NCR-SARE Farmer Rancher Grant Program

Final Report

PROJECT IDENTIFICATION

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- Project Title: Measuring the Value of Inter-seeding Legumes into Established Cool Season Pastures in North Central Kansas—part 2
- Project Number: FNC09-753
- Project Duration: Two Years
- Date of Report: 3/23/2012

PROJECT BACKGROUND

My Wife Sue and I operate a 450-acre grass farm in SE Mitchell County, Kansas (North Central KS). It is about 1/2 native rangeland and 1/2 cool-season grasses. We utilize management intensive grazing on all of our grass. We have custom grazed sale barn stockers for some time now, taking one group from green-up in spring to mid-July and a second group from mid-September to December each year. I learned the basics of grazing management at the basic and advanced Management Intensive Grazing schools taught by Jim Gerrish at the Missouri Forage Systems Research Center. I have attended various local workshops and schools since then including those conducted by the Kansas Society for Range Management and the Kansas Graziers Assoc. Cost-share funds for water and fencing systems have been received through the NRCS Environment Quality Incentives Programs, the Kansas Rural Center Clean Water Farm Program, and the Mitchell County Conservation District State Conservation Commission Program.

The last 10 years I have collected data to evaluate annual forage production, species composition and range and pasture trend and health. These data provide the basis for many of our management decisions. I actively network with fellow graziers as a co-founder of our local graziers group and am on the board of directors of the Kansas Graziers Assn. and KGLC. Lastly, I sit on NRCS's Kansas Technical Committee, with active participation in the EQIP subcommittee.

In 2009 the Kansas Chapter of Society for Range Management gave me their Excellence in Rangeland Management Award

For the past 11 years I (with the assistance of Dwayne Rice, an NRCS range mgt specialist) have used exclusion chambers to measure forage production, done Transects to measure species composition, and used EKG analysis to measure range health, and trends.

See Also my previous grant FNC07-660.

PROJECT DESCRIPTION

Research from Missouri and eastern Kansas has shown that adding legume forages to cool-season pastures is a highly desirable practice. Little research has evaluated legume inter-seeding into cool-season grasses in north central Kansas, especially west of U.S. Highway 81. Climatic conditions between north central Kansas and portions of eastern Kansas vary significantly, with a possible precipitation gradient of 15 inches. The objective of this study was to establish one or more of eight desired legumes into a mature stand of smooth bromegrass used in an intensive rotational grazing program.

As a producer, the problem is quite significant: (1) We are in the process of trying to enter the grass finished beef segment of our industry. Adding legumes to our cool season pastures could substantially improve the quantity and quality of forage produced, as well as help fill the July-August “hole” in cool-season production. (2) Commercial fertilizer costs are soaring and their use can potentially produce ground and surface water quality problems. (3) Reducing commercial fertilizer rates reduces per acre forage production as well as the water efficiency of the cool-season pasture (annual precipitation is 26 inches, so water use and efficiency are critical factors). (4) Adding legumes can potentially reduce the amount of commercial fertilizer needed to maintain smooth bromegrass forage production. (5) Adding legumes will extend the summer grazing season by increasing the quantity and quality of forage produced, improve animal weight gain and profitability potential and reduce methane production (a contributing greenhouse gas).

In the spring of 2009 we began this project by seeding 8 legumes into 2 paddocks of a 12 paddock rotationally grazed, smooth bromegrass system. The 2 paddocks we inter-seeded have two distinct soils: one is an upland soil with a moderate 5-7 percent slope, and the other is a lowland soil with minimal 1-3 percent slope. Each is representative of similar fields and landscape positions in North Central KS. Each paddock is approximately 440 ft. x 660 ft. Each of 8 legumes (Magnagraze purple flowered alfalfa, yellow flowered alfalfa, yellow sweetclover, birdsfoot trefoil, white clover, Korean lespedeza, cicer milkvetch, and hairy vetch) were inter-seeded in alternating strips with a total of 4 replications across both paddocks with a 10 ft. wide no-till drill with 7.5 inch spacing between rows. An unseeded 10 – 20 ft. strip was also included in each replication as a grass only control.

