Screening and Evaluation of Perennial Legumes in the Missouri Coteau Region of North Dakota

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Forty-two field plots were used to screen and evaluate perennial legume forage species/varieties with regard to production, nutrition and soil nitrogen (N) fixation in the Missouri Coteau region for diverse management goals. The comparison of selected and established species with regard to production and nutrition under several harvest regimes is presented here to fulfill different management goals and to diversify forage production systems in this region.

Summary

Several legumes showed successful establishment in our region: alsike clover, alfalfa, birdsfoot trefoil, cicer milkvetch, crown vetch, red clover, sainfoin and white clover. However, northern sweetvetch, silver mountain lupine and thermopsis 'Montana' failed twice during two consecutive years of seeding. Black medic, Canada milkvetch, kura clover, strawberry clover, purple prairie clover and white prairie clover had fair establishment one out of two years. Varietal effect was minimal on production and nutrition except for 'Falcata' alfalfa and 'Empire' birdsfoot trefoil; their production was lower than other varieties.

Alsike clover, red clover and white clover are early growing season species, with an early harvest (early June) requirement; alfalfa and sainfoin are middle growing season species, and are harvested based on their blooming stage (late June); birdsfoot trefoil, cicer milkvetch and crown vetch are late growing season species, with production increasing dramatically if the first harvest comes late in the season (late July or early August).

Alsike clover, alfalfa, red clover and white clover warrant a multi-cut system to increase the total production. However, cicer milkvetch and crown vetch produced more in less frequent cutting systems. Birdsfoot trefoil was in between and could be harvested once or twice, based on the farm schedule, without much change in production. Sainfoin is better managed if harvested once in the 10 percent blooming stage due to its poor capability of regrowth. Alsike clover and red clover suffered stand loss from year to year, while alfalfa, sainfoin, birdsfoot trefoil and cicer milkvetch stands improved during the study period.

Compared with alfalfa production on average at 3.4 ton/acre, alsike clover, crown vetch, sainfoin and white clover produced less (2.6, 2.6, 2.0 and 1.5 ton/acre, respectively), while red clover (4.2) and cicer milkvetch (3.6) produced more in two years under multi-cut systems.

White clover had superior forage quality, compared with other species during the growing season.

Production information related to the time of first harvest, harvest frequency, year-to-year stability and nutrition of diverse perennial legume forage species can serve the producers' specific needs in their forage production systems.

Introduction

Legume forage species are of interest to producers because of their high crude protein content and production, as well as their function of nitrogen fixation in the soils. Among these species, alfalfa has a long history of playing a very important role.

Extensive studies have been done on genetic variation, breeding, biotechnology development and field management of alfalfa (Bouton 2012). In North Dakota, more than half of the hay land is occupied by alfalfa alone and in mixture with other species.

More recently, farmers and scientists have embraced the use of new legume species, especially in Australia and Europe (Nichols et al. 2012). While such "old" species as alfalfa, white clover and red clover still play an important role in forage production systems, "new" species such as birdsfoot trefoil, sainfoin, cicer milkvetch and Canada milkvetch have expanded the range of legume options to reduce groundwater recharge and the spread of soil salinity. Expanding the use of alfalfa is of considerable interest; however, alternative perennial species are needed to increase biodiversity and fill niches where alfalfa is less suited (Dear et al. 2003).

Recently, several producers in our 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.

Many studies have been done since the 1980s or even earlier for "old" legume forage species, as well as to some extent for "new" species (Acharya et al. 2006). However, these studies were scattered in different study sites with a variety of climatic and soil conditions. This makes the comparison among different legumes difficult. Furthermore, the earlier work did not mention soil health concerns. Therefore, a long-term study of perennial legumes was initiated in 2010 at the Central Grasslands Research Extension Center (CGREC) northwest of Streeter, N.D., as a starting project for the forage program to screen and evaluate "old" and "new" perennial legume forage species.

Specific objectives to be studied are: (1) Establish and monitor perennial legume species for their adaptation, morphology, phenology, nutrition, productivity, stability and stand longevity. This information will be collected to build a database of perennial forage legume species/varieties for our region; (2) Determine the soil health under different legume species/varieties, including soil organic matter, soil N, soil infiltration and soil aggregate stability. The results presented here are mainly the production data and some nutrition data from the 2011 and 2012 growing season monitoring program.

