Virginia Cooperative Extension
Virginia Tech • Virginia State University

Publication CSES-55P

Yield Potential of Native Warm-Season Grasses Grown in Mixture

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Introduction

Farmers must respond to variations in weather almost every growing season. In the coming years though, farmers may be faced with unprecedented climate change. New climate patterns and more extreme drought may become the norm in response to rising global temperatures and carbon dioxide concentrations (Solomon et al. 2007). The rising cost of fertilizers and other inputs are a growing concern as well. To deal with these issues, forage-livestock producers may want to look toward using alternative forages like native warm-season grasses (NWSG).

These grasses were once part of native grasslands that covered much of the United States before Europeans arrived. Some of the more common species include switchgrass, big bluestem, Indiangrass and eastern gama grass. Historically, these grasses have seen limited use in forage-livestock operations here in Virginia, where most pasture and hayland is dominated by cool-season grasses like tall fescue and bluegrass.

Because of their physiology, NWSG grow most vigorously in summer when cool-season grasses grow slowly or not at all. Because of the differences in growth, adding pastures that contain NWSG to a farm can provide much-needed forage during the so-called "summer slump" of forage production. Also, due to their physiology, NWSG tend to use nitrogen very efficiently. This means these grasses can produce a lot of dry matter with minimal fertilization. Moreover, this characteristic allows these grasses to be planted on more marginal ground and still thrive. We have found that NWSG pastures under grazing can produce 6 to 7 tons DM per acre with no fertilization (Tracy et al. 2010). In addition, the deep rooting systems of NWSG make them quite drought-tolerant. Although the forage quality of NWSG can be lower than its cool-season counterparts, proper management can ensure adequate nutritional value for nonlactating cows (Bonin and Tracy 2011).

Plots of native warm-season grass mixtures the year of establishment (2008) in Blacksburg Va. Fast-establishing black-eyed Susan (yellow daisy-like flowers in photo) dominated many mixture plots in Year 1 but largely disappeared by Year 2.

According to some studies, mixtures of NWSG can yield more than monocultures (Tilman, Hill, and Lehman 2006; DeHaan et al. 2010). How diverse or complex these polycultures should be to provide the most yield benefit has not been well-studied. A question also arises about whether adding native legumes and broadleaf forbs could benefit the forage yield of NWSG mixtures and improve nutritive value for cattle. To address these questions, we conducted a study using 10 native prairie plant species grown in monoculture and mixtures of two, four, six, and all 10 species. A major goal of this study was to determine whether diverse mixtures of NWSG and other broadleaf forbs would yield more than monocultures.

Produced by Communications and Marketing, College of Agriculture and Life Sciences, Virginia Polytechnic Institute and State University, 2013

VT/0713/CSES-55P

Procedures

This study was conducted over a four-year period in Blacksburg, Va. Soil was primarily well-drained Unison and Braddock cobbly soil on a relatively even surface. Initial Virginia Tech Soil Testing Laboratory (www.soiltest.vt.edu/PDF/lab-procedures.pdf; www.soiltest.vt.edu/Files/publications.html) results showed that average soil phosphorous was 18 pounds per square acre, soil potassium was 135 pounds per square acre, and soil calcium was 1,125 pounds per square acre. Soil pH averaged 6.3, and organic matter was 2 percent.

The experiment was planted May 15, 2008, and consisted of mixtures having one, two, four, six, and all 10 species created from a pool of 10 prairie plant species (table 1). Mixtures of two to six species were constructed by randomly selecting species from the 10-species pool and replicating the mixtures six times. This procedure replicated the species number in mixture but not species composition. For example, the four-species mixture treatment contained six mixtures each having a different combination of species but with the number of species (four) held constant. This procedure tests how the number of species in each mixture affected yield without the confounding effect of species composition. If the same species composition were used for each mixture, it would increase the chance that a single species could dominate the yield response. This makes it harder to determine whether there might be a true diversity effect on forage yield. Details on the specific composition of each mixture and more information about diversity relationships in these mixtures can be found in Bonin and Tracy (2012).

Seeds were broadcasted into a clean seedbed within small plots (6.5 feet by 9.8 feet) and worked into the soil to a depth of 0.25 inch. Seeding rate was 12 pounds per acre on a pure live seed (PLS) basis. Within mixtures, each species was equally divided by weight. The 10 species chosen were part of a mix recommended for conservation and wildlife plantings in this climatic region (Ernst Conservation Seeds, Meadville, Pa.). No fertilizers, irrigation, or pesticides were applied during the experiment. Yield and species composition data were collected each August so we would be harvesting the plots near peak biomass for most species.

Table 1. The native plant species used in the diversity experiment.

