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Using alternative forages on traditional small grain crop land in rotational grazing systems for the Northern Great Plains[a]

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Expected Results

This is a new 2-year project funded by North Central Region (NCR) Sustainable Agriculture Research and Education (SARE). Crop selection for producers in the Northern Great Plains is environmentally limited due to low annual precipitation, seasonal precipitation patterns and a relatively short growing season. These same problems limit the length of time that high quality forage is available from perennial pastures and native range. Integrating crop and livestock enterprises using late summer forage production could be mutually beneficial. Forage consumption by livestock could create a marketable commodity for crop producers without having to let the crop develop seed. Selecting warm season or long season crops would provide high quality forage in late summer when the nutritional quality of perennial forage typically limits livestock production. The results of this study will determine the economic feasibility of producing summer forage for grazing or haying in the Northern Great Plains. Positive results would increase the amount of quality forage that could be available to support livestock production, while expanding the number of crops available for use in developing economically, as well as environmentally, sustainable crop rotations.

Objectives and Rationale

1. Determine production of and yearling heifer performance from forages produced on traditional small grain crop land in the Northern Great Plains during late summer.

2. Determine if economic returns to crop land from growing forages and grazing cattle are competitive with returns from small grain production in the Northern Great Plains.

Prices received for agricultural commodities are often low compared to the high costs of production. This results in relatively low net returns per acre for the amount of capital invested. Traditional cropping systems in the Northern Great Plains include continuous small grains or a small grain-fallow rotation. However as governmental control of agricultural production recedes, producers are being given greater flexibility in the development of unique farming plans. As producers contemplate possible cropping decisions, crop rotations involving annual forages are gaining in popularity among diversified operations that manage both crops and cattle enterprises.

Annual forage production can provide a basis for establishing an integrated system between crop and cattle production. Annual forages offer crop producers a wider variety of alternative crops that can be included in a rotating crop sequence. In addition to diversified agricultural operations, when cattle and crops are produced in close proximity, local livestock can create a readily-available market for excess forage production.

Cattle enterprises can also benefit from integrated crop-livestock systems. One of the principal limitations to cattle production in the Northern Great Plains is the need to supply a sufficient quantity of high-quality forage for grazing during the mid- to late-summer months (late July through September). This is a time frame when most traditional pastures become unproductive, provide lower quality forage, or both. Expanding annual forage production within the region would expand the total feed base available to cattle producers. Using this forage within the context of a grazing system should help reduce costs of beef production, while simultaneously generating revenue on crop acreage.

Previous work in North Dakota at the Dickinson Research Extension Center has demonstrated that barley, oat, pea and oat-pea intercrop can be used to provide productive annual pastures when grazed during the early- to mid-summer period. Preliminary data suggests that grazing annual forages with cattle has the potential of producing more net return per acre when compared to traditional cereal crops in western North Dakota. Producers are becoming aware of the potential of using annual forages in grazing systems (Paul Klamm, SARE Producer Grant; FNC97-055), but are frustrated by the lack of data from which to base recommendations. This is particularly true during the mid- to late summer time period.

The need for grazable forage production during the late summer period is universal in the northern United States. Dr. Burt Weichenthal and co-workers in 1998 received SARE funding (LNC 98-135) for evaluating warm-season annual forages in integrated crop and livestock systems. The primary focus of this project is to assess the yield and quality characteristics of annual grasses in the Central Great Plains. Absent from this study is some assessment of the potential for grazing livestock production from annual forages.

The use of legumes or grass-legume mixtures in grazing systems is not new or unique. SARE-funded projects have demonstrated the advantages of maintaining legumes in integrated, sustainable agricultural systems. Previous work at Dickinson has assessed the potential of integrating cool season legumes (e.g., field pea, lentil) into integrated crop-livestock systems. One challenge for producers in the Northern Great Plains is to find legumes that can provide a high-quality, grazable forage in late summer. Sweetclover and alfalfa are adaptable to production in the region, however the potential of using these legumes in an integrated cropping system or in combination with an annual grass has not been tested.

