Growth and Yield of Legumes in Mixtures with Grasses on a Mountain Range[1]

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Highlight

Nine legumes, including three strains of variegated alfalfa, were planted in mixture with each of four grasses in the fall of 1950. Alfalfa A-169 was the most productive legume. In 1965 it yielded 100 lb/acre, about 35% more than cicer milkvetch or Ladak alfalfa and 160 lb/acre more than sickle milkvetch or Rhizoma alfalfa. Siberian alfalfa was clearly inferior to all the above. Flat pea, birdsfoot trefoil, and perennial vetch disappeared from the plots early in the study. Intermediate and crested wheatgrasses were more productive than smooth brome, both in combination with legumes and as pure stands. The highest yielding plots in 1965 were those originally sown to mountain brome. This short-lived grass afforded less competition to the legumes which became well established prior to invasion by crested and intermediate wheatgrass or smooth brome grass. The use of a legume with the grass, on the average, increased production by 144 lb/acre.

The need for suitable legumes for mountain rangelands has been stressed by many workers, including Hafenrichter et al. (1949), Plummer et al. (1955), and Keller (1959), but plantings have not been encouraging. This paper presents results from a range planting made in central Utah to determine the best legumes for planting in grass–legume mixture and to determine the effects of the plant association on relative yield of grasses and legumes.

Area, Species, and Methods

The study was conducted on a small terrace in the mountain brush type in central Utah locally known as Majors Flat. It is at an elevation of 7,100 ft on the Manti–LaSal National Forest. The soil is a productive silt loam of limestone origin. Average annual precipitation during the study was 17.8 inches.

Native vegetation consists primarily of big sagebrush (*Artemisia tridentata* Nutt.) interspersed with small patches of gambel oak (*Quercus gambelii* Nutt.) and mountain snowberry (*Symphoricarpos oreophilus* A. Gray). A few remnants of bluebunch wheatgrass (*Agropyron spicatum* (Pursh) Scribn. & Smith), squirreltail (*Sitanion hystrix* (Nutt.) J. G. Smith), Indian ricegrass (*Oryzopsis hymenoides* (Roem. & Schult.) Ricker), and lupine (*Lupinus* sp.) persist under the shrubs. Cheatgrass (*Bromus tectorum* L.) and other annuals are abundant in the openings.

All vegetation was removed by burning, plowing, and grubbing, and a good seedbed was prepared during the spring and summer of 1950. The plots were seeded in the fall. The experimental design was a randomized split plot with four replications. Four grasses, crested wheatgrass (*Agropyron desertorum* (Fisch. ex Link) Schult.), intermediate wheatgrass (*A. intermedium* (Host) Beauv.), smooth brome (*Bromus inermis* Leyss.), and mountain bromegrass (*B. marginatus* Nees) constituted the main plots. Nine legumes, including three varieties of variegated alfalfa (*Medicago sativa* L.), A-169, Ladak, and Rhizoma; Siberian alfalfa (*M. falcata* L.); cicer milkvetch (*Astragalus cicer* L.); sickle milkvetch (*A. falcatus* Lam.); birdsfoot trefoil (*Lotus corniculatus* L.); flat pea (*Lathyrus sylvestris* L.); and perennial vetch (*Vicia tenuifolia* Roth) constituted the subplots. Each main plot contained 27 parallel rows 10 ft long spaced 20 inches apart and was sown to one grass. Superimposed on the main plot were nine subplots each consisting of three of the main plot rows sown to one legume. Both grasses and legumes were seeded at 8 lb/acre, the seed was covered 0.5 inch, and the soil was firmed. A specific inoculant was worked into the soil for all rows seeded to birdsfoot trefoil.

Plant numbers and estimated herbage productions were taken in 1951, 1952, and 1953. Pocket gophers were controlled by poisioning from 1951 to 1953, but the area was open to natural grazing until 1957. Early in 1957 any remaining herbage from previous years was removed from the area; pocket gophers were trapped and poisoned; and a rabbit, deer, and livestock exclosure was constructed. Plot ratings were made in 1957, 1958, 1961, and 1965. In 1957 and 1965 all legume plants were counted and clipped. Grass plots were rated and yields were determined by total clipping in 1957. In 1965 only a portion of each plot was clipped. Air-dry weights were taken on all forage samples, and oven-dry weights were taken on selected samples.

Results and Discussion

Climatic conditions were favorable for seed germination and seedling emergence in the spring of 1951. All grass stands rated by the method of Hull (1954) were good to excellent and estimated production averaged 1,380, 1,330, 630, and 375 lb/acre for crested wheatgrass, intermediate wheatgrass, mountain brome, and smooth brome, respectively. Fair to excellent stands of seedling legumes were obtained, but legume seedling mortality was high after the residual soil moisture had been depleted. By late July 1951, the legume plants remaining in the crested wheatgrass and intermediate wheatgrass plots rated poor to fair, with an average of .8 and 1.9 plants/ft of row. Legume plants remaining in the mountain brome and smooth brome plots rated fair with an average of 1.3 and 1.4 plants/ft of row.

