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

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Abstract

Herbage quality of meadow bromegrass [*Bromus biebersteinii* Roem 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 2 legumes in pure stands at 2 dates of harvest (June 5, June 26) and with 4 rates of fertilizer (0 kg N/ha–0 kg P/ha, O kg N/ha–22 kg P/ha, 45 kg N/ha–0 kg P/ha, 45 kg N/ha–22 kg P/ha) was studied in western Nebraska in 1977 and 1978. Soil at the study site was a loam (Typic Argiustoll) and average annual precipitation is 386 mm. Alfalfa-grass mixtures maintained a higher percentage crude protein than the respective cicer milkvetch-grass mixtures, with the alfalfa-Russian wildrye mixture producing the highest percentage crude protein. Percentage in vitro dry matter digestibility (IVDMD) of the cicer milkvetch-Russian wildrye mixture was the highest of all mixtures, and the percentage IVDMD of the cicer milkvetch-crested wheatgrass mixture the lowest. Herbage quality was higher for the June 5 harvest than the June 26 harvest. Percentage IVDMD of regrowth, which developed after the June harvests, was higher for plots harvested on June 26 than on June 5. Fertilizer rates had a variable effect on herbage quality. Russian wildrye-legume mixtures generally maintained the highest level of herbage quality.

Herbage quality of cool-season perennial grasses grown under various fertilization and harvest schemes in Canada and western United States is well documented (Mason and Miltmore 1959, Smika et al. 1960, Lawrence et al. 1971, Sneva 1973, Hanson et al. 1976). Under semiarid conditions in western Nebraska, however, no herbage quality data are presently available for introduced cool-season grasses or cool-season grass-legume mixtures.

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One of the primary attributes of legumes is the improvement of the quality of herbage through an increase in protein content of the mixed herbage. Several investigators have reported that legumes exert a beneficial effect by increasing the protein content of the nonlegume component of the mixture (Wagner 1954). Dubbs (1968) showed that sainfoin *(Onobrychis viciaefolia)* in a mixture with 10 cool-season grasses maintained a higher crude protein content than the separate grasses, but less than sainfoin alone, when grown in Montana.

Eleven cool-season grasses with no supplemental nitrogen (N) produced significantly less protein than those with alfalfa *(Medicago sativa)* in western South Dakota. However, grasses grown with alfalfa had a lower percentage crude protein than those with commercial fertilizers (Johnson and Nichols 1969). Dotzenko and Ahlgren (1951) found that the crude protein content of an alfalfa-smooth bromegrass *(Bromus inermis)* mixture was highest at the first cutting treatment and decreased with later harvests.

Sitt (1958), Brouse and Burzlaff (1968), and Lutwick and Smith (1977), working in Montana, western Nebraska, and Alberta, Canada, respectively, reported that N fertilization of a grass-legume mixture stimulated the grass, while depressing the legume growth, thus producing hay with a lower protein content. Nitrogen applied with phosphorus (P) fertilizer usually resulted in a reduction of the percentage of protein below that of P applied alone, because P stimulated the legumes and with few exceptions increased the protein content of mixed hay (Brouse and Burzlaff 1968). Parsons (1958) determined that N application significantly increased the protein percentage in the grass component of 3 alfalfa-grass (smooth bromegrass, timothy [*Phleum pratense*], orchardgrass [*Dactylis glomerata*]) mixtures studied in Ohio, but found that the protein percentage in the alfalfa component did not change.

A high correlation between crude protein content and digestibility of forages has been reported by various researchers (Ferebee et al. 1972, Lema 1973, Burzlaff and Daigger 1974), but little information is available on in vitro dry matter digestibility (IVDMD) of cool-season and grass legume mixtures. Rehm et al. (1971) stated that the digestibility of forage varies with the stage of maturity rather than fertilization. Newell and Moline (1978) studied the quality of 12 grasses, in Nebraska, in relation to season for grazing and found that cool-season grasses have a high IVDMD percentage at the spring harvest, a reduction in the summer and an increase in IVDMD for the regrowth in the late summer/early fall.

