SEASONAL CHANGES IN QUALITY OF THREE COOL SEASON PERENNIAL GRASSES

by

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INTRODUCTION

This study was instituted to generate forage quality data throughout the year to be used in developing better pasture management practices for cool-season grasses in eastern Kansas.

In the past few years cow-calf operators have been turning to forages as a potential year-round feed for cows. This trend has been due to increased production costs along with the ever increasing competition between man and domestic animals for cereal grains. Van Kuren (1975) noted approximately 70 percent of the total cost of a beef cow and calf enterprise is feeding cost, with wintering estimated at two-thirds of feed cost. Therefore, more information is needed on the year-round potential for forage utilization by livestock. Of particular importance with cool-season perennial grasses is the value of forage available in summer and winter when these species are relatively dormant.

There are over two and a half million acres of tame pastures in Kansas. The majority of these are located in eastern Kansas and are mainly established in cool-season perennial grasses which make most of their growth in spring and fall.

The performance both in yield and quality of forage depends on many factors such as soil type and fertility, geographical area, rainfall, grazing pressure, stage of maturity, level of applied fertility, and season of the year. Because of these varying factors, it is difficult to predict forage yield and quality in one area from data obtained under different conditions in another area. Therefore, this study was designed to determine seasonal changes in selected quality and mineral factors, using laboratory analyses in tall fescue, _Festuca arundinacea_ Schreb., smooth brome, _Bromus inermis_ Leyss., and reed canarygrass, _Phalaris arundinacea_ L. growing in the Kansas Flint Hills area.

LITERATURE REVIEW

FORAGE RESPONSE TO NITROGEN FERTILIZER

Nitrogen, in many cases, is the first factor limiting growth in pure grass stands, and a deficiency in this element generally results in both low yield and low quality (Carter and Scholl, 1964).

In researching the utilization of fertilizer by six pasture grasses, including reed canarygrass, orchardgrass, brome and tall fescue, Duell (1960) in New Jersey, found that the protein content increased similarly with each increment of fertilizer. Working in Wyoming with eight grasses including brome, orchardgrass and reed canarygrass, Lewis and Long (1957) found a highly significant increase in crude protein production for each increment of nitrogen. However, there were no appreciable differences among the grasses in average crude protein yield. As the level of nitrogen fertilization increased, Barth et al. (1959) found a corresponding increase in protein and moisture content of brome and reed canarygrass, and a small decrease in fiber in brome. In Maryland, nitrogen fertilizer increased the protein content of forage even when the forage was cut at advanced maturity (Gordon et al., 1962). In New Jersey Ramage et al., (1958) found that nitrogen applications significantly increased protein content and significantly decreased crude fiber content of orchardgrass and reed canarygrass.

Researchers presented conflicting data on the effect of nitrogen on forage dry matter digestibility. Neihaus (1971) and Clovos et al. (1961), working with reed canarygrass and brome respectively, found that the dry matter digestibility was not greatly affected by nitrogen fertilization. However, Reid et al. (1967b), grazing sheep on orchardgrass in West Virginia found that the digestible dry matter was increased in all grazings for all dates with increased nitrogen. Reid _et al_. (1967a) found significant increases in dry matter digestibility of tall fescue, due to fertilizer treatments. Kane _et al_. (1961) showed that, under favorable conditions, digestibility and energy yields of forage can be significantly increased by use of nitrogen fertilizer.

Researchers also presented conflicting data on the effects of nitrogen on ash content of forages. Woelfel _et al_. (1960) reported that ash content of timothy increased slightly with nitrogen application. However, Ramage _et al_. (1958) found that percentage ash decreased when fertilized with nitrogen. Clovos _et al_. (1961) reported that, with brome, percentage ash tended to decrease with increasing rates of nitrogen up to approximately 100 pounds of nitrogen per acre, and then to increase slightly with higher nitrogen applications. However, Reid and Jung (1965) found the opposite in tall fescue, with ash increasing up to the medium nitrogen rate of 150 pounds per acre and then decreasing at the highest rate of 450 pounds per acre.

Whitehead (1966), evaluating the effects of a given fertilization treatment on mineral concentration in plants, emphasized the three following factors.

1. Addition of a nutrient to the soil can be expected to cause an increase in the level of that element in the plant (unless growth has previously been limited by a deficiency of the element).