The proposed experiment will address the potential of using a warm-season grass (foxtail millet), sweetclover, and alfalfa as grazable forages during late summer in an integrated crop-livestock system. In addition to documenting forage production and quality and livestock production, economic returns to various harvesting options will be evaluated.

Literature Review

Crop rotation has been defined as a system of growing different kinds of crops in recurrent succession on the land (Martin et al., 1976). General advantages of crop rotations are improved soil physical and chemical properties, reduced soil erosion, reduced toxic substances in crop residues, reduced disease and insect problems, spreading of workload, reduced risk of weather damage and reduced reliance on agricultural chemicals (Badaruddin, 1988). Early experiments into crop rotations demonstrated the potential for increased grain yield in small grain production systems (Martin et al., 1976). Wheat yields and gross return were improved 2.0% and $4.50/acre, respectively, when a wheat-corn (*Zea mays*) rotation was compared to a wheat-fallow system (Carr et al., 1995). In this same study, a continuous wheat system depressed yield (-2.5%) and gross return (-$10/acre). Ashley (1998) demonstrated that the impact of root disease on crop quantity and quality can be reduced through the use of appropriate crop rotations.

Income stability (Peel, 1998) and increased net profits (Badaruddin, 1988) have been listed as economic benefits to crop rotations. In the Northern Great Plains, these benefits hinge upon the alternative crop(s) in the rotation (non-small grain) having market access and potential for creating compensating gross return. Although including a hay crop into a typical grain production system has been shown to be economically and environmentally beneficial (Badaruddin, 1988; Peel, 1998), if there is not an active forage market available the system may fail economically.

Livestock production from grazing cool-season, domesticated grasses (e.g. crested wheatgrass; *Agropyron desertorum*) and native range in the Northern Great Plains becomes nutritionally-limited by mid June and mid to late July, respectively (L. Manske, per. comm.). Combining these types of forages can provide quality forage for grazing livestock from late April until early August. Subsequently, livestock production is limited due to a lack of forage quality. Growing annual forages in small grain rotations may provide an adequate quantity of quality forage to help sustain livestock production longer into the grazing season (Poland et al., 1998b). Grazing livestock production may help improve the market potential of the forages produced in a crop rotation, thus increasing the possibility improving net return to total crop acres.

Mr. Paul Klamm (Watford City, ND), using a producer grant from NCR SARE (FNC 97-176), demonstrated that cattle can "successfully and profitability graze annual forages in the Northern Great Plains during the growing season" (Klamm and Naze, 1998). In this system, yearling beef heifers and steers grazed a sequence of annually seeded forages from mid May until mid September. Yearlings averaged 1.76 lbs daily gain and produced 1.33 animal unit months (AUM) and 110 lbs of live weight gain per acre. Net income for the grazing enterprise over all costs was $4.35/acre. Since agronomic production exceeded grazing demand for forage, a portion of the acreage in the system was either harvested for hay or grain or harvested and grazed in the same season. Including the income from harvested production, the system produced $21.07/acre in net income. This compares directly to a net income of $8.25/acre for traditional spring wheat production.

The utilization of annual forages by beef cattle is currently being evaluated in the North Great Plains (Manske and Nelson, 1995; Poland et al., 1995, 1998a,b). Studies include feeding annual forages as hay to drylot cattle and grazing annual forages by beef cows and yearling heifers. Results to date suggest that 1) cereal/pulse intercropped hay has an energy value similar to cereal hay, 2) pulse forage or grain can be used to replace supplemental protein sources in beef cattle diets and 3) annual forages can be used to produce productive pastures during the growing season in the Northern Great Plains.

Pastures of annual forage (Poland et al., 1998b) have been reported to produce .8 AUM/acre grazing capacity and 66 lb/acre in live weight gain. Individual daily gains have averaged 2.5 lbs for suckling calves and 2.0 lbs for bred heifers. Data from specific forage types suggest that seasonal production parameters can be improved. New research is needed to support the development of optimally matched annual forage production and grazing strategies.

