Herbage Yield of Fertilized Cool-Season Grass-Legume Mixtures in Western Nebraska

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Abstract

Herbage yield from five cool-season grasses (meadow bromegrass [*Bromus biebersteinii* Toem and Schult.], smooth bromegrass [*Bromus inermis* Leyss.], intermediate wheatgrass [*Agropyron intermedium* (Host) Beauv.], Russian wildrye (*Elymus junceus* Fisch.], crested wheatgrass [*Agropyron cristatum* (L.) Gaertn.]) in mixtures with alfalfa [*Medicago sativa* L.] or cicer milkvetch [*Astragalus cicer* L.] and with the two legumes in pure stands at two dates of harvest (June 5, June 26) and with four rates of fertilizer (0 kg N/ha-0 kg P/ha, 0 kg/ha-22 kg P/ha, 45 kg N/ha-22 P/ha) was studied in western Nebraska in 1977 and 1978. Higher precipitation and more complete stand establishment during the second year caused dry matter production to be higher in 1978 than 1977. Herbage yields were greater for the alfalfa-grass mixtures than the cicer milkvetch-grass mixtures. Dry matter yields were greater for the June 26 harvest than the June 5 harvest during both years which was attributed to the extra 3 weeks for growth to occur. Plots fertilized with 45 kg N/ha-22 kg P/ha and 45 kg N/ha-0 kg P/ha produced more herbage than plots receiving the other treatments during both years. The highest yields were recorded for the intermediate wheatgrass- and crested wheatgrass-legume mixtures and the lowest yields for the Russian wildrye-legume mixtures during the 2 years of this study.

Several introduced cool-season, perennial grasses are adapted to the dryland conditions of the Northern Great Plains, but little is known of their performance with legumes or of the adaptation of legumes for semiarid areas in western Nebraska.

The impact of fertilization schemes on seasonal distribution of herbage production also is an important consideration in grassland management. However, animal performance and production are often higher from legume-grass mixtures than from diets of perennial grasses. Mixtures of cool-season perennial grasses and legumes also may provide more uniform season distribution of herbage production than do grasses alone.

Chan (1971), in a study in North Carolina, reported that positive benefits obtained by grass growing in a mixture with a legume were very small. Winch et al. (1970) established that legume yields in a pure stand and in mixtures with grasses were similar in Ontario, Canada. However, others have reported higher yields and better seasonal forage distribution when legumes are included with grasses (Jones 1967; Wagner 1954a, 1954b).

Competition and interaction between grasses and legumes play an important role in obtaining a maximum yield from a grass-legume mixture. Kilcher et al. (1966), Kilcher and Heinrichs (1966b), and Dubbs (1968) found Russian wildrye to be a highly competitive grass when grown with alfalfa in Saskatchewan and Montana, because alfalfa was eventually depleted from the stand. Production from a Russian wildrye-alfalfa mixture on dryland was lower than yields of intermediate wheatgrass and crested wheatgrass [*Agropyron cristatum* (L.) Gaertn.] grown with alfalfa. It has been reported that smooth bromegrass [*Bromus inermis* Leyss.] reduced the alfalfa component in two-way mixtures which resulted in reduced production (Kilcher and Heinrichs 1966a). Alfalfa also remained in a stand longer when competing with only one grass (Kilcher et al. 1966), and cool-season grass-legume mixtures yield more when seeded in mixed rows rather than in alternate rows (Hanna et al. 1977).

Variable rates and combinations of nitrogen (N) and phosphorus (P) fertilizer have been shown to have measurable effects on grass-legume mixtures. Brouse and Burzlaff (1968) summarized several studies and concluded that the addition of P caused significant increases in growth of legumes on subirrigated meadows, and N stimulated growth of grasses and had a depressing effect on the legumes. Yield of a mixture, when subject to fertilization, was dependent on the grass-legume ratio. In Washington, Jackobs (1952) reported when a mixture was predominantly legume, only a slight response to N fertilizer was noted whereas a marked response to P was found. Just the opposite response occurred if the mixture was predominantly grass. Templeton (1976) concluded that N fertilizer shound not be used in cool-season grass-legume mixtures because it encouraged grass growth, increased shading of legumes and reduced nodulation or N_2 fixation. However, McElgunn et al. (1972) and Lutwick and Smith (1977) reported that N fertilization increased yield of grass-legume mixtures in Canada.