Procedures

The study was carried out at the CGREC from 2010 through 2012. Twenty-eight legume species/varieties were seeded in May 2010: alsike clover, alfalfa (five varieties), birdsfoot trefoil (five), black medic, Canada milkvetch, cicer milkvetch (two), crown vetch, kura clover, northern sweetvetch, red clover, sainfoin (three), silver mountain lupine, strawberry clover, thermopsis 'Montana,'

white clover, white prairie clover and purple prairie clover. Each of these species/varieties was drilled into field plots that were prepared by disking and harrowing. Each plot was 20 feet by 20 feet with a 20-foot border between them. The border between the plots was seeded with crested wheatgrass.

In 2011, 12 more perennial legume species/varieties were added to the trial: alfalfa (six varieties), birdsfoot trefoil (one), white clover (two) and red clover (three). Black medic, Canada milkvetch, kura clover, northern sweetvetch, silver mountain lupine, strawberry clover, thermopsis 'Montana,' white prairie clover and purple prairie clover were reseeded due to stand failure in 2011.

Each plot was split into four strips. The first strip was harvested on July 7 and Aug. 23, 2011, in a multi-cut system. The other three strips were harvested on Aug. 23 and Sept. 23, 2011, and April 2012 in a single-cut system. The multi-cut system demonstrates the common forage harvest regime in this region with the Aug. 23 single cut as a comparison baseline. The Sept. 23 single-cut system will demonstrate bioenergy or late-season grazing regimes and the April single-cut system will demonstrate early season grazing regimes. In 2012, only the first strip of the plot was harvested on June 2, July 26 and Sept. 18 for production monitoring.

Forage samples were ground through a 1-millimeter (mm) screen for lab analysis of nutrition levels. Soil samples were collected in August from 2010 to 2012 at depths of 0 to 6 and 6 to 12 inches. The soil samples were air-dried, passed through a 2-mm soil sieve and sent to the laboratory for analysis of soil organic matter, soil total nitrogen, soil sulfur and soil phosphorus.

During establishment, different schedules of mowing were employed to control common weeds. Generic select herbicide (Volunteer at 6 to 8 ounces/acre) was applied to the plots to control undesirable grasses in the late growing season of each year.

Results and Discussion

Establishment. Nineteen out of 28 plots of perennial legumes were established from the 2010 growing season: alsike clover, alfalfa (five varieties), birdsfoot trefoil (five), cicer milkvetch (two), crown vetch, red clover, sainfoin (three) and white clover. Nine species (black medic, Canada milkvetch, kura clover, northern sweetvetch, purple prairie clover, silver mountain lupine, strawberry clover, thermopsis 'Montana, and white prairie clover) had stand failure and were reseeded in spring 2011. Based on the establishment success, more varieties of alfalfa (six), birdsfoot trefoil (one), red clover (three) and white clover (two) were seeded in 2011 to broaden the scope of varieties of well-established species. All of these added varieties were well-established in 2012; however, black medic, Canada milkvetch, kura clover and strawberry clover had a fair to good stand in 2012. Northern sweetvetch, silver mountain lupine and thermopsis 'Montana' experienced stand failure again in 2012. Purple prairie 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.

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 mentioning: First, this study includes the objective of screening available perennial legume forage species. Due to winter kill, drought, diseases, soils and other factors, not all the species we screened could establish 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 will alleviate weed infestation in our region. 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 at weed control was not as good as expected.

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

Time of harvest. No significant difference was found in production across all harvest times among different varieties of alfalfa ('PGI427,' 'Pioneer,' 'Rugged,' 'TS4002' and 'Vernal'), birdsfoot trefoil ('Empire,' 'Leo,' 'Norcern,' 'Pardee' and 'Viking'), cicer milkvetch ('Lutana' and 'Monarch') and sainfoin ('Eski,', 'Remont' and 'Shoshone') (Table 1). From the first harvest time study, several groups of perennial legume forage species can be classified by their phenology: early season group, including alsike clover, red clover and white clover, with an early harvest requirement; middle season group, including alfalfa and sainfoin, with the harvest time based on blooming stage (10 percent blooming); and late season group, including birdsfoot trefoil, cicer milkvetch and crown vetch, in which a late harvest will increase their production dramatically (Table 1).

Harvest frequency. Comparing one-cut and two-cut system production data showed that alsike clover, alfalfa, red clover and white clover warrant a multi-cut system to increase the total production (Table 2). However, cicer milkvetch and crown vetch produced more in less frequent cutting systems. Birdsfoot trefoil was in between and could be harvested once or twice, based on the farm schedule, with little change in production. Sainfoin would be better managed if harvested once when it is in the 10 percent blooming stage due to its poor capability of regrowth (Table 2).