The legume plant family, *Leguminasae*, is one of the largest in the world and has played an essential role in human development and civilizations (Frame et al., 1998). Legumes have been used and studied extensively in cropping and grazing systems throughout the world. This intent is demonstrated by the number of past and current grants awarded by NCR SARE since 1991. In addition to the general benefits of crop rotations, legumes have been praised for their contribution to the nitrogen economy of grass and crop land ecosystems from N_2 fixation and their superior feeding quality in relation to grasses (Frame et al., 1998).

In an era of reduced governmental regulation of cropping decisions, legumes should be considered as an alternative to fallow in wheat production systems of the Northern Great Plains (Badaruddin, 1988). Legumes were used quite extensively in crop rotations prior to the advent of cheap N fertilizers (Brown, 1964; Badaruddin, 1988). There is some concern with harvesting the legume as forage or grain, as opposed to green manure, due to the removal of potential N from the system. However, harvesting management practices which allow for soil incorporation of some of the above-ground growth may be able to provide sufficient N to support subsequent small grain crops (Badaruddin, 1988). Livestock grazing may provide another viable harvesting alternative that could return a significant portion of the N fixed by a legume back to the soil for subsequent crop production.

Annual legumes (e.g. clovers; *Trifolium sp.*) have been used in grazing environments of the south-eastern US where perennial clovers do not persist to reduce production costs and improve livestock performance (Hoveland and Evers, 1995). The benefits of legume inclusion include improved forage quality, extended grazing season, reduction or elimination of N fertilization and spring weed control (Hoveland and Evers, 1995). In the Northern Great Plains, cool-season annual pulses produce less dry matter yield and higher protein concentrations than cool-season annual grasses (Carr et al., 1998). Intercropping a pulse with a cereal dramatically reduced the yield depression of the pulse monoculture, while enhancing the protein concentrations of a cereal monoculture. Whether intercropping cereals and pulses would lead toward higher grazing livestock performance has not been demonstrated to date.

Approach and Methods

Objective 1. Twenty-six, 1-ha paddocks have been established (1997-1998) to support research efforts involving summer grazing of annual forages by beef cattle in the Northern Great Plains. Forage treatments will be seeded into replicated paddocks (n=2) in each of two years. Treatments (Table 1) will include Siberian millet (M; *Setaria italica*), sweetclover (C; *Melilotus alba*), alfalfa (A; *Medicago sativa*), barley

(*Hordeum vulgare*), field pea (*Pisum arvense*) and combinations of M/C and M/A. Forage production resulting from these seedings will be grazed using yearling beef heifers. Additionally, subsequent forage production from previously seeded biennial (sweetclover) or perennial (alfalfa) legumes will also be available for grazing in year 2 of the study (2001).

Paddocks will be seeded to respective forages using no-till seeding techniques in the spring of each year. Grazing of paddocks with yearling beef heifers will initiate in late July or early August of each year and continue for at least 28 days (actually length will depend upon forage availability). Forage samples and animal weights will be collected at the beginning and end of the grazing period, and at 14-day intervals during the grazing period. Forage samples will be used to determine dry matter available for grazing, rate of dry matter disappearance and chemical composition (nitrates, crude protein, acid detergent fiber and neutral detergent fiber). Rate of dry matter disappearance and residual dry matter remaining at the end of grazing will be used to estimate length of potential grazing period. Animal weights will be used to calculate average daily performance and total live weight production during the grazing period.

Animal and forage data will be analyzed as a completely random design (Steel and Torrie, 1980). Forage treatment will be considered as a fixed effect, while year and pasture replicate will be considered random. Sources of variation will include year, treatment, a year by treatment interaction and pasture nested within year and treatment combinations. Significant treatment effects will be described using a pre-determined set of orthogonal (6) and nonorthogonal (2) contrasts (Table 2).

