.

Genus *Tradescantia*, reference to John Tradescant the elder, a 17th century English plant collector and nurseryman; species *ohioensis* i.e. 'of Ohio'.

Family: Dayflower of Spiderwort family (Commelinaceae)

Other Common Name(s): Common spiderwort, Bluejacket, Cow-slobbers, Snotweed

Description: Native perennial. 1 ½ - 2 ½ ' tall. Smooth, unbranched stem. Umbel of few to many flowers arising from stem tip and upper leaf axils. Flower buds bent downwards, bending upwards only as each bud flowers, on smooth flowering stalks. Each flower only opens for a day, primarily in the morning hours. Three petals, blue to purple about ½" long. Three sepals, smooth. Blue, hairy stamens with orange-yellow anthers. Leaves alternate, linear, joining main stem as a sheath, up to 2' long and ½" wide. Dark grey to black seeds develop inside three-parted capsules that split open and drop seed at maturity.



Adaptation/Habitat: Mesic soils, prefers sandy soil conditions in remnant prairies and open woodlands, often in areas with some disturbance. Full sun and well-drained loam soils preferred soils for seed production.

Threatened/Endangered Status: Endangered (PA).

General Comments: This species is easily propagated in the greenhouse and readily transplanted into production beds. Plants will spread with good management. Timing of seed harvest is challenging, since flowering and seed maturity occur gradually over, and bracts will still appear green after mature seed has dropped. Also, plants have a slimy, sticky sap (hence the unglamorous but obvious common name 'snotweed'), which makes direct combining unadvisable.

Establishment for Seed Production (Appendix A)

Direct seeding:

Seeding rate: 4.5 PLS lbs/acre (40 seeds/linear foot)
Row Spacing: 30-36" rows
Seeding Depth: ¼"
Seeding Methods: Drill
Time of Seeding: Dormant
Weed Control: Prepare clean, firm, weed free seedbed prior to seeding

Greenhouse:

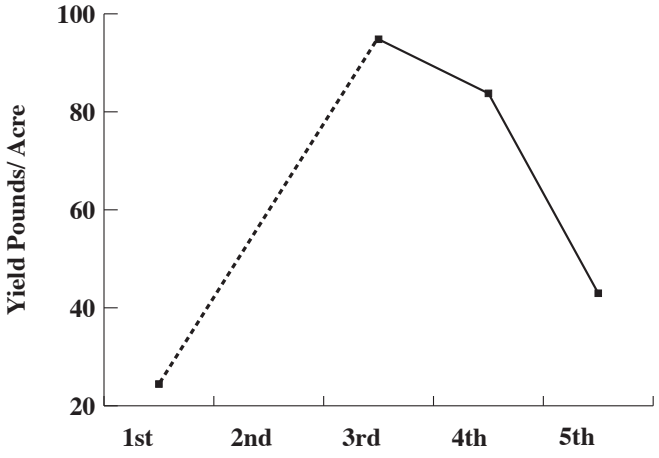
Seed pre-treatment: High percentage of dormancy, seed must be wet stratify 12 weeks at 40 F. Sow seed ¼" depth in greenhouse two months before last frost-free date. Transplant into bare soil or weedbarrier at 30-36" row spacing after all danger of frost is past.

Stand Management

Weeds – Post emergence grass herbicide, tillage, hand roguing.
Pests – No serious pest known. Rabbit and deer will browse foliage.
Diseases – No serious diseases known
Pollination: Insects, primarily bumblebees.

Seed Production (Appendix B)

- First Harvest: Some flowering and seed set end of first growing season from greenhouse grown transplants. We harvested 24 bulk pounds per acre first growing season.
- Yield/Acre: 40-100 bulk lbs/ac
- Stand Life: Peak harvests second and third full growing season after establishment. Seed production declined somewhat 4th year and was about half peak harvest 5th year. Chisel plowing can reinvigorate stands. Spiderwort is reportedly tolerant of low rates (1%) glyphosate.
- Flowering Date: Flowering occurs late May to late June.
- Seed Maturity/Harvest Date: Maturity begins in June, but optimal harvest early to mid-July.
- Seed Retention: Shattering occurs as soon as seed ripens.
- Harvest date range at TPC (2002-2006): July 7 to July 23
- Recommended Harvest Method: Hand clip seed heads and dry on tarps for several days and thresh. Large fields may be machine swathed, but seed will shatter out of heads as material dries down.



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Seed Cleaning (Appendix C)

Cleaning Process: Pre-clean air-dried material by scalping thru ½' and ¼" mesh to remove large particles, and then air-screen.

Seed Characteristics (Appendix D)

Seed count (de-hulled): 8,000 seeds/oz (128,000/lb)

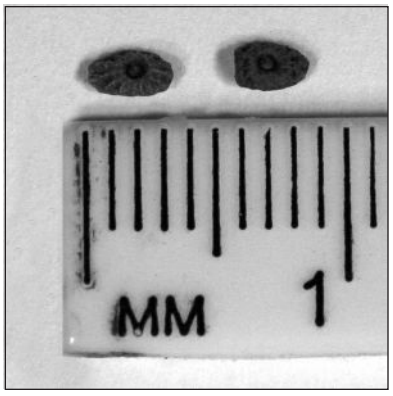


Photo credit: Dave Williams

Description: Seeds develop inside three-parted capsules that split open and drop seed at maturity. Seed coats are dark grey to black, very intricate, wrinkled ornamentation. Hard seed coat can visually mask seed quality. Aspiration (air screening) of seed is critical to remove unfilled, but otherwise normal looking seed.

Seed Storage: Stores well in refrigerated conditions (50 F, 30% RH).

Typical Seed Test(%):

- Purity: 99.76
- Germination: 6.0
- Dormancy: 74.0

Released Germplasm (Appendix E):

Source Identified Material: Northern, Central Iowa *Natural Selections™*.

Cultivated Varieties: None known

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 14 August 2007.

An Illustrated Guide to Iowa Prairie Plants, p. 185. Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

Wikipedia, http://en.wikipedia.org/wiki/Tradescantia. Reference for attribution of the genus Tradescantia to John Tradescant, 17th Century English plant collector and nurseryman Accessed 14 August 2007.

Illinois Wildflowers, Ohio Spiderwort, *Tradescantia ohioensis*; http://www.illinoiswildflowers.info/prairie/plantx/oh_spiderwortx.htm. John Hilty. All Rights Reserved. Last updated 10-29-06. Accessed 14 August 2007.

Notes:

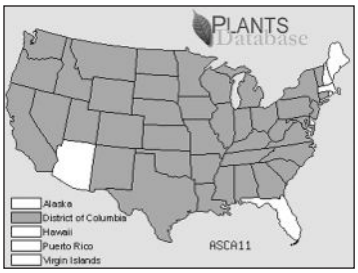
Canada Milkvetch
Astragalus canadensis L.

Genus *Astragalus* Latin, from Greek astragalos, 'anklebone'; species *canadensis* Latin 'from Canada'.

Family: Bean (Fabaceae)

Other Common Name(s): Canadian milkvetch, Milk-vetch, Little Rattlepod

Description: Native perennial, 2-3 feet tall. Stem is branched above, lightly hairy. Leaves are alternate, odd-pinnately compound, with 10 or more pairs of leaflets, plus terminal leaflet. Leaflets are 1-4 cm long (1/2 – 1 ½ inches) and 5–15 mm wide (1/4 – 5/8 inch), smooth or slightly hairy above and short hairs below. Flowers are a creamy greenish-white, crowded on racemes on leafless hairy stalks arising from leaf axils on upper portion of the plant.



Adaptation/Habitat: Wet-mesic to mesic soils, full sun. Moist, fertile, loamy soils preferred for seed production. Threatened/Endangered Status: Endangered (MD); Threatened (MI, VT)

General Comments: Canada milkvetch is a short lived species, usually dying out in production plots after flowering and setting seed. Spreads prolifically from stolons the second year after establishment. It's usually found as small, somewhat stable colonies in prairies in disturbed areas, over a few years at least. Grazing or clipping prolongs the life-span of the plant, but of course this precludes seed production.

Establishment for Seed Production (Appendix A)

Direct seeding:

Seeding rate (40 seeds/linear foot):
2.1 PLS lbs/acre for 30-36" rows
6.3 PLS lbs/acre for 7" rows and solid stands
Seeding Depth: 1/4 – 1/2 inch
Seeding Methods: drill
Time of Seeding: Dormant fall seeding of unscarified seed. Scarify and inoculate seed with Astragalus (Spec 1) inoculum for early spring planting.
Weed Control: Prepare clean, firm, weed free seedbed prior to seeding

Greenhouse:

Seed pre-treatment: Scarify seed (see text) and wet stratify 2 weeks at 40 F. Sow seed in greenhouse two months before last frost free date. Transplant mature seedlings into bare soil or weedbarrier in rows convenient for tillage equipment after all danger of frost is past. Use a temporary weedbarrier that can be removed before the second growing season to accommodate plant spread from stolons.

Stand Management

Weeds – Mow stand above seedling height during establishment year. Use tillage and hand-roguing to control weeds.
Pests – Seed predators may become a problem
Diseases – No serious diseases known.
Pollination: Insects, particularly bumblebees.

Seed Production (Appendix B)

- First Harvest: Abundant flowering and seed set end of second growing season from greenhouse grown transplants and well-managed direct seeded stands.
- Yield/Acre: 100-200 bulk lbs/ac
- Stand Life: Peak harvests second year. Many plants die out after flowering and setting seed, usually the second or third year after planting.
- Flowering Date: Flowering occurs mid-July to early August
- Seed Maturity: Mid August to early September
- Seed Retention: Pods split partially open at maturity, and seeds will shake out of pods if disturbed by strong wind or passing animals.
- Harvest date range at TPC (2002-2006): August 11 to September 2
- Recommended Harvest Method: Combine at maturity

Seed Cleaning (Appendix C)

Cleaning Process: Pre-clean air-dried material by scalping thru 1/2' and 1/4" mesh to remove large particles. If hand clipped, break up pods with brush machine. If combined then simply air-screen to clean (see appendix for settings).

Seed Characteristics (Appendix D)

Seed count (de-hulled):
17,000 seeds/oz (275,000/lb)
[266,000-275,000/lb NRCS Bismarck PMC]

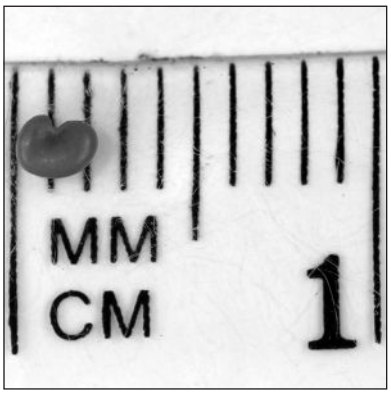


Photo credit: Dave Williams

Description: Fruits are small pods containing several loose seeds. Pods are about 1 cm long (1/2 inch), green at first, turning black at maturity, splitting partially open. Seeds are a small, flat bean, about 2mm (1/16 inch) in diameter.
Seed Storage: Stores well in refrigerated conditions (50 F, 30% RH).

Typical Seed Test (%):
- Purity: 95-99
- Germination: 6-10
- Hard Seed: 80-90

Released Germplasm (Appendix E):
Source Identified Material: Northern, Central Iowa
Natural Selections™ release pending.

Cultivated Varieties: Sunrise (SD), exclusive release by South Dakota State University and South Dakota Agricultural Experiment Station, 1997.

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 7 March 2007.

Plant Fact Sheet, Canadian Milkvetch, Astragalus canadensis L. USDA-NRCS Bismarck Plant Materials Center. 31 May 2006

An Illustrated Guide to Iowa Prairie Plants, p 93. Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

Notes:

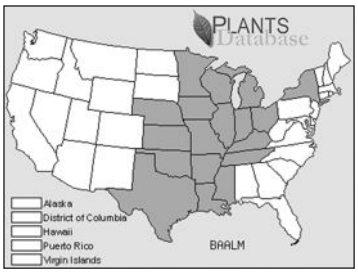
White Wild Indigo
Baptisia alba (L.)
Vent var. macrophylla (Larisey) Isely

Formerly *Baptisia lactea* (Raf.) Thieret
Genus *Baptisia*, Latin; species *alba* Latin 'white', referring to flower color.

Family: Bean (Fabaceae)

Other Common Name(s): White false indigo, Large leaf wild indigo

Description: Native, deep rooted perennial, 2.5 to 3 feet tall in flower. Stem with shrub-like branching, smooth. Leaves are alternate, compound with three leaflets. Large white, showy flowers occur on erect racemes, up to 2 ' long. Secondary racemes may also be present. Petals drop after pollination, and large inflated green pods form.



Adaptation/Habitat: Occurs and tolerates a range of soil conditions, from wet-mesic to dry. Full sun. Moist, well-drained soils preferred for seed production.
Threatened/Endangered Status: Not listed

General Comments: Mature white wild indigo plants come up quickly, nearly fully formed like asparagus, in late spring when soil temperatures warm. The tissues expand quickly, becoming shrub-like in form and blooming by early to mid June. Tissues turn black if bruised, as do seed pods at maturity. Entire plant blackens with fall dormancy. Pods eventually split open, revealing orderly rows of attached seeds. Seeds are somewhat sticky, initially. Stem breaks off at ground level in late fall and plants will tumble with the wind, shaking out any seed remaining in the pods, aiding seed dispersal.

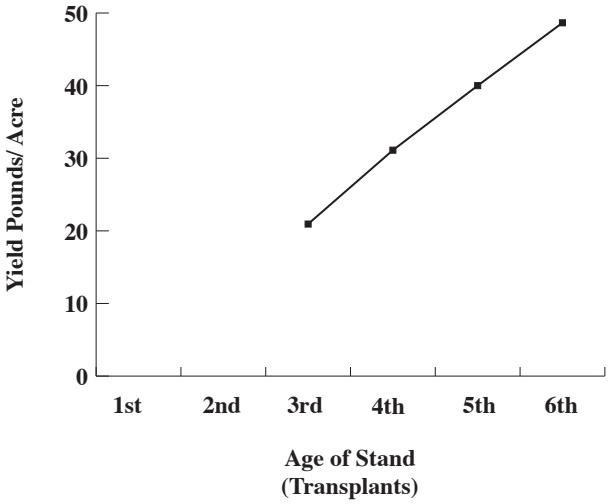
Establishment for Seed Production (Appendix A)

Direct seeding:
NOT RECOMMENDED FOR THIS SPECIES

Greenhouse:
Seed pre-treatment: Scarify seed (see text) and wet stratify 2 weeks at 40 F. Inoculate seed with a Baptisia inoculum, if desired. Sow seed in greenhouse two months before last frost free date. Damping off (fungal pathogen) can be a problem on seedlings if soil is kept too moist, or seedlings are planted too thickly. Avoid excess moisture on soil surface by applying a thin layer of perlite over the top of the soil, improving air circulation with fans, thinning seedlings, and/or watering from the bottom of the containers only. Seedlings form a fleshy taproot with few lateral roots, unless allowed to grow until taproot is air-pruned as it reaches the bottom drainage holes of the conetainer. Use care when transplanting to keep soil intact around roots system. Transplant mature seedlings into bare soil in rows convenient for tillage equipment or into weedbarrier at 8" intervals after all danger of frost is past.

Stand Management

Weeds – Mow stand above seedling height during establishment year. Control weeds with tillage and hand rouging. The Tallgrass Prairie Center is currently experimenting with over-seeding tall dropseed (*Sporobolus asper*) as a companion crop to reduce competition from weeds and to provide a fuel matrix for annual burning, which enhances seed production and seems to reduce weevil predation.
Pests – Seed production can be curtailed or even eliminated in some years by a seed-eating weevil (*Apion rostrum*). The weevil oviposits eggs in the developing fruit, and the larvae emerge a few days later inside the sealed pods and feed on the developing seeds. Plants may also selectively abort pods containing fewer seeds due to seed predation (Petersen 1994). It may take a few years for weevils to find and colonize a new production field. Deer are known to eat the entire inflorescence while in bud.
Diseases – No serious diseases known. Damping off can be serious in greenhouse environment (see above).
Pollination: Insects, primarily bumble bees.



Seed Production (Appendix B)

- First Harvest: Plants are slow to reach reproductive maturity. Some flowering and seed set may occur the third growing season under optimal conditions, but it may require 4 to 5 years for a full harvest.
- Yield/Acre: 50-150 bulk lbs/ac
- Stand Life: Plants appear to be long-lived, estimated stand life 10 years.
- Flowering Date: Flowering occurs mid-June to mid-July.

- Seed Maturity: September
- Seed Retention: Shattering occurs gradually through September into October
- Harvest date range at TPC (2002-2006): Sept.. 16 to Oct. 21
- Recommended Harvest Method: Combine or hand strip pods at maturity.

Seed Cleaning (Appendix C)

Cleaning Process: Pre-clean air-dried material by scalping through 1/2" mesh to remove large particles. Air-screen to clean (see appendix for settings). Black-colored seeds are non-viable and usually less dense than viable (yellowish-colored) seeds, and most should be removed by increasing aspiration.

Seed Characteristics (Appendix D)

Seed count (de-hulled): 1,700 seeds/oz (27,200/lb)

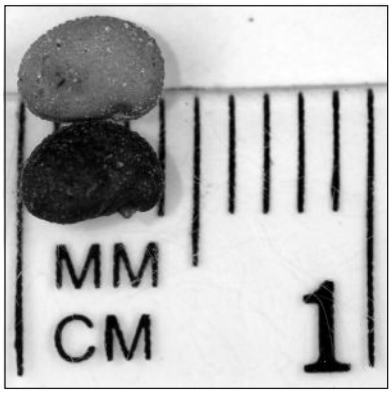


Photo credit: Dave Williams

Description: Fruits are a several-seeded legume (pod). Pods are about 2.5 cm long (1 inch) by 1 cm wide (1/2 inch), turning black when seeds mature. Seeds are a bean about 4-5 mm long (1/4 inch), covered with a sticky resin when freshly mature.

Seed Storage: Stores well in refrigerated conditions (50 F, 30% RH).

Typical Seed Test (%):

- Purity: 95-99
- Germination: 3-10
- Hard Seed: 85-95

Released Germplasm (Appendix E):

Source Identified Material: Northern, Central, Southern Iowa *Natural Selections™*, pending.

Cultivated Varieties: None known

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 9 March 2007.

An Illustrated Guide to Iowa Prairie Plants, p 97. Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

Selective Pod Abortion by *Baptisia leucantha* (Fabaceae) as affected by a Curculioni seed predator, *Apion rostrum* (Coleoptera). Petersen, C. and J.A. Sleboda. 1994. The Great Lakes Entomologist, Vol. 27, No. 3.

Notes:

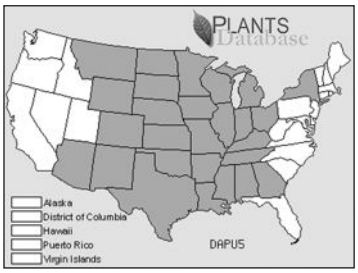
Purple Prairie Clover
Dalea purpurea Vent.

Genus *Dalea*; species *pupurea* Latin 'of a purple color'.

Family: Bean (Fabaceae)

Other Common Name(s): Violet prairie clover

Description: Native perennial 1.5-2.5 feet tall, stem, hairy. Purple flowers, each with 5 golden stamens are arranged on dense, oblong heads on stem tips 1-7 cm (1/2 – 3 inches) long. Flowers open first from the bottom of the head. Leaves are alternate, pinnately compound. Leaflets very narrow, usually 5 per leaf, smooth but with black dots on lower leaf surface. Seedhead elongate, compact head at stem tips. Crushed leaves have a strong citrus odor. Purple prairie clover has a woody, branched taproot.



Adaptation/Habitat: Found on mesic to dry upland sites, rocky and sandy soils, full sun. Very well-drained, loamy soil preferred for seed production.

Threatened/Endangered Status: Special Concern (KY); Extirpated (MI, OH); Endangered (TN).

General Comments: Purple prairie clover is an important component on mesic to dry upland prairies. It tends to increase following spring burning (Bidwell 1990), though burning production fields is usually not an option because of a lack of continuous grass fuels to carry fire. Purple prairie clover seed should be de-hulled when cleaned for the commercial market. Seed test are more accurate on de-hulled seed, and seed count per pound is higher.

Establishment for Seed Production (Appendix A)

Direct seeding:

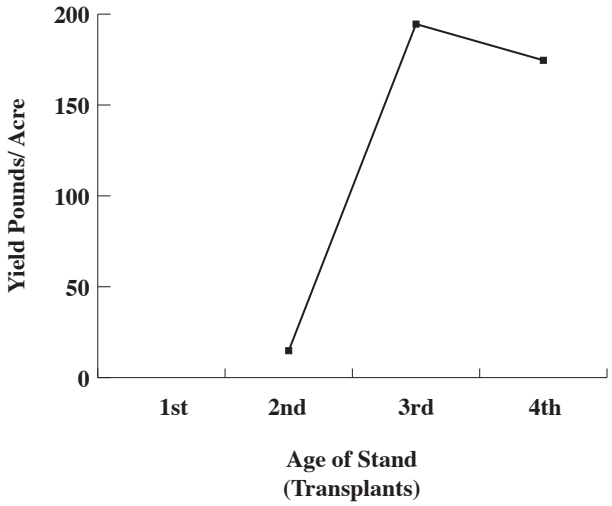
Seeding rates (40 seeds/linear foot):
2.0 PLS lbs/acre for 30-36" rows
6.0 PLS lbs/acre for 7" rows or solid stands
Seeding Depth: 1/4 inch
Seeding Methods: drill
Time of Seeding: Dormant fall seeding of unscarified seed. Scarify and inoculate seed (Dalea, F inoculum) for spring planting.
Weed Control: Prepare clean, firm, weed free seedbed prior to seeding

Greenhouse:

Seed pre-treatment: Scarify seed (see text). Moist stratification isn't required, but seed should be stored in cold, dry condition until planting time. Sow seed 1/4 inch deep in greenhouse two months before last frost free date. Damping off (fungal pathogen) can be a problem on seedlings if soil is kept too moist, or seedlings are planted too thickly. Avoid excess moisture on soil surface by applying a thin layer of perlite over the top of the soil, improving air circulation with fans, thinning seedlings, and/or watering from the bottom of the containers only. Transplant mature seedlings into bare soil in rows convenient for tillage equipment or into weedbarrier at 8" intervals after all danger of frost is past.

Stand Management

Weeds – Mow stand above prairie clover seedling height during establishment year. Poast (sethoxydim) or Prowl (pendimethalin) herbicide after establishment can be used to control weedy grasses. Plateau is labeled for pre- and post-emergence application. Note: These herbicides may not be labeled for this species in your state, Always check the label and follow recommendations.
Pests – Herbivory by rabbits, deer, may be a problem. Weevils may infest seed heads.
Diseases – No serious diseases known. Damping off can be serious in greenhouse environment (see above).
Pollination: Insects, particularly bees, wasps, small butterflies, skippers, beetles.



Seed Production (Appendix B)

- First Harvest: Flowering and seed set end of second growing season from greenhouse grown transplants and well-managed direct seeded stand.
- Yield/Acre: 50-200 bulk lbs/ac
- Stand Life: Five to ten years. Peak harvests third year.
- Flowering Date: Flowering occurs early July to early August.
- Seed Maturity: September
- Seed Retention: Shattering potential is low. Seed heads hold seed into October
- Harvest date range at TPC (2002-2006): Sept.. 20 to Nov. 5

- Recommended Harvest Method: Combine at maturity. If plants still retain green leaves, don't cut any lower than necessary to harvest seed heads.

Seed Cleaning (Appendix C)

Cleaning Process: Pre-clean air-dried material by scalping thru ½' and ¼" mesh to remove large particles. Use brush machine to remove hulls, then air-screen. Re-brush any seed still in the hull, if necessary, and air-screen.

Seed Characteristics (Appendix D)

Seed count (de-hulled): 18,000 seeds/oz (288,000/lb); [300,000/lb, NRCS Plant Fact Sheet]

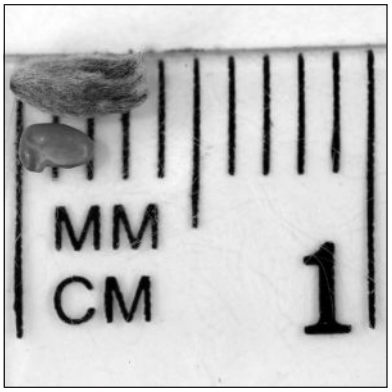


Photo credit: Dave Williams

Description: Fruits are a 1 to 2 seeded legume. Seeds are small bean, about 2 mm (1/16 inch) long, olive green to tan or brown.
Seed Storage: Stores well in refrigerated conditions (50 F, 30% RH).

Typical Seed Test (%):
- Purity: 95-99
- Germination: 20-30
- Hard Seed: 70-80

Released Germplasm (Appendix E):

Source Identified Material: Northern, Central, and Southern Iowa *Natural Selections™*.

Selected Varieties: Kaneb (Riley County, KS); Bismarck Germplasm (Lyman County, SD).

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 6 March 2007.

Fact Sheets For Some Common Plants On Rangelands In Western Canada, Range Ecosystems and Plants. Romo, J.T. Department of Plant Sciences: Rangeland Resources, University of Saskatchewan. (http://www.usask.ca/agriculture/plantsci/classes/range/daleapurpurea.html). Accessed 6 March 2007.

Plant Fact Sheet, Violet Prairie Clover, *Dalea purpurea* Vent. USDA-NRCS Elsberry Plant Materials Center. 13 June 2001.

An Illustrated Guide to Iowa Prairie Plants, p. 102. Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

Bidwell, T.G., Engle, D.M., and P.L. Claypool. 1990. Effects of spring headfires and backfires on tallgrass prairie. J. Range Manage. 43:209-212.

