Leopold Center
FOR SUSTAINABLE AGRICULTURE

COMPETITIVE
GRANT REPORT
98-09

Evaluation of the nitrogen and energy utilization of legume forages by growing cattle and sheep

Abstract: *Forages can help maintain or enhance environmental quality by preventing soil erosion and increasing soil nitrogen so that less nitrogen fertilizer is needed. However, because the protein in most legume forages is highly degraded in the rumen of cattle or sheep, utilization of forage protein may be inefficient. This research project looked at the possibilities for using berseem clover and kura clover to increase feed efficiency of growing animals and lactating dairy cows.*

Principal Investigator:
James R. Russell
Animal Science
Iowa State University

Co-investigator:
Mohammadreza Ghaffarzadeh
Pioneer Hi-Bred International
Johnston, Iowa

Budget:
$20,250 for one year

Background

Use of rotational cropping systems, including forage legume species, conserves soil, disrupts plant disease and insect cycles, and reduces the need for nitrogen fertilizer. Because berseem clover fixes nitrogen like other legumes, is productive, and is an annual forage under Midwestern environmental conditions, it may be used in short rotational crop systems with no application of herbicide to kill the legume. In contrast, because of its rhizomes, kura clover is a perennial legume which may serve as a perennial cover and strip crop into which corn can be inter-seeded.

In order to best employ these legumes in crop rotations, profitable animal production systems must be integrated with the cropping system. Legume forages will result in greater live weight gains in cattle than grass forages. Their successful performance springs primarily from the greater consumption of legume forages than grass forages. Although legume forages like alfalfa have a high nutritive value, the efficiency with which they are utilized by growing or lactating cattle is limited by the large proportion of their protein that is degraded to ammonia during ruminal fermentation. The amount of forage crude protein that is degraded from silages is even greater than that from hay because of the amount of protein that is converted to nonprotein nitrogen during the ensiling process, particularly when harvested at a high moisture concentration.

Studies have shown that degradation of the protein in alfalfa may be reduced by chemical treatments. However, these require expensive chemicals and may be dangerous to human health and the environment. As a result, considerable effort is being made to identify legume species with proteins that experience reduced ruminal degradation.

Forage species such as birdsfoot trefoil and lespedeza have been identified as having an increased proportion of protein avoiding proteolysis during ruminal or silage fermentation. The high concentrations of undegraded protein in these species seem to be caused by the elevated proportion of protein bound to tannins. Not only does this property improve the efficiency with which the forage's protein is utilized, but it also reduces the incidence of bloat, a condition commonly observed in cattle grazing other legume forages.

Berseem clover also is recognized as a legume that will not cause bloat. Recent work has shown that the protein in stockpiled berseem has a lower concentration of neutral detergent fiber and greater dry matter digestibility than alfalfa hay. Berseem also had a lower ruminal degradability than alfalfa/hay. Because of these characteristics, it seemed likely that

Kura clover in corn plots

berseem clover would result in greater weight gains of young steers than alfalfa.

Little is know about the nutritional characteristics of kura clover. Because of its persistence and utility in intercropping systems in an upper Midwestern environment, however, kura clover would seem to be useful for forage-based production systems in Iowa.

The experiment objective was to characterize the energy and protein utilization of different legume forages by ruminant animals.

Approach and methods

Evaluation of the effects of the fiber concentration and protein degradation characteristics of berseem clover silage In spring 1997, berseem clover was seeded with oats in a 20-acre field adjacent to a 40-acre field containing second-year alfalfa at the ISU Rhodes Research Farm. One cutting of the oat-berseem and alfalfa forage was harvested as hay. It was intended that a second cutting be analyzed for chemical composition and fed to steers in a feedlot performance and digestion trial. Unfortunately, despite initial positive appearances, the survival rate for the berseem plantings during the dry spring was extremely poor and did not yield enough material to conduct any of the planned analyses. The drought sensitivity of the berseem made it a less appealing candidate for further investigation and it was decided to evaluate the nutritional qualities of kura clover instead.

