PRODUCTIVITY OF GRASSES AND LEGUMES IN EASTERN KANSAS

by

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INTRODUCTION

Forage grasses are quite low in productivity when restricted to the nitrogen levels supplied by most soils. Grasses obtain nitrogen from five sources: mineralization of soil organic matter, precipitation, fixation by free-living organisms, symbiotic fixation, and fertilizers. The recent increase in the price of nitrogen fertilizer has renewed interest in the use of legumes to fix atmospheric nitrogen. Nitrogen fixation in legume-grass mixtures has the potential to increase forage production without nitrogen fertilizer. If it were not for the nitrogen supplied by legumes, the number of low producing pastures would greatly increase (Beaton and Berger, 1974; Templeton, 1976). Pure-grass pasture swards without the benefit of symbiotic fixation or fertilizer normally yield only one to two metric tons of dry matter (DM) per hectare (Wagner, 1954; Cowling and Lockyer, 1965). At such low levels of production, three to six hectares are required to support a beef cow and calf.

In the eastern 26 counties of Kansas there are 2.7 million acres of grassland. Cool season tame grasses account for 1.1 million of these acres. Improved management is needed for 350,00 of these acres and 300,000 need complete renovation.

This report will discuss the merits of grass-legume systems for pasture land, review establishment and maintenance procedures and report research findings concerning forage yield and animal performance from grass-legume systems.

FORAGE SYSTEMS

Grass plus nitrogen fertilizer and grass plus legume systems both have potential to improve pasture land productivity. There are several factors to consider when choosing between these systems.

Grass plus nitrogen fertilizer

The grass + nitrogen system normally increases overall forage production compared to grass alone. Nitrogen fertilizer applied in late winter or early spring can help overcome sub-optimal temperatures provided other environmental factors are favorable for grasses. Grass + nitrogen provides earlier spring grazing and more stockpiled forage in late fall than grass alone.

The nitrogen system is subject to varying price and supply of fertilizer. Also lower production per animal unit, grass, tetany, nitrate poisoning, and increased grass alkaloid content have been associated with nitrogen fertilization.

Grass plus legume

The grass + legume system is used primarily to fix atmospheric nitrogen but it also results in a high production per animal unit. This system requires excellent management to maintain a balance of grass and legume species. (The possibility of bloat exists with some legume species.)

Cool season grasses are usually less sensitive to edaphic, weather and management variables than legumes. Grass + legume provides a better seasonal distribution of forage production than grass alone or grass + nitrogen. Cool-season grasses have a flush of growth in the spring followed by a period of near dormancy in the summer.

When a legume such as birdsfoot trefoil (Lotus corniculatus) or alfalfa (Medicago sativa), is combined with a grass (such as bromegrass), there is greater production in the summer (Table 1). During this period almost all of the production comes from the legume component of the stand. Its tap root reaches deep into the soil profile for moisture (Forage Handbook, 1973).

Table 1. Seasonal distribution of forage production (% of the season total).

Forage specie	May-June	July-August	September-October
Bromegrass	60	15	25
Bromegrass + birdsfoot trefoil	35	45	20
Bromegrass + alfalfa	45	40	15

(Forage Handbook, 1973)

NUTRITIVE VALUE OF GRASSES AND LEGUMES

The nutritive value of a forage is determined by its maximum voluntary intake, when it constitutes the entire ration, and by its yield of digestible energy (Crampton et al, 1960).

Voluntary Intake

Data in Table 2 shows that sheep gained more and consumed more feed when fed legume forages than when fed grass forages.

Consumption is limited primarily by the rate of digestion of cellulose and hemicellulose rather than other nutrients or the completeness of their utilization.

Table 2. Relative gain and daily intake of dry matter and energy.

Forage	Relative gain	Daily intake: Dry matter, lbs.	Daily intake: Dig. kcal
Birdsfoot Trefoil	100	5.51	3100
Red Clover	81	5.25	2900
Bromegrass	45	3.13	1650
Timothy	33	2.38	1225
Straw	0	1.23	565

(Crampton, 1957)

The rate of digesta flow causes differences in voluntary intake. The faster digesta moves out of the digestive tract, the sooner hunger can recur and thus the more feed consumed for a given time. Ingalls (1966) found the rumen retention time to be approximately 0.65 days for legumes and 1.0 days for grasses (Table 3).