Notes:

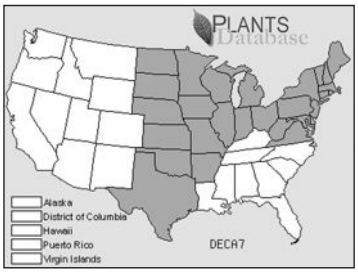
Showy Tick Trefoil
Desmodium canadense, (L.) DC.

Genus *Desmodium*, Latin; species *canadense* Latin 'from Canada'.

Family: Bean (Fabaceae)

Other Common Name(s): Tick clover, Canadian tick trefoil

Description: Native perennial, 3-4 feet tall, stem usually unbranched, hairy. Pink flowers arranged on branched stalks from stem tip and upper leaf axils. Leaves alternate, divided into three leaflets with rounded base and pointed tips, hairy on upper and lower surfaces. Narrow, pointed bracts (stipules) on either side of leaf petiole. Fruits are jointed pods (loments) covered with hooked hairs that break apart and cling to passing mammals. Showy tick trefoil has a woody tap-root.



Adaptation/Habitat: Wet-mesic to dry-mesic soil conditions, full sun. Moist, fertile, well-drained loamy soils preferred for seed production.

Threatened/Endangered Status: Not listed

General Comments: Showy tick trefoil is an important component of black soil prairies, increasing with spring burning. It's seeds are an important food source for upland game birds.

Establishment for Seed Production (Appendix A)

Direct seeding:

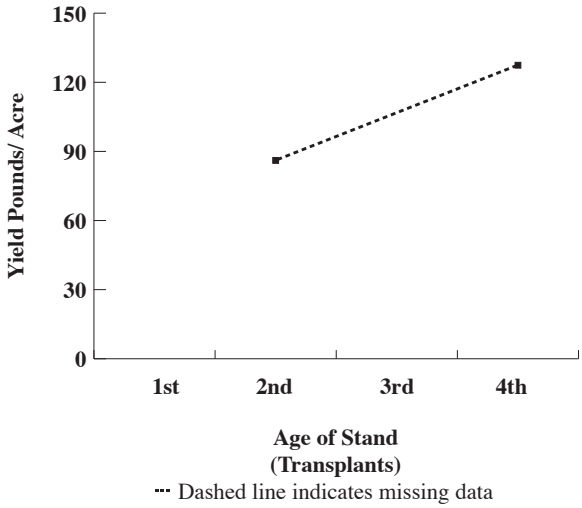
Seeding rate (12 pure live seeds/linear foot):
2.0 PLS lbs/acre for 30-36" rows
6.0 PLS lbs/acre for 7" rows and solid stands
Seeding Depth: 1/4 inch
Seeding Methods: drill
Time of Seeding: Dormant fall seeding of unscarified seed. Scarify and inoculate (Desmodium EL inoculum) seed for spring planting.
Weed Control: Prepare clean, firm, weed free seedbed prior to seeding

Greenhouse:

Seed pre-treatment: Scarify seed (see text). Moist stratification generally isn't required, but seed should be stored in dry, cold conditions until sowing. Sow seed in greenhouse two months before last frost free date. Inoculate seed with appropriate rhizobium at time of sowing, if desired. Seedlings form a fleshy taproot with few lateral roots, unless allowed to grow until taproot is air-pruned as it reaches the bottom drainage holes of the conetainer. Use care when transplanting to keep soil intact around roots system. Transplant mature seedlings into bare soil in rows convenient for tillage equipment or into weedbarrier at 8" intervals after all danger of frost is past.

Stand Management

Weeds – Mow stand above showy tick trefoil seedling height during establishment year to reduce weed competition and increase light to seedlings. Poast (sethoxydim) herbicide can be used for annual grass control, post emergence. Pursuit (imazethapry) can be used post-seeding for broadleaf weed control. Note: These herbicides may not be labeled for this species in your state, Always check the label and follow recommendations.
Pests – Seed weevils may infest and seriously curtail seed production. Herbivory by deer, rabbits, groundhogs may be an issue on young plants.
Diseases – No serious diseases known. Powdery mildew may affect foliage.
Pollination: Insects, primarily bees.



Seed Production (Appendix B)

- First Harvest: Seedling growth is vigorous, and flowering and seed set may occur at end of first growing season from greenhouse grown transplants and well managed direct seeded stands.
- Yield/Acre: 50-150 bulk lbs/ac
- Stand Life: Stand may persist for 5-10 years.
- Flowering Date: Flowering occurs mid-July to mid-August.
- Seed Maturity: September
- Seed Retention: Shattering occurs in late September into October.
- Harvest date range at TPC (2002-2006): Sept.. 18 to Oct. 10
- Recommended Harvest Method: Combine at maturity

Seed Cleaning (Appendix C)

Cleaning Process: Use brush machine to remove hulls (loments). Re-brush any seed still in the hull, if necessary. Airscreen to clean (see Appendix C for settings).

Seed Characteristics (Appendix D)

Seed count (de-hulled): 5,500 seeds/oz (88,000/lb) [88,000/lbs USDA PLANTS DATABASE]

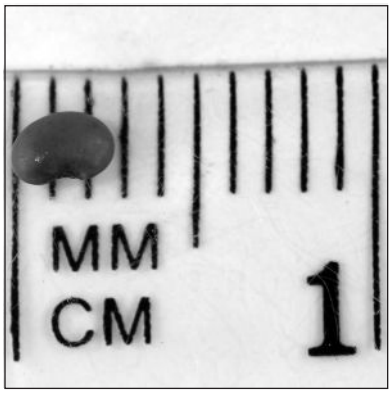


Photo credit: Dave Williams

Description: Fruits are a segmented pod (commonly 5 segments) seeded legume (loment), each segment with a single seed. Pods are covered with hooked hairs that cling to passing mammals and aid in seed dispersal. Seeds are a small bean, about 2.5-3 mm (about 1/8 inch), are olive green to tan.

Seed Storage: Stores well in refrigerated conditions (50 F, 30% RH).

Typical Seed Test (%):

- Purity: 95-99
- Germination: 85
- Hard Seed: 10

Released Germplasm (Appendix E):

Source Identified Material: Northern Iowa *Natural Selections™*.

Cultivated Varieties: Alexander Germplasm (IL).

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 7 March 2007.

Plant Fact Sheet, Showy Tick Trefoil, Desmodium canadense (L.) DC. USDA-NRCS Elsberry Plant Materials Center. 20 November 2003.

An Illustrated Guide to Iowa Prairie Plants, p. 104. Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

Notes:

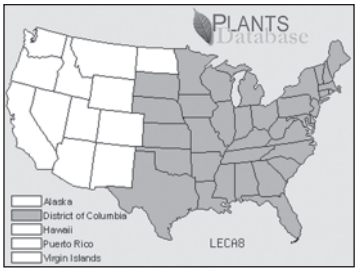
Roundheaded Bushclover
Lespedeza capitata Michx.

Genus *Lespedeza*, after V.M. de Céspedez (misread as Léspedez; fl. 1785), Spanish governor of Florida; species capitata, Latin capitatus, having a head, due to the head-like flower/seed cluster.

Family: Bean (Fabaceae)

Other Common Name(s): Roundhead lespedeza, Bushclover, Rabbitfoot

Description: Native perennial, 2-5 feet tall. Stem is usually unbranched, with stiff hairs on upper portions. May be multiple stems from base. Flowers are small, cream to white petals with a purple throat, clustered into rounded heads at stem tip and in upper leaf axils. Leaves are alternate and compound, divided into three leaftets with a prominent mid-vein, somewhat hairy below, smooth above. Seeds form in one-seeded pods clustered in heads.



Adaptation/Habitat: Occurs in mesic to dry soil conditions, sandy soils, full sun. Very-well drained loamy soils preferred for seed production.

Threatened/Endangered Status: Special Concern (KY)

General Comments: Roundheaded bushclover

Establishment for Seed Production (Appendix A)

Direct seeding:

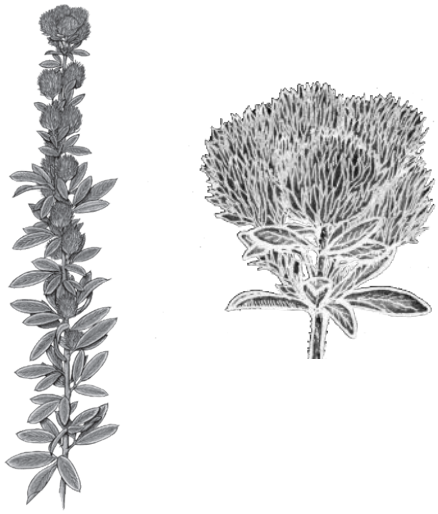
Seeding rate ((40 seeds/linear foot):
4.0 PLS lbs/acre for 30-36" rows
Seeding Depth: 1/4 – 1/2 inch
Seeding Methods: drill
Time of Seeding: Dormant fall seeding of unscarified seed. Scarify and inoculate seed (EL inoculum) for early spring planting.
Weed Control: Prepare clean, firm, weed free seedbed prior to seeding

Greenhouse:

Seed pre-treatment: Scarify seed (see text) and wet stratify 2 weeks at 40 F. Sow inoculated seed in greenhouse two months before last frost free date. Damping off (fungal pathogen) can be a problem on seedlings if soil is kept too moist, or seedlings are planted too thickly. Avoid excess moisture on soil surface by applying a thin layer of perlite over the top of the soil, improving air circulation with fans, thinning seedlings, and/or watering from the bottom of the containers only. Seedlings form a fleshy taproot with few lateral roots, unless allowed to grow until taproot is air-pruned as it reaches the bottom drainage holes of the conetainer. Transplant mature seedlings into bare soil in rows convenient for tillage equipment or into weedbarrier at 8" intervals after all danger of frost is past.

Stand Management

Weeds – Mow stand above seedling height during establishment year. Poast (sethoxydim) herbicide can be used to control weedy grasses. Prowl (pendimethalin) after establishment for grass control. Plateau should NOT be used on this species.
Pests – Herbivory may be a problem.
Diseases – No serious diseases known. Damping off can be serious in greenhouse environment (see above).
Pollination: Insects, primarily bees.



Seed Production (Appendix B)

- First Harvest: Though some plants may flower the first year, two growing season are required for stand establishment and seed production.
- Yield/Acre: 100 - 250 bulk lbs/ac
- Stand Life: 5-10 years, seed production decreases after 5 years.
- Flowering Date: Flowering occurs from mid-August to early September
- Seed Maturity: October
- Seed Retention: Shattering begins in late October into November
- Harvest date range at TPC (2002-2006): Oct. 16 to Oct. 23
- Recommended Harvest Method: Combine at maturity

Seed Cleaning (Appendix C)

Cleaning Process: Use brush machine/huller-scarifier to remove hulls, then air-screen (see Appendix C for settings).

Seed Characteristics (Appendix D)

Seed count (de-hulled): 8,000 seeds/oz (128,000/lb) [154,000/lb USDA-NRCS]

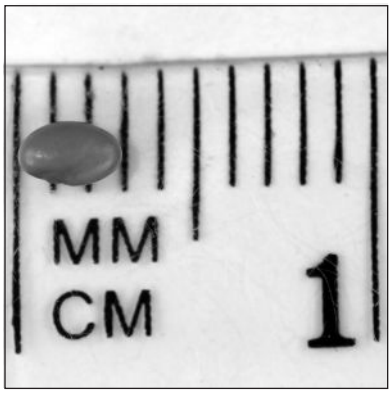


Photo credit: Dave Williams

Description: Fruits are a one-seeded legume, seeds are a small bean, 4-5mm (about 3/16 inch) long.
Seed Storage: Stores well in refrigerated conditions (50 F, 30% RH).

Typical Seed Test(%):
- Purity: 95-99
- Germination: 60-70
- Hard Seed: 30-40

Released Germplasm (Appendix E):

Source Identified Material: Northern, Central, Southern Iowa *Natural Selections™*.

Cultivated Varieties: Kanoka (KS);

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 7 March 2007.

Plant Solutions, Roundhead Lespedeza. NRCS Elsberry Plant Materials Center. February 2000.

Plant Guide, Roundhead Lespedeza, *Lespedeza capitata* Michx. USDA-NRCS National Plant Data Center, University of California, Davis. 5 December 2000.

An Illustrated Guide to Iowa Prairie Plants, p 108. Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

Notes:

Big bluestem
Andropogon gerardii Vitman

Genus *Andropogon*, Greek *andro* 'man', and *pogon* 'beard'; species *gerardii* , after John Gerard, English botanist of the late 16th and early 17th centuries.

Family: Grass (Poaceae)

Other Common Name(s): Turkey foot

Description: Native perennial, warm-season grass, flowering culms 3'-7' tall, smooth. Leaf sheaths compressed, purplish at base, lower sheath sometimes hairy. Leaf blades 1'-2' long, 1/4" wide, ligule is a fringe of hairs (ciliate). Seed head consist of 2-6 finger-like panicles, commonly 3, giving rise to the name 'turkey foot'. Big bluestem is sod forming spreading from short rhizomes, but often appears bunch-like.

Adaptation/Habitat: Wet-mesic to mesic soil conditions, full sun. Moist, loamy, deep, well-drained soils preferred for seed production.

Threatened/Endangered Status: Not listed

General Comments: Big bluestem is a dominant component of the tallgrass prairie ecosystem. This species establishes readily from direct seeding, particularly if seeded into crop ground where good weed control has been achieved (i.e. following a glyphosate-resistant crop, for example). Takes two to three years for stand to develop, with good management and weed control.

Establishment for Seed Production (Appendix A)

Direct seeding rate(s):

•Row Spacing:	36"	24"	12"	Solid Stand
•PLS lbs/acre:	3.6	4.8	9.7	10-12

Seeding Depth: 1/4"-1/2"
Seeding Methods: native grass drill
Time of Seeding: Mid to late spring
Weed Control: Prepare clean, firm, weed free seedbed prior to seeding.

Greenhouse:

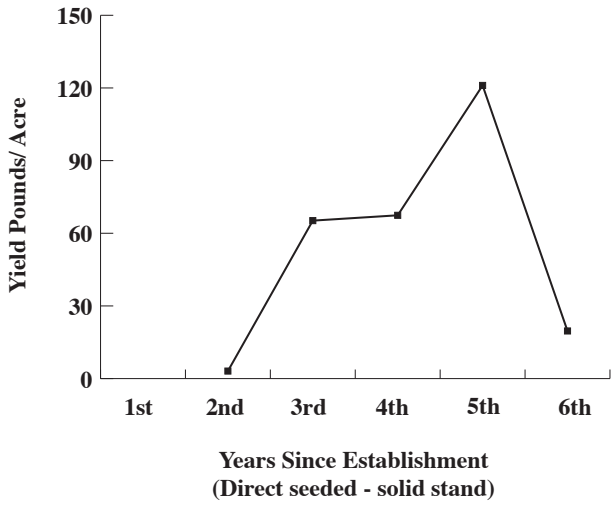
Seed pre-treatment: No stratification necessary. Germination of grass seed usually improves with proper storage (cool, dry conditions) throughout the first year after harvest. Sow seed in greenhouse two months before last frost free date at 1/4" depth. Transplant after all danger of frost.

Stand Management

Weed Control: During establishment - Mow stand high (6–12 inches) first growing season to prevent weed canopy from shading seedlings. Established stand – Atrazine, 2,4-D, Plateau (imazapic), Outlook (Dimethenamid-P).
Pests – yellow midges may infest florets, reducing seed yields
Diseases – Smut fungus affects florets
Pollination: Wind pollinated

Seed Production (Appendix B)

- First Harvest: Flowering and seed set end of 2nd growing season from direct seeding, three years for stand to fill out.
- Yield/Acre: 80-150 bulk lbs/ac (solid stand)
- Stand Life: Peak harvests 3rd year and after. If seed yields decline because stands are sod-bound, they can be chisel plowed to reinvigorate. Annual spring fire when green shoots are 2" tall helps control weeds and increase flowering and seed production. (Note: This recommendation is strictly for production fields, NOT REMNANT PRAIRIES). Productive stand life 10-15 years.
- Flowering Date: Flowering occurs early August to mid-September
- Seed Maturity: October
- Seed Retention: Shattering begins in mid to late October
- Harvest date range at TPC (2002-2006): Oct. 5 – Oct. 15
- Recommended Harvest Method: Combine at medium to hard dough stage, when some shattering is just beginning to occur of the very top of the main panicles.



Seed Cleaning (Appendix C)

Cleaning Process: Air-dry material, remove awns with debearder or brush machine, then air-screen.

Seed Characteristics (Appendix D)

Seed count (debearded): 10,000 seeds/oz (160,000/lb); [144,000/lb USDA PLANTS DATABASE]

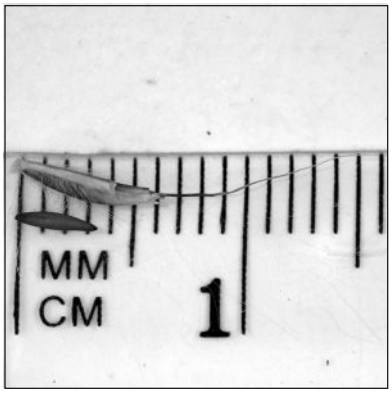


Photo credit: Dave Williams

Description: Fertile spikelet with long awn, 1-2 cm long (1/2 – 3/4"), attached stalk(s) are covered with hairs prior to debearding. Caryopsis smooth brown, 3-5 mm long. Stores well in refrigerated conditions (33-50 F, 30-50% RH). Germination often improves up to a year after harvest.

Typical Seed Test (%):

- Purity: 70-95
- Germination: 40-50
- Dormancy: 15-50

Released Germplasm (Appendix E)

Source Identified Material: Northern, Central, Southern Iowa Natural Selections™; Northern Missouri, 'OH-370', 'Refuge' (MO); Suther Germplasm, Cabarrus County, North Carolina.
Cultivated Varieties: Midwestern adapted varieties include Kaw (KS), Rountree (IA)

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 24 January 2007.

Plant Fact Sheet, Big bluestem, Andropogon gerardii Vitman. USDA-NRCS Elsberry Plant Materials Center. August 2000.

An Illustrated Guide to Iowa Prairie Plants, p. 202 Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

North American Range Plants, 4th Edition. P. 32-33. Stubbendieck, J., S.L. Hatch, C.H. Butterfield. University of Nebraska Press, Lincoln, NE. 1992

Notes:

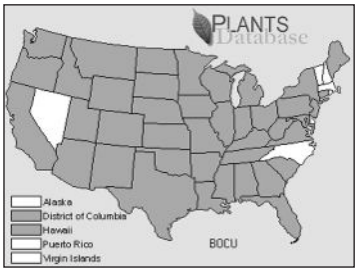
Sideoats grama
Bouteloua curtipendula (Michx.) Torr.

Genus *Bouteloua*, named after the brothers Claudio (1774-1842) and Estéban (1776-1813) Boutelou, Spanish botanists and horticulturists; species *curtipendula* Latin curtus 'short, broken', and pendulus 'hanging, pendent', for the short, interrupted arrangement of spikes hanging to one-side of the rachis. The oat-like spikelets hanging on one-side of the flowering stalk give rise to the common name 'side-oats'.

Family: Grass (Poaceae)

Other Common Name(s): Sideoats

Description: Native perennial warm-season bunch grass. Flowering culms 1.5- 2' tall, slightly hairy. Leaf sheath mostly smooth. Leaf blades are 6- 8" long, tapered to a sharp point. Stiff hairs with glandular bases arise from the leaf margins, sticking out at a right-angle from the main axis of the blade. Ligule is a very short fringe of hairs. Seedhead is 4- 12" long, and consists of many short spikes (1/2- 1 1/4" long), each with 3-7 spikelets, all turned to one side of the main stem. Lower leaves curl and turn a light, tawny color when dry.



Adaptation/Habitat: Found on mesic to dry soil conditions, in fine textured, calcium-rich soils, full sun. Well-drained soil preferred for seed production.

Threatened/Endangered Status: Endangered (CT, NJ, NY); Threatened (MI, PA); Special Concern (KY)

General Comments: This species is an important component of tall and mixed-grass prairies, occurring on well-drained, dry, rocky, alkaline soils. This species establishes readily from direct seeding, particularly if seeded into crop ground where good weed control has been achieved (i.e. following a glyphosate-resistant crop, for example).

Establishment for Seed Production (Appendix A)

Direct seeding rate(s):

•Row Spacing:	36"	24"	12"	Solid Stand
•PLS lbs/acre: *(spikelets)*	3.0	4.0	8.0	9.0

Seeding Depth: 1/4"-1/2"
Seeding Methods: native grass drill
Time of Seeding: late spring when soil temperature reaches 55° F
Weed Control: Prepare clean, firm, weed free seedbed prior to seeding.

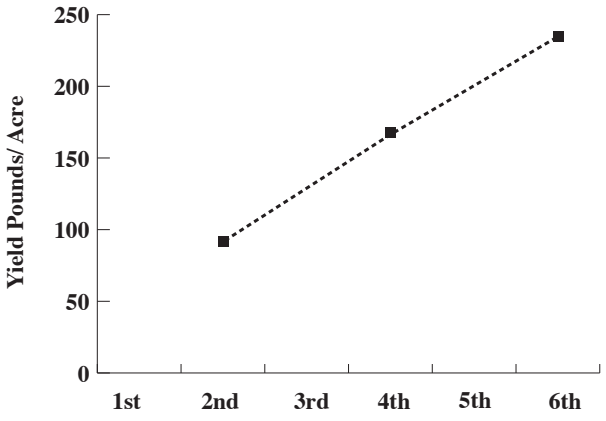
Greenhouse:
Seed pre-treatment: No stratification necessary. Germination of grass seed usually improves with proper storage (cool, dry conditions) throughout the first year after harvest. Sow seed in greenhouse two months before last frost free date at 1/4" depth. Transplant after all danger of frost.

Stand Management

Weed Control: During establishment – Mow stand high (6–12 inches) first growing season to prevent weed canopy from shading seedlings. Do not use atrazine the year of establishment. Established stand – Plateau (imazapic); Outlook (dimethenamid-P), 2,4-D; hand rouging, cultivation.
Pests – No serious pest known.
Diseases – No serious diseases known.
Pollination: Wind pollinated

Seed Production (Appendix B)

- First Harvest: Flowering and seed set end of second growing season from greenhouse grown transplants
- Yield/Acre: 50-250 bulk lbs/ac (solid stand)
- Stand Life: Peak harvests 3rd year and after. Annual late spring fire when shoots are 1 inch tall helps control weeds and increase flowering and seed production. (Note: This recommendation is strictly for production fields, NOT REMNANT PRAIRIES). Stand should persist up to 10 years if properly matched to soils, and well managed.
- Flowering Date: Flowering occurs mid-June to early July
- Seed Maturity: September
- Seed Retention: Holds seed fairly well, shattering occurs in October
- Harvest date range at TPC (2002-2006): Sept.. 22 – Oct. 7
- Recommended Harvest Method: Combine at hard dough stage



Seed Cleaning (Appendix C)

Cleaning Process: Sideoats can be air screened initially to sort off spikelets. Larger intact spikes can be run quickly through a debearder or hammer mill to break up spikes, and re-air screen.

Seed Characteristics (Appendix D)

Seed count: 11,900 seeds/oz (191,000/lb) [159,200/lb. USDA PLANTS DATABASE]

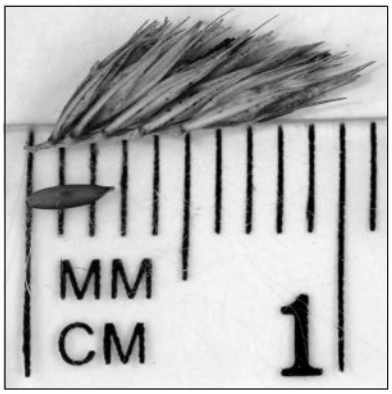


Photo credit: Dave Williams

Description: Seed unit is the spikelet, up to 1/4" long. Caryopsis 3-4 mm long, smooth brown.
Stores well in refrigerated conditions (33-50˚ F, 30-50% RH). Germination often improves up to a year after harvest in warm-season grasses.

Typical Seed Test (%):

- Purity: 85+
- Germination: 90
- Dormancy: 0

Released Germplasm (Appendix E)

Source Identified Material: Northern, Central, Southern Iowa *Natural Selections™*

Cultivated Varieties: Midwest adapted cultivars include El Reno (KS), Killdeer (ND), Pierre (ND).

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 30 January 2007.

Planting Guide, *Bouteloua curtipendula* (Michx.) Torr. USDA-NRCS Elsberry Plant Materials Center. 4/24/2000.

An Illustrated Guide to Iowa Prairie Plants, p. 203. Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

North American Range Plants, 4th Edition. P. 78-79. Stubbendieck, J., S.L. Hatch, C.H. Butterfield. University of Nebraska Press, Lincoln, NE. 1992

Notes:

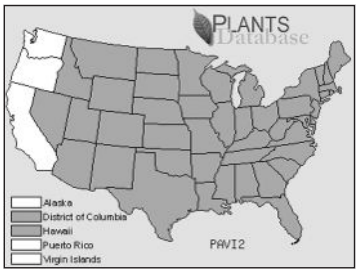
Switchgrass
Panicum virgatum (L.)

Genus *Panicum*, Latin *panicul* 'with panicles'; species *virgatum* Latin 'twig, wand-like'.

Family: Grass (Poaceae)

Other Common Name(s): Thatchgrass, Wobsqua grass, Blackbent

Description: Native perennial warm-season grass, flowering culms 3-5 feet tall, smooth stem. Leaf sheaths smooth. Leaf blades 5/16 inch wide, 6-22 inches long, hairy on upper surface, especially near the ligule. Ligule is a fringe of dense hairs about 1/8 inch tall. Seedhead consists of an openly branched, airy panicle, with spikelets near the ends of the branches. Spreads from seeds, tillers, and rhizomes.



Adaptation/Habitat: Wet-mesic to mesic soil conditions, full sun. May become abundant in disturbed prairies, much less common in high-quality prairies. Fertile, well-drained soils preferred for seed production.