2. The degree of change in plant mineral composition may be affected by the time period between application and harvesting or grazing.

3. Effects of a given fertilization treatment on plant mineral uptake and concentration may be significantly related to the effect the treatment has on soil pH.

Hojjati et al. (1977), in Kentucky, and Reid et al. (1967 and 1970), in West Virginia, reported that higher levels of nitrogen fertilizer generally were associated with an increased concentration of K, Ca and Mg in cool-season grasses. They also noted that the effect of nitrogen fertilization on P in plant tissue was not consistent. However, the latter researchers indicated that increasing levels of nitrogen tended to depress P in forage. Reid et al. (1966) found that higher levels of nitrogen fertilization increased the K and Mg contents of orchardgrass but that there was no uniform effect of nitrogen level on content of P or Ca. Stewart and Holms (1953) noted that high levels of soil nitrogen decreased K and increased Ca, Mg, and Na while having little effect on concentration of P in plant tissue.

Reid et al. (1967a) working with tall fescue, showed that nitrogen-treated herbage generally contained higher levels of K than grass without applied nitrogen. Reid also noted that higher nitrogen levels had no effect on concentrations of P, Ca, and Mg. Follet et al. (1975) also reported that fertilizing with nitrogen had no significant effect on Ca concentration. Reid et al. (1965) determined the chemical composition of tall fescue hay at four rates of nitrogen fertilization. They reported a significant increase in percentage of K and Ca with increasing nitrogen rates. Percentages of P and Mg showed no consistent response to nitrogen rate.

In Wyoming, nitrogen applications significantly increased average Ca and P percentages in brome, orchardgrass and reed canarygrass, although increase in the percentage of P was relatively small (Lewis and Long, 1957). They also indicated that Ca percentage was influenced more by grass species than by nitrogen application. Reith et al. (1964), in Great Britain, reported that nitrogen treatment increased percentage of Mg, generally depressed percentage of K, and had relatively little effect on concentration of P. Russell et al. (1954), in Nebraska, reported a noticeable increase in percentage K with decreases in percentages of Ca and Mg due to nitrogen fertilization.

In western South Dakota, Thomas et al. (1959) found a highly significant increase in yield of brome due to residual carryover from all nitrogen treatments. Residual nitrogen from high nitrogen rates significantly increased protein percentage of the brome. In Canada, Kin Look and MacKenzie (1970), working with brome, indicated that fall- or spring- applied nitrogen had some residual effect on summer growth. However, no significant differences in crude protein percentage were found among spring, prewinter, and spring-plus-prewinter applications of nitrogen. Kin Look reported a residual effect of nitrogen on crude protein percentage for prewinter-plus-spring nitrogen treatment cut August 3. However, no significant differences in crude protein percentage were found among spring, prewinter, and spring-plus-prewinter applications of nitrogen for a June 14 cut.

SEASONAL CHANGES

Increased production of stem, and the resulting changes in ratio of stem to leaf, associated with advancing plant maturity, have a marked influence upon the yield and feeding value of forage. Rapid increase of stem during the period preceding bloom, and loss of lower leaves in the advancing stages of maturity, account for marked changes, not only in yield but also in chemical composition, palatability and digestibility of a grass plant (Bird, 1943).

Composition of dry matter undergoes continual change in the growing plant. Several researchers found that with advancing maturity, there is a downward trend in the percentage of protein, ether extract, and ash, and an upward trend in crude fiber percentage. (Lloyd *et al.*, 1961 Muncrief, 1944; and Phillips *et al.*, 1954; Sotola, 1941 and Reid *et al.*, 1967a) also reported a decline in percentage of crude protein with advancing maturity. Lloyd *et al.* (1961) noted a decrease in *in vitro* cellulose digestion with advancing maturity of forage.

CRUDE PROTEIN

Level of crude protein in herbage, at different times of the year, was positively correlated with amount of nitrogen fertilizer (Gardner and Hunt, 1955). Buckner *et al.* (1967), in Kentucky, found protein highest during cool damp conditions of early spring after nitrogen fertilization, and lowest during the hot dry summer months.