Intake of dry matter, fiber and lignin was higher for sheep receiving legumes than grasses. Rapid rate of passage of legumes may be responsible for decreased digestion coefficients for cell wall constituents (CWC). Increased intake of energy from legumes more than makes up for the lower digestibility associated with rapid rate of passage. Data in Table 4

Table 3. Retention and intake time of legume and grasses

	Legumes		Grass	
	Alfalfa	Birdsfoot trefoil	Bromegrass	Canarygrass
Rumen retention time, days	0.60	0.64	1.00	1.17
DM intake, gm/kg body wt.	32.5	38.7	17.8	20.8

(Ingalls, 1966)

indicates that more legume dry matter is removed from the rumen during the first 6 hours following feeding than grass dry matter.

Table 4. Rate of dry matter removal from the rumen (% of 12 hour intake)

	1-6 hours	6-12 hours
Legumes		
Alfalfa	49	51
Birdsfoot trefoil	76	24
Grasses		
Timothy	39	61
Reed Canarygrass	30	70

(Ingalls, 1966)

Nutritive Value Index

Crampton *et al.* (1960) developed a Nutritive Value Index (NVI) for forages on the basis of relative intake and digestibility of energy. Relative intake is a comparison of observed intake, to expected intake of a standard forage. The researchers conducted intake trials to determine the consumption per unit of metabolic size of the standard forage; a mixed legume hay (alfalfa, birdsfoot trefoil and red clover). This was then compared to the observed intake of other types of forage. Observed intake is divided by expected intake to determine intake relative to the standard. NVI is calculated by multiplying relative intake by digestibility of energy (measured *in vivo*). NVI for legumes is higher than it is for grasses (Table 6). These same researchers developed an estimated NVI using *in vitro* digestibility. The *in vitro* index and the NVI were well correlated, r = .91.

Table 6. Nutritive Value Indexes of selected grasses and legumes determined using sheep.

Forage	No. of Animals	Relative Intake	% Dig. of Energy	NVI for sheep	In vitro Index
Timothy	5	56	61	34 ± 4	21
Bromegrass	5	71	60	43 ± 5	21
Alfalfa	5	79	63	50 ± 9	25
Trefoil	5	99	63	63 ± 9	31
Red Clover	5	106	67	71 ±10	34
Red Clover Early bloom	4	98	55	54 ±10	24
Full bloom	4	92	53	49 ± 5	25
Timothy Early bloom	4	66	58	38 ± 3	22
Full bloom	4	69	50	34 ± 5	12

(Crampton *et al.*, 1960)

ESTABLISHMENT OF GRASSES AND LEGUMES

Forages receive low priority from many farmers. It is more difficult to determine pasture production than it is the production of other crops like corn or wheat. Farmers do not normally measure grazing days possible from pastures or weigh individual animals to determine the weight gain.

Stand establishment is the first step after a farmer decides to use the grass-legume system. To obtain good stands soil nutrient deficiencies must be corrected and proper establishment methods must be used.

Soil tests should be taken early so that lime can be applied six months prior to planting when needed. Th pH of the soil is very important to the growth of legume species. Birdsfoot trefoil grows best at a pH of 6.5 to 7.0. Research at the Mound Valley Branch Experiment Station (1966) found that lime must be worked into the soil before it can be utilized by alfalfa. The average increase in production from proper liming was .96 tons of dry matter per year. Phosphorus and potassium levels are more important for legumes than grasses. Soil tests will show the adequacy or inadequacy for these elements. When stands of pure grasses are used, nitrogen levels become much more important.

The two common methods of establishing legume-grass mixtures are complete renovation and interseeding. Complete renovation involves establishing a completely new stand of both grass and legume. Interseeding usually involves seeding a legume into an existing stand of grass. The vigor of the grass stand must be reduced temporarily so the legume can become established. Two methods used to reduce the vigor of the grass are discing and using a herbicide. Discing to disturb 60% of the grass sod is adequate for good legume establishment. Paraquat is a nonselective contact herbicide which kills the part of the grass plant above ground but does not harm the grass stand. This allows legume to get started before the grass recovers.