Five cool-season grasses and 2 legumes exhibiting herbage quality potential in western Nebraska are, respectively, meadow bromegrass *(Bromus biebersteinii)*, smooth bromegrass, intermediate wheatgrass *(Agropyron intermedium)*, Russian wildrye *(Elymus junceus)*, crested wheatgrass *(Agropyron cristatum)*, alfalfa, and cicer milkvetch *(Astragalus cicer)*. Russian wildrye, crested wheatgrass, and meadow bromegrass are bunch grasses, whereas intermediate wheatgrass and smooth bromegrass are rhizomatous. Cicer milkvetch is considered equal to alfalfa in quality (Smoliak and Hanna 1975).

Objectives of this study were to evaulate herbage quality of cool-season grass-legume mixtures and each legume separately, at 2 initial harvest dates and one regrowth harvest and to determine the effect of N and P fertilizers on quality.

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 at the study site was 386 mm, although 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 in the Typic Argiustoll soil subgroup. 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).

Three replicate seedings of 10 grass-legume mixtures and the 2 separate legume species were made on April 8, 1976, into a previously summer-fallowed field. Legumes and grasses were seeded in the same row 'Dawson' alfalfa and 'Lutana' cicer milkvetch were seeded at 11 and 13 kg/ha, respectively, in pure plots but at 2 and 4 kg/ha, respectively, in grass-legume mixtures. '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.

Main plots were 4.3 × 36.6 m in size. Each main plot was then divided into four 4.3 × 9.1 m subplots to which one of 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) was applied March of 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).

Each fertilizer subplot was divided into two subplots (2.2 × 9.1) which were randomly allotted to two harvest dates. A 1-m (four rows) × 3-m plot was harvested at a 5-cm clipping height. One of the 4 harvested rows was separated in the field into the following components: (1) seeded grasses, (2) seeded legumes, and (3) unseeded material. 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.

The herbage samples were placed in paper bags and dried in a forced air oven at 70° C until a constant weight was reached. After drying, the samples were ground in a Wiley mill to pass through a 40-mesh screen. All samples were placed in air-tight plastic vials until the laboratory analyses were initiated.

Herbage samples were analyzed for percentage nitrogen content by the standard Kjeldahl procedures (Association of Official Agricultural Chemists 1960). In vitro dry matter digestibility was determined for all herbage samples by the standard two-stage procedure described by Tilley and Terry (1963).

The experimental design was a randomized complete block with 3 replications. Factors considered were replications, entries (species), fertilization rates, and harvests. Data for each respective year were 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 (Steele and Torrie 1960).

Results and Discussion

Values contained within all tables are averages of 1977 and 1978 data because performance of the herbage over the 2 years of the study is the most important consideration. All entries abbreviations are the first letter of the genus and first 2 letters of the species of each seed grass or legume.

Crude Protein

Differences in percentage crude protein were observed between the 12 entries studied (Table 1). Alfalfa and the alfalfa-Russian wildrye mixture produced a significantly higher percentage crude protein than the other entries. The cicer milkvetch-crested wheatgrass mixture consistently had the lowest percentage crude protein content.

Fertilization effects were highly variable between and within entries at both harvest dates (Table 1). Nonfertilized plots were similar to the fertilized plots and frequently maintained a higher percentage crude protein.

All entries declined in percentage crude protein from the first to second harvest date under all 4 fertilizer treatments. This trend is consistent with the literature which reports a decline in crude

Table 1. Percentage crude protein of 10 cool-season grass-legume mixtures and 2 pure legume seedings at the 2 initial harvest dates under 4 fertilizer treatments, averaged over years.

