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can expect high rates of clean up which is important with plants where there are commonly only small amounts of plant tissue available during a few weeks in the early spring.

While we have been successful over the years in establishing trillium rhizomes in the field, success has been very inconsistent. We were interested in developing a protocol that could be used to improve the consistency of rhizome reestablishment. We decided to compare the starch status of rhizomes that were clonal, or identical, to each other but that were either maintained in vitro or in a field plot. We examined the starch content in 5-year-old field maintained *T. grandiflorum* clone 6 rhizomes, at dormant (29 Jan. 2002) and vegetative (30 March 2002) growth points, and compared it to the starch content of in vitro-maintained rhizomes. In vitro-maintained rhizomes had starch profiles similar to dormant, field-established rhizomes.

We also compared the starch content within *T. grandiflorum* clone 11 rhizomes that had been established in the field for less than 1 year or for more than 5 years. Rhizomes established in the field for less than 1 year had a starch profile similar to the starch profile found in the dormant 5-year-old field-maintained rhizomes.

Successful establishment of rhizomes in the greenhouse or field requires the production of roots. *Trillium discolor* rhizomes were cultured on proliferation or rooting media and placed in cold (4°C) or ambient laboratory (27°C) environments. Rhizomes were oriented either with the apical bud facing upright or sideways. Rhizomes oriented sideways rooted compared to upright-oriented rhizomes that did not root.

To determine the correct planting environment, rhizomes were placed either in tall black pots or deep seed flats. Rhizomes were potted using Metro Mix 510 and were cold treated at 4°C for 10 weeks after which they were potted in tall black pots and placed in a field shade house until the experiment was terminated at 42 weeks. There was no difference in weight gain, survival, rooting percentage, or root number during the course of the experiment.

We know that larger seedling-generated rhizomes flower earlier. We were interested in examining the effect of liquid culture on rhizome weight gain and subsequent effects on survival and rooting compared to gelled medium. In the laboratory, rhizomes were grown on either liquid or gelled medium for 12 weeks. Rhizomes in liquid gained significantly more weight. Fourteen of 18 rhizomes on liquid medium were vitrified and not planted out. However, the liquid-medium-treated rhizomes that were planted out survived and rooted better compared to the control rhizomes.

CONCLUSIONS

In-vitro-maintained rhizomes had starch profiles similar to dormant field-established rhizomes. A horizontal rhizome orientation improved rooting. Rhizomes survived a cold treatment equally well in tall black pots and deep seed flats. Liquid medium may be a better pre-establishment treatment compared to gelled medium.

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Developing Techniques to Produce Native Warm and Cool Season Grasses and Forbs in Missouri©

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BACKGROUND

There is a vast source of native plants in prairies and other natural areas with landscaping potential that could be planted for beautification in backyards, land restoration projects, and roadsides. Native plants maintain biological diversity necessary to provide food and cover for wildlife. Diversity also increases tolerance to diseases, pests, and climate extremes.

Interest in including native plants in landscaping has increased during the last decade (Diboll, 1997); however, commercially available prairie mixes usually include wildflowers and warm-season grasses. Very few include native cool-season grasses. Ideally, a prairie seed mix should contain both cool- and warm-season grasses for soil protection and to provide adequate conditions for biological activity throughout the year. Also the addition of native cool-season grasses to a selected seed mix would extend the planting period of seed mixes from fall to spring (Shirley 1994).

Some warm-season grasses recommended for soil conservation plantings, pasture, or wildlife habitat are Indian grass (*Sorghastrum nutans* L. Nash), little bluestem (*Schizachyrium scoparium* Michx. Nash var. *scoparium*),and Eastern gamma grass (*Tripsacum dactyloides*). Some non-native cool-season grasses are timothy (*Phleum pratense* L.), reed canary grass (*Phalaris arundinacea* L.), Kentucky bluegrass (*Poa pratensis* L.), and tall fescue (*Festuca arundinacea* Schreb) (Missouri Department of Conservation, 2001; Pitts, 1999). Tall fescue is one of the most planted grasses in pastures because it establishes well and provides good forage; however, tall fescue can encroach native vegetation and could be toxic to cattle and horses when consumed in high quantities (Randall and Marinelli, 1996). The University of Missouri is presently searching for native cool-season grasses that can be offered to landowners as alternatives to this and other invasive introduced grasses.