Grass-legume mixtures are more competitive with weeds for space and nutrients than a pure seeding of either herbage component (Wagner 1954a, Cooke et al. 1968). The competitive ability of the seeded species with weeds also had a direct effect on yield of the mixture components and varied between mixtures.

Clipping management may strongly affect herbage yield due to vulnerability of plants to stress at varying periods of their growth. In North Dakota (Lorenz and Rogler 1973). Shirk et al. (1968) found that a delayed first cutting from June 1 to June 20 of alfalfa-mixed grass hay reduced the alfalfa content; however, the rate of regrowth was not altered whether clipped on June 1 or June 20.

Five cool-season grasses and two legumes exhibiting herbage production potential in western Nebraska are, respectively, meadow bromegrass [*Bromus biebersteinii* Toem and Schult.], smooth bromegrass, intermediate wheatgrass, Russian wildrye, crested wheatgrass, alfalfa, and cicer milkvetch [*Astragalus cicer* L.]. Russian wildrye, crested wheatgrass, and meadow bromegrass grow in bunches, while intermediate wheatgrass and smooth bromegrass are rhizomatous. Cicer milkvetch is equal to alfalfa in quality, but compares unfavorably with alfalfa since it has lower yields, longer establishment period, and less persistence (Stroh et al. 1972, Smoliak and Hanna 1975).

Objectives of this study were to evaluate herbage yields of cool-season grass-legume mixtures as well as the two legumes separately, at two initial harvest dates and one regrowth harvest and to determine the effect of N and P fertilizers on yield.

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Materials and Methods

The study site was located in western Nebraska, approximately 10 km northwest of Alliance, on the University of Nebraska Northwest Agricultural Laboratory. The long-term average annual precipitation levels during the 2-year study were above average at 544 and 606 mm for 1977 and 1978, respectively. The area is generally frost free from May 20 through September 25.

The soil at the study site was classified as a Keith very fine, sandy loam. This soil is a deep, medium textured soil developed in loess, with a 1–3% slope and is subject to slight erosion (Fenster and McCalla 1970). The soil is a Typic Arguistoll.

Three replications of 10 grass-legume mixtures and the two separate legume species, for a total of 12 main plots, were seeded on April 8, 1976, into a previously summer-fallowed field. Legumes and grasses were seeded in the same row. In pure stands, 'Dawson' alfalfa and 'Lutana' cicer milkvetch were seeded at 11 and 13 kg/ha, respectively, while in the grass-legume mixtures they were seeded at 2 and 4 kg/ha, respectively. 'Regar' meadow brome, 'Lincoln' smooth brome, 'Slate' intermediate wheatgrass, 'Vinall' Russian wildrye, and 'Ruff' crested wheatgrass were seeded at 9, 9, 11, 8, and 8 kg/ha, respectively, in the grass-legume mixtures. Prior to seeding, the entire study area was sprayed with paraquat (1,1-dimethyl-4-bipyridinium ion) to control annual weeds. Herbage was not harvested during the growing season of 1976, but all herbage was removed from the area after the first killing frost.

The twelve individual main plots were 4.3 × 36.6 m in size. Four fertilizer combinations (0 kg N/ha-0 kg P/ha, 0 kg N/ha-22 kg P/ha, 45 kg N/ha-0 kg P/ha, and 45 kg N/ha-22 kg P/ha) were applied at random in sub-plot applications of the main plots in March, 1977 and 1978. Nitrogen was applied in the form of ammonium nitrate (34-0-0) and P was applied in the form of triple superphosphate (0-46-0). The four fertilizer treatments divided the main plots into 4.3 × 9.1 m subplots.

