Establishment, Persistence and Production of Perennial Legumes in the Missouri Coteau Region of North Dakota

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Alfalfa, a perennial legume, is the "queen" in the forage realm. However, it has some problems with winterkill, soil salt intolerance, pest infestation such as alfalfa weevil and root cutworms, and causing livestock bloating. Therefore, research on the various cultivars of alfalfa, along with other adapted perennial legumes, is of interest to livestock producers in the Missouri Coteau region.

However, information about the selection, establishment, winter hardiness, phenology, productivity and quality of perennial legumes is scattered and not site-specific. Therefore, 42 field plots were used to screen and evaluate perennial legumes at the Central Grasslands Research Extension Center (CGREC) in the Missouri Coteau region of North Dakota. The comparison of selected species/varieties with regard to their establishment and production is presented here to fill the information gap and then diversify forage production systems in this region.

Summary

Several perennial legumes showed successful establishment at the CGREC: alfalfa, birdsfoot trefoil, Canadian milkvetch, cicer milkvetch, crownvetch, sainfoin, alsike clover, kura clover, red clover and white clover. In contrast, the crownvetch, alsike clover, red clover and white clover stands lasted only two to three years. Cultivar effect was minimal on production except for 'Falcata' alfalfa and 'Empire' birdsfoot trefoil; their production was lower than other selected cultivars.

For short-lived perennial legumes, white clover (1.66 tons/acre) produced less forage than alfalfa (2.39 tons/acre) in 2011, while alsike clover (2.70 tons/acre) and crownvetch (2.48 tons/acre) were comparable. Red clover (4.05 tons/acre) production was higher than alfalfa in 2011.

For long-lived perennial legumes, the three-year average forage production (2011 through 2013) of birdsfoot trefoil (2.43 tons/acre) and cicer milkvetch (2.52 tons/acre) were comparable with alfalfa (2.30 tons/acre), while sainfoin (1.71 tons/acre) was lower. In 2013 alone, however, a dry year, cicer milkvetch (1.63 tons/acre) and sainfoin (1.60 tons/acre) produced more forage than alfalfa (1.09 tons/acre) and birdsfoot trefoil (1.09 tons/acre). Canadian milkvetch and kura clover production varied significantly from year to year and needs further investigation.

Introduction

Legumes, especially perennial legumes, are considered very critical forage species for several reasons. The ability of perennial legumes to fix nitrogen biologically can improve forage production and quality without intensive fertilization (Carlsson and Huss-Danell, 2003). The use of perennial legumes with various seasonalities of production and quality can extend the grazing season in the late fall or early spring (Butler and Muir, 2012; Suriyagoda et al., 2013).

Some perennial legumes are drought-tolerant due to their deep tap roots (Pang et al., 2011). Also, because their root system, perennial legumes can be used to improve soil health such as in saline soil alleviation (Nichols et al., 2012).

Among perennial legume species, alfalfa has a long history of playing a very important role in forage production (Bouton, 2012). Due to its own biological characteristics and historical development, alfalfa is the "queen" of the forage realm. In North Dakota, more than half of the hayland is occupied by alfalfa alone and in mixture with other species.

However, it has some problems with winterkill, soil salt intolerance, pest infestation such as alfalfa weevil and root cutworms, and causing livestock bloating. Efforts to expand the use of alfalfa have drawn Considerable interest; however, a need also exists for alternative perennial species to increase biodiversity and fill niches where alfalfa is less suited (Dear et al., 2003).

Farmers and scientists have embraced the use of new perennial legume species (Dear et al., 2003; Real et al., 2011; Nichols et al., 2012). While "old" species such as alfalfa, white clover and red clover still play an important role in forage production systems, "new" species such as birdsfoot trefoil (McKenzie et al., 2004; Marley et al., 2005), sainfoin (Peel et al., 2004), cicer milkvetch (Loeppky et al., 1996; Acharya et al., 2006), kura clover (Sheaffer and Marten, 1991) and crownvetch (Burns and Cope, 1974) have expanded the range of legume options to produce high-quality forage.

Recently, several producers in the Missouri Coteau region contacted us regarding perennial forage legume species related to their ranch- or farm-specific situations. These phone calls demonstrate the need to study other species as well as alfalfa for forages in our region. Therefore, a long-term study of perennial legumes was initiated in 2010 at the CGREC.

