Cluster Fescue (*Festuca paradoxa* Desv.): A Multipurpose Native Cool-Season Grass

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Native cool-season grasses (NCSG) are adapted to a wide range of habitats and environmental conditions, and cluster fescue (*Festuca paradoxa* Desv.) is no exception. Cluster fescue can be found in unplowed upland prairies, prairie draws, savannas, forest openings, and glades (Aiken et al. 1996). Although its range includes 23 states in the continental United States (Figure 1), it is rarely abundant in natural stands. Cluster fescue is found scattered in some states such as Arkansas and Missouri (Yaskievych 1999); however, it occurs less frequently in Iowa, is listed of special concern in Tennessee, and is listed as endangered in Indiana, Maryland, and Pennsylvania (Natural Resources Conservation Service 2004).

NCSG are C3 grasses that utilize the Calvin cycle for CO_2 fixation in contrast to the more efficient warm-season grasses (WSG) that utilize both the Calvin cycle and the C4 pathway during photosynthesis. NCSG typically exhibit rapid vegetative growth in the fall and early spring and flower in mid- to late spring. The seed matures in early summer before plants become dormant during the hottest part of summer (Navarrete-Tindall et al. 2003, Yatskievych 1999). The growth season of NCSG can be extended when grown under shade in moist soils (Navarrete-Tindall et al. 2003). On the other hand, WSG start growing in late spring or early summer, bloom in the summer, and produce mature seed in late fall before becoming dormant. Many CSG such as tall fescue (*Festuca arundinacea*) are known to be infected by fungal endophyte. The relationship between endophytes and host grasses is a mutualistic relationship (Christiansen and Bennett 2003), beneficial for both grasses and fungi. Cluster fescue samples tested for the presence of endophyte in southern Illinois were found 100% infected (Spyreas et al. 2001).

Limited information is available on the ecological, physiological, and agronomic aspects or wildlife value of cluster fescue probably because it is not well known throughout its range. Yatskievych (1999) and Hitchcock (1971) indicate that cluster fescue lacks rhizomes and produces leaves 10 to 40 cm long with inflorescence panicles 12 to 20 cm long that droop at maturity. Cluster fescue is easily confused with the more shade-tolerant nodding fescue (*F. subverticillata*) (Aiken and Leptovitch 1993, Aiken et al. 1996). We have observed that cluster fescue seed is 3 to 4 mm long or slightly smaller than the seed of tall fescue with approximately 1,000 seed per gram (Navarrete-Tindall et al. 2003). Although the seed matures from June to July, harvest can be extended to October or later as seed remains in the panicles into the winter. Mechlin (1999) reported that cluster fescue produces more vigorous growth after summer burns than after spring burns in trials done at Tucker Prairie. Landowners and conservationists are interested in including NCSG for pasture restoration with native warm-season grasses to provide forage in the spring and fall when WSG are dormant. When seed is readily available, cluster fescue along with other NCSG such as manna grass (*Glyceria striata*), bottlebrush grass (*Elymus hystrix*), or Virginia wild rye (*E. virginica*) need to be planted in pastures with WSG to determine their competitive ability and suitability for wildlife habitat, conservation cover, and livestock forage (V.R. Shelton and W. Vassar personal communications).

The main goal of our studies has been to evaluate the ecological, physiological, and agronomic aspects of cluster fescue and other NCSG to promote their inclusion in natural areas and native plantings. Our main objective for this paper includes developing information on the effects of different planting times and plant spacing on seed production using seed collected from natural populations within several Missouri ecoregions. A second objective is to examine the persistence and effects of different light levels on growth of cluster fescue and other NCSG in replicated studies and demonstration areas in Missouri.

Natural Stands Identification, Seed Collection, and Seed Germination

Initially, we visited sites within the four ecoregions of Missouri where cluster fescue had been previously reported based on the Nomenclature Database of the Missouri Botanical Garden (Missouri Botanical Garden 2004) to study the natural history of cluster fescue and to collect seed (Erickson and Navarrete-Tindall 2004). We also visited several natural areas including prairies, state parks, back roads, and private properties to collect seed in collaboration with the Missouri Ecotype Program, the Plant Materials Center in Elsberry, and the Iowa Department of Natural Resources. We visited several sites and found that private sites had been developed and no longer maintained native vegetation or were not accessible. During the first year of the study, we found cluster fescue at Paintbrush Prairie in Pettis County and at Tucker Prairie in Callaway County. At the end of the second year, we had seed from a total of seven sites, two from Ecoregion 1, one from Ecoregion 2, and two from Ecoregion 3 of Missouri and two sites from southern Iowa.

In one experiment, we tested for the presence of hard and dormant seed of two seed sources collected in Ecoregions 1 and 2 of Missouri. The Missouri Seed Improvement Association in Columbia conducted the seed germination trials by first exposing seed to a moist-chilled environment for three days at 20°C and then placing on moist germination paper in growth chambers at 30°C. Seedling emergence was counted four times over the next 35 days without a purity analyses. Untreated, one-year old seed from Tucker Prairie produced 62% germination with 26% dormant seed. Freshly collected seed from Tucker Prairie and Paintbrush Prairie produced 1 and 2% germination with 89 and 88% dormant seed, respectively. This suggested that cold-moist stratification may be necessary for good seed germination.