To minimize competition from the existing smooth bromegrass stand, most of the area comprising the test plots was not fertilized. What was fertilized were two 40 ft. wide swaths, running perpendicular to the direction of seeding with 40 lb nitrogen /acre each spring and fall. One strip is across the upland site, and one across the lowland site. We thus have the ability to evaluate our legumes under four conditions: upland unfertilized, upland fertilized, lowland unfertilized and lowland fertilized. Inclusion of an unseeded strip between each replication also allows us to have a grass only control condition against which the legume production can be evaluated.

Establishment was measured within a square frequency frame divided into 100 subframes each 4 in. x 4 in. in size. The number of 4x4 subframes with a desired legume rooted within it was counted for each frame. A total of 2 frequency frames were counted in each legume strip in the fertilized, unfertilized, upland and lowland portions of the paddocks. With 4 replications, a total of 8 frames were counted in each treatment combination. Since only presence or absence of a desired legume was recorded within a subframe when actually many more legume seedlings within a subframe could have been present, a conservative estimate of legumes/sq. ft. was calculated from frequency data. Sampling occurred 2 times during the establishment year, once on 5/16/09 and again on 9/15/09.

Analysis of these data indicated the following:

1. Four of the legumes (purple flowered alfalfa, yellow flowered alfalfa, yellow sweetclover, and Korean lespedeza) established at acceptable plant densities.
2. Fertilized versus unfertilized and upland versus lowland effects were significant at the $P<0.05$ level.
3. Stand densities improved from June to September.

For more detail see the attached summary or Final Report for FNC07-660 on the national SARE reporting website.

We wish to study this newly established stand of four legumes to determine whether and to what extent they can maintain and mature into meaningfully productive stands that positively affect forage production, forage quality and soil quality.

We propose to do four things:

1. Continue monitoring stand density by doing square frequency frame counts twice each year (once early and once late in the growing season).
2. Do forage nutrient sampling by using a standard 1ft. x 2ft. frame and clipping to expected grazing height in each legume combination and the non-seeded grass only control strip just prior to each grazing rotation each year. Each sample will be oven dried, weighed, and analyzed at a commercial laboratory for protein, fiber, minerals, and digestibility.
3. Take soil samples at the end of year 2. Using standard soil sampling instruments, we will sample at 0-3 in., 3-6 in., and 6- 24 in. increments in each of the legume combinations and the non-seeded grass only control strip. The samples will be analyzed at a commercial laboratory for nitrogen, phosphorous, potassium, other macro minerals, organic matter and pH.
4. Do limited monitoring of legume densities using frequency frames of two additional 2009 mixed legume plantings into another brome pasture to follow legume population trends under routine grazing conditions.

Our previous grant disclosed that legumes did better in unfertilized than fertilized sites, and that upland sites had better stands than lowland sites. Both effects were statistically significant across all four successfully established legume species. Retaining these distinctions in our analysis leads to a proliferation of the number of samples that need to be taken.

To continue monitoring stand density, we will take counts of four species X 2 fertilizations X2 landscapes X 4 replications with 2 count/condition = 128 counts X2 count/year X 2 years = 512 total counts.

To evaluate forage nutrient content, we will evaluate: 5 species (4 legumes and non-seeded grass only control) X 2 fertilizations X 2 landscapes X 4 replications = 80 samples/grazing X 2 grazing events/yr = 160 samples/yr X 2 years = 320 total forage samples.

To evaluate soil quality changes, we will analyze: 5 species X 2 fertilizations X 2 landscapes X 2 replications X 3 samples (0-3, 3-6, 6-24 inch increments)/site = 120 total samples. Soil samples will only be taken during the last year as that is when we have the best potential to see the most pronounced affect in the soil between the legume seeded strips and the grass only control strips.