Threatened/Endangered Status: Not listed

General Comments: A number of cultivars of switchgrass have been developed for forage and seed production, winter hardiness, and grazing tolerance by the USDA-NRCS Plant Materials program. These cultivars have been planted widely as mono cultures and in early prairie reconstructions. Because seed has been commercially available at affordable prices for decades, it was usually seeded heavily and tended to dominate stands. For these reasons it has been considered aggressive. Switchgrass can form dense colonies on lowland prairies, but is usually uncommon on high-quality remnant upland prairies and tends to occur in isolated patches near disturbance activities such as gopher mounds (Weaver 1954). Switchgrass establishes readily from seed, is relatively easy to harvest and clean.

Establishment for Seed Production (Appendix A)

Direct seeding rate(s):

•Row Spacing:	36"	24"	12"	Solid Stand
•PLS lbs/acre:	2.6	3.5	6.0	6.0

Seeding Depth: 1/4"

Seeding Methods: native grass drill, or broadcast seed and cultipack for solid stand

Time of Seeding: Spring

Weed Control: Prepare clean, firm, weed free seedbed prior to seeding

Greenhouse:

Seed pre-treatment: Moist stratify seed for 4 weeks to improve germination. Sow seed in greenhouse two months before last frost free date at 1/4" depth. Transplant after all danger of frost, into rows convenient for tillage equipment.

Stand Management

Weeds – Mow stand high (6–12 inches) first growing season to prevent weed canopy from shading seedlings. Broadleaf herbicides can be used to control broadleaf weeds in established stands. Switchgrass is atrazine resistant, and can be applied at the label rate at planting time.

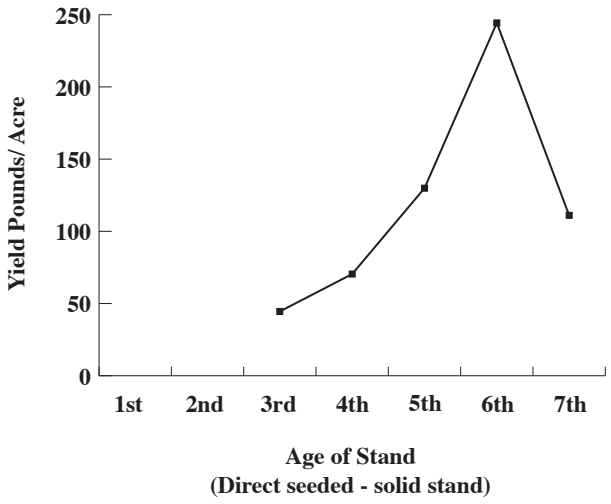
Pests – No serious pest known

Diseases – Seed smut, if left unchecked, can seriously decrease seed yields on switchgrass. The smut is caused by a fungus, *Tilletia maclaganii*. Glumes may exhibit an uncharacteristic purple coloration, and seeds are replaced by fungal spores that are red-orange when immature turning dark brown at maturity. Fields may need to be destroyed or relocated if diseased (NRCS 2003).

Pollination: Wind pollinated

Seed Production (Appendix B)

- First Harvest: Flowering and seed set end of first growing season from greenhouse grown transplants, second growing season from direct seeding.
- Yield/Acre: 100-250 bulk lbs/ac (solid stand)
- Stand Life: Stands should persist 10-15 years. Good seed production 2nd year and after.
- Flowering Date: Flowering occurs from late July to early September
- Seed Maturity: September
- Seed Retention: Shattering begins in late September to early October
- Harvest date range at TPC (2002-2006): Sept.. 24 to Oct. 8
- Recommended Harvest Method: Combine at hard dough stage before significant shattering has occurred



Seed Cleaning (Appendix C)

Cleaning Process: Pre-clean air-dried material by scalping thru 1/2' and 1/4" mesh to remove large particles. Brush to remove all floral parts from the grain, air-screen to clean.

Seed Characteristics (Appendix D)

Seed count: 14,000 seeds/oz (224,000/lb) [259,000/lb USDA PLANTS DATABASE]

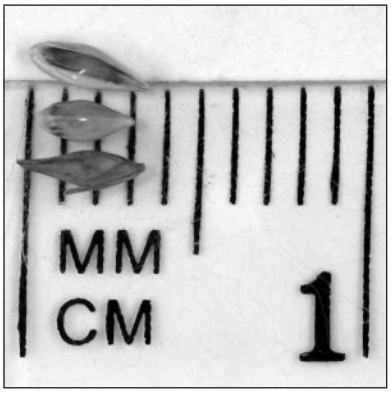


Photo credit: Dave Williams

Description: Spikelet is two-flowered, fertile floret uppermost, smooth. No awn. Grain is shiny, smooth, 3-4 mm (about 1/8 inch) long. Stores well in refrigerated conditions (33-50˚ F, 30-50% RH). Germination often improves up to a year after harvest in warm-season grasses.

Typical Seed Test (%):

- Purity: 95+
- Germination: 40
- Dormancy: 50

Released Germplasm (Appendix E)

Source Identified Material: Central Iowa *Natural Selections™*

Cultivated Varieties: Mid-west adapted include Blackwell (KS), Cave-In-Rock (IL), Dacotah, Forestburg (ND), Nebraska 28 (NE), Shawnee (MO).

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 9 February 2007.

Seed Smut of Switchgrass. USDA-NRCS Plant Materials Program. Manhattan Plant Materials Center Newsletter, Vol. 10, No. 3. July 2003.

Notice of Release of Central Iowa Germplasm, Switchgrass. USDA-NRCS Elsberry Plant Materials Center. 2003.

An Illustrated Guide to Iowa Prairie Plants, p. 216. Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

North American Range Plants, 4th Edition. P. 152-153. Stubbendieck, J., S.L. Hatch, C.H. Butterfield. University of Nebraska Press, Lincoln, NE. 1992

North America Prairie. pp. 33-34. Weaver, J.E. Johnson Publishing Company, Lincoln, NE 1954.

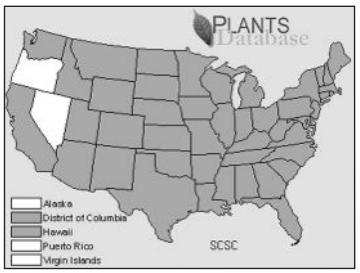
Notes:

Little bluestem
Schizachyrium scoparium, (Michx.) Nash

Genus *Schizachyrium*, Greek *schizo* meaning 'to split', and *achyron* 'chaff', referring to the divided lemma; species *scoparium*, Latin *scopae* 'broom'.

Family: Grass (Poaceae)
Other Common Name(s): Prairie beardgrass, Broom beardgrass

Description: Native perennial warm-season grass, flowering culms 2-3" tall, smooth. Leaf sheaths strongly flattened (keeled), usually smooth, sometimes hairy. Leaf blades narrow, up to 8" long . Ligule is a fringed (ciliate) membrane. Seed heads consists of single spikes, about 1" long, arising from upper leaf axils, appearing as white, fluffy appendages at maturity. Little bluestem is bunch-forming in growth habit.



Adaptation/Habitat: Dry-mesic to dry soil conditions, full sun. Well-drained, moderately moist soils are preferred for seed production.

Threatened/Endangered Status: Not a listed species

General Comments: Little bluestem is a dominant component on dry or well-drained soils within the tallgrass prairie region. Careful site selection, seedbed preparation, and weed control are critical to successful establishment from seed. No-till drilling with a native seed drill into cropland following a glyphosate-resistant crop, (soybeans for example) is an excellent method. Takes two to three years for stand to develop.

Establishment for Seed Production (Appendix A)

Direct seeding rate(s):

•Row Spacing:	36"	24"	12"	Solid Stand
•PLS lbs/acre:	2.4	3.2	6.4	8.0

Seeding Depth: 1/4"
Seeding Methods: native grass drill
Time of Seeding: Late spring, early summer
Weed Control: Prepare clean, very firm, weed free seedbed prior to seeding

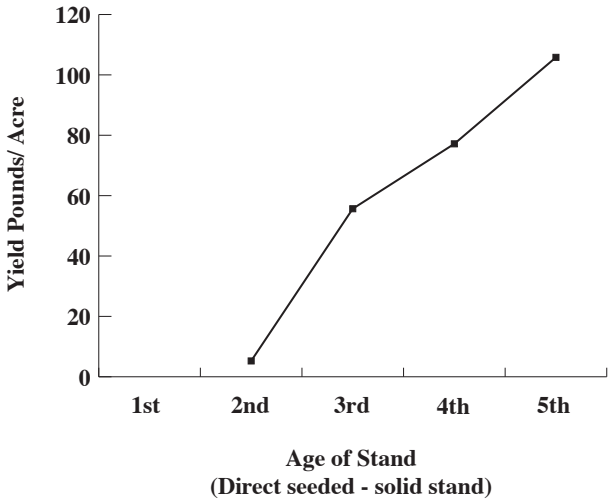
Greenhouse:
Seed pre-treatment: No stratification necessary. Germination of grass seed usually improves with proper storage (cool, dry conditions) throughout the first year after harvest. Sow seed in greenhouse two months before last frost free date at 1/4" depth. Transplant after all danger of frost.

Stand Management

Weeds – Mow stand high (6–12 inches) first growing season to prevent weed canopy from shading seedlings. Plateau (imazepic) can be used to control grass and broadleaf weeds in established stands. Pre-emergent grass and broadleaf herbicides can also be used for weed control. Check chemical labels.
Pests – No serious pest known
Diseases – No serious diseases known
Pollination: Wind pollinated

Seed Production (Appendix B)

- First Harvest: Flowering and seed set end of 2nd growing season from direct seeding, three years for stand to fill out.
- Yield/Acre: 50-120 bulk lbs/ac (solid stand)
- Stand Life: Peak harvests 3rd year and after. If seed yields decline stands can be chisel plowed to reinvigorate. Annual late spring fire helps control weeds and increase flowering and seed production. (Note: This recommendation is strictly for production fields, NOT REMNANT PRAIRIES). Productive stand life 10-15 years.
- Flowering Date: Flowering occurs late July to late August.
- Seed Maturity: Late September to October
- Seed Retention: Shattering is moderate, beginning in late September
- Harvest date range at TPC (2002-2006): Oct. 10 – Oct. 29
- Recommended Harvest Method: Stripper, or Combine at hard dough to maturity, when most of spikes are fluffed out and shattering is just beginning to occur.



Seed Cleaning (Appendix C)

Cleaning Process: Air-dry material, remove awns with debearder or brush machine, then air-screen.

Seed Characteristics (Appendix D)

Seed count (debearded): 15,000 seeds/oz (240,000/lb); [220,000/lb USDA PLANTS DATABASE]

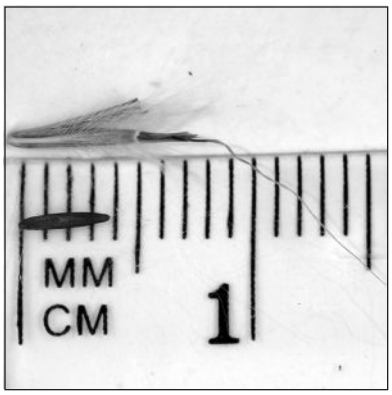


Photo credit: Dave Williams

Description: Fertile spikelet with bent, twisted awn, 9-16 mm long (1/4-5/8 inches), attached stalks (rachis and pedicel) hairy prior to debearding. Caryopsis smooth, brown, thickened, about 3-5 mm long. Stores well in refrigerated conditions (33-50˚ F, 30-50% RH). Germination often improves up to a year after harvest.

Typical Seed Test (%):

- Purity: 80+
- Germination: 54
- Dormancy: 33

Released Germplasm (Appendix E)

Source Identified Material: Northern, Central, Southern Iowa *Natural Selections™*; Northern, Western, Southern Missouri;

Cultivated Varieties: Midwest adapted varieties include 'Aldous (KS); 'Camper', 'Blaze' (NE, KS); 'Cimmaron' (KS, OK).

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 25 January 2007.

Grasses of Iowa, website: http://www.eeob.iastate.edu/research/iowagrasses/index.html. Iowa State University Department of Ecology, Evolution, and Organismal Biology. Accessed 8 February 2007.

Plant Fact Sheet, Little bluestem, *Schizachyrium scoparium* (Michx.) Nash. USDA-NRCS Elsberry Plant Materials Center. January 2001.

An Illustrated Guide to Iowa Prairie Plants, p. 219. Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

North American Range Plants, 4th Edition. P. 40-41. Stubbendieck, J., S.L. Hatch, C.H. Butterfield. University of Nebraska Press, Lincoln, NE. 1992

Notes:

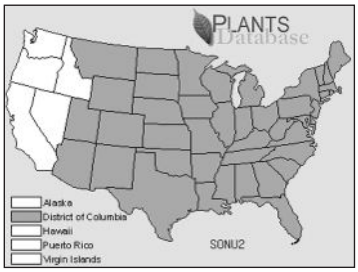
Indiangrass
Sorghastrum nutans (L.) Nash

Genus *Sorghastrum*, Greek meaning 'a poor imitation of sorghum'; species *nutans* Latin 'to nod, sway', in reference to nodding, plume-like seed head.

Family: Grass (Poaceae)

Other Common Name(s): Yellow Indiangrass

Description: Native perennial warm-season grass. Flowering culms 3-5 ' tall, smooth. Leaf sheaths smooth. Leaf blades up to 12" long, constricted at the base, then widening to about 3/8", and tapered to a point. Ligule is a thin membrane, with prominent pointed leaf-like projections (auricles) on either side. These are sometimes referred to as the 'gun-sight', 'mule-ears', or 'boot straps' character of Indiangrass. Seedhead consists of a dense, yellowish plume-like panicle up to a foot in length. Indiangrass has short scaley rhizomes, but is bunch-forming in growth habit.



Adaptation/Habitat: Wet-mesic to dry-mesic soil conditions, full sun. Deep, moist, well-drained soils preferred for seed production.

Threatened/Endangered Status: Endangered (ME)

General Comments: Indiangrass is a dominant component of the tallgrass prairie ecosystem. This species generally establishes readily from seed, if good seed bed preparation and good weed control are achieved (i.e. following a glyphosate-resistant crop, for example). Takes two to three years for stand to develop.

Establishment for Seed Production (Appendix A)

•Row Spacing:	36"	24"	12"	Solid Stand
•PLS lbs/acre:	3.3	5.0	10	10-12

Seeding Depth: 1/4"-1/2"
Seeding Methods: native grass drill
Time of Seeding: late spring, early summer
Weed Control: Prepare clean, very firm, weed free seedbed prior to seeding.

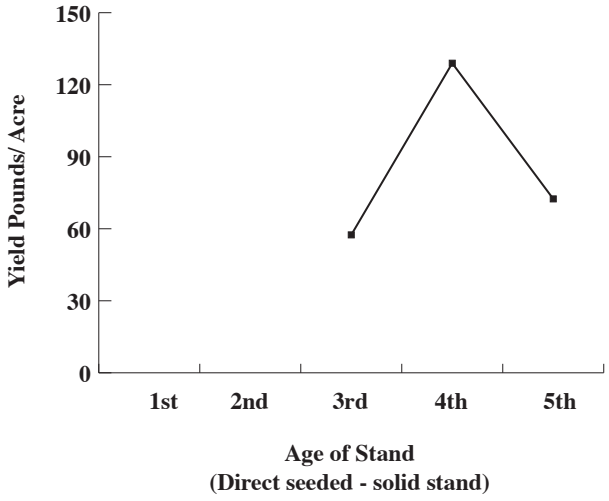
Greenhouse:
Seed pre-treatment: No stratification necessary. Germination of grass seed usually improves with proper storage (cool, dry conditions) throughout the first year after harvest. Sow seed in greenhouse two months before last frost free date at 1/4" depth. Transplant after all danger of frost.

Stand Management

Weeds – Mow stand high (6–12 inches) first growing season to prevent weed canopy from shading seedlings. Established stands – Plateau (imazepic) for grass and broadleaf control, Atrazine for grass control.
Pests – No serious pest known
Diseases – No serious diseases known
Pollination: Wind pollinated

Seed Production (Appendix B)

- First Harvest: Flowering and seed set end of 2nd growing season from direct seeding, three years for stand to fill out.
- Yield/Acre: 50-130 bulk lbs/ac (solid stand)
- Stand Life: Peak harvests 3rd year and after. If seed yields decline stands can be chisel plowed to reinvigorate. Annual late spring fire helps control weeds and increase flowering and seed production. (Note: This recommendation is strictly for production fields, NOT REMNANT PRAIRIES). Productive stand life 10-15 years.
- Flowering Date: Flowering occurs mid-August to mid-September
- Seed Maturity: Late September to early October
- Seed Retention: Shattering occurs soon after maturity. **Very susceptible to seed shattering from wind.** A single, windy afternoon when seed is mature and dry can take most of the crop.
- Harvest date range at TPC (2002-2006): Oct. 1 – Oct. 9.
- Recommended Harvest Method: Seed stripper, or Combine at medium to hard dough stage



Seed Cleaning (Appendix C)

Cleaning Process: Air-dry material, remove awns with debearder or brush machine, then air-screen.

Seed Characteristics (Appendix D)

Seed count (debearded): 12,000 seeds/oz (192,000/lb); [175,000/lb USDA PLANTS DATABASE]

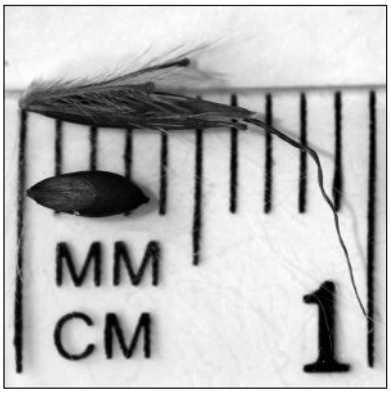


Photo credit: Dave Williams

Description: Fertile spikelet with a bent, twisted awn, about 1.2 cm long (1/2 inches), attached stalks (rachis and pedicel) hairy prior to debearding. Caryopsis smooth, brown, thickened, about 3-5 mm long. Stores well in refrigerated conditions (33-50 F, 30-50% RH). Germination often improves up to a year after harvest.

Typical Seed Test (%):

- Purity: 90+
- Germination: 28
- Dormancy: 59

Released Germplasm (Appendix E)

Source Identified Material: Northern, Central, Southern Iowa *Natural Selections*™; Northern, Western Missouri

Cultivated Varieties: Midwestern adapted varieties include 'Cheyenne', 'Osage' (KS); 'Holt' (NE); 'Oto' (KS,NE) 'Rumsey' (IL).

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 25 January 2007.

Plant Fact Sheet, Indiangrass, *Sorghastrum nutans* L, USDA-NRCS Elsberry Plant Materials Center. January 2001.

An Illustrated Guide to Iowa Prairie Plants, p. 220. Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

North American Range Plants, 4th Edition. P. 42-43 Stubbendieck, J., S.L. Hatch, C.H. Butterfield. University of Nebraska Press, Lincoln, NE. 1992

Notes:

Tall dropseed
Sporobolus compositus, (Poir.) Merr. *var. compositus*

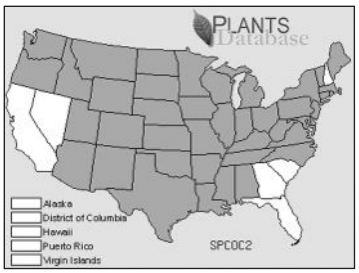
(Formerly *Sporobolus asper* (Beauv.) Kunth)

Genus *Sporobolus*, Greek *sporo* 'seed' and *ballein* 'to throw', referring to the free seeds that are dropped or forcibly ejected in some species of this genera; species *compositus* Latin meaning 'compound'. Former species name *asper*, Latin meaning 'rough'.

Family: Grass (Poaceae)

Other Common Name(s): Rough dropseed, Dropseed. Flag grass

Description: Native perennial warm-season grass, flowering culms 1.5-3 feet tall, smooth. Leaf sheaths smooth, tuft of hairs on each side near the junction with the blade (collar) and at the throat. Leaf blades about 3/16 " wide, up to 9" long, tapered to a threadlike tip, upper surface rough. Ligule is a short fringe of hairs (ciliate). Seedhead consists of a narrow contracted spike-like panicle 4-8" long, developing within the sheath of uppermost leaf, and is only partially exposed at maturity.



Adaptation/Habitat: Dry-mesic to dry, on well-drained clay or silt loams. Also on intermittently wet and dry sandy or rocky soils, full sun. Preferred well-drained loamy soils for seed production.

Threatened/Endangered Status: Endangered (ME, VT); Special Concern (CT).

General Comments: Tall dropseed may become abundant on dry sites, as a bunchgrass or spreading by short rhizomes. Also common on the shoulders of gravel roads in some areas. This species produces abundant seed, is very competitive when direct seeded into appropriate soils, and is relatively easy to harvest and clean. It has potential as an important nurse or cover crop for high diversity native plantings where quick establishment is needed when planting time is during warm soil temperatures.

Establishment for Seed Production (Appendix A)

Direct seeding rate(s):

• Row Spacing:	36"	24"	12"	Solid Stand
• PLS lbs/acre:	1.2	1.8	3.6	3.6

Seeding Depth: 1/4"

Seeding Methods: native grass drill, or broadcast for solid stand

Time of Seeding: Late spring

Weed Control: Prepare clean, firm, weed free seedbed prior to seeding

Greenhouse:

Seed pre-treatment: No stratification necessary. Germination of grass seed usually improves with proper storage (cool, dry conditions) throughout the first year after harvest. Sow seed in greenhouse two months before last frost free date at 1/4" depth. Transplant after all danger of frost.

Stand Management

Weeds – Mow stand high (6–12 inches) first growing season to prevent weed canopy from shading seedlings. Herbicides include Outlook (dimethenamid-P) for grass control. Pendimax (pendimethalin) can be used to control broadleaf weeds in established stands.

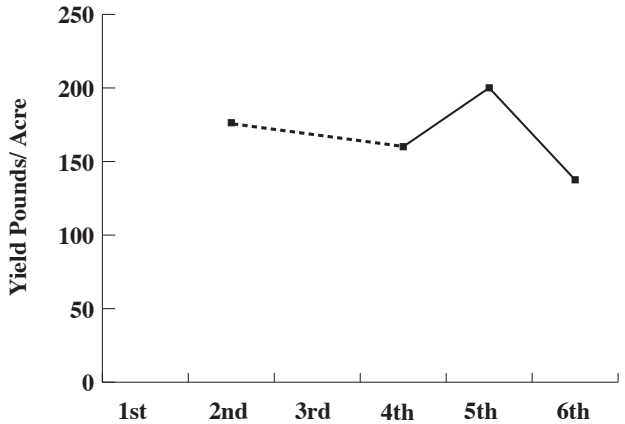
Pests – no serious pest

Diseases – no serious diseases

Pollination: Wind pollinated

Seed Production (Appendix B)

- First Harvest: Flowering and seed set end of second growing season from direct seeding.
- Yield/Acre: 150-250 bulk lbs/ac (solid stand)
- Stand Life: Stand remains productive over several years, projected stand life 10-15 years. Annual late spring fire helps control weeds and increase flowering and seed production.
- Flowering Date: Flowering begins in mid- to late-August.
- Seed Maturity: Mid to late September
- Seed Retention: Shattering occurs soon after maturity.
- Harvest date range at TPC (2002-2006): Oct. 1-Oct. 15
- Recommended Harvest Method: Combine. Tall dropseed has very tough stems and leafy material that tends to clog the sickle bar cutting head. Slow groundspeed to compensate.



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Seed Cleaning (Appendix C)

Cleaning Process: Pre-clean air-dried material by scalping thru 1/2" and 1/4" mesh if necessary to remove large particles. Glumes can be removed with a brush machine prior to air-screening if desired, or simply air-screen to clean.

Seed Characteristics (Appendix D)

Seed count: 30,000 seeds/oz (480,000/lb) [759,362 USDA PLANTS DATABASE]

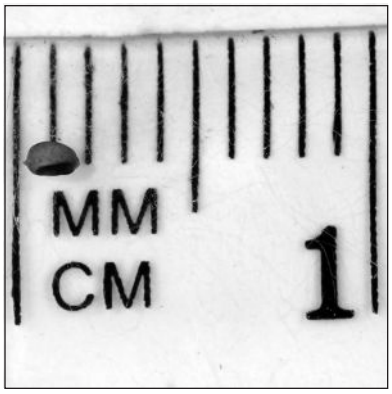


Photo credit: Dave Williams

Description: Spikelets are one-flowered, no awns present, 3.3-7mm long (about 1/4" inch). Grain is about 2 mm (1/16") in diameter, smooth, rounded, often dark brown. Stores well in refrigerated conditions (33-50˚ F, 30-50% RH).

Typical Seed Test (%):

- Purities: 99
- Germination: 90
- Dormancy: 0

Released Germplasm (Appendix E)

Source Identified Material: Northern, Central, Southern Iowa *Natural Selections™*; Northern Missouri

Cultivated Varieties: None known

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 9 February 2007.

Grasses of Iowa, website: http://www.eeob.iastate.edu/research/iowagrasses/index.html. Iowa State University Department of Ecology, Evolution, and Organismal Biology. Accessed 8 February 2007.

Plant Solutions, Iowa Germplasm, Tall Dropseed. USDA-NRCS Elsberry Plant Materials Center. March 2000.

An Illustrated Guide to Iowa Prairie Plants, p. 222. Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

North American Range Plants, 4th Edition. P. 138-139. Stubbendieck, J., S.L. Hatch, C.H. Butterfield. University of Nebraska Press, Lincoln, NE. 1992

Notes:

Prairie dropseed
Sporobolus heterolepis, (Gray) Gray

Genus *Sporobolus*, (see definition under Sporobolus asper); species *heterolepis* Latin *heteros* 'different, unlike' and *lepis* 'scale', reference to the unequal, scale-like glumes of the spikelet in this species.

