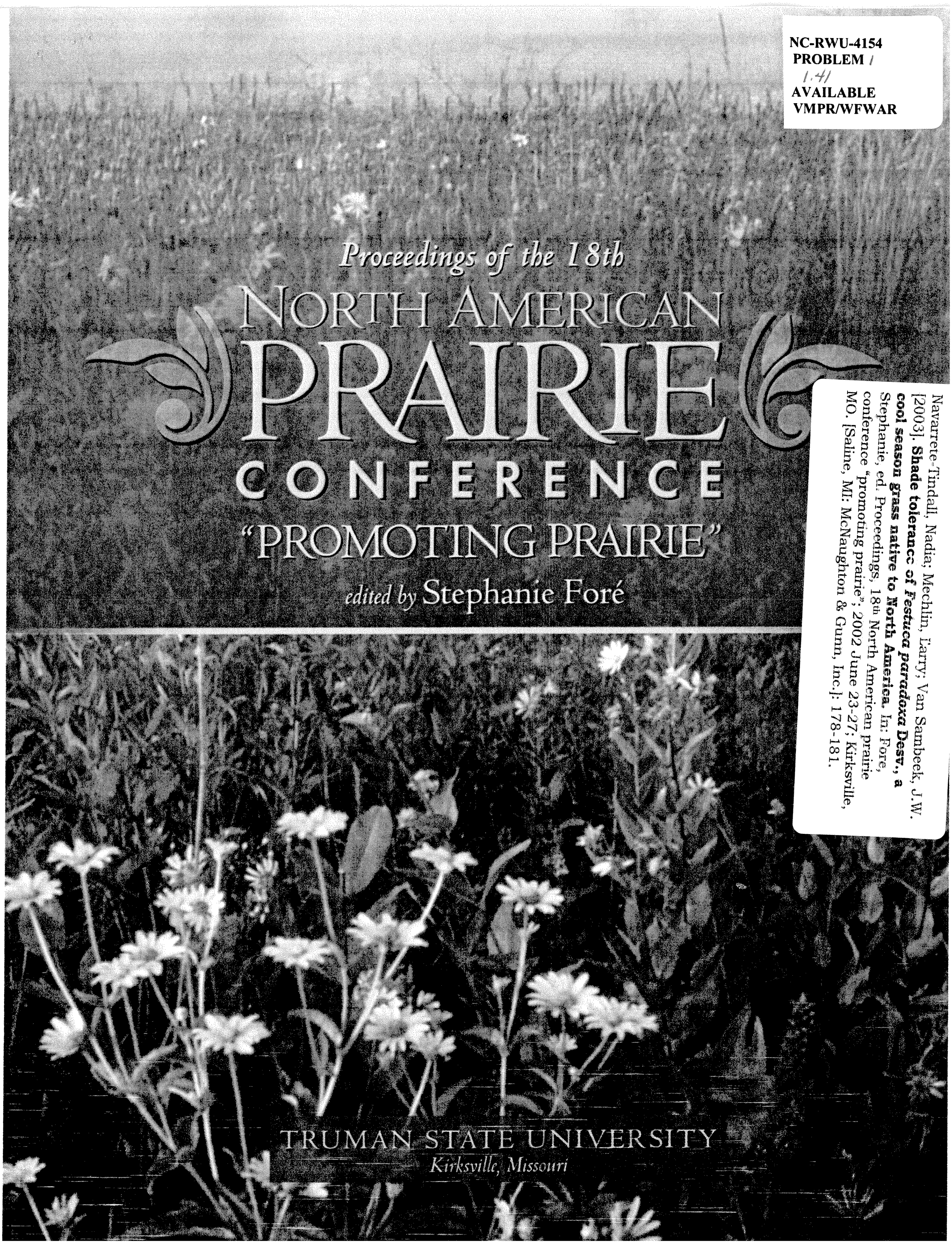

Proceedings of the 18th

NORTH AMERICAN PRAIRIE CONFERENCE

"PROMOTING PRAIRIE"

edited by Stephanie Foré

TRUMAN STATE UNIVERSITY
Kirksville, Missouri

CONTENTS

PREFACE v

PART 1. INVITED PAPERS

Conservation priorities on fragmented, homogenized Great Plains landscapes . . . . . *DM Engle, SD Fuhlendorf, BR Coppedge* 1

Grow Native! Connecting conservation and commerce from the backyard to the back forty . . . . . *J Allmon* 7