To monitor plant density on the 2 additional plantings, we will set up 3 transects in each planting and take frequency frame counts at 3 locations on each transect twice each year.

The forage samples will be dried in a forced air oven at the KSU Ag Research Center-Hays to determine dry matter yield. We will send the samples to a commercial lab for NIR analysis to determine moisture, crude protein, acid detergent fiber, neutral detergent fiber, calculated TDN, calculated NEg, NE, calcium, phosphorous, potassium, magnesium, ash, lignin, fat, NDF, digestibility, RFV, and RFQ.

The soil samples will be sent to the same lab for soil analysis. They will test for nitrate-nitrogen, phosphorous, potassium, calcium, magnesium, sodium, CEC, sulfate-sulfur, zinc, organic matter, pH and buffer pH, and ammonium nitrogen.

GOALS: See discussion above

PROCESS

Cool season, introduced pasture (Smooth bromegrass) makes up a considerable portion of my custom grazing operation. I wished to add legumes to my existing Smooth bromegrass pastures to improve animal performance, decrease the use of commercial fertilizers, and improve profitability. I recruited two highly qualified professionals to assist me, and conducted the research reported here. See this report for details.

PEOPLE

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RESULTS

Results and Discussion

A frequency of at least 21 percent was set as the criterion for successful establishment. By dividing the frequency percentage by 10.76 (the number of square feet within the frequency frame), a conservative density estimate of established legumes/ft^2 can be calculated. Successful establishment with 21 percent frequency subsequently translates into a plant density of at least 2 plants/ft^2, because more than one legume was rooted within some of the sub-squares that were counted.

The data revealed a number of important and interesting findings. First and foremost, some legumes had consistently successful establishment the first year of the study, but frequency of some declined with each successive year (Table 1). Also, legume establishment was different depending on the landscape position and the addition of nitrogen fertilizer (Table 2). Legumes that initially showed acceptable overall establishment at both landscape positions were Korean lespedeza, yellow-flowered alfalfa (*falcata*), and purple-flowered alfalfa (*sativa*). Yellow sweetclover also established successfully in 2009, but frequency of yellow sweetclover and Korean lespedeza have declined each successive year. Establishment on the upland site was greater than on the lowland site for these legumes (Table 2). The remaining legumes did not establish consistently well at either landscape position. Averaged over all legume species, upland sites had approximately 43 percent greater legume establishment than lowland sites.

Fertilization also affected stand establishment. Legumes that showed acceptable overall establishment with or without added N fertilizer were Korean lespedeza, yellow-flowered alfalfa (*falcata*), and purple-flowered alfalfa (*sativa*; Table 2). However, averaged over all years, establishment was greater for these legumes and for yellow sweetclover and white clover on sites without added N fertilizer. Averaged over all legume species, establishment on unfertilized sites doubled the establishment on fertilized sites.

Lowland sites in general had greater yield than upland sites (Table 3). Fertilization with 40 lb N/a did not increase season forage yield. However, on upland sites, unfertilized areas with purple alfalfa and yellow alfalfa had greater yield than fertilized areas. Purple- and yellow-flowered alfalfa on the unfertilized uplands also had greater yield than the grass-only control sites. On lowland sites that were fertilized, purple and yellow alfalfa also had greater yield than the grass-only control.

Forage quality in terms of crude protein was greater than the grass only control for seeded strips of two legumes on the lowland site and for three legumes on the upland site (Table 4). Also, crude protein was greater for two legumes on fertilized sites compared to the grass only control strip (Table 4). On unfertilized sites, three of the legumes also had greater crude protein than the grass only control (Table 4). Purple alfalfa and yellow alfalfa also had crude protein that was over 1.1 percentage units greater on unfertilized sites compared to fertilized sites, indicating that the greater frequency of established legumes was contributing significantly to forage quality.