Family: Grass (Poaceae)

Other Common Name(s): Northern dropseed

Description: Native perennial warm-season grass, flowering culms 2-3' tall, smooth stem. Leaf sheaths smooth, with tuft of hairs at throat and collar. Leaf blades about 1/16" wide, up to 2' long, tapered to thread-like point. Ligule is a short fringe of hairs. Seedhead consists of a diffuse, openly branched panicle. Bunchgrass forming large clumps. The long leaves and seedheads create a 'fountain-like' effect making this species desirable for horticultural landscape plantings. Glands at the base of branches in the panicle give off a buttery odor when in flower and seed set.

Adaptation/Habitat: Infrequent on mesic to dry prairies, full sun. Well-drained loamy soils preferred for seed production. This species is seldom abundant in prairies, occurring in groupings as scattered clumps.

Threatened/Endangered Status: Endangered (CT, KY, MD, NC, PA); Threatened (NY, OH)

General Comments: Seedlings develop slowly, so this species is best propagated in the greenhouse and transplanted in rows convenient for tillage equipment as into a well-prepared, weed-free, and firmly packed increase field. Plants are very long-lived, forming large clumps after 2-3 growing seasons. Spring burning stimulates prolific flowering and seed production, but bunches can also be killed or damaged by burning if soil conditions are excessively dry. Timing of seed harvest is critical, since seed drops soon after maturity.

Establishment for Seed Production (Appendix A)

Direct seeding rate(s):
NOT RECOMMENDED FOR THIS SPECIES (slow seedling development)

Greenhouse:
Seed pre-treatment: Moist stratify seed at 35-40° F for 4 weeks. Sow seed in greenhouse two months before last frost free date at 1/4" depth. Transplant (after all danger of frost), into rows convenient for tillage equipment.

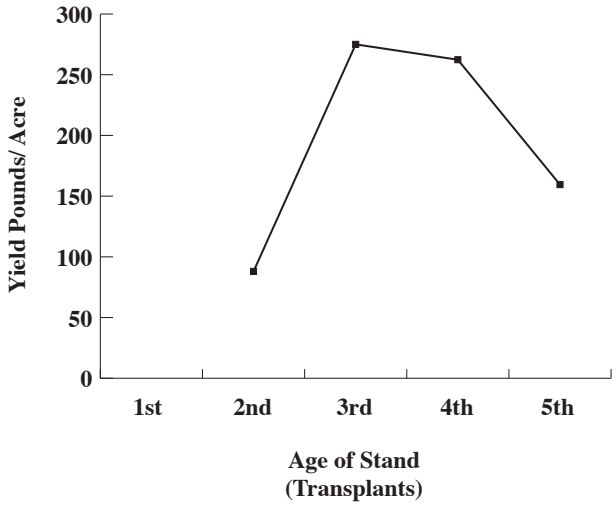
Vegetative reproduction: Large established clumps in the production field can be divided in early spring by spading down into the middle of a clump and lifting out half, leaving remaining half undisturbed. Further divide lifted material, if desired, and replant immediately.

Stand Management

Weed Management – Transplant into well-prepared, weed free increase field. Pre-emergent herbicides may be used after transplanting. Be sure to water in transplants to help seal soil around roots so pre-emergent won't chemically damage root systems. Cultivate, hoe, and hand rogue around young plants later in the season, if necessary.
Pests – No serious pests known
Diseases – No serious diseases known
Pollination: Wind pollinated

Seed Production (Appendix B)

- First Harvest: Flowering and seed set end of second growing season from greenhouse grown transplants
- Yield/Acre: 100-250 bulk lbs/ac (34" rows)
- Stand Life: Stand remains productive over several years, projected stand life 10-15 years.
- Flowering Date: Flowering occurs mid-August to early September
- Seed Maturity: Late September to early October
- Seed Retention: Shattering occurs soon after maturity
- Harvest date range at TPC (2002-2006): Oct. 1- Oct. 15
- Recommended Harvest Method: Combine harvest when



Seed Cleaning (Appendix C)

Cleaning Process: Pre-clean air-dried material by scalping thru 1/2" and 1/2" mesh to remove large particles, if necessary. Air-screen to clean.

Seed Characteristics (Appendix D)

Seed count: 16,000 seeds/oz (256,000/lb)

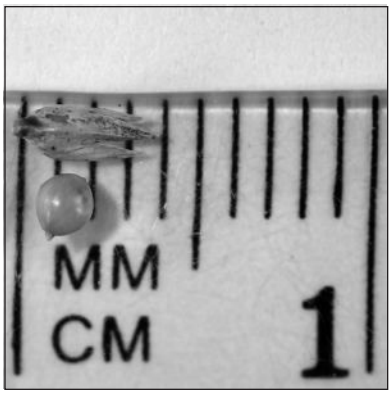


Photo credit: Dave Williams

Description: Spikelets are one-flowered, no awns present, about 4 mm long (5/32 inch), Grain round, firm about 2.5 mm (3/32 inch) long.
Seed reportedly has a high oil content that can shorten viability in storage. Some producers recommend storing seed at freezing temperatures for extended storage after proper drying and cleaning. Store seed in moisture-proof containers before freezing. Seed should not be left at room temperatures for more than a few weeks after harvest. Refrigerated conditions (33-50˚ F, 30-50% RH) are adequate for at least a year after harvest.

Typical Seed Test(%):

- Purity: 99
- Germination: 43
- Dormancy: 6-10

Released Germplasm (Appendix E)

Source Identified Material: Southern Iowa *Natural Selections™*

Cultivated Varieties: None known

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 9 February 2007.

An Illustrated Guide to Iowa Prairie Plants, p. 223. Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

Notes:

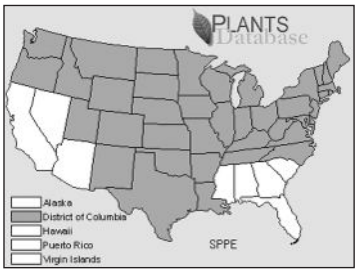
Prairie Cordgrass
Spartina pectinata Bosc ex Link

Genus *Spartina*, Greek *spartine* 'a type of cord made from vegetable fibers', a possible reference to the long, fibrous leaves, or the cord-like appearance of the stout rhizomes; species *pectinata* Latin 'comb' referring to the comb-like one-sided inflorescence and seedhead.

Family: Grass (Poaceae)

Other Common Name(s): Slough grass, Marshgrass, Ripgut

Description: Native perennial warm-season grass, flowering culms up to 10 feet tall, smooth. Leaf sheath smooth with ridges (striate). Leaf blades 6-15 mm wide (to just over 1/2 inch), and 20-120 cm (8 inches to 4 feet) long. Ligule is a short fringe of hairs (ciliate), 1-3 mm long (1/16-1/8 inch). Seedhead consists of a one-sided panicle, 4-15 cm long (2-6 inches). Margins of leaves are serrate, and easily cause minor lacerations on exposed skin, hence the name ripgut. This species is strongly rhizomatous, forming large colonies in wet and wet-mesic soils. Rhizomes are stout, 4-10 mm thick (1/4 –1/2 inch), and scaley.



Adaptation/Habitat: Prefers wet to wet-mesic soil conditions, swale, roadside ditches, marshy areas, drainage areas, wetlands. Full sun. It will grow on seasonally dry sites, but won't tolerate prolonged flooding. Ability to irrigate production stand is necessary for good seed production.

Threatened/Endangered Status: Sensitive (WA)

General Comments: Cordgrass has a reputation for poor seed production. It's primary mode of growth is vegetative, spreading by rhizomes. Cordgrass often forms large, dense colonies with few flowering stalks, and these mostly situated on the outer, leading edges of the colony. Insect predation of the seed heads further limits seed production from native stands. Yet cordgrass does grows readily from good seed, as long as it's viable. Direct seeding for a seed increase stand, however, is not recommended.

Establishment for Seed Production (Appendix A)

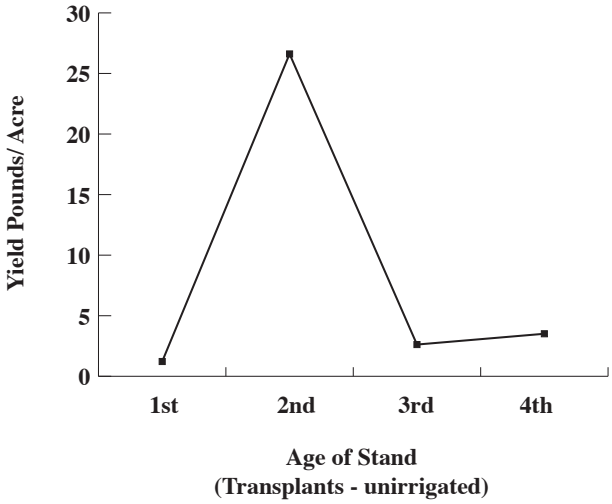
Direct seeding rate(s):
NOT RECOMMENDED FOR THIS SPECIES

Greenhouse:
Seed pre-treatment: Moist stratify seed for up to 4 weeks, or soak in water for 24 hrs and freeze over night to improve germination. Sow seed in greenhouse two months before last frost free date at 1/2" - 3/4" depth. Transplant after all danger of frost. Greenhouse grown plugs can be transplanted into wide row spacing, 6-8 feet between rows, and plants should be 2-3 feet apart within the rows. This gives the newly established plants adequate root-space for rhizome spread, and promotes more flowering and seed set after establishment.

Vegetative Production: Cordgrass can be vegetatively propagated from pieces of rhizome, as long as some roots and buds are present. The best time to transplant is early spring. New shoots are sharply pointed, and arise from rhizomes at the base of the previous years growth, and make ideal transplant material. Our approach has been to establish nursery beds from greenhouse grown seedlings to capture more genetic diversity. In subsequent years, these nurseries provide rhizome material for transplanting into larger production fields.

Stand Management

Weed Control – Pre-emergent herbicides can be used after transplanting seedling plugs or pieces of rhizome. It's critical to water-in transplants to seal soil around roots to prevent herbicide from coming into contact with and possibly damaging roots.
Pests – Insects of the genera *Batra* bore through the seedhead and severely reduce seed production. A stem-boring insect in the genus *Eucosma* can also reduce seed yield (USDA-NRCS Manhattan Plant Materials Center 1998). Reportedly controlled with insecticide application during flowering. Also reportedly less predation when grown in northern climes (e.g. North Dakota)
Diseases – No serious diseases known
Pollination: Wind pollinated



Seed Production (Appendix B)

- First Harvest: Some flowering and seed set occur in the second growing season from greenhouse grown transplants. Seed production may occur the first year from transplanted rhizomes.

- Yield/Acre: 15-30 bulk lbs/ac. (un-irrigated stand) Reported averages of 31 bulk lbs/acre (USDA-NRCS Manhattan PMC 1992); Yields of 30-75 bulk lbs/acre reported for Red River variety at USDA-NRCS Bismarck PMC.
- Stand Life: Irrigation is critical to successful establishment and good seed production of this species over the first few years of stand life. Expect 2-3 years for stand to establish. Stand may become root-bound by 5th year and seed production curtailed. Best to establish new stand from rhizomes.
- Flowering Date: Flowering occurs from mid-July to early September
- Seed Maturity: Late September to early October
- Seed Retention: Shattering occurs by mid to late October
- Harvest date range at TPC (2002-2006): Oct. 7 – Oct. 29
- Recommended Harvest Method: Combine at maturity and before shattering. (No combine settings available in Appendix).

Seed Cleaning (Appendix C)

Cleaning Process: Pre-clean air-dried material by scalping thru 1/2" and 1/4" mesh to remove large particles. Remove awns with debearder. Seeds are long and flat, and easily damaged by a brush machine. Air-screen to clean. Refer to Appendix C for settings.

Seed Characteristics (Appendix D)

Seed count: 66,000 seeds/oz (105,600/lb) [183,000/lb reported by USDA-Bismarck PMC]

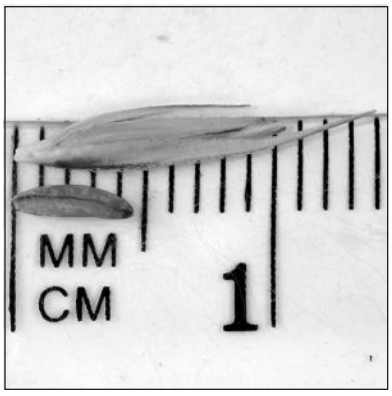


Photo credit: Dave Williams

Description: One-flowered spikelet with short awn (less than 1/4 inch). Seeds are very flat. Caryopsis about 5 mm long.
Stores well in refrigerated conditions (33-50˚ F, 30-50% RH). Germination often improves up to a year after harvest in warm-season grasses.

Sample Seed Test (%):
- Purity: 85+
- Tetrazolium (TZ): 91

Released Germplasm (Appendix E)

Source Identified Material: Iowa germplasm *Natural Selections*^{TM} (pending development)
Cultivated Varieties: Red River Natural Germplasm, Selected Class (ND, SD, & MN); Atkins (Selected Class, vegetative material only, KS);

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 14 February 2007.

Plant Guide, Prairie cordgrass, *Spartina pectinata* Link. USDA-NRCS Bismarck Plant Materials Center. Bismarck, ND.

An Illustrated Guide to Iowa Prairie Plants, p. 221. Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

Notice of Selected Class Release of Atkins Germplasm Prairie Cordgrass. USDA-NRCS Manhattan PMC/Kansas State University Agricultural Experiment Station, Manhattan, KS. 1998.
(http://plant-materials.nrcs.usda.gov/pubs/kspmcrnsppe.pdf). Accessed 14 February 2007.

North American Range Plants, 4th Edition. P. 106-107. Stubbendieck, J., S.L. Hatch, C.H. Butterfield. University of Nebraska Press, Lincoln, NE. 1992.

Species Guide for Wetland Plantings, Spartina pectinata (Draft). Wynia, R.L. USDA-NRCS Manhattan Plant Materials Center. March 1992. (http://plant-materials.nrcs.usda.gov/pubs/kspmcpgsppe.pdf). Accessed 14 February 2007.

Notes:

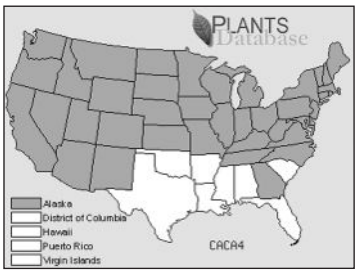
Bluejoint reedgrass
Calamagrostis canadensis, (Michx.) Beauv.

Genus *Calamagrostis*, Greek *Kalomos* meaning 'reed' and *agrostis* meaning 'grass'; species *canadensis* Latin 'of Canada'.

Family: Grass (Poaceae)

Other Common Name(s): Bluejoint, Canada bluejoint, Canada reedgrass, marsh reedgrass, meadow pinegrass

Description: Native perennial cool-season grass, highly rhizomatous. Flowering culms 3-5 feet tall, smooth stem. Leaf sheaths smooth with prominent veins. Leaf blades 3-8 mm (3/16-3/8 inch) wide, up to 30 cm (12 inches) long. Ligule is a membrane, about 3mm (1/8 inch) tall. Seedhead consists of a loosely branched spikelike panicle, 10-20 cm (4-8 inches) long. Flag leaf just below panicle is short and tends to stick out at a 90 degree angle from the stem.



Adaptation/Habitat: Wet to wet-mesic soil conditions, bogs, marshes, wet swales, along rivers and streams. Full sun. Tolerates acid soils (up to pH 8), an low-oxygen (anaerobic) conditions. Prefers nutrient-rich, seasonally-inundated soils. Irrigation is essential for optimal seed production on upland sites.

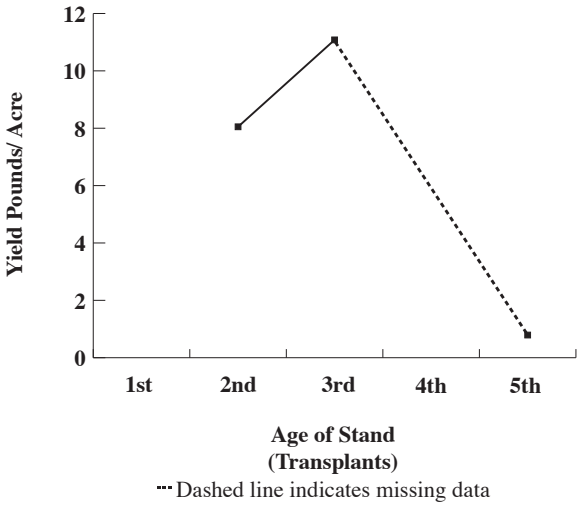
Threatened/Endangered Status: A variety of this species (var. macouniana (Vasey) Stebbins) is listed as endangered in Kentucky.

General Comments: Bluejoint reedgrass is a highly rhizomatous species forming large colonies in preferred habitats, occupying sites even more wet than cordgrass (*Spartina pectinata*) seems to prefer. Like cordgrass, seed production occurs mostly on the outer edges of colonies, and is generally low. Bluejoint is best propagated in controlled conditions of the greenhouse, and transplanted into wide row spacings.

Establishment for Seed Production (Appendix A)

Direct seeding:
NOT RECOMMENDED FOR THIS SPECIES

Greenhouse:
Seed pre-treatment: No stratification necessary. Germination of grass seed usually improves with proper storage (cool, dry conditions) throughout the first year after harvest. Sow seed in greenhouse two months before last frost free date at ¼" depth. Transplant after all danger of frost. . Greenhouse grown plugs can be transplanted into wide row spacing, 6-8 feet between rows, and plants should be 1-2 feet apart within the rows. This gives the newly established plants adequate root-space for rhizome spread, and promotes more flowering and seed set after establishment. Irrigate during establishment and as needed for flowering and seed production.



Vegetative Production:
Bluejoint reedgrass can be vegetatively propagated from pieces of rhizome, as long as some roots and buds are present. The best time to transplant is early spring. Nursery beds can be established from greenhouse grown seedlings to capture more genetic diversity, and plugs of roots and rhizomes removed in subsequent years for transplanting into larger production fields.

Stand Management

Weed Control – Pre-emergent herbicides can be used after transplanting seedling plugs or pieces of rhizome. It's critical to water-in transplants to seal soil around roots to prevent herbicide from coming into contact with and possibly damaging roots.
Pests – Nematode (*Subanguina calamagrostis)* invades leaf tissue and form galls, causing leaves to twist, and allowing subsequent infection by a fungus (Norton 1987); reportedly an insect invades the sheath of the flag leaf and severs the culm below the seedhead (Mitchell 1979a).
Diseases – No serious diseases known
Pollination: Wind pollinated

Seed Production (Appendix B)

- First Harvest: Plants remain vegetative first growing season. Some flowering and seed set second growing season from greenhouse grown transplants.
- Yield/Acre: 5-10 bulk lbs/ac (un-irrigated). [20-50 bulk lbs/ac reported by Mitchell (1979b) in well-managed stands.]
- Stand Life: Stands long-lived in proper soils/hydrology. Seed production declines as stand become sod-bound in approximately 4-5 years.
- Flowering Date: Flowering occurs from mid- to late June
- Seed Maturity: Early July
- Seed Retention: Shattering occurs soon after maturity. Seed is windblown at maturity.
- Harvest date range at TPC (2002-2006): June 29 to July 7
- Recommended Harvest Method: Hand harvest at maturity, but before dispersal. Seed is very light and wind dispersed.

Seed Cleaning (Appendix C)

Cleaning Process: Brush seed to remove tuft of hairs at base of spikes. See settings in Appendix.

Seed Characteristics (Appendix D)

Seed count (de-hulled): 280,000 seeds/oz (4,480,000/lb); [3,837,472/lbs USDA PLANTS DATABASE]

Photo credit: Dave Williams

Description: Spikelets about 2mm (3/32 inch) long. Grains about 1/16 inch long, with tuft of hairs at the base, slightly shorter than the grain. Caryopsis about 1 mm (1/32 inch) long. Stores well in refrigerated conditions ((33-50 F, 30-50% RH).

Typical Seed Test(%):

- Purity: 95+
- Germination: 80
- Dormancy: 5

Released Germplasm (Appendix E):

Released Germplasm (Appendix E): Source Identified Material: Northern Iowa *Natural Selections*^{TM}.

Cultivated Varieties: 'Sourdough' (AK), developed for revegetation from composite of 36 collections in interior, western, and south central Alaska.

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 7 March 2007.

Plant Fact Sheet, Bluejoint, *Calamagrostis Canadensis* (Michx.) Beauv. USDA-NRCS Plant Materials Center, Corvallis, OR. 23 March 2006.

Plant Guide, Bluejoint Reedgrass, *Calamagrostis Canadensis* (Michx.) Beauv, USDA-NRCS Plant Materials Center, Manhattan, KS. 7 March 2007.

An Illustrated Guide to Iowa Prairie Plants, p. 206. Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

Subanguina calamagrostis and its biology in Calamagrostis spp. in Iowa, Ohio, and Wisconsin. Norton, D.C., A.M. Coldy, and A.W. Gabel. 1987. Journal of Nematology. Vol 19, pp 260-262.

Three varieties of native Alaskan grasses for revegetation purposes. Mitchell, W.W. 1979a. Circular 32, Agricultural Experiment Station, University of Alaska, Fairbanks, AK.

Managing native bluejoint reedgrass for forage production. Mitchell, W.W. 1979b. Agroborealis. Vol 11, pp. 15-19. Go to: <http://www.uaf.edu/snras/afes/pubs/agro/> for information about obtaining a copy.

Notes:

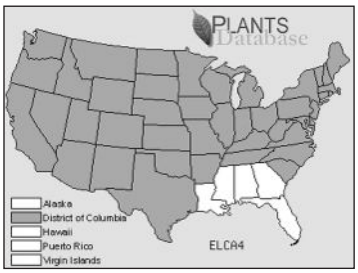
Canada wildrye
Elymus canadensis L.

Genus *Elymus*, Latin; species *canadensis* Latin 'from Canada, i.e. northeastern North America'.

Family: Grass (Poaceae)

Other Common Name(s): Nodding wildrye. Western wildrye

Description: Native perennial cool-season grass, flowering culms 3-4 feet tall, smooth stem. Leaf sheaths are usually smooth, with well developed auricles clasping stem at juncture of leaf sheath and blade. Leaf blades up to 16 inches long, ¼ to ¾ inches wide. Ligule is a short truncated membrane. Seedhead consists of a thick spike, 3 – 10 inches long, nodding. Bunch grass growth habit.



Adaptation/Habitat: Broadly adapted to a range of soil conditions, upland and lowland, open areas, disturbed areas. Prefers full sun. Preferred soils for production are well-drained loams.

Threatened/Endangered Status: Not listed

General Comments: Canada wildrye is a relatively short-lived perennial bunch grass which establishes readily from seed in mixed plantings. These two traits make it ideally suited as a nurse crop for prairie restorations. It can also be direct-seeded as a seed production field into a well-prepared, weed-free seed bed (i.e. following a glyphosate-resistant crop, for example).

Establishment for Seed Production (Appendix A)

Direct seeding:

• Row Spacing:	36"	24"	12"	Solid Stand
• PLS lbs/acre:	7.0	10.5	21	21

Seeding Depth: 1/4-1/2"
Seeding Methods: native grass drill
Time of Seeding: Fall, or early spring preferred.
Weed Control: Prepare clean, firm, weed free seedbed prior to seeding

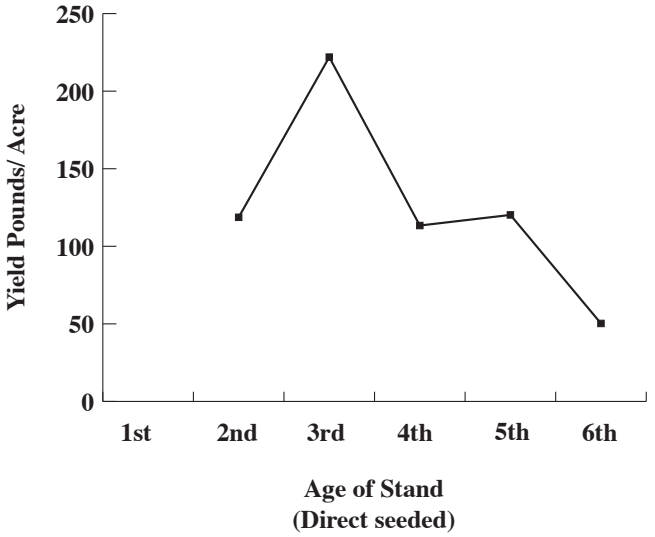
Greenhouse:
No stratification necessary. Germination of grass seed usually improves with proper storage (cool, dry conditions) throughout the first year after harvest. Sow seed in greenhouse two months before last frost free date at ¼" depth. Transplant after all danger of frost.

Stand Management

Weeds – Mow stand high (6–12 inches) first growing season to prevent weed canopy from shading seedlings. Broadleaf herbicides can be used to control broadleaf weeds in established stands.
Pests – No serious pest known
Diseases – Susceptible to leaf and stem rust, also ergot.
Pollination: Wind pollinated

Seed Production (Appendix B)

- First Harvest: Flowering and seed set will occur end of first growing season from previous fall seeding or early spring seeding, or late spring transplants.
- Yield/Acre: 100-250 bulk lbs/ac
- Stand Life: 4-6 years. Seed production declines significantly 5th year and after. Annual fall burning will prolong stand life and seed yield.
- Flowering Date: Flowering occurs mid-July to mid-August
- Seed Maturity: September
- Seed Retention: Shattering occurs early to mid-October
- Harvest date range at TPC (2002-2006): Sept.. 15 to Oct. 11
- Recommended Harvest Method: Combine at maturity (hard dough stage). Long awns make harvesting a challenge, causing seed to ball up and not flow. Additional de-awning bars or other modifications to the combine may be required for successful harvest of this species.



Seed Cleaning (Appendix C)

Cleaning Process: Debeard to remove long awns and to make the material flowable. Air-screen to clean. See Appendix C for settings.