PART 2. SYMPOSIUM — NATIVE PLANT MARKET NICHES

Wild Ones Natural Landscapers: Gardening with native plants in St Louis region for three years . . . . *S Woodbury* 10

Creating native gardens . . . . . *A Wakeman* 10

Selling native plants in the retail garden center: Challenges and opportunities . . . . . *N Hamill* 11

Growing native plants for fun, or profit? . . . . . *N Diboll* 11

MoDOT and the expansion of native use on roadsides . . . . . *S Armstrong* 12

Small-scale field production of forb seed . . . . . *RS Arndt* 13

PART 3. CONTRIBUTED PAPERS

EDUCATION, OUTREACH, AND ORGANIZATIONAL INITIATIVES TO PRESERVE PRAIRIE

Student-generated field guides teach about identification of local prairie plants and animals . . . . . *GD Bisbee* 14

The coastal prairie habitat as a model to promote sustainability in the agricultural curriculum . . . . . *B Borsari* 17

Status of railroad prairies in west central Illinois . . . . . *AK Moorehouse* 24

Innovative land acquisition and fund-raising techniques used to preserve a threatened Missouri prairie . . . . . *AL Thomas, G Galbraith* 27

RESTORATION AND RECONSTRUCTION OF PRAIRIE

Ecosystem restoration at the landscape scale: Design and implementation at the Efroymson Restoration at Kankakee Sands . . . . . *CH O'Leary, JA Shuey* 30

The prairie reconstruction at Kaufmann Museum in south central Kansas . . . . . *DR Platt, LH Harder* 41

Comparison of planting treatments in a tallgrass prairie restoration . . . . . *TA Aschenbach, K Kindscher* 44

Soil carbon assessment across a native prairie restoration chronosequence . . . . . *CA Cambardella, TM Isenhart, KE Schilling, P Drobney, RC Schultz* 49

Restoration of a prairie–savanna mosaic in northern Missouri . . . . . *GW Hartman* 54

Spring haying as an alternative to spring burning on a reconstructed roadside prairie . . . . . *D Tix, I Charvat* 58

Are there keystone plant species driving diversity in Midwest prairies? . . . . . *RA Henderson* 63

The efficacy of herbicides for eradicating tall fescue . . . . . *ME Ruffner, TG Barnes* 67

Prairie restoration at Midewin National Tallgrass Prairie . . . . . *W Glass, E Ulaszek* 75

Remnants to roadsides: The Iowa Ecotype Project . . . . . *G Houseal* 78

From borrow pit to long-term prairie study site . . . . . *D Geiger, D Conover, A Wischmeyer, D Brannen, L Jablonski* 85

The Cajun Prairie Gardens: Demonstrations of sustainable landscaping in southwestern Louisiana . . . . *MF Vidrine, GJ Quillman-Vidrine , DJ Vidrine, CE Vidrine* 95

Effects of small herbivores on a grassland undergoing restoration . . . . . *M Murphy, M Stokes, T Cummins, B Legg* . . . 100

MANAGEMENT, INVENTORY, AND ASSESSMENT

Using spatially oriented databases as a tool to manage roadside prairie remnants . . . . *C Shulse, A Houchins, T Wren, S Armstrong* . . . 111

A comparison of nested quadrant and point–line intercept sampling methods for fire effects monitoring in shortgrass prairie . . . . *PK Benjamin, JA Stumpf, NB Pavlovic* . . . 116

Ecosystem restoration at the landscape scale: Assessing conservation success at the Efroymson Restoration at Kankakee Sands . . . . *JA Shuey, CH O'Leary* . . . 124

Water quality in streams of Tallgrass Prairie National Preserve: Inferences from chemical, physical, and macroinvertebrate data . . . . *WM Rizzo, GD Willson, JF Fairchild* . . . 127

Reed canary grass control (Displacement by a diverse native-species mix) . . . . *C Kurtz* . . . 136

PRAIRIE AS POLLUTION CONTROL AND ENVIRONMENTAL IMPROVEMENT

The effects of tallgrass prairie restoration on soil quality indicators . . . . *VL McKinley, R Wolek* . . . 138

The control of the nitrogen cycle as a mechanism for the self-organization of prairie ecosystems . . . . *NS Allen, SH Emerman* . . . 151

PRAIRIE ECOLOGY

Comparison of managed cemetery and unmanaged railroad mesic prairie remnants in central Illinois . . . . *EA Corbett, GA Corbett* . . . 157

The vascular plant community composition of three fens in the Sandhills of Nebraska . . . . *M Borgmann-Ingwersen, J Jonas* . . . 164