Each subplot was randomly divided into two sub-plots (2.2 × 9.1 m), delineating two harvest dates. A 1-m (four rows) × 3-m plot was harvested at a 5-cm clipping height. One of the four harvested rows was separated in the field into the following components: (1) seeded grasses, (2) seeded legumes, and (3) unseeded material, and these components were used to calculate percentage yield of the total herbage. Herbage was harvested during the first week in June and the last week in June in both 1977 and 1978. Following the first killing frost each fall, regrowth was harvested. Regrowth consisted of the herbage growth from the initial harvest to the fall harvest.

The herbage samples were placed in paper bags and dried in a forced air oven at 70°C until a constant weight was reached. All herbage yields were calculated from the oven-dry weights.

The experimental design was a randomized complete-block with three replications. Factors considered were years, replications, entries (species), fertilization rates, and harvests. Data for each respective year was analyzed separately. A split, split-plot analysis of variance was computed for each variable. *F* tests were conducted at the 5% level of significance. The least significant difference (LSD) test was used to compare treatment means for significant main effects (Steel and Torrie 1960).

Results and Discussion

Initial Yield

Performance of the herbage over the 2 years of the study is most important; thus, table values are averages of 1977 and 1978 data. All entries abbreviations are the first letter of the genus and first two letters of the species of each seeded grass or legume.

Significant differences existed between dry matter herbage yields of the 12 seeded entries, with alfalfa in a mixture with intermediate or crested wheatgrass maintaining the highest levels of production (Table 1). The cicer milkvetch-Russian wildrye mixture produced the lowest dry matter herbage yields.

Plots receiving 45 kg N/ha-22 kg P/ha or 45 kg N/ha-0 kg P/ha produced more herbage than plots fertilized with 0 kg N/ha-22 kg P/ha or nonfertilized, at both harvest dates.

Table 1. Dry matter herbage yield (kg/ha) of ten cool season grass-legume mixtures and two pure legume seedings at the two initial harvest dates under four fertilizer treatments for the combined years 1977 and 1978.

		Fertilizer treatments (kg/ha)				
Harvest date	Entries	0N 0P	45N 22P	0N 22P	45N 0P	Mean
June 5	Msa	1333	1440	1613	1577	1491[1]
	Aci	589	1227	585	1025	856
	Msa-Bbi	1296	1600	1699	1973	1620
	Msa-Bin	1454	2014	1784	2217	1867
	Msa-Ain	1457	2028	1989	2414	1972
	Msa-Eju	1266	1364	1487	1775	1473
	Msa-Acr	1615	2282	1813	2354	2016
	Aci-Bbi	748	1595	675	1716	1184
	Aci-Bin	763	1956	845	1593	1289
	Aci-Ain	705	1691	1003	1809	1302
	Aci-Eju	476	1004	588	1072	785
	Aci-Acr	602	2001	798	2002	1351
	Mean	1025	1684	1233	1794	
June 26	Msa	1548	1764	2067	2040	1855
	Aci	1344	2153	1082	2208	1697
	Msa-Bbi	1871	2381	2006	2351	2152
	Msa-Bin	1983	2765	2262	3087	2524
	Msa-Ain	1954	3041	2592	3158	2686
	Msa-Eju	1401	1675	1881	1997	1739
	Msa-Acr	1986	2978	2216	2922	2526
	Aci-Bbi	1847	2113	1207	2495	1915
	Aci-Bin	1374	2829	1403	2887	2124
	Aci-Ain	1502	2751	1881	2765	2225
	Aci-Eju	1162	1385	1309	1710	1391
	Aci-Acr	1140	2886	1881	2858	2191
	Mean	1593	2393	1816	2540	

[1]$LSD_{.05}$ = 413 for comparing entries within and between harvests, averaged over fertilizer treatments.
$LSD_{.05}$ = 246 for comparing the same entry between harvests, averaged over fertilizer treatments.

