ISSN 0097 0484

PERFORMANCE OF GRASS-LEGUME MIXTURES IN EASTERN KANSAS

Bulletin 649
Agricultural Experiment Station
Kansas State University, Manhattan
Walter R. Woods, Director

PERFORMANCE OF GRASS-LEGUME MIXTURES IN EASTERN KANSAS[1]

Gerry L. Posler, Francis L. Barnett, and Joseph L. Moyer[2]

ABSTRACT

Renewed interest in N-fixing forage crops warrants updating of early conclusions relative to species of legumes and combinations of legumes and grasses to be grown for forage in Kansas. Four cool-season, perennial grasses and four perennial legumes were grown in all possible two-species, grass-legume combinations and in pure stands of individual species, at three locations in eastern Kansas. Grasses were: smooth brome, *Bromus inermis Leyss.;* Turkish brome, *B. biebersteinii* Roem. & Schult.; tall fescue, *Festuca arundinacea* Schreb.; and reed canarygrass, *Phalaris arundinacea* L. Legumes were: alfalfa, *Medicago sativa* L.; birdsfoot trefoil, *Lotus corniculatus* L.; red clover, *Trifolium pratense* L.; and crownvetch, *Coronilla varia* L. Forage stands were evaluated for dry matter yield, forage quality, persistence, and compatibility of mixture components. Grass-legume mixtures yielded as much or more dry matter than grasses alone receiving 80 lbs N/acre/year (90 kg N/ha/year). Mixtures generally showed better seasonal distribution of forage production than grasses alone and were superior to grasses in forage quality during the summer. Red clover established more readily and was lost from stands more rapidly than other species in the study. Alfalfa was the highest yielding legume in pure stands as well as in mixtures, but birdsfoot trefoil and trefoil mixtures also performed well. Grasses did not differ greatly in performance, although stands of reed canarygrass tended to deteriorate in some instances. No serious compatibility problems occurred in any of the grass-legume mixtures.

[1]Contribution no. 86-85-B from the Kansas Agricultural Experiment Station.

[2]Professors, Department of Agronomy, Kansas State University and Research Agronomist, Southeast Kansas Branch Station, respectively.

CONTENTS

Page

INTRODUCTION 3

MATERIALS AND METHODS
- Locations, Soils, and Weather 5
- Plant Materials 5
- Plot Layout and Statistical Design 8
- Stand Establishment 8
- Harvesting Procedures 8
- Percentage of Legume in Mixture 8
- Forage Quality 8

RESULTS
- Annual Dry Matter Production 9
- Forage Quality 13
- Seasonal Trends in Production and Quality 15
- Persistence and Compatibility of Species 18

DISCUSSION
- Grass-Legume Mixtures 18
- Legumes Alone 19
- Grasses Alone 19

SUMMARY 19

REFERENCES 20

APPENDIX 22

ACKNOWLEDGMENTS

The authors acknowledge the assistance of N.S. Hill, A. Jamshedi, J. McLaughlin, M. Nuwanyakpa, and R.J. Stephenson in collection and analysis of data and laboratory analyses, and of S.C. Fransen and K. Janssen in field plot establishment and maintenance.

INTRODUCTION

During the past several years, many pastures in eastern Kansas have been improved by seeding either smooth brome, *Bromus inermis* Leyss., or tall fescue, *Festuca arundinacea* Schreb. These grasses are very productive over a wide range of soil types and produce excellent quality pasture and hay. However, application of 60-100 lbs N/acre/year (67-112 kg N/ha/year) is needed to ensure optimum productivity and to maintain satisfactory stands. Because of the increased cost of nitrogen fertilizers and less than satisfactory cost/return ratios for many farming enterprises, producers have been reluctant to apply adequate nitrogen to these grasses.

An alternative to the use of nitrogen fertilizer with cool-season grasses is the addition of a legume to the grass or the direct seeding of a grass-legume mixture. Mixtures have long been recognized as having several advantages over grasses or legumes alone. The legume component of a mixture generally increases total forage yield, fixes N from the atmosphere (part of which can be utilized by the grass), and enhances the quality of the pasture or hay, by virture of its higher crude protein content and digestibility. The grass component also provides forage, reduces soil erosion, resists heaving of the legume, and reduces the possibility of bloat. Since grasses and legumes differ in chemical composition, physiology, and other respects, mixtures generally are assumed to provide better balanced diets and more efficient utilization of moisture and nutrients, and to involve less risk of serious loss from insects and diseases than single-species crops.

The primary disadvantage of mixtures is the additional management skill required to maintain mixture components compared to grasses alone. Legumes require a highersoil pH than grasses, and harvest of mixtures must be timed to enhance the longevity of legume components without sacrificing quality of the grass.

Nitrogen requirements for productive forage crops are well documented (Mays, 1974). In Kansas, pure stands of cool-season, perennial grasses declined sharply in yield and quality of forage without annual applications of commercial nitrogen (Barnett et al., 1978; Owensby et al., 1969). Nitrogen rates of 60 to 100 lb/acre (67 to 112 kg/ha) have been recommended for annual grass forages in southeastern Kansas (Kilgore, 1975). Data by Robinson (1971) indicate that, in Kansas, maximum forage yields of corn, *Zea mays* L., require as much applied nitrogen as maximum grain yields. Observations at the Kansas Agricultural Experiment Station at Manhattan (Owensby and Smith, 1979) indicate that carrying capacity and gains per acre of native range can be increased through aerial nitrogen fertilization in conjunction with burning for weed control. Forage crops require at least as much nitrogen as comparably productive grain crops.

Prior to 1950, use of nitrogen-fixing legumes in forage mixtures and as pure stands in crop rotations was commonly recommended to reduce the need for commercial nitrogen and maintain soil productivity (Wheeler, 1950). As commercial nitrogen became abundant and inexpensive in the 1950s, use of legumes as nitrogen suppliers became less economically tenable, and the growing of easily managed, liberally fertilized, all-grass stands became common practice. Since 1974, however, increasing nitrogen prices have made forage fertilization less attractive. Many farmers are inclined to save costly nitrogen for cash crops and to accept yield and quality losses with the less economically visible forage crops.

A general decline in forage crop productivity has serious implications for the livestock industry. It has been estimated that forages provide approximately 47% of the total feed units consumed by livestock in the north central states (Heath, 1974). In Kansas, approximately 30% of the adjusted cash sale value of all livestock products is attributable to forages (Burzlaff, 1974). Losses in forage yields can be compensated for only by increasing forage crop acreage or by increasing the ratio of grain to forage in livestock rations. In view of world food needs and the increasing demand for cash crop production, neither of these options appears viable for the long run. Forage crop productivity must be maintained, or increased, in the face of declining availability of commercial nitrogen. That translates into increased use of nitrogen-fixing forage crops.

Currently, symbiotic nitrogen fixation by legumes and their associated rhizobia constitutes the only practical means by which significant amounts of noncommercial nitrogen can be added to agricultural soils. While several nonrhizobial nitrogen-fixing systems are known, none fix nitrogen on a scale of practical significance under conventional field conditions (Silver and Hardy, 1976). Advances in the understanding of symbiotic and asymbiotic nitrogen-fixation processes offer some hope for eventual extension of practical nitrogen-fixing capability to nonleguminous crops (Silver and Hardy, 1976). Research in this area, however, is just beginning and, realistically, cannot be expected to have significant impact on agricultural practice fordecades. In the meantime, there will be a pressing need to optimize the use of legumes in both forage and cash-crop production.

Review of forage production in the pre-1950 period, when commercial nitrogen fertilization was, as now, an expensive practice, seems a logical first step in any attempt to reemphasize the use of legumes in farming systems. Pertinent literature of that period is now well organized. Many forage and crop-production texts discuss the management, uses, and problems of most forage legumes and provide comprehensive bibliographies (Ahlgren, 1956; Heath et al., 1973; Martin et al., 1967; Piper, 1924; and Wheeler, 1950). Researchers at the Kansas Agricultural Experiment Station had done considerable work with alfalfa, *Medicago sativa* L., and sweetclover, *Melilotus officinalis* L., by 1950 (Dean and Smith, 1933; Grandfield, 1943, 1945; Kroulik and Gainey, 1940; Sloan, 1961; and Smith et al., 1955). Although sweeping changes have occurred in forage harvesting and storage during the last 30 years, many of the earlier conclusions concerning use and management of forage legumes are still valid.

However, updating of early conclusions is warranted, relative to species of legumes and combinations of legumes and grasses to be grown in Kansas forage-production programs. During the past 30 years, plant introductions and plant breeding have expanded the number of leguminous species with forage potential in the state. While it is unlikely that alfalfa will be replaced as the leading forage legume, birdsfoot trefoil, *Lotus corniculatus* L., and crownvetch, *Coronilla varia* L., deserve further evaluation as pasture species in eastern Kansas, because they are nonbloating and adapted to shallow soils. During an 8-year trial in southern Iowa, pastures renovated with trefoil increased beef/ha 2.7 times, whereas N-fertilization gave a 1.7 times increase over unimproved bluegrass, *Poa pratensis* (Wedin *et al*, 1967). These authors also noted improved seasonal forage distribution of the trefoil-grass mixture compared to the fertilized grass but were concerned that the trefoil stand declined during the trial. Birdsfoot trefoil also showed promise as sheep pasture in a brome-trefoil mixture at Manhattan, Kansas (Sears, 1979).

Red clover, *Trifolium pratense* L., is shortlived but is a good nitrogen fixer and has good seedling vigor. It may have a role as a legume that can be reestablished periodically in permanent grass stands. Cicer milkvetch, *Astragalus cicer* L., another nonbloating legume, has not received adequate evaluation in Kansas. Sainfoin, *Onobrychis viciaefolia* Scop., also nonbloating, appears adapted to the northern Rocky Mountain region but has not been impressive in Kansas, Oklahoma, or Texas (Hackerott, 1969). Several native legumes are worthy of consideration as potential domestic forage crops; notable among these are Illinois bundleflower, *Desmanthus illinoensis* (Michx.) MacM., and purple prairieclover, *Petalostemum purpureum* Michx. The advent of interseeding, which makes possible the addition of new components to established stands, has created new roles and potentials for some legumes.

The primary objective of this study was to evaluate the productivity and compatibility of four cool-season grasses and four legumes in all possible two-species, grass-legume combinations. We also compared these mixtures with pure stands of legumes and of grasses with and without nitrogen. We evaluated dry matter yield, forage quality, and persistence of the forage species. Seasonal distribution of forage production was determined by harvesting two to four times per year, depending on growth of the forages.

MATERIALS AND METHODS

Locations, Soils, and Weather

Field experiments were located at Manhattan, Ottawa, and Mound Valley, Kansas. The soil at Manhattan was a Wymore silty clay loam of the fine, montmorillonitic, mesic family in the Aquic Argiudolls subgroup of the Mollisols. The soil at Ottawa was a Woodson silt loam of the fine, mixed thermic family in the Abruptic Argiaquolls subgroup of the Mollisols. The soil at Mound Valley had been severely modified as a result of the previous location of an airstrip on the experimental area. It was provisionally classified as a Parsons silty clay loam of the fine, mixed, thermic family in the Mollic Albaqualf subgroup of the Alfisols. The Mound Valley soil had low infiltration and permeability rates, which resulted in droughtiness during the late growing season except in years of above-normal rainfall.

Precipitation and temperature data for the three locations are shown for appropriate years in Tables 1 and 2 (Environmental Data Service, 1976-81). Conditions were extremely droughty at Ottawa in 1976 and moderately so at Manhattan in 1978 and 1980 and at Mound Valley in 1978. Precipitation was considerably above normal at all locations in 1977 and at Ottawa in 1981. It was near normal at Ottawa in 1978 and at all locations in 1979. Subnormal January temperatures characterized 1977-80 at all locations, and July temperatures were much above normal in 1980.

Plant Materials

Perennial legumes in the study were: ‘Kanza’ alfalfa, ‘Kenstar’ red clover, ‘Dawn’ birdsfoot trefoil, and ‘Emerald’ crownvetch (Fig. 1). Cool-season, perennial grasses were: commercial smooth brome; ‘Regar’ Turkish brome, *B. biebersteinii* Roem. & Schult.; ‘Kentucky 31’ tall fescue; and ‘loreed’ reed canarygrass, *Phalaris arundinacea* L. All seedlots were of certified or higher class except those of smooth brome and tall fescue, which were from reliable sources.

Kanza alfalfa (alfalfa) was developed by the Kansas Agricultural Experiment Station and the U.S. Department of Agriculture. It is a synthetic of seven clones selected for resistance or tolerance to several insects and pathogens (Sorensen et al., 1969). The cultivar has been suggested for use in Kansas (Anonymous, 1975).

Kenstar red clover (clover) was released by the Kentucky Agricultural Experiment Station and the U.S. Department of Agriculture in 1973. It is a synthetic of 10 clones selected for persistence under Kentucky conditions (Taylor and Anderson, 1973). It has not been tested widely in Kansas but was in the top yield group of a three-year trial at Ottawa (Posler, 1980).

Dawn birdsfoot trefoil (trefoil) was released by the Missouri Agricultural Experiment Station and the U.S. Department of Agriculture in 1965. It is a synthetic of four clones selected for persistence and other agronomic characteristics. Under Missouri conditions, Dawn resembles ‘Empire’ but differs from that cultivar in being slightly more erect, somewhat earlier, more resistant to root rot, and longer lived (Cavanah, 1979). Dawn has not been tested widely in Kansas, but has performed satisfactorily as sheep pasture, in mixture with smooth brome, at the Kansas Agricultural Experiment Station, Manhattan (Sears, 1979).

Emerald crownvetch (crownvetch) was developed by the Iowa Agricultural Experiment Station and the U.S. Department of Agriculture (Hawk and Schaller, 1964). It was released in 1961 (Phillips and Schaller, 1966). Emerald has not been tested widely as a forage crop in Kansas but has been used for soil stabilization along highways in the eastern part of the state.

The commercial seedlot of smooth brome (S. brome) was harvested from a field in Kansas and was believed to trace to ‘Achenbach,’ a farmers’ cultivar released in 1944 by the Kansas Agricultural Experiment Station (Hanson, 1972). Smooth brome is the most popular cool-season, perennial forage grass in eastern Kansas and, other things being equal, is the grass most likely to be seeded in mixtures with perennial legumes.

Regar Turkish brome (T. brome) was released in 1966 by the Idaho and Washington Agricultural Experiment Stations and by the U.S. Department of Agriculture (Hanson, 1972). It has not been tested widely in Kansas but is believed by some growers to be more drought tolerant than smooth brome. Regar spreads less aggressively than most strains of smooth brome and, for this reason, might be expected to behave differently in mixtures.

Kentucky 31 tall fescue (fescue) was released by the Kentucky Agricultural Experiment Station. It is a very old cultivar tracing to a collection made on a farm in Menifee County, Kentucky in 1931 (Hanson, 1972). Kentucky 31 is widely adapted and has been recommended for use in Kansas (Anonymous, 1975).

Loreed reed canarygrass (canarygrass) was released in 1946 by the Iowa Agricultural Experiment Station and the U.S. Department of Agriculture (Hanson, 1972). In eastern Kansas, it appears well adapted for waterways and other sites where moisture is likely to be abundant (Barnett et al., 1978).

Table 1. Monthly precipitation (inches) at Manhattan, Ottawa, and Mound Valley (Environmental Data Service, 1976-81).