Bird (1943) noted a decrease in percentage of crude protein, from 16.6 to 6.0 from short-grass stage to end of bloom. Furthermore, a seasonal influence was observed for cool-season grasses, indicating midsummer depression in protein percentage. Sullivan *et al.* (1956), working in the northeastern United States with reed canarygrass, tall fescue, and brome, found protein percentage to be fairly stable in the spring, with summer values lowest and fall values highest. Muncrief (1944) also noted that fall crude protein values were higher than spring values with ryegrass grown in Oklahoma.

IN VITRO DRY MATTER DIGESTIBILITY

Type of herbage and stage of morphological development are main factors determining the extent to which herbage is digested by ruminants (Minson *et al*., 1960). Crampton and Jackson (1944), studying seasonal variation in chemical composition of pasture herbage, noted that seasonal trends in digestibility of the energy yielding portion reflect changes in the nutritive value of the feed. They suggested that digestibility of pasture herbage by steers and sheep follows the leaf-stem ratio quite closely.

Several researchers have pointed out that the digestibility of grasses decreases with advancing maturity. Reid *et al*. (1967a), in West Virginia, showed that significant differences in dry matter digestibility were due to fertilization treatment and stage of maturity, with the interaction between fertilization treatment and trial date being highly significant. Using sheep to study the digestibility of several grass species at different stages of maturity, Minson *et al*. (1960) found that the percentages of digestible dry matter of first growths in the spring remained almost constant until heads started to emerge, and then fell rapidly.

Investigating seasonal variation in chemical composition of several grass species in Canada, Crampton and Jackson (1944) concluded that digestibility of dry matter may vary from 80 percent in early spring to 60 percent or less in midsummer. Growing Kentucky 31 tall fescue in chambers with long days and high temperatures significantly lowered percentage of *in vitro* dry matter digestibility. These changes were associated with increased levels of structural components (Allinson, 1971).

Berry and Hoveland (1969), using the nylon bag technique to determine digestibility of tall fescue, also concluded that summer forage was of low quality. Swift et al. (1952) determined the digestibility of successive cuttings of orchardgrass by grazing sheep. They observed a seasonal decline in digestibility from spring to fall cuttings. However, Buckner et al. (1967) found that digestibility of 'Kentucky 31' tall fescue harvested spring, summer, and fall, increased from July to October. Brown et al. (1963) noted that dry matter digestibility of Kentucky 31 tall fescue did not decrease with advancing age of plants in the fall.

FIELD DRY MATTER

Sullivan et al. (1956) concluded that moisture content is a characteristic of the species of grass and is negatively correlated with lignin content. Moisture percentage was found to be highest at spring harvest, lowest in the summer, and then to trend upward in early fall. In work done in Washington State, moisture content was found to decrease progressively through the growing season from early May through mid August (Sotola, 1941).

Lassiter et al. (1956) noted a seasonal trend in field dry matter which was similar for all cool-season grasses tested. They found dry matter content to be low in the early spring and early fall while crude protein content was high at those times. They also reported that dry-matter digestibility was high when dry matter was low. Archibald et al. (1943) found that moisture content was positively correlated with acceptance by animals. In another study, dry matter intake remained at a high level from March through July but decreased to a suboptimal level in August and September, except with tall fescue which maintained a medium-high intake during August (Lassiter et al., 1956).

AFTERMATH CROPS (REGROWTH)

Aftermath crops do not show marked changes in nutritive value (Wright et al., 1967). Several researchers have documented that in vitro dry-matter digestibility declines much more slowly in regrowth than in first growth (Reid et al., 1959; Decker et al., 1967; and Wright et al., 1967). Minson et al. (1960) used sheep to determine digestibilities of orchardgrass and ryegrass regrowths. They found values to be much less variable than in first growths. Reid et al. (1967a) concluded that dry matter digestibility of tall fescue regrowth in vegetative stage was uniformly lower than digestibility of the vegetative growth of the first cut. Rhykerd et al. (1966) reported that nitrogen content of first-cut brome at early heading was considerably lower than the content of an aftermath cutting which consisted entirely of vegetative growth. Minson et al. (1960) noted that in regrowths of orchardgrass and ryegrass percentages of nitrogen and ash were increased in successive cuts while digestible dry matter was decreased. Reid et al. (1966) reported that orchardgrass aftermath cut in late July in West Virginia was higher in concentrations of P and Mg and lower in K than first-cut grass harvested in mid-May. In two later studies in West Virginia, Reid et al. (1967 and 1970) found that in general, K was higher and Ca and Mg lower in first growth than in regrowth.