Species of legumes and grasses to be used will depend on location, drainage and duration of stand desired. Alfalfa requires a very well drained, highly fertile soil. Birdsfoot trefoil will grow in poorly drained soil of low fertility. Red clover grows best on well drained non-acid soils and fits into crop rotation systems due to its short duration time. Reed canarygrass is adapted to moist or even swampy soils. Smooth bromegrass is adapted to a wide variety of soil types and is resistant to drought and temperature extremes. Orchardgrass requires well drained soils. Tall fescue does well in a wide variety of soils.

Legumes should be seeded in a firm seedbed ¼ inch deep directly above a band of phosphorus starter fertilizer. Legume seed should be inoculated just prior to planting for maximum nitrogen fixation.

MAINTENANCE OF GRASS-LEGUME STANDS

Legumes are not strong competitors. Management of a legume-grass system should be aimed at maintaining the legume in the stand for as long as possible. Although grass species grown without legumes need yearly nitrogen application, nitrogen fertilization of legume-grass mixtures results in stands which are predominantly grass (Wolf and Smith, 1964). Nitrogen fertilizer gives grasses too much of an advantage over legumes.

Legume species differ greatly in their growth habits. Smith (1962) found that alfalfa and red clover maintain a high level of carbohydrate root reserves during the growing season and produce regrowth from the crowns following each complete defoliation. Birdsfoot trefoil was found to have a low level of carbohydrate reserves during the growing season and when clipped closely, regrowth was slow to develop. During the growing season birdsfoot trefoil relys on existing topgrowth for regrowth.

Van Keuren et al. (1969) found that continuously grazed birdsfoot trefoil pastures gave significantly fewer animal days per hectare than rotationally grazed pastures and showed sharply reduced stands. Davis and Bell (1957) reported that birdsfoot trefoil remained productive in a forage mixture when grazed two weeks and then rested four weeks. Nelson et al. (1975) found that alfalfa was much less adapted to frequent defoliation than was birdsfoot trefoil. Thus, alfalfa should be grazed closely but not frequently and birdsfoot trefoil should be grazed frequently but not closely.

Dobson et al. (1976) clipped Fescue-Viking Birdsfoot trefoil stands at 5 and 10 cm heights and measured the percent of soil area covered by the legume (Table 7). From 1971 to 1973 the area covered by the legume declined at the 5 cm cutting height, but increased at the 10 cm cutting height. At the 10 cm height enough Birdsfoot trefoil leaf area was present for adequate synthesis of nutrients for regrowth.

Table 7. Percent of soil area covered by legume in in a Fescue-Viking Birdsfoot trefoil stand

	Clipping height	
	5 cm	10 cm
1971	58	50
1973	35	72

(Dobson et al., 1976)

Greub and Wedin (1971) found the possibility of reduced vigor or intermediate stand loss in birdsfoot trefoil following one severe defoliation in mid-summer.

In fall all legumes must store carbohydrates to survive the winter and initiate growth the next spring. Legumes should not be harvested 4 to 5 weeks before the first freeze to allow for adequate root carbohydrate storage. Fall application of phosphorus and potassium is also recommended to aid this winter hardening process.

Nelson et al. (1975) found that the persistance of a birdsfoot trefoil stand is dependent on getting some seed produced. In many areas, trefoil has been used very little as a pasture legume since maintaining an acceptable stand is difficult. Taylor *et al*. (1973) were able to maintain trefoil stands through natural reseeding by permitting the second growth to set seed. Data in Table 8 shows that trefoil made up a larger part of the sward when it was permitted to reseed. In 1969 plots not allowed to set seed were 77.5% legume but by 1972 these plots had declined to 34.6% legume. The plots allowed to set seed in 1969 and 1970 were 64.1% legume in 1969 but by 1972 these plots had declined to 44.2% legume.

In this same study, the researchers determined the number of plants per square meter (m^2) for the two management systems (hay vs. hay-reseed). They found the number of legume plants per m^2 at the end of four years was higher in those plots which were allowed to reseed (Table 9).

Table 8. Effect of reseeding on total yield, legume yield and % legume.