	Manhattan						Ottawa							Mound Valley			
Month	1977	1978	1979	1980	1981	Normal[a]	1976	1977	1978	1979	1980	1981	Normal[b]	1977	1978	1979	Normal[a,c]
January	0.83	0.38	3.16	1.13	0.07	0.86	0.76	1.00	0.35	3.02	1.38	0.06	1.07	0.68	0.69	2.61	1.39
February	0.07	1.22	0.27	1.02	0.63	0.92	0.33	0.60	1.17	0.62	1.43	0.89	0.71	1.61	2.12	1.39	1.35
March	2.38	1.79	4.30	4.97	1.15	1.85	2.17	2.36	3.29	3.27	5.65	3.86	2.17	2.24	2.97	3.45	2.56
April	3.85	1.46	1.86	1.38	2.21	3.00	3.31	3.41	4.25	2.44	0.71	1.42	2.71	2.12	3.71	2.69	4.35
May	9.86	5.12	2.74	1.80	7.06	4.35	4.27	5.56	4.93	4.98	1.41	6.78	4.71	9.08	5.06	4.80	5.51
June	11.55	4.79	3.09	2.81	6.54	5.84	3.44	10.55	4.73	5.82	5.10	12.84	4.71	13.37	7.12	5.00	5.76
July	1.30	3.14	5.55	1.20	5.59	4.38	0.17	3.36	1.74	5.48	0.65	5.98	3.46	3.73	0.24	5.94	4.02
August	7.25	1.23	2.92	2.94	2.76	3.60	0.46	5.86	3.95	0.94	4.46	3.68	2.92	10.14	4.63	4.02	3.18
September	5.95	4.56	1.26	2.52	1.39	3.96	1.80	5.04	2.33	2.79	1.28	1.73	4.89	7.10	1.86	0.26	4.90
October	2.07	0.24	5.95	3.43	2.33	2.72	2.99	4.37	0.80	3.87	4.65	4.92	3.61	4.94	0.35	3.21	3.46
November	2.45	2.90	1.46	0.11	5.26	0.98	0.29	2.56	3.74	3.80	0.64	4.15	2.04	3.96	5.27	8.41	1.98
December	0.04	0.23	0.03	3.05	0.72	1.06	0.13	0.24	1.60	0.00	1.73	1.04	1.10	0.53	0.75	0.13	1.56
Total	47.60	27.06	32.59	26.36	35.71	33.52	20.12	44.91	32.88	37.03	29.09	47.35	34.10	59.50	34.77	41.91	40.02

[a]Average for 1941-70. [b]Average for 1967-76.
[c]From weather station at Parsons, Kansas, approximately 12 miles north and 6 miles east of Mound Valley.

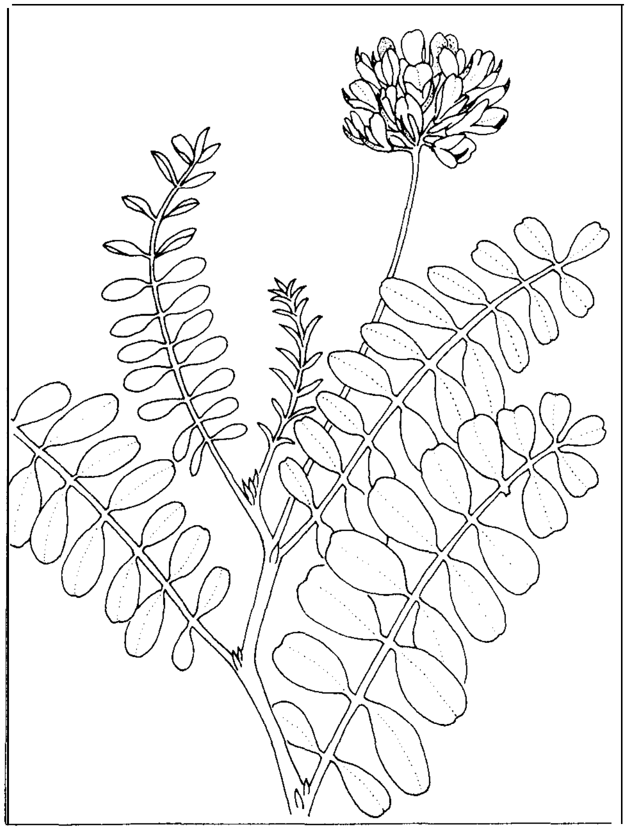
Table 2. Mean monthly temperatures (°F) at Manhattan, Ottawa, and Mound Valley (Environmental Data Service, 1976-61).

	Manhattan						Ottawa							Mound Valley			
Month	1977	1978	1979	1980	1981	Normal[a]	1976	1977	1978	1979	1980	1981	Normal[b]	1977	1978	1979	Normal[a,c]
January	20.1	18.4	15.0	29.9	32.6	28.8	31.7	18.9	18.0	14.9	32.5	34.3	30.6	-	22.9	20.0	34.6
February	38.9	21.6	21.1	27.8	37.4	34.0	46.8	39.6	22.6	23.2	28.4	37.7	35.6	-	26.3	27.5	39.7
March	49.5	40.8	44.8	40.0	46.8	42.1	47.9	48.8	40.5	45.9	43.1	48.3	43.3	51.2	44.3	48.6	46.7
April	60.3	58.0	53.2	54.0	63.5	55.4	58.6	61.0	56.9	55.7	56.0	65.2	56.3	60.5	60.4	57.3	59.5
May	70.5	63.7	63.6	64.7	62.5	65.1	61.7	69.8	63.9	65.7	66.1	61.9	65.7	70.2	66.6	65.6	67.9
June	76.5	75.7	73.6	78.4	76.1	74.3	74.1	75.9	75.8	74.2	78.3	75.7	74.3	76.4	76.6	74.0	76.3
July	82.0	81.1	77.9	87.8	79.5	79.0	79.7	80.3	82.2	77.9	87.5	79.8	78.8	81.0	83.7	80.0	80.9
August	76.6	79.8	77.9	83.9	75.0	78.4	78.4	76.5	78.9	77.2	82.1	74.7	77.9	77.4	80.6	77.4	80.3
September	70.5	74.4	70.7	72.5	70.0	69.1	70.1	71.0	73.9	70.2	72.6	70.8	69.4	72.4	75.8	70.7	72.2
October	58.2	57.1	59.9	56.0	56.1	58.6	52.9	57.9	56.8	60.8	57.0	57.6	59.4	60.0	61.6	63.2	62.1
November	44.4	44.2	41.0	46.1	46.8	43.5	37.8	44.3	45.1	43.2	47.2	47.9	45.1	48.7	49.3	45.0	48.1
December	32.6	31.3	37.2	34.3	32.0	32.4	32.9	32.3	32.0	38.0	37.6	32.4	34.3	36.6	36.5	40.8	38.1
Total	56.7	53.8	53.0	56.3	56.5	55.1	56.0	56.4	53.9	53.9	57.4	57.2	55.9	-	57.1	55.8	59.0

[a]Average for 1941-70.
[b]From weather station at Parsons, Kansas, approximately 12 miles north and 6 miles east of Mound Valley.

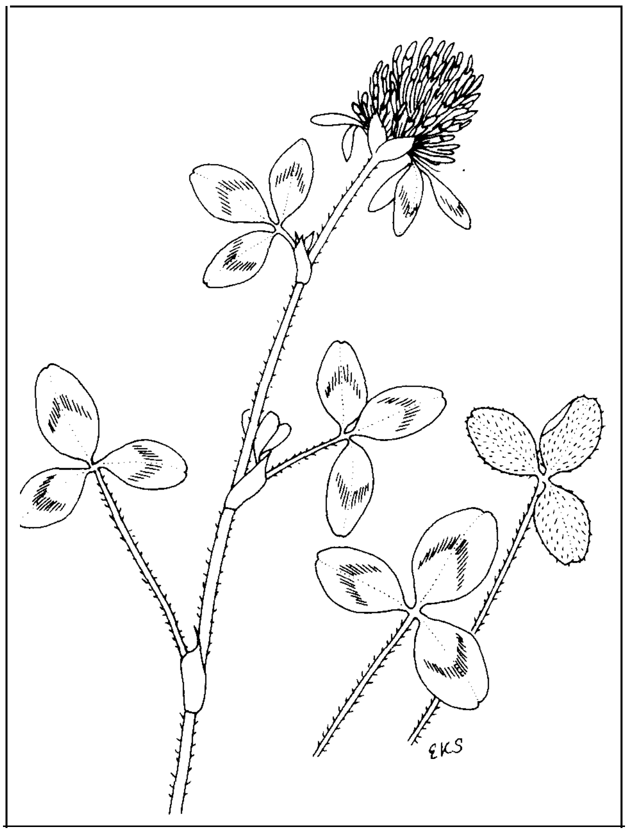
Figure 1

Birdsfoot trefoil, *Lotus corniculatus*



Crownvetch, *Coronilla varia*

Alfalfa, *Medicago sativa*



Red clover, *Trifolium pratense*

Plot Layout and Statistical Design

The same planting arrangement, with different plot randomization, was used at all locations. Each grass was grown in a two-species combination with each legume. Each grass also was grown in a pure stand, with and without commercial nitrogen (80 lb N/acre or 90 kg N/ha), applied in spring as NH_4NO_3. Plots were arranged in a four-replicate, split-plot design with grasses as main plots and legumes and nitrogen treatments as subplots. Legumes were grown in pure stands in an adjacent, four-replicate, randomized-block planting.

Individual plots were 20 x 5 ft (6.1 x 1.5 m). Drill rows were lengthwise in the plots, and drill-row spacing was approximately 7 in (18 cm). Mixed stands were obtained by alternating all-grass and all-legume drill rows.

Stand Establishment

Plots at Ottawa, Mound Valley, and Manhattan were seeded August 21, August 22, and September 9, 1975, respectively. Seeding was by a hand-operated Planet Junior seeder. Legume seed was inoculated with appropriate strains of rhizobia immediately prior to seeding.

Excellent stands were obtained at Ottawa, and plots were harvested there in 1976. Establishment was less successful at Mound Valley and Manhattan, producing only fair stands. Plot harvest was not feasible at those locations until 1977. Because of a rapid decline in stands of clover, this species was reintroduced into grass plots at Ottawa by interseeding on April 20,198O. The operation was only partially successful because of competition from the grasses.

Harvesting Procedures

Harvest dates are summarized in Table 3. The pattern of cutting dates permitted categorization of harvests at each location as spring, early summer, late summer, or fall. In spring and early summer cuttings, all plots at each location were harvested when alfalfa was in an early flowering stage. Clover and trefoil generally were slightly more advanced in maturity than alfalfa at spring and early summer harvests, whereas crownvetch was somewhat less advanced. Grasses generally were in early heading at spring harvest but usually were in a vegetative stage at early summer and subsequent harvests. Recovery following early summer harvest varied sharply from species to species and from year to year, so that late summer and fall harvests seldom were obtained from all treatments.

Harvesting at all locations was done with a flail harvester at a cutting height of approximately 3.5 in (9.0 cm). Cutting width was 36 in (0.92 m) at Manhattan and Ottawa, and 30 in (0.76 m) at Mound Valley. At all locations, harvest of forage for yield determination involved a single lengthwise pass of the harvester through the middle of each plot. Forage from plot borders also was removed at a cutting height of approximately 3.5 in (9.0 cm) immediately following harvest for yield determination.

Samples of freshly harvested material were weighed in the field, dried to constant weight in a forced-air dryer at approximately 120 F (49 C), and reweighed to estimate percentage of dry matter. Dry matter yield was calculated as the product of the weight of freshly harvested material and percentage of dry matter.

Percentage of Legume in Mixtures

At Ottawa, percentages of legume in forage mixtures were estimated from samples taken from grass-legume plots immediately prior to each harvest. Each sampling area consisted of a 12-in (30-cm) section of adjacent grass and legume drill rows. Two sampling areas for each plot were selected randomly within the area to be harvested for yield determination and were at least 3 ft (0.92 m) apart. Sampling areas were delineated by use of a metal rod, 1/4 in (63 mm) in diameter, and bent in the shape of a U with 12 in (30-cm) arms and a base of 14 in (36 cm, i.e., two drill rows). Forage from the two sampling areas in each plot was composited and hand separated into grass and legume fractions. Amounts of weeds in the samples were negligible. Grass and legume fractions were dried in a forced-air dryer at approximately 120 F (49 C) and weighed. Proportion of legume in the forage was estimated as the percentage, by dry weight, of the legume fraction in the total sample. Dry matter yields for grass-legume plots at Ottawa were adjusted to compensate for the reduction in plot harvest area resulting from removal of the hand-clipped samples.

Forage Quality

At Manhattan and Ottawa, percentage of crude protein (CP) in flail-harvested forage was estimated for each plot at each harvest in each year. Forage samples employed in estimating dry matter percentages were used for this determination. Crude protein percentage was estimated as 6.25 times the percentage of total nitrogen in dried forage, as determined calorimetrically through a procedure described by Nuwanyakpa (1979).

At Manhattan and Ottawa, *in vitro* dry matter digestibility (IVDMD) of forage was determined for each plot at each harvest in each year. Samples used for this determination were also the same ones employed in estimation of dry matter percentage. Analytical procedure was a modification of the Tilley and Terry method outlined by Nuwanyakpa (1979).

Table 3. Harvest dates at Manhattan, Ottawa, and Mound Valley, 1976-61.

	Manhattan					Ottawa						Mound Valley		
Harvest	1977	1978	1979	1980	1981	1976	1977	1978	1979	1980	1981	1977	1978	1979
Spring	5-16	6-5	5-25	5-27	5-15	6-3	5-26	5-30	5-24	5-28	5-22	5-10	5-31	5-18
Early Summer	7-5	7-14	7-9	6-25	6-24	7-13	7-12	7-12	7-2	-	6-23	6-14	7-11	6-22
Late Summer	9-6[a]	8-18[a]	8-20[b]	7-23[a]	8-5	-	8-25[a]	-	8-7	-	8-4	7-19	-	7-27[a]
FalI	11-16	10.31[b]	-	8-26[a]	10-16	-	11-23	-	10-5	-	-	11-7	10-26	-

[a] Alfalfa and alfalfa-grass plots only. [b] Alfalfa and trefoil.

RESULTS

Statistical analyses indicated that forages responded differentially among locations, years, and harvests for all variables. Data for each location, by harvests and years, are shown in Appendix Tables1-9.

Annual Dry Matter Production

Total annual dry matter yields for grass-legume mixtures, grasses alone, with and without N, and legumes alone are shown in Table 4 for Manhattan, Table 5 for Ottawa, and Table 6 for Mound Valley.

Mixtures vs. Pure Stands

Mixtures were clearly superior to unfertilized grasses in all years at all locations. Alfalfa and trefoil mixtures usually produced more dry matter than grass receiving 80 lb N/acre. Crownvetch mixtures yielded more than fertilized grass at Manhattan and Ottawa, but less at Mound Valley. Clover mixtures outyielded fertilized grass only at Ottawa in 1976. Although comparisons of mixtures and legumes alone were not statistically valid, all-legume stands appeared to produce more dry matter than mixtures in the early years of the study but to lose their yield advantage as stands aged. That trend was especially pronounced at Manhattan and Ottawa. Mixtures were never clearly superior to legumes alone, however, except where legume stands were seriously depleted.

Grass Comparisons

At Manhattan and Ottawa, annual dry matter yields, whether of mixtures or all-grass stands, were little affected by grasses. At Mound Valley, however, dry matter yields were affected by grasses in all-grass stands as well as in mixtures. T. brome was consistently the lowest yielding species in all-grass stands at Mound Valley, but mixtures combining it with either alfalfa or trefoil compared favorably with those combining the same legumes with other grasses. Fescue ranked above other grasses in yield of all-grass stands at Mound Valley.

Legume Comparisons

Alfalfa generally outyielded other legumes in pure stands, often by a substantial margin. The highest annual production of dry matter recorded in the study was 7.38 tons/acre (16.53 Mg/ha) for alfalfa alone at Manhattan in 1978. An obvious advantage of alfalfa in several instances was its ability to recover following harvest for an extra one or two cuts during the growing season. Trefoil generally was second to alfalfa in pure stand performance and was essentially equal to it at Mound Valley. Relative overall performance of clover was biased downward at Manhattan and Mound Valley by the fact that no yield measurements were made at these locations in 1976.

Differences in pure-stand productivity of legumes were strongly reflected in the relative performance of grass-legume mixtures. Alfalfa mixtures generally were highest in dry matter production. Trefoil mixtures followed and were essentially equal to alfalfa combinations at Mound Valley. Crownvetch mixtures were comparable to those of trefoil at Manhattan and Ottawa but performed poorly at Mound Valley, especially after 1977. Clover mixtures performed poorly at all locations after 1977 and were lowerthan the other combinations in overall dry matter production. However, yields of clover-grass mixtures were often greaterthan those of unfertilized grass, even in the fourth and fifth years at Manhattan and Ottawa. These results show that newer varieties of red clover, such as Kenstar, can be productive beyond the second year.

Table 4. Annual dry-matter yields of grasses, legumes, and grass-legume mixtures at Manhattan.

