

Legume Establishment on Strip Mined Lands in Southeastern Montana

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Abstract

Research was conducted on topsoiled strip mined lands at Colstrip, Mon., over a 6-year period to evaluate germination, survival, productivity, and cover characteristics of Eski sainfoin (*Onobrychis viciaefolia*), Lutana cicer milkvetch (*Astragalus cicer*), birdsfoot trefoil (*Lotus corniculatus*), and ranger and spreader alfalfa (*Medicago sativa*). Nitrogen and phosphorus fertilizer were applied at a low rate during the first year of study. None of the experimental units received irrigation. Lutana cicer milkvetch and both varieties of alfalfa demonstrated good establishment, survival, canopy cover, and productivity characteristics. Eski sainfoin showed good initial establishment but declined in following years. Birdsfoot trefoil appeared to be unsuitable for revegetation of mined lands at Colstrip. Spreader alfalfa was superior to ranger alfalfa in the parameters evaluated. Lutana cicer milkvetch showed much potential for mined lands revegetation in the study area because of site stabilization, persistence, palatability, nitrogen fixation, and productivity characteristics.

Revegetation of coal strip mined lands in the Northern Great Plains has received considerable attention in recent years due to acceleration of mining and associated land disturbance. A number of investigations have been reported comparing the establishment of different grass species on strip mined lands in the Northern Great Plains (Sindelar et al. 1973; Farmer et al. 1974; Meyn et al. 1976; DePuit et al. 1977; DePuit et al. 1978; DePuit and Coenenberg, 1979; Holechek 1981, 1982; Holechek et al. 1981a,b). Several legumes have shown potential on strip mined lands at Colstrip, Mon. and other mining locations in the Northern Great Plains (Sindelar et al. 1973; Sindelar et al. 1974; Dollhopf and Majerus 1975; DePuit and Coenenberg 1977; Holechek 1981, 1982). These include ranger and spreader alfalfa (*Medicago sativa*), Eski sainfoin (*Onobrychis viciaefolia*), and Lutana cicer milkvetch (*Astragalus cicer*). However, specific research has not been conducted to compare the effectiveness of these species in revegetating strip mine lands in the Northern Great Plains. The objectives of this study were to determine the emergence, survival, productivity, and cover characteristics of the four legume species previously mentioned and birdsfoot trefoil (*Lotus corniculatus*) on mined lands at Colstrip, Mon.

Methods

During the spring of 1975, 15 experimental plots, 10 × 10 m, were established on strip mined land at Colstrip that had been previously graded, ripped, and topsoiled. The experimental design

included three blocks of five plots. The five species/varieties were randomly assigned to plots in each block. Seeding was accomplished by broadcasting and then cultipacking on May 3, 1975. All species were seeded at the rate of 538 pure live seeds per m². All seed was obtained from Northrup and King Company and was mixed with nitrogen fixing bacteria prior to planting. Fertilizer was applied to each plot on June 10, 1975, with a hand operated broadcast spreader at the rate of 37-94-0 kg/ha of N, P₂O₅ and K₂O.

The average chemical composition of soil samples from the study area at Colstrip is given in Table 1. Approximately 20 cm of topsoil with a sandy loam texture was applied over the spoil. The topsoil had about 0.5% organic matter and was low in nitrogen and phosphorus. The pH averaged 8.5. The spoil material beneath the topsoil was variable in texture and had less than 0.2% organic matter. The pH was between 8.2 and 8.4. The raw spoils material was also low in nitrogen and phosphorus.

The mean annual precipitation for the Colstrip area is 40.1 cm (DePuit and Coenenberg 1979). The annual precipitation totals for the years of 1975 through 1979 at Colstrip were 44.4, 40.8, 39.1, 57.8, and 22.3 cm respectively. In 1975, 1976, and 1980 when sampling was conducted, precipitation values during the spring growing season (March through June) were 113%, 129%, and 49% of the mean, respectively. Conditions were very favorable for plant growth in 1978 because spring growing season precipitation was 140% of the mean. Both 1979 and 1980 were years of severe spring drought. Irrigation was not used during any year of study.