Subsequently, we examined the effect of cold-moist stratification on germination of four seed sources in a greenhouse experiment. Initially seed was sown into 12 plastic 38-plug trays. The 5-cm by 7-cm tall plugs were filled with ProMix® 200 growing media. After watering, half of the trays were stored at 5°C in a walk-in cooler, and the second half were set in the greenhouse at 30°C. After 21 days, trays stored in the cooler were set in the greenhouse with the rest of the trays. Seed germination was determined every 10 days for 40 days. Percent seed germination varied depending on the source (Table 1). Average percent germination was slightly higher for stratified seed compared to nonstratified seed. Also seed collected from plants grown at the Horticulture and Agroforestry Research Center (HARC) in New Franklin from seed originally collected at Tucker Prairie had higher percent germination than freshly collected seed from Paintbrush Prairie.

Seed Production Plots

In 2002, we established a study to determine the effect of planting time and plant spacing on growth and seed yield of cluster fescue. Trays from the seed germination experiment were set on wire-top tables for four months to allow the root system to develop (B. Erickson, personal communication). Half of the four-month-old seedlings were planted in the fall of 2002 into plots seeded with perennial ryegrass at the Horticulture and Agroforestry Research Center. Seedlings were planted in rows spaced 90 cm apart with plugs planted 30, 60, or 90 cm apart. Remaining seedlings were overwintered in a walk-in cooler and planted the following spring in plots adjacent to the fall-planted seedlings. Analysis of results from this experiment established as a split plot design with three replications show no differences for tiller number or height or foliage biomass when seedlings were planted 30, 60, or 90 cm apart. Seedlings established in the fall were larger and produced more seed than those planted the following spring (Table 2). Seed yields were approximately 119 kg/ha for seedlings planted in the fall and only 20 kg/ha for seedlings established the same year in the spring. Only seedlings established in the spring with little or no seed production persisted into a second year when they yielded a heavy crop of seed and then died.

Cluster Fescue Natural Regeneration

Because plants may not persist after heavy seed yields, we decided to determine if plant populations persist through natural regeneration and if cluster fescue could effectively suppress other competition from the seed bank. To do this, we placed four 40 by 40 cm Anderson® trays filled with ProMix® 200 medium in each of the seed production plots. We left trays in the field during the fall and winter and brought them to the greenhouse in early spring to observe germination. Trays were watered three times a week. Three months later, we counted the number of seedlings of cluster fescue and other vegetation. We found the number of cluster fescue seedlings per m^2 was higher for trays set in seed production plots when plants were 30 cm apart than for seed production plots when seedlings were established 60 or 90 cm apart (Table 3). Total number of seedlings of perennial rye, other grasses, and forbs was 178, 158, and 250 seedlings per m^2 for plants planted 30, 60, and 90 cm apart, respectively. Our results are similar to results from other studies done at Tucker Prairie, where yearly environmental fluctuations had little effect on cluster fescue reproduction over a nine-year period (Rabinowitz et al. 1989).

Shade Tolerance Trials in Field Conditions and Demonstration Plots

Because NCSG are well adapted to light to moderate shade, we examined productivity of cluster fescue to that of seven other NCSG under artificial and natural shading. In summer 2003, four-month-old seedlings of cluster and nodding fescue, river oats (*Chasmanthium latifolium*), Canada wild rye, Virginia wild rye, bottlebrush grass, prairie junegrass (*Koeleria macrantha*), and fowl manna grass were established as row plots in 5 x 10 m irrigated plots covered with 2 m tall frames. Frames were left uncovered or covered with 30% or 50% shade cloth. This split plot experiment with three replications is being repeated because of poor survival when in competition with perennial ryegrass at the Horticulture and Agroforestry Research Center. In summer 2003, seedlings of the same eight species were also established under the shade of a thinned 15-year-old sweetgum planting at the Turf Research Center near Columbia. Crown cover and light were measured to determine shade levels. We plan to evaluate survival, forage and seed production, and forage quality in both experiments for three years. It is anticipated our findings will help us to make future recommendations for inclusion of NCSG in several agroforestry practices, the restoration of savanna and woodlands, and the creation of native wildlife habitat and landscapes.

Demonstration Plantings

Additional test and demonstration plots for cluster fescue and other NCSG have been established in Columbia, New Franklin, and Sedalia (Table 4). The purposes of our demonstration plots are to increase public awareness of the importance of including NCSG in restoration and wildlife projects and to make seed available to other researchers, conservationists, and seed producers. These plots are used for field days and open to the public. We continue to monitor ease of establishment, persistence, plant growth, and seed production at each of these demonstration plantings.