Year	Legume or N Treatment	Dry Matter, Tons/Acre[a]					
		Grass					Legume Alone
		S. brome	T. brome	Fescue	Canary	LSD (.05)	
1977	Alfalfa	4.07	4.25	4.54	5.31	0.96	5.98
	Clover	1.67	2.20	3.40	3.86	0.96	3.93
	Trefoil	2.30	2.43	4.25	4.95	0.96	5.11
	Crownvetch	1.70	1.99	3.72	3.72	0.96	4.38
	0 lb N/A	1.41	1.90	1.99	2.71	0.96	-
	80 lb N/A	2.54	2.92	3.70	3.89	0.96	-
	LSD (.05)	0.99	0.99	0.99	0.99		0.82
1978	Alfalfa	6.32	6.56	6.56	7.03	NS	7.38
	Clover	1.01	1.26	2.10	2.29	1.00	2.80
	Trefoil	2.02	2.32	3.53	3.82	1.00	4.25
	Crownvetch	0.76	1.46	3.17	3.48	1.00	3.17
	0 lb N/A	1.16	0.76	0.88	0.90	NS	-
	80 lb N/A	2.43	2.88	2.87	2.60	NS	-
	LSD (.05)	0.99	0.99	0.99	0.99		1.46
1979	Alfalfa	6.04	6.36	6.24	6.34	NS	5.46
	Clover	0.80	0.84	0.68	0.88	NS	0.84
	Trefoil	2.03	2.60	2.83	3.15	NS	2.86
	Crownvetch	0.91	1.25	1.90	2.03	NS	1.46
	0 lb N/A	0.65	0.48	0.36	0.55	NS	-
	80 lb N/A	2.69	1.81	1.17	1.24	NS	-
	LSD (.05)	0.60	0.60	0.60	0.60		1.10
1980	Alfalfa	6.12	6.27	4.71	4.69	NS	5.57
	Clover	0.53	0.79	0.90	0.96	NS	1.09
	Trefoil	1.42	1.88	1.96	2.25	NS	1.39
	Crownvetch	0.89	1.67	2.12	2.52	NS	1.25
	0 lb N/A	0.29	0.25	0.46	0.63	NS	-
	80 lb N/A	1.54	1.17	1.22	0.73	NS	-
	LSD (.05)	0.82	0.82	0.82	0.82		0.89
1981	Alfalfa	5.59	5.77	4.96	5.44	NS	4.60
	Clover	1.17	1.19	2.16	0.33	NS	-
	Trefoil	3.55	3.96	3.75	4.64	NS	2.53
	Crownvetch	2.50	3.55	3.62	4.80	NS	1.29
	0 lb N/A	0.76	1.17	1.13	-	NS	-
	80 lb N/A	1.45	1.60	2.23	-	NS	-
	LSD (.05)	2.11	2.11	2.11	2.11		0.45

[a]Multiply by 2.24 for Mg/ha.

Table 5. Annual dry-matter yields of grasses, legumes, and grass-legume mixtures at Ottawa.

		Dry Matter, Tons/Acre[a]					
		Grass					
Year	Legume or N Treatment	S. brome	T. brome	Fescue	Canary	LSD (.05)	Legume Alone
1976	Alfalfa	3.12	2.78	3.12	3.32	NS	3.03
	Clover	4.33	4.03	4.22	4.81	0.77	4.42
	Trefoil	2.73	3.11	3.10	2.70	NS	3.53
	Crownvetch	1.88	2.20	2.50	1.45	0.77	2.16
	0 lb N/A	2.14	2.54	2.31	1.06	0.77	-
	80 lb N/A	3.98	3.82	4.45	3.19	0.77	-
	LSD (.05)	0.46	0.46	0.46	0.46		0.50
1977	Alfalfa	3.95	3.72	3.76	4.00	NS	4.17
	Clover	2.41	3.10	2.76	3.23	NS	3.31
	Trefoil	3.74	3.77	3.64	4.16	NS	5.04
	Crownvetch	4.01	4.23	4.05	4.73	NS	5.50
	0 lb N/A	1.07	1.41	1.60	1.48	NS	-
	80 lb N/A	3.12	3.58	3.48	3.58	NS	-
	LSD (.05)	0.52	0.52	0.52	0.52		0.78
1978	Alfalfa	3.90	3.44	3.52	3.01	NS	3.77
	Clover	1.84	1.90	1.85	1.50	NS	2.15
	Trefoil	3.50	3.11	3.26	3.16	NS	3.55
	Crownvetch	3.05	2.81	2.55	2.80	NS	3.29
	0 lb N/A	1.16	0.77	0.77	0.79	NS	-
	80 lb N/A	1.69	2.09	2.55	2.33	NS	-
	LSD (.05)	1.06	1.06	1.06	1.06		1.01
1979	Alfalfa	4.60	5.02	4.87	4.49	NS	5.45
	Clover	1.85	2.32	1.49	1.49	NS	0.64
	Trefoil	3.84	3.88	3.32	3.98	NS	3.85
	Crownvetch	2.90	3.13	2.69	2.78	NS	3.00
	0 lb N/A	1.47	1.33	1.03	1.05	NS	-
	80 lb N/A	2.04	2.47	2.15	2.24	NS	-
	LSD (.05)	0.95	0.95	0.95	0.95		0.93
1980	Alfalfa	1.87	1.61	1.53	1.85	0.34	1.52
	Clover	0.74	0.53	0.54	0.54	NS	-
	Trefoil	1.46	1.06	1.07	1.49	0.34	1.15
	Crownvetch	1.40	1.05	0.94	1.31	0.34	1.13
	0 lb N/A	0.39	0.42	0.26	0.40	NS	-
	80 lb N/A	1.66	0.69	1.16	1.15	0.34	-
	LSD (.05)	0.29	0.29	0.29	0.29		0.23
1981	Alfalfa	3.83	3.34	3.22	4.36	NS	3.74
	Clover	1.39	1.50	0.97	1.47	NS	-
	Trefoil	2.85	2.91	2.59	2.46	NS	2.90
	Crownvetch	2.97	2.56	2.45	3.42	NS	3.19
	0 lb N/A	1.32	1.61	0.87	1.05	NS	-
	80 lb N/A	1.72	1.54	1.38	1.50	NS	-
	LSD (.05)	0.78	0.78	0.78	0.78		0.62

[a]Multiply by 2.24 for Mg/ha

Table 6. Annual dry-matter yields of grasses, legumes, and grass-legume mixtures at Mound Valley.

Year	Legume or N Treatment	Dry Matter, Tons/Acre[a]					
		Grass					Legume Alone
		S. brome	T. brome	Fescue	Canary	LSD (05)	
1977	Alfalfa	4.03	4.32	4.47	3.23	0.57	4.10
	Clover	2.76	3.16	3.43	3.46	0.57	3.82
	Trefoil	3.40	4.41	4.40	4.16	0.57	4.54
	Crownvetch	1.76	1.54	2.28	2.37	0.57	3.39
	0 lb N/A	0.66	0.39	0.99	0.79	0.57	
	80 lb N/A	1.92	1.86	2.48	2.23	0.57	-
	LSD (.05)	0.56	0.56	0.56	0.56	-	0.89
1978	Alfalfa	1.63	1.90	1.84	1.40	0.47	2.33
	Clover	1.31	1.09	1.46	1.42	NS	1.46
	Trefoil	2.22	2.47	2.36	2.05	NS	2.17
	Crownvetch	0.40	0.25	1.11	0.75	0.47	0.18
	0 lb N/A	0.48	0.23	0.81	0.74	0.47	-
	80 lb N/A	1.71	0.90	2.16	1.59	0.47	-
	LSD (.05)	0.44	0.44	0.44	0.44	-	0.86
1979	Alfalfa	2.21	2.54	2.32	1.93	-	2.26
	Clover	0.50	0.22	0.41	0.34	-	-
	Trefoil	1.40	1.65	1.53	1.73	-	1.47
	Crownvetch	0.28	0.07	0.39	0.20	-	0.10
	0 lb N/A	0.42	0.12	0.27	0.30	-	
	80 lb N/A	1.11	0.19	0.70	0.72	-	
	LSD (.05)	-	-	-	-	-	-

[a]Multiply by 2.24 for Mg/ha.

Table 7. First-harvest crude protein contents (%) of grasses, legumes, and grass-legume mixtures at Manhattan.

Year	Legume or N Treatment	Crude Protein Content, %					
		Grass					Legume Alone
		S. brome	T. brome	Fescue	Canary	LSD (.05)	
1977	Alfalfa	9.4	9.2	10.0	12.5	1.9	13.4
	Clover	7.9	7.1	10.6	11.6	1.9	13.0
	Trefoil	8.1	8.0	9.9	12.3	1.9	14.7
	Crownvetch	7.0	8.1	9.6	12.2	1.9	15.0
	0 lb N/A	7.1	7.9	8.2	10.0	1.9	-
	80 lb N/A	10.4	9.6	10.3	11.3	NS	-
	LSD (.05)	2.1	2.1	2.1	2.1	-	NS
1978	Alfalfa	15.9	15.1	15.9	15.9	NS	18.0
	Clover	11.6	10.9	12.5	14.9	2.5	18.1
	Trefoil	13.6	14.1	16.5	13.0	2.5	18.7
	Crownvetch	9.3	10.4	16.4	18.0	2.5	19.8
	0 lb N/A	9.0	8.3	6.9	8.8	NS	-
	80 lb N/A	10.4	11.3	10.1	12.4	NS	-
	LSD (.05)	2.6	2.6	2.6	2.6	-	NS
1979	Alfalfa	16.4	17.7	17.0	17.1	2.7	16.6
	Clover	8.2	8.6	10.5	13.3	2.7	17.6
	Trefoil	13.6	14.0	18.3	16.7	2.7	17.5
	Crownvetch	11.9	13.3	18.0	18.5	2.7	17.4
	0 lb N/A	9.4	9.6	8.6	11.8	2.7	-
	80 lb N/A	11.7	11.1	12.4	14.2	2.7	-
	LSD (.05)	2.8	2.8	2.8	2.8	-	NS

Table 6. First-harvest crude protein contents (%) of grasses, legumes, and grass-legume mixtures at Ottawa.

Year	Legume or N Treatment	Crude Protein Content, % Grass S. brome	T. brome	Fescue	Canary	LSD (.05)	Legume Alone
1976	Alfalfa	16.1	18.5	14.6	17.6	3.3	20.2
	Clover	14.4	15.1	14.5	15.3	NS	20.4
	Trefoil	13.9	13.5	12.7	16.6	3.3	20.5
	Crownvetch	10.4	9.8	10.2	12.4	NS	20.8
	0 lb N/A	8.3	8.4	7.5	10.5	NS	-
	80 lb N/A	10.5	9.5	9.2	13.4	3.3	-
	LSD (.05)	2.4	2.4	2.4	2.4	-	NS
1977	Alfalfa	8.7	9.2	11.6	12.6	2.1	19.1
	Clover	7.7	8.8	7.1	9.4	2.1	16.8
	Trefoil	11.8	10.0	9.7	11.9	2.1	16.1
	Crownvetch	13.8	11.3	11.6	15.3	2.1	16.8
	0 lb N/A	7.0	7.4	6.1	8.1	NS	-
	80 lb N/A	7.7	9.8	7.7	8.6	2.1	-
	LSD (.05)	1.9	1.9	1.9	1.9	-	NS
1978	Alfalfa	16.8	17.0	15.9	17.2	NS	21.0
	Clover	12.1	13.2	12.7	12.1	NS	17.4
	Trefoil	17.8	18.5	16.3	18.0	NS	21.0
	Crownvetch	17.8	16.5	18.0	14.6	NS	25.1
	0 lb N/A	8.2	9.9	8.8	9.3	NS	-
	80 lb N/A	8.8	9.3	8.9	9.5	NS	-
	LSD (05)	3.8	3.8	3.8	3.8	-	4.4
1979	Alfalfa	14.6	14.7	15.0	15.1	NS	16.4
	Clover	8.7	8.6	7.8	10.7	2.4	-
	Trefoil	14.8	14.9	14.0	17.6	2.4	16.0
	Crownvetch	16.1	13.8	14.0	16.5	2.4	18.3
	0 lb N/A	9.6	9.3	8.3	9.5	NS	-
	80 lb N/A	8.7	9.7	8.3	11.0	2.4	-
	LSD (.05)	2.5	2.5	2.5	2.5	-	1.2

Forage Quality

Crude protein contents of forages are presented for Manhattan in Table 7 and for Ottawa in Table 8. Considering both locations for 1977-79, mixtures containing alfalfa, trefoil, and crownvetch were similar in CP content, and all were higher than grasses alone with orwithout nitrogen. Clovercombinations were lower in protein than other mixtures and by 1979, when most of the clover had been lost from mixed stands, were similarto grasses alone in CP content. Nitrogen fertilization generally increased the CP content of all-grass stands, but the response at 80 Ibs N/acre was much less impressive than that of dry matter yield.

In vitro digestibilities (IVDMD) of mixtures and grasses alone are presented for Manhattan in Table 9 and for Ottawa in Table 10. Trends for IVDMD of forage were similar to those for CP content but were less pronounced and, with all-grass stands, showed little effect of nitrogen fertilization. Mixtures containing alfalfa and trefoil usually showed higher IVDMD than grasses alone. Crownvetch mixtures were higher than grasses alone at Ottawa but not at Manhattan. Clover mixtures were similar to all-grass stands in IVDMD of forage at both locations.

Table 9. First-harvest IVDMD (%) of grasses, legumes, and grass-legume mixtures at Manhattan.

		IVDMD, %					
		Grass					Legume
Year	Legume or N Treatment	S. brome	T. brome	Fescue	Canary	LSD (.05)	Alone
1977	Alfalfa	58.8	57.6	56.0	59.3	NS	55.0
	Clover	63.5	61.0	53.8	56.4	5.7	60.5
	Trefoil	61.9	59.1	59.2	60.5	NS	62.7
	Crownvetch	62.4	62.3	51.3	55.6	5.7	57.2
	0 lb N/A	59.1	58.8	56.3	51.8	5.7	-
	80 lb N/A	65.4	63.1	56.5	58.0	5.7	-
	LSD (.05)	5.6	NS	5.6	5.6	-	5.6
1978	Alfalfa	65.0	63.6	64.9	64.1	NS	63.2
	Clover	63.5	57.7	59.1	61.4	4.0	61.6
	Trefoil	63.3	62.3	62.6	59.6	NS	63.1
	Crownvetch	61.9	57.9	59.7	62.7	4.0	61.3
	0 lb N/A	60.8	56.1	53.8	52.7	4.0	-
	80 lb N/A	59.6	60.0	57.5	58.9	NS	-
	LSD (.05)	3.9	3.9	3.9	3.9	-	NS
1979	Alfalfa	69.5	69.0	68.9	68.7	NS	62.9
	Clover	68.7	63.2	66.2	65.1	5.0	61.5
	Trefoil	69.9	68.7	70.3	66.8	NS	66.6
	Crownvetch	68.5	65.0	64.8	65.7	NS	64.3
	0 lb N/A	69.5	63.8	63.4	65.8	5.0	-
	80 lb N/A	66.9	67.1	67.5	68.3	NS	-
	LSD (.05)	NS	NS	NS	NS	-	2.8

Table 10. First-harvest IVDMD (%) of grasses, legumes, and grass-legume mixtures at Ottawa.