	Management	Sward lbs/acre	BFT lbs/acre	% BFT
1969	hay	5152	3991	77.5
	hay-reseed	4516	2894	64.1
1970	hay	5655	4498	79.5
	hay-reseed	4843	3707	76.5
1971	hay	4301	2036	47.3
	hay-reseed	5811	3168	54.5
1972	hay	3098	1071	34.6
	hay-reseed	4162	1839	44.2

(Taylor *et al*., 1973)

Table 9. Effect of reseeding on the number of birdsfoot trefoil plants per m^2 after four years.

	Management	
	Hay	Hay reseed
Birdsfoot trefoil (plants/m^2)	19	85

(Taylor et al., 1973)

PRODUCTIVITY OF GRASSES AND LEGUMES

Steer Grazing Performance

Wedin et al. (1967) in Iowa compared three pasture management systems: unimproved bluegrass, nitrogen fertilized bluegrass and birdsfoot trefoil (BFT) renovated pastures. In 1956 and 1957 they used cow-calf pairs and from 1958 to 1963 they used steers to measure beef production per acre. Results show a 2.7 fold increase in beef production per acre for pastures renovated with trefoil over unimproved pastures. They found a 1.7 fold increase for grass fertilized with 60 lbs. of nitrogen per acre annually over the unimproved pasture in the steer trials (Tables 10 and 11). The authors reported that it was more economical to renovate a pasture with a legume than to use nitrogen fertilizer. Data in Table 12, using 1977 prices, show the advantage of the legume is still present.

Scholl et al. (1974) evaluated five pastures treatments in a 4 year grazing study and found that pastures containing alfalfa or birdsfoot trefoil produced as much beef/acre as pastures receiving 120 to 150 lbs. of nitrogen/acre annually. The five treatments included a grass mixture receiving no

Table 10. Cumulative weight gains for each management system.

	BFT renovated	Fertilized bluegrass	Unimproved
Total N applied lbs./acre (8 years)	0	480	0
1956-1957			
cow gains, lbs./acre	98	85	60
calf gains, lbs./acre	220	242	181
1958-1963			
steer gains, lbs./acre	2258	1340	847

(Wedin *et al*., 1967)

Table 11. Yearly and average steer gain per acre for each management system.

	Steer gain/acre, lbs.						
Management	1958	1959	1960	1961	1962	1963	Avg.
unimproved bluegrass	149	122	196	147	140	92	140
fertilized bluegrass	234	162	295	264	207	175	223
BFT renovated	390	360	473	428	313	291	377

(Wedin *et al*., 1967)

Table 12. Economics of nitrogen fertilization and legume renovation.

Management system	Gross return/acre	Added Expense	Advantage/acre over unimproved
Unimproved	$ 50.40	0	0
Fertilized bluegrass	$ 80.28	$10.13	$19.75
Renovated	$135.72	$19.80	$65.52

nitrogen, 2 grass mixtures which received nitrogen fertilizer and 2 grass mixtures which were interseeded with legumes. Daily gain and gain per acre were higher in the legume treatments except in the case of average daily gain on the bromegrass, orchardgrass, alfalfa mixture. The authors did not offer an explanation. They reported the per acre cost of seeding legumes was less than the cost of the 510 lbs. of nitrogen applied during the four years. Data in Table 13 shows the results of the first two years of the trial. During the second two years of the trial all of the cattle became infected with bovine viral diarrhea and average daily gains were abnormally low.

Table 13. Average daily gain, gain per acre and total steer days for five pasture treatments.

Pasture treatment	Average daily gain/lbs.	Gain per acre, lbs.	Total steer days/acre
bluegrass, redtop timothy (0 lb. N)	1.49	219	148
same grasses as No. 1 (120 lb. N)	1.32	349	267
same grasses as No. 1 (seeded with BFT)	1.39	355	257
bromegrass and orchard-grass (120 lb. N)	1.26	330	264
bromegrass and orchard-grass (seeded with alfalfa)	1.06	384	367

(Scholl *et al.* 1974)

In Iowa, researchers compared unimproved bluegrass pasture, an improved grass pasture supplied with nitrogen, phosphorus and potassium; a birdsfoot trefoil pasture supplied with phosphorus and potassium grazed continuously and a birdsfoot trefoil pasture grazed alternately with an improved grass pasture to allow for regrowth and seed formation of the birdsfoot trefoil (Posler, 1977). The continuously grazed BFT pasture produced the highest avg. daily gains, steer grazing days/acre and steer gains/acre (Table 14). The alternately grazed BFT produced a higher avg. daily gain and steer gain/acre than improved grass.