Plant density samples were collected on June 14 and August 14, in 1975; June 22, 1976; and July 9, 1980 using 20 × 20 cm square quadrats. Ten randomly placed quadrats were evaluated on each experimental unit on each sampling date. Plant canopy cover and frequency were estimated according to the methods of Daubenmire (1970) on June 22, 1976, and July 10, 1980. One 14-m sampling transect was established diagonally across each plot, and ten 20 × 50-cm quadrats were evaluated per transect at randomly selected points within each 1-meter interval. Sampling was not conducted at the top or the bottom 2-m of each plot. Aerial biomass was estimated June 22, 1976, by harvesting to ground level ten 0.25-m² quadrats per plot at random locations along the opposite side of the diagonal line used for cover sampling. No samples of any parameter were taken in a 1-m buffer strip around each experimental unit. Density canopy cover and aerial biomass data were analyzed with a randomized complete block design (three blocks) using the procedures of Steel and Torrie (1960). Comparisons were made between the five species/varieties of legumes seeded using Newman-Keuls Test.

Results and Discussion

Plant density data collected in 1975, 1976, and 1980 are presented in Table 2. Eski sainfoin had significantly ($P < .05$) the highest percent emergence followed by Lutana cicer milkvetch. Seedling density was measured again on August 14, 1975, to determine first year establishment. In terms of first growing season survival and/or increase Lutana cicer milkvetch and ranger alfalfa were superior to other species. These species have shown good first-year

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Table 1. Average chemical composition of soil samples from the study area at Colstrip, Mon.¹

Depth	No. of Samples	pH	NO ₃ -N (ppm)	PO ₄ -P (ppm)	K (ppm)	Ca (meg/ 100g)	Mg (meg/ 100g)	Na (meg/ 100g)	E.C. (mmhos/cm)
(0-20 cm)	3	8.50	2.20	.60	54.17	29.36	2.18	.13	.41
(21-60 cm)	3	8.35	5.27	.53	56.67	21.20	2.21	.13	.75
(61-90 cm)	3	8.23	3.86	.45	55.83	19.78	2.32	.13	.80
(91-120 cm)	3	8.23	4.52	.47	56.67	19.87	2.12	.13	.80

¹Soil samples were collected on November 17, 1974, prior to treatment application.

establishment in other studies at Colstrip (Sindelar et al. 1974; DePuit and Coenberg 1979; Holecchek 1981, 1982).

The density of spreader alfalfa and Lutana cicer milkvetch increased between August 14, 1975, and June 22, 1976. Survival of Eski sainfoin and ranger alfalfa was relatively high from 1975 to 1976. Birdsfoot trefoil suffered considerable mortality between 1975 and 1976 although survival of this species was high during the first year of seeding.

Data collected in 1980 showed drastic reductions in the density of all species. Both natural thinning and two consecutive years of drought probably account for the reduction in plant numbers. Lutana cicer milkvetch had a higher density than all species, although its density was statistically similar to that of spreader and ranger alfalfa. The percent survival of Eski sainfoin and birdsfoot trefoil was significantly lower ($P < .05$) than that of the other three species. Density data alone, however, do not entirely indicate the relative effectiveness of the different legumes in revegetation of the mine spoils. Biomass, frequency, and canopy cover data provide an appraisal of soil stabilization effectiveness, plant distribution and plant vigor.

The density of invading species was significantly higher ($P < .05$) on experimental units seeded to birdsfoot trefoil compared to other species in 1980. The average densities of invading species on birdsfoot trefoil, Eski sainfoin, Lutana cicer milkvetch, range alfalfa and spreader alfalfa plots in plants/m² were 43, 19, 11, 8 and 8, respectively. Russian thistle (*Salsola kali*) was the primary invader found on the plots. It had an average density of 14 plants/m². The second most common invaders were spreader alfalfa and crested wheatgrass (*Agropyron cristatum*) each of which had an average density of 0.5 plants/m². The area surrounding the study was seeded to a 16 species mixture, native range occurred approximately 50 m to the north, and the study site was topsoiled. Howard and Samuel (1979) found that topsoil could provide a valuable source of native plant materials in reclamation of mined

lands in Wyoming. However, the average density of native species on the plots was less than 0.1 plant/m² in the present study. These data suggest that natural revegetation on the mine spoils at Colstrip may be a very slow process even when a native seed source is available from nearby native range and in applied topsoil.