Dry matter herbage yields were significantly different for the entries × harvest date interaction (Table 1). This is attributed to an increase in production at the later harvest date. Dry matter yields increased for all mixtures from the June 5 harvest to the June 26 harvest. Dry matter production was greater for the alfalfa-grass mixtures when compared with the respective cicer milkvetch-grass mixtures at both harvest dates. Intermediate and crested wheatgrass, grown in mixtures with alfalfa or cicer milkvetch and compared only within the same legume mixture, consistently produced the most dry matter at both harvest dates, averaged over fertilizer treatments. The alfalfa-crested wheatgrass mixture produced the most dry matter at the June 5 harvest, followed by the alfalfa-intermediate wheatgrass mixture. The same mixtures maintained the highest levels of production at the June 26 harvest, however, the order was reversed. The lowest producing mixture at both harvest dates was cicer milkvetch-Russian wildrye. Alfalfa-Russian wildrye and cicer milkvetch-Russian wildrye mixtures were generally the lowest in dry matter production within the alfalfa- or cicer milkvetch-grass mixtures. Yields of dry matter at the June 26 harvest were 45% greater than for the June 5 harvest when averaged over all entries.

Regrowth Yield

Dry matter yield of regrowth of the entries was significantly different (Table 2). Generally, alfalfa-grass mixtures produced more regrowth than the respective cicer milkvetch-grass mixtures during both years. Difference existed between the entries in ability to regrow after an early harvest.

Mixtures receiving 45 kg N/ha-22 kg P/ha or 45 kg N/ha-0 kg P/ha consistently produced more regrowth than mixtures receiving 0 kg N/ha-22 kg P/ha which produced more regrowth than the nonfertilized plots (Table 2). The nonfertilized plots were consistently the lowest in dry matter yields. Regrowth yield for the entries × fertilizer rate interaction was significant, associated with the

Table 2. Dry matter regrowth yields (kg/ha) following the two initial harvest dates under four fertilizer treatments for the combined years of 1977 and 1978.

Harvest date	Entries	Fertilizer treatments (kg/ha) 0N 0P	45N 22P	0N 22P	45N 0P	Mean
June 5	Msa	683	810	1287	1028	952[1]
	Aci	434	631	546	496	527
	Msa-Bbi	704	1044	1035	1111	973
	Msa-Bin	563	1158	1090	1440	1063
	Msa-Ain	594	1127	1059	1282	1015
	Msa-Eju	469	881	762	959	768
	Msa-Acr	624	949	834	1337	936
	Aci-Bbi	541	941	503	1076	765
	Aci-Bin	360	404	475	464	826
	Aci-Ain	264	459	937	506	541
	Aci-Eju	171	452	402	479	376
	Aci-Acr	234	319	348	427	332
	Mean	470	764	773	884	
June 26	Msa	655	875	1202	1179	978
	Aci	216	458	348	336	339
	Msa-Bbi	746	1067	992	1240	1011
	Msa-Bin	766	1183	949	1317	1054
	Msa-Ain	623	1001	961	1358	986
	Msa-Eju	509	945	979	1350	946
	Msa-Acr	531	996	648	1069	811
	Aci-Bbi	378	578	399	686	510
	Aci-Bin	228	402	337	419	346
	Aci-Ain	132	460	148	503	311
	Aci-Eju	159	377	319	383	310
	Aci-Acr	75	316	233	270	223
	Mean	418	721	626	842	

[1]$LSD_{.05}$ = 317 for comparing entries within and between harvests, averaged over fertilizer treatments.
$LSD_{.05}$ = 123 for comparing the same entry between harvests, averaged over fertilizer treatments.