Harvest date	Entries	Fertilizer treatments (kg/ha) ON OP	45N 22P	ON 22P	45N OP	Mean[1]
June 5	Msa	18.7	18.4	19.7	19.0	18.9
	Aci	17.9	15.5	18.2	13.3	16.2
	Msa-Bbi	17.4	17.0	16.6	16.8	16.9
	Msa-Bin	15.9	17.6	16.4	15.4	16.3
	Msa-Ain	17.2	16.3	16.5	15.5	16.4
	Msa-Eju	19.2	19.5	19.1	18.7	19.1
	Msa-Acr	15.3	15.1	15.5	15.9	15.4
	Aci-Bbi	14.0	13.4	12.7	12.0	13.0
	Aci-Bin	13.6	11.4	11.9	12.6	12.4
	Aci-Ain	12.2	12.6	13.6	12.3	12.7
	Aci-Eju	16.4	16.7	17.0	18.0	17.0
	Aci-Acr	10.0	10.7	11.6	12.1	11.1
	Mean	15.6	15.3	15.7	15.1	
June 26	Msa	15.6	14.3	15.0	13.9	14.7
	Aci	14.4	10.0	12.9	10.6	12.0
	Msa-Bbi	13.9	14.0	13.9	13.0	13.7
	Msa-Bin	13.9	12.4	10.9	10.9	12.0
	Msa-Ain	12.6	12.0	12.0	12.4	12.2
	Msa-Eju	14.6	15.4	14.7	15.0	14.9
	Msa-Acr	10.3	11.2	11.0	10.8	10.8
	Aci-Bbi	12.0	9.1	9.5	9.5	10.0
	Aci-Bin	9.8	9.0	9.8	9.0	9.4
	Aci-Ain	9.7	9.8	10.2	9.1	9.7
	Aci-Eju	14.2	12.2	13.6	13.3	13.3
	Aci-Acr	9.0	9.5	9.7	7.8	9.0
	Mean	12.5	11.6	11.9	11.3	

[1]$LSD_{.05}$ = 2.0 for comparing entries within and between harvests, averaged over fertilizer treatments.
$LSD_{.05}$ = 1.0 for comparing the same entry between harvests, averaged over fertilizer treatments.

protein content as plants mature (Burzlaff et al. 1968). The alfalfa-grass mixtures maintained higher percentage crude protein than the respective cicer milkvetch-grass mixtures at both harvest dates under all fertilization treatments. The pure seeding of alfalfa and the alfalfa-Russian wildrye mixture contained the highest crude protein at both harvest dates. The cicer milkvetch-Russian wildrye mixture maintained the highest percentage crude protein of cicer milkvetch-grass mixtures, being over 3.3 percentage units higher than the next higher mixture, cicer milkvetch-meadow bromegrass.

Percentage crude protein varied for the entries × harvest date interaction (Table 1). The alfalfa-Russian wildrye mixture produced the highest percentage crude protein at both harvest dates, being significantly greater than all entries with the exception of alfalfa. Alfalfa-grass mixtures were significantly higher than the respective cicer milkvetch-grass mixtures at both harvest dates.

An average, lactating cow has a crude protein requirement of 9%, therefore it is important to harvest herbage at a time when this crude protein level can be met. This is important to the livestock producer not only for meeting the cows' needs, but also for eliminating the cost of protein supplement. All herbage initially harvested in this study maintained a crude protein content about 9%, except the crested wheatgrass-cicer milkvetch mixture when fertilized with 45N and harvested June 26.

Russian wildrye, when separated from the mixtures, maintained the highest percentage crude protein at both harvest dates, ranging from 12.5 to 18.2 (Figure 1). Percentage crude protein of crested wheatgrass was the lowest for all grasses within each respective legume mixture. The lowest value (7.1% crude protein) was produced when crested wheatgrass was grown with cicer milkvetch.

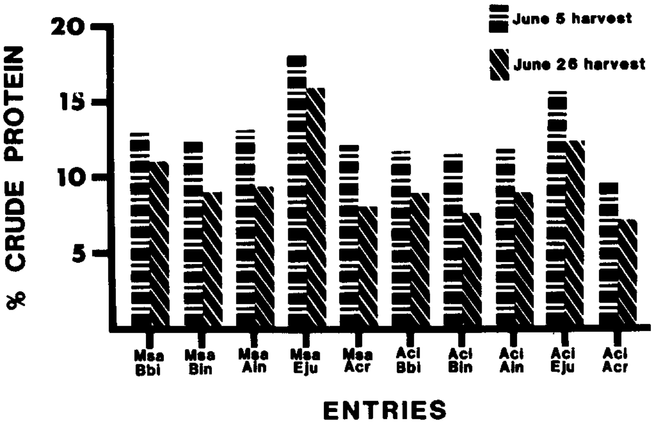

Fig. 1. *Percentage crude protein of the grass in the 10 cool-season grass-legume mixtures at the 2 initial harvest dates averaged over fertilizer treatments and years.*

The 2 legumes maintained similar crude protein values at both harvest dates. All grasses maintained a higher percentage crude protein when grown with alfalfa than when grown with cicer milkvetch. This may be due to alfalfa fixing more N/ha than cicer milkvetch, thus increasing the percentage crude protein of grass within the mixture (Bleak 1968).