Each of the established legumes offers unique opportunities and challenges. The two alfalfas, as perennials, offer the possibility of long-term survival and production without having to worry about frequent re-seeding. The biennial yellow sweetclover may present a long-term maintenance problem depending on timing of grazing. Pasture rest during flowering and seed set should allow natural reseeding to occur. Yellow sweetclover had completed its life cycle and seed set by late summer 2010. New seedlings had not germinated from the biennial species by the September sampling period, and thus it had a low frequency in the fall of 2010. New biennial sweetclover seedlings appeared in spring of 2011, but were not as dense as desired. The new, young sweetclover seedlings also did not contribute to increase forage yield in 2011. Korean lespedeza, a summer annual, may present a problem with maintenance and reseeding at northern locations. It is a major component in most cool-season pastures in southeast Kansas, and it did set seed each fall to successfully reestablish itself the next year. However, the frequency of lespedeza has declined each successive year, and may do so again in 2012. As long as grazing management allows rest or plants are allowed to flower and set seed without heavy defoliation, Korean lespedeza should be able to produce seed annually, or at least periodically, to maintain stands. However, the lespedeza did not appear robust and contributed little to the overall yield of the pastures even though plant frequency values were well above 21 percent. An investigation of the lespedeza root systems showed that nodulation was poor, which likely contributed to the lack of increased yield, and possibly lower seed set. Of the four legumes with the most successful establishment, purple alfalfa and yellow alfalfa showed the greatest potential to increase forage yield and quality.

Implications and Possible Impacts

Adding legumes to smooth bromegrass pasture could reduce the amount of commercial fertilizer needed to attain optimal forage production. Furthermore, adding legumes to brome pasture could extend the brome pasture grazing season by increasing the quantity and quality of forage produced in mid-summer, and could improve animal weight gain and profitability potential. Eight legumes were inter-seeded into two paddocks of a twelve paddock smooth bromegrass rotational grazing system. Of the eight legumes, purple-flowered alfalfa and yellow-flowered alfalfa no-till seeded into smooth bromegrass pasture established at acceptable plant densities of more than 2 plants/ft^2 and increased forage yield. Both alfalfa types provided increased forage quantity above that of fertilized or unfertilized smooth bromegrass pasture, and also increased forage quality compared to unfertilized brome pasture. At current approximate costs to seed the purple-flowered alfalfa and yellow-flowered alfalfa, savings in N fertilizer application alone could pay for alfalfa seeding in two to three growing seasons. The added yield and quality of forage within the purple- and yellow-flowered alfalfa stands would also likely result in increased animal production and income. Purple- and yellow-flowered alfalfas seeded into smooth bromegrass pasture have potential to contribute to greater season forage quantity, quality, and improved net income within two years of seeding.

Table 1. Average frequency, or number of 4-in. by 4-in. subsquares out of 100, having at least one desired (target) legume rooted within it at each landscape position in 2009, 2010, and 2011. Values are averaged across both fertilized and unfertilized plots, across both upland and lowland landscape positions, and across spring and fall counts.

	2009	2010	2011
	--------Frequency (%)-------		
Birdsfoot trefoil	5	1	1
Cicer milkvetch	5	5	2
Hairy vetch	3	0	0
Korean lespedeza	78	49	14
Purple alfalfa	36	44	32
Yellow sweetclover	22	10	2
White clover	14	14	5
Yellow alfalfa	40	46	37
$LSD^{1}_{0.05}$		9	
Average	25	21	13

[1] $LSD_{0.05}$ = Least significant difference. Values compared within rows or columns that differ by more than the LSD value are statistically different.

Table 2. Average frequency, number of 4-in. by 4-in. subsquares out of 100, having at least one desired (target) legume rooted within it at each landscape position and at each fertilization level averaged from 2009-2011. Values are also averaged across both spring and fall sampling.