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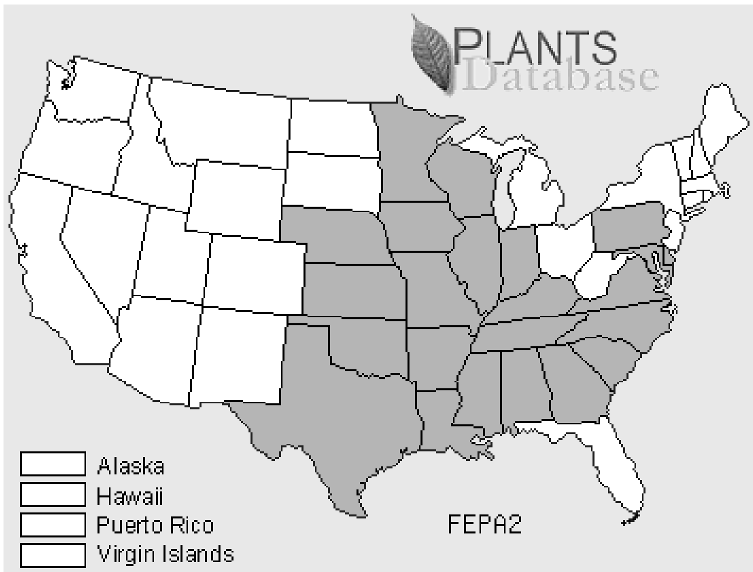

Figure 1. States where cluster fescue (*Festuca paradoxa* Desv.) is naturally found. (Syn: *Festuca nutans* Biehler and *Festuca shortii* Kunth ex Wood)
Source: Adapted from USDA NRCS 2004 Web site:http://plants.usda.gov/.

Alabama	Illinois	Kentucky	Mississippi	Oklahoma	Texas
Arkansas	Indiana	Louisiana	Missouri	Pennsylvania	Virginia
Delaware	Iowa	Maryland	Nebraska	South Carolina	Wisconsin
Georgia	Kansas	Minnesota	North Carolina	Tennessee	

Table 1. Mean percent germination of six 38-plug trays 40 days after sowing of cluster fescue seed collected in 2003 from four locations in Missouri.

Stratification	**Tucker**	**New Franklin***	**Cosmo Park***	**Paintbrush**
	----------	---------- %	----------	----------
No	37	42	36	10
Yes	38	52	39	12

* Second generation of seed originally collected at Tucker Prairie in 2002.

Table 2. Average tiller number and height for cluster fescue seedlings field-planted in fall 2002 or spring 2003 and average foliage and seed dry weight when harvested in July 2003.

Planting Time	Tiller Number*	Tiller Height*	-----Plant Dry Weight---- Foliage*	Seed*
	-no.-	-cm-	-g/plant	-g/plant-
Fall '02	15	77	7.6	2.7
Spring '03	6	58	1.4	0.9

* Values in columns are significantly different at the 0.05 level of probability according to Duncan's multiple range test.

Table 3. *Festuca paradoxa* seedling regeneration in the presence of a seed bank of perennial rye and other volunteer vegetation.

Stock Plant Spacing	*Festuca paradoxa*	*Perennial Rye*	*Other Grasses*	*Horse Weed*	*Other Forbs*
	no. seedlings/m²				
30 cm (1 ft)	*184*	*20*	*20*	*105*	*31*
60 cm (2 ft)	*59*	*26*	*7*	*118*	*7*
90 cm (3 ft)	*53*	*39*	*59*	*138*	*13*

Values are averages from 12 trays.

Table 4. *Location, NCSG species, establishment year, and purpose of demonstration plots established in Missouri to evaluate growth and seed production of cluster fescue.*

Cosmo City Park, Columbia	*Cluster fescue*	*2002*	*Planted with other native species for ornamental purposes*
UMC-South Farm, Columbia	*Cluster fescue and manna grass*	*2003*	*To show plant competition with two invasive introduced grasses*
UMC-South Farm, Columbia	*Cluster fescue*	*2003*	*Weed control with and without weed barrier fabrics to protected plants*
Horticulture and Agroforestry Research Center (HARC), New Franklin	*Several NCSG, NWSG, and native legumes and forbs*	*2003*	*Established in the Plant Hardiness Zone 5 arboretum*
Bradford Research and Extension Center (BREC), Columbia	*Cluster fescue, other NCSG, NWSG, and native forbs and shrubs*	*2004*	*Established seed production plots for several Missouri and Iowa seed collections*
Recently upgraded intersection right-of-way near Sedalia	*Cluster fescue*	*2004*	*Hydroseeding of cluster fescue seed at 0.5 lb per 1000 ft² (24 kg/ha)*

Sandhill Restoration: Structure and Process

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Abstract

The Nature Conservancy's Northwest Florida Program is involved in an ambitious sandhill community restoration at the Apalachicola Bluffs and Ravines Preserve, Liberty County, Florida. In the late 1950s, the St. Joe Paper Company clear cut longleaf pines (*Pinus palustris*) and pushed remaining vegetation and topsoil into windrows to establish a slash pine (*Pinus*