Objective 2. To evaluate the economic return of various crop and harvesting combinations tested in this study, regional budgets published by the North Dakota State University Extension Service for small grains, forages and livestock will be used. These budgets will be compared against the actual direct expenses incurred in this trial. This will insure that the relationship among direct costs used in the published budgets matches the actual direct expenses incurred in the trial. For analysis purposes the regional budgets will be used since some direct costs may be skewed due to the small size of research plots. Costs will not include overhead expenses. Returns will be reported as returns to overhead costs. Using measured animal performance and reported regional prices for livestock, small grain and forage crops grown for sale, estimates of returns to overhead will be made for each treatment.

In addition a model farm will be created using the Finpack financial analyzer. This model farm will be representative of farms/ranches in the Northern Great Plains. This farm will include small grain crops, forage crops and livestock typical of farms/ranches in the region. The model farm as created will be the economic control. The model will then be tested using whole farm analysis to determine effects on the returns to owners labor, management, equity and risk of adding each treatment individually to the base farm.

Education and Outreach

Results from this experiment will be presented at various field days and producer (both crop and livestock) meetings. Follow-up surveys of meeting participants will assess attitudes toward annual forage production and integration of crop-livestock systems. Intended changes in cropping systems to include annual forages and/or livestock will also be addressed.

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Table 1. Grazing forage treatments for replicated paddocks (n=2) in years 1 and 2.

	Year 1 (2000)	Year 2 (2001)
1.	Siberian Millet[1]	Pea[1]
2.	Annual alfalfa[1]	Siberian Millet[1]
3.	Siberian Millet + perennial (P) alfalfa[1]	P Alfalfa[2] - graze in spring, July burn down
4.	Barley[1]	Pea[1]
5.	Sweetclover[1]	Sweetclover[2] - graze in spring, July burn down
6.	Siberian Millet + Sweetclover[1]	Sweetclover[2] - graze in spring, July burn down
7.	Pea (prep for yr 2)[1]	Barley[1]
8.	Pea (prep for yr 2)[1]	Siberian Millet[1]

9.	Siberian Millet[1]	Annual alfalfa[1]
10.	OPEN	Siberian Millet + P Alfalfa[1]
11.	OPEN	Sweetclover[1]
12.	OPEN	Siberian Millet + Sweetclover[1]
13	OPEN	OPEN

[1] Seeded and grazed the same year.
[2] Seeded the previous year and subsequent forage grazed.

Table 2. Contrasts to be used to describe significant treatment effects.

Forage treatment	Years of data	Contrast number[1]							
		1	2	3	4	5	6	7	8
Siberian Millet[2] (M)	2	-1	0	-2	0	0	0	0	0
Annual alfalfa[2]	2	0	-1	1	-1	-1	-1	0	0
M + perennial (P)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

alfalfa[2]	2	0	0	1	1	-1	1	0	0
Barley[2]	2	2	0	0	0	0	0	0	0
Sweetclover[2]	2	0	-1	1	-1	1	1	0	0
M + Sweetclover[2]	2	0	0	1	1	1	-1	0	0
Pea (prep for yr 2)[2]	2	0	1	0	0	0	0	0	0
Pea (prep for yr 2)[2]	2	0	1	0	0	0	0	0	0
M[2]	2	-1	0	-2	0	0	0	0	0
P Alfalfa[3,4]	1	0	0	0	0	0	0	-2	0
Sweetclover[3,5]	1	0	0	0	0	0	0	1	-1
Sweetclover[3,6]	1	0	0	0	0	0	0	1	1

[1] Numbers in table refer to individual treatment coefficients for a contrast comparison.
[2] Seeded and grazed the same year.
[3] Seeded the previous year and subsequent forage grazed.
[4,5,6] Second year of legume growth following Siberian millet + perennial alfalfa, sweetclover and Siberian millet + sweetclover seedings in year 1, respectively.