All grass species thrived. Estimated production in 1952 was 3,160, 3,220, 1,920, and 2,420 lb/acre for crested wheatgrass, intermediate wheatgrass,

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FIG. 1. Left, crested wheatgrass maintained the original rows. Right, the rhizomatous intermediate wheatgrass filled in the interspaces between the rows.

mountain brome, and smooth brome, respectively. Cicer milkvetch, alfalfa A-169, Ladak, and Rhizoma made the best showing in mixture with the four grasses. Estimated legume production was 55, 40, 125, and 130 lb/acre when grown with crested wheatgrass, intermediate wheatgrass, mountain bromegrass or smooth bromegrass, respectively. This low herbage production by the legumes in their second growing season was attributed to rapid soil moisture depletion and partial shading in the seedling year by the more rapidly developing grasses.

All grasses maintained stand ratings in 1953, but average production was only 73, 88, 57, and 91%, respectively, of the 1952 yield of crested wheatgrass, intermediate wheatgrass, mountain brome, and smooth brome. All of the flat-pea plants and most of the perennial vetch plants perished prior to late summer of 1953. Mortality of the birdsfoot trefoil and Siberian alfalfa was high, especially in mixture with the two wheatgrasses. Other legumes maintained fair ratings. Estimated production for all legumes varied from 90 lb/acre in mixture with intermediate wheatgrass to 370 lb/acre in mixture with mountain brome.

During the period 1954 to 1961, crested wheatgrass, intermediate wheatgrass, and smooth brome maintained full stand ratings. They also completely replaced the mountain bromegrass which had died prior to 1961. Crested wheatgrass maintained the original rows (Fig. 1), and invaded open adjacent areas by natural seeding. By 1965 the rhizomatous grasses had made limited ingress into most of the adjoining plots, especially the crested wheatgrass plots. The number of legumes decreased from 1954 to 1965. Most of this legume mortality was attributed to pocket gopher activity, although the area was poisoned each year.

Legume composition and herbage production were determined in 1957 and 1965. Grass and legume composition in these years were similar except that the plots originally sown to mountain brome were least productive in 1957 and most productive in 1965. Total yields on intermediate and crested wheatgrasses were similar in both years. Smooth brome plots were the lowest yielders in 1965.

Analysis of the grass yields (Duncan, 1955) shows significance at the 5% level for grasses, but no difference for legumes in 1957. Both grass and legume yields were significant in 1965. There were no significant differences in the grass yields in 1957 because of the planting of legumes, but significant differences were found by 1965. Tables 1 and 2 summarize yields for grass and legumes, respectively.

Since three of the legumes had no production, they were omitted from analysis. In these analyses, grass and legume yields were significant, but the

Table 1. Mean dry-weight yield in pounds/acre of grasses in combination with six legumes and in the absence of legumes, 1965. Each mixture is the mean of 24. Each yield for grass alone is the mean of 12.

Mixture	Mountain brome[1]	Crested wheat	Intermediate wheat	Smooth brome	Mean
Grass fraction	723	808	918	501	737
Legume fraction	390	244	108	248	247
Total yield	1113	1052	1026	749	984
Grass alone[2]	883	867	914	678	835
Advantage of mixture	230	185	112	71	144

[1] Mountain brome being short-lived had nearly disappeared from the plots and the grass present consisted of associated species which had invaded.

[2] From plots originally seeded to grass in combination with flat pea, birdsfoot trefoil, or perennial vetch, none of which persisted.

Table 2. Mean dry-weight yield in pounds/acre of legumes in combination with four grasses, 1965. Each value is a mean of 16.

	A-169	Cicer	Ladak	Sickle	Rhizoma	Siberian	Mean
Grass	699	768	720	784	688	784	737
Legume	390	287	290	213	230	74	247
Total yield	1059	1055	1010	997	918	858	984

grass × legume interactions were not significant. Averaging the four grasses in mixture with the legume, alfalfa A-169, yielded highest in both 1957 and 1965, although cicer milkvetch and Ladak yields were not significantly less either year.

Legume yields were smallest when planted with intermediate wheatgrass and largest when planted with the short-lived mountain bromegrass. Legume production in mixture with crested wheatgrass or smooth bromegrass were similar. The use of a legume with the grass, on the average, increased production 144 lb/acre. On the invaded plots initially seeded to mountain brome, the average gain from legumes was 230 lb/acre. The crested wheatgrass plots benefited by 185 lb from the presence of legumes while intermediate wheatgrass benefited 112 lb and smooth brome 71 lb.

Negative correlations of .207 and .245 were found between the legume and grass yields in 1957 and 1965. This indication of competition effect between the established legumes and grasses is significant, but it is not an adequate indication of the severe competition which occurred during the seedling year and later establishment period. Most of the variegated alfalfa and milkvetch herbage was produced by a few relatively large plants. This indicates that once established these legumes can successfully compete with the grasses on this site. Procedures could be devised which would provide for legume establishment before the grasses were planted.

Other varieties of alfalfa may be equal to or superior for range plantings with grasses. Later alfalfa plantings at this location have usually demonstrated that Nomad, A-169, Ladak, Sevelera, and Rhizoma have maintained stand ratings and have been relatively productive. Nomad and A-169 were damaged less by pocket gophers than the other varieties. Rambler alfalfa was not included in these early range plantings, but should persist in mixture with grass (Heinrichs and Bolton, 1958) and be equally resistant to pocket gopher damage.

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