A Comparison of Two Sweetclover Strains and Ladak Alfalfa Alone and in Mixtures with Crested Wheatgrass for Range and Dryland Seeding[1]

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The adverse soil, climate, and moisture conditions characteristic of rangeland sites have largely limited usable species to the grasses. Finding suitable legumes for grass-legume mixtures and management practices which will keep legumes in dryland seedings are major problems.

Different legumes have been used with variable results depending on the site. One of the most used legumes in rangeland seedings has been sweetclover (*Melilotus officinalis* (L.) *Lam.*). It is well known for its ability to grow almost anywhere provided moisture and lime are adequate in the soil. It will grow on soils low in fertility or too high in al-

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Table 1. Monthly and annual precipitation recorded at the Red Bluff Ranch[1]

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
	(Inches)												
1958	.35	.36	1.05	2.04	.62	3.33	2.25	1.06	1.64	.17	1.01	.27	14.15
1959	.13	1.32	.59	.53	3.45	3.89	1.13	.41	1.49	1.31	.94	.90	16.09
1960	.39	.54	1.21	2.57	1.81	1.50	.88	1.58	.18	.96	.43	.28	12.33

[1]Reference U. S. Weather Bureau, 1958, 1959, 1960.

kali for alfalfa and has been used under such conditions for soil improvement. Investigations by Christ (1934), Short (1943), Pickford and Jackman (1944), Lavin (1955), and Plummer *et al.* (1955) have shown sweetclover to be adapted and successfully used for seeding under varied range conditions.

Sweetclover has two major limitations as a dryland legume. First, it is biennial and may be lost from a mixture after the second growing season. (However, where moisture conditions are adequate and the plant is allowed to produce seed, it will reseed itself.) A second problem is the establishment of good stands. Larger seed size may be one answer to this problem.

This paper compares the establishment and growth of two sweetclover strains and alfalfa alone and in mixtures with crested wheatgrass under dryland conditions.

Materials and Procedures

Experimental site

Studies were conducted on an abondoned cropland site heavily infested with cheatgrass (*Bromus tectorum* L). The study area was at an elevation of 4,800 feet near Norris, Montana, on the Red Bluff Research Ranch of the Montana Agricultural Experiment Station. It had a uniform five percent slope to the southeast. The soil was a sandy loam derived from an alluvial deposit of decomposed metamorphic material.

During the study period annual precipitation ranged from 12.3 to 16.1 inches (Table 1) with approximately 70 to 80 percent occurring during April-September. Except for short periods during winter, the ground was free from snow. Soil moisture was considered adequate each year for germination and seedling establishment.

Plant materials

Two strains of yellow-blossom sweet clover were studied. They were Madrid, a widely adapted strain, and an unnamed large-seeded strain, PI-187985-L57, hereafter referred to as PI-L57. Ladak alfalfa (*Medicago sativa* L. x *M falcata* L.) and Nordan variety of crested wheatgrass (*Agropyron desertorum* (Fisch. ex Link) Schult. were included in some studies.

Procedure

The seedbed was prepared by plowing with a moldboard plow, packing with a culti-packer, and dragging with a float to smooth the soil surface. A single-row cone-type seeder was used in seeding immediately after seedbed preparation. Seeding was at a one-inch depth except where the depth was purposely changed.

In pure stands Madrid sweetclover and Ladak alfalfa were seeded at five pounds per acre, PI-L57 at ten pounds, and crested wheatgrass at six pounds per acre. (Comparative numbers of seed per pound were estimated as follows: Madrid 260,000; Ladak 200,000; PI-L57 130,000; and crested wheatgrass 175,000.) At these rates, about 25 pure live seeds were seeded per foot of row. In mixtures the seeding rates per acre for the legume and the grass were reduced by one-half.

Plots five by 20 feet were replicated four times in a randomized block design.