Specific objectives are to establish and monitor perennial legume species for their establishment success and productivity.

Procedures

The study was carried out at the CGREC from 2010 through 2013. Twenty-eight legume species/cultivars were seeded in mid-May, 2010 (Table 1). Each of these species/cultivars was drilled into field plots that were prepared by disking and harrowing. Each plot was 20 by 20 feet. In 2011, 11 more perennial legume species/cultivars were added to the trial (Table 1).

Due to stand failure in 2010, several selections were reseeded in 2011. They were: black medic, Canada milkvetch, kura clover, mountain goldenbanner, silvery lupine, strawberry clover, Utah sweetvetch, white prairie clover and purple prairie clover (Table 1).

Each plot was evaluated visually for seeded species establishment. The establishment scale was: failed (no seedlings of seeded species and plots covered by weeds), poor (sparse seedlings of seeded species and covered by weeds at least 50 percent), fair (regularly spaced seedlings of seeded species and covered by weeds at most 50 percent) and excellent (dense seedlings of seeded species and covered by weeds at most 25 percent). Each plot was harvested when the alfalfa reached the 10 percent blooming stage in a multi-cut system started in 2011. Oven-dried samples were collected to calculate forage production by dry-matter basis.

During establishment, several schedules of mowing were employed to control common weeds. Generic select herbicide (Volunteer [clethodim] at 6 to 8 ounces/acre) was applied to the plots each year to control undesirable grasses.

Results

Establishment. Nineteen out of 28 plots of perennial legumes were established from the 2010 seeding: alsike clover, alfalfa (five cultivars), birdsfoot trefoil (five cultivars), cicer milkvetch (two cultivars), crown vetch, red clover, sainfoin (three cultivars) and white clover (Table 1). Nine species had stand failure (black medic, Canada milkvetch, kura clover, mountain goldenbanner, purple prairie clover, silvery lupine, strawberry clover, northern sweetvetch and white prairie clover) and were reseeded in mid-May of 2011 (Table 1). Based on establishment success, more cultivars of alfalfa (six), red clover (three) and white clover (two) were seeded in 2011 to broaden the scope of cultivars of the well-established species (Table 1). All of these added varieties were well-established in 2012 (Table 1).

Canada milkvetch and kura clover had a successful establishment in 2012 (Table 1). However, silvery lupine and Utah sweetvetch experienced stand failure again in 2012 (Table 1). Black medic, mountain goldenbanner, purple prairie clover, strawberry clover and white prairie clover stands were sparse, and more viable seeds were added to the plots during the growing season in 2012 after a solid rainfall. This re-seeding did not improve these stands by 2013.

Persistence. Crownvetch, alsike clover, red clover and white clover seeded in 2010 had stand thinning from 2011 to 2012. This pattern also was observed for red clover and white clover (seeded in 2011) from 2012 to 2013. Alfalfa, Canadian milkvetch, cicer milkvetch and kura clover showed stand improvement during the second and third year after seeding. Birdsfoot trefoil and sainfoin stands stayed fairly steady through the three years.

Production. Cultivar effect was minimal on production except for 'Falcata' alfalfa and 'Empire' birdsfoot trefoil, which showed lower productivity than other selected cultivars (Tables 2 and 3). For short-lived perennial legumes, white clover (1.66 tons/acre) produced less forage than alfalfa (2.39 tons/acre), while alsike clover (2.70 tons/acre) and crownvetch (2.48 tons/acre) production was comparable to that of alfalfa. Red clover (4.05 tons/acre) produced more forage than alfalfa one year after seeding in 2010.

For long-lived legumes, the three-year averages of forage production of birdsfoot trefoil (2.43 tons/acre) and cicer milkvetch (2.52 tons/acre) were comparable to alfalfa (2.30 tons/acre), while sainfoin (1.71 tons/acre) was lower. However, in 2013, a dry year, (see Figure 1, page 48) cicer milkvetch (1.63 tons/acre) and sainfoin (1.60 tons/acre) produced more forage than alfalfa (1.09 tons/acre) and birdsfoot trefoil (1.09 tons/acre). Canadian milkvetch and kura clover production varied significantly from year to year and needs further investigation.