Legume canopy cover, frequency and aerial biomass data are presented in Table 3. In 1976 spreader alfalfa produced more aerial biomass than any other legume species/variety in the study. However, both Lutana cicer milkvetch and Eski sainfoin had higher plant density and frequency values. After two years of severe drought in 1980 only Lutana cicer milkvetch had higher canopy cover, frequency, and density values than spreader alfalfa. Spreader alfalfa is a rhizomatous, low growing variety of alfalfa that appears to have much potential for mined land revegetation at Colstrip because of its germination, survival, ground cover, and productivity characteristics. However, the effectiveness of this alfalfa variety in a seeding mixture remains to be evaluated.

Throughout the 6 years of study, Lutana cicer milkvetch maintained the highest plant densities and exhibited the most even distribution. In 1976 it was superseded by both Eski sainfoin and spreader alfalfa in canopy cover and productivity. However, in 1980 it had more canopy cover than the other legume selections. Because of its low, spreading and rhizomatous nature, initial evaluations of cicer milkvetch in the western United States were primarily concerned with its ability as a ground cover species to retard erosion (Carleton et al. 1971; Stroh et al. 1972). However more recently cicer milkvetch has also proven to be nutritious, palatable, non-bloating, and grazing tolerant (Stroh et al. 1972). Under the proper conditions cicer milkvetch appears to be capable of significant nitrogen fixation (Townsend et al. 1975; Rauzi et al. 1974). Unlike certain other members of the genus *Astragalus*, it apparently does not accumulate alkaloids to toxic levels. Research has also shown cicer milkvetch to perform well in species mixtures (Carleton et al. 1971; Stroh et al. 1972; DePuit and Coenberg

Table 2. Legume density and survival in 1975, 1976, and 1980.

Species ¹	Plants/M ²	Plants/M ²	Plants/M ²	Plants/M ²	% Emergence	% Survival July 9, 1980
	June 14, 1975	August 14, 1975	June 22, 1976	July 9, 1980		
Lutana cicer milkvetch	200 ^b	254 ^a	361 ^a	32 ^a	37 ^b	16 ^a
Spreader alfalfa	172 ^{bc}	148 ^a	248 ^a	28 ^a	32 ^{bc}	16 ^a
Ranger alfalfa	145 ^{bc}	191 ^a	156	23 ^{ab}	27 ^{bc}	13 ^a
Eski sainfoin	304 ^a	241 ^a	216 ^{bc}	15 ^b	57 ^a	5 ^b
Birdsfoot trefoil	113 ^c	115 ^a	32 ^d	4 ^c	21 ^c	4 ^b

¹Densities of legume species/ varieties with different letters are significantly different ($P < .05$) using Newman-Keuls Test.

Table 3. Legume canopy cover (%), frequency (%), and aerial biomass (kg/ha).

Species	Frequency		Canopy Cover		Aerial Biomass 1976 ¹
	1976 ²	1980 ²	1976 ²	1980	
Lutana cicer milkvetch	100	89	40	43 ^a	597.1 ^b
Spreader alfalfa	90	83	53	32 ^b	1225.2 ^a
Ranger alfalfa	83	78	33	25 ^c	557.7 ^b
Eski sainfoin	100	56	53	12 ^d	755.2 ^b
Birdsfoot trefoil	50	14	2	1 ^e	10.3 ^c

¹Values followed by different letters are significantly different at $P < .05$ (Newman-Keuls Test).