Seed Characteristics (Appendix D)

Seed count (de-hulled): Seed count: 5,200 seeds/oz (83,200/lb). [114,000 /lb USDA PLANTS DATABASE]

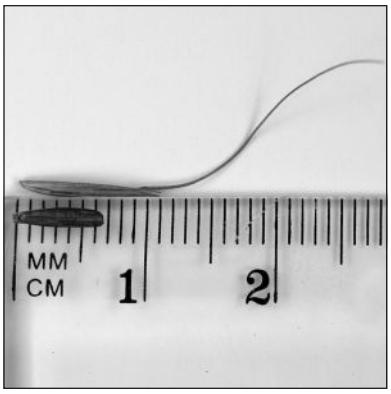


Photo credit: Dave Williams

Description: The profusion of awns make this species difficult to clean. Long curving awns on lemmas, up to 5 cm (2 inches). Glumes taper to awns 1 – 3 cm (1/2 – 1 ¼ inches) long. Caryopsis dark brown at maturity, 5 - 8 mm long.

Typical Seed Test(%):

- Purity: 95+
- Germination: 73
- Dormancy: 20

Released Germplasm (Appendix E):

Source Identified Material: Northern, Central, Southern Iowa *Natural Selections™*

Cultivated Varieties: 'Mandan' variety (ND); 'Icy Blue', Tested Class Natural Germplasm (MI); Lavaca Selected Class Natural Germplasm. (TX).

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 19 February 2007.

Plant Fact Sheet, Canada wildrye, *Elymus Canadensis* L. USDA-NRCS Rose Lake Plant Materials Center, East Lansing, MI 12 September 2000.

An Illustrated Guide to Iowa Prairie Plants, p. 212 Christiansen, P. and M. Muller. University of Iowa Press. Iowa City, IA. 1999.

North American Range Plants, 4th Edition. P. 206-207 Stubbendieck, J., S.L. Hatch, C.H. Butterfield. University of Nebraska Press, Lincoln, NE. 1992

Notes:

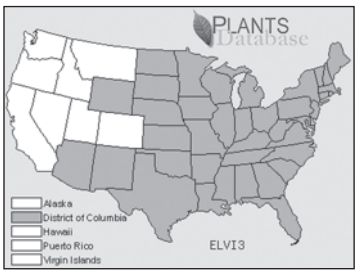
Virginia wildrye
Elymus virginicus, L.

Genus *Elymus*,; species *virginicus* Latin 'of Virginia'.

Family: Grass (Poaceae)

Other Common Name(s): Terrell grass

Description: Native perennial, cool-season bunchgrass, flowering culms 2-3 feet tall, smooth stem. Leaf sheaths usually smooth, sometimes with fine hairs. Leaf blades are rough, about 12-35 cm (5-14 inches) long and .5-1.5cm (up to 5/8 inch) wide. Ligule is a short membrane. Seedhead consists of spike 5-17 cm (2-7 inches) long, the base of which is often partially enclosed by the uppermost, inflated leaf sheath.



Adaptation/Habitat: Prefers wet-mesic to mesic soil conditions with high fertility, and is shade tolerant. Preferred soils for production are well-drained loams

Threatened/Endangered Status: Not listed

General Comments: Virginia wildrye is commonly found in open forest, savannas, and along woodland edges, and can be particularly abundant in open forests along creeks and rivers. It readily establishes from seed, and holds promise as a nurse crop for prairie and savanna reconstructions. Because of it's shade tolerance, it will spread in open woodlands, but gives way to full-sun adapted prairie species in a prairie reconstruction.

Establishment for Seed Production (Appendix A)

Direct seeding:

• Row Spacing:	36"	24"	12"	Solid Stand
• PLS lbs/acre:	8.6	11.5	23	20-35

Seeding Depth: 1/4-1/2"
Seeding Methods: native grass drill
Time of Seeding: Fall, or early spring
Weed Control: Prepare clean, firm, weed free seedbed prior to seeding (e.g. following a glyphosate-resistent crop, for example).

Greenhouse:
Seed pre-treatment: No moist stratification is necessary. Germination of grass seed usually improves with proper storage (cool, dry conditions) throughout the first year after harvest. Sow seed in greenhouse two months before last frost free date at 1/4-1/2" depth. Transplant after all danger of frost into rows spaced convenient for tillage equipment.

Stand Management

Weeds – Mow stand high (6–12 inches) first growing season to prevent weed canopy from shading seedlings. Broadleaf herbicides can be used to control broadleaf weeds in established stands. Cultivate between rows.
Pests – No serious pest known
Diseases – Grubworms are reportedly a problem in Texas. Ergot is known to occur on seedheads.
Pollination: Wind pollinated

Seed Production (Appendix B)

- First Harvest: Abundant flowering and seed set end of first growing season from greenhouse grown plugs transplanted into weed-barrier.
- Yield/Acre: Estimates range from 300-1500 bulk lbs/acre. Annual early spring burn will prolong the life of the stand.
- Stand Life: Estimated stand life 5-8 years.
- Flowering Date: Flowering occurs mid-July to mid-August
- Seed Maturity: Late August to early September
- Seed Retention: Shattering occurs mid- to late October
- Harvest date range at Elsberry, MO: Aug. 29 to Sept.. 12
- Recommended Harvest Method: Combine at hard dough stage. See Appendix for combine settings.

Seed Cleaning (Appendix C)

Cleaning Process: Pre-clean air-dried material by scalping thru ½' mesh to remove large particles. Debeard or brush gently to remove short awns and break up seedheads, airscreen to clean. See Appendix for settings.

Seed Characteristics (Appendix D)

Seed count (de-hulled): 4,200 seeds/oz (67,200/lb) [73,000/lb USDA PLANTS DATABASE]

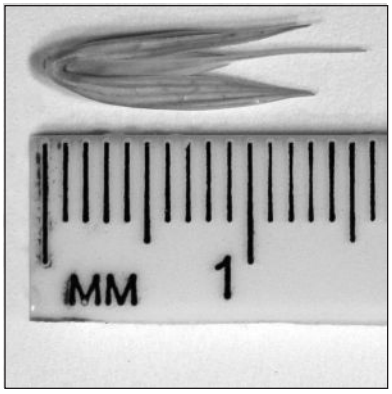


Photo credit: Brent Butler

Description: Two to three florets per spikelet, awned .5-2 cm (1/4 – 7/8 inch) long including awns. Empty scales (glumes) on either side of spikelet thickened, rigid, with awns, up to 2.5 cm long (1 inch) long, including awn. Lots of variability in awn length of this species.
Stores well in refrigerated conditions (33-50 F, 30-50% RH).

Typical Seed Test(%):

- Purity: 70-80
- Germination: 75
- Dormancy: 10

Released Germplasm (Appendix E):

Source Identified Material: Northern Missouri

Cultivated Varieties: 'Cuivre River' Selected Class Natural Germplasm (MO); Kinchefoonee, Selected Class Germplasm, (TX).

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 19 February 2007.

Plant Fact Sheet, Virginia wildrye, Elymus virginicus L. USDA-NRCS Kika de la Garza Plant Materials Center. Kingsville, TX 2006.

Notice of Release of 'Cuivre River Gerplasm Virginia wildrye, Selected Class of Natural Germplasm. USDA-NRCS Elsberry Plant Materials Center, Elsberry, MO. March 2002.

An Illustrated Flora of the Northern United States and Canada. Vol. I. p 291. Britton and Brown. Dover Publications, Inc. New York, NY. 1970.

Notes:

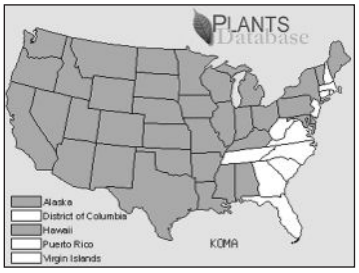
Junegrass
Koeleria macanthra, (Ledeb.) J.A. Schultes

Genus *Koeleria*, Latin from 'Koeler', a German botanist, George Wilhelm Koeler (1765-1807); species *macrantha* Latin *macanthrus* meaning 'large flowered' referring to the dense spikelike panicle.

Family: Grass (Poaceae)

Other Common Name(s): Prairie Junegrass, Crested hairgrass, Koeler's grass

Description: Native perennial cool-season bunchgrass, flower culms 1- 2 feet tall. Fine hairs on stem at base of spike-like panicle and at nodes. Leaf sheaths smooth or hairy, with hairs on the margins of the collar. Leaf blades 3-25 cm long (1.25 – 10 inches), and 1-3mm wide (up to 3/16 inch) Ligule is a very short membrane. Seedhead consists of spike-like panicle, 3-18 cm long (1.25-7.25 inches) and 1-3 cm wide (0.5-1.25 inches).



Adaptation/Habitat: May be common on dry, upland rocky, or sandy prairies, becoming more abundant on northern prairies. Full sun. Very-well drained soils preferred for seed production.

Threatened/Endangered Status: Endangered (KY, OH); Extirpated (PA).

General Comments: Junegrass is an important cool-season grass component, particularly in prairies on drier, very-well drained sites. It is seemingly short-lived, and may rely on re-seeding itself to persist.

Establishment for Seed Production (Appendix A)

Direct seeding: NOT RECOMMENDED

• Row Spacing:	36"	24"	12"	Solid Stand
• PLS lbs/acre:	0.25	0.4	0.75	0.75-1.0

Seeding Depth: 1/8"
(seeds require light to germinate)
Seeding Methods: native grass drill
Time of Seeding: Late spring
Weed Control: Good weed control before seeding is essential. Seedlings are small and slow growing.

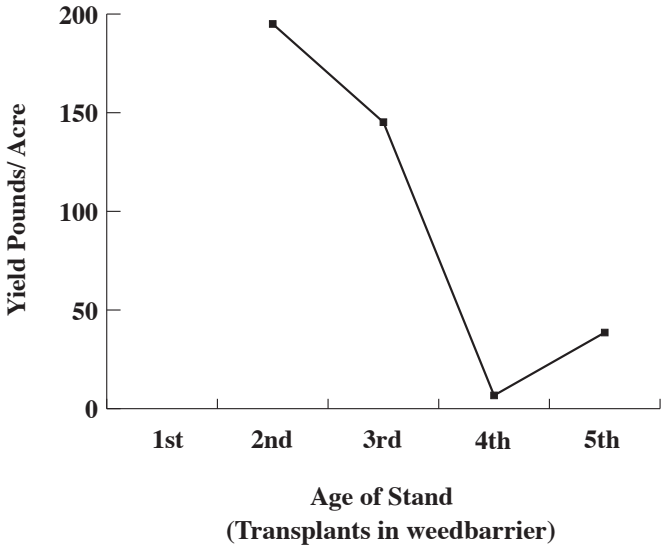
Greenhouse:
Seed pre-treatment: No moist stratification is necessary. Germination of grass seed usually improves with proper storage (cool, dry conditions) throughout the first year after harvest. Sow seed in greenhouse two months before last frost free date at 1/4-1/2" depth. Transplant after all danger of frost into rows spaced convenient for tillage equipment, or into weed barrier 8" apart.

Stand Management

Weeds – Mow stand high (6–12 inches) first growing season to prevent weed canopy from shading seedlings. Broadleaf herbicides can be used to control broadleaf weeds in established stands. Cultivate between rows.
Pests – No serious pest known
Diseases – Grubworms are reportedly a problem in Texas. Ergot is known to occur on seedheads.
Pollination: Wind pollinated

Seed Production (Appendix B)

- First Harvest: Flowering and seed set end of second growing season from greenhouse grown transplants. Plants will remain vegetative the first growing season.
- Yield/Acre: 50-190 bulk lbs/ac (high-end yield when transplanted and grown in weed-barrier)
- Stand Life: Potentially 4-5 years. Peak harvests second and third year. Seed production declines significantly 4th year and after. Stands quickly invaded by other cool-season grasses (e.g. Kentucky bluegrass, *Poa pratensis*, and Smooth brome, *Bromus inermis*).
- Flowering Date: Flowering occurs early to late June.
- Seed Maturity: Late June to early July
- Seed Retention: Shattering occurs mid- to late July.
- Harvest date range at TPC (2002-2006): July 1 to July 8.
- Recommended Harvest Method: Combine harvesting is practical for larger plots. We've used a modified hedge-trimmer with attached collection tray for harvesting small plots.



Seed Cleaning (Appendix C)

Cleaning Process: Pre-clean air-dried material by scalping thru ½' and ¼" mesh to remove large particles. Run through brush machine to break up seed heads, then air-screen to clean. See appendix for settings.

Seed Characteristics (Appendix D)

Seed count (de-hulled): 200,000 seeds/oz (3,200,000/lb) [2,315,000/lb USDA PLANTS DATABASE]

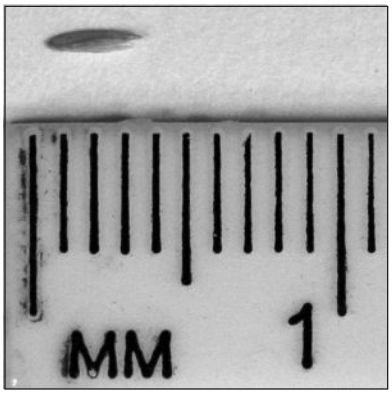


Photo credit: Brent Butler

Description: Two-five flowers per spikelet. Grain about 2-3 mm long (1/8 inch). Stores well in refrigerated conditions (33-50 F, 30-50% RH). Germination often improves up to a year after harvest in grasses.

Typical Seed Test(%):

- Purity: 95+
- Germination: 74
- Dormancy: 5

Released Germplasm (Appendix E):

Source Identified Material: Northern, Central Iowa *Natural Selections™*.

Cultivated Varieties: 'Barkoel' is the only known released variety, and was developed as a turf grass, originating from Barenburg, Holland, and is not recommended for native seedings. A native selection is being developed by the Upper Colorado Environmental Plant Center, in Meeker, CO.

References:

USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed 19 February 2007.

Grasses of Iowa (website), 2007. http://www.eeob.iastate.edu/research/iowagrasses/. Iowa State University, Ames, IA. Accessed 19 February 2007

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Notes:

Table 1A:
Establishment Recommandations for Seed Production

This table lists recommendations for propagating native species for seed production purposes.

Seed Weights: Published seed counts, Prairie Moon Nursery 2007, *www.prairiemoonnursery.com*
Establishment methods: DS = Direct Seed with a native seed drill or plot planter; GH = Greenhouse propagation from seed; DIV = Division of roots or corms for immediate transplanting.
Seeding times: Dormant (soil temperature below 32- 38 F°), Fall/Early Spring (soil temperatures 40-50 F°), Late Spring (soil temperatures above 60 F°)
Transplanting Time:
Seedlings - Spring = when soil warms and frost is not imminent. These species are somewhat cold hardy, but seedlings should be hardened-off for at least one week before transplanting. Late Spring= (soil temperatures above 50 F°) and seedlings have been hardened off. After Last Frost = especially critical for legume species, which are seriously damaged by frost after Spring transplanting. *Divison* – Recommendations are for root/corm division and immediate transplanting in the field.
Seeding Depth: Most native prairie species should be planted at shallow depths usually ranging from 1/8 to 1/4". Larger seeded species can be planted up to 1/2" in depth. Very tiny seeds should be surface sown, either because they are otherwise planted too deep to emerge, or they require light for germination.
Direct Seeding Rates: Rates have been calculated for most species, even if Direct Seeding (DS) is not recommended. These are intended as guidelines, only, if direct seeding is attempted. Thorough weed suppression and control BEFORE direct seeding is always critical to successfully establishment a seed production field.

SPECIES		SEED WEIGHTS		Recommended Estbl. Method	SEEDING TIME	TRANSPLANTING TIME		SEEDING	DIRECT SEEDING RATES (Calculated @ 40 seeds linear/ft2)		
Common Name	Scientific Name	Seeds/Oz	Seeds/lb		DIRECT SEED	SEEDLINGS	DIVISION	DEPTH	36" Rows	24" Rows	12" Rows
WILDFLOWERS											
Canada anemone	*Anemone canadensis*	8000	128000	DS, GH, DIV	Dormant	Spring	Spring/Fall	1/4"	4.5	6.1	12.1
Thimbleweed	*Anemone cylindrica*	26000	416000	GH	-	Spring		1/4"	1.3	1.8	3.7
Prairie sage	*Artemisia ludoviciana*	250000	4000000	GH, DIV	-	Spring	Spring/Fall	SURFACE	0.1	0.1	0.3
Butterfly milkweed	*Asclepias tuberosa*	4300	68800	DS, GH	Dormant	Spring	Fall	1/4"	8.4	11.2	22.5
Sky blue aster	*Aster azureus*	80000	1280000	GH	-	Spring		1/4"	0.4	0.6	1.2
Smooth blue aster	*Aster laevis*	55000	880000	GH	-	Spring		1/4"	0.6	0.8	1.7
New England aster	*Aster novae-angliae*	66000	1056000	DS	Dormant	Spring	Spring/Fall	1/4"	0.5	0.7	1.4
Prairie coreopsis	*Coreopsis palmata*	10000	160000	DS	Dormant	Spring	Spring/Fall	1/4"	3.6	4.8	9.6
Pale purple coneflower	*Echinacea pallida*	5200	83200	DS, GH	Dormant	Spring		Cover Lightly	6.9	9.3	18.6

Table 1A:
Establishment Recommandations for Seed Production

SPECIES		SEED WEIGHTS		Recommended Estbl. Method	SEEDING TIME	TRANSPLANTING TIME		SEEDING	DIRECT SEEDING RATES (Calculated @ 40 seeds linear/ft2)		
Common Name	Scientific Name	Seeds/Oz	Seeds/lb		DIRECT SEED	SEEDLINGS	DIVISION	DEPTH	36" Rows	24" Rows	12" Rows
WILDFLOWERS											
Rattlesnake master	*Eryngium yuccifolium*	7500	120000	DS, GH	Dormant	Spring	Spring	1/4"	4.8	6.4	12.9
Bottle gentian	*Gentiana andrewsii*	280000	4480000	GH	-	Spring		SURFACE	0.1	0.1	0.3
Oxeye false-sunflower	*Heliopsis helianthoides*	6300	100800	DS	Dormant	Spring		1/4"	5.7	7.6	15.3
Rough blazing-star	*Liatris aspera*	16000	256000	GH, DIV	-	Spring	Fall	1/4"	2.2	3.0	6.1
Blazing-star	*Liatris pychnostachya*	11000	176000	GH, DIV	-	Spring	Fall	1/4"	3.3	4.4	8.7
Great blue lobelia	*Lobelia siphilitica*	500000	8000000	GH	-	Spring		SURFACE	0.1	0.1	0.1
Wild bergamot	*Monarda fistulosa*	70000	1120000	DS	Dormant	Spring	Spring/Fall	SURFACE	0.5	0.6	1.3
Wild quinine	*Parthenium integrifolium*	7000	112000	DS, GH	Dormant	Spring		1/4"	5.1	6.9	13.8
Hairy Mt. mint	*Pycnanthemum pilosum*	185000	2960000	DS, GH	Dormant	Spring		SURFACE	0.1	0.2	0.5
Narrowleaved Mt. mint	*Pycnanthemum tenuifolium*	378000	6048000	GH	-	Spring		SURFACE	0.1	0.1	0.2
Virginia Mt. mint	*Pycnanthemum virginianum*	220000	3520000	DS, GH	-	Spring		SURFACE	0.1	0.2	0.4
Greyhead coneflower	*Ratibida pinnata*	30000	480000	DS	Dormant	Spring		1/4"	1.2	1.6	3.2
Sweet coneflower	*Rudbeckia subtomentosa*	43000	688000	DS?, GH	Dormant	Spring		1/4"	0.8	1.1	2.2
Rosinweed	*Silphium integrifolium*	1200	19200	GH	-	Spring		1/4-1/2"	-	-	-
Compass plant	*Silphium laciniatum*	660	10560	GH	-	Spring		1/4-1/2"	-	-	-
Stiff goldenrod	*Solidago rigida*	41000	656000	DS	Dormant	Spring	Spring/Fall	1/4"	0.8	1.1	2.3
Showy goldenrod	*Solidago speciosa*	95000	1520000	GH	-	Spring		1/4"	0.3	0.5	1.0
Prairie spiderwort	*Tradescantia bracteata*	10000	160000	GH, DIV	-	Spring	Spring/Fall	1/4"	3.6	4.8	9.6

Table 1A:
Establishment Recommandations for Seed Production

SPECIES		SEED WEIGHTS		Recommended Estbl. Method	SEEDING TIME	TRANSPLANTING TIME		SEEDING	DIRECT SEEDING RATES (Calculated @ 40 seeds linear/ft2)		
Common Name	Scientific Name	Seeds/Oz	Seeds/lb		DIRECT SEED	SEEDLINGS	DIVISION	DEPTH	36" Rows	24" Rows	12" Rows
WILDFLOWERS											
Ohio spiderwort	*Tradescantia ohioensis*	8000	128000	GH, DIV	-	Spring	Spring/Fall	1/4"	4.5	6.1	12.1
Culver's root	*Veronicastrum virginicum*	800000	12800000	GH, DIV	-	Spring	Spring/Fall	SURFACE	0.0	0.1	0.1
Golden Alexander	*Zizia aurea*	11000	176000	DS, GH	Dormant	Spring		1/4"	3.3	4.4	8.7

SPECIES		SEED WEIGHTS		Recommended Estbl. Method	SEEDING TIME	TRANSPLANTING TIME		SEEDING	DIRECT SEEDING RATES (Calculated @ 40 seeds linear/ft2)			
Common Name	Scientific Name	Seeds/Oz	Seeds/lb		DIRECT SEED	SEEDLINGS	DIVISION	DEPTH	36" Rows	24" Rows	12" Rows	Solid Stand
GRASSES-WARM												
Big bluestem	*Andropogon gerardii*	10000	160000	DS	Late Spring	Late Spring		1/4"-1/2"	3.6	4.8	9.7	10-12
Side-oats grama	*Bouteloua curtipendula*	11900	191000	DS	Late Spring	Late Spring		1/4"-1/2"	3.0	4.0	8.0	9.0
Switchgrass	*Panicum virgatum*	14000	224000	DS	Dormant	Late Spring		1/4"	2.6	3.5	6.0	6.0
Little bluestem	*Schizachyrium scoparium*	15000	240000	DS	Late Spring	Late Spring		1/4"	2.4	3.2	6.5	8.0
Indian grass	*Sorghastrum nutans*	12000	192000	DS	Late Spring	Late Spring		1/4"	3.3	5.0	10.0	10-12
Prairie cordgrass	*Spartina pectinata*	6600	105600	GH, DIV	Late Spring	Late Spring	Spring	1/4"	NOT RECOMMENDED			
Tall dropseed	*Sporobolus asper*	30000	480000	DS	Late Spring	Late Spring		1/4"	1.2	1.8	3.6	4.0
Prairie dropseed	*Sporobolus heterolepis*	16000	256000	GH, DIV		Late Spring		1/4"	NOT RECOMMENDED			

Table 1A:
Establishment Recommandations for Seed Production

SPECIES		SEED WEIGHTS		Recommended Estbl. Method	SEEDING TIME	TRANSPLANTING TIME		SEEDING	DIRECT SEEDING RATES (Calculated @ 40 seeds linear/ft2)		
Common Name	Scientific Name	Seeds/Oz	Seeds/lb		DIRECT SEED	SEEDLINGS	DIVISION	DEPTH	36" Rows	24" Rows	12" Rows
GRASSES-COOL											
Bluejoint grass	*Calamagrostis canadensis*	280000	4480000	GH, DIV	Fall/Early spring	Spring	Spring/Fall	1/4"	NOT RECOMMENDED		
Canada wildrye	*Elymus canadensis*	5200	83200	DS	Fall	Spring		1/4"	7.0	9.3	18.6
Virginia wildrye	*Elymus virginicus*	4200	67200	DS	Fall	Spring		1/4"	8.6	11.5	23.1
Junegrass	*Koeleria macanthra*	200000	3200000	GH	-	Spring		Cover Lightly	NOT RECOMMENDED		
LEGUMES											
Canada milkvetch	*Astragalus canadensis*	17000	272000	DS	Dormant	After last frost		1/4"	2.1	2.8	5.7
White wild indigo	*Baptisia alba*	1700	27200	GH	Dormant	After last frost		1/4"	-	-	-
Cream Wild Indigo	*Baptisia bracteata*	1400	22400	GH	Dormant	After last frost		1/4"	-	-	-
White prairie clover	*Dalea camdida*	19000	304000	DS?, GH	Dormant	After last frost		1/4"	1.9	2.5	5.1
Purple prairie clover	*Dalea purpurea*	18000	288000	DS	Dormant	After last frost		1/4"	2.0	2.7	5.4
Showy tick-trefoil	*Desmodium canadense*	5500	88000	DS	Dormant	After last frost		1/4"	6.6	8.8	17.6
Roundhead bush clover	*Lespedeza capitata*	8000	128000	DS	Dormant	After last frost		1/4"	4.5	6.1	12.1

Table 2A:
Seed Pre-treatments for Germination, Greenhouse Propagation

This table list recommendations for pre-treatment of seed to induce germination of listed species. See introductory material at the beginning of the manual for details on techniques.

In summary, most of the listed wildflower species either require or benefit from a period of cold moist stratification. Grass seed germination tends to improve slightly up to a year after harvest if stored properly, and only requires dry, cold storage to preserve viability. A few grass species are known to benefit from cold, moist stratification, either by improved germination or more synchronized germination in the greenhouse environment. Legume species typically benefit from scarification (see introductory chapters) followed by moist stratification. Seeds may be inoculated with rhizobium at time of sowing, if desired.

Please Note: Moist stratification is only recommended when sowing seeds in a controlled environment where adequate soil moisture can be maintained throughout the germination period, and is never recommended for fall seeding.