Year effect. Alsike clover had stand thinning in 2012 and produced less in 2012, as compared with 2011 (Table 3). Red clover suffered stand loss in 2012; however its production was comparable to 2011. The white clover stand was comparable in 2012 to 2011 and the production was lower than 2011.

All three clovers act as biennial species in some regions with hard winter or drought conditions as shown in some studies. A decision was made based on the field observation and production data that all three clovers will be dropped from the perennial legume species list and moved to biennial legume plots, as are sweetclovers.

Alfalfa and cicer milkvetch showed stand improvement from year two to year three, counting the seeding year as year one. This is normal for most perennial species in that forage production will increase for several years, stay steady for several years, then turn to stand loss due to plant longevity. Sainfoin showed the same trend as alfalfa and cicer milkvetch; however, a wet plot in our study area had a disease problem, and the production decreased correspondingly. Birdsfoot trefoil produced more in 2012 than 2011, except for 'Empire,' due to stand loss. Crown vetch produced less in 2012, compared with 2011, due to a "dwarf" syndrome that may come from herbicide sensitivity or some other factor.

Nutrition. The crude protein content of all perennial forage legume species was above 8 percent from all harvest times and frequencies. White clover was superior in the context of crude protein content (19.11 to 25.75 percent), followed by alsike clover, red clover, alfalfa, birdsfoot trefoil, cicer milkvetch and crown vetch; the lowest crude protein content was in sainfoin (Table 4). Normally, the second cut in August following a July first cut produces crude protein higher than other harvests.

Crude protein of alsike clover, alfalfa and sainfoin decreased with the first harvest time postponed. However, cicer milkvetch, red clover, white clover and crown vetch increased, and birdsfoot trefoil stayed steady, with the first harvest time postponed.

White clover had superior digestibility (greater than 70 percent), compared with other species (Table 4), during a long period. Alsike clover (70.72 percent) and red clover (62.75 percent) had high digestibility in the early season then dropped sharply as the growing season went on. The same trend was true for alfalfa, sainfoin and birdsfoot trefoil; however, the digestibility decreases with the growing season were not as sharp as noticed in red clover and alsike clover. Cicer milkvetch digestibility stayed steady through the growing season, while crown vetch digestibility increased with the growing season.

From a production and nutrition perspective, alsike clover and red clover benefit from a more frequent harvest regime, with the first harvest earlier than other species. Crown vetch and cicer milkvetch requires a less frequent harvest regime, with the first harvest later than other species. Alfalfa and birdsfoot trefoil need a moderate harvest regime, while sainfoin only warrants one early harvest due to its poor regrowth and also due to its drop in crude protein content and digestibility during the growing season.

Literature Cited

Acharya, S.N., J.P. Kastelic, K.A. Beauchemin and D.F. Messenger. 2006. A review of research progress on cicer milkvetch (*Astragalus cicer* L.). Canadian Journal of Plant Science 86: 49-62.

Bouton, J.H. 2012. An overview of the role of lucerne (*Medicago sativa* L.) in pastoral agriculture. Crop & Pasture Sci. 63:734-738.

Dear, B.S., G.A. Moore and S.J. Hughes. 2003. Adaptation and potential contribution of temperate perennial legumes to the southern Australian wheatbelt: a review. Australian Journal of Experimental Agriculture 43: 1-18.

Nichols, P.G.H., C.K. Revell, A.W. Humphries, J.H. Howie, E.J. Half, G.A. Sandral, K. Ghamkhar and C.A. Harris. 2012. Temperate pasture legumes in Australia-their history, current use, and future prospects. Crop & Pasture Science 63: 691-725.

Table 1. Harvest date effects on forage production of different perennial forage legume species in the Missouri Coteau region 2011-2012.