Changes in chemical composition and digestion kinetics of stockpiled kura clover in late fall Over three years kura clover was established in four plots at the University of Wisconsin's Lancaster Research Station. In spring 1997, one-third of the area in each of the plots was treated with glyphosate and planted with corn using no tillage. Forage from the kura clover plot adjacent to the corn-kura clover strips was harvested twice during the summer. After grain harvest, kura clover was sampled from amongst the corn crop residues and from the area adjacent to the corn plots at 14-day intervals starting on October 10, 1997. All samples were oven-dried and analyzed for dry matter, crude protein, neutral detergent fiber, acid detergent fiber, acid detergent insoluble nitrogen, and in vitro digestible dry matter. Another three samples were collected from the same plot at each date, freeze-dried, and used to determine the protein degradation characteristics of the forage.

To determine the kinetics of protein degradation in the rumen, approximately 3 g of each forage sample were placed in Dacron bags and placed in the rumens of two fistulated steers grazing smooth bromegrass. After intubation periods ranging from zero to 48 hours, the bags were removed, washed, dried, and crude protein concentrations were analyzed. Researchers measured the disappearance of nitrogen that was potentially digestible, the rate of digestion, and the time required for digestion.

Ruminal microbial protein degradation and synthesis in sheep fed forages of varying nutritive values Although the berseem clover at the Rhodes Farm did not grow in 1997, an experiment evaluating energy and protein utilization

of oat-berseem clover and alfalfa hays produced at the ISU Beef Nutrition Research Center in 1996 was already in progress and is relevant to this project.

A digestibility trial was conducted using six wether (male castrated) sheep, surgically fitted with a rubber tube in the rumen and a closed t-type tube in the duodenum. First harvest forage from a field containing a mixture of oats and berseem clover was mowed when the oats were at boot stage. Third harvest alfalfa forage was mowed at the first flower stage. The two hays and crop residues from corn were baled as large round bales and stored. Prior to feeding, all three forage mixtures were ground.

Diets consisted of corn crop residues, alfalfa hay, or oat-berseem clover fed at *ad libitum* (as desired) and limited level of intake, which was 75 percent of the *ad libitum* intake level of corn residues. The sheep were fed twice daily and had continuous access to water and salt blocks. Twelve days of diet adaptation were followed by ten days of sample collection.

Results and discussion

Changes in chemical composition and digestion kinetics of stockpiled kura clover in late fall Yields of stockpiled kura clover were 950 and 2,544 pounds per acre from within and adjacent to the corn crop residues. Nutritional quality of this forage was high with concentrations of *in vitro* digestive dry matter and crude protein of 76.2 and 22.6 percent respectively. At the Lancaster site, kura clover appears to be an effective supplement for cows grazing corn crop residues.

As the kura clover weathered over 28 days, concentrations of crude protein decreased, while the proportion of protein that was indigestible increased. The proportion of total protein that was removed during the washing procedure (soluble protein) or was indigestible increased while the proportion of protein that was insoluble, but potentially digestible, decreased. However, none of these effects was extreme over the sampling period.

The average proportion of protein that escaped ruminal degradation was 31.3 percent of total protein and was not affected by the weathering period. There was little change in the concentration of digestible dry matter in kura clover over four weeks of weathering.

Ruminal microbial protein degradation and synthesis in sheep fed forages of varying nutritive values As expected, both alfalfa and oat-berseem clover hay had lower neutral detergent fiber and acid detergent fiber concentrations and higher crude protein concentrations than corn crop residues. Alfalfa hay had lower concentrations of neutral detergent fiber and acid detergent fiber and a higher crude protein concentration than oat-berseem clover hay. This likely reflects the high proportion of oats in the first harvest oat-berseem clover forage.

Organic matter intake of sheep fed alfalfa hay was higher than those fed oat-berseem clover hay or corn crop residues ad libitum, expressed either as grams per day or as a percentage of body weight. As the experiment was designed, limit-fed sheep had lower organic matter intakes than sheep fed *ad libitum*.

Amounts of organic matter digested in the rumen and apparently digested in the total tract were lower in sheep fed corn crop residues than the two hays, and were lower in sheep fed oat-berseem clover hay than in those fed alfalfa hay because of the differences in organic matter intake. As designed, amounts of organic matter apparently or truly digested in the rumen and total tract were higher in sheep fed *ad libitum* than in those limit-fed. However, the true digestibility of organic matter was greater in sheep fed hay than in those fed corn

crop residues, because the hay had lower neutral detergent fiber and acid detergent fiber concentrations than corn crop residues.