SPECIES COMPARISONS

In comparing tall fescue and reed canarygrass on five successive harvest dates in Iowa, Wedin et al. (1966) noted a distinct difference between in vitro dry matter digestibilities of the two grasses, digestibility of tall fescue being higher than that of reed canarygrass. In *vitro* dry matter digestibility values for tall fescue did not vary significantly as fall harvest date was delayed whereas those for reed canarygrass decreased markedly. Furthermore, the fall dry matter percentage for tall fescue was consistently lower than for reed canarygrass, an indication of better frost tolerance in tall fescue. However, canarygrass was higher in crude protein percentage and lower in crude fiber percentage than tall fescue. In a New York study, Monson and Reid (1968) observed only small differences among *in vitro* dry matter digestibilities of reed canarygrass, brome, and orchardgrass in early May. In late June, however, differences were larger with reed canarygrass showing the least decline in digestibility.

Assessing chemical composition of reed canarygrass, tall fescue, and brome in successive cuttings during the growing season, Sullivan *et al*. (1956) found canarygrass and tall fescue significantly higher in protein than brome. However, Lassiter *et al*. (1956) noted that the crude protein percentage of brome was significantly higher than that of Kentucky 31 tall fescue. Smith *et al*. (1974), in Wisconsin, concluded that reed canarygrass was significantly higher than brome in crude protein percentage, ash, and *in vitro* dry matter digestibility. Brome and tall fescue were significantly higher in cellulose and lignin than reed canarygrass, and tall fescue and canarygrass were significantly higher in ash than bromegrass (Sullivan *et al*., 1956).

FALL-SAVED PASTURES

In Kentucky, Taylor and Templeton (1976) stockpiled tall fescue forage for winter pasturage. At 100 kg N/ha, tall fescue continued to accumulate dry matter at a significant level during November. From December to March, accumulated dry matter of standing crops decreased due to unfavorable growing conditions, weathering, and leaf drop, the greatest losses occurring on the plots with highest levels of applied nitrogen. In Missouri, Matches et al. (1973) observed that tall fescue stockpiled for winter grazing suffered losses in digestibility, dry matter, and crude protein from October to January. Gardner and Hunt (1955) reported average losses of 37 percent in dry matter and 46 percent in crude protein, in orchardgrass, from December to February.

Swards of Kentucky bluegrass and tall fescue were sufficiently high in protein throughout the winter to meet the requirements of non-lactating beef brood cows, although the grasses decreased in protein from October through the winter. Percentage of P was high in October, November, and early December but declined markedly during late winter. Digestibility and protein decreased only slightly during autumn (Taylor and Templeton, 1976).

In West Virginia, nitrogen fertilization stimulated growth of autumn-saved pastures and also tended to increase crude protein percentage. Application of 100 kg N/ha in late summer produced up to 50 percent more dry matter by early winter than zero nitrogen. In vitro dry matter digestibility of the forage was not affected by nitrogen fertilization (Archer and Decker, 1977). From early October to early November, little dry matter accumulation was observed with tall fescue at zero nitrogen, whereas the grass continued to grow 50 to 100 kg N/ha. This indicated that appreciable amounts of dry matter can be produced in fall under moderate levels of nitrogen fertilization with tall fescue. Generally, nitrogen-treated plots had a higher percentage of green herbage at any given time than zero-nitrogen plots. However, by March no differences were observed among fertilization rates (Taylor and Templeton, 1976).

In evaluation of reed canarygrass and tall fescue as spring, summer, and fall-saved pasture in Iowa, Bryan et al. (1970) found that in early November, tall fescue was superior to reed canarygrass in digestibility, voluntary intake, crude protein percentage and yield. Percentage of crude protein was greater for canarygrass in all periods except late July and early November. Both grasses were highest in crude protein in early October and lowest in June and July. Tall fescue was superior to canarygrass in nutritive value in early November. Field dry matter of canarygrass increased after the first series of low temperatures in November, and the grass appeared to be adversely affected by cold temperatures. Wedin et al. (1967), working with fall-saved forages, found tall fescue maintained in vitro dry matter digestibility better than canarygrass or brome during late fall and early winter, although crude protein percentage held up best in brome. They also noted that fescue was more frost tolerant than canarygrass.