		IVDMD, %					
		Grass					
Year	Legume or N Treatment	S. brome	T. brome	Fescue	Canary	LSD (.05)	Legume Alone
1977	Alfalfa	60.3	62.3	59.3	61.2	**NS**	60.6
	Clover	62.8	64.4	55.9	61.7	4.1	65.1
	Trefoil	64.6	65.2	59.5	63.5	4.1	65.4
	Crownvetch	63.7	61.9	61.9	64.6	NS	64.1
	0 lb N/A	60.6	57.2	57.8	59.7	NS	-
	80 lb N/A	62.6	64.9	56.6	61.8	4.1	-
	LSD (.05)	3.6	3.6	3.6	3.6	-	**NS**
1978	Alfalfa	64.5	64.1	59.0	61.9	**NS**	62.5
	Clover	59.1	61.6	56.6	55.7	**NS**	62.5
	Trefoil	62.2	62.8	61.3	61.0	**NS**	61.5
	Crownvetch	62.0	62.6	59.9	61.4	**NS**	65.1
	0 lb N/A	56.1	61.7	53.9	58.1	**NS**	-
	80 lb N/A	57.6	60.0	53.2	54.4	**NS**	-
	LSD (.05)	NS	NS	NS	NS	-	2.1
1979	Alfalfa	66.0	66.0	67.8	66.1	**NS**	64.0
	Clover	68.1	66.6	66.0	67.0	**NS**	-
	Trefoil	66.6	67.6	66.7	68.2	**NS**	65.7
	Crownvetch	69.6	68.8	67.6	69.4	**NS**	63.2
	0 lb N/A	69.4	67.1	67.9	66.8	**NS**	-
	80 lb N/A	67.7	67.7	67.8	66.0	**NS**	-
	LSD (.05)	2.6	2.6	NS	2.6	-	**NS**

Seasonal Trends in Production and Quality

Seasonal changes in dry matter productivity and in CP contents and IVDMD of harvested dry matter are indicated in Appendix Tables 1-9. Trends at Ottawa for combinations of S. brome, fescue, alfalfa, and trefoil are presented graphically for 1977 through 1979 in Figs. 2 and 3. Mixtures generally were intermediate to legumes alone and grasses alone in seasonal distribution of dry matter production. Both legumes and mixtures consistently produced a greater proportion of their total annual dry matter in summer and fall than did grasses alone, with or without commercial nitrogen. Spring-applied commercial nitrogen had little effect on dry matter productivity of grasses beyond the spring harvest, so that fertilized grasses produced a much greater proportion of their dry matter in the spring than did the unfertilized ones. Dry matter digestibility of forage from all-grass stands was sharply lower in summer and fall harvests than in spring cuttings. With legumes and mixtures, on the other hand, IVDMD of harvested materials was essentially unchanged across harvests. In most cases, percent CP of harvested dry matter was higher in summer and fall cuttings than in spring. With all-grass stands, however, CP content in summer and fall was negligible because of sharply reduced dry matter yield.

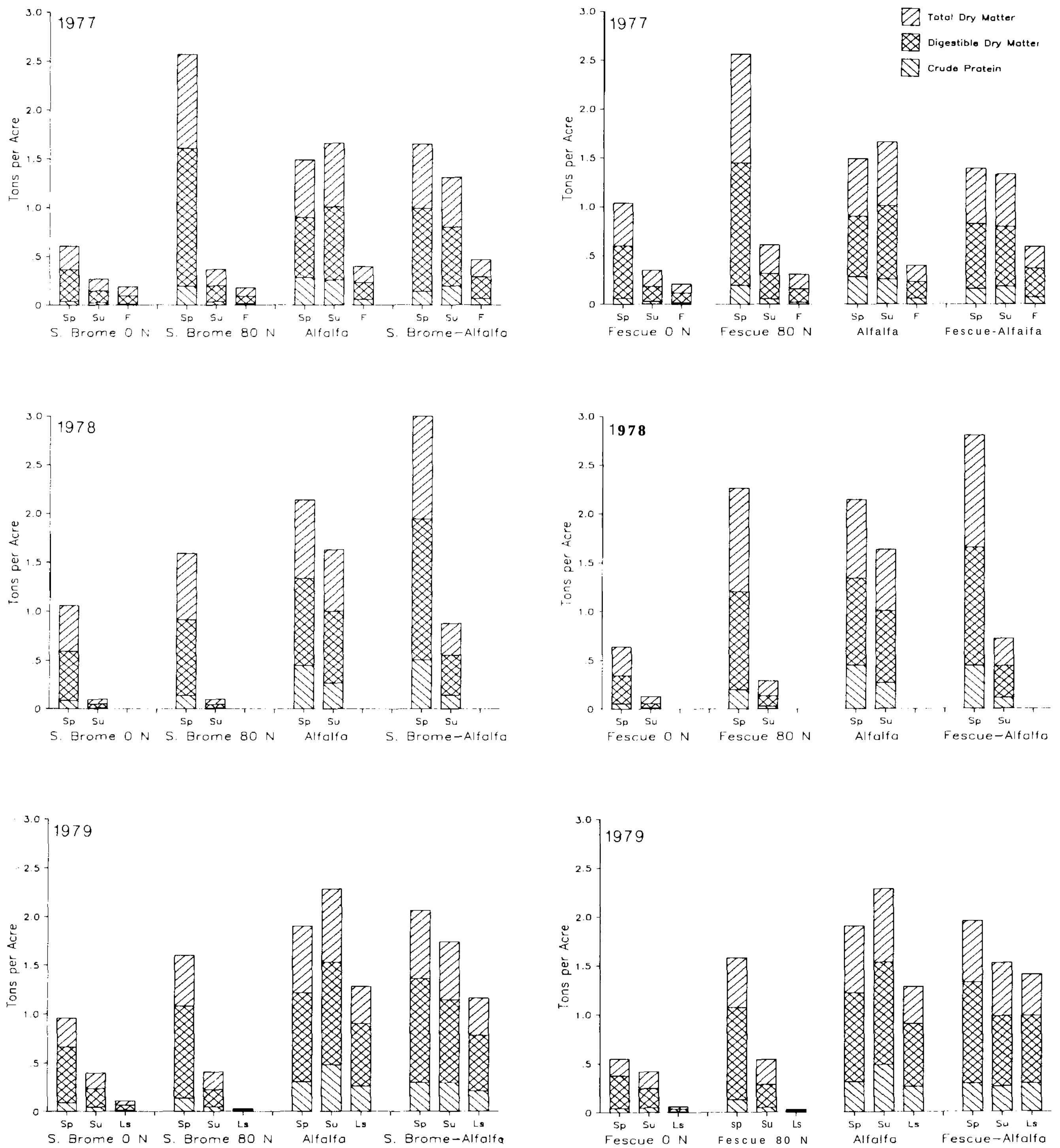


Figure 2. Production of total dry matter, digestible dry matter, and crude protein for spring (Sp), summer (Su), late summer (Ls), and fall (F) harvests of S. brome and alfalfa combinations (left) and fescue and alfalfa combinations (right) for 3 years at Ottawa. Data for 1977 do not include a late summer harvest for alfalfa alone and alfalfa-grass mixtures. Multiply tons/acre by 2.24 for Mg/ha.

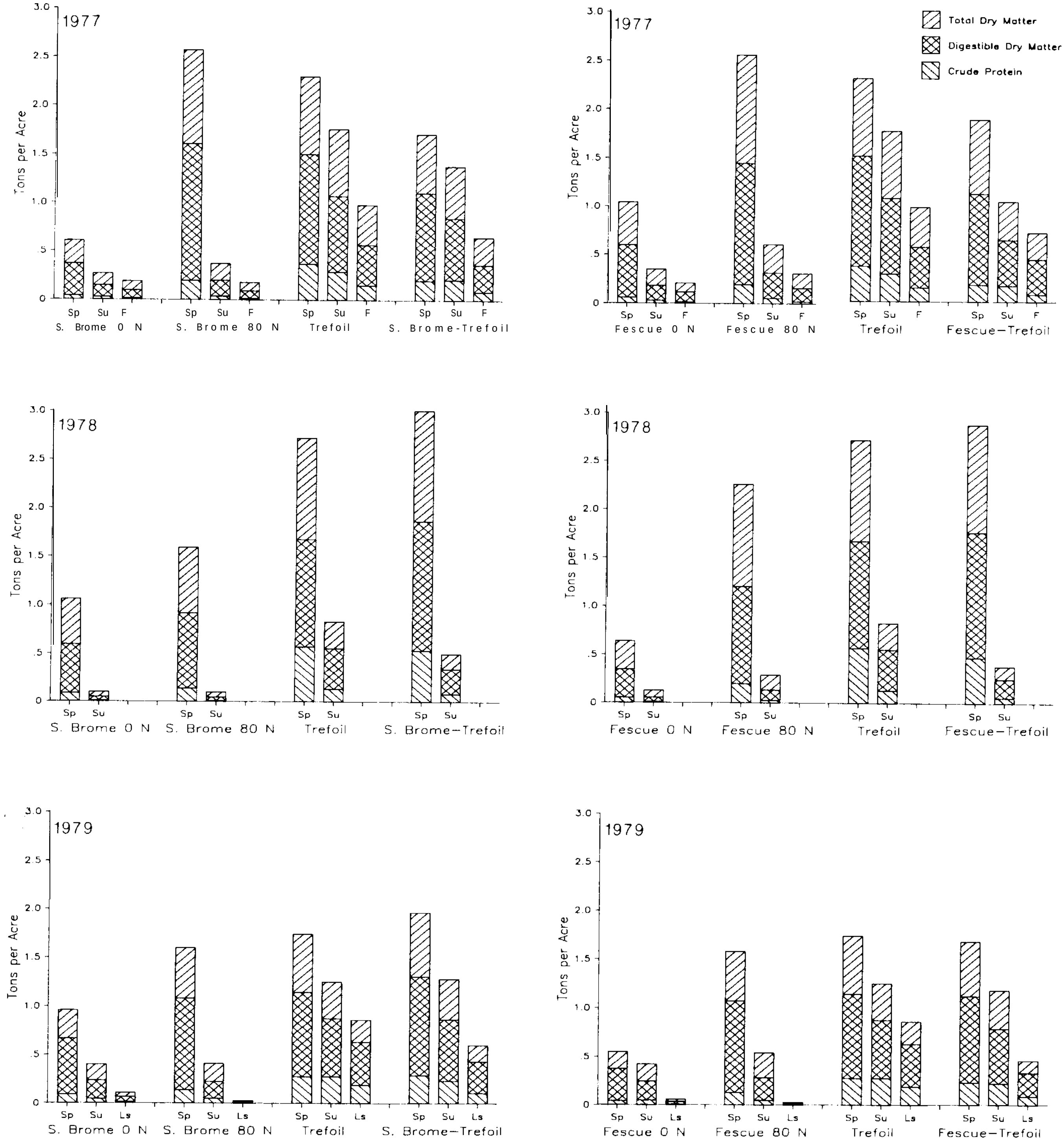


Figure 3. Production of total dry matter, digestible dry matter, and crude protein for spring (Sp), summer (Su), late summer (Ls), and fall (F) harvests of S. brome and trefoil combinations (left) and fescue and trefoil combinations (right) for 3 years at Ottawa. Multiple tons/acre by 2.24 for Mg/ha.

Table 11. Percent legumes in mixtures at Ottawa and Manhattan. 1976-81.

Year	Alfalfa	Red Clover	Birdsfoot Trefoil	Crownvetch	$LSD_{.05}$
		Ottawa-Spring Harvest-Dry Matter Basis			
1976	47	58	45	23	7
1977	35	20	44	57	10
1978	63	43	66	62	12
1979	77	6	68	65	8
1980	75	22	70	62	4
1981	65	11	61	68	9
Mean	60	28	59	56	-
		Manhattan-Spring Harvest-Visual Estimate			
1980	81	17	68	49	a
1981	83	4	63	55	a

Persistence and Compatibility of Species

Clover established more readily and was lost from stands more rapidly than other species in the study. It was essentially absent from stands at Ottawa by 1979 and at Manhattan by 1981 (Table 11). Reintroduction of clover at Ottawa in 1980 was not very successful, probably because no attempt was made to suppress the grass. Crownvetch established slowly but, at Manhattan and Ottawa, persisted well after establishment. At Mound Valley, however, it performed well only in 1977 and was virtually lost from stands by 1979. Stand loss at Mound Valley may have resulted from close forage removal under hot, dry conditions in summer and fall, 1978. Alfalfa stands were good to excellent throughout the study. At Ottawa, the percentage of alfalfa in mixtures increased steadily as stands aged. The percentage of trefoil in mixtures at Ottawa increased from 1976 to 1978 and thereafter was relatively constant (Table 11). At Mound Valley, trefoil persisted better than alfalfa. All grasses established successfully and persisted throughout the study, except canarygrass, which showed some stand loss at Manhattan and had declined markedly at Mound Valley by 1979.

No serious compatibility problems were apparent in any of the 16 grass-legume combinations. Clover, though short-lived, persisted as well in mixtures as in pure stands. Canarygrass, though known as an aggressive sod former, was not overly competitive in these trials, possibly because moisture was not usually abundant at any of the experimental sites. Decline of canarygrass at Manhattan and Mound Valley appeared to be less in mixtures than in pure stands. Although crownvetch declined in stands at Mound Valley, it tended to spread into adjoining plots during the latter years of the study at Manhattan and Ottawa. Some stand loss of grasses occurred in alfalfa-grass plots during the very dry summer of 1980.

DISCUSSION

Grass-Legume Mixtures

These data clearly demonstrate that mixtures of grasses and the longer-lived legumes offer a viable alternative to commercially fertilized all-grass stands. In eastern Kansas, substantial acreages of brome and fescue pasture become depleted and unproductive without regular applications of commercial nitrogen. Adding nonbloating legumes, such as trefoil or crownvetch, to such swards could improve pasture productivity and maintain forage quality at acceptable levels without use of commercial nitrogen. Addition of alfalfa to such pastures, to produce mixed stands comparable to those evaluated in this study, could increase the hazard of bloat, since the legume component often accounted for over 50% of the dry matter produced by mixtures in our tests (Table 11). Additional research is needed to determine whether the alfalfa content of such mixtures can be reduced to levels compatible with safe grazing without sacrificing the essential merits of the grass-alfalfa combination. Use of clover-grass mixtures as alternatives to fertilized all-grass stands would require periodic reestablishment of the clover through some form of sod seeding or overseeding. The economic feasibility of such a procedure is questionable, given the currently high cost of sod seeding and the rapid rate at which clover was lost from mixed stands in this study. However, further research may show that this short-lived legume could be maintained in mixed stands through some simple, inexpensive form of overseeding. Development of clover cultivars of increased longevity also would reduce the cost of maintaining the legume in mixed stands with perennial grasses.

Legumes Alone

Where new stands of forage are to be established, pure legumes, as well as grass-legume mixtures, warrant consideration. Alfalfa has long been recognized as the preeminent, high-protein hay crop, but its tendency to cause bloat in grazing animals has restricted its use as a pasture species. Long-lived, non-bloating legumes like trefoil appear to have considerable potential as pure-stand, permanent pasture crops in eastern Kansas. Though somewhat lower yielding than alfalfa, trefoil produces forage of equally high quality, and, by virtue of its more shallow taproot system, probably is better suited to the highly eroded upland sites generally reserved for permanent pasture. Trefoil has performed well in a mixture with brome as sheep pasture at Manhattan (Sears, 1979). Recent performance tests indicated that several varieties of trefoil have excellent yield potential in eastern Kansas (Posler et al., 1985). Its exceptional capacity for natural reseeding, a manifestation of its indeterminant flowering habit, makes it superior to alfalfa in ability to reoccupy vacant and weedy areas following stand loss.

Grass Comparisons

Data for dry matter yield and forage quality provide little basis for discriminating among the four perennial grasses. Smooth brome has been considered the most suitable cool-season, perennial grass foreastern Kansas, with fescue having an advantage on the heavy-textured soils in the southeastern part of the state and in grazing programs emphasizing fall forage production. Canarygrass has been viewed as a special-purpose species for use near waterways and other sites where moisture deficiency is unlikely to be a common problem (Barnett et al., 1978). Results by Barnett and Posler (1983) indicate that relative performance of cool-season grasses as components of mixtures is predictable from pure-stand performance. In this study, contrasting relative performance of T. brome in pure stands and in mixtures with alfalfa and trefoil, at Mound Valley, appears to be an exception to those findings. The tendency of fescue to be somewhat lower than the other grasses in CP and in IVDMD of forage dry matter supports earlier findings of low forage quality in fescue (Barnett et al., 1978). Grasses differed in maturity, however, and, since all were harvested on the same schedule, small differences in CP content and in IVDMD of forage must be interpreted with caution. The excessively aggressive behavior of canarygrass, which has been reported to make the species difficult to manage in mixtures, was not apparent in this study, possibly because all experiments were conducted on upland sites where moisture seldom was abundant. Early loss of canarygrass from Mound Valley stands indicatesa need for further evaluation of the species before it is widely recommended for use in southeastern Kansas. Credible performance of T. brome suggests that this grass has a place in Kansas forage production and should be further evaluated in the state, both as a forage crop in its own right and as a source of germ plasm for improvement of S. brome (Barnett et al., 1978).