Table 14. Five year results for different pasture systems.

Treatment	Avg. daily gain, lbs.	Steer days/acre	Steer gain/acre
Unimproved	1.18	67	80
Improved grass + N, P, K	1.29	187	238
BFT + P, K	1.70	215	362
BFT + P, K (alternated with grass + N, P, K to allow seed formation)	1.54	186	288

(Posler, 1977)

Sullivan et al. (1959) conducted grazing studies in Pennsylvania with yearling steers to compare orchardgrass and Kentucky bluegrass fertilized with nitrogen or interseeded with alfalfa, Ladino clover or birdsfoot trefoil. The average gain (153 days) of steers grazing the fertilized grass was 137 kg compared to 143 kg for the grass-legume pastures. The average carcass grade for all steers was "High Standard." Dressing percentages were influenced by the species grazed. Steers grazed on the grass-legume dressed 50.6%. Those grazed on the nitrated grass dressed 48.5%.

Alfalfa was a beneficial addition to both smooth bromegrass and crested wheat grass. In studies reported by Ensminger et al. (1944), they measured performance of yearling cattle in Washington that grazed smooth bromegrass and alfalfa, crested wheatgrass, crested wheatgrass and alfalfa, or a combination of the two grasses and alfalfa. The grazing season averaged 80 to 87 days. The liveweight gain per hectare for the smooth bromegrass averaged 94 kg, compared to 252 kg when alfalfa was added to the bromegrass. The crested wheatgrass produced 101 kg of liveweight gain per hectare compared to 245 kg when alfalfa was added. When both grasses were combined with alfalfa, the weight gain per hectare was 272 kg. Swards containing alfalfa also provided a slightly longer grazing season.

Wedin and Vetter (1970) summarized results from pasture experiments including grasses (smooth bromegrass, orchardgrass, tall fescue, reed canarygrass, timothy, and Kentucky bluegrass) mixed with or not mixed with alfalfa. Alfalfa-grass pastures were equal or superior to grass plus N (135 kg./ha). The average daily gain of the steers was 0.80 kg. for the grass-legume swards and 0.74 kg. for the grass only.

Lancashire (1971) used twin calves in New Zealand to study the relative quality of perennial ryegrass with white clover and perennial orchardgrass fertilized with nitrogen. Calves grazing on the grass-clover sward gained .68 kg per day during a 104-day grazing season. This gain was 44% greater than that of the calves grazing the fertilized grass sward. The author concluded that the superiority of the grass-clover sward was due to the improved forage growth during the first part of the grazing season and toward the end of the grazing season.

Cow-calf performance

Smith *et al*. (1975) in Indiana reported several benefits from over-seeding Ladino clover into a tall fescue sward. Cows nursing calves on tall fescue alone gain .05 kg daily on tall fescue alone, compared to .31 kg for cows on tall fescue with Ladino clover. Similarly, the calves grazing tall fescue gained only .58 kg daily compared to .83 kg for calves grazing tall fescue with Ladino clover. Conception rates were higher for the cows grazing clover swards.

In a Florida study, Warnick *et al*. (1965) grazed replacement heifers on two types of pastures for 30 months. Pasture treatmen one was an all-grass pasture containing Pangola digitgrass and Pensacola bahiagrass. Pasture treatment two was Pangola digit-grass and Pensacola bahiagrass to which "Nolins" white clover was added.

Heifers raised on grass-clover pastures were 47 kg heavier at 30 months of age than were heifers raised on grass pastures. Heifers raised on grass-clover had a 96% calving percentage compared to 81% for the heifers raised on the grass pastures.

Eighty-nine percent of the heifers from grass-clover pastures weaned calves. Only 76% on all-grass pastures weaned calves.