Flowering phenology of Cajun Prairie plants . . . . *CM Allen, MF Vidrine* . . . 174

Shade tolerance of *Festuca paradoxa* desv., a cool-season grass native to North America . . . . *N Navarrete-Tindall, L Mechlin, JW Van Sambeek* . . . 178

Genetic variation in two prairie plant species populations: A comparison of native remnant populations and populations derived from collected seed. . . . . *CA Hilker, JE Jurgenson* . . . 182

Western prairie fringed orchid: Its status, ecology, and in vitro propagation . . . . *J Sharma, JW Van Sambeek, CJ Starbuck* . . . 189

Foraging ecology of selected prairie wildflowers (*Echinacea, Liatris, Monarda,* and *Veronicastrum*) in Missouri prairie remnants and restorations . . . . *RR Clinebell II* . . . 194

Observations on the status of the Dakota skipper at Prairie Couteau in Pipestone County, Minnesota . . . . *DW Schlicht* . . . 213

Tebenna silphiella (Grote, 1881) (Lepidoptera: Choreutidae): A prairie moth is rediscovered in Wisconsin and Illinois . . . . *EH Metzler, RA Henderson, LA Ferge* . . . 217

PART 4. ABSTRACTS OF OTHER PAPERS AND POSTERS PRESENTED 219

SHADE TOLERANCE OF *FESTUCA PARADOXA* DESV., A COOL-SEASON GRASS NATIVE TO NORTH AMERICA

Nadia Navarrete-Tindall, University of Missouri, 202 Natural Resources Building, Columbia MO 65211 USA
Larry Mechlin, Resource Science Center, Missouri Department of Conservation, 1110 South College Avenue, Columbia MO 65211 USA
JW Van Sambeek, North Central Research Station, US Department of Agriculture Forest Service, Columbia MO 65211 USA

Abstract: Paradox grass (*Festuca paradoxa* Desv.) is a native cool-season grass found in prairies and forest openings. Paradox grass has not been included in tree plantings. To determine paradox grass adaptation to shaded environments, we established a pot experiment in the shade laboratory at the University of Missouri Horticulture and Agroforestry Research Center in New Franklin, Missouri. We grew paradox grass for 2 consecutive years to determine the effects of 0%, 55%, or 80% shade on growth, forage quality, flowering, and seed production. Cumulative biomass from 2 harvests at year 2 averaged 468 to 766 g/m^2 originally established with 30 seedlings/m^2. All plants flowered with the greatest number of panicles under full sun. Seed yield ranged from 66 g/m^2 under heavy shade to 138 g/m^2 under full sun. Protein averaged 7.4% under full sun and increased to 12.3% under shade. Neutral detergent fiber, primarily indigestible cell wall constituents, averaged 37% under full sun and 46% under shade. Because paradox grass grows well under full sun or moderate shade, it may be a suitable native cool-season grass for inclusion in native plantings and agroforestry practices.

Key words: cluster fescue, native fescue, paradox grass, native grasses, forage quality, forage yield

Little is known about using native cool-season grasses in agroforestry practices in the Midwest. Also, most of the grasses recommended for soil conservation or wildlife habitat are native warm-season grasses like little bluestem (*Schizachyrium scoparium* (Michx.) Nash var. *scoparium*), Eastern gama grass (*Tripsacum dactyloides* L.), and Indian grass (*Sorghastrum nutans* L. Nash); or non-native cool-season grasses like timothy (*Phleum pratensis* L.), reed canary grass (*Phalaris arundinacea* L.), and Kentucky bluegrass (*Poa pratensis* L.). These grasses are used because they are easy to establish and provide cover and refuge for wildlife[1]; however, native cool-season grasses should be included to increase biodiversity.

We are searching for native cool-season grasses that could establish and compete with warm-season grasses and forbs under full sun or shade. Paradox grass or cluster fescue (*Festuca paradoxa* Desv.) is a cool-season grass that is native to eastern and central North America[2,3] and distributed in 23 states in the continental United States[4]. Paradox grass lacks rhizomes, has 10- to 40-cm-long leaves, up to 1.2-m-long panicles, and panicles that droop at maturity[2,5]. It is found under full sun in prairies and under moderate shade in forest openings and prairie draws[2]. It is found scattered throughout Missouri[3]; however, only 2 areas have been identified recently where paradox grass grows abundantly. Paradox grass can be confused with the native nodding grass (*Festuca subverticillata* Pers.); however, nodding grass is only found growing under heavy shade in natural wooded stands[6].