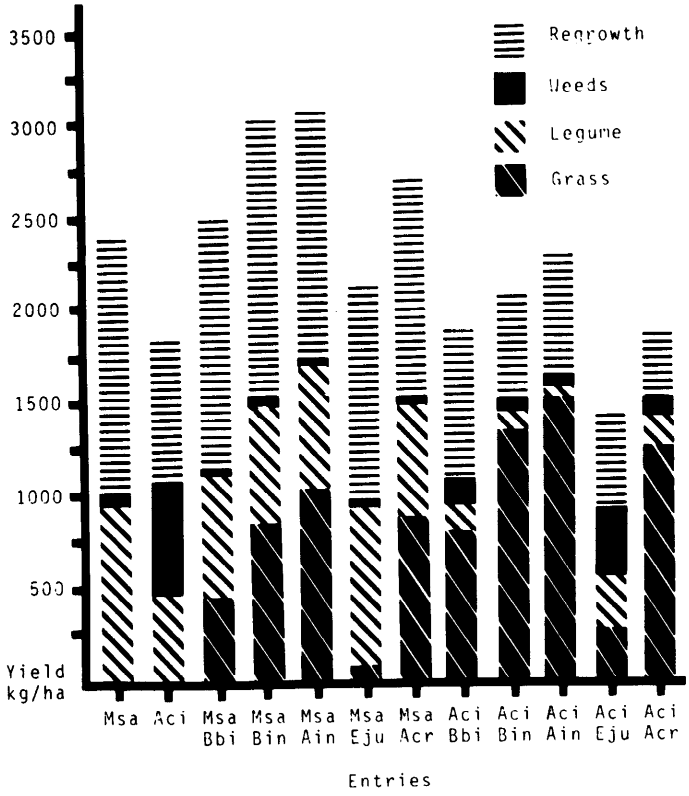

Fig. 1. *Dry matter yield of the initial harvests (grass, legume, weeds) and regrowth of ten cool-season grass-legume mixtures and two pure legume seedings averaged over four fertilizer treatments and two initial harvest dates for 1977.*

entries' differences in responding to the four fertilizer treatments. Dry matter yields of regrowth following the two initial harvest dates were significantly different.

Dry matter yields of regrowth differed between the alfalfa-grass mixtures and the cicer milkvetch-grass mixtures following the two initial harvest dates, causing a significant entries × harvest data interaction (Table 2). The dry matter yields of regrowth of alfalfa and alfalfa-grass mixtures were significantly greater than the respective cicer milkvetch and cicer milkvetch-grass mixtures, with the alfalfa-smooth bromegrass mixture producing the most dry matter.

Dry matter yields of regrowth showed a trend toward a decline in production following the later initial harvest, particularly for the cicer milkvetch-grass mixtures (Table 2). This decline in regrowth production is due to the fact that there is less time for the herbage to regrow following the later initial harvests. Alfalfa and the two mixtures, alfalfa-meadow bromegrass and alfalfa-Russian wildrye, consistently produced more regrowth following the June 26 harvest date than the June 5 harvest date. All cicer milkvetch-grass mixtures, averaged over fertilizer treatments, produced less regrowth following the June 26 harvest date than the June 5 harvest date. Averaged over harvest dates and fertilizer treatments, the alfalfa-smooth bromegrass mixture produced the greatest yield of total regrowth, followed closely by the two mixtures, alfalfa-intermediate wheatgrass and alfalfa-meadow bromegrass.

Total Yield

Total dry matter yields in 1978 were equivalent to or greater than, the yield in 1977 (Fig. 1 and 2). Increased yield in 1978 was due to an increase in the grass and legume components and a decrease in the weed component at the initial harvests. In 1977 and 1978, the grass component made up a larger portion of the initial harvest yields of the cicer milkvetch-grass mixtures than of the mixtures than of the alfalfa-grass mixtures. This was attributed to