Studies

Four plantings were established. The first, seeded in April 1958, compared the two sweetclover strains with each other, with Ladak alfalfa, and with Nordan crested wheatgrass in pure stands and in simple legume-grass mixtures. Rows were spaced one foot apart. In mixtures the legume and grass were seeded in alternate rows. The second study also seeded in April 1958 compared the two sweetclover strains seeded at varying depths ranging from broadcasting on the soil surface to drilling to a two-inch depth. A third study was initiated in April 1959 as a repetition of the 1958 seeding depth study with two treat-

Table 2. Seedlings per foot of row and percent stand of two sweetclover strains in the first and second years of growth.[1]

Seeding depth	1958[2]		1959[3]		1959[2]		1960[3]	
	Madrid	PI-L57	Madrid	PI-L57	Madrid	PI-L57	Madrid	PI-L75
(Inches)	(Number)				(Percent)			
Broadcast	0.4b	0.6c	0.6c	0.9b	1b	8b	3d	4c
¼	7.0a	7.3ab	7.2a	7.0a	76a	62a	83a	80ab
½	5.9a	9.6ab	7.0a	6.8a	75a	66a	84a	76ab
1	9.4a	5.9b	8.1a	7.5a	80a	62a	75ab	86a
1½	7.6a	8.9ab	7.1a	7.4a	78a	70a	71ab	79ab
2	5.6a	11.7a	6.5ab	7.5a	78a	90a	58abc	84a
2½	.....	.....	5.6ab	6.6a	.....	.....	42bcd	73ab
3	.....	.....	3.2b	6.4a	.....	.....	30cd	52b

[1]Values within columns followed by the same letter are not significantly different at the five percent level (Duncan, 1955).
[2]Seeded in 1958.
[3]Seeded in 1959.

ments added, seeding at depths of 2½ and three inches. In both depth-of-seeding studies, rows were spaced one foot apart. The fourth study, also seeded in April 1959, compared the two sweetclover and Nordan crested wheatgrass in pure stands and in simple grass-legume mixtures. Mixing legume and grass seed before planting and planting legume and grass in alternate rows were compared. Rows were spaced six inches apart.

Observations

In the year of seeding, the number of seedlings per foot of row space was determined in mid-June by counting the plants in the center ten feet of the center row on each pure-seeding plot. In mixed seedings the numbers of plants were recorded by grass or legumes from two center rows. In the second year, stands were compared by visual estimates of the percent of row space occupied by the basal area of seeded plants and is referred to here as percent stand.

Plant height was determined by measuring to the highest portion of average-looking plants. Measurements were made June 6, 1958, and June 5 and July 7, 1959.

Hay yields were determined from the second-year growth by clipping two 9.6-square-foot samples per plot at ground level. Harvests were made in early July when Madrid was in early bud stage and PI-L57 was in full bloom. Harvested samples were separated by grass and legume. Oven-dry weights were expressed as pounds per acre.

Samples harvested in 1959 were analyzed for crude protein (N x 6.25) by the Kjeldal method (A.O.A.C., 1945).

Plant development was recorded as observed in the field.

Results

Depth of seeding

The sweetclover strains responded differently to depth-of-seeding treatments. The most Madrid seedlings were established when seeding was at the one-inch depth. In 1958, however, none of the drilled treatments of this strain differed significantly (Table 2). In 1959, seeding at the three-inch depth gave fewer seedlings than depths of ¼ to 1½ inches. Broadcast seeding of both strains consistently rated lower than any of the drilled treatments.

The large-seeded strain, PI-L57, produced the greatest number of seedlings, 11.7 per foot of row, when seeded at the two-inch depth. None of the drilled treatments of PI-L57 differed except seeding at the one-inch depth. Because of unknown factors, this strain seeded in 1958 at the one-inch depth produced fewer seedlings than at the two-inch depth. Madrid at the one-half-inch depth was also unexpectedly low, but neither difference was significant.

Seedling count differences were not apparent between strains seeded at one-fourth to 1½-inch depths. At two-inch depths or greater and in broadcast treatments, PI-L57 produced more established plants than the Madrid strain. In the second year of growth, the percentage of row-space occupied by sweetclover continued to be related to differences in seedling numbers (Table 2).