Unlike the non-native tall fescue (*F. arundinacea* Schreb.) that has replaced diverse native herbaceous communities[7], native fescues are not invasive. An 8-y-old study showed that paradox grass was persistent at Tucker Prairie and maintains itself in competition with more common grasses[8]. More recent studies conducted at Tucker Prairie demonstrated that paradox grass responded well to summer burns, producing seed the following fall, while spring burns favored warm-season grasses[9].

Seed prairie mixes usually include warm-season grasses and forbs and a few native cool-season grasses. The addition of paradox grass or other grasses like Canada or Virginia wild ryes (*Elymus canadensis* L. and *E. virginicus* L.) and river oats (*Chasmantium latifolium* (Michx.) H.O.) to seed mixes would introduce the native cool-season grass component and would provide forage for wildlife or cattle in early spring and fall. Several native prairie mixes now recommended by Missouri's Grow Native! Program for soil conservation in rights-of-way will include paradox grass, Virginia wild rye, and river oats in addition to native warm-season grasses and forbs[10].

Endophytic fungi are known to form a mutualistic association with fescue grasses, protecting them from pests and diseases, but the alkaloids produced can be detrimental for cattle and horses when consumed in large quantities[11,12]. Samples of paradox grass collected from the wild in Illinois were reported to be highly infected with endophytic fungi[13]. During preliminary observations at the University of Missouri, these fungi were not found in paradox grass seed collected at Tucker Prairie.

Paradox grass is established by direct seeding or asexually from tillers that develop around the crown of the original seedling, and 2-y-old plants flower in the spring from multiple tillers (personal observations). Seed matures as early as the 1st week of July and can be harvested into the fall because seed persists in the panicles. There are approximately 1000 seeds per gram, and 70% to 80% of the seed germinates 10 to 12 d after planting at 20° to 25°C without any seed treatments.

Information about forage quality of paradox grass was not found. Two of the most common parameters to test forage quality are protein and neutral detergent fiber (NDF) content. NDF primarily is slowly digested or indigestible hemicellulose, cellulose, and lignin found in cell walls[14], in contrast to the more digestible compounds like sugars, less complex carbohydrates, and protein. Protein contains on average 16% nitrogen and is estimated by multiplying 6.25 by percent nitrogen. Information on protein content and NDF is needed before paradox grass can be recommended for planting as forage or for wildlife habitat improvement both under full sunlight and shade. The objective of our study was to determine how shade affects growth, forage quality, flowering, and seed production of paradox grass.

METHODS

Paradox grass seed was harvested in July from Tucker Prairie in Callaway County, Missouri, and planted in the greenhouse in germination trays the following February. Seedlings were individually transplanted into 5-cm dia×7-cm deep plugs in April. One month later, 3 plugs were transplanted to white 7.6-L pots with a surface area of 480 cm^2. Growing medium consisted of equal parts of quartz sand, sphagnum peat moss, and finely crushed pine bark prepared on site. The fertilizer Osmocote Slow Release Plant Food! (Scotts Co) was added at a rate of 500 g/m^3 of medium.

After planting, pots were immediately transferred to the shade tolerance laboratory at the Horticulture and Agroforestry Research Center in New Franklin, Missouri. This outdoor laboratory consists of 9 rectangular frames (5 m wide×15 m long×2.5 m high). Three frames each were covered with 55% or 80% polypropylene shade fabric to provide shade. Pots were placed on white gravel 0.7 m apart within each frame. Plants were maintained near field capacity with drip irrigation. Pots were covered in mid-November with heavy white plastic and a 6-mm-thick nursery blanket (Hummert International) to protect them from freezing in the winter. The covering was removed the following May.

We harvested the aboveground biomass in September of the 1st growing season. The 2nd year, 3 of 6 pots within each frame were harvested in early June (before anthesis) and again in September. The other 3 pots were harvested in late July when seed was mature, and again in September. We counted the number of panicles and then harvested and air-dried the seed before weighing. Aboveground biomass was cut to a 2.5-cm stubble and oven dried at 55°C for 2 d before weighing.

To measure forage quality we determined neutral detergent fiber (NDF) by using an ANKON200 Fiber Analyzer (ANKON Technology) and protein by determining percent nitrogen with a LECO Model FP-528 Nitrogen Determinator (LECO Corp). To determine NDF, 0.5 g of oven-dried sample is weighed and placed in an ANKON F57 filter bag (ANKON Technology) before boiling in an acid detergent (soap) solution for 1 h. The liquid containing starch, sugar, protein, and other compounds is discarded. To determine NDF, the residue is oven dried at 105°C for 2 h and weighed.