GREENHOUSE PROPAGATION		PRE-TREATMENT							SOWING			TRANSPLANTING
SPECIES			Stratification						RHIZOBIUM	LIGHT	PLANTING	
Common Name	Scientific Name	SCARIFICATION	Moist	Dry	Warm	Cold	Outdoor	# Weeks	INOCULUM	REQUIRED	DEPTH	DATE
WILDFLOWERS					**68-76° F**	**32-45° F**	Winter Ambient					
Canada anemone	*Anemone canadensis*	X	X		?	X	or X	12			1/4”	Spring
Thimbleweed	*Anemone cylindrica*	X	X			X		12			1/4”	Spring
Prairie sage	*Artemisia ludoviciana*			X		X		12		?	SURFACE	Spring
Butterfly milkweed	*Asclepias tuberosa*		X			X		4-8			1/4”	Spring
Sky blue aster	*Aster azureus*		X			X		8			1/4”	Spring
Smooth blue aster	*Aster l aevis*		X			X		8			1/4”	Spring
New England aster	*Aster novae angliae*		X			X		8			1/4”	Spring
Prairie coreopsis	*Coreopsis palmata*		X			X		12			1/4”	Spring
Pale purple coneflower	*Echinacea pallida*		X			X		12		X	CoverLightly	Spring
Rattlesnake master	*Eryngium yuccifolium*		X			X		8-12			1/4”	Spring
Bottle gentian	*Gentiana andrewsii*		X			X		12		?	SURFACE	Spring
Oxeye false-sunflower	*Heliopsis helianthoides*		X			X		12			1/4”	Spring

Table 2A:
Seed Pre-treatments for Germination

GREENHOUSE PROPAGATION		PRE-TREATMENT							SOWING			TRANSPLANTING
SPECIES			Stratification						RHIZOBIUM	LIGHT	PLANTING	
Common Name	Scientific Name	SCARIFICATION	Moist	Dry	Warm	Cold	Outdoor	# Weeks	INOCULUM	REQUIRED	DEPTH	DATE
WILDFLOWERS					**68-76° F**	**32-45° F**	Winter Ambient					
Rough blazing-star	*Liatris aspera*		X			X		8-12			1/4"	Spring
Blazing-star	*Liatris pychnostachya*		X			X		8-12			1/4"	Spring
Great blue lobelia	*Lobelia siphilitica*			X		X		12		X	SURFACE	Spring
Wild bergamot	*Monarda fistulosa*			X		X		8-12			SURFACE	Spring
Wild quinine	*Parthenium integrifolium*		X			X		8-12			1/4"	Spring
Hairy Mt. mint	*Pycnanthemum pilosum*			X		X		12		?	SURFACE	Spring
Narrowleaved Mt. mint	*Pycnanthemum tenuifolium*			X		X		12		?	SURFACE	Spring
Virginia Mt. mint	*Pycnanthemum virginianum*			X		X		12		?	SURFACE	Spring
Greyhead coneflower	*Ratibida pinnata*		X			X		8-12			1/4"	Spring
Sweet coneflower	*Rudbeckia subtomentosa*		X			X		8-12			1/4"	Spring
Rosinweed	*Silphium integrifolium*		X			X		8-12			1/4-1/2"	Spring
Compass plant	*Silphium laciniatum*		X			X		8-12			1/4-1/2"	Spring
Stiff goldenrod	*Solidago rigida*		X			X		8-12			1/4"	Spring
Showy goldenrod	*Solidago speciosa*		X			X		8-12			1/4"	Spring
Prairie spiderwort	*Tradescantia bracteata*	X	X			X		12			1/4"	Spring
Ohio spiderwort	*Tradescantia ohioensis*	X	X			X		12			1/4"	Spring
Culver's root	*Veronicastrum virginicum*			X		X		12		X	SURFACE	Spring
Golden Alexander	*Zizia aurea*	?	X		?	X	or X	12			1/4"	Spring

Table 2A:
Seed Pre-treatments for Germination

GREENHOUSE PROPAGATION		PRE-TREATMENT							SOWING			TRANSPLANTING
SPECIES			Stratification						RHIZOBIUM	LIGHT	PLANTING	
Common Name	Scientific Name	SCARIFICATION	Moist	Dry	Warm	Cold	Outdoor	# Weeks	INOCULUM	REQUIRED	DEPTH	DATE
GRASSES-WARM					**68-76° F**	**32-45° F**	Winter Ambient					
Big bluestem	*Andropogon gerardii*			X		X		-			1/4”-1/2”	Late Spring
Side-oats grama	*Bouteloua curtipendula*			X		X		-			1/4”-1/2”	Late Spring
Switchgrass	*Panicum virgatum*		X			X		4			1/4”	Late Spring
Little bluestem	*Schizachyrium scoparium*			X		X		-			1/4”	Late Spring
Indian grass	*Sorghastrum nutans*			X		X		-			1/4”	Late Spring
Prairie cordgrass	*Spartina pectinata*		X			X		4			1/4”	Late Spring
Tall dropseed	*Sporobolus asper*			X		X		-			1/4”	Late Spring
Prairie dropseed	*Sporobolus heterolepis*		X			X		4			1/4”	Late Spring
GRASSES-COOL												
Bluejoint grass	*Calamagrostis canadensis*			X		X		-			1/4”	Spring
Woodland reedgrass	*Cinna arundinacea*			X		X		-			CoverLightly	Spring
Canada wildrye	*Elymus canadensis*			X		X		-			1/4”	Spring
Virginia wildrye	*Elymus virginicus*			X				-			1/4”	Spring
Junegrass	*Koeleria macanthra*			X		X		-			CoverLightly	Spring
Upland wild timothy	*Muhlenbergia racemosa*			X		X		-			CoverLightly	Spring
Porcupine grass	*Stipa spartea*		X			X	or X	12			1/4”	Spring

Table 2A:
Seed Pre-treatments for Germination

GREENHOUSE PROPAGATION		PRE-TREATMENT							SOWING			TRANSPLANTING
SPECIES			Stratification						RHIZOBIUM	LIGHT	PLANTING	
Common Name	Scientific Name	SCARIFICATION	Moist	Dry	Warm	Cold	Outdoor	# Weeks	INOCULUM	REQUIRED	DEPTH	DATE
LEGUMES					**68-76° F**	**32-45° F**	Winter Ambient					
Cream Wild Indigo	*Baptisia bracteata*	X	X			X		2	X		1/4”	After last frost
White prairie clover	*Dalea camdida*	X		X		X		12	X		1/4”	After last frost
Purple prairie clover	*Dalea purpurea*	X		X		X		12	X		1/4”	After last frost
Showy tick-trefoil	*Desmodium canadense*	X or Not		X		X		12	X		1/4”	After last frost
Roundhead bush clover	*Lespedeza capitata*	X	X			X		2	X		1/4”	After last frost
Canada milkvetch	*Astragalus canadensis*	X	X			X		2	X		1/4”	After last frost
White wild indigo	*Baptisia alba*	X	X			X		2	X		1/4”	After last frost
SEDGES												
Prairie sedge	*Carex bicknellii*		X			X		8		?	SURFACE	Spring/Fall
Plains Oval Sedge	*Carex brevior*		X[1]			X		8		?	SURFACE	Spring/Fall
Heavy sedge	*Carex gravida*		X			X		8		?	SURFACE	Spring/Fall
SHRUBS												
Leadplant	*Amorpha canescens*	X	X			X		2	X		1/4”	After last frost
New Jersey tea	*Ceanothus americana*	X[2]	X			X		12			1/4”	After last frost

• [1]This species will germinate from fresh seed
• [2]Cover fresh seed with boiling hot water for a few moments, drain.

Table 1B:
Seed Production – Harvesting

'Seed Maturity' and 'Harvest Date Range' are based on data from the Tallgrass Prairie Center in Cedar Falls, IA, (Approximately 42° 33' N, 92° 24' W) between 2001-2006. 'Yield Range/Acre' is extrapolated from small seed increase plots. Wildflower and legume (forb) plots are on the order of 1000-2500 sq ft, mostly at 34" row spacing, either in weed barrier or bare soil with cultivation between rows. Grass increase fields are mostly direct-seeded solid stands on the order of 0.1 to 0.5 acres, except for those recommending greenhouse propagation. 'Productive Stand Life' is an estimate based on data at the Tallgrass Prairie Center and/or published NRCS data.

COMMON NAME	SCIENTIFIC NAME	Harvest Method	Seed Maturity	Harvest Date Range[1]	Shatter Potential	Yield Range	Productive Stand Life
GRASSES-WARM							
Big bluestem	*Andropogon gerardii*	Combine	Oct.	10/5 - 10/15	Moderate	80-150	10-15
Side-oats grama	*Bouteloua curtipendula*	Combine	Sept.-Oct.	9/22 - 10/7	Low	100-200	10-15
Switchgrass	*Panicum virgatum*	Combine	Sept.-Oct.	9/24 - 10/8	Moderate	100-250	10-15
Tall dropseed	*Sporobolus compositus*	Combine	Oct.	10/8 - 10/25	High	150-250	10-15
Prairie cordgrass	*Spartina pectinata*	Combine	Sept.-Oct.	10/7 - 10/29	Moderate	15-30	3-5?
Prairie dropseed	*Sporobolus heterolepis*	Combine	Oct.	10/7 - 10/17	High	100-250	10-15
Little bluestem	*Schizachyrium scoparium*	Combine	Oct.	10/10 - 10/29	Moderate	50-120	10-15
Indian grass	*Sorghastrum nutans*	Combine	Sept.-Oct.	10/1 - 10/9	High	50-130	10-15
GRASSES-COOL							
Bluejoint grass	*Calamagrostis canadensis*	Hand-pick	Early July	6/29 - 7/7	High	5-10	?
Canada wildrye	*Elymus canadensis*	Combine	Sept.	9/15 - 10/11	Moderate	100-250	3-6
Virginia wildrye	*Elymus virginicus*	Combine	Aug.-Sept.	8/29-9/12	Moderate	600-?	3-6?
Junegrass	*Koeleria macanthra*	Combine?	Early July	7/1 - 7/8	Low	50-200	1-3
Porcupine grass	*Stipa spartea*	Hand-pick	Late June	~End of June	Very High	?	?

• [1]Harvest Dates are at the Tallgrass Prairie Center, Cedar Falls, IA.

Table 1B: Seed Production – Harvesting

COMMON NAME	SCIENTIFIC NAME	Harvest Method	Seed Maturity	Harvest Date Range[1]	Shatter Potential	Yield Range	Productive Stand Life
LEGUMES							
Leadplant	*Amorpha canescens*	Hand-pick	Oct.	10/12 - 10/14	Low	10-50	10-15?
Canada milkvetch	*Astragalus canadensis*	Hand-pick	Aug.-Sept.	8/11 - 9/2	Moderate	100-200	2-3?
Cream Indigo	*Baptisia lactea*	Hand-pick	Aug.-Sept.	9/13 - 10/8	Low	50-150	5-10
White wild indigo	*Baptisia leucantha*	Hand-pick	Sept.-Oct.	9/16 - 10/21	Low	50-150	5-10
White prairie clover	*Dalea candida*	Combine	Sept.-Oct.	11/1 - 11/6	Low	?	5-10
Purple prairie clover	*Dalea purpurea*	Combine	Sept.-Oct.	9/20 - 11/05	Low	50-200	5-10
Showy tick-trefoil	*Desmodium canadense*	Combine	Sept.-Oct.	9/18 - 10/10	Low	50-150	5-10
Roundhead bush clover	*Lespedeza capitata*	Combine	Oct.	10/16 - 10/23	Low	50-?	5-10
WILDFLOWERS							
Canada anemone	*Anemone canadensis*	Combine	July	7/17 - 7-26	High	50-180	5-10
Thimbleweed	*Anemome cylindrica*	Hand-pick	July	7/28-7/29	Moderate	?	2-3
Prairie sage	*Artemisia ludoviciana*	Combine	October	10/16 - 10/24	Moderate	5-15	2-3
Butterfly milkweed	*Asclepias tuberosa*	Hand-pick	Aug.-Oct.	9/2 -10/17	High	10-80	3-5
Smooth blue aster	*Aster laevis*	Combine	Oct.	10/20 - 10/31	High	40-90	3-5
New England aster	*Aster novae-angliae*	Combine	Sept.-Oct.	10/7 - 10/25	High	20-40	3-5
Stiff coreopsis	*Coreopsis palmata*	Combine	Oct.	10/9 - 10/20	Low	40-140	3-5
Pale purple coneflower	*Echinacea pallida*	Combine	Sept.	9/1 - 9/23	Low	50-250	3-5
Rattlesnake master	*Eryngium yuccifolium*	Combine	Oct.	10/8 - 10/25	Moderate	200-800	3-5
Bottle gentian	*Gentiana andrewsii*	Hand-pick	Sept.-Oct.	9/22 - 10/14	High	40-90	3-5

• [1]Harvest Dates are at the Tallgrass Prairie Center, Cedar Falls, IA.

Table 1B: Seed Production – Harvesting

COMMON NAME	SCIENTIFIC NAME	Harvest Method	Seed Maturity	Harvest Date Range[1]	Shatter Potential	Yield Range	Productive Stand Life
WILDFLOWERS							
Oxeye false-sunflower	*Heliopsis helianthoides*	Combine	Sept.-Oct.	9/22 - 10/10	High	50-150	5-7
Rough blazing-star	*Liatris aspera*	Combine?	Sept.-Oct.	10/1 - 10/13	High	50-150	3-5
Blazing-star	*Liatris pychnostachya*	Combine?	Sept.-Oct.	9/12 - 10/9	High	150-450	3-5
Great blue lobelia	*Lobelia siphilitica*	Hand-pick	Sept.	9/27 - 10/9	High	50-280	1-3
Wild bergamot (Horsemint)	*Monarda fistulosa*	Combine	Sept.-Oct.	9/30 - 10/1	Moderate	30-90	3-5
Wild quinine	*Parthenium integrifolium*	Combine	Oct.	10/23 - 11/3	Moderate	150-250	5-10
Mountain mint	*Pycnanthemum virginianum*	Combine	Sept.-Oct.	10/6 - 10/20	Moderate	25-70	3-5
Hairy mountain mint	*Pycnanthemum pilosum*	Combine	Sept.-Oct.	10/8 - 10/21	Moderate	20-90	3-5
Slender mountain mint	*Pycnanthemum tenuifolium*	Combine	Sept.-Oct.	10/16 - 10/18	Moderate	10-80	3-5
Greyhead coneflower	*Ratibida pinnata*	Combine	Sept.	9/20 - 10/12	Low	100-250	3-5
Sweet coneflower	*Rhudbeckia subtomentosa*	Combine	Oct.	10/18 - 11/3	Moderate	80-170	3-5
Rosinweed	*Silphium integrifolium*	Combine	Sept.-Oct.	9/24 - 10/10	High	100-370	3-5
Compass plant	*Silphium laciniatum*	Combine	Aug.-Sept.	8/30 - 9/27	High	40-130	5-7
Stiff goldenrod	*Solidago rigida*	Combine	Oct.	10/9 - 10/25	High	100-250	3-7
Showy goldenrod	*Solidago speciosa*	Combine	Oct.-Nov.	10/12 - 11/3	High	30-130	2-3
Ohio spiderwort	*Tradescantia ohioensis*	Hand-pick	July	7/6 - 7/23	Very High	40-100	3-5
Culver's root	*Veronicastrum virginicum*	Combine	Sept.-Oct.	9/25 -10/8	High	80-150	2-4
Golden Alexander	*Zizia aurea*	Combine	Aug.-Sept.	8/31 - 9/8	High	100-270	3-5

• [1]Harvest Dates are at the Tallgrass Prairie Center, Cedar Falls, IA.

Table 2B:
Massey-Ferguson Plot Combine Settings Model Breeders Special 8

Combine Settings
These combine settings are for selected species based on harvesting experience at USDA-NRCS Elsberry Plant Materials Center, Elsberry, MO.

Common Name	Scientific Name	Concave Settings	Amount of Air	Sieve Opening	Where Bagged
Big Bluestem	Andropogon *gerardi*	9	1	1/4	Rear
New England Aster	Aster *novae-angliae*	6	No Air	1/4	Rear
Sideoats Gramma	Bouteloua *curtipendula*	6	No Air	1/8	Rear
Prairie Coreopsis	Coreopsis *palmata*	6	No Air	Closed	Rear
Purple Prairie Clover	Dalea *purpurea*	6	1	1/8	Rear
Tick Trefoil (Sticktites)	Desmodium *canadense*	6	1	1/4	Rear
Pale Purple Coneflower	Echinacea *pallida*	6	1	1/4	Rear
Canada Wild Rye	Elymus *canadense*	9	1	1/2	Hopper
Virginia Wild Rye	Elymus *virginicus*	8	1	1/4	Hopper
Rattlesnake Master	Eryngium *yuccifolium*	6	No Air	1/4	Rear
Oxeye False Sunflower	Heliopsis *helianthoides*	6	1	Closed	Rear
Roundhead Bushclover	Lespedeza *capitata*	6	1	1/8	Rear
Rough Blazing Star	Liatris *aspera*	6	No Air	1/4	Rear
Prairie Blazing Star	Liatris *pycnostachya*	6	No Air	1/8-1/4	Rear
Great Blue Lobelia	Lobelia *siphilitica*		Hand Harvested		
Horsemint	Monarda *fistulosa*	6	No Air	Closed	Rear
Foxglove Beardtongue	Penstemon *digitalis*		Hand Harvested		
Grayhead Coneflower	Ratibida *pinnata*	6	No Air	1/8	Rear
Little Bluestem	Schizachrium *scoparium*	6	No Air	1/4	Rear
Stiff Golenrod	Solidago *rigida*	6	No Air	Closed	Rear
Indiangrass	Sorgatrum *nutans*	6	1	1/4	Rear
Tall Dropseed	Sporobolus *asper*	6	No Air	Closed	Rear

• When amount of air is (NO AIR), belt running fan is disconnected.
• Sieve opening is an estimation, trial and error may be needed.

Table 1C:
SCREEN SIZES, WESTRUP LABORATORY AIR SCREEN CLEANER

Westrup Laboratory Air Screen Cleaner Settings

The Westrup Laboratory Air Screen Cleaner has three screens and an aspiration chamber for blowing off light seed and chaff. Screen and valve settings are beginning points only and will need to be adjusted for annual variations in seed size, seed quality, and contaminating weed species. Valve settings are unique to the Westrup air screen cleaner, but screen sizes can be converted to numerical sieve sizes or inches using Screen Conversion chart in this appendix.

SPECIES	Harvest Method	Treatment before A/S Cleaning	Westrup A/S CLEANER Screens (mm) SCALPING Top	Middle	SIFTING Bottom	Air-flow Valves Cyclone #1	Damper #2	Final #3	General Notes
GRASSES									
Big bluestem (ANGE)	Combined	Debeard	4.00	1.6 slot	0.80	1.00	1.75	1.75	Indent to remove foxtail
Side-oats grama (BOCU)	Combined		5.50	5.00	3.00	6.00	2.50	1.00	
Bluejoint grass (CACA)	Clipped	Brush	1.00	0.80	0.50	9.50	0.50	0.50	
Canada wildrye (ELCA)	Combined	Debeard	4.40	3.60	1.20	4.00	2.00	2.50	Indent to remove foxtail
Junegrass (KOMA)	Combined	Brush	1.6 slot	.8 slot	0.50	1.50	0.50	.5-1.5	
Switchgrass (PAVI)	Combined		3.00	2.00	0.90	6.00	1.00	2.00	
Little bluestem (SCSC)	Combined	Debeard	4.00	1.6 slot	0.70	2.00	1.00	2.50	Indent to remove foxtail
Indian grass (SONU)	Combined	Debeard	4.00	3.40	0.80	1.00	0.75	1.75-2.25	Indent to remove foxtail
Prairie cordgrass (SPPE)	Combined		7.00	1.8 slot	2.00	3.00	1.50	1.5-2.0	
Tall dropseed (SPAS)	Combined	1/4" mesh*	3.00	1.40	0.70	6.50	4.00	2.00	
Prairie dropseed (SPHE)	Combined	1/4" mesh	4.00	3.20	1.50	2.00	2.50	2.50	
LEGUMES									
Leadplant (AMCA)	Combined	Brush	3.40	3.20	1.00	6.00	6.00	2.00	
Canada milkvetch (ASCA)	Combined		2.80	1.80	1.00	6.00	2.00	3.25-4.00	
Cream Indigo (BALA)	Combined		5.00	6.00	3.50				
White wild indigo (BALE)	Combined		4.80	4.40	2.40	5.00	6.00	4-4.5	
White prairie clover (DACA)	Combined	Brush	6.00	2.00	1.75	6.00	2.00	1.75	
Purple prairie clover (DAPU)	Combined	Brush	3.00	1.70	0.90	6.00	2.00	2-3	
Showy tick-trefoil (DECA)	Combined	Brush	3.00	2.80	1.20	6.00	2.00	3.5-4.0	
Roundhead bush clover (LECA)	Combined	Brush	4.00	2.00	1.20	6.50	4.00	2.50	
WILDFLOWERS									
Canada anemone (ANCA)	Combined	1/2" mesh	5.50	5.00	3.00	3.00	2.00	2.25	
Thimbleweed (ANCY)	Combined	Brush	5.00	2.80	1.00	5.00	2.25	1.25	
Prairie sage (ARLU)	Combined	Brush	0.90	0.80	0.50	6.00	1.50	1.00	

• Combined material is rough-screened through indicated mesh size (hardware cloth) to remove large stems to make material more flowable for airscreening

Table 1C:
SCREEN SIZES, WESTRUP LABORATORY AIR SCREEN CLEANER

SPECIES	Harvest Method	Treatment before A/S Cleaning	Westrup A/S CLEANER Screens (mm) SCALPING Top	Middle	SIFTING Bottom	Air-flow Valves Cyclone #1	Damper #2	Final #3	General Notes
WILDFLOWERS									
New England aster (ASNO)	Combined	Brush	1.6 slot	.8 slot	0.60	4.00	1.00	1.0-2.0	Airscreen 2x
Smooth blue aster (ASLA)	Combined	Brush	1.6 slot	.8 slot	0.70	6.00	1.00	1.00	
Butterfly milkweed (ASTU)	Hand pick	Hammermill/ Debearder?	6.00	5.50	3.00	6.00	3.00	.75-1.5	Airscreen 2x
Stiff coreopsis (COPA)	Combined	1/4" mesh	3.40	3/1.6 slot	.6 slot	3.00	1.00	2-2.5	Airscreen repeatedly
Pale purple coneflower (ECPA)	Combined	1/4" mesh	4/3.8	3.60	1.7/2	4.00	2.00	1.75-2	Airscreen 2x
Rattlesnake master (ERYU)	Combined	1/4" mesh	5.00	3.60	1.20	3.00	4.00	1.25-2	Airscreen 2x
Bottle gentian (GEAN)	Hand pick	1/8" mesh	1.40	.6 slot	.7 rnd	0.00	0.00	0.75	Static buildup, remove shaker balls!
Oxeye false-sunflower (HEHE)	Combined	1/4" mesh	4.00	2.70	1.4-1.7	5.00	2.50	2.50	
Rough blazing-star (LIAS)	Hand pick	1/2" mesh /brush	3.00	2.40	1.20	2.75	2.00	1.5-2.25	Airscreen 2x
Prairie blazing-star (LIPY)	Hand pick	1/2" mesh /brush	3.00	2.40	1.20	2.75	2.00	1.5-1.75	Airscreen 2x
Great blue lobelia (LOSI)	Hand pick	1/8" mesh	1.60	0.70	0.50	6.00	0.25	0.25	Airscreen 2x
Wild bergamot (MOFI)	Combined	1/4" mesh	1.50	1.20	0.70	3.00	2.00	1.50	Airscreen 2x
Wild quinine (PAIN)	Combined	1/2" mesh /brush	3.40	2.80	1.30	4.00	2.00	1-1.25	Airscreen 2x
VA Mountain mint (PYVI)	Combined	1/4" mesh	1.20	1.10	0.50	6.00	2.00	1.00	Airscreen 2x
Hairy mountain mint	Combined	1/4" mesh	1.10	0.70	0.50	6.00	2.00	1.00	Airscreen 2x
Slender mountain mint	Combined	1/4" mesh	1.10	1.00	0.50	3.00	1.00	0.50	Airscreen 2x
Greyhead coneflower (RAPI)	Combined	1/4" mesh	3.00	2.00	1.20	4.50	1.50	1.75	Airscreen 2x
Sweet coneflower (RUSU)	Combined	1/4" mesh	2.00	1.50	0.70	4.50	1.50	1.75-1.9	Airscreen 2x
Rosinweed (SIIN)	Combined	1/2" mesh	4.0 slot	8.00	4.00	2.00	2.00	2.00	Airscreen repeatedly
Compass plant (SILA)	Combined	1/2" mesh	4.0 slot	10.00	6.00	2.00	2.00	2.50	Airscreen repeatedly
Stiff goldenrod (SORI)	Combined	1/2" mesh /brush	3.00	1.80	0.60	2.50	1.00	2.25	Airscreen 2x
Showy goldenrod (SOSP)	Combined	1/4" mesh/brush	1.00	.6 slot	0.50	7.50	1.00	1-1.5	Airscreen 2x
Bracted spiderwort (TRBR)	Combined	1/4" mesh	3.40	2.80	1.30	6.00	2.00	2.50	
Ohio spiderwort (TROH)	Combined	1/4" mesh	3.40	2.80	1.30	6.00	2.00	3.00	
Culver's root (VEVI)	Combined	1/4" mesh	0.90	0.70	0.50	2.00	0.50	0.50	Airscreen 2x
Golden Alexander (ZIAU)	Combined	1/4" mesh	4.00	3.00	1.20	6.50	2.50	1.5-2	

• Combined material is rough-screened through indicated mesh size (hardware cloth) to remove large stems to make material more flowable for airscreening

Table 2C:
SEED PROCESSING - WESTRUP BRUSH MACHINE SETTINGS

The brush machine is versatile and can be used to de-awn grasses, de-hull legumes, remove the pappus or other appendages, and break up seed heads of hand-collected materials. The machine rotates two brushes against a drum screen, thus rubbing the material between the brushes and the drum screen (see text in introductory chapters). The brush machine is more aggressive than a debearder, which rubs seed against itself as the chamber becomes filled with seed, so greater care is needed to avoid damaging the seed. These settings have been used effectively at the Tallgrass Prairie Center for brushing the species listed.