Cope et al. (1972) evaluated four summer pasture systems for beef cows in an Alabama experiment. The grasses were Coastal bermudagrass and Pensacola bahiagrass in the ratio of approximately 2:1. The legumes included ball clover on all areas, crimson clover on uplands and white clover on low lands. Clovers were reseeded and the sod disced lightly each October because adequate natural reseeding was not anticipated. Cows remained in the same system throughout the four-year experiment. System one included grass and legume plus fertilizer (112 kg nitrogen/ha annually); system two included grass and legume with no fertilizer; system three was grass alone plus fertilizer (112 kg nitrogen/ha annually) and system four was grass without legume or fertilizer. Performance of the cows is summarized in Table 15. Cows grazing the grass pastures without legume or nitrogen lost weight during the year. Obviously, the beef cows in this treatment could not continue indefinitely at an annual weight loss. Cows on the other three systems had an annual weight gain. Performance of calves from these cows is summarized in Table 16. Calves on the grass pastures without legume or nitrogen had the lowest performance. The performance of the calves among the other three systems was similar. These results show the importance of a legume in grass swards to maintain nutritional quality of the pasture over an entire season.

Table 15. Average weights and weight changes of cows as affected by summer pasture system (5-year average).

Item	Summer pasture system: Grass + legume + N	Grass + legume	Grass + N	Grass alone
Number of cows	75	75	75	75
Initial weight, kg 1st fall	485	474	477	474
Spring weight, kg	374	377	373	380
Winter loss, kg	-111a	-97b	-104a	-94b
2nd fall weight, kg	490	480	478	457
Summer gain, kg	116a	103b	105b	77c
Annual change, kg	5a	6b	1b	-17c

[a,b,c]Values within a row having different letter designations are different (P<.01).

(Cope *et al.*, 1972)

Table 16. Average performance of calves from birth to weaning as affected by summer pasture system (5-year average).

Item	Summer pasture system: Grass + legume + N	Grass + legume	Grass + N	Grass Alone
Number of calves	75	75	75	75
Birth weight, kg	34	29	28	28
Age end of winter, days	110	111	106	105
Adjusted weight, 108 days, kg	88	92	87	80
Adjusted weight, 250 days, kg	210a	213a	198b	176c
Summer gain, kg	122a	121a	111a	90b
Daily gain, summer, kg	.86	.85	.80	.63
Gain (kg/ha)	210	170	163	100

[a,b,c]Values within a row having different letter designations are different

(Cope *et al.*, 1972)

Forage dry matter yield

In trials conducted at the East Central Kansas Experiment Field, Barnett et al. (1977) compared four grasses (smooth brome, turkish brome, tall fescue and reed canarygrass) and four legumes (alfalfa, red clover, birdsfoot trefoil and crownvetch), each grown alone and in all possible grass-legume combinations. Pure grass stands of each specie received two fertilizer treatments, 0 or 80 lbs. of nitrogen per acre. Nitrogen was not applied to the grass-legume combinations. Each of the plots was harvested twice, spring and summer, and dry matter yield determined. Results for the first year (1976) are shown in Table 17. The summer of 1976 was extremely dry and the pure-grass plots made essentially no growth following the spring cutting. In the grass-legume plots, summer growth was almost entirely legume. The red clover-grass plots produced higher yields than any of the other legume-grass combinations. Only the red clover-grass plots yielded more than the grasses alone with 80 lbs. of nitrogen. However, alfalfa-grass and BFT-grass plots did yield more than grasses alone with no nitrogen. Crownvetch is slow to establish which may account for its low yields in the first year.

In the same trial the authors compared each legume and fertilizer treatment over all grass treatments to see the effectiveness of each legume at fixing nitrogen (Table 18). Red clover produced the highest yield overall followed by the 80 lb. N treatment on grasses alone. These were followed by alfalfa and birdsfoot trefoil. In this first year data, crownvetch was

Table 17. Yield of grass-legume and grass swards.