Species/Varieties	Forage Production (ton/acre)			
	July 7, 2011	**Aug. 23, 2011**	**Sept. 23, 2011**	**April 25, 2012**
Alsike Clover	1.98 bcd[1] A[2]	1.49 f AB	0.83 i B	**0.00** d C
Alfalfa/PGI427	1.45 b-e A	1.90 de fA	1.86 efg A	1.23 abc A
Alfalfa/Pioneer 55v48	1.52 b-e A	2.09 c-f A	2.21 bd-g A	1.36 ab A
Alfalfa/Rugged	1.53 b-e AB	2.02 def A	1.95 efg A	1.25 abc B
Alfalfa/TS4002	1.40 b-e A	1.95 def A	1.82 g A	1.26 abc A
Alfalfa/Vernal	1.41 b-e BC	2.15 c-f AB	2.36 b-g A	1.18 abc C
Birdsfoot Trefoil/Empire	1.48 b-e B	2.34 b-f A	2.48 a-g A	1.10 abc B
Birdsfoot Trefoil/Leo	1.92 bcd B	3.54 a A	2.97 a-d A	1.07 bc C
Birdsfoot Trefoil/Norcern	1.77 b-e C	3.25 abc A	2.79 a-e B	0.91 bc D
Birdsfoot Trefoil/Pardee	2.26 ab BC	3.50 ab A	3.21 ab AB	1.36 ab C
Birdsfoot Trefoil/Viking	2.02 abc BC	3.46 ab A	3.19 ac AB	**1.67** a C
Cicer Milkvetch/Lutana	1.09 de B	2.96 a-d A	3.25 a A	0.82 bc B
Cicer Milkvetch/Monarch	**0.93**[3] e B	2.69 a-e A	2.72 a-df A	0.73 c B
Crown Vetch/Penngift	1.43 b-e A	**3.70** a A	**3.41** a A	1.26 abc A
Red Clover/Medium	**2.93** a A	2.65 a-e A	2.15 d-g A	0.97 bc B
Sainfoin/Eski	1.65 b-e B	2.07 c-f A	1.84 eg AB	0.86 bc C
Sainfoin/Remont	1.41 b-e AB	1.90 def A	1.64 gh A	0.77 c B
Sainfoin/Shoshone	1.13 cde A	1.68 ef A	1.73 g A	0.95 bc A
White Clover/New Zealand	0.98 e A	**1.17** f A	**0.67** i A	**0.00** d B

[1] Different lowercase letters within a column for different species/varieties means significant difference ($P < 0.05$).
[2] Different capital letters within a row for each species means significant difference ($P< 0.05$).
[3] Bold numbers are the highest or lowest production in each harvest time.

Table 2. Harvest frequency effects on forage production of different perennial forage legume species in the Missouri Coteau region 2011.

	Forage Production (ton/acre)			
	Multi-cut System			Single-cut System
Species/Varieties	First-cut July	Second-cut Aug.	1st +2nd cut total	Aug. single-cut
Alsike Clover	1.98 bcd[1] B[2]	1.28 c-g B	3.26 b-e A	1.49 f B
Alfalfa/PGI427	1.45 b-e B	1.34 c-g B	2.79 b-f A	1.90 def B
Alfalfa/Pioneer 55v48	1.52 b-e A	1.27 c-g A	2.79 b-f A	2.09 c-f A
Alfalfa/Rugged	1.53 b-e BC	1.22 d-g C	2.76 b-f A	2.02 def B
Alfalfa/TS4002	1.40 b-e B	1.21 dfg B	2.61 c-f A	1.95 def AB
Alfalfa/Vernal	1.41 b-e C	1.32 c-g C	2.72 b-f A	2.15 c-f B
Birdsfoot Trefoil/Empire	1.48 b-e C	1.65 a-d C	3.13 b-f A	2.34 b-f B
Birdsfoot Trefoil/Leo	1.92 bcd B	1.68 abc B	3.60 a-d A	3.54 a A
Birdsfoot Trefoil/Norcern	1.77 b-e C	**2.06**[3] a C	3.83 abc A	3.25 abc B
Birdsfoot Trefoil/Pardee	2.26 ab BC	1.76 abc C	4.02 ab A	3.50 ab AB
Birdsfoot Trefoil/Viking	2.02 abc BC	1.68 abc C	3.70 abc A	3.46 ab AB
Cicer Milkvetch/Lutana	1.09 de B	1.65 abce AB	2.74 b-f AB	2.96 a-d A
Cicer Milkvetch/Monarch	**0.93** e B	1.53 b-f AB	2.46 def A	2.69 a-e A
Crown Vetch/Penngift	1.43 b-e A	1.40 b-g A	2.83 b-f A	**3.70** a A
Red Clover/Medium	**2.93** a B	1.83 ab C	**4.76** a A	2.65 a-e BC
Sainfoin/Eski	1.65 b-e B	1.00 g C	2.65 c-f A	2.07 c-f B
Sainfoin/Remont	1.41 b-e B	1.15 fg B	2.57 c-f A	1.90 def AB
Sainfoin/Shoshone	1.13 cde B	**0.98** g B	2.11 ef A	1.68 ef AB
White Clover/New Zealand	0.98 e B	1.06 g AB	**2.04** f A	**1.17** f AB

[1] Different lowercase letters within a column for different species/varieties means significant difference ($P < 0.05$).
[2] Different capital letters within a row for each species/varieties means significant difference ($P < 0.05$).
[3] Bold numbers are the highest or lowest production in each harvest frequency.