Discussion

Establishment of these perennial legume forage species is the first step of this study and is a key for their production and field management. Two comments warrant a mention: First, this study includes the objective of screening available

perennial legume forage species. Due to winterkill, drought, diseases, soils and other factors, not all the species we screened established well. Second, field management can play a critical role for species establishment. Different seeding strategies and weed control measures can contribute to stand establishment.

Selection of the seeding time and tillage type can alleviate weed infestation. The common weeds in our field plots are foxtails, Canada thistle and redroot pigweeds. The annual grass weeds could be controlled easily by herbicides such as Select; however, broadleaf weeds are difficult to control. The herbicide Pursuit is an option, but its efficiency was not as good as expected.

With the same field management protocol, alfalfa, alsike clover, birdsfoot trefoil, Canadian milkvetch, cicer milkvetch, crownvetch, kura clover, red clover, sainfoin and white clover can be established in the Missouri Coteau region, and they deserve more detailed study of their growth phenology, nutrition and effects on soil fertility.

More species or cultivars will be added to this trial based on the screening results. The difficult part after the screening process is seed availability on the commercial scale, and this constrains the use of "new" perennial forage legume species.

Species with various stand longevities can be utilized in specific situations or agronomic practices. Crownvetch, alsike clover and red clover are short-lived and quite productive in the year after seeding. Further research should focus on improving their production in the seeding year. These short-lived species can be used as a rotation crop in row crop production systems for soil health benefits and short-term forage production. They also can be used as a cover crop component, and all of these need further study to develop appropriate production systems.

Stands of our long-lived species - alfalfa, Canadian milkvetch and cicer milkvetch - improved year by year. This is typical for these species due to their slow process of establishment. Furthermore, Canadian milkvetch and cicer milkvetch have a high proportion of hard seeds, sometimes more than 80 percent. These hard seeds serve as insurance to increase stand density if the initial stand is sparse. We seeded alfalfa at low seeding rate due to a seed problem, which may explain their extensive branching in the later years. Birdsfoot trefoil and sainfoin stands were fairly constant, and their longevity needs further study.

Our results showed that for these perennial legumes, seasonality production varied by species. For example, alsike clover and red clover are early season species with fair regrowth potential. Canadian milkvetch, cicer milkvetch and crownvetch are late-season species with less regrowth, and an early season harvest will hurt their total production. Sainfoin and birdsfoot trefoil are midseason species with less regrowth potential.

We also found that species varied in drought tolerance. Cicer milkvetch and sainfoin are more drought-tolerant than alfalfa and birdsfoot trefoil. The variability in different species can be employed by livestock producers to design their grazing systems and their whole-farm production for different purposes, such as grazing, haying, green manure and cover crops.

Future Research

In 2014, all perennial legumes, including well-established and newly seeded species, will be monitored with regard to their phenology, morphology, production and quality. Soil samples were collected in 2011 and will be collected again in 2015 to study the effect that these species have on soil health, especially soil fertility.

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Figure 1. Monthly precipitation during the four-year period of 2010 through 2013.