SUMMARY

Data from this study show that several cool-season grasses and legumes are well adapted to eastern Kansas and can be effectively combined in two-species mixtures. Grass-legume mixtures regularly yielded as much or more than grasses alone receiving 80 lbs N/acre/year (90 kg N/ha/year). Mixtures generally showed better seasonal distribution of forage than grasses alone and were superior in quality during the summer because of the legume production. It is recognized, however, that grass-legume mixtures are more difficult to manage than N-fertilized grasses in pure stands.

All grasses tested except canarygrass appear suitable for eastern Kansas. Canarygrass did not persist as well as other grasses at Manhattan or Mound Valley. Quality of fescue was slightly below that of S. brome or T. brome and canarygrass.

Alfalfa was, as expected, the most productive legume, but trefoil also yielded and persisted well. The nonbloating and natural reseeding traits of trefoil would be valuable assets in permanent pasture. Clover produced well for a short time following establishment, but early stand loss limits its potential as a permanent pasture species. Development of an inexpensive method for successfully overseeding this legume would enhance its usefulness in mixtures. Crownvetch was more difficult to manage in mixtures because of its aggressive growth habit and did not persist as well as other legumes at Mound Valley. Crownvetch is not currently recommended for forage use, and more research is needed to determine its suitability.

REFERENCES

Ahlgren, Gilbert H. 1956. Forage Crops. McGraw-Hill, New York.

Anonymous. 1975. Crop varieties for Kansas. L-110 (revised). Coop. Ext. Service, Kansas State Univ., Manhattan.

Barnett, F.L., and G.L. Posler. 1983. Performance of cool-season perennial grasses in pure stands and in mixtures with legumes. Agron. J. 75:582-586.

Barnett, F.L., G.L. Posler, and S.C. Fransen. 1978. Performance of cool-season perennial grasses in eastern Kansas. Kansas Agric. Exp. Sta. Bull. 623.

Burzlaff, Donald F. 1974. Impact of forages on the agricultural income of the Great Plains. *In:* Howard B. Sprague (ed.). Grasslands of the United States. Iowa State Univ. Press, Ames.

Cavanah, L.E. 1979. Notice of naming and release of Dawn birdsfoot trefoil. Personal Communication.

Dean, George A., and Roger C. Smith. 1933. Insects injurious to alfalfa in Kansas. Kansas Agric. Exp. Sta., Kansas State Board Agr., 29th Bien. Rep. 34:202-249.

Environmental Data Service. 1976-81. Climatological data. Ann. Sum. Nat. Oceanic and Atmos. Admin., U.S. Dept. of Comm., Washington, D.C.

Grandfield, C.O. 1943. Food reserves and their translocation to the crown buds as related to cold and drought resistance in alfalfa. J. Agric. Res. 67:33-46.

Grandfield, C.O. 1945. Alfalfa seed production as affected by organic reserves, airtemperature, humidity, and soil moisture. J. Agric. Res. 70:123-132.

Hackerott, Harold. 1969. Sainfoin. Unpublished. Kansas Agric. Exp. Sta., Hays.

Hanson, A.A. 1972. Grass varieties in the United States. Agric. Handbook No. 170. U.S. Gov't. Printing Office, Washington, D.C.

Hawk, Virgil B., and Frank Schaller. 1964. Emerald crownvetch-a pasture legume. Iowa Farm Science 3-71 to 5-73.

Heath, Maurice E. 1974. Significance of forages to the economy of the North Central Region. *In:* Howard B. Sprague (ed.). Grasslands of the United States. Iowa State Univ. Press, Ames.

Heath, Maurice E., Darrel S. Metcalfe, and Robert E. Barnes. 1973. Forages. 3rd ed. Iowa State Univ. Press, Ames.

Kilgore, Gary L. 1975. Summer annual forages in southeast Kansas. C-541. Coop. Ext. Service, Kansas State Univ., Manhattan.

Kroulik, J.T., and P.L. Gainey. 1940. Relative nodulation of varieties of Medicago sativa varying in susceptibility to alfalfa wilt. Soil Sci. 50:135-140.

Martin, John H., Warren H. Leonard, and David L. Stamp. 1967. Principles of Field Crop Production. 2nd ed. MacMillan Publ. Co., New York.

Mays, D.A. (ed.). 1974. Forage Fertilization. Amer. Soc. Agron., Madison, Wis.

Nuwanyakpa, M. 1979. Evaluation of yield and quality of six summer annual grasses. Part I. M.S. Thesis, Kansas State Univ., Manhattan.

Owensby, Clenton E., and Ed F. Smith. 1979. Fertilizing and burning Flint Hills bluestem. J. Range Mgmt. 32:254-258.

Owensby, Clenton E., Kling L. Anderson, and D.A. Whitney. 1969. Some chemical properties of silt loam soil after 20 years' nitrogen and phosphorus fertilization of smooth bromegrass. Soil Sci. 108:24-29.

Phillips, J.A., and F.W. Schaller. 1966. Growing crownvetch for pasture and seed. Pam. 336. Coop. Ext. Service, Iowa State Univ., Ames.

Piper, Charles V. 1924. Forage Plants and Their Culture. MacMillan, New York.

Posler, Gerry L. 1980. Performance tests of red clovervarieties in eastern Kansas. Kansas Agric. Exp. Sta., Keeping Up With Research 48.

Posler, G.L., J.L. Moyer, A. Jamshedi, and K. Janssen. 1985. Performance tests of birdsfoot trefoil in eastern Kansas. Kansas Agric. Exp. Sta., Keeping Up With Research 87.

Robison, Donald L. 1971. The influence of nitrogen, phosphorus, and plant population on yield and quality of forage corn. Ph.D. Dissertation, Kansas State Univ.. Manhattan.

Sears, S. 1979. The performance of two legume-smooth brome mixtures compared to nitrogen fertilized smooth brome under grazing. M.S. Thesis, Kansas State Univ., Manhattan.

Silver, WS., and R.W.F. Hardy. 1976. Newer developments in biological dinitrogen fixation of possible relevance to forage production. *In:* C.S. Hoveland (ed.). Biological Fixation in Forage-Livestock Systems. Spec. Pub. 28, Amer. Soc. Agron., Madison, Wis.

Sloan, Robert F. 1961. Results of agronomic experiments at the north-central Kansas experiment fields 1942-1960. Kansas Agric. Exp. Sta. Bull. 437.

Smith, F.W., F.E. Davidson, and V.H. Peterson. 1955. Soil fertility investigations at Columbus experiment field 1924-54. Kansas Agric. Exp. Sta. Bull. 372.

Sorensen, E.L., R.H. Painter, H.L. Hackerott, and T.L. Harvey. 1967. Registration of Kanza alfalfa. Crop Sci. 9:847.

Taylor, Norman L., and Melvern K. Anderson. 1973. Kenstar red clover. AGR-24. Coop. Ext. Service, Univ. of Kentucky, Lexington.

Wedin, W.F., R.L. Vetter, J.M. Scholl, and W.R. Woods. 1967. An evaluation of birdsfoot trefoil *(Lotus corniculatus)* in pasture improvement. Agron. J. 59:525-28.

Wheeler, W.A. 1950. Forage and Pasture Crops. Van Nostrand, New York.

Appendix Table 1. Dry matter yields (tons/acre) of grass-legume mixtures, Manhattan, 1977-79.

	1977							1978							1979						
		Grass*							Grass							Grass					
Legume or N treatment	Harvest**	SB	TB	TF	RCG	Mean	Legume Alone	Harvest	SB	TB	TF	RCG	Mean	Legume Alone	Harvest	SB	TB	TF	RCG	Mean	Legume Alone
Alfalfa	Spring	1.58	1.43	1.42	1.67	1.52	2.13	Spring	2.93	2.85	3.01	3.09	2.97	3.33	Spring	2.53	2.74	2.68	2.63	2.64	2.56
	Summer	1.05	1.25	1.48	1.65	1.36	1.72	Summer	1.45	1.52	1.60	1.74	1.58	1.63	Summer	1.44	1.50	1.60	1.62	1.54	1.32
	L. Summer	1.01	1.13	1.23	1.34	1.18	1.50	L. Summer	0.99	1.10	1.03	1.16	1.07	1.38	L. Summer	2.07	2.12	1.96	2.09	2.07	1.56
	Fall	0.43	0.44	0.41	0.65	0.48	0.63	Fall	0.95	1.09	0.92	1.04	1.00	1.04	Total	6.04	6.36	6.24	6.34	6.25	5.44
	Total	4.07	4.25	4.54	5.31	4.54	6.26	Total	6.32	6.56	6.56	7.03	6.62	7.38							
Red clover	Spring	1.03	0.96	1.22	1.32	1.13	1.45	Spring	0.71	0.83	1.24	1.55	1.08	2.07	Spring	0.69	0.64	0.55	0.50	0.60	0.64
	Summer	0.34	0.71	0.89	1.36	0.82	1.72	Summer	0.30	0.34	0.74	0.68	0.52	0.73	Summer	0.11	0.20	0.13	0.38	0.20	0.20
	Fall	0.30	0.54	1.29	1.19	0.83	1.42	Fall		0.09	0.12	0.05	0.07								
	Total	1.67	2.20	3.40	3.86	2.78	3.93	Total	1.01	1.26	2.10	2.29	1.67	2.80	Total	0.80	0.84	0.68	0.88	0.80	0.84
Birdsfoot trefoil	Spring	1.08	0.85	1.44	1.69	1.26	1.74	Spring	1.42	1.62	2.38	2.72	2.03	3.11	Spring	1.12	1.38	1.26	1.39	1.29	1.35
	Summer	0.59	0.73	1.53	1.90	1.19	1.84	Summer	0.44	0.50	0.83	0.78	0.64	0.83	Summer	0.41	0.37	0.64	0.88	0.58	0.62
	Fall	0.64	0.85	1.29	1.36	1.03	1.49	Fall	0.16	0.20	0.32	0.32	0.25	0.31	L Summer	0.50	0.85	0.93	0.88	0.79	0.89
	Total	2.30	2.43	4.25	4.95	3.48	5.07	Total	2.02	2.32	3.53	3.82	2.92	4.25	Total	2.03	2.60	2.83	3.15	2.66	2.86
Crownvetch	Spring	1.13	0.79	1.40	1.18	1.12	1.37	Spring	0.58	0.97	2.29	2.53	1.60	2.61	Spring	0.73	0.89	1.23	1.28	1.03	1.03
	Summer	0.34	0.64	1.02	1.24	0.81	1.46	Summer	0.18	0.35	0.66	0.66	0.46	0.56	Summer	0.18	0.36	0.67	0.75	0.49	0.43
	Fall	0.24	0.56	1.30	1.30	0.85	1.55	Fall	-	0.14	0.22	0.29	0.16	-	-						
	Total	1.70	1.99	3.72	3.72	2.78	4.38	Total	0.76	1.46	3.17	3.48	2.22	3.17	Total	0.91	1.25	1.90	2.03	1.52	1.46
0 lb N/A	Spring	0.95	0.82	1.00	1.04	0.95	-	Spring	0.99	0.48	0.57	0.53	0.64	-	Spring	0.51	0.32	0.26	0.25	0.33	-
	Summer	0.23	0.67	0.47	0.87	0.56	-	Summer	0.17	0.21	0.22	0.25	0.21	-	Summer	0.14	0.16	0.10	0.30	0.17	-
	Fall	0.23	0.41	0.52	0.80	0.49	-	Fall	-	0.07	0.09	0.12	0.07	-							
	Total	1.41	1.90	1.99	2.71	2.00	-	Total	1.16	0.76	0.88	0.90	0.92	-	Total	0.65	0.48	0.36	0.55	0.50	-
80 lb N/A	Spring	1.68	1.26	1.35	1.56	1.46	-	Spring	2.12	2.22	2.28	2.22	2.21	-	Sprmg	2.52	1.59	0.91	1.00	1.51	-
	Summer	0.56	1.13	1.44	1.37	1.12	-	Summer	0.23	0.23	0.42	0.33	0.30	-	Summer	0.17	0.22	0.26	0.24	0.22	-
	Fall	0.31	0.53	0.91	0.96	0.68	-	Fall	0.08	0.43	0.17	0.05	0.18	-							
	Total	2.54	2.92	3.70	3.89	3.26	-	Total	2.43	2.88	2.87	2.60	2.69	-	Total	2.69	1.81	1.17	1.24	1.72	-
Mean	Spring	1.24	1.02	1.30	1.41	1.24	1.67	Spring	1.46	1.50	1.96	2.10	1.76	2.78	Spring	1.35	1.26	1.15	1.17	1.23	1.40
	Summer	0.52	0.86	1.14	1.40	0.98	1.52	Summer	0.46	0.52	0.75	0.74	0.62	0.94	Summer	0.41	0.47	0.57	0.70	2.15	0.66
	Fall	0.36	0.56	0.95	1.04	0.73	1.34	Fall	0.20	0.33	0.31	0.31	0.28	0.34	L. Summer	0.43	0.49	0.48	0.50	0.48	1.22
	Total	2.28	2.62	3.60	4.07	3.14	4.91	Total	2.28	2.54	3.18	3.35	2.84	4.40	Total	2.19	2.22	2.20	2.37	2.26	3.28

	1977 Spring	1977 Summer	1977 Fall	1977 Total	1978 Spring	1978 Summer	1978 Fall	1978 Total	1979 Spring	1979 Summer	1979 Total
LSD .05 for comparing grasses	NS	0.10	0.20	0.42	0.34	0.11	NS	0.48	NS	0.08	NS
LSD .05 for comparing legumes or N treatments	0.24	0.20	0.16	0.50	0.39	0.11	0.12	0.49	0.22	0.07	0.30
LSD.05 for comparing grasses within a legume or N treatment	NS	0.38	0.33	0.96	0.78	0.22	NS	1.00	NS	0.15	NS
LSD.05 for comparing legumes or N treatment w/thin a grass	0.49	0.40	0.31	0.99	0.79	0.21	0.24	0.99	0.44	0.15	0.60
LSD.05 for comparing legumes alone	0.37	0.38	0.39	0.82	NS	0.32	0.15	1.46	0.74	0.30	1.10

*SB=Smooth brome; TB=Turkish brome, TF=Tall fescue, RCG=Reed Canaryrrass **L. Summer = Late Summer

Appendix Table 2. Dry matter yields (tons/acre) of grass-legume mixtures, Manhattan, 1980-81.