Although differences existed between the main effects, there were no significant interactions concerning the percentage crude protein of regrowth (Table 2). Some generalizations can be made based upon consistent trends. Regrowth of the alfalfa-grass mixtures maintained a higher percentage of crude protein than the cicer milkvetch-grass mixtures, with the alfalfa-Russian wildrye mixture producing the highest values. Generally, the crude protein of regrowth was higher following the June 26 harvest than the June 5 harvest, because there was less time for the herbage to mature between the June 26 harvest and the regrowth harvest.

Regrowth is important to the livestock producer as a forage resource which can be grazed after frost-induced dormancy. Percentage crude protein of the regrowth of these mixtures exceeded the crude protein needs of most types of animals at this time of the year. By grazing a high quality herbage, the animal can receive an early boost in conditioning for the winter months.

Table 2. Percentage crude protein of regrowth following the 2 initial harvest dates under 4 fertilizer treatments, averaged over years.

		Fertilizer treatments (kg/ha)				
Harvest date	Entries	ON OP	45N 22P	ON 22P	45N OP	Mean[1]
June 5	Msa	12.8	12.5	12.4	12.3	12.5
	Aci	10.8	10.0	11.1	10.2	10.5
	Msa-Bbi	12.2	11.7	12.7	12.0	12.2
	Msa-Bin	13.5	12.6	13.0	12.7	13.0
	Msa-Ain	13.5	12.3	13.4	13.2	13.1
	Msa-Eju	14.6	13.3	13.4	13.3	13.6
	Msa-Acr	13.3	12.1	13.2	12.8	12.8
	Aci-Bbi	10.7	8.8	10.5	8.1	9.5
	Aci-Bin	12.6	10.9	11.5	11.1	11.5
	Aci-Ain	9.5	7.9	10.7	9.4	9.4
	Aci-Eju	10.7	10.4	11.3	12.0	11.1
	Aci-Acr	10.8	9.1	11.4	11.2	10.6
	Mean	12.1	11.0	12.0	11.5	
June 26	Msa	14.4	14.3	14.0	13.3	14.0
	Aci	11.1	10.5	13.3	11.6	11.6
	Msa-Bbi	13.8	12.7	13.3	12.6	13.1
	Msa-Bin	14.1	13.5	13.6	13.0	13.5
	Msa-Ain	14.7	14.0	14.1	13.2	14.0
	Msa-Eju	15.0	14.8	14.6	14.1	14.6
	Msa-Acr	14.9	13.8	14.2	14.1	14.2
	Aci-Bbi	11.1	7.8	9.8	9.0	9.4
	Aci-Bin	13.2	10.7	12.2	11.5	11.9
	Aci-Ain	11.6	9.1	10.9	10.0	10.4
	Aci-Eju	12.6	11.3	12.0	12.4	12.1
	Aci-Acr	11.1	10.1	13.0	10.9	11.3
	Mean	13.1	11.9	12.9	12.1	

[1]No significant difference between mean values.

In Vitro Dry Matter Digestibility

Percentage IVDMD of cicer milkvetch and the cicer milkvetch-Russian wildrye mixture was higher than for all other entries (Table 3), but there were no significant interaction effects. All entries decreased in percentage IVDMD from the 5 to the June 26 harvest. Fertilization treatments had no significant impact on the relative quality of entries.

The separated grasses contained a higher percentage IVDMD when grown with alfalfa than cicer milkvetch (Figure 2). The alfalfa appeared to be less competitive with grasses because grasses were at a less advanced stage of maturity in alfalfa as compared to cicer milkvetch mixtures. The IVDMD values were the highest for Russian wildrye (66–68%), with crested wheatgrass containing the lowest percentage IVDMD (56–64%), possibly due to Russian wildrye having a lower stem/leaf ratio than the other grasses. Percentage IVDMD of all grass components was higher at the June 5 harvest.

Cicer milkvetch, in a pure seeding or mixture, contained a higher percentage of IVDMD than alfalfa (Figure 3). When grown in a mixture, cicer milkvetch contained the highest IVDMD values (70%) when associated with Russian wildrye or intermediate wheatgrass. The percentage IVDMD in both legumes decreased from the June 5 harvest to the June 26 harvest. The lowest IVDMD values of 63% were observed at the June 26 harvest date when alfalfa was in a mixture with smooth bromegrass, crested or intermediate wheatgrass.