1979). The primary disadvantage of cicer milkvetch has been slow initial establishment due to both low germination and rate of spreading (Carleton et al. 1971; Montana Agricultural Experiment Station 1976). Research in the region of study concerning the establishment of Lutana cicer milkvetch has been contradictory. Studies conducted by Sindelar et al. (1973), Hodder and Atkinson (1974), and Dollhopf and Majerus (1975) have shown either low or nonexistent initial establishment. However, DePuit and Coenenberg (1979), and Holechek et al. (1981) reported Lutana cicer milkvetch had high initial and long term establishment in a 16 species mixture. Meyn et al. (1976) also reported that Lutana cicer milkvetch has typically either maintained itself or increased once established on mined lands at Colstrip. In the present study Lutana cicer milkvetch showed good initial establishment and superior long term growth even under conditions of severe drought when compared with other legumes.

Although Ranger alfalfa produced an adequate stand, it was inferior to spreader alfalfa and Lutana cicer milkvetch in emergence, survival, productivity, distribution, and canopy cover. This variety of alfalfa gives good persistence and lacks in aggressiveness when grown in grass mixtures (Ditterline et al. 1976). Holechek et al. (1981) reported that ranger alfalfa showed good initial establishment when planted in a four species mixture on mined lands at Colstrip.

Eski sainfoin showed good initial establishment and productivity in this study. However, between 1976 and 1980 this species declined drastically in both density and vigor. The long term survival of Eski sainfoin was inferior to Lutana cicer milkvetch, spreader alfalfa, and ranger alfalfa. Research regarding the establishment of Eski sainfoin has been conflicting in the Colstrip area. It has proven to be comparable or superior to ranger or Ladak alfalfa in terms of initial establishment and production in studies by Dollhopf and Majerus (1975), Hodder and Atkinson (1974), and Sindelar et al. (1973). In contrast DePuit and Coenenberg (1979) found that Eski sainfoin exhibited poor establishment, cover, and productivity compared to Ladak alfalfa and Lutana cicer milkvetch in a 16 species mixture planted at Colstrip. Research conducted by Meyn et al. (1976) on mined lands at Colstrip showed that with time Eski sainfoin decreased in a grass-legume mixture. Because it is nonbloating, nutritious, and initially productive, sainfoin is in some respects superior to alfalfa (Ditterline and Cooper 1975). However, one undesirable characteristic, particularly for mined lands plantings, is apparent limited nitrogen fixing ability (Townsend et al. 1975). Results from the present study and Townsend et al. (1975) suggest an additional disadvantage is lack of persistence, particularly during drought.

Birdsfoot trefoil was inferior to other legume species in all parameters evaluated. Other researchers working on mine spoils in the region have reported similar findings (Sindelar et al. 1973; Hodder and Atkinson 1974; Dollhopf and Majerus 1975).

Conclusions

Based on the evidence from this study, Lutana cicer milkvetch, spreader alfalfa and ranger alfalfa appear to be suitable legume species/varieties for revegetation of mined lands in the Colstrip area. Lutana cicer milkvetch may be a very valuable legume species for mined lands plantings in the Northern Great Plains region because of persistence, site stabilization qualities, forage value, nitrogen fixation benefits, relative drought tolerance, and eventual productivity. Although low initial establishment has been reported in other studies, Lutana cicer milkvetch did not manifest this problem in the present study. Eski sainfoin exhibited good initial establishment and productivity, but showed poor persistence. It has the added disadvantage of apparent inability to fix nitrogen. The prime utility of this species in mined land revegetation may hence be as a rapidly developing pioneer species with a major function of initially incrementing systemic organic matter content. Birdsfoot trefoil was found to be an unsuitable legume species for mined land plantings at Colstrip. Spreader alfalfa may be superior

to ranger alfalfa for reclamation in the Colstrip area. However, more research is needed to evaluate the response of spreader alfalfa in a grass-legume mixture. In addition research is needed to evaluate the long term response of spreader alfalfa, ranger alfalfa, and Lutana cicer milkvetch under grazing pressure.

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