Legume or nitrogen treatment	Harvest	Grass: Smooth brome	Turkish brome	Tall fescue	Reed canarygrass
		tons of dry matter/acre			
Alfalfa	Spring	2.37	2.02	2.46	2.45
	Summer	0.75	0.76	0.66	0.87
	Total	3.12	2.78	3.12	3.32
Red Clover	Spring	3.56	3.17	3.53	3.54
	Summer	0.77	0.86	0.69	1.27
	Total	4.33	4.02	4.22	4.81
Birdsfoot Trefoil	Spring	2.35	2.41	2.70	2.10
	Summer	0.38	0.70	0.40	0.60
	Total	2.73	3.11	3.10	2.70
Crownvetch	Spring	1.66	1.86	2.28	1.09
	Summer	0.22	0.34	0.22	0.36
	Total	1.88	2.20	2.50	1.45
0 lb. Nitrogen per acre	Spring	2.09	2.40	2.18	0.87
	Summer	0.05	0.14	0.13	0.19
	Total	2.14	2.54	2.31	1.06
80 lb. Nitrogen per acre	Spring	3.91	3.57	4.27	2.96
	Summer	0.07	0.25	0.18	0.23
	Total	3.98	3.82	4.45	3.19

(Barnett *et al.*, 1977)

found to have no effect on fixing nitrogen. Yields of crownvetch-grass mixtures were equal to those of grasses alone which did not receive nitrogen.

Table 18. Mean yields of legume and grass swards (tons of dry matter per acre).

Legume or nitrogen treatment	Tons of dry matter/acre
Alfalfa	3.08
Red Clover	4.35
Birdsfoot Trefoil	2.91
Crownvetch	2.00
0 Nitrogen	2.01
80 lb. Nitrogen	3.86

(Barnett *et al.*, 1977)

AREAS OF FUTURE RESEARCH

Research is needed in Kansas to develop improved varieties of grasses and legumes. Legumes are not strong competitors and are susceptible to various diseases. Legume varieties which are able to remain productive for a longer time will be better accepted by farmers who do not want to reseed often. New varieties should be grown in small plots to check disease resistance, forage yield and compatability.

Acceptable grass and legume varieties should then be grown in larger acreages under eastern Kansas conditions for grazing studies with cattle. This would add valuable information about forage palatability, animal carrying capacity and beef production per acre.

Finally, mechanically harvested grasses and legumes need to be stored and processed by various methods and fed to cattle in feedlots. Physical form of the forage (ei. long hay, ground hay, silage or pellets) does affect its voluntary intake (see appendix, page 29) and utilization by livestock. Optimum ways of handling grasses and legumes from the field to the feedbunk should be developed.

SUMMARY

Forage grasses are quite low in productivity when not supplied with supplemental nitrogen. Nitrogen can be added either through symbiotic fixation by legumes or fertilizer. The recent increases in the price of nitrogen fertilizer have renewed interest in the use of legumes to fix atmospheric nitrogen. Providing plant nutrients and selecting proper establishment methods are necessary to obtain good grass and legume stands. Management of grass-legume systems should be aimed at maintaining the legume.

Normally, the Nutritive Value Index is higher for legumes than it is for grasses. A review of the literature indicates that a grass-legume system with steers produces as many pounds of beef per acre as a fertilized grass system. In cow-calf trials equal or superior performance (weight gain, calving percentage and conception rate) was found with grass-legumes compared to fertilized grasses. In preliminary trials grass-legume systems were found to increase forage yields over non-fertilized grass in Eastern Kansas.

The nutritive value of a forage is affected by voluntary intake and digestibility. In two trials 24 crossbred feeder lambs were used to measure consumption of whole-plant wheat forage fed in three forms: silage, ground hay and pellets. In the first trial, lambs were not given a choice of forage; in the second, lambs were offered a choice of forage in a cafeteria system. Dry matter intakes by lambs given only one form of

forage were 1.92 lbs. of silage, 1.94 lbs. of hay and 2.90 lbs. of pellets per day. Lambs offered a choice of the three forages consumed less hay than silage or pellets.

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Appendix - Voluntary Intake of Wheat Silage, Hay and Pellets by Lambs

Introduction

Physical form of a forage influences intake of that forage. Bolsen et al. (1975) found lambs fed milo stover pellets gained faster ($P<.01$) and more efficiently ($P<.01$) than lambs fed milo stover silage. Lambs fed pellets consumed 118% more dry matter than those fed silage. In another trial (Oltjen et al. 1977) lambs fed silage consumed more dry matter than those fed hay (2.74 vs. 2.47 lbs./day).