The regrowth maintained digestibility levels between 46 and 55% (Table 4). Regrowth IVDMD values were generally higher for those entries containing alfalfa. Lower IVDMD values for those entries containing cicer milkvetch were attributed to a larger proportion of grass, which reduced the digestibility of the total herbage sample.

Table 3. Percentage IVDMD of 10 cool-season grass-legume mixtures and 2 pure legume seedings at the 2 initial harvest dates under 4 fertilizer treatments, averaged over years.

Harvest date	Entries	Fertilizer treatments (kg/ha) ON OP	45N 22P	ON 22P	45N OP	Mean[1]
June 5	Msa	68	69	68	68	68
	Aci	71	75	73	74	73
	Msa-Bbi	69	68	67	68	68
	Msa-Bin	68	69	65	67	67
	Msa-Ain	68	69	69	68	68
	Msa-Eju	69	69	68	67	68
	Msa-Acr	66	68	67	67	67
	Aci-Bbi	69	67	68	66	67
	Aci-Bin	68	63	67	66	66
	Aci-Ain	66	66	66	66	66
	Aci-Eju	70	73	69	74	71
	Aci-Acr	65	64	65	65	65
	Mean	68	68	68	68	
June 26	Msa	63	65	64	64	64
	Aci	69	66	69	69	68
	Msa-Bbi	64	65	63	61	63
	Msa-Bin	63	61	61	61	61
	Msa-Ain	64	64	62	62	63
	Msa-Eju	63	65	63	62	63
	Msa-Acr	61	61	61	62	61
	Aci-Bbi	64	62	63	63	63
	Aci-Bin	62	58	61	59	60
	Aci-Ain	62	62	63	61	62
	Aci-Eju	68	68	67	68	68
	Aci-Acr	59	59	60	58	59
	Mean	63	63	63	62	

[1]No significant difference between mean values.

Fertilizer treatments, because of the high variability within and between entries, had no significant effect on percentage IVDMD of the regrowth.

All entries maintained a higher level of digestibility when the regrowth was harvested from plots originally clipped on June 26 (Table 4). Herbage from the plots originally clipped on June 26 had less time to regrowth when clipped in October as compared to plots originally clipped on June 5. The reduction in growing time resulted in a leafy, less mature herbage which maintained a higher level of quality.

Table 4. Percentage IVDMD of regrowth of 10 cool-season grass-legume mixtures and 2 pure legume seedings following the 2 initial harvest dates under 4 fertilizer treatments.

Harvest date	Entries	Fertilizer treatments (kg/ha) ON OP	45N 22P	ON 22P	45N OP	Mean[1]
June 5	Msa	48	49	48	49	49
	Aci	48	48	47	49	48
	Msa-Bbi	48	51	52	52	51
	Msa-Bin	51	53	51	51	51
	Msa-Ain	49	50	51	50	50
	Msa-Eju	48	50	50	49	49
	Msa-Acr	50	49	50	50	50
	Aci-Bbi	53	49	50	46	49
	Aci-Bin	53	52	52	52	52
	Aci-Ain	49	48	49	50	49
	Aci-Eju	49	47	50	51	49
	Aci-Acr	50	47	50	49	49
	Mean	50	49	49	50	
June 26	Msa	54	53	52	51	52
	Aci	50	50	54	50	51
	Msa-Bbi	52	53	52	53	53
	Msa-Bin	54	52	52	52	53
	Msa-Ain	53	52	52	51	52
	Msa-Eju	55	54	54	52	54
	Msa-Acr	53	53	53	54	53
	Aci-Bbi	54	47	52	50	51
	Aci-Bin	52	50	51	51	51
	Aci-Ain	50	48	49	48	49
	Aci-Eju	54	51	52	52	52
	Aci-Acr	50	50	54	50	51
	Mean	53	51	52	51	

[1]$LSD_{.05}$ = 4 for comparing entries within and between harvests, averaged over fertilizer treatments.

$LSD_{.05}$ = 3 for comparing the same entry between harvests, averaged over fertilizer treatments.

The entries × harvest date interaction was significant for percentage IVDMD of the regrowth (Table 4). Cicer milkvetch-smooth bromegrass and alfalfa-Russian wildrye maintained the highest levels of digestibility following the June 5 and June 26 initial harvests, respectively.