Native cool-season grasses grow well under the shade found in woodlands or in moist and dry prairies (Yatskievych, 1999) and are easily propagated from seed and tillers that develop around the original plant (Navarrete-Tindall et al., 2002). Some North American cool-season grasses found in Missouri are river oats (*Chasmanthium latifolium*), an attractive shade-tolerant grass used in landscaping; Canada wild rye (*Elymus canadensis*) and Virginia wild rye (*E. virginicus*), which grow well under full sunlight or moderate shade; oatgrass (*Danthonia spicata*), a ground-hugging grass which grows well in poor, dry and well drained soils, but maintains its foliage in mesic conditions in the summer; and prairie junegrass (*Koeleria macrantha*), a grass with fine foliage that remains green in the summer in moist conditions also (Kucera, 1998).

Two other cool-season grasses with excellent potential for landscaping or forage in agroforestry practices are paradox and nodding grasses (*Festuca paradoxa* and *F. subverticillata*) (Navarrete-Tindall et al., 2002). For more information about these and other grasses see Tables 1 and 2. Paradox grass, also known as cluster fescue, is found in forest openings and prairies and nodding grass grows under heavy shade in woodlands (Aiken and Leptovitch,1993; Kucera, 1998). Navarrete-Tindall et al. (2002) found that paradox grass grew well and produced seed under shade or full sunlight. Paradox grass maintains itself in natural prairies under some management. Mechlin (1999) reported that this grass responded better to summer burns than to spring burns in Tucker Prairie in Callaway County, Missouri.

The Missouri Ecotype Program. The Missouri Ecotype Program (MOEP) was created in 1997 to produce native grass and forbs seed for landowners wanting to establish natives for seed production in Missouri, and follows an approach similar to the Iowa Ecotype Program. The main objective of MOEP is to increase seed supplies of selected native forbs and grasses collected from three ecoregions in Missouri by establishing 1/10th acre seed production plots. The seed harvested from these plots will be distributed to landowners to establish plots for larger scale production. The seed harvested by private landowners will be used to fulfill Missouri's demand for future roadside plantings and habitat restoration.

Opportunities for Native Seed Producers and Grow Native! in Missouri. There are several nurseries and landowners that grow exclusively native plants and are certified as providers of local ecotype seed; however, the demand is growing and the amount of ecotype seed still does not meet the demand. The Missouri Department of Transportation has an agreement with the Missouri Department of Conservation through the Grow Native! Program to plant native species on right-of-ways to reduce mowing and for beautification. Four seed mixes are now recommended for planting under different soil conditions in right-of-ways (Grow Native, 2002). Each mix contains a variety of cool- and warm-season forbs and grasses including paradox grass, wild ryes, and river oats. The Missouri Department of Conservation, University of Missouri, the Plant Material's Center at Elsberry, other institutions and private landowners are helping to meet this demand by establishing seed production plots.

Ongoing Research on Native Plants. Little is known about the best prairie seed combination of warm and cool season grasses and forbs for poor sites in roadside plantings. The University of Missouri in cooperation with the Missouri Department of Conservation, the Center for Agroforestry, and the USDA Forest Service, North Central Research Station, are presently evaluating the effect of different ecological conditions on seed yields and persistence of different combinations of native grasses and forbs. The results of these studies may determine the best combinations of natives to be grown in poor soil conditions like those encountered in right-of-ways and under different shade levels found in agroforestry practices or in savannas.