The objectives of these trials were: (1) to measure intake of silage, hay and pellets by lambs not given a choice of forage and (2) to measure preference for physical form of forage by lambs offered a choice of silage, hay and pellets cafeteria style.

Experimental Procedure

Trial 1. Twelve crossbred feeder lambs averaging 83.5 lbs. were used in a 12-day trial. Four lambs were randomly assigned to each of three whole-plant, dough-stage wheat forages: silage, ground hay, and pellets. A 5-day feeding stall and ration adjustment time preceded a 7-day voluntary intake period. The lambs were fed individually twice daily to appetite. Molasses was added only to the hay to reduce dustiness. Hay was ground and processed in a ¼-inch pellet without molasses.

Trial 2. Twelve crossbred feeder lambs averaging 81.6 lbs. were used in a 16-day trial to determine which form of forage used in trial 1, lambs preferred when given a choice. The lambs were randomly assigned to three pens of four lambs each and each pen was offered the silage, hay, and pellets free-choice. Locations in the bunk of each forage were changed daily to prevent a position preference from influencing the results.

Results and Discussion

Results of trial 1 are shown in Table 1. Lambs consumed significantly more ($P<.05$) wheat pellets than either hay or silage. Similarly, Bolsen et al. (1975) found heifers fed milo stover pellets consumed more dry matter than those fed forage sorghum or milo stover silages. In a lamb growing trial lambs fed milo stover pellets consumed more dry matter (1.30 vs. .59 kg/day), gained faster (.11 vs. .02 kg/day) and gained more per kg of feed (.08 vs. .04 kg) than those fed milo stover silage. In results here, intake between hay and silage was not different.

Results of trial 2 are shown in Table 2. Lambs offered a choice of forages consumed more pellets than silage or hay, however; there was no significant difference in intake between pellets and silage (1.39 vs. 1.08 lbs./day). Lambs consumed significantly less ($P<.05$) hay than pellets or silage.

Appendix Table 1. Consumption by lambs not given a choice of forage.

Item	Wheat Silage	Wheat hay	Wheat pellets
No. of lambs	4	4	4
Avg. daily feed, lbs.[1]	1.92[b]	1.94[b]	2.90[a]
% dry matter of the forage	41.13	91.5	92.75

[1] 100% dry matter basis.

[a,b] Means on the same line with different superscripts differ significantly ($P<.05$).

Appendix Table 2. Consumption by lambs offered a choice of forage.

	Wheat silage	Wheat hay	Wheat pellets	Total
Avg. daily feed, lbs.[1]	1.08[a]	.29[b]	1.39[a]	2.76
Total ration consumed, %[1]	39.1	10.5	50.4	100.0

[1] 100% dry matter basis.

[a,b] Means on the same line with different superscripts differ significantly ($P<.05$).

PRODUCTIVITY OF GRASSES AND LEGUMES IN EASTERN KANSAS

by

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Forage grasses are quite low in productivity when not supplied with supplemental nitrogen. Nitrogen can be added either through symbiotic fixation by legumes or fertilizer. The recent increases in the price of nitrogen fertilizer have renewed interest in the use of legumes to fix atmospheric nitrogen. Providing plant nutrients and selecting proper establishment methods are necessary to obtain good grass and legume stands. Management of grass-legume systems should be aimed at maintaining the legume.

Normally, the Nutritive Value Index for legumes is higher than it is for grasses. A review of the literature indicates that a grass-legume system with steers produces as many pounds of beef per acre as a fertilized grass system. In cow-calf trials equal or superior performance (weight gain, calving percentage, weaning percentage and conception rate) was found with grass-legumes compared to fertilized grasses. In preliminary trials grass-legume systems were found to increase forage yields over non-fertilized grass in Eastern Kansas.

The nutritive value of a forage is affected by voluntary intake and digestibility. In two trials 24 crossbred feeder lambs were used to measure consumption of whole-plant wheat forage fed in three forms: silage, ground hay and pellets. In the first trial, lambs were not given a choice of forage; in the second, lambs were offered a choice of forage in cafeteria system. Dry matter intakes by lambs given only one form of forage were 1.92 lbs. of silage, 1.94 lbs. of hay and 2.90 lbs. of pellets per day. Lambs offered a choice of the three forages consumed less hay than silage or pellets.