In evaluating all-season pastures for beef cows in Ohio, Van Keuren and Neihas (1975) found that tall fescue winter pasture was of adequate quality and quantity for pregnant beef cows, with standing forage averaging 9.3 percent protein over three years. In digestion trials with steers confined in stalls, Bryan et al. (1970) showed that tall fescue was more digestible than reed canarygrass, except in June, and that steers consumed more dry matter of tall fescue than of canarygrass in all months except June. However, it was pointed out that first growth tall fescue matured more quickly and was lower in nutritive value than first growth canarygrass on the same date.

MINERALS

Underwood (1962) suggested that the four most important factors controlling mineral concentration are: 1) genus, species or strain of plant, 2) type of soil on which the plant is grown, 3) climatic or seasonal conditions during growth, and 4) stage of maturity of the plant.

Effects of growth stage on mineral content of forage plants have been well documented, although there are some conflicting reports. Whitehead (1966) pointed out that it is sometimes difficult to distinguish among maturation, seasonal, and climatic effects. Kivima (1959), working with a range of forage crops, showed a linear rate of decline in ash content with time and found that the rate varied with species. The Ca content of timothy was highest in the leaf stage and declined slowly towards flowering. Two other studies reported that Ca followed no set pattern with advance of maturity (Van Riper et al., 1961). Whitehead (1966) concluded that in grasses K, Ca, Mg, and Na tend to be lower in concentration in mature than in young plant tissue, although peak values sometimes occur at intermediate states of growth.

For several grass species, Thomas et al. (1952) and Fleming (1965) showed that the levels of N, P, K, Ca and Na decreased with plant age. The latter workers found that Mg content exhibited little change with advancing maturity. However, two other researchers reported a significant increase in Mg content with advance of growing season (Reith et al., 1954; Todd, 1961). Studies by Pritchard et al. (1964) and McCreary (1927) showed that mineral nutrients in forage vegetation tended to decrease as growth increased. Watkins (1943) reported that range vegetation decreased in P and N during the winter while Ca content remained unchanged. Old (1969) found that the amount of Mg, P, and K in prairie litter decreased during decomposition in June, July, and August. Koeling and Kucera (1965) reported that foliage of bluestem, (Andropogon gerardi), remained constant in Ca and decreased in N, P, K, and Mg during one growing season and the following winter. Thus, nutrients in prairie vegetation are not returned to the soil or to run off water at the same rates.

White (1973), investigating over-winter changes in Ca, Mg, and K contents of prairie vegetation and mulch in South Dakota, found that change was least for Ca, greatest for K and intermediate for Mg. Over three sampling dates, early September, early November, and late April, percentages of Ca, Mg, and K in the mulch tended to be greatest in November, possibly because of addition to these ions from partially decomposed vegetation, or from leaching of standing vegetation.

Reid et al. (1970) and Russell et al (1954) found that K, P, Ca, and Mg showed significant decrease with advancing maturity of grass. The former researcher indicated that peak concentrations of K and P occurred in early spring, while levels of Ca and Mg tended to be low at this time and to increase through summer and fall. Percentages of P and K showed regular decline into fall and winter. Rates of decline in concentrations of the major elements resulted in critically low concentrations of P, Ca, and Mg at more advanced stages of maturity.

Loneragan et al. (1968) found that in grasses Ca accumulation was slower than dry matter increase so that the concentration of Ca in the tops decreased with age. These data suggest that Ca supply may be marginal for animals grazing mature grass. Reith et al. (1964) noted that percentage of P in herbage showed no large seasonal variation. However, they found definite seasonal increases in percentages of both

Ca and Mg. Duell (1960) presented data on K content showing regular seasonal and annual declines. It was indicated that declines were due to removal of more K by cropping than was applied as fertilizer.

MATERIALS AND METHODS

Location and Plant Materials

A field study was initiated on the Agronomy Farm of Kansas State University, Manhattan, Kansas, in 1973 to gather more information on the potentials of selected cool-season, perennial grasses grown in eastern Kansas. The present thesis study began in 1975 and made use of three cultivars from the 1973 planting. 'Achenbach' smooth brome (SB), 'Kentucky 31' tall fescue (TF) and 'Ioreed' reed canarygrass (RCG) were the selected cultivars. Achenbach and Kentucky 31 were recommended in Kansas at the time of the study. Ioreed was selected as an appropriate representative of reed canarygrass in eastern Kansas.