The experiment was established as a randomized complete block design with 3 shade levels (0%, 55%, and 80%) and 3 replications. Data from individual pots within each replication were averaged to determine treatment means and subjected to ANOVA. When ANOVA showed significant differences at the $P=0.05$ level, Duncan's new multiple range test was used to separate the means.

RESULTS AND DISCUSSION

Aboveground biomass varied depending on the time of the year foliage was harvested (Table 1). During the 1st year, dry weight was higher for plants grown under 0% and 55% shade than for those grown under 80% shade. During the 2nd year, cumulative biomass for established plants harvested in June and again in September was similar to cumulative biomass of plants harvested in July and again in September for all shade levels. The lowest aboveground biomass was obtained in September from pots previously harvested in July. Plants harvested in June initiated regrowth before summer, while plants harvested in July remained dormant during the hot summer with minimal regrowth in the fall.

All paradox grass plants flowered in June during the 2nd growing season (Table 2). The number of flowering stems was higher for plants grown under 0% shade than for plants grown under 55% and 80% shade. No significant differences were observed for seed dry weight among shade levels; however, there was a trend for seed production to decrease with increasing shade. Seed matured on plants under full sun 2 weeks earlier (1st week of July) than seed on plants growing under shade (3rd week of July).

Table 1 Plant biomass (g/m^2 dry weight) of paradox grass foliage grown in pots for 2 y

COLLECTION DATE	SHADE LEVELS		
	0%	55%	80%
September year 1†	260 a	318 a	216 b
June year 2‡	504 a	477 a	245 b
September year 2‡	88 b	288 a	223 a
July year 2*	492 a	553 a	505 a
September year 2*	68 b	92 ab	104 a

†First year; all plants were harvested once in the fall.
‡Harvested in early spring and again in the fall of year 2
*Harvested in late spring and again in the fall of year 2
Average values in rows followed by different letters are significantly different at the 0.05 level of probability, according to Duncan's multiple range test.

Table 2 Number of flowering stems and seed biomass of paradox grass at year 2[a]

VARIABLE	SHADE LEVELS		
	0%	55%	80%
Flowering stems	38 a	22 b	17 b
Seed dry weight (g/m^2)	138 a	115 a	66 a

[a]Average values in rows followed by different letters are significantly different at the 0.05 level of probability, according to Duncan's multiple range test.

The aboveground biomass NDF ranged from 37% to 46% and was higher for plants grown under 80% shade than for plants grown under moderate or no shade (Table 3). Values for paradox grass were lower than the values of 55% to 64% for Kentucky blue, orchard, smooth bromegrass, tall fescue, timothy, and annual rye grasses[15]. Their NDF values were higher than in our study possibly because we collected our samples when plants were still vegetative and less mature. Other studies suggest that shaded plants store less nonstructural carbohydrates and have thinner leaves with less of the more easily digested mesophyll tissues than plants in full sun[16].

Protein content of paradox grass harvested in September of year 1 and in June of year 2 growing under full sun averaged 8.5% and increased to 12.3% under 80% shade (Table 3). Other studies have also shown that protein increases with increasing shade[15,17]. The relatively low protein content of paradox grass in our study may be a consequence of growing plants with irrigation in the same medium for 2 y without applying additional fertilizer. Compared to plants in full sun, shaded plants store less soluble carbohydrates and produce more lignin resulting in higher protein content[18].

CONCLUSION

Our results indicate that paradox grass grows well under moderate shade or full sunlight. Paradox grass may be more digestible than most introduced cool-season grasses and in the growing stage may be comparable to those of forage legumes.

The best time to harvest paradox grass for us was at the boot stage before anthesis where some regrowth occurs before plants become dormant for the summer. In addition at boot stage indigestible NDF is relatively low.

Although the number of panicles and seed production was higher for plants grown under full sunlight, seed was produced at 55% shade—levels expected under trees in a well-managed agroforestry practice—and at 80% shade—levels expected under trees in managed woodlands.

Table 3 Fiber analysis and protein content of paradox grass grown under 3 shade levels[a]

COLLECTION DATE	SHADE LEVELS					
	0%	55%	80%	0%	55%	80%
	NEUTRAL DETERGENT FIBER (%)			PROTEIN CONTENT (% NITROGEN×6.25) (%)		
September year 1	37c	40 b	44 a	7.4 b	8.9 b	12.3 a
June year 2	42 b	43 b	46 a	9.6 b	9.5 b	12.3 a

[a]Average values in rows followed by different letters are significantly different at the 0.05 level of probability, according to Duncan's multiple range test.