	1980							1987						
		Grass*							Grass”					
Legume or N treatment	Harvest**	SB	TB	TF	RCG	Mean	Legume Alone	Harvest	SB	TB	TF	RCG	Mean	Legume Alone
Alfalfa	Spring	2.95	2.98	2.39	2.16	2.62	2.69	Spring	2.03	2.13	1.84	1.87	1.96	1.45
	Summer	1.37	1.44	1.05	1.19	1.26	1.36	Summer	1.30	1.30	1.03	1.25	1.22	1.20
	L. Summer	0.88	0.89	0.59	0.65	0.75	0.75	L. Summer	1.40	1.26	1.01	1.42	1.27	1.41
	Fall	0.92	0.96	0.68	0.69	0.81	0.77	Fall	0.86	1.08	1.08	0.90	0.98	0.54
	Total	6.12	6.27	4.71	4.69	5.44	5.57	Total	5.59	5.77	4.96	5.44	5.43	4.60
Red clover	Spring	0.40	0.35	0.67	0.60	0.50	0.63	Spring	0.27	0.24	0.56		0.27	
	Summer	0.13	0.44	0.23	0.36	0.29	0.46	Summer	0.23	0.34	0.27		0.21	-
	Total	0.53	0.79	0.90	0.96	0.79	1.09	L. Summer	0.31	0.30	0.55		0.29	
								Fall	0.36	0.31	0.78	0.33	0.44	
								Total	1.17	1.19	2.16	0.33	1.21	-
Birdsfoot trefoil	Spring	1.01	1.31	1.38	1.46	1.29	0.94	Spring	1.22	1.37	1.15	1.15	1.22	0.55
	Summer	0.41	0.57	0.58	0.79	0.59	0.45	Summer	0.92	1.01	0.79	1.14	0.97	0.89
	Total	1.42	1.88	1.96	2.25	1.88	1.39	L. Summer	0.85	0.78	0.96	1.05	0.91	1.09
								Fall	0.56	0.80	0.84	1.30	0.87	
								Total	3.55	3.96	3.75	4.64	3.97	2.53
Crownvetch	Spring	0.68	1.23	1.61	1.79	1.33	0.92	Spring	0.74	1.32	1.23	1.82	1.28	0.48
	Summer	0.21	0.44	0.51	0.73	0.47	0.33	Summer	0.67	0.91	0.80	1.12	0.87	0.81
	Total	0.89	1.67	2.12	2.52	1.80	1.25	L. Summer	0.46	0.66	0.78	0.89	0.70	
								Fall	0.49	0.66	0.81	0.97	0.73	
								Total	2.50	3.55	3.62	4.80	3.58	1.29
0 lb N/A	Spring	0.23	0.17	0.34	0.30	0.26		Spring	0.21	0.26	0.35		0.20	
	Summer	0.06	0.08	0.12	0.34	0.14		Summer	0.10	0.25	0.17		0.12	
	Total	0.29	0.25	0.46	0.63	0.40		L Summer	0.17	0.28	0.25	-	0.18	
								Fall	0.28	0.38	0.36		0.25	
								Total	0.76	1.17	1.13	-	0.75	
80 lb N/A	Spring	1.45	0.89	1.03	0.53	0.97		Spring	0.81	0.63	0.79		0.56	
	Summer	0.09	0.28	0.19	0.20	0.19		Summer	0.17	0.35	0.39		0.23	
	Total	1.54	1.17	1.22	0.73	1.16		L. Summer	0.15	0.25	0.40		0.20	-
								Fall	0.33	0.37	0.65		0.34	
								Total	1.45	1.60	2.23	-	1.33	
Mean	Spring	1.12	1.15	1.23	1.14	1.16	1.29	Spring	0.88	0.99	0.99	0.80	0.91	0.83
	Summer	0.38	0.54	0.45	0.60	0.49	0.65	Summer	0.57	0.69	0.57	0.58		0.97
	Total	1.80	2.00	1.89	1.96	1.91		L. Summer	0.56	0.59	0.66	0.56	0.59	
								Fall	0.48	0.60	0.75	0.58	0.60	
								Total	2.49	2.87	2.97	2.53	2.78	

	1980 Spring	1980 Summer	1980 Total	1987 Spring	1987 Summer	1987 L. Summer	1987 Fall	1987 Total
$LSD_{.05}$ for comparing grasses	NS	NS	NS	NS	NS	NS	NS	NS
$LSD_{.05}$ for comparing legumes or N treatments	0.26	0.13	0.41	0.20	0.11	0.17	0.15	1.05
$LSD_{.05}$ for comparing grasses within a legume or N treatment	NS	NS	NS	NS	NS	NS	NS	NS
$LSD_{.05}$ for comparing legumes or N treatment within a grass	0.53	0.28	0.82	0.40	0.22	0.34	0.30	2.11
$LSD_{.05}$ for comparing legumes alone	0.62	0.23	0.89	0.25	0.32	NS		0.45

*SB=Smooth brome; TB=Turkish brome. TF=Tallfescue, RCG=Reed canarygrass **L Summer=Late Summer

Appendix Table 3. Dry matter yields (tons/acre) of grass-legume mixtures, Ottawa, 1976-78.

1976

Legume component or nitrogen treatment	Harvest**	Grass* SB	TB	TF	RCG	Mean	Legume Alone
Alfalfa	Spring	2.37	2.02	2.46	2.45	2.32	2.17
	Summer	0.75	0.76	0.66	0.87	0.76	0.86
	Total	3.12	2.78	3.12	3.32	3.08	3.03
Red clover	Spring	3.56	3.17	3.53	3.54	3.45	3.35
	Summer	0.77	0.86	0.69	1.27	0.90	1.07
	Total	4.33	4.03	4.22	4.81	4.35	4.42
Birdsfoot trefoil	Spring	2.35	2.41	2.70	2.10	2.39	2.68
	Summer	0.38	0.70	0.40	0.60	0.52	0.85
	Total	2.73	3.11	3.10	2.70	2.91	3.53
Crownvetch	Spring	1.66	1.86	2.28	1.09	1.72	1.46
	Summer	0.22	0.34	0.22	0.36	0.28	0.70
	Total	1.88	2.20	2.50	1.45	2.00	2.16
0 lb N/A	Spring	2.09	2.40	2.18	0.87	1.88	-
	Summer	0.05	0.14	0.13	0.19	0.13	-
	Total	2.14	2.54	2.31	1.06	2.01	-
80 lb N/A	Spring	3.91	3.57	4.27	2.96	3.68	-
	Summer	0.07	0.25	0.18	0.23	0.18	-
	Total	3.98	3.82	4.45	3.19	3.86	-
Mean	Spring	2.66	2.57	2.90	2.17	2.57	2.42
	Summer	0.37	0.51	0.38	0.59	0.46	0.87
	Total	3.03	3.08	3.28	2.76	3.03	3.29

1977

Legume component or nitrogen treatment	Harvest	Grass SB	TB	TF	RCG	Mean	Legume Alone
Alfalfa	Spring	1.65	1.50	1.39	1.42	1.49	1.49
	Summer	1.31	1.08	1.33	1.52	1.31	1.66
	L Summer	0.52	0.63	0.45	0.57	0.54	0.62
	Fall	0.47	0.51	0.59	0.49	0.52	0.40
	Total	3.95	3.72	3.76	4.00	3.86	4.17
Red clover	Spring	1.45	1.52	1.46	1.49	1.49	1.22
	Summer	0.59	0.77	0.75	1.12	0.80	1.47
	Fall	0.37	0.81	0.55	0.62	0.58	0.62
	Total	2.41	3.10	2.76	3.23	2.86	3.31
Birdsfoot trefoil	Spring	1.71	1.56	1.88	1.89	1.76	2.30
	Summer	1.38	1.25	1.04	1.48	1.29	1.76
	Fall	0.65	0.96	0.72	0.79	0.78	0.98
	Total	3.74	3.77	3.64	4.16	3.83	5.04
Crownvetch	Spring	2.28	2.20	2.35	2.48	2.33	2.64
	Summer	0.87	0.82	0.76	1.11	0.89	1.18
	Fall	0.86	1.21	0.95	1.14	1.04	1.68
	Total	4.01	4.23	4.05	4.73	4.26	5.50
0 lb N/A	Spring	0.61	0.70	1.04	0.59	0.74	-
	Summer	0.27	0.45	0.35	0.52	0.40	-
	Fall	0.19	0.26	0.21	0.37	0.26	-
	Total	1.07	1.41	1.60	1.48	1.40	-
80 lb N/A	Spring	2.57	2.61	2.56	2.46	2.55	-
	Summer	0.37	0.67	0.61	0.71	0.59	-
	Fall	0.18	0.30	0.31	0.41	0.30	-
	Total	3.12	3.58	3.48	3.58	3.44	-
Mean	Spring	1.71	1.69	1.78	1.73	1.73	1.91
	Summer	0.80	0.84	0.81	1.07	0.88	1.52
	Fall	0.45	0.67	0.55	0.63	0.58	0.92
	Total	3.05	3.30	3.21	3.53	3.27	4.52

1978

Legume component or nitrogen treatment	Harvest	Grass SB	TB	TF	RCG	Mean	Legume Alone
Alfalfa	Spring	3.02	2.72	2.80	2.80	2.70	2.14
	Summer	0.88	0.72	0.72	0.73	0.76	1.63
	Total	3.90	3.44	3.52	3.01	3.46	3.77
Red clover	Spring	1.36	1.52	1.54	1.13	1.39	1.42
	Summer	0.48	0.38	0.31	0.37	0.39	0.73
	Total	1.84	1.90	1.85	1.50	1.78	2.15
Birdsfoot trefoil	Spring	3.00	2.62	2.88	2.69	2.80	2.72
	Summer	0.50	0.49	0.38	0.47	0.46	0.83
	Total	3.50	3.11	3.26	3.16	3.26	3.55
Crownvetch	Spring	2.72	2.42	2.26	2.34	2.43	2.73
	Summer	0.33	0.39	0.29	0.46	0.36	0.56
	Total	3.05	2.81	2.55	2.80	2.80	3.29
0 lb N/A	Spring	1.06	0.57	0.64	0.56	0.71	-
	Summer	0.10	0.20	0.13	0.23	0.17	-
	Total	1.16	0.77	0.77	0.79	0.88	-
80 lb N/A	Spring	1.59	1.91	2.26	2.10	1.96	-
	Summer	0.10	0.18	0.29	0.23	0.20	-
	Total	1.69	2.09	2.55	2.33	2.16	-
Mean	Spring	2.12	1.96	2.06	1.84	1.98	2.25
	Summer	0.40	0.39	0.35	0.41	0.38	0.94
	Total	2.52	2.35	2.41	2.25	2.36	3.19

	1976 Spring	1976 Summer	1976 Total	1977 Spring	1977 Summer	1977 L Summer	1977 Total	1978 Spring	1978 Summer	1978 Total
$LSD_{.05}$ for comparing grasses	0.53	0.07	0.50	NS	0.16	0.14	NS	0.13	NS	NS
$LSD_{.05}$ for comparing legumes or N treatments	0.32	0.07	0.32	0.18	0.12	0.09	0.25	0.44	0.08	0.53
$LSD_{.05}$ for comparing grasses within a legume or N treatment	1.06	0.15	0.77	NS	0.25	0.20	NS	0.60	NS	NS
$LSD_{.05}$ for comparing legumes or N treatment within a grass	0.64	0.15	0.46	0.37	0.23	0.17	0.52	0.92	0.17	1.06
$LSD_{.05}$ for comparing legumes alone	0.48	0.24	0.50	0.62	0.27	0.22	0.78	0.28	0.32	1.01

*SB=Smooth brome. TB=Turkish brome, TF=Tallfescue. RCG=Reed Canarygrass **L. Summer=LateSummer

Appendix Table 4. Dry matter yields (tons/acre) of grass-legume mixtures, Ottawa, 1979-81.

1979

Legume or N treatment	Harvest**	Grass* SB	TB	TF	RCG	Mean	Legume Alone
Alfalfa	Spring	2.06	1.96	1.95	1.78	1.94	1.90
	Summer	1.74	1.79	1.52	1.56	1.65	2.28
	L. Summer	1.16	1.27	1.40	1.15	1.24	1.28
	Total	4.96	5.02	4.87	4.49	4.83	5.45
Red clover	Spring	1.02	1.48	0.96	0.55	1.00	0.32
	Summer	0.55	0.72	0.46	0.71	0.61	-
	L. Summer	0.28	0.12	0.07	0.23	0.17	0.32
	Total	1.85	2.32	1.49	1.49	1.78	0.64
Birdsfoot trefoil	Spring	1.96	1.89	1.68	1.74	1.82	1.74
	Summer	1.28	1.32	1.18	1.25	1.26	1.25
	L. Summer	0.60	0.67	0.46	0.99	0.68	0.86
	Total	3.84	3.88	3.32	3.98	3.76	3.85
Crownvetch	Spring	1.68	1.77	1.71	1.52	1.67	1.58
	Summer	0.91	1.07	0.79	0.96	0.93	1.01
	L. Summer	0.31	0.29	0.19	0.30	0.27	0.42
	Total	2.90	3.13	2.69	2.78	2.87	3.01
0 lb N/A	Spring	0.96	0.63	0.55	0.49	0.66	-
	Summer	0.40	0.58	0.42	0.48	0.47	-
	L. Summer	0.11	0.12	0.06	0.08	0.09	-
	Total	1.47	1.33	1.03	1.05	1.22	-
80 lb N/A	Spring	1.60	1.64	1.58	1.55	1.59	-
	Summer	0.41	0.72	0.54	0.59	0.56	-
	L. Summer	0.03	0.11	0.03	0.10	0.07	-
	Total	2.04	2.47	2.15	2.24	2.22	-
Mean	Spring	1.54	1.56	1.40	1.27	1.44	1.38
	Summer	0.88	1.03	0.82	0.92	0.91	1.14
	L. Summer	0.41	0.43	0.37	0.48	0.42	0.72
	Total	2.83	3.02	2.59	2.67	2.77	3.24

1980

Legume or N treatment	Harvest	Grass SB	TB	TF	RCG	Mean	Legume Alone
Alfalfa	Spring	1.87	1.61	1.53	1.85	1.71	1.52
	-	-	-	-	-	-	-
	-	-	-	-	-	-	-
	-	-	-	-	-	-	-
Red clover	Spring	0.74	0.53	0.54	0.54	0.59	-
	-	-	-	-	-	-	-
	-	-	-	-	-	-	-
	-	-	-	-	-	-	-
Birdsfoot trefoil	Spring	1.46	1.06	1.07	1.49	1.27	1.15
	-	-	-	-	-	-	-
	-	-	-	-	-	-	-
	-	-	-	-	-	-	-
Crownvetch	Spring	1.40	1.05	0.94	1.31	1.18	1.13
	-	-	-	-	-	-	-
	-	-	-	-	-	-	-
	-	-	-	-	-	-	-
0 lb N/A	Spring	0.39	0.42	0.26	0.40	0.37	-
	-	-	-	-	-	-	-
	-	-	-	-	-	-	-
	-	-	-	-	-	-	-
80 lb N/A	Spring	1.66	0.69	1.16	1.15	1.16	-
	-	-	-	-	-	-	-
	-	-	-	-	-	-	-
	-	-	-	-	-	-	-
Mean	Spring	1.25	0.89	0.92	1.12	1.05	1.27
	-	-	-	-	-	-	-
	-	-	-	-	-	-	-
	-	-	-	-	-	-	-

1981

Legume or N treatment	Harvest	Grass SB	TB	TF	RCG	Mean	Legume Alone
Alfalfa	Spring	0.79	0.64	0.69	0.80	0.73	0.56
	Summer	2.01	1.68	1.56	2.50	1.94	1.95
	L. Summer	1.03	1.03	0.97	1.06	1.02	1.23
	Total	3.83	3.34	3.22	4.36	3.69	3.74
Red clover	Spring	0.63	0.65	0.48	0.66	0.61	-
	Summer	0.49	0.51	0.26	0.38	0.41	-
	L. Summer	0.27	0.34	0.23	0.42	0.31	-
	Total	1.39	1.50	0.97	1.47	1.33	-
Birdsfoot trefoil	Spring	1.10	1.05	0.91	0.94	1.00	0.64
	Summer	1.35	1.27	1.25	0.94	1.20	1.81
	L. Summer	0.40	0.59	0.43	0.58	0.50	0.45
	Total	2.85	2.91	2.59	2.46	2.70	2.90
Crownvetch	Spring	1.09	1.06	1.12	1.28	1.13	1.14
	Summer	1.50	1.08	0.92	1.63	1.28	1.63
	L. Summer	0.38	0.42	0.41	0.51	0.43	0.42
	Total	2.97	2.56	2.45	3.42	2.84	3.19
0 lb N/A	Spring	0.47	0.56	0.48	0.54	0.51	-
	Summer	0.67	0.67	0.23	0.28	0.46	-
	L. Summer	0.18	0.28	0.16	0.23	0.21	-
	Total	1.32	1.51	0.87	1.05	1.18	-
80 lb N/A	Spring	1.04	0.78	0.93	0.92	0.92	-
	Summer	0.54	0.54	0.28	0.37	0.43	-
	L. Summer	0.14	0.22	0.17	0.21	0.19	-
	Total	1.72	1.54	1.38	1.50	1.54	-
Mean	Spring	0.85	0.79	0.77	0.86	0.82	0.78
	Summer	1.09	0.96	0.75	1.02	0.95	1.80
	L. Summer	0.40	0.48	0.39	0.50	0.44	0.70
	-	-	-	-	-	-	-

	1979 Spring	1979 Summer	1979 L. Summer	1979 Total	1980 Spring	1981 Spring	1981 Summer	1981 L Summer	1981 Total
$LSD_{.05}$ for comparing grasses	0.07	0.13	NS	0.31	0.21	0.07	NS	NS	NS
$LSD_{.05}$ for comparing legumes or N treatment	0.27	0.10	0.22	0.44	0.23	0.10	0.30	0.08	0.39
$LSD_{.05}$ for comparing grasses within a legume or N treatment	0.51	0.66	NS	0.86	0.34	0.19	NS	NS	NS
$LSD_{.05}$ for comparing legumes or N treatment within a grass	0.54	0.20	0.44	0.89	0.29	0.20	0.60	0.16	0.78
$LSD_{.05}$ for comparing legumes alone	0.60	0.75	0.49	0.93	0.23	0.13	NS	0.16	0.62

*SB=Smooth brome, TB=Turkish brome. TF=Tall fescue, RCG=Reed Canarygrass **L Summer=Late Summer

Appendix Table 5. Dry matter yields (tons/acre) of grass-legume mixtures, Mound Valley, 1977-79.