Table 3. Year effects on forage production of different perennial forage legume species in the Missouri Coteau region 2011-2012.

	Forage Production (ton/acre)						
	July 2011	**Aug. 2011**	**Total[4], 2011**	**June 2012**	**July 2012**	**Sept. 2012**	**Total[4] 2012**
Alsike Clover	1.98 bcd[1] B[2]	1.28 c-g B	3.26 b-e A	0.33 efg C	1.41 d-g B	0.11 fg C	1.84 ef B
Alfalfa/PGI427	1.45 b-e C	1.34 c-g C	2.79 b-f B	1.16 bcd C	1.86 b-f BC	0.95 ab C	3.98 ab A
Alfalfa/Pioneer 55v48	1.52 b-e CD	1.27 c-g CD	2.79 b-f B	1.13 bcd D	2.07 a-d BC	**1.14**[3] a D	4.33 a A
Alfalfa/Rugged	1.53 b-e CD	1.22 d-g D	2.76 b-f B	1.32 abc D	2.47 a-d BC	0.79 bc D	4.58 a A
Alfalfa/TS4002	1.40 b-e CD	1.21 dfg D	2.61 c-f B	1.00 cd D	2.53 abc BC	0.76 bc D	4.30 ab A
Alfalfa/Vernal	1.41 b-e CD	1.32 c-g CD	2.72 b-f AB	0.83 cde CD	1.96 b-e BC	0.69 bcd D	3.49 a-d A
Birdsfoot Trefoil/Empire	1.48 b-e B	1.65 a-d B	3.13 b-f A	**0.06** g C	1.66 c-g B	0.39 def C	2.11 def B
Birdsfoot Trefoil/Leo	1.92 bcd C	1.68 abc CD	3.60 a-d A	1.11 bcd D	2.61 abc B	0.06 fg E	3.78 abc A
Birdsfoot Trefoil/Norcern	1.77 b-e CD	**2.06** a BC	3.83 abc A	0.73 c-f DE	2.24 a-d BC	0.11 fg E	3.09 b-e AB
Birdsfoot Trefoil/Pardee	2.26 ab B	1.76 abc BC	4.02 ab A	1.08 cd C	2.77 ab B	0.10 fg D	3.95 ab A
Birdsfoot Trefoil/Viking	2.02 abc CD	1.68 abc D	3.70 abc AB	1.13 bcd DE	**3.04** a BC	0.28 efg E	4.45 a A
Cicer Milkvetch/Lutana	1.09 de CD	1.65 abce BCD	2.74 b-f B	1.78 ab BC	2.74 ab B	0.23 fg D	**4.74** a A
Cicer Milkvetch/Monarch	**0.93** e CD	1.53 b-f BC	2.46 def B	**1.84** a BC	2.25 a-d B	0.20 fg D	4.29 ab A
Crown Vetch/Penngift	1.43 b-e AB	1.40 b-g ABC	2.83 b-f A	0.11 gf BC	2.15 a-d A	**0.02** g C	2.29 c-f A
Red Clover/Medium	**2.93** a BC	1.83 ab CD	**4.76** a A	0.74 c-f DE	2.30 a-d C	0.57 cde E	3.61 abc AB
Sainfoin/Eski	1.65 b-e AB	1.00 g BC	2.65 c-f A	1.03 cd BC	0.99 efg BC	0.06 fg C	2.08 def A
Sainfoin/Remont	1.41 b-e BC	1.15 fg BC	2.57 c-f A	0.65 d-g CD	**0.77** g BCD	0.17 fg D	1.59 f B
Sainfoin/Shoshone	1.13 cde B	**0.98** g BC	2.11 ef A	0.30 efg CD	0.80 fg BCD	0.20 fg D	1.29 f B
White Clover/New Zealand	0.98 e B	1.06 g B	**2.04** f A	0.10 gf C	0.78 g BC	0.04 g C	**0.93** f B

[1] Different lowercase letters within a column for different species/varieties means significant difference ($P< 0.05$).
[2] Different capital letters within a row for each species means significant difference ($P< 0.05$).
[3] Bold numbers are the highest or lowest production in each harvest.
[4] Total for each year is the sum of the multi-cut production.