SPECIES	BRUSH MACHINE						GENERAL NOTES:
	Drum Screen	Brush Type	End Gate	No. Times	RPM	Seed Comes Thru:	
GRASSES							
Big bluestem (ANGE)	7	medium	closed	1	7	screen	
Side-oats grama (BOCU)	10	medium	1/8”	1	7	screen	
Bluejoint grass (CACA)	*14	medium	closed	2-3X	8	screen	*(wrap paper around front half of drum screen)
Canada wildrye (ELCA)	14	stiff	1-1.5”	1	1.5	gate	
Junegrass (KOMA)						screen	
Switchgrass (PAVI)	10	medium	closed	1	7	screen	
Little bluestem (SCSC)	12	medium	1/8-1/4”	1	7	gate	
Indian grass (SONU)	14	soft	1/4-1/2”	1	7	gate	
Prairie cordgrass (SPPE)	5	medium	wide open	1	3	screen	not recommended, may damage seed
Tall dropseed (SPAS)	12	medium	close	1	7	screen	to remove palea/lemma
Prairie dropseed (SPAS)							not recommended
LEGUMES							
Leadplant (AMCA)	14	stiff	1/2 “		7	gate	Difficult to de-hull
Canada milkvetch (ASCA)	7	medium	closed		7	screen	
Cream Indigo (BABR)							
White wild indigo (BAAL)							
White prairie clover (DACA)						screen	
Purple prairie clover (DAPU)	12	stiff	open	2-3X	7	screen	Re-run un-hulled material
Showy tick-trefoil (DECA)	7	medium	closed	1	7	gate	(some seed thru screen)
Roundhead bush clover (LECA)	10	stiff	closed	1	7	screen	
WILDFLOWERS							
Thimbleweed (ANCY)	14	stiff	1/4 “		8.5	screen	
Prairie sage (ARLU)	14	stiff	closed	1	5	screen	Caution! Minimum vacuum!
New England aster (ASNO)	12	soft	closed	1	6	screen	Caution! Minimum vacuum!
Smooth blue aster (ASLA)	12	soft	closed	1	6	screen	Caution! Minimum vacuum!
Butterfly milkweed (ASTU)	14	medium	1”	1		gate	
Prairie coreopsis (COPA)	5	beaters	closed	1	6.5	screen	
Pale purple coneflower (ECPA)	5	*beaters	1/2”	1	7	screen	*all the way in
Rattlesnake master (ERYU)	7	stiff		1	7	gate	
Oxeye false-sunflower (HEHE)	7	medium		1	7	screen	
Rough blazing-star (LIAS)	7	soft	open 1/2”	1	7	screen	
Prairie blazing-star (LIPY)	7	soft	open 1/2”	1	7	screen	
Great blue lobelia (LOSI)	14	medium	1/8”	1	5	screen	Caution! Minimum vacuum!
Wild bergamot (MOFI)	7	medium	1/8-1/4”	1	5	screen	Caution! Minimum vacuum!
Wild quinine (PAIN)	7	medium	open 1/2”	1	7	gate	
VA Mountain mint (PYVI)	10	stiff	1/8-1/4”	1	5	screen	Caution! Minimum vacuum!

Table 2C:
SEED PROCESSING - WESTRUP BRUSH MACHINE SETTINGS

SPECIES	BRUSH MACHINE						GENERAL NOTES:
	Drum Screen	Brush Type	End Gate	No. Times	RPM	Seed Comes Thru:	
WILDFLOWERS							
Hairy mountain mint	10	stiff	1/8-1/4”	1	5	screen	
Slender mountain mint	10	stiff	1/8”	1	5	screen	
Stiff goldenrod (SORI)	12	medium	closed	1	7	screen	Caution! Reduce Vacuum!
Showy goldenrod (SOSP)	12	medium	closed	1	7	screen	Caution! Reduce Vacuum!
Culver’s root (VEVI)	14	stiff	closed	1	7	screen	Caution! Minimum vacuum!

Table 3C:
Westrup Settings as used by USDA-NRCS Elsberry Plant Materials Center

This table includes settings used as a reference point by Elsberry Plant Materials Center, Elsberry, MO. Some of the variation in screen sizes and valve settings as compared to setting used at the Tallgrass Prairie Center may reflect regional differences in seed size, seed quality, and contaminating weed species.

		Westrup Brush Machine			Westrup Air and Screen Cleaner					
Common Name	Scientific Name	Screen Size	RPM Speed	# of Times	#1 Valve	#2 Valve	#3 Valve	Top Screen	Middle Screen	Bottom Screen
Big Bluestem	*Andropogon gerardi*	10	7	1	6.5	1	2	400	330	90
New England Aster	*Aster novae-angliae*	12	7	2	5	0.25	1.75	300	170	90
Sideoats Gramma	*Bouteloua curtipendula*	10	7	1	6.5	2.5	1.5	300	240	90
Prairie Coreopsis	*Coreopsis palmata*		N/A		5.25	0.5	1	400	300	200
Purple Prairie Clover	*Dalea purpurea*	12	7	1	6	2	2	300	170	110
Tick Trefoil (Sticktites)	*Desmodium canadense*	7	7	1	6.5	4	2	400	270	140
Pale Purple Coneflower	*Echinacea pallida*	5	7	1	4.5	0.75	1.5	400	360	240
Canada Wild Rye	*Elymus canadense*	7	2	1	4	1	1.75	500	360	200
Virginia Wild Rye	*Elymus virginicus*		N/A							
Rattlesnake Master	*Eryngium yuccifolium*	7	7	1	3	2	1.5	500	270	120
Oxeye False Sunflower	*Heliopsis helianthoides*	7	7	1	5	2.5	2.5	400	270	170
Roundhead Bushclover	*Lespedeza capitata*	10	7	1	6.5	3.5	2.5	400	200	120
Rough Blazing Star	*Liatris aspera*	7	7	1	6.5	2.75	1.75	400	270	120
Prairie Blazing Star	*Liatris pycnostachya*	7	7	2	6.5	3	2	300	240	120
Great Blue Lobelia	*Lobelia siphilitica*	12	1	1	0	0.5	0.5	300	60	Solid Screen
Horsemint	*Monarda fistulosa*	7	7	1	5	1	1	300	120	90
Foxglove Beardtongue	*Penstemon digitalis*	5	7	2	5	0.75	1.75	300	120	60
Grayhead Coneflower	*Ratibida pinnata*	12	6	1	4.5	0.75	1.5	300	200	120
Little Bluestem	*Schizachrium scoparium*	12	7	2	6.5	1	1.75	300	270	90
Stiff Golenrod	*Solidago rigida*	12	7	1	6.5	1	2	300	140	90
Indiangrass	*Sorgatrum nutans*	10	7	2	6.5	0.75	1.75	400	300	170
Tall Dropseed	*Sporobolus asper*	12	7	3	6.5	4	2	300	140	90

• Westrup Brush Machine: Barrel screen sizes are numerical, larger number indicates smaller mesh size.
• Westrup Air/Screen Cleaner: Screen sizes are in millimeters (example: 500 is 5.00 mm or 90 is 0.90 mm)

Table 4C:
SCREEN SIZES AND CONVERSIONS

WESTRUP SCREEN SIZES used by the TPC		
Slotted Hole	Round Hole	
Metric (mm)	Metric (mm)	Inches
-	0.50	0.02
0.60	0.60	0.02
0.70	0.70	0.03
0.80	0.80	0.03
0.90	0.90	0.04
1.00	1.00	0.04
-	1.10	0.04
1.20	1.20	0.05
-	1.30	0.05
1.40	1.40	0.06
-	1.50	0.06
1.60	1.60	0.06
-	1.70	0.07
1.80	1.80	0.07
-	1.90	0.07
2.00	2.00	0.08
-	2.20	0.09
2.40	2.40	0.09
-	2.60	0.10
2.80	2.80	0.11
-	3.00	0.12
-	3.20	0.13
-	3.40	0.13
-	3.60	0.14
-	3.80	0.15
4.00	4.00	0.16
-	4.40	0.17
-	4.80	0.19
-	5.00	0.20
-	5.50	0.22
-	6.00	0.24
-	6.50	0.26
-	7.00	0.28
-	7.50	0.30
-	8.00	0.31
-	10.00	0.39

U.S.A STANDARD TESTING SIEVE SIZES		
Sieve Size	Metric (mm)	Inches
#10	2.00	0.079
#14	1.40	0.056
#16	1.18	0.047
#18	1.00	0.039
#20	0.850	0.033
#25	0.710	0.028
#30	0.600	0.023
#35	0.500	0.020
#40	0.425	0.017
#45	0.355	0.014
#50	0.300	0.012
#60	0.250	0.010
#70	0.212	0.008

HARDWARE CLOTH (for rough screening)		
	Inches	Metric (mm)
	1/2” mesh	12.7
	1/4” mesh	6.4
	1/8” mesh	3.2

These tables list screen sizes(metric and English equivalents) in use by the Tallgrass Prairie Center.

Included are screens used in Westrup Air Screen Cleaner, U.S.A Standard sieve sizes (soil sieves), and hardware cloth mesh used for rough screening combine run material.

Table 1D:
SAMPLE SEED TEST

This table presents purity, germination, and dormancy from actual seed test for the species listed. Higher quality lots were intentionally chosen to illustrate the quality of seed that can be produced and cleaned for native species. Note the high percentage of dormancy that can by expected in most legumes, many wildflowers, and even in some species of grasses. This is why proper pre-treatment of seed is so important for germination in greenhouse production. This high percentage of dormant seed is also why fall, dormant, or early spring seeding (which allows for natural cold stratification) is beneficial for many species. Much of the dormancy in grasses is removed during storage (up to a year) and warm-season grasses, particularly, benefit from being seeded into warm soils in late spring (above 60 F).

SAMPLE SEED TEST, FRESH SEED				
SPECIES				
GRASSES-WARM	PURITY	GERM	DORMANT	PLS
Big bluestem (ANGE)	90.19	50.0	44.0	84.8
Side-oats grama (BOCU)	89.95	90.0	0.0	81.0
Bluejoint grass (CACA)	98.37	80.0	5.0	83.6
Canada wildrye (ELCA)	98.31	73.0	20.0	91.4
Junegrass (KOMA)	95.39	74.0	5.0	75.4
Switchgrass (PAVI)	99.94	40.0	55.0	94.9
Little bluestem (SCSC)	82.53	54.0	33.0	71.8
Indian grass (SONU)	94.75	28.0	59.0	82.4
Prairie cordgrass (SPPE)	85.83	91(TZ)	-	-
Tall dropseed (SPAS)	99.91	90.5	0.0	90.4
Prairie dropseed (SPHE)	99.22	43.0	6.0	48.6
Porcupine grass (STSP)	62.89	22.0	57.0	49.7
LEGUMES	PURITY	GERM	HARD	PLS
Leadplant (AMCA)	96.35	7.5	84.0	88.2
Canada milkvetch (ASCA)	95.77	6.0	86.5	88.6
Cream Indigo (BABR)				0.0
White wild indigo (BAAL)	99.98	3.5	95.0	98.5
New Jersey Tea (CEAM)	92.06	12.0	68.0	73.6
White prairie clover (DACA)	99.87	77.0	5.0	81.9
Purple prairie clover (DAPU)	99.69	21.0	74.0	94.7
Showy tick-trefoil (DECA)	99.48	26.5	65.5	91.5
Roundhead bush clover (LECA)	99.74	62.0	34.0	95.8
WILDFLOWERS	PURITY	GERM	DORMANT	PLS
Canada anemone (ANCA)	99.05	21.5	70.5	91.1
Thimbleweed (ANCY)	98.41	91(TZ)	-	-
Prairie sage (ARLU)	98.95	70.0	13.0	82.1
New England aster (ASNO)	91.75	49.0	24.5	67.4
Smooth blue aster (ASLA)	99.24	71.0	19.0	89.3
Skyblue aster (ASAZ)	99.22	72.0	22.0	93.3
Butterfly milkweed (ASTU)	98.37	50.5	40.0	89.0
Prairie coreopsis (COPA)	70.30	42.0	47.0	62.6
Pale purple coneflower (ECPA)	93.65	43.5	50.0	87.6
Rattlesnake master (ERYU)	95.78	24.5	71.0	91.5
Bottle gentian (GEAN)	75.83	3.5	82.0	64.8
Oxeye false-sunflower (HEHE)	99.84	71.0	19.0	89.9

- High dormancy in some grass species, and many forb species.
- High percentage of hard seed in legume species

Table 1D:
Sample Seed Test

SAMPLE SEED TEST, FRESH SEED				
SPECIES				
WILDFLOWERS	PURITY	GERM	DORMANT	PLS
Rough blazing-star (LIAS)	98.41	36.0	61.0	95.5
Prairie blazing-star (LIPY)	98.28	3.5	92.5	94.3
Great blue lobelia (LOSI)	92.20	21.5	38.0	54.9
Wild bergamot (MOFI)	95.51	62.5	2.0	61.6
Wild quinine (PAIN)	96.13	81.0	10.0	87.5
VA Mountain mint (PYVI)	97.06	77.5	8.0	83.0
Hairy mountain mint (PYPI)	98.70	92.0	0.0	90.8
Slender mountain mint (PYTE)	95.03	75.5	11.0	82.2
Greyhead coneflower (RAPI)	98.68	89.5	0.0	88.3
Sweet coneflower (RUSU)	98.02	71.0	25.0	94.1
Rosinweed (SIIN)	81.03	40.0	54.5	76.6
Compass plant (SILA)	86.88	23.0	72.0	82.5
Stiff goldenrod (SORI)	95.31	60.0	22.0	78.2
Showy goldenrod (SOSP)	86.45	26.0	66.0	79.5
Bracted spiderwort (TRBR)	99.98	5.0	51.0	56.0
Ohio spiderwort (TROH)	99.76	6.0	74.0	79.8
Culver's root (VEVI)	93.04	22.0	37.5	55.4
Golden Alexander (ZIAU)	99.33	22.0	61.0	82.4

• High dormancy in some grass species, and many forb species.
• High percentage of hard seed in legume species

Table 2D: Seeds Per Unit Weight

A good estimate of seeds/oz or seeds/lb is critically important in calculating seeding rates. Seed count data is an approximation derived from counting out a small quantity of seed and weighing them, repeating the process a few times, and taking an average seed count per unit weight (800 seeds/gram, for example). This is then used to calculate seeds per ounce or seeds per pound. Variations in seed size, seed fill, and degree of cleaning can greatly affect the estimate. Hulls, awns, hairs, if left in place on the seed, will greatly reduce the number of seeds/lb as compared to the same seed when properly cleaned. This table lists published values of seed counts for the species listed. Prairie Moon Nursery, Winona, MN, publishes seed counts for a comprehensive list of species in their catalog each year. Their counts are based on seed lots deemed 'typical' for the native seed trade. Many of the actual seed count values have been adjusted down slightly (by .8 or .9 of the actual estimate) to give an approximation of 'viable seed count' per unit weight estimate, and so is a more conservative seed count. USDA PLANTS Database values, if available, are also listed. Large discrepancies in seed counts for a species are often inexplicable, but may reflect different degrees of cleaning (hulls, awns, pappus), larger seed size of 'improved' varieties, or even typographical errors.

SPECIES		SEED WEIGHTS (Prairie Moon[1])		USDA PLANTS[2]
Common Name	Scientific Name	Seeds/Oz	Seeds/lb	Seeds/lb
WILDFLOWERS				
Canada anemone	*Anemone canadensis*	8000	128000	-
Thimbleweed	*Anemone cylindrica*	26000	416000	-
Prairie sage	*Artemisia ludoviciana*	250000	4000000	3,750,000
Butterfly milkweed	*Asclepias tuberosa*	4300	68800	70,000
Sky blue aster	*Aster azureus*	80000	1280000	-
Smooth blue aster	*Aster laevis*	55000	880000	1,014,000
New England aster	*Aster novae-angliae*	66000	1056000	1,100,000
Prairie coreopsis	*Coreopsis palmata*	10000	160000	-
Pale purple coneflower	*Echinacea pallida*	5200	83200	106,000
Rattlesnake master	*Eryngium yuccifolium*	7500	120000	177,000
Bottle gentian	*Gentiana andrewsii*	280000	4480000	9,000,000
Oxeye false-sunflower	*Heliopsis helianthoides*	6300	100800	154,000
Rough blazing-star	*Liatris aspera*	16000	256000	217,920
Blazing-star	*Liatris pychnostachya*	11000	176000	120,000
Great blue lobelia	*Lobelia siphilitica*	500000	8000000	-
Wild bergamot	*Monarda fistulosa*	70000	1120000	1,272,500
Wild quinine	*Parthenium integrifolium*	7000	112000	-

Table 2D:
Seeds Per Unit Weight

SPECIES		SEED WEIGHTS (Prairie Moon[1])		USDA PLANTS[2]
Common Name	Scientific Name	Seeds/Oz	Seeds/lb	Seeds/lb
WILDFLOWERS				
Hairy Mt. mint	*Pycnanthemum pilosum*	185000	2960000	-
Narrowleaved Mt. mint	*Pycnanthemum tenuifolium*	378000	6048000	-
Virginia Mt. mint	*Pycnanthemum virginianum*	220000	3520000	-
Greyhead coneflower	*Ratibida pinnata*	30000	480000	1,000,000?
Sweet coneflower	*Rudbeckia subtomentosa*	43000	688000	-
Rosinweed	*Silphium integrifolium*	1200	19200	-
Compass plant	*Silphium laciniatum*	660	10560	-
Stiff goldenrod	*Solidago rigida*	41000	656000	1,009,000
Showy goldenrod	*Solidago speciosa*	95000	1520000	-
Prairie spiderwort	*Tradescantia bracteata*	10000	160000	-
Ohio spiderwort	*Tradescantia ohioensis*	8000	128000	-
Culver's root	*Veronicastrum virginicum*	800000	12800000	-
Golden Alexander	*Zizia aurea*	11000	176000	-
GRASSES-WARM				
Big bluestem	*Andropogon gerardii*	10000	160000	144,240
Side-oats grama	*Bouteloua curtipendula*	6000	96000	191,000
Switchgrass	*Panicum virgatum*	14000	224000	259,000
Little bluestem	*Schizachyrium scoparium*	15000	240000	240,670
Indian grass	*Sorghastrum nutans*	12000	192000	174,720
Prairie cordgrass	*Spartina pectinata*	6600	105600	183,000
Tall dropseed	*Sporobolus asper*	30000	480000	759,362
Prairie dropseed	*Sporobolus heterolepis*	16000	256000	-

• [1]Prairie Moon Nursery Catalog, Prairie Moon Nursery, Winona, MN *www.prairiemoon.com*.
• [2]USDA-PLANTS DATA BASE *http://plants.usda.gov/*

Table 2D:
Seeds Per Unit Weight

SPECIES		SEED WEIGHTS (Prairie Moon[1])		USDA PLANTS[2]
Common Name	Scientific Name	Seeds/Oz	Seeds/lb	Seeds/lb
GRASSES-COOL				
Bluejoint grass	*Calamagrostis canadensis*	280000	4480000	3,837,472
Canada wildrye	*Elymus canadensis*	5200	83200	115,000
Virginia wildrye	*Elymus virginicus*	4200	67200	80,000
Junegrass	*Koeleria macanthra*	200000	3200000	2,315,000
SEDGES				
Prairie sedge	*Carex bicknellii*	17000	272000	-
Plains Oval Sedge	*Carex brevior*	29000	464000	-
Heavy sedge	*Carex gravida*	12000	192000	-
LEGUMES				
Canada milkvetch	*Astragalus canadensis*	17000	272000	120,000
Leadplant	*Amorpha canescens*	16000	256000	195,333
White wild indigo	*Baptisia alba*	1700	27200	-
Cream Wild Indigo	*Baptisia bracteata*	1400	22400	
White prairie clover	*Dalea camdida*	19000	304000	-
Purple prairie clover	*Dalea purpurea*	18000	288000	300,000
Showy tick-trefoil	*Desmodium canadense*	5500	88000	88,000
Roundhead bush clover	*Lespedeza capitata*	8000	128000	275,000

• [1]Prairie Moon Nursery Catalog, Prairie Moon Nursery, Winona, MN *www.prairiemoon.com*.
• [2]USDA-PLANTS DATA BASE *http://plants.usda.gov/*

Soil Moisture Requirements

The wetness ratings presented here are intended as a guide to the soil moisture requirements for the species listed, and should not be strictly equated to degrees of wetness required for seed production. Many obligate wetland species (-5 rating) occur in permanently or seasonally flooded wetlands. The facultative upland species (2-4 ratings) include a diverse collection of plants, some adapted to exist in a variety of environmentally stressful or disturbed sites (including wetlands). For definitions of the terms 'obligate' and 'facultative' see Table 2, Wetland Indicator Categories. See Table 3, Soil Moisture Characteristics, for definition of the terms 'xeric', 'mesic', and 'hydric' as relates to soil characteristics.

Table 1. Wetness Rating* (Coefficient of Wetness=CW)
For North Central Region (IA, IL, IN, MI, MN, MO, WI)

SPECIES Common Name	Scientific Name	Wet-Dry (-/+)
GRASSES - WARM		
Big bluestem	*Andropogon gerardii*	1
Side-oats grama	*Bouteloua curtipendula*	5
Switchgrass	*Panicum virgatum*	-1
Little bluestem	*Schizachyrium scoparium*	4
Indian grass	*Sorghastrum nutans*	2
Prairie cordgrass	*Spartina pectinata*	-4
Tall dropseed	*Sporobolus asper*	5
Prairie dropseed	*Sporobolus heterolepis*	4
GRASSES - COOL		
Bluejoint grass	*Calamagrostis canadensis*	-5
Canada wildrye	*Elymus canadensis*	1
Virginia wildrye	*Elymus virginicus*	-2
Junegrass	*Koeleria macanthra*	5
Porcupine grass	*Stipa spartea*	5
SEDGES		
Plains Oval Sedge	*Carex brevior*	0
Prairie Sedge	*Carex bicknelli*	1
LEGUMES		
Canada milkvetch	*Astragalus canadensis*	-1
Cream Indigo	*Baptisia bracteata*	5
White wild indigo	*Baptisia leucantha*	3
White prairie clover	*Dalea candida*	5
Purple prairie clover	*Dalea purpurea*	5
Showy tick-trefoil	*Desmodium canadense*	1
Roundhead bush clover	*Lespedeza capitata*	3
American vetch	*Vicia americana*	
SHRUBS		
Leadplant	*Amorpha canescens*	5
New Jersey tea	*Ceanothus americanus*	5

KEY:

Wetland Indicator Categories	Wetness Rating (CW)
Upland	5
Facultative Upland-	4
Facultative Upland	3
Facultative Upland+	2
Facultative -	1
Facultative	0
Facultative+	-1
Facultative Wetland-	-2
Facultative Wetland	-3
Facultative Wetland+	-4
Obligate Wetland	-5

Ladd 1997, Vascular Plants of Midwestern Tallgrass Prairies, Appendix A in: The Tallgrass Restoration Handbook, Ed. Packard and Mutel.

Note: Regional Wetland Indicator Categories express the estimated probability (likelihood) of a species occurring in wetlands versus non-wetlands in the region.

Soil Moisture Requirements Continued

SPECIES Common Name	Scientific Name	Wet-Dry (-/+)
WILDFLOWERS		
Canada anemone	*Anemone canadensis*	-3
Thimbleweed	*Anemome cylindrica*	5
Prairie sage	*Artemisia ludoviciana*	5
Butterfly milkweed	*Asclepias tuberosa*	5
Smooth blue aster	*Aster laevis*	5
New England aster	*Aster novae-angliae*	-3
Stiff coreopsis	*Coreopsis palmata*	5
Pale purple coneflower	*Echinacea pallida*	5
Rattlesnake master	*Eryngium yuccifolium*	-1
Bottle gentian	*Gentiana andrewsii*	-3
Oxeye false-sunflower	*Heliopsis helianthoides*	5
Rough blazing-star	*Liatris aspera*	5
Blazing-star	*Liatris pychnostachya*	1
Great blue lobelia	*Lobelia siphilitica*	-4
Wild bergamot (Horsemint)	*Monarda fistulosa*	3
Wild quinine	*Parthenium integrifolium*	5
Mountain mint	*Pycnanthemum virginianum*	-4
Slender mountain mint	*Pycnanthemum tenuifolium*	0
Hairy mountain mint	*Pycnanthemum pilosum*	5
Greyhead coneflower	*Ratibida pinnata*	5
Sweet coneflower	*Rudbeckia subtomentosa*	-3
Rosinweed	*Silphium integrifolium*	5
Compass plant	*Silphium laciniatum*	4
Stiff goldenrod	*Solidago rigida*	4
Showy goldenrod	*Solidago speciosa*	5
Bracted spiderwort	*Tradescantia bracteata*	4
Ohio spiderwort	*Tradescantia ohioensis*	5
Culver's root	*Veronicastrum virginicum*	0
Golden Alexander	*Zizia aurea*	-1

*Ladd 1997, Vascular Plants of Midwestern Tallgrass Prairies, Appendix A in: The Tallgrass Restoration Handbook, Ed. Packard and Mutel.