1977

Legume or N treatment	Harvest**	Grass* SB	TB	TF	RCG	Mean	Legume Alone
Alfalfa	Spring	1.86	1.79	1.73	1.09	1.62	1.68
	Summer	0.98	1.08	1.00	0.67	0.93	0.70
	L Summer	0.52	0.90	0.81	0.74	0.74	0.98
	Fall	0.67	0.55	0.93	0.73	0.72	0.74
	Total	4.03	4.32	4.47	3.23	4.01	4.10
Red clover	Spring	1.31	1.62	1.57	1.46	1.49	1.69
	Summer	0.50	0.58	0.48	0.57	0.53	0.65
	L. Summer	0.43	0.39	0.50	0.61	0.48	0.67
	Fall	0.52	0.58	0.89	0.82	0.70	0.81
	Total	2.76	3.16	3.43	3.46	3.20	3.82
Birdsfoot trefoil	Spring	1.51	1.85	1.85	1.58	1.70	1.89
	Summer	0.47	0.63	0.52	0.67	0.57	0.76
	L. Summer	0.59	0.85	0.76	0.86	0.77	0.77
	Fall	0.83	1.08	1.27	1.06	1.05	1.12
	Total	3.40	4.41	4.40	4.16	4.09	4.54
Crownvetch	Spring	1.35	1.33	1.39	1.47	1.38	2.34
	Summer	0.15	0.16	0.20	0.21	0.18	0.64
	L. Summer	0.08	0.04	0.07	0.26	0.11	-
	Fall	0.18	0.01	0.62	0.43	0.31	0.41
	Total	1.76	1.54	2.28	2.37	1.98	3.39
0 lb N/A	Spring	0.62	0.36	0.59	0.20	0.44	-
	Summer	0.02	0.01	0.01	0.12	0.04	-
	L Summer	0.01	0.01	0.01	0.19	0.05	-
	Fall	0.01	0.01	0.38	0.28	0.17	-
	Total	0.66	0.39	0.99	0.79	0.70	-
80 lb N/A	Spring	1.78	1.72	1.98	1.44	1.73	-
	Summer	0.06	0.12	0.17	0.19	0.13	-
	L. Summer	0.01	0.01	0.01	0.22	0.06	-
	Fall	0.07	0.01	0.32	0.38	0.19	-
	Total	1.92	1.86	2.48	2.23	2.11	-
Mean	Spring	1.40	1.45	1.52	1.20	1.39	1.90
	Summer	0.36	0.43	0.40	0.40	0.40	0.69
	L. Summer	0.27	0.37	0.36	0.48	0.37	0.60
	Fall	0.38	0.37	0.73	0.62	0.52	0.77
	Total	2.42	2.61	3.01	2.70	2.68	3.96

1978

Legume or N treatment	Harvest	Grass SB	TB	TF	RCG	Mean	Legume Alone
Alfalfa	Spring	0.91	1.12	1.21	0.56	0.95	1.34
	Summer	0.35	0.43	0.42	0.27	0.37	0.43
	Fall	0.37	0.35	0.41	0.47	0.40	0.56
	Total	1.63	1.90	1.84	1.40	1.72	2.33
Red clover	Spring	0.82	0.66	1.04	0.84	0.84	1.09
	Summer	0.32	0.29	0.23	0.32	0.29	0.37
	Fall	0.17	0.14	0.19	0.26	0.19	0.10
	Total	1.31	1.09	1.46	1.42	1.32	1.46
Birdsfoot trefoil	Spring	1.70	1.78	1.82	1.52	1.71	1.61
	Summer	0.27	0.41	0.30	0.32	0.32	0.33
	Fall	0.25	0.28	0.24	0.21	0.24	0.23
	Total	2.22	2.47	2.36	2.05	2.27	2.17
Crownvetch	Spring	0.25	0.25	0.86	0.29	0.41	-
	Summer	-	-	-	0.12	0.03	-
	Fall	0.15	-	0.25	0.34	0.18	0.18
	Total	0.40	0.25	1.11	0.75	0.62	0.18
0 lb N/A	Spring	0.32	0.23	0.59	0.32	0.37	-
	Summer	-	-	-	0.16	0.04	-
	Fall	0.16	-	0.22	0.26	0.16	-
	Total	0.48	0.23	0.81	0.74	0.57	-
80 lb N/A	Spring	1.51	0.74	1.92	1.18	1.34	-
	Summer	-	-	-	0.16	0.04	-
	Fall	0.20	0.16	0.24	0.25	0.21	-
	Total	1.71	0.90	2.16	1.59	1.59	-
Mean	Spring	0.92	0.79	1.24	0.78	0.93	1.01
	Summer	0.16	0.19	0.16	0.22	0.18	0.26
	Fall	0.22	0.15	0.26	0.30	0.23	0.27
	Total	1.30	1.13	1.66	1.30	1.34	1.54

1979

Legume or N treatment	Harvest	Grass SB	TB	TF	RCG	Mean	Legume Alone
Alfalfa	Spring	1.23	1.29	1.29	0.94	1.19	1.21
	Summer	0.52	0.64	0.52	0.46	0.54	0.53
	L. Summer	0.46	0.61	0.51	0.53	0.53	0.52
	Total	2.21	2.54	2.32	1.93	2.26	2.26
Red clover	Spring	0.50	0.22	0.41	0.34	0.37	-
	-	-	-	-	-	-	-
	-	-	-	-	-	-	-
	-	-	-	-	-	-	-
Birdsfoot trefoil	Spring	0.82	0.93	0.88	0.93	0.89	0.80
	Summer	0.58	0.72	0.65	0.80	0.69	0.67
	-	-	-	-	-	-	-
	Total	1.40	1.65	1.53	1.73	1.58	1.47
Crownvetch	Spring	0.28	0.07	0.39	0.20	0.24	0.10
	-	-	-	-	-	-	-
	-	-	-	-	-	-	-
	-	-	-	-	-	-	-
0 lb N/A	Spring	0.42	0.12	0.27	0.30	0.28	-
	-	-	-	-	-	-	-
	-	-	-	-	-	-	-
	-	-	-	-	-	-	-
80 lb N/A	Spring	1.11	0.19	0.70	0.72	0.68	-
	-	-	-	-	-	-	-
	-	-	-	-	-	-	-
	-	-	-	-	-	-	-
Mean	Spring	0.73	0.47	0.66	0.57	0.61	-
	-	-	-	-	-	-	-
	-	-	-	-	-	-	-
	-	-	-	-	-	-	-

	1977 Spring	Summer	L Summer	Fall	Total	1978 Sorina	Summer	Fall	Total
$LSD_{.05}$ for comparing grasses	0.19	0.10	0.12	0.14	0.32	0.20	NS	NS	0.31
$LSD_{.05}$ for comparing legumes or N treatments	0.14	0.08	0.10	0.12	0.25	0.14	0.03	0.09	0.22
$LSD_{.05}$ for comparing grasses within a legume or N treatment	0.31	0.18	0.19	0.24	0.57	0.35	NS	NS	0.47
$LSD_{.05}$ for comparing legumesor N treatments within a grass	0.29	0.17	0.17	0.23	0.56	0.27	0.15	0.17	0.44
$LSD_{.05}$ for comparing legumes alone	0.52	0.35	0.12	0.44	0.89	0.36	0.15	0.17	0.86

*SB=Smooth brome TB=Turkish brome TF=Tall fescue. RCG=Reed Canarygrass **L. Summer=Late Summer

Appendix Table 6. Percent crude protein of grass-legume mixtures, Manhattan, 1977-79.

1977

Legume or N treatment	Harvest**	Grass* SB	Grass* TB	Grass* TF	Grass* RCG	Grass* Mean	Legume Alone
Alfalfa	Spring	9.4	9.2	10.0	12.5	10.3	13.4
	Summer	12.8	12.5	13.7	13.7	13.2	14.6
	L. Summer	-	-	-	-	-	19.4
	Fall	16.5	16.3	13.7	15.2	15.4	18.0
Red clover	Spring	7.9	7.1	10.6	11.6	9.3	13.0
	Summer	9.6	8.1	12.2	11.9	10.5	15.3
	Fall	10.5	9.1	9.5	11.8	10.2	16.3
Birdsfoot trefoil	Spring	8.1	8.0	9.9	12.3	9.6	14.7
	Summer	12.8	9.9	14.2	13.0	12.5	15.2
	Fall	10.6	10.2	11.8	9.6	10.5	12.8
Crownvetch	Spring	7.0	8.1	9.6	12.2	9.2	15.0
	Summer	8.9	7.8	13.0	12.2	10.5	16.4
	Fall	8.9	9.1	12.7	12.0	10.7	15.6
0 lb N/A	Spring	7.1	7.9	8.2	10.0	8.3	-
	Summer	8.6	7.6	8.1	8.6	8.2	-
	Fall	9.4	7.9	8.1	7.6	8.3	-
80 lb N/A	Spring	10.4	9.6	10.3	11.3	10.4	-
	Summer	9.4	8.0	9.5	9.3	9.1	-
	Fall	8.6	10.7	7.4	7.9	8.7	-
Mean	Spring	8.3	8.3	9.8	11.7	9.5	14.0
	Summer	10.4	9.0	11.8	11.5	10.6	15.4
	Fall	10.7	10.5	10.5	10.7	10.6	15.7

1978

Legume or N treatment	Harvest	Grass SB	Grass TB	Grass TF	Grass RCG	Grass Mean	Legume Alone
Alfalfa	Spring	15.9	15.1	15.9	15.9	15.7	18.0
	Summer	16.0	16.0	15.7	15.7	15.8	17.0
	L. Summer	15.7	16.2	16.0	16.8	16.2	15.4
	Fall	13.7	13.6	14.1	13.7	-	15.6
Red clover	Spring	11.6	10.9	12.5	14.9	12.5	18.1
	Summer	11.7	11.7	14.3	14.8	13.1	16.7
	Fall	-	11.5	12.0	-	-	-
Birdsfoot trefoil	Spring	13.6	14.1	16.5	13.0	14.3	18.7
	Summer	17.3	15.5	16.6	16.2	16.4	17.3
	Fall	12.4	13.4	12.9	13.7	-	14.9
Crownvetch	Spring	9.3	10.4	16.4	18.0	13.5	19.8
	Summer	12.5	13.1	15.4	18.1	14.7	19.0
	Fall	-	12.5	13.2	13.9	-	-
0 lb N/A	Spring	9.0	8.3	6.9	8.8	8.2	-
	Summer	10.1	9.8	10.0	11.7	10.4	-
	Fall	-	10.3	8.9	53.5	-	-
80 lb N/A	Spring	10.4	11.3	10.1	12.4	11.1	-
	Summer	11.3	11.6	10.7	12.5	11.5	-
	Fall	-	11.1	9.9	10.4	-	-
Mean	Spring	11.6	11.7	13.0	13.9	12.6	18.7
	Summer	13.2	12.9	13.8	14.8	13.7	17.5
	Fall	-	12.6	10.2	-	-	-

1979

Legume or N treatment	Harvest	Grass SB	Grass TB	Grass TF	Grass RCG	Grass Mean	Legume Alone
Alfalfa	Spring	16.4	17.7	17.0	17.1	17.1	16.6
	Summer	16.7	15.2	15.1	14.9	15.5	17.8
	L. Summer	-	-	-	-	-	-
	Fall	15.2	15.7	14.0	14.8	14.9	-
Red clover	Spring	8.2	8.6	10.5	13.3	10.1	17.6
	Summer	11.5	11.5	11.9	14.3	12.3	9.1
	Fall	13.4	11.9	11.2	14.2	12.7	-
Birdsfoot trefoil	Spring	13.6	14.0	18.3	16.7	15.6	17.5
	Summer	16.1	16.5	19.1	17.1	17.2	20.7
	Fall	15.2	15.6	15.9	16.7	15.9	-
Crownvetch	Spring	11.9	13.3	18.0	18.5	15.4	17.4
	Summer	14.9	15.3	19.3	20.0	17.4	23.2
	Fall	13.4	14.3	18.7	18.1	16.1	-
0 lb N/A	Spring	9.4	9.6	8.6	11.8	9.9	-
	Summer	10.3	10.7	10.1	14.7	11.4	-
	Fall	11.2	10.1	9.4	13.7	11.1	-
80 lb N/A	Spring	11.7	11.1	12.4	14.2	12.4	-
	Summer	14.3	12.4	11.3	15.7	13.4	-
	Fall	13.0	12.6	11.9	15.0	13.1	-
Mean	Spring	11.9	12.4	14.1	15.3	13.4	17.3
	Summer	14.0	13.6	14.5	16.1	14.6	20.2
	Fall	13.6	13.4	13.5	15.4	14.0	-

	1977 Spring	1977 Summer	1977 Fall	1978 Spring	1978 Summer	1979 Spring	1979 Summer
$LSD_{.05}$ for comparing grasses	1.4	0.9	NS	1.4	NS	1.5	2.3
$LSD_{.05}$ for comparing legumes or N treatments	0.9	0.7	1.3	1.3	0.5	1.3	1.9
$LSD_{.05}$ for comparing grasses within a legume or N treatment	2.1	1.5	NS	2.6	NS	2.8	3.9
$LSD_{.05}$ for comparing legumes or N treatment within a grass	1.9	1.5	2.5	2.5	2.7	2.7	3.8
$LSD_{.05}$ for comparing legumes alone	NS	NS	3.0	NS	NS	NS	2.4

*SB=Smooth brome; TB=Turkish brome, TF=Tall fescue RCG=Reed Canarygrass **L. Summer=Late Summer

Appendix Table 7. Percent crude protein of grass-legume mixtures, Ottawa, 1976-79.