Crude protein intake, represented by nitrogen intake, was higher in sheep fed the two hays than in those fed corn crop residues, was higher in sheep fed alfalfa hay than in those fed oat-berseem clover hay, and was higher in sheep fed forages at the *ad libitum* level than in those that were limit-fed. Sheep fed oat-berseem clover or alfalfa hay had greater amounts of crude protein in the form of nitrogen flowing in the duodenum compared to sheep fed corn crop residues.

The proportions of consumed protein in corn crop residues, oat-berseem clover hay, and alfalfa hay that escaped ruminal degradation were 60, 34, and 17 percent when limit-fed and 43, 31, and 15 percent when fed at the *ad libitum* intake level. Because sheep fed oat-berseem clover or alfalfa hay at the *ad libitum* intake level had greater microbial protein synthesis in the rumen and escape dietary protein entering the duodenum compared to sheep that were limit-fed, sheep fed oat-berseem clover or alfalfa hay at the *ad libitum* intake level had greater amounts of protein-nitrogen flowing into the duodenum than limit-fed sheep.

Kura clover in corn plots

Sheep receiving corn crop residues had lower ruminal ammonia-nitrogen concentrations at all times than sheep fed either of the hays. Intake level did not affect ammonia-nitrogen concentrations.

Conclusions

- While berseem clover is a legume with considerable versatility in cropping systems, it is highly sensitive to drought and therefore risky to use.
- Fall-stockpiled kura clover has high dry matter digestibility and crude protein concentration at the initiation of fall grazing, and its protein is not degraded in the animal's rumen as highly as the protein in alfalfa.
- The nutritive value of kura clover forage is not greatly affected by weathering in the fall. Although it has high fiber but lower protein concentrations than alfalfa hay, oat-berseem clover hay is almost as digestible as alfalfa hay and its protein is less degradable.
- The efficiency of sheep ruminal microbial protein synthesis is related to the proportion of amounts of nitrogen and organic matter truly digested in the rumen. Optimal efficiency of protein and energy utilization for microbial protein synthesis in the rumen will occur at 3.69 g of nitrogen to 100 gm of organic matter truly digested in the rumen.

Impact of results

Although berseem clover fields were successfully established for three years prior to this project, the investigators were unable to obtain adequate berseem clover forage growth to conduct this experiment in 1997. This situation and the experiences of some producers seem to indicate that berseem clover is very

susceptible to drought and is not a reliable forage source.

The evaluation of stockpiled kura clover showed that kura clover is an extremely high quality forage as evidenced by its high concentrations of digestible dry matter and crude protein and low concentrations of neutral detergent and acid detergent fiber. Furthermore, the proportion of protein that escapes ruminal degradation is approximately twice that commonly observed for alfalfa. This characteristic should be beneficial for ruminants with high nutrient requirements such as growing steers or lactating cows. Findings suggest that some decrease in nutritional value of kura clover will occur during the winter, but the nutritional value of kura clover at the beginning of the period is so high that it is likely to be a valuable forage for early winter grazing.

In a comparison of utilization of organic matter and protein from different forages by sheep, it was found that the proportion of protein that escaped ruminal degradation in oat-berseem clover hay was 100 percent higher than that in alfalfa. Identifying that the efficiency of microbial protein production is maximized in the rumen should assist in the preparation of forage-based rations that enhance protein utilization, thereby optimizing the utilization of protein supplements and reducing feed costs while minimizing the amounts of nitrogen excreted back into the environment in the animal's urine.

Education and outreach

Information developed during this project will be distributed to the public in cattle research reports and within future presentations on winter grazing and protein supplementation of high forage diets.

After deciding to evaluate the corn-kura clover intercropping system developed at the University of Wisconsin in 1997, a joint effort was made with Dr. Kenneth Albrecht from the University of Wisconsin's Department of Agronomy to collect kura clover samples from his field plots at the UW Lancaster Research Farm.

For more information contact James Russell, Animal Science, Iowa State University, Ames, Iowa 50011; (515) 294-4631; e-mail jrussell@iastate.edu.