KEY:

Wetland Indicator Categories	Wetness Rating (CW)
Upland	5
Facultative Upland-	4
Facultative Upland	3
Facultative Upland+	2
Facultative -	1
Facultative	0
Facultative+	-1
Facultative Wetland-	-2
Facultative Wetland	-3
Facultative Wetland+	-4
Obligate Wetland	-5

Table 2. Wetland Indicator Categories

Indicator Code	Wetland Type	Comment
OBL	Obligate Wetland	Occurs almost always (estimated probability 99%) under natural conditions in wetlands.
FACW	Facultative Wetland	Usually occurs in wetlands (estimated probability 67%-99%), but occasionally found in non-wetlands.
FAC	Facultative	Equally likely to occur in wetlands or non-wetlands (estimated probability 34%-66%).
FACU	Facultative Upland	Usually occurs in non-wetlands (estimated probability 67%-99%), but occasionally found on wetlands (estimated probability 1%-33%).
UPL	Obligate Upland	Occurs in wetlands in another region, but occurs almost always (estimated probability 99%) under natural conditions in non-wetlands in the regions specified. If a species does not occur in wetlands in any region, it is not on the National List.

Notes: A positive (+) and negative (-) sign is used for facultative categories; (+) means more frequently found in wetlands, (-) means less frequently found in wetlands.
http://plants.usda.gov/wetinfo.html#categories
Accessed 12/8/06

Table 3. Soil Moisture Characteristics

GENERAL MOISTURE GRADIENT	SOIL CHARACTERISTICS
XERIC	Excessively drained, and somewhat excessively drained sandy or gravelly soils, or shallow loam soils on steep slopes and ridges
↑ (dryer)	↑
MESIC	Well-drained and moderately well-drained loamy soils
(wetter) ↓	↓
HYDRIC	Somewhat poorly drained, poorly drained, very poorly drained soils with standing water part or most of the year

This table is presented as a guide to soil moisture characteristics implied by the terms xeric, mesic, and hydric, as used in this manual.

This table shows relative degree of difficulty within the four main aspects of seed production for the species listed. This information is subjective, and is based upon seed production experience at the Tallgrass Prairie Center. Factors such as climate, soils, labor, equipment, and experience available to other producers will alter perceptions regarding difficulty of seed production. The information is presented here to help producers anticipate requirements for native seed production of these species.

Relative Degree of Difficulty for Seed Increase (by species) **8/22/2007**

Common Name	Scientific Name	Mkt Price*	Ease of Propagation	Stand Mngmnt	Ease of Harvest	Cleanability /Yield	Relevant Comments:
GRASSES - WARM		**(PLS lbs)**					
Big bluestem	*Andropogon gerardii*	$10.00					Seed requires debearding
Side-oats grama	*Bouteloua curtipendula*	$12.00					
Switchgrass	*Panicum virgatum*	$10.00					
Little bluestem	*Schizachyrium scoparium*	$12.00					Seed requires debearding
Indian grass	*Sorghastrum nutans*	$12.00					Seed requires debearding
Prairie cordgrass	*Spartina pectinata*	$120.00					Requires irrigation; Low seed yield
Tall dropseed	*Sporobolus asper*	$45.00					
Prairie dropseed	*Sporobolus heterolepis*	$150.00					Seed viability generally low
GRASSES - COOL							
Bluejoint grass	*Calamagrostis canadensis*	$60.00 (oz)					Requires irrigation; tiny fluffy seed; low seed yield
Canada wildrye	*Elymus canadensis*	$10.00					Long awns make combining, cleaning challenging
Virginia wildrye	*Elymus virginicus*	$5.00					
Junegrass	*Koeleria macanthra*	$120.00					Small seeded; poor competitor in mesic soils
Porcupine grass	*Stipa spartea*	$120.00					Prolonged dormancy; difficult to handle, clean
SEDGES							
Prairie Sedge	*Carex bicknelli*	$300.00					Low yield?
Plains Oval Sedge	*Carex brevior*	$120.00					
LEGUMES							
Canada milkvetch	*Astragalus canadensis*	$60.00					Stand very short-lived
Cream Indigo	*Baptisia bracteata*	$200.00					Low statured plant; low yield
White wild indigo	*Baptisia leucantha*	$120.00					Good seed germination can be difficult to achieve
White prairie clover	*Dalea candida*	$30.00					
Purple prairie clover	*Dalea purpurea*	$60.00					
Showy tick-trefoil	*Desmodium canadense*	$5.00					Seeds cling together
Roundhead bush clover	*Lespedeza capitata*	$120.00					
SHRUBS							
Leadplant	*Amorpha canescens*	$180.00					Min. three years first crop; hand harvest
New Jersey tea	*Ceanothus americanus*	$750.00					Difficult to germinate; min. three years first crop

Relative Degree of Difficulty for Seed Increase (by species) Continued **8/22/2007**

Common Name	Scientific Name	Mkt Price*	Ease of Propagation	Stand Mngmnt	Ease of Harvest	Cleanability /Yield	Relevant Comments:
WILDFLOWERS		(per ounce)					
Canada anemone	Anemone canadensis	$15.00					Difficult to germinate (double dormancy)
Thimbleweed	Anemome cylindrica	$60.00					Low yield; cottony seeds difficult to clean
Prairie sage	Artemisia ludoviciana	$30.00					Very tiny seeds; short stand life
Butterfly milkweed	Asclepias tuberosa	$20.00					Hand harvest as pods ripen; challenging to clean
Smooth blue aster	Aster laevis	$15.00					
New England aster	Aster novae-angliae	$10.00					Tiny seeds; difficult to harvest and clean
Stiff coreopsis	Coreopsis palmata	$15.00					Difficult to clean
Pale purple coneflower	Echinacea pallida	$5.00					
Rattlesnake master	Eryngium yuccifolium	$6.00					
Bottle gentian	Gentiana andrewsii	$30.00					Hand harvest over time; small papery seeds
Oxeye false-sunflower	Heliopsis helianthoides	$2.00					
Rough blazing-star	Liatris aspera	$25.00					
Blazing-star	Liatris pychnostachya	$15.00					
Great blue lobelia	Lobelia siphilitica	$15.00					Irrigation; Very tiny seeds; hand harvest
Wild bergamot (Horsemint)	Monarda fistulosa	$8.00					
Wild quinine	Parthenium integrifolium	$15.00					
Hairy mountain mint	Pycnanthemum pilosum	$12.00					
Slender mountain mint	Pycnanthemum tenuifolium	$20.00					
Mountain mint	Pycnanthemum virginianum	$30.00					
Greyhead coneflower	Ratibida pinnata	$3.00					
Sweet coneflower	Rudbeckia subtomentosa	$8.00					
Rosinweed	Silphium integrifolium	$8.00					Low yield
Compass plant	Silphium laciniatum	$6.00					Min. three years first crop; Low yield; Diff. to clean
Stiff goldenrod	Solidago rigida	$4.00					
Showy goldenrod	Solidago speciosa	$20.00					Small seeds; dispersed immediately
Bracted spiderwort	Tradescantia bracteata	$30.00					Plants wither to ground soon after seed ripe
Ohio spiderwort	Tradescantia ohioensis	$20.00					Seed shatters as it ripens, long flowering period
Culver's root	Veronicastrum virginicum	$25.00					Very tiny seeds
Golden Alexander	Zizia aurea	$6.00					

*Mkt (Market) Price is based on Prairie Moon Nursery Catalog and Cultural Guide 2007. This information is presented here simply to show relative retail market value of the species listed and does not reflect wholesale prices or competitive bidding prices.

***KEY: Relative Degree of Difficulty for Seed Increase**

	Easy to Moderately easy	**Moderately Difficult to Difficult**	**Challenging to Very Challenging**
Ease of Propagation	Can be direct seeded	Best to greenhouse grow	Low germination, and/or pro-longed dormancy
Stand Mngmnt	Long-lived and/or competitive with weeds, or herbicides available	Short-lived and/or non-competitive and/or requires weed barrier	Stand very short-lived and/or requires supplemental irrigation
Ease of Harvest	Can be mechanically harvested	Hand harvest and/or tiny seeds; or difficult to combine	Hand harvest over time and/or seed shatters immediately as it ripens
Cleanability/Yield	Only requires air-screen cleaning; good yield	Requires some degree of pre-cleaning; and/or low yield	Difficult to clean, and/or very low yield.

*See specific factors listed under 'Relevant Comments' in table.

Native Plant Propagation Websites

Native Plant Information Network, Lady Bird Johnson Wildflower Center
http://wildflower.utexas.edu/

The PLANTS Database, USDA, NRCS. 2006 http://plants.usda.gov. National Plant Data Center, Baton Rouge, LA 70874-4490 USA. The PLANTS Database provides standardized information about vascular plants, mosses, liverworts, hornworts, and lichens of the U.S. and its territories. It includes names, plant symbols, checklists, distributional data, species abstracts, characteristics, images, crop information, automated tools, onward Web links, and references. This information primarily promotes land conservation in the United States and its territories, but academic, educational, and general use is encouraged. PLANTS reduces government spending by minimizing duplication and making information exchange possible across agencies and disciplines.

Native Plant Propagation Protocol Database, sponsored by the *NativePlants Journal*
http://www.nativeplantnetwork.org/network/. The Native Plant Network is devoted to the sharing of information on how to propagate native plants of North America (Canada, Mexico, and US). Searchable database, can upload protocols of species you successfully grow. Not sure anyone is editing the information for accuracy?!

Prairie Moon Nursery, Winona, MN
http://www.prairiemoon.com/plantingguidelines.php
Guidelines for planting a prairie and post-planting management, seed counts, propagation information, seed treatments, price list

PlantFinder Database, Missouri Botanical Garden, Kemper Center for Home Gardening
http://www.mobot.org/gardeninghelp/plantfinder/Alpha.asp
Plant info for comprehensive list of species, woody, annual, perennial, etc, not exclusively natives.

Native Iowa Woodland Understory Restoration: A Guide to Collecting and Germinating Seeds, Center for Prairie Studies, Grinnell College, Grinnell, IA
http://web.grinnell.edu/individuals/mottll/resources.htm

Illinois Wildflowers
http://www.illinoiswildflowers.info/index.htm.. This website has descriptions, photographs, and range maps of many native species of vascular plants in Illinois from various habitats (prairie, savanna, woodlands, wetlands). Copyright © 2002-2006 by John Hilty, All Rights Reserved.Last Updated: 10-29-06

Ontario Rock Garden Society
http://www.onrockgarden.com/, this guide provides recommendations for germination of over 4600 seeds listed in the seed exchange of the Ontario Rock Garden Society from 1995 to 2003. For each species, a single germination technique has been chosen from several successful approaches for dry seed stored 6 months @ 20 °C, except where noted. While this data is based primarily on the experience of ORGS members, we have also relied extensively on methods described by Norman Deno (Seed Germination Theory and Practice), Dr. Pavel Slaby (http://web.kadel.cz/flora) and Tom Clothier (www.anet-chi.com/~manytimes/index.htm).

Manual of Grasses for North America, Utah State University. <http://herbarium.usu.edu/grassmanual/ > Species distribution maps, good line illustrations, taxanomic treatments, etc.

Grasses of Iowa. Iowa State University Department of Ecology, Evolution, and Organismal Biology
http://www.eeob.iastate.edu/research/iowagrasses/index.html.

Green Landscaping with Native Plants Environmental Protection Agency (EPA)
http://www.epa.gov/greenacres/ website for native landscaping in Mid-West

Native Plant Propagation/ID Books

An illustrated guide to Iowa prairie plants. Christiansen P, and M. Muller. 1999. University of Iowa Press. Iowa City, Iowa. 237p.

Handbook of Wildflower Cultivation.
Taylor K, and S. Hamblin. 1963. Macmillan Company. New York. 307p.

How to Know the Grasses. Pohl, Ricard W. 1978. William C. Brown Company, Dubuque, IA.

Native Grass Seed Production Manual.
Smith, R. Jr. and S. Smith, Eds. Cooperative publication of USDA-NRCS Plant Materials Program, Ducks Unlimited Canada, Manitoba Forage Seed Assoc., and Univ. of Manitoba. Contact Ducks Unlimited, Winnepeg 204-953-8200 ($30.00 plus shipping)

The New England Wild Flower Society guide to growing and propagating
wildflowers of the United States and Canada. Cullina W. 2000. Houghton Mifflin Company. Boston, Massachusetts. 322p. Some helpful information for propagating native forbs.

North American Prairie. Weaver, J.E. 1954. Lakeside Press, R.R Donnelley & Sons Company, Chicago, IL and Crawfordsville, IN. (excellent source of information on habitat preferences of native species, root development).

North American Range Plants, 4th Ed. Stubbendieck, James, S.L. Hatch, C.H. Butterfield. 1992. University of Nebraska Press, Lincoln and London Good line drawings of native grasses with field characters, soil preferences, range maps.

Nursery Manual, The. Bailey L. 1928. Macmillan Company. New York. 456p.

Plant Propagation. Hartmann H, Kester D, Davies F. 1990. Prentice-Hall, Inc. Englewood Cliffs, New Jersey. 647 p.

Prairie Propagation Handbook. Rock, H. Milwaukee Boener Botanical Garden.

Prairie Seedlings Illustrated: An identification guide. Vol. 1: Twenty selected grasses and forbs. Jackson, L. and Dittmer, L. 1997. Dept. of Biology, Univ. of Northern Iowa, Cedar Falls, IA. (Write to: Prairie Seedlings Illustrated, Dept. of Biology, Univ. of N. Iowa, Cedar Falls, IA 50614, $5/copy)

The Prairie Garden: 70 native plants you can grow in town or country.
Smith R, and B. Smith. 1980. University of Wisconsin Press. Madison, Wisconsin. 219p.

Propagation of Wetland Plants, Herbaceous Plants, Shrubs and Trees.
McIninch, S.M., and E.W. Garbisch. 2003. Environmental Concerns, Inc., P.O. Box P, 201 Boundary Lane, St. Michaels MD 21663.

Restoring the Tallgrass Prairie: An illustrated Manual for Iowa and the Upper Midwest. 1994. Shirley, S. University of Iowa Press, Iowa City. (good information on propagation by seed, division)

Seed Germination Theory and Practice. Deno, Norman C. 1993.: based on experiments on 145 families, 805 genera, and about 4000 species. 2nd Ed. (Write to: Norman C. Deno, 139 Lenor Drive, State College PA 16801)

Seed Production, Principles and Practices. McDonald,M. and L.O. Copeland, International Thomson Publishing.

Tallgrass Restoration Handbook. Packard S, and C. Mutel. 1997. Island Press. Washington, D.C. 463p.

The Complete Handbook of Plant Propagation.
Wright, R. 1973. Macmillan Publishing. New York, New York. 191 p.

Tallgrass Prairie Wildflowers.
Ladd, D. and F. Oberle. 1995. Published in cooperation with The Nature Conservancy. Falcon Press Publishing Co., Inc. Helena-Billings, MT.

Wildflowers of the Tallgrass Prairie, the Upper Midwest.
Runkel, S. and D. Roosa. 1989. Iowa State University Press, Ames, IA.

Research Papers on Native Seed Germination

Seeds: Ecology, Biogeography, and Evolution of Dormancy and Germination. Baskin, C. and Baskin, J. 1998.. Academic Press. (highly technical, but lots of tables summarizing germination treatments by family, and summaries of germination research, including native genera)

Seed germination and dormancy
Black, M. 1970.. Sci. Prog. Oxford Vol. 58 pp. 379-393.

Viability and germination of seeds and early life history of prairie plants.
Blake, A.K. 1935. Ecol. Monographs, Vol. 5. No. 4 pp 405-460

Notes on prairie species in Iowa. I. Germination and establishment of several species. Christiansen, P. and Landers, R.Q. 1966. J. of Iowa Acad. of Science. Vol. 73 pp 51-59.

Germination of priarie forbs *Liatris aspera* Michx. and *Amorpha canescens* Pursh. Churbuck, L. M. 1975. M.S. Thesis, University of Northern Iowa, Cedar Falls, IA 50614.

Germination studies of Wisconsin prairie plants.
Greene, H.C. and J.T. Curtis. 1950. The American Midland Naturalist. Vol. 43. No. 1 pp 186-194.

The influence of exposure to winter temperatures upon seed germination in various native american plants.
Nichols, G.E. 1934. Ecology, Vol. 15, No. 4 pp 365-373.

Seed dormancy of Panicum virgatum L. on the Shoreline Sand Dunes of Lake Erie.
Zhang, J. and M. Maun. 1989. American Midland Naturalist. 122:77-87.

Native Seedlings:

Prairie Seedlings Illustrated: An identification guide. Vol. 1: **Twenty selected grasses and forbs.** Jackson, L. and Dittmer, L. 1997. Dept. of Biology, Univ. of Northern Iowa, Cedar Falls, IA. (Write to: Prairie Seedlings Illustrated, Dept. of Biology, Univ. of N. Iowa, Cedar Falls, IA 50614, $5/copy)

Central Region Seedling ID Guide for Native Prairie Plants.
October 2005. USDA NRCS Elsberry Plant Materials Center, Missouri Dept. of Conservation (MDC), Grownative! Write to: Missouri Dept. of Conservation, PO Box 180, Jefferson City, MO 65102. Ph 573-751-4115. http://mdc.mo.gov/grownative/plantID/

Weeds/Weed Seedling ID References

Common Weed Seedlings of the North Central States.
Chomas, A.J., J.J. Kells, J.B. Carey. 1998. Michigan State University, East Lansing, MI. Copies can be purchased from: Bulletin Office, 10-B Ag. Hall, Michigan State University, East Lansing, MI 48824-1039; phone 517-355-0240).

Weed Seedlings. Kummer, Anna P. 1951. The University of Chicago Press, Chicago, Ill. (includes drawings of a number of native plants)

Nebraska Weeds. Nebraska Dept. of Agriculture. 1971. Nebr. Dept. of Ag., Lincoln, NE (includes native species!)

Weeds of Northern U.S. and Canada. Royer, F. and R. Dickinson. 1999. The Univ. of Alberta Press/Lone Tree Publishing.

Websites:

http://www.extension.unm.edu/distribution/cropsystems/DC1351.html#tail
(U. of MN Extension, list of species w/link to seedling photo)

http://www.weeds.iastate.edu/weed-id/weedid.htm
(Iowa State, list of species w/link to seedling photo)

http://www.ppws.vt.edu/scott/weed_id/rightsid.htm
(Virginia Tech, Procedure and Q's about identifying weed seedlings, step by step)

http://www.msue.msu.edu/msue/iac/e1363/e1363.htm
(Michigan St, many seedling pics, talks about each species, Nice)

http://www.gov.on.ca/OMAFRA/english/crops/weedquiz/index.html
(Weed seedling quiz from Ontario)

http://www.btny.purdue.edu/Faculty/Gibson/slideviewer.fcgi/folder=Faculty/Gibson/Weed_Seedlings_PPT
(Weed seedling identification slide show)

http://www.theseedsite.co.uk/seedlings11.html
(Many weed seedling photos)

Seeding/Harvesting Equipment Vendors

AGCO, www.agcocorp.com/
See website for equipment and dealers
Manufacturer, marketer, distributor of agricultural equipment worldwide.

Ag-Renewal, Inc., www.ag-renewal.com/
1710 Airport Road, Weatherford, OK 73096 PH 800.658.1446, FAX 405.772.6887, email: ag-renewal@itlnet.net
Flail-Vac seed harvesters, cleaners

BEFCO, Inc. www.befco.com/
1781 S. Wesleyan Blvd., Rocky Mount, NC 27802. PH 252.977.9920, FAX 252.944.9718.
Hop Spreaders (fertilizer/seed)

Brillion Farm Equipment, www.brillionfarmeq.com/
200 Park Ave., Brillion, WI 54110. PH 800.409.9749, FAX 920.756.3409, Email: biwfesales@brillionironworks.com.
Manufactures a full line of tillage, seedbed preparation and planting equipment.

Great Plains, www.greatplainsmfg.com/
1525 E. North Street, P.O. Box 5060, Salina, KS 67401.
Planters, precision seeding, drills, sprayers, tillage equipment

Herd Seeder Co. Inc., www.herdseeder.com/
2383 South US 35, Logansport, IN 46947. PH 574.753.6311.
Spreaders (fertilizer/seed)

Land Pride, Div. of Great Plains Mfg., Inc., www.landprinde.com/
1525 E. North Street, P.O. Box 5060, Salina, KS 67401.
Turf type seeders, mowers, turf equipment.

Kincaid Equipment Mfg, www.kincaidequipment.com/
P.O. Box 400, Haven, KS 67543. PH 620.465.2204 or 800.854.7287.
Combines, cleaners, harvesting equipment

Prairie Habitats, Inc., www.prairiehabitats.com/
P.O. Box 10, Argyle, Manitoba. Canada, ROC OBO. PH 204.467.9371, FAX 204.467.5004. Pull-type, front-end loader, and hand held seed strippers

Sukup Manufacturing Company, www.sukup.com/
P.O. Box 677, 1555 255th St, Sheffield, IA USA 50475-0677. PH 641.892.4222, FAX 641.892.4629, Email: info@sukup.com.
Landscape seeders (turf)

Truax Company, Inc., www.truaxcomp.com/
4300 Quebec Avenue North, New Hope, MN 55428. PH 763.537.6639, FAX 763.537.8353.
Native grass drills, Trillion broadcast seeder, Seed slinger, Range drills

Market Farm Implement, www.marketfarm.com/
257 Fawn Hollow Road, Friedens, PA 15541. PH 814.443.1931
Vicon Fertilizer Spreader (broadcast seeding) /cfms/vicon_fertilizer_spreader.cfm

Seed Processing/Cleaning Equipment

A.T. Ferrell Company, Inc. www.clipperseparation.com/
1440 South Adams Street, Bluffton, IN 46714 USA. PH 800.248.8318, FAX 260.824.5463, Clipper Cleaner seed and grain cleaners

Carter Day International www.carterday.com/
Large scale seed cleaning equipment

Cimbria Bratney Companies, Inc. www.bratney.com/cim/
3400 109th St., Des Moines , IA 50322 PH 800.247.6755 FAX 515-276-2067
Seed cleaning/processing equipment

Commodity Traders International, www.commoditytraders.biz/
101 E. Main Street, PO Box 6, Trilla, IL 62469 USA.
PH 217.235.4322, FAX 217-235-3246. Email: sales@commoditytraders.biz
Seed cleaning, grain handling, feed milling, recycle processing equipment

Crippen Manufacturing Company www.crippenmfg.com/
400 Woodside Drive, St. Louis, MI USA 48880, PH. 800.872.2474, FAX 989.681.3818
Seed and grain processing equipment

Forsbergs Inc. www.forsbergs.com/
P.O. Box 510, 1210 Pennington Ave, Thief River Falls, Mn. 56701-0510
1-800-654-1927
Forsberg electric seed scarifier, they also offer a full line of seed cleaning equipment.

Mill-Mac, LLC www.mill-mac.com/
Box 16355, Missoula, MT 59808. PH 866-240-0069
Seed and grain cleaning equipment

Oliver Manufacturing Company, Inc. www.olivermfgco.com/
P.O. Box 512, Rocky Ford, CO 81067, PH 888.254.7813, FAX 719.254.6371
Gravity tables

Popp Engineering, Inc. www.poppengineeringinc.com/
P.O. Box 1871, Ames, IA. 50010, (515) 232-6118
Seed production facility services, equipment resources

Seedburo Equipment Company www.seedburo.com/
1022 W. Jackson Blvd. Chicago, IL 60607
Phone Toll-Free: 800-284-5779 (US & Canada) Fax: 312-738-5329
Seed cleaning/storage equipment

Westrup, Inc. , www.westrup.com/
700 E. Park Blvd., Ste. 210, Plano, TX 75074
Westrup seed cleaning equipment air/screen cleaner, gravity table, brush machine, indent cylinder, belt sorter, debearder

Winona Attrition Mill Co., www.winonaattritionmill.com/
1009 W 5th Street, Winona, MN, 55987. PH 507.452.2716.
Seed cleaning equipment, conveyors, hammer mills

Horticultural Supplies

DeWitt Company, www.dewittcompany.com/
905 South Kingshighway, Sikeston, MO 63801, 800.888.9669
Landscape fabrics, weedbarrier 6 ft and 12 ft widths.

Hummert International, www.hummert.com/
4510 Earth City Expressway, Earth City, MO 63045. PH 800.325.3055
Comprehensive horticultural supplies, greenhouses. On-line catalog.

Inman Irrigation, Inc., www.inmanirrigation.tripod.com/
892 Arapaho Road, Inman, KS 67546. PH 800.886.2380
Irrigation equipment

EMD Crop BioScience www.nitragin.com/
(Formerly Liphatech) PH 800.558.1003.
Innoculants for legumes

Stuewe and Sons, Inc. www.stuewe.com/
2290 SE Kiger Island Dr, Corvallis, OR 97333-9425 USA, 800.553.5331
Greenhouse conetainers, trays, dibbles, zipset bands, etc.

Seed Storage Equipment/Supplies

Bag Lady, The
1743 Hwy. 601 South, Lugoff, S.C. 29078, 1-800-BAG-LADY
custom sized cotton duct bags with draw strings to fit 30 gallon plastic can for bulk harvest of small production plots

Cerf Brothers Bag Company
4240 Ryder Trail Drive, Earth City, MO PH 800.237.3224
Manufacture seed bags.

Hubco, Inc., www.hubcoinc.com/
P.O. Box 1286, 215 South Poplar, Hutchinson, KS 67504-1286. PH 800.563.1867, FAX 620.663.5053, Email: hubcoinc@mindspring.com
Manufacture and printer of cloth, woven and non-woven packaging, custom bags

Kapak Corporation. www.kapak.com/
5305 Parkdale Dr, St. Louis Park, Mn. 55416-1681, 1-800-527-2557
Heat sealer and foil pouches for long term seed storage of small lots.

Fischbein Company, www.fischbein.com/
151 Walker Road, Statesville, NC 28625. PH 704.871.1159, FAX 704.872.3303, Email: sales@fischbein.com.
Bag closing (sewing, sealing, etc), bag packaging technology

Spear Envelope Company, www.spearenvelope.com/
2802 Hedberg Dr, Hopkins, MN 55305. PH 952.545.7124, FAX 952.545.0196, Email: thegang@spearenvelope.com

Spot Cooler, Inc. www.spot-coolers.com/
38243 Eagle Way, Chicago, IL 60678. PH 800.367.8675
Dehumidifiers, compact coolers, portable or permanent