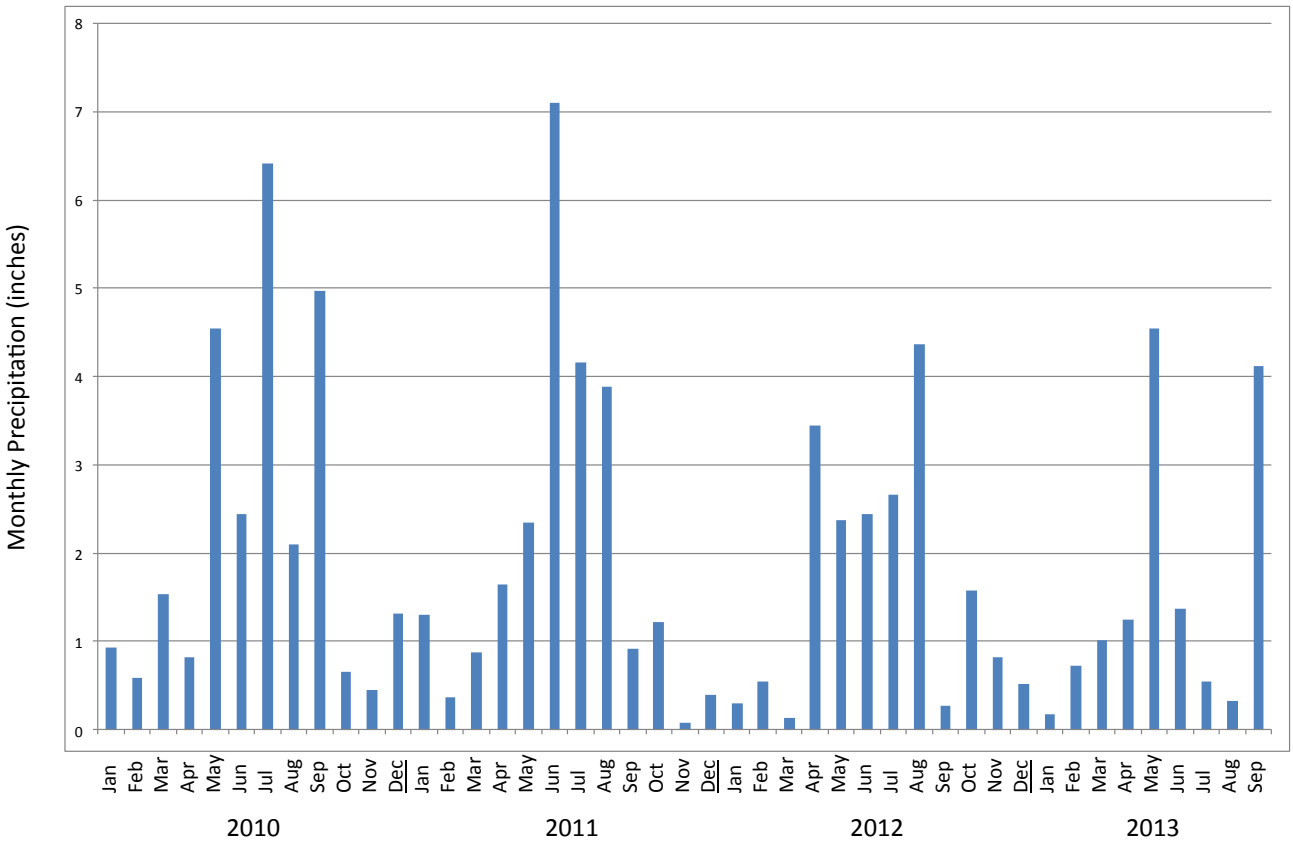

Table 1. Perennial legume species/varieties screened and evaluated at the CGREC 2010 through 2013. (Footnotes on next page.)