1976

Legume or N treatment	Harvest**	Grass* SB	TB	TF	RCG	Mean	Legume Alone
Alfalfa	Spring	16.1	18.5	14.6	17.6	16.7	20.2
	Summer	18.5	18.1	17.9	17.8	18.1	19.2
	L. Summer	-	-	-	-	-	-
	Fall	-	-	-	-	-	-
Red clover	Spring	14.4	15.1	14.5	15.3	14.8	20.4
	Summer	18.7	18.6	18.2	17.8	18.3	18.5
	Fall	-	-	-	-	-	-
Birdsfoot trefoil	Spring	13.9	13.5	12.7	16.6	14.2	20.5
	Summer	16.5	16.3	18.0	17.0	16.9	19.0
	Fall	-	-	-	-	-	-
Crownvetch	Spring	10.4	9.8	10.2	12.4	10.7	20.8
	Summer	17.2	16.2	16.2	14.4	16.0	21.3
	Fall	-	-	-	-	-	-
0 lb N/A	Spring	8.3	8.4	7.5	10.5	8.7	-
	Summer	12.7	10.3	12.5	12.9	12.1	-
	Fall	-	-	-	-	-	-
80 lb N/A	Spring	10.5	9.5	9.2	13.4	10.6	-
	Summer	12.0	11.7	10.4	13.5	11.9	-
	Fall	-	-	-	-	-	-
Mean	Spring	12.3	12.4	11.5	14.3	12.6	20.5
	Summer	15.9	15.2	15.5	15.6	15.6	19.5
	Fall	-	-	-	-	-	-

1977

Legume or N treatment	Harvest	Grass SB	TB	TF	RCG	Mean	Legume Alone
Alfalfa	Spring	8.7	9.2	11.6	12.6	10.5	19.1
	Summer	15.2	11.0	13.7	14.2	13.5	15.6
	L. Summer	-	-	-	-	-	24.0
	Fall	15.2	13.7	12.4	13.8	13.8	15.7
Red clover	Spring	7.7	8.8	7.1	9.4	8.3	16.8
	Summer	12.9	11.3	11.0	12.8	12.0	13.3
	Fall	12.2	11.8	11.2	10.0	11.3	14.3
Birdsfoot trefoil	Spring	11.8	10.0	9.7	11.9	10.9	16.1
	Summer	15.2	14.2	16.7	16.0	15.5	16.6
	Fall	13.8	13.0	11.5	11.3	12.4	15.4
Crownvetch	Spring	13.8	11.3	11.6	15.3	13.0	16.8
	Summer	14.6	12.5	12.8	13.8	13.4	13.9
	Fall	14.6	13.9	14.2	10.9	13.4	16.2
0 lb N/A	Spring	7.0	7.4	6.1	8.1	7.1	-
	Summer	11.0	8.0	8.9	10.9	9.7	-
	Fall	8.5	8.4	8.2	8.3	8.3	-
80 lb N/A	Spring	7.7	9.8	7.7	8.6	8.5	-
	Summer	10.4	8.3	9.3	9.7	9.4	-
	Fall	9.4	8.1	7.4	9.9	8.7	-
Mean	Spring	9.4	9.4	8.9	11.0	9.7	17.2
	Summer	13.2	10.8	12.1	12.9	12.3	14.9
	Fall	12.3	11.5	10.8	10.7	11.3	15.4

	1976 Spring	1976 Summer	1977 Spring	1977 Summer	1977 Fall
$LSD_{.05}$ for comparing grasses	1.0	NS	1.4	NS	0.6
$LSD_{.05}$ for comparing legumes or N treatments	1.2	NS	0.9	1.4	1.1
$LSD_{.05}$ for comparing grasses within a legume or N treatment	3.3	NS	2.1	NS	2.2
$LSD_{.05}$ for comparing legumes or N treatments within a grass	2.4	NS	1.9	2.9	2.3
$LSD_{.05}$ for comparing legumes alone	NS	0.9	NS	1.8	NS

*SB=Smooth brome; TB=Turkish brome. TF=Tall fescue, RCG=Reed Canarygrass **L Summer=Late Summer

	1978							1979					
	Grass*					Legume		Grass					Legume
Harvest	SB	TB	TF	RCG	Mean	Alone	Harvest	SB	TB	TF	RCG	Mean	Alone
Spring	16.8	17.0	15.9	17.2	16.7	21.0	Spring	14.6	14.7	15.0	15.1	14.8	16.4
Summer	16.4	15.1	16.0	16.1	15.9	16.5	Summer	17.1	16.8	17.2	18.3	17.4	21.3
L. Summer	-	-	-	-	-	-	L. Summer	18.1	18.2	20.9	18.0	18.8	20.4
Fall	-	-	-	-	-	-	Fall	-	-	-	-	-	-
Spring	12.1	13.2	12.7	12.1	12.5	17.4	Spring	8.7	8.6	7.8	10.7	9.0	-
Summer	13.5	11.7	13.0	13.1	12.8	14.0	Summer	13.7	10.7	10.4	15.0	12.5	-
Fall	-	-	-	-	-	-	L Summer	17.6	14.1	13.6	14.6	15.0	-
Spring	17.8	18.5	16.3	18.0	17.7	21.0	Spring	14.8	14.9	14.0	17.6	15.3	16.0
Summer	16.7	15.3	15.8	15.8	15.9	16.1	Summer	18.2	16.8	18.9	15.9	17.5	22.1
Fall		-	-	-	-	-	L Summer	18.1	18.1	20.1	19.6	19.0	22.2
Spring	17.8	16.5	18.0	14.6	16.8	25.1	Spring	16.1	13.8	14.0	16.5	15.1	18.3
Summer	17.5	15.0	16.8	16.0	16.3	18.5	Summer	20.8	17.8	18.9	20.0	19.4	21.0
Fall	-	-	-	-	-	-	L. Summer	22.3	20.3	20.4	21.7	21.2	24.8
Spring	8.2	9.9	8.8	9.3	9.0	-	Spring	9.6	9.3	8.3	9.5	9.2	-
Summer	11.0	10.4	9.1	12.1	10.6	-	Summer	12.1	11.1	12.2	1.18	11.8	-
Fall	-	-	-	-	-	-	L Summer	13.8	12.7	16.0	14.3	14.2	-
Spring	8.8	9.3	8.9	9.5	9.1	-	Spring	8.7	9.7	8.3	11.0	9.3	-
Summer	10.3	10.4	9.8	12.3	10.7	-	Summer	12.4	11.1	9.5	12.1	11.3	-
Fall	-	-	-	-	-	-	Fall	14.8	12.4	11.0	14.3	13.1	-
Spring	13.6	14.0	13.4	13.4	13.6	21.1	Spring	12.1	11.8	11.2	13.4	12.1	16.9
Summer	14.2	13.0	13.4	14.2	13.7	16.3	Summer	15.7	14.1	14.5	15.5	15.0	21.5
Fall	-	-	-	-	-	-	L. Summer	17.5	16.0	17.0	17.1	16.9	22.5

Spring	Summer
NS	0.7
1.9	1.8
NS	1.1
3.8	1.6
4.4	1.5

Spring	Summer	L Summer
0.8	0.8	0.9
1.3	1.2	1.2
2.5	2.3	2.5
1.2	NS	1.2

Appendix Table 8. Percent in vitro digestibility of grass-legume mixtures, Manhattan, 1977-79

	1977							1978							1979						
		Grass*							Grass							**Grass**					
Legume or N treatment	Harvest**	SB	TB	TF	RCG	Mean	Legume Alone	Harvest	SB	TB	TF	RCG	Mean	**Legume** Alone	Harvest	SB	TB	TF	RCG	Mean	**Legume** Alone
Alfalfa	Spring	58.8	57.6	56.0	59.3	57.9	55.0	Spring	65.0	63.6	**64.9**	64.1	64.4	63.2	Spring	**69.5**	69.0	68.9	68.7	69.0	62.9
	Summer	66.4	63.7	65.7	60.7	64.1	63.2	Summer	60.9	59.8	58.0	57.9	59.1	60.7	Summer	**66.9**	67.4	65.7	63.0	65.7	65.0
	L. Summer	-	-	-	-	-	66.6	L. Summer	65.0	64.3	64.4	63.8	59.1	60.8	L. Summer						
	Fall	63.5	60.2	59.6	54.1	59.4	54.1	Fall	66.9	65.3	64.7	61.7	-	60.7	Fall	67.4	66.0	65.1	67.0	66.4	-
Red clover	Spring	63.5	61.0	53.8	56.4	58.7	60.5	Spring	63.5	57.7	59.1	61.4	60.4	61.6	Spring	68.7	63.2	66.2	65.1	65.8	61.5
	Summer	62.5	61.3	56.4	61.8	60.5	56.5	Summer	48.6	48.1	52.7	50.8	50.1	51.5	Summer	51.4	48.8	50.8	53.6	51.1	57.7
	Fall	53.1	54.6	47.4	48.1	50.8	59.1	Fall	-	59.3	61.1			-	Fall	-	-	-	-	-	-
Birdsfoot trefoil	Spring	61.9	59.1	59.2	60.5	60.2	62.7	Spring	63.3	62.3	62.6	59.6	61.9	63.1	Spring	69.9	68.7	70.3	66.8	68.9	66.6
	Summer	67.9	65.2	66.5	66.2	66.4	65.4	Summer	59.2	58.3	57.1	59.3	58.5	58.6	Summer	64.4	65.9	67.1	64.9	65.6	67.7
	Fall	58.3	57.2	53.5	50.9	55.0	62.3	Fall	60.4	65.5	68.0	67.9	-	62.4	Fall	69.3	69.2	69.1	70.9	69.6	-
Crownvetch	Spring	62.4	62.3	51.3	55.6	57.0	57.2	Spring	61.9	57.9	59.7	62.7	60.6	61.3	Spring	68.5	65.0	64.8	65.7	66.0	64.3
	Summer	62.1	65.5	58.0	59.9	61.4	62.0	Summer	48.9	50.9	52.5	54.5	51.7	54.3	Summer	54.6	58.1	63.7	63.4	59.9	62.6
	Fall	53.3	54.6	57.3	53.0	54.5	56.9	Fall	-	61.9	61.4	59.0	-	-	Fall	-	-	-	-	-	-
0 lb N/A	Spring	59.1	58.8	56.3	51.8	56.5	-	Spring	60.8	56.1	53.8	52.7	55.9	-	Spring	69.5	63.8	63.4	65.8	65.6	-
	Summer	61.1	59.3	55.5	56.6	58.1	-	Summer	46.2	50.3	46.5	51.5	48.7	-	Summer	51.9	54.6	51.9	60.0	56.5	-
	Fall	54.2	54.6	53.2	43.9	51.5	-	Fall	-	55.8	57.2	11.0	-	-	Fall	-	-	-	-	-	-
80 lb N/A	Spring	65.4	63.1	56.5	58.0	60.8	-	Spring	59.6	60.0	57.5	58.9	59.0	-	Spring	66.9	67.1	67.5	68.3	67.5	-
	Summer	68.8	63.9	62.9	59.3	63.9	-	Summer	47.3	53.1	47.2	50.4	49.5	-	Summer	56.1	57.7	51.2	61.1	54.6	-
	Fall	51.3	51.4	51.2	47.3	50.3	-	Fall	-	62.1	59.7	55.7	-	-	Fall						
Mean	Spring	61.9	60.3	55.5	56.9	58.7	58.8	Spring	62.4	59.6	59.6	59.9	60.4	62.3	Spring	68.8	66.1	66.9	66.7	67.1	63.8
	Summer	64.8	63.1	60.8	60.9	62.4	61.8	Summer	51.9	53.4	52.4	54.1	52.9	56.3	Summer	57.6	58.7	58.4	61.0	58.9	63.3
	Fall	55.6	55.4	53.7	49.6	53.6	58.1	Fall	-	61.6	62.0	-	-	-	Fall	68.3	67.6	67.1	68.9	68.0	-

	1977 Spring	1977 Summer	1977 Fall	1978 Spring	1978 Summer	1979 Spring	1979 Summer
$LSD_{.05}$ for comparing grasses	2.5	NS	4.5	1.6	NS	NS	NS
$LSD_{.05}$ for comparing legumes or N treatments	2.8	3.0	2.8	2.0	1.0	2.5	2.7
$LSD_{.05}$ for comparing grasses within a legume or N treatment	5.6	NS	4.5	3.9	NS	NS	NS
$LSD_{.05}$ for comparing legumes or N treatment within a grass	5.7	5.9	5.5	4.0	4.9	5.0	5.5
$LSD_{.05}$ for comparing legumes alone	5.6	5.9	6.6	NS	5.1	2.8	4.6

*SB= **Smooth brome, TB=Turkish brome: TF=Tall fescue, RCG= Reed Canarygrass** ****L. Summer = Late Summer**

Appendix Table 9. Percent in vitro digestibility of grass-legume mixtures, Ottawa, 1977-79.

	1977							1978							1979						
		Grass*							Grass							Grass					
Legume or N treatment	Harvest**	SB	TB	TF	RCG	Mean	Legume Alone	Harvest	SB	TB	TF	RCG	Mean	Legume Alone	Harvest	SB	TB	TF	RCG	Mean	Legume Alone
Alfalfa	Spring	60.3	62.3	59.3	61.2	60.8	60.6	Spring	64.5	64.1	59.0	61.9	62.4	62.5	Spring	66.0	66.0	67.8	66.1	66.5	64.0
	Summer	61.2	46.2	59.7	58.3	56.4	60.8	Summer	63.3	59.7	61.1	62.2	61.6	61.6	Summer	65.7	64.2	64.3	65.6	64.9	67.1
	L. Summer	-	-	-	-	-	64.7	L. Summer	-	-	-	-	-	-	L. Summer	-	-	-	-	-	-
	Fall	61.7	59.8	62.4	58.1	60.5	58.2	Fall	-	-	-	-	-	-	Fall	67.4	69.7	69.9	69.7	69.2	70.5
Red clover	Spring	62.8	64.4	55.9	61.7	61.2	65.1	Spring	59.1	61.6	56.6	55.7	58.3	62.5	Spring	68.1	66.6	66.0	67.0	66.9	-
	Summer	57.3	57.0	55.9	53.7	56.0	54.6	Summer	54.8	52.2	54.2	52.9	53.5	53.3	Summer	59.1	56.4	53.5	56.6	56.4	-
	Fall	55.2	57.6	56.2	51.0	55.0	54.2	Fall	-	-	-	-	-	-	Fall	65.6	64.4	62.3	63.8	64.0	-
Birdsfoot trefoil	Spring	64.6	65.2	59.5	63.5	63.2	65.4	Spring	62.2	62.8	61.3	61.0	61.8	61.5	Spring	66.6	67.6	66.7	68.2	67.3	65.7
	Summer	61.4	59.3	61.9	59.1	60.4	60.8	Summer	69.1	68.5	66.3	64.9	67.2	67.0	Summer	67.7	64.6	66.8	65.6	66.2	70.0
	Fall	56.4	57.3	61.8	56.4	58.0	58.1	Fall	-	-	-	-	-	-	Fall	72.1	71.5	72.2	71.2	71.7	73.4
Crownvetch	Spring	63.7	61.9	61.9	64.6	63.0	64.1	Spring	62.0	62.6	59.9	61.4	61.5	65.1	Spring	69.6	68.8	67.6	69.4	68.9	63.2
	Summer	55.2	53.7	53.7	55.7	54.6	53.4	Summer	59.5	57.5	59.1	58.1	58.6	61.4	Summer	61.0	61.1	59.6	60.6	60.5	60.3
	Fall	64.6	62.8	62.1	60.7	62.6	61.2	Fall	-	-	-	-	-	-	Fall	64.8	63.5	62.4	62.5	63.3	66.9
0 lb N/A	Spring	60.6	57.2	57.8	59.7	58.8	-	Spring	56.1	61.7	53.9	58.1	57.4	-	Spring	69.4	67.1	67.9	66.8	67.8	-
	Summer	54.7	53.5	52.7	51.4	53.0	-	Summer	51.1	51.4	44.1	51.9	49.6	-	Summer	59.4	57.8	58.6	59.2	58.8	-
	Fall	51.8	59.0	56.2	48.2	53.8	-	Fall	-	-	-	-	-	-	Fall	62.0	61.4	61.8	63.4	62.1	-
80 lb N/A	Spring	62.6	64.9	56.6	61.8	61.5	-	Spring	57.6	60.0	53.2	54.4	56.3	-	Spring	67.7	67.7	67.8	66.0	67.3	-
	Summer	54.0	56.5	51.8	51.3	53.4	-	Summer	48.0	53.1	46.8	51.9	50.0	-	Summer	55.0	56.4	52.5	54.6	54.6	-
	Fall	52.2	56.7	52.0	48.2	52.3	-	Fall	-	-	-	-	-	-	Fall	58.7	63.6	57.5	62.3	60.5	-
Mean	Spring	62.4	62.7	58.5	62.1	61.4	63.8	Spring	60.2	62.1	57.3	58.8	59.6	62.9	Spring	67.9	67.3	67.3	67.3	67.5	64.4
	Summer	57.3	54.3	55.9	54.9	55.6	57.4	Summer	57.6	57.1	55.3	57.0	56.7	60.9	Summer	61.3	60.1	59.2	60.4	60.2	65.8
	Fall	57.0	58.9	58.5	53.8	57.0	58.0	Fall	-	-	-	-	-	-	Fall	65.1	65.7	64.4	65.5	65.1	70.2

	1977 Spring	1977 Summer	1977 Fall	1978 Spring	1978 Summer	1979 Spring	1979 Summer	1979 Fall
$LSD_{.05}$ for comparing grasses	2.7	NS	2.2	NS	NS	NS	1.1	NS
$LSD_{.05}$ for comparing legumes or N treatments	1.8	4.7	1.8	NS	1.8	1.3	1.2	1.6
$LSD_{.05}$ for comparing grasses within a legume or N treatment	4.1	NS	3.8	NS	NS	NS	2.4	NS
$LSD_{.05}$ for comparing legumes or N treatment within a grass	3.6	9.5	3.6	NS	3.7	2.6	2.4	3.3
$LSD_{.05}$ for comparing legumes alone	NS	3.7	5.3	2.1	3.3	NS	3.0	2.8

*SB= Smooth brome, TB=Turkish brome: TF= Tall fescue; RCG = Reed Canarygrass **L. Summer = Late Summer

KANSAS STATE UNIVERSITY

Agricultural Experiment Station, Kansas State University, Manhattan 66506

Bulletin 649 April 1986

4-86-6M