	Upland	Lowland	40 lb/a N	0 lb/a N
	-----------------Frequency (%)-----------------			
Birdsfoot trefoil	3	2	2	3
Cicer milkvetch	5	3	3	5
Hairy vetch	1	1	1	1
Korean lespedeza	54	40	39	54
Purple alfalfa	47	28	24	50
Yellow sweetclover	16	7	6	17
White clover	9	13	3	19
Yellow alfalfa	49	32	25	56
$LSD^{1}_{0.05}$	8		8	
Average	23	16	13	26

[1] $LSD_{0.05}$ = Least significant difference. Values compared within rows or columns that differ by more than the LSD value are statistically different.

Table 3: Average total yield (lb/a) of legume-bromegrass mixtures at two landscape positions and two N fertilizer levels for two years following legume interseeding. Yields are the sum of two spring harvests and one fall harvest each year in 2010 and 2011. Due to poor establishment, birdsfoot trefoil, cicer milkvetch, and hairy vetch plots were similar to the grass-only control and were not harvested.

	Lowland		Upland	
	40 lb/a N	0 lb/a N	40 lb/a N	0 lb/a N
	-------------------Yield (lb/a)-------------------			
Grass-only control	4170	4490	2490	2660
Korean lespedeza	4960	5100	3010	2730
Purple alfalfa	6610	5360	2750	4080
Yellow sweetclover	4750	4480	2920	3100
White clover	4740	4350	2620	1980
Yellow alfalfa	6660	4370	2570	4100
LSD[1] $_{0.05}$		1290		
Average	5320	4690	2730	3110

[1]$LSD_{0.05}$ = Least significant difference. Values compared within rows or columns that differ by more than the LSD value are statistically different.

Table 4: Average crude protein % of legume-bromegrass mixtures at two landscape positions and at two N fertilizer levels for two years following legume interseeding. Values are the weighted % of two spring harvests and one fall harvest each year in 2010-2011. Due to poor establishment, birdsfoot trefoil, cicer milkvetch, and hairy vetch plots were similar to the grass-only control and were not harvested for yield or quality.

	Lowland	Upland	40 lb/a N	0 lb/a N
	-------------------Crude Protein (%)----------------			
Grass-only control	11.0	12.7	12.2	11.4
Korean lespedeza	11.2	12.6	12.2	11.6
Purple alfalfa	13.0	15.7	13.3	15.4
Yellow sweetclover	11.1	13.8	12.1	12.9
White clover	11.0	12.3	11.4	11.8
Yellow alfalfa	12.5	16.2	13.7	15.0
LSD[1] $_{0.05}$	1.1		1.1	
Average	11.6	13.9	12.5	13.0

[1]$LSD_{0.05}$ = Least significant difference. Values compared within rows or columns that differ by more than the LSD value are statistically different.

OUTREACH

1. Hay and Grazing Conference , Manhattan , Kansas Jan. 18, 2010. Oral presentation
2. Kansas Natural Resources Conference, Feb. 4-5, 2010, At the Airport Hilton , in Wichita , Ks. Poster session.
3. Kansas Graziers Assoc. Winter Conference , Jan. 23, 2010 , McPherson, Ks. Poster session
4. Post Rock Graziers Assoc. Coffeshop Meetings Jan. 13, Jan. 20 and Jan30th 2010, Beloit, Kansas. Poster sessions
5. Hay and Grazing Conference, Salina Ks Dec 7,2011 Oral Presentation
6. The Rural Advantage/Healthy Farms Conference, Lied Lodge and Conference Center, Nebraska City, Ne. Feb 10-11,2012 Invited Oral Presentation
7. Harmoney, K., C. Adams, D. Rice, and H. Jansonius. 2011. Establishing different legumes in grass: an of-farm research trial. *In* Roundup 2011: Report of Progress 1050. Pgs. 35-39. Kansas State University Agricultural Experiment Station and Cooperative Extension Service, Manhattan, KS.
8. Adams, C., D. Rice, and K. Harmoney. 2010. Establishing different legumes in grass: an on-farm research trial. *In* Kansas Waters- Signs of Prosperity and Health, 2010 Kansas Natural Resources Conference Abstracts, Wichita, KS. Pg. 33.