Common Name	Latin Name	Seeding Year[1]	Variety[2]	Seeding Rate[3]	Establishment[4]
Alfalfa	*Medicago sativa* L.	2010	Pioneer	5.57	Fair
		2010	PGI427	5.57	Fair
		2010	Rugged	5.57	Fair
		2010	TS4002	5.57	Fair
		2010	Vernal	5.57	Fair
		2011	Falcata	15.70	Excellent
		2011	Multileaf	15.70	Excellent
		2011	Ameristand 433T-RR	15.70	Excellent
		2011	Graze N Hay 3.10-RR	15.70	Excellent
		2011	Maxi-Pro 3.01-RR	15.70	Excellent
		2011	WL 355-RR	15.70	Excellent
		2013	Rhirst Extra Hybrid	17.44	NA
		2013	Vernal	17.44	NA
Alsike clover	*Trifolium hybridum* L.	2010	VNS	8.71	Excellent
		2013	VNS	13.08	NA
Birdsfoot trefoil	*Lotus corniculatus* L.	2010	Empire	6.98	Excellent
		2010	Leo	6.98	Excellent
		2010	Norcern	6.98	Excellent
		2010	Pardee	6.98	Excellent
		2010	Viking	6.98	Excellent
		2013	Languille	8.72	NA
Black medic	*Medicago lupulina* L.	2010	CT Organic	8.71	Failed
		2011	CT Organic	13.08	Poor
Canadian milkvetch	*Astragalus canadensis* L.	2010	MN Native	6.98	Failed
		2011	MN Native	10.90	Fair
		2013	MN Native	130.84	NA
Cicer milkvetch	*Astragalus cicer* L.	2010	Monarch	17.44	Excellent
		2010	Lutana	17.44	Excellent
		2013	OxleyII	21.81	NA
		2013	Veldt	21.81	NA
Crown vetch	*Coronilla varia* L.	2010	Penngift	13.11	Excellent
		2013	Penngift	21.81	NA
Kura clover	*Trifolium ambiguum* M. Bieb.	2010	VNS	6.98	Failed
		2011	VNS	13.96	Excellent
		2013	VNS	8.72	NA
Mountain goldenbanner	*Thermopsis montana* Nutt.	2010	VNS	26.15	Failed
		2011	VNS	47.36	Poor
Purple prairie clover	*Dalea purpurea* Vent.	2010	VNS	5.23	Failed
		2011	VNS	15.70	Poor
Red clover	*Trifolium pretense* L.	2010	Medium	8.71	Excellent
		2011	Arlington	9.16	Excellent
		2011	Mammoth	9.16	Excellent
		2011	Marathon	9.16	Excellent
		2013	Cinnamon Plus	13.08	NA
Sainfoin	*Onobrychis viciifolia* Scop.	2010	Eski	34.87	Excellent
		2010	Remont	34.87	Excellent
		2010	Shoshone	34.87	Excellent
		2013	Melrose	52.33	NA
		2013	Nova	52.33	NA
Silvery lupine	*Lupinus argenteus* Pursh	2010	VNS	26.15	Failed
		2011	VNS	27.26	Failed
Strawberry clover	*Trifolium fragiferum* L.	2010	O'Conners	13.11	Failed
		2011	O'Conners	15.70	Poor
Utah sweetvetch	*Hedysarum boreale* Nutt.	2010	Timp CT	15.69	Failed
		2011	Timp CT	21.81	Failed
White clover	*Trifolium repens* L.	2010	New Zealand	3.49	Excellent
		2011	Dutch	3.49	Excellent
		2011	Ladino	3.49	Excellent
		2013	Alice	6.98	NA
White prairie clover	*Dalea candida* Michx. ex Wild.	2010	Slider	5.23	Failed
		2011	Antelope	15.70	Poor

Footnotes for **Table 1**.

[1] Twenty-eight perennial forage legume species/varieties were seeded in 2010. Nine species failed to establish and they were reseeded in the same plots in 2011. Another 11 promising species/varieties were seeded also in 2011 to test different varieties of well-established species from the 2010 seeding. When evaluated in 2012, two out of those nine species seeded in 2010 and reseeded in 2011 established well. In 2013, 11 promising species/varieties were seeded in the seven failed plots seeded in 2010 and 2011.

[2] VNS: variety not stated.

[3] Pounds pure live seed per acre.

[4] Establishment level was evaluated visually one year after seeding in the early spring in a scale of 0 – 3: 0 – failed (no seedlings found); 1 – poor (sparse seedlings found); 2 – fair (regularly spaced seedlings found); 3 – excellent (dense seedlings found and few or no weeds found).

Table 2. Forage yield (tons/acre) of established perennial legume species/varieties at the CGREC seeded in 2010.