We are presenting a series of basic steps to propagate native grasses and forbs for seed production plots as follows:

PROCEDURES TO ESTABLISH SEED PRODUCTION PLOTS OF NATIVE PLANTS

Collecting and Storing Seed. Seed is collected from prairies, prairie remnants, private areas, or forest openings by hand from July to December depending on the species. A list of six native cool-season grasses is included in Table 1. Seed is collected in paper bags and information about location and type of site is recorded. Seed is air dried and stored in cool and dry conditions at 5 to 10°C and cleaned manually or mechanically before treating the seed for germination.

Seed Treatments. Before planting seed may be stratified at 5°C at different time periods depending on the species. For example milkweed (*Asclepias* spp.) seed is planted in trays with moist growing medium with good water-holding capacity and good drainage, then trays are stored in coolers for up to 40 days, and covered with plastic to keep the growing medium moist.

Other seed, like *Baptisia* spp., is scarified manually or with hot water and planted directly in the soil. Most grasses do not require any seed treatment. Although some propagators recommend cold-dry or cold-moist stratification for some cool-season grasses like oatgrass, nodding, paradox, wild rye, and prairie june grasses, these grasses readily germinate without any seed treatment. Oatgrass germinates 2 to 4 days after planting and other grasses included in Table 1 germinate 10 to 25 days after planting at 20 to 25°C. Germination rates ranged from 80% to 95% for all grasses in Table 1.

Seed Germination. Seed can be started in the greenhouse at 20 to 25°C as early as February or March in small-plug trays (1 inch diameter by 2 inches deep) or in germination flats using a horticultural soil mix containing sphagnum moss, perlite, and vermiculite (7.5 : 1.5 : 1, by volume). Thirty or 40 days after germination, or when seedlings have a strong root system, seedlings are transferred to bigger plugs (2 inches diameter by 3 inches deep) and kept there for 2 to 4 months, depending on the species.

Establishing Seed Production Plots. Three- or four-month-old seedlings are established in tilled plots free of competing vegetation in the spring or fall. Plots are plowed and sprayed with glyphosate about a month before planting and seeded with perennial rye or other non-aggressive groundcover to avoid erosion. Seed production plots of different forbs and grasses are established at the Green Conservation Area of the Missouri Department of Conservation, the U.S.D.A.-N.R.C.S. Plant Materials Center in Elsberry, at the University of Missouri, Horticulture and Agroforestry Research Center in New Franklin, and at South Farm and by private landowners. The MOEP and its cooperators have established plots for 26 native species, including forbs and warm and cool season grasses. Information about seven out of these 26 is provided in Table 2.

Maintaining Seed Production Plots. Borders of plots are mowed two or three times a year and the area around seedlings is weeded manually or treated with selective herbicides twice a year. Seedlings are irrigated as needed soon after planting and forced to grow deeper roots by lengthening irrigation intervals later in the season.

Table 1. Characteristics of six perennial native cool-season grasses in the U.S.A.

Species	Habitat	Flowering period	Collection period	Seed persistence in plant
Chasmanthium latifolium (river oats)	Forests openings part shade to sunny	June-August	Sept.-Dec.	thru winter
Dantonia spicata (oatgrass)	Dry prairies, glades moderate shade to sunny	June-July	July	short period
Elymus canadensis (Canada wild rye)	Prairies, full sun or draws, moderate shade forest openings	May-June	July-Oct.	thru winter
Festuca paradoxa (paradox grass or cluster fescue)	Moist prairies dry prairies in draws forest openings	May-June	July-Dec.	thru winter
Festuca subverticillata (nodding grass)	Deep shade-woodlands	May-June	June-July	short period
Koeleria macrantha (prairie junegrass)	Prairies June moderate shade	July-August	July-Sept.	1 or 2 months

References: Hitchcock, 1971; Kucera, 1998; Shirley, 1994; Yatskievych, 1999; and personal observations.