Table 4. First harvest time and frequency effects on forage crude protein content and in vitro dry-matter digestibility content of different perennial forage legume species in the Missouri Coteau region 2011.

	Crude Protein Content (%)				In vitro Dry-matter Digestibility Content (%)			
	Multi-cut system		Single-cut system		Multi-cut system		Single-cut system	
	July: first cut	August: second cut	August cut	Sept. cut	July: first cut	August: second cut	August cut	Sept. cut
Alsike Clover	17.70 ab[1] A	13.87 eg B	12.65 d B	12.15 fgh B	70.72 a A	63.87 b A	48.81 cd B	47.04 e-i B
Alfalfa/PGI427	16.15 ab A[2]	15.56 cde A	13.22 cd B	12.41 fgh B	62.00 b A	59.86 b-f A	46.94 d B	42.57 hij C
Alfalfa/Pioneer 55v48	15.60 abc A	14.85 cde A	13.74 bcd A	11.17 gh A	60.17 b A	57.80 def A	47.71 cd B	**40.52**[3] j C
Alfalfa/Rugged	16.00 abc A	16.94 bc A	13.19 cd B	12.13 fgh B	61.33 b A	62.94 bc A	48.39 cd B	41.36 j C
Alfalfa/TS4002	14.52 bcd AB	16.73 bc A	13.76 bcd B	13.11 d-g B	61.61 b A	61.96 bce A	48.80 cd B	44.36 f-j B
Alfalfa/Vernal	14.95 bcd A	15.90 cde A	13.23 cd AB	10.92 hi B	60.72 b A	59.27 c-f A	46.94 d B	41.84 ij C
Birdsfoot Trefoil/Empire	15.92 abc A	13.92 d-g BC	12.65 cd C	14.54 b-e AB	53.24 cd B	59.02 b-f A	47.23 d C	50.92 cde BC
Birdsfoot Trefoil/Leo	15.64 bc A	15.79 cde A	12.66 d B	11.50 gh B	**49.24** d B	60.65 b-e A	48.29 cd B	45.96 e-j B
Birdsfoot Trefoil/Norcern	16.48 ab A	15.12 cde A	12.73 cd B	12.75 e-h B	49.74 d B	56.70 df A	47.29 d B	49.46 c-g B
Birdsfoot Trefoil/Pardee	16.17 abc A	15.97 cde A	12.26 d A	14.02 c-f A	51.02 d B	62.01 bcd A	45.34 d C	46.00 e-j C
Birdsfoot Trefoil/Viking	16.45 ab A	16.05 cde A	12.83 d B	12.95 efg B	52.48 cd B	60.66 b-e A	45.33 d C	47.68 d-h C
Cicer Milkvetch/Lutana	12.88 cde A	16.39 cd A	15.56 b A	14.86 bcd A	63.42 b A	**55.99** f B	56.76 b B	53.52 bc B
Cicer Milkvetch/Monarch	11.84 de B	14.95 cde A	14.95 bc A	15.29 bc A	61.74 b A	59.03c-f AB	53.54 bc B	56.05 b B
Crown Vetch/Penngift	15.48 bc A	18.98 ab A	16.00 b A	16.37 b A	50.44 d A	63.36 bc A	54.31 bc A	53.42 bcd A
Red Clover/Medium	14.99 bcd A	15.46 cde A	14.19 bcd A	16.06 bc A	62.75 b A	59.66 b-f A	49.23 cd B	49.51 c-f B
Sainfoin/Eski	11.01 e A	11.87 gh A	9.22 e AB	**8.16** j B	55.47 c B	59.49 b-f A	45.64 d C	42.67 hij C
Sainfoin/Remont	**10.16** e AB	**11.01** h A	**9.00** e AB	8.39 j B	55.36 c A	57.83 def A	47.94 d B	43.50 g-j B
Sainfoin/Shoshone	10.29 e A	11.45 fh A	9.37 e A	9.06 ij A	55.43 c A	57.95 def A	**44.01** d B	43.38 g-j B
White Clover/New Zealand	**19.11** a C	**20.95** a BC	**22.89** a B	**25.75** a A	**73.44** a B	**80.07** a A	**81.02** a A	**83.19** a A

[1] Different lowercase letters within a column for different species/varieties means significant difference ($P < 0.05$).
[2] Different capital letters within a row for each species means significant difference ($P < 0.05$).
[3] Bold numbers are the highest or lowest production in each harvest.

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