Species/Variety	2011			2012				2013		
	July	August	Total	June	July	Sept.	Total	June	July	Total
Alfalfa										
Pioneer	1.27b-e[1]	1.16d-g	2.43c-g	0.95a-d	1.72a-d	0.87a	3.54ab	0.69e	0.49a	1.17a-d
PGI427	1.22be	1.21c-g	2.44b-g	0.98a-d	1.55b-e	0.70ab	3.23ab	0.56e-g	0.33a-d	0.90c-e
Rugged	1.30b-e	1.10e-g	2.40c-g	1.13a-c	2.14a-c	0.61bc	3.88a	0.86c-e	0.43ab	1.28a-d
TS4002	1.20b-e	1.09fg	2.30d-g	0.83cd	2.15a-c	0.62bc	3.60ab	0.59ef	0.34a-c	0.93b-d
Vernal	1.20b-e	1.20c-g	2.40c-g	0.70c-e	1.61b-e	0.55bc	2.86a-d	0.82de	0.37a-c	1.18a-d
Alsike clover										
VNS	1.55b-d	1.15d-g	2.70b-f	0.27e-g	1.16d-f	0.07ef	1.49ef	NA	NA	NA
Birdsfoot trefoil										
Empire	1.19b-e	1.47b-e	2.66b-f	0.07fg	1.35c-f	0.27de	1.69e-f	NA	NA	NA
Leo	1.58b-d	1.50b-d	3.08b-e	0.87b-d	2.20ab	0.04ef	3.11ab	0.75e	0.11de	0.86de
Norcern	1.42b-e	1.88a	3.30a-c	0.59c-f	1.82a-d	0.09ef	2.50b-e	0.73e	0.17c-e	0.91c-e
Pardee	1.80ab	1.57a-c	3.37ab	0.84cd	2.26ab	0.07ef	3.17ab	0.95c-e	0.30a-d	1.25a-d
Viking	1.61bc	1.52a-d	3.13a-d	0.89b-d	2.51a	0.19d-f	3.60ab	0.99c-e	0.37a-c	1.35a-d
Cicer milkvetch										
Monarch	0.79e	1.37b-f	2.16e-g	1.46a	1.87a-d	0.14ef	3.47ab	1.59ab	0.00e	1.59ab
Lutana	0.91de	1.49b-d	2.40c-g	1.39ab	2.32ab	0.15ef	3.85a	1.67a	0.00e	1.67a
Crown vetch										
Penngift	1.23b-e	1.25c-g	2.48b-g	0.09fg	1.80a-d	0.02f	1.90c-f	NA	NA	NA
Red clover										
Medium	2.41a	1.63ab	4.05a	0.59c-f	1.96a-d	0.43cd	2.98a-c	0.12fg	0.14c-e	0.26ef
Sainfoin										
Eski	1.43b-e	0.91g	2.34d-g	0.87b-d	0.83ef	0.04ef	1.75e-f	1.37a-c	0.22b-e	1.59a
Remont	1.20b-e	1.04fg	2.24d-g	0.55d-g	0.65f	0.12ef	1.32f	1.31a-d	0.36a-c	1.67a
Shoshone	0.96c-e	0.88g	1.84fg	0.25e-g	0.67f	0.14ef	1.06f	1.09b-e	0.43ab	1.53a-c
White clover										
New Zealand	0.76e	0.90g	1.66g	0.05g	0.65f	0.03ef	0.73f	0.05g	0.00e	0.05f

[1] Forage yields within columns followed by same letters were not statistically different at $p \leq 0.05$.

Table 3. Forage yield (tons/acre) of established perennial legume species/varieties at the CGREC seeded in 2011.

Species/Variety	2012				2013		
	June	July	Sept.	Total	June	July	Total
Alfalfa							
Falcata	0.42bcde[1]	1.20ef	0.01c	1.63de	1.33abc	0.00e	1.33bcd
Multileaf	0.99a	1.35def	0.76b	3.10ab	0.84de	0.51abc	1.35bcd
Ameristand 433T-RR	0.82ab	1.97abcd	1.09a	3.88a	1.41ab	0.69a	2.10a
Graze N Hay 3.10-RR	0.63abc	1.69abcde	0.71b	3.03abc	1.03bcde	0.55ab	1.58ab
Maxi-Pro 3.01-RR	0.79abc	1.59abcdef	0.85ab	3.22ab	1.21abcd	0.62a	1.83ab
WL 355-RR	0.67abc	1.50cdef	0.58b	2.76abcd	1.03bcde	0.49abcd	1.51abc
Canadian milkvetch							
MN Native	0.19de	0.98f	0.03c	1.20e	0.89cde	0.00e	0.89cde
Kura clover							
VNS	0.38cde	1.41def	0.10c	1.88cde	1.64a	0.00e	1.64ab
Red clover							
Arlington	0.63abcd	2.22ab	0.62b	3.47ab	0.33fg	0.26cde	0.60ef
Mammoth	0.84ab	2.17abc	0.09c	3.10ab	0.62ef	0.22de	0.85de
Marathon	0.85ab	2.25a	0.77ab	3.87a	0.28fg	0.30bcd	0.58ef
White clover							
Dutch	0.68abc	1.81abcde	0.04c	2.54bcd	0.19fg	0.00e	0.19f
Ladino	0.08e	1.55bcdf	0.16c	1.79de	0.07g	0.00e	0.07f

[1] Forage yield number followed by same letters was not statistically different at $p \leq 0.05$.