PI-L57 developed more rapidly than Madrid in the seedling stage. Its seedlings were also larger and more vigorous. In the second year the two strains developed at about the same rate until after early June. By early July, PI-L57 had reached full bloom and maximum height (Table 3). At that time Madrid was in the early bud stage and averaged approximately eight inches taller. Madrid bloomed

Table 3. Height of sweetclover plants from 1958 seeding as affected by strain differences and seeding depths.[1]

Seeding depth	June 6, 1958		June 5, 1959		July 7, 1959	
	Madrid	PI-L57	Madrid	PI-L57	Madrid	PI-L57
	(Inches)					
Broadcast	3.0c	5.0b	11.6b	12.5a	33.0a	24.5b
¼	6.0a	7.8a	15.5a	15.0a	34.5a	24.5b
½	3.5bc	8.2a	14.0a	15.5a	36.5a	28.0ab
1	5.2ab	8.5a	15.2a	14.2a	37.0a	31.5a
1½	5.2ab	8.8a	14.5a	16.0a	36.0a	27.0b
2	5.5ab	8.8a	15.0a	16.0a	34.5a	27.0b

[1]Values within columns followed by the same letter are not significantly different at the five percent level (Duncan, 1955).

Table 4. Herbage yields of sweetclover strains in the second year of establishment as affected by seeding depth.[1]

Seeding depth	1959[2]		1960[3]	
	Madrid	PI-L57	Madrid	PI-L57
(Inches)	(Pounds per acre)			
Broacast	250b	775b	102d	168c
¼	4850a	3775a	655ab	342bc
½	4150a	3900a	525bc	262bc
1	4725a	3950a	962a	655a
1½	4400a	3825a	650ab	288bc
2	4400a	2975a	300cd	328bc
2½	.....	.....	675ab	430ab
3	.....	.....	220cd	450ab

[1]Values within columns followed by the same letter are not significantly different at the five percent level (Duncan, 1955).
[2]Seeded in 1958.
[3]Seeded in 1959.

Table 5. Herbage yield of legumes, grass, and simple mixtures in different years.[1]

Species or mixture	1959[2]	1960[2]	1960[3]
	— — — (Pounds per acre) — — —		
Madrid	4725a	0	962a
PI-L57	2950c	0	655a
Ladak	2700cd	307b	.....
Nordan	1725e	1300a	975a
Madrid + Nordan (mixed seed)	.....	.....	1282a
Madrid + Nordan (alternate row)	4875a	1612a	1262a
PI-L57 + Nordan (mixed seed)	.....	.....	722a
PI-L57 + Nordan (alternate row)	3575b	1475a	940a
Ladak + Nordan (alternate row)	2250e	1422a	.....

[1]Values in columns followed by the same letter are not significantly different at the five percent level (Duncan, 1955).
[2]Seeded in 1958.
[3]Seeded in 1959.

two weeks later. Seeding depth had little effect on the height of the plants except that broadcast plants were shorter than drilled ones.

Yield differences were not significant among drilled treatments in 1959 but broadcasting yielded considerably less than drilling (Table 4). In 1960, highest yields of both sweetclover strains were from drilled plots seeded at the one-inch depth. Madrid consistently yielded more than PI-L57 except on the plots where seed was drilled to the three-inch depth or was broadcast. This difference was attributed to the slightly better PI-L57 stands produced under these two treatments.

Yearly differences in herbage production between 1959 and 1960 were large and in proportion to the amount of precipitation received.

Species comparisons

Seedlings of alfalfa and the sweetclover strains established equally well in pure stands ranging from 7.5 to 8.9 seedlings per foot, respectively, for Madrid sweetclover and Ladak alfalfa. In mixtures with crested wheatgrass the numbers of legume seedlings were fewer than in pure stands. Madrid was reduced to four seedlings and Ladak to 4.5 seedlings per foot in the legume-grass mixtures. Crested wheatgrass, however, established equally well with the different legumes and in pure stands averaging nine seedlings per foot of row.

Madrid yielded more in 1959 than either of the other two legumes with 4725 pounds per acre (Table 5). Yields of PI-L57 and Ladak with 2950 and 2700 pounds per acre, respectively, were similar. In mixed stands the average yields indicate that sweetclover-grass stands returned higher yields than either species alone. The alfalfa-grass mixture produced less than alfalfa alone but more than grass alone.

By 1960 sweetclover was lost from the 1958 seeding and alfalfa yields were low. Differences between grass yields in pure stand and in legume-grass mixtures were not significant. Averages, however, suggest that yields from plots containing alfalfa and those which had contained sweetclover were slightly higher than grass in pure seedings (Table 5). These increases were attributed to the legume effect in making additional nitrogen available for plant growth or to the greater area from which the grass could draw nitrogen. Yields in 1960 from the 1959 seeding were not significantly different. Averages, however, suggest as was shown in 1959 that sweetclover-grass seedings may yield better than either species seeded alone. Mixing the seed before seeding compared with seeding the legume and grass in alternate rows had no effect on yield.