Management Implications

Based upon crude protein data, the alfalfa-Russian wildrye mix-

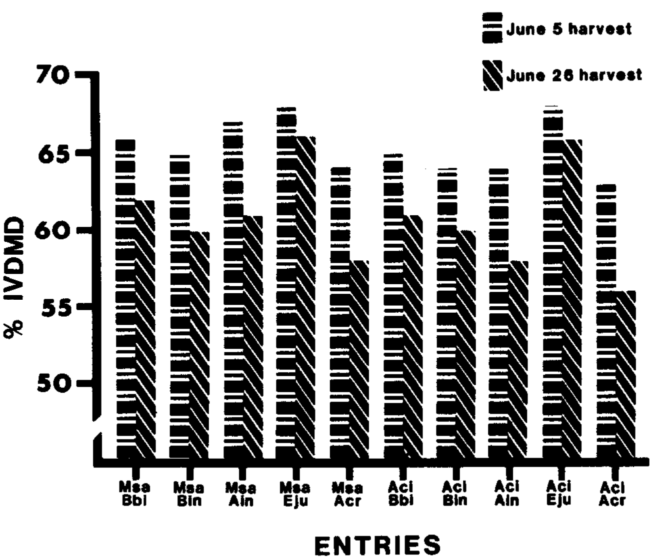

Fig. 2. *Percentage IVDMD of the grass in the 10 cool-season grass-legume mixtures at the 2 initial harvest dates averaged over fertilizer treatments and years.*

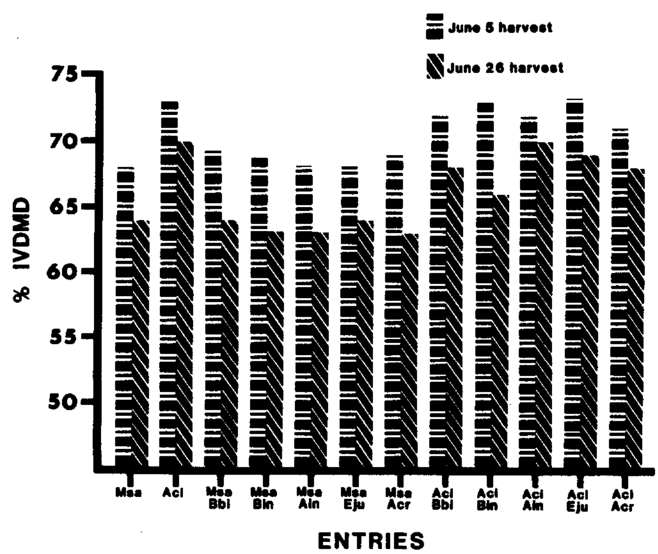

Fig. 3. *Percentage IVDMD of the legume in the 10 cool season grass-legume mixtures and 2 pure legume seedings at the 2 initial harvest dates averaged over fertilizer treatments and years.*

ture is superior. It maintains a higher percentage crude protein throughout the growing season than the other mixtures. Alfalfa, in a mixture with any of the cool-season grasses, will provide the rancher with a herbage unit containing an acceptable level of crude protein. Differences in percentage crude protein of the regrowth are too small to rate one alfalfa-grass mixture superior to another.

Selection of one mixture, based on IVDMD values, would not be feasible because variation between the mixtures was small. Fertilization had little effect on the IVDMD of the herbage and appears to be of little value in increasing the quality of one herbage unit over another under the conditions of this study.

Harvesting the mixtures at an earlier date, in our case June 5, will provide herbage that is substantially higher in quality than if harvested 3 weeks later. Crude protein and IVDMD differences as high as 4 and 6 percentage units, respectively, between harvests have been recorded. This is very important if the herbage is to be utilized in conditioning cattle prior to calving.

Although quality of herbage is important, evaluation of the yielding capacity of the various mixtures is critical, also. The alfalfa-Russian wildrye mixture was the most desirable in terms of crude protein and IVDMD, but did not fare as well in yield evaluations (Schultz and Stubbendieck 1982). Another mixture with good quality potential, as well as maintaining a high yielding capacity, may fit the ranchers needs better. The rancher will have to select the quality and yielding characteristics to best fit his operation and choose the mixture accordingly.

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