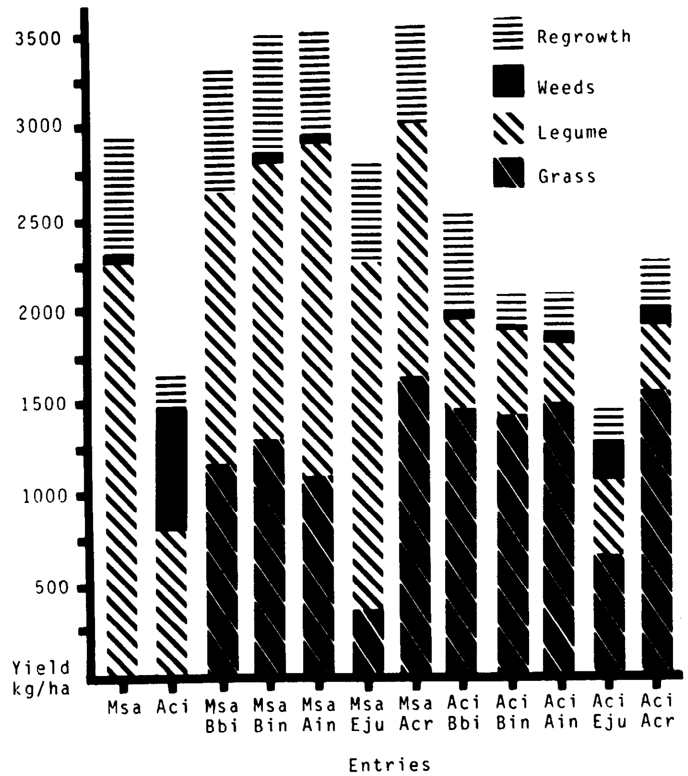

Fig. 2. *Dry matter yield of the initial harvests (grass, legume, weeds) and regrowth of 10 cool-season grass-legume mixtures and two pure legume seeding averaged over four fertilizer treatments and two harvest dates for 1978.*

cicer milkvetch being less competitive with the various grasses and weeds than alfalfa. Legumes made up a larger portion of the total yield in 1978 and 1977 for all mixtures.

The alfalfa-grass mixtures maintained a more favorable ratio of legume to grass than did the cicer milkvetch-grass mixtures. Alfalfa should comprise less than half of the total herbage of an alfalfa-grass mixture, when used for grazing, which was the case in 1977 but not in 1978 (Turner 1967). However, too little legume in a mixture, which is the case with cicer milkvetch-grass mixtures, can off-set the benefits of seeding a legume with a grass (Jones 1967; Wagner 1954a, 1954b).

The mixtures producing the greatest yield of dry matter in both years were those mixtures which maintained close to a 1:1 ratio of legume to grass. In 1977 and 1978, the three mixtures producing the most dry matter (alfalfa-smooth bromegrass, alfalfa-intermediate wheatgrass, and alfalfa-crested wheatgrass) also showed a favorable grass-legume ratio. A decrease in the legume component of the cicer milkvetch-grass mixtures apparently was related to a decreased dry matter yield (Fig. 1 and 2).

Smooth bromegrass, intermediate wheatgrass, and crested wheatgrass appeared to be the most compatible grasses (Fig. 1 and 2). Russian wildrye was the least competitive when grown with either alfalfa or cicer milkvetch. Cicer milkvetch yielded considerably less dry matter than alfalfa when grown with any of the five cool-season grasses. Cicer milkvetch did appear to be more competitive with Russian wildrye; however, this combination produced the lowest yield in both years, as well as having the highest composition of weeds.

Management Implications

Long-range studies need to be carried out to better understand the complex effects that fertilizer treatments and harvest schedules, as well as changing climatic patterns, have on cool-season grass-legume mixtures. Sound management practices designed to produce a better forage unit could then be recommended with higher certainty.

Under the conditions of the two-year study, the alfalfa-intermediate wheatgrass mixture was the most desirable because of its high yielding capability. Under normal or below normal precipitation conditions, the crested wheatgrass-alfalfa mixture may be a more desirable selection because of the adaptability of crested wheatgrass to drier areas.

Yields increases justify the 45 kg/ha-22 kg P/ha fertilizer treatment over the other treatments tested; however, this may not be the case in the near future with energy costs constantly increasing. Harvesting the cool-season grass-legume mixtures in late June will provide the highest yields. Based upon quality, a more desirable harvest time may be in mid-June for cool-season grass-legume mixtures.

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