Crude-protein content of the herbage varied with both plant species and seeding treatment (Table 6). The two sweetclover strains were equal in protein content and higher than alfalfa or grass in pure stands. Mixed species were slightly lower in protein than the legumes grown in pure stand but considerably above the grass grown in pure stand. Grass from mixtures was generally higher in protein than from pure stands. This increase in protein content of grass grown in a mixture with a legume was attributed to the additional available nitrogen.

Table 6. Crude protein in legumes, grass, grass-legume mixture, and grass from mixtures with legumes harvested in 1959.[1]

Species or mixture	Protein
	(Percent)
Madrid	17.9a
PI-L57	17.7a
Ladak	14.1c
Nordan	6.5e
Madrid + Nordan	15.0bc
PI-L57 + Nordan	16.9ab
Ladak + Nordan	13.7c
Nordan from Madrid + Nordan mixture	9.3d
Nordan from PI-L57 + Nordan mixture	8.9de
Nordan from Ladak + Nordan mixture	7.1de

[1]Values followed by the same letter are not significantly different at the five percent level (Duncan, 1955).

Discussion

Although these studies indicate Madrid to be superior in herbage yield, PI-L57 has high potential for seeding under range conditions because of its large seed. The ability of PI-L57 to germinate and emerge from depths of two inches without reduction in stand and its vigor in the seedling stage make it a valuable plant for seeding under conditions where moisture is rapidly depleted from the soil surface. Its characteristic of early seed development may also insure natural reseeding in areas where the growing season is short.

Summary

At the Red Bluff Ranch near Norris, Montana, two strains of yellow sweetclover were compared with each other and with Ladak alfalfa for establishment and growth characteristics.

PI-187985-L57, an unnamed large-seeded variety, emerged successfully from two- to three-inch depths with only slight reduction in number of seedlings established. Seedling numbers of Madrid seeded at depths greater than one inch declined rapidly. The seedling plants of PI-L57 were also larger and developed faster than those of Madrid during the first growing season.

In the second year PI-L57 reached full bloom two weeks before Madrid, but was about eight inches shorter. Except under extreme seeding treatments (broadcasting and drilling to three-inch depth) Madrid produced considerably more herbage than PI-L57. Madrid also produced more than Ladak alfalfa.

Mixtures of the sweetclovers with Nordan crested wheatgrass produced more forage than either the grass or the legume alone. In the following year averages indicated that grass in plots which had contained sweetclover in mixed stand continued to yield more than pure stands of grass.

The crude-protein content in herbage from the two sweetclover strains was equal to each other but higher than alfalfa. Protein content of grass grown in mixtures with legumes was generally higher than when grown in pure stand.

There was no significant effect on yield from mixing legume and grass seed before seeding or seeding legume and grass in alternate rows.

LITERATURE CITED

ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS. 1945. Official and tentative methods of analysis. Compiled by the Committee on Editing Methods of Analysis. 6th ed. Washington, D.C.

CHRIST, J. H. 1934. Reseeding burned-over lands in northern Idaho. Idaho Agr. Expt. Sta. Bul. No. 201.

DUNCAN, D. B. 1955. Multiple range and multiple F tests. Biometrics 11:1-42.

LAVIN, FRED. 1955. Seeding in the southwestern pine zone. U.S. Dept. Agr. Agr. Hdbk. No. 89.

PICKFORD, G. D. AND E. R. JACKMAN. 1944. Reseeding eastern Oregon summer ranges. Oregon Agr. Expt. Sta. Cir. 159.

PLUMMER, A. PERRY, A. C. HULL, JR., GEORGE STEWART, AND JOSEPH H. ROBERTSON. 1955. Seeding rangelands in Utah, Nevada, southern Idaho, and western Wyoming. U.S. Dept. Agr. Agr. Hdbk. No. 71.

SHORT, L. R. 1943. Reseeding to increase the yield of Montana rangelands. U.S. Dept. Agr. Farmers Bul. No. 1924.

U.S. WEATHER BUREAU. 1958, 1959, 1960. Climatological Data: Montana. U.S. Dept. Com. Annual Summaries Vol. 61, 62, 63.