Functional group	Common name	Genus and species
Grass	Switchgrass	*Panicum virgatum* L.
Grass	Big bluestem	*Andropogon gerardii* Vitman
Grass	Indiangrass	*Sorghastrum nutans* (L.) Nash
Grass	Little bluestem	*Schizachyrium scoparium* (Michx.) Nash
Grass	Virginia wild rye	*Elymus virginicus* L.
Legume	Illinois bundleflower	*Desmanthus illinoensis* (Michx.) MacMill. ex B.L. Rob. & Fernald
Legume	Showy tick trefoil	*Desmodium canadense* (L.) DC.
Legume	Partridge pea	*Cassia fasciculata* Michx.
Forb	Black-eyed Susan	*Rudbeckia hirta* L.
Forb	Oxeye sunflower	*Heliopsis helianthoides* (L.) Sweet

Results and Discussion

In the first year, mixtures with six and 10 species yielded more than monocultures (table 2), mainly because these were dominated by black-eyed Susan. Native grasses were not productive during the first year because it usually takes at least two years for them to reach maximum productivity. Initial dominance by black-eyed Susan shifted over time to shared dominance of perennial grasses in 2010 and 2011. This species shift was noted in the yield trends. Biomass yields were two to four times higher in 2009 compared with 2008, but did not change appreciably in six- and 10-species mixtures. The highest forage yields were recorded in Year 4 (2011) and were more than two and one-half times greater than yields recorded in 2009 and 2010 (table 2). By the second season, monocultures had lower yields compared to most of the mixtures, mainly due to high weed pressure.

Overall, the four- and 10- species mixtures yielded the most over the four years, with both averaging more than 4 tons per acre. These yields were higher than typical cool-season hay in Virginia, which usually averages around 2.5 tons per acre.

The high yields measured in Year 4 were particularly notable because these plots received no fertilizer, irrigation, or pesticides. By 2011, stands had been established for three full years — enough time needed for full establishment due to seed dormancy and slow initial aboveground growth. Also, the weather was very favorable for NWSG growth. Compared with historical averages, the 2011 growing season was warmer in July and August, and precipitation met or exceeded historical averages in April, May, and July (table 3).

The high yields may also reflect our harvest strategy in these plots: They were not mowed until late fall when the grasses were dormant. An earlier harvest schedule or multiple harvests, which would be common for commercial forage production, might have reduced yields beyond those reported in this study. Regardless, the high yields reported in this study are a testament to the potential of high resource-use efficiency exhibited by many of these prairie species.

From a forage perspective, consistently high yields are beneficial, but a drawback of many NWSG is their comparatively low nutritive value for livestock (Reid, Jung, and Allinson 1988). In a related study, we also evaluated the 10 prairie species used in this experiment for nutritive value and elemental concentration. Overall, most species provided adequate forage nutritive value for nonlactating cows despite minimal management and harvesting plants past full maturity (Bonin and Tracy 2011). Details of this study can be found in "Forage and Grazinglands," DOI: 10.1094/FG-2011-1103-01-RS (online).

Table 2. Biomass yield (tons per acre) of the different mixtures from 2008-11. Statistical significance means that yield differed among the mixtures that year.

	Number of species in mixture					
Year	1	2	4	6	10	Statistical significance
2008	0.8	0.7	1.5	2.6	2.3	Yes
2009	2.1	2.6	2.8	2.5	2.8	No
2010	2.0	2.8	3.2	1.5	2.8	No
2011	3.0	7.1	9.5	4.9	8.5	Yes
Average	2.0	3.3	4.2	2.9	4.1	No

Table 3. Historic and monthly average temperatures and total precipitation for April through September of 2008, 2009, 2010, and 2011 at the study site.

	Historic Averages		2008		2009		2010		2011	
Month	Temp (° F)	Precip (in)	Temp (° F)	Precip (in)	Temp (° F)	Precip (in)	Temp (° F)	Precip (in)	Temp (° F)	Precip (in)
April	60.1	4.0	52.9	3.8	52.7	2.7	55.0	1.3	55.6	5.0
May	67.5	3.9	59.0	2.1	61.5	7.4	63.7	2.5	61.7	6.3
June	71.4	3.7	69.6	2.2	69.6	3.6	72.7	1.5	70.7	1.1
July	70.2	2.8	70.2	5.6	68.4	3.7	74.5	2.4	74.3	4.4
August	63.9	3.1	67.5	2.8	70.5	2.9	73.2	3.5	71.6	1.7
September	52.7	2.9	64.4	1.3	63.3	2.7	65.3	3.3	64.2	4.1
Average temperature	64.2	–	63.9	–	64.4	–	67.3	–	66.4	–
Total precipitation	–	20.5	–	17.8	–	23.0	–	14.4	–	22.6

Conclusions

The main purpose of this study was to evaluate the yield benefit of planting mixtures of NWSG as opposed to single monocultures. Although it took several years for these plots to reach maximum production, by Year 4, most mixtures were much more productive than monocultures on average. It is difficult to recommend an optimal mixture of these species, but our study suggests potential directions.

1. A good strategy for success may be to combine one fast-establishing, short-lived species with at least two to three NWSG in a mixture.

Our study suggests that a fast-establishing species could be black-eyed Susan. Its aggressive growth in the early years of stand establishment can help to suppress weeds and provide well-needed groundcover as the perennial grasses are establishing.

2. In terms of grasses, mixtures containing Indiangrass and big bluestem were particularly effective.

Our study also showed how remarkably productive these grass mixtures can be even with no fertilizer applications. Of course, producers must consider more than just the species composition of NWSG mixtures when trying to implement these grasses within a farm. Choices of planting method, weed control, grazing management, and cutting frequency are other critical management decisions that will need to be addressed.

Recent extension bulletins published by the Center for Native Grasslands Management at the University of Tennessee are excellent sources for additional management information about NWSG production (http://nativegrasses.utk.edu/).

3. While we do not advocate replacement of all cool-season haylands with these species, mixtures of NWSG can play a valuable role in many forage-livestock systems by complementing the low productivity of cool-season grass fields in summer.

Their high productivity, drought tolerance and low dependency on fertilizer could make them a valuable commodity in years to come.

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