ACKNOWLEDGMENTS

Sara Cawthon, Monica Deuschle, Steven Kirk, Randy Tindall, and the Horticulture and Agroforestry Research Center staff for technical support. In addition, we appreciate the assistance of Monty Kerley and his laboratory staff when evaluating forage quality.

CITED REFERENCES

1. Missouri Department of Conservation. Rich grasslands for Missouri landowners. Jefferson City: Missouri Department of Conservation; 2001. 36 p. Available from: www.conservation.state.mo.us/landown/documents. Accessed 2003 Jul 19.
2. Hitchcock A. Manual of the grasses of the United States. New York: Dover Pub; 1971. 2 volumes.
3. Steyermark JA. Steyermark's flora of Missouri. Volume 1. Rev ed. Yatskievych G, editor. Jefferson City: Missouri Department of Conservation; 1999. 953 p.
4. US Department of Agriculture–Natural Resources Conservation Service. Plant profile for *Festuca paradoxa*. The PLANTS Database Version 3.5. Baton Rouge (LA): National Plant Data Center; 2002. Available from: http://plants.usda.gov. Accessed 2003 Jul 19.
5. Aiken SG, Dallwitz MJ, McJannet CL, Consaul LL. *Festuca* of North America: Descriptions, illustrations, identification, and information retrieval. DELTA online database; 1996 onwards. Available from: www.biodiversity.uno.edu/delta/festuca. Accessed 2003 Jul 19.
6. Aiken SG, Leptovitch LP. On the separation of two species within *Festuca* subg. *Obtusae* (Poaceae) Taxon. J Int Assoc Plant Taxon 1993;42:323–37.
7. Randall JM, Marinelli J. Invasive plants: Weeds of the global garden. Brooklyn (NY): Brooklyn Botanic Garden; 1996. 111 p.
8. Rabinowitz D, Rapp JK, Cairns S, Mayer M. The persistence of rare prairie grasses in Missouri: Environmental variation buffered by reproductive output of sparse species. Am Nat 1989;134:425–544.
9. Mechlin L. Unpublished project update. Assessment of a prairie restoration technique utilizing

native prairie hay. Columbia: Missouri Department of Conservation; 1999. Available from: Missouri Department of conservation, 1110 S College Avenue, Columbia, MO 65211.

10. Navarrete-Tindall NE, Erickson B. Developing techniques to produce native warm- and cool-season grasses and forbs in Missouri. International Plant Propagators Society Combined Proceedings. 2002;52:429–34.
11. Clay K. Fungal endophytes of grasses: A defensive mutualism between plants and fungi. Ecology 1988;69:10–6.
12. Ball DM, Pedersen JF, Lacefield GD. The tall fescue endophyte. Am Sci 1993;81:370–9.
13. Spyreas G, Gibson DJ, Basinger MJ. Endophyte infection levels of native and naturalized fescues in Illinois and England. J Torrey Bot Soc 2001;128:25–34.
14. Grant R. Evaluating the feeding value of fibrous feeds for dairy cattle. G91-1034. Lincoln: University of Nebraska Cooperative Extension; 1996. Available from: www.ianr.unl.edu/pubs/Dairy/g1034.htm. Accessed 2003 Jul 19.
15. Lin CH, McGraw RL, George MF, Garrett HE. Nutritive quality and morphological development under partial shade of some forage species with agroforestry potential. Agrofor Sys 2001;53:269–81.
16. Allard G, Nelson CJ, Pallardy SG. Shade effects on growth of tall fescue: I. Leaf anatomy and dry matter partitioning. Crop Sci 1991;31:163–7.
17. Huck MB, Kerley MS, Garrett HE, McGraw RL, Van Sambeek JW, Navarrete-Tindall NE. Effect of shade in forage quality. In: Schroeder W, Kort J, editors. Temperate agroforestry. Proceedings of the Seventh Biennial Conference on Agroforestry in North America and the Sixth Annual Conference of the Plains and Prairie Forestry; 2001 Aug 13–15; Regina, Saskatchewan, Canada. Regina Saskatchewan (Canada): Assoc Temperate Agroforestry; 2001. p 125–34.
18. Deinum B. Climate, nitrogen, and grass: Some effects of light intensity on nitrogen metabolism. Netherlands J Agr Sci 1971;19:184–8.