Table 2. Climatic adaptations and information about seed production, price, and yield for seven species grown by the Missouri Ecotype Program.

Species	Climatic adaptations	No. seed per g	Price range[1] ($ per lbs)	Bulk seed/ acre[2] (lbs)
Asclepias tuberosa (butterfly weed)	Dry to mesic (full sunlight)	150	250-300	20
Coreosis palmata (prairie coreopsis)	Dry to mesic full sunlight-moderate shade)	350	320-1100	220
Dalea purpurea (purple prairie clover)	Dry to mesic (full sunlight)	650	25-110	86
Echinacea pallida (pale purple coneflower)	Dry to mesic full sunlight-moderate shade)	180	60-300	70
Penstemon digitalis (foxglove beard tongue)	Moist to mesic (moderate shade)	4600	150-220	43
Andropogon gerardii (big bluestem)	Dry to wet (full sunlight)	58	6-20	83
Elymus virginicus (Virginia wild rye)	Dry to moist (Full sunlight – moderate shade)	50	12-45	263

[1]Price range is for bulk seed produced by seed producers across the United States.
[2]Germination rate varies from 60% to 100% depending on the species.

Harvesting Seed from Seed Production Plots. Seed collection can begin the same year or the next year after planting, depending on the species. For example, wild rye, river oats, and some legumes like purple prairie clover (*Dalea purpurea*) can produce seed the same year of planting. Other species like paradox grass and cream wild indigo (*Baptisia bracteata*) produce seed 2 and 3 years after planting, respectively. Information about number of seeds per gram, range of seed prices, and approximate amount of seed produced per acre is given for some selected species in Table 2.

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Ground Cover Production on Plastic Mulch©

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INTRODUCTION

Sometimes you run across a good idea and just have to take advantage of it. That is what we have done to get a very efficient system to rapidly produce groundcover plants in the Florida climate. During the 1950s, the University of Florida developed a system at its Bradenton Gulf Coast Research Center to grow vegetables in Florida's sandy soils. This system concentrates fertilizer, holds moisture, and minimizes weed growth, plus it allows the grower to mechanize many functions. It is known as the plastic mulch system.

The soils in central Florida often are sandy and devoid of organic matter. In fact, when people see our soils, they want to know how we grow a crop in "that stuff." With that in mind, producers grow in an environment that mimics hydroponics. All the nutritional elements are added at some time during the process.

LAND PREPARATION

The system involves growing in a plastic-covered, banked row. To use this system there are certain land requirements. The land has to be leveled. You can have a slope, but the land can't have dips or hills. This is necessary to allow the water to flow freely without accumulating in the low-volume irrigation system. Also, it is helpful to have a shallow hard pan to hold the water level high in the soil profile.

As you know, Florida is flat — really flat. You can see for miles, but still it is necessary to level the land. On unprepared land, we use a laser level to set a slope of 2.5 cm (1 inch) drop every 30.5 m (100 ft). The laser system also fills holes and scrapes down rises. When the land has previously been used for crops, we use a device called a level board to smooth out the soil and fill any holes. The level board is pulled behind a tractor and consists of several blades set at angles to move the soil back and forth as it smooths.

Next, we plow water ditches about 5.5 m (18 ft) on center. The ditches are flooded to allow the water to seep laterally across the field and bring the moisture level up to a sufficient level. After hydrating the soil, a bed press gathers soil and forms a raised bed 15 cm (6 inches) high and 71 cm (28 inches) wide. During the same process, a bead of fertilizer is laid down the middle of the bed.

The next step is to fumigate the bed with methyl bromide, lay drip tape on top of the bed near the fertilizer strip, and then cover the bed with 2-mil plastic sheeting. A specialized piece of equipment does all of these functions in one process.

An additional device punches holes in the plastic and forms a cavity to receive plant or bib. This process is done 10 days to 2 weeks after the methyl bromide is injected. This time gives the gas a chance to sterilize the soil before it dissipates.