Plots were seeded April 2-6, 1973 using a modified Planet Junior seeder fitted with a double-disk furrow opener. Drill-row spacing was 17 cm. Fifty-six kg N/ha as anhydrous ammonia was applied September 2, 1973 to all plots. All cultivars had good-to-excellent stands in early spring, 1974.

The soil was an Ivan silt loam of the fine, silty, mixed, mesic family in the Cumuic Hapludolls subgroup of the Mollisols. Available phosphorus and exchangeable potassium were 101 and 773 Kg/ha, respectively. Soil was limed to a pH of approximately 6.8 in 1973; initial pH was 5.7.

Precipitation at Manhattan was slightly above normal in 1975 with conditions extremely droughty in 1976 (Table 1). Temperatures were fairly normal (Table 2).

Table 1. Monthly Precipitation[1/] (Environmental Data Service, 1975-76)

Month	Precipitation	Departure from Normal[2/]
August, 1975	4.17	0.57
September	4.82	0.86
October	0.10	-2.62
November	4.17	3.73
December	0.78	-0.22
January, 1976	0.45	-0.41
February	0.52	0.40
March	2.16	0.31
April	6.01	3.01
May	3.86	-0.49
June	5.93	0.09
July	1.15	-3.23
August	0.29	-3.31

[1/] In inches.

[2/] Average for 1941-70.

Table 2. Mean Monthly Temperatures[1/] (Environmental Data Service, 1975-76)

Month	Temperature	Departure from Normal[2/]
August, 1975	80.95	2.6
September	65.45	-3.6
October	61.35	2.8
November	46.70	3.2
December	36.65	3.2
January, 1976	31.00	2.3
February	45.15	11.2
March	45.75	3.8
April	58.15	2.7
May	61.45	-3.7
June	73.40	-0.9
July	79.75	-0.7
August, 1976	79.75	1.4

[1/]Fahrenheit degrees.

[2/]Average for 1941-70.

Nitrogen Treatments

Six nitrogen treatments (KgN/ha) were used on each of the three cultivars. These included no nitrogen (00), 90 Kg/ha in fall (01), 180 Kg/ha in fall (02), 90 Kg/ha in spring (10), 90 Kg/ha in spring and fall (11) and 180 Kg/ha in spring (20). Nitrogen was applied as NH_4NO_3 with a Gandy spreader. Spring applications, February 27, 1974, April 10, 1975, and March 2, 1976. Fall applications, September 7, 3, and 20 in 1974, 1975, and 1976, respectively.

Sampling and Sample Preparation

Plant samples used for laboratory analyses were hand harvested approximately three inches from the ground using a manual grass clipper. At least three random cuttings were taken from each plot, sixteen times over a twelve month period. Samples of the freshly harvested material were weighed in the field, then forced-air dried to a constant weight at approximately 55 C. Samples were dried approximately 48 hours and then reweighed. Field dry matter was calculated by dividing the dried weight by the wet weight and multiplying by 100. After determination of field dry matter percentage, samples were ground through a Wiley Mill, using a 1 mm screen, and stored in air-tight containers.

Hand sampling began September 25, 1975, on new growth, and continued through February 19, 1976, on standing forage. On February 26, 1976 plots were mowed. Plots were fertilized March 2, 1976. Hand sampling resumed on March 25, on regrowth, and continued through May 27, 1976. Hand samples after June 1, 1976 consisted of summer regrowth after plots were again mowed. Hand samples were taken more frequently during seasons of rapid growth. Sampling dates are presented in Table 3.

Table 3. Sampling Dates

Harvest	Dates
1	September 25, 1975
2	October 9, 1975
3*	October 23, 1975
4*	November 12, 1975
5*	December 3, 1975
6*	January 30, 1976
7*	February 19, 1976
8*	March 25, 1976
9	April 12, 1976
10*	April 22, 1976
11	May 8, 1976
12*	May 19, 1976
13	May 27, 1976
14*	June 1, 1976
15	June 28, 1976
16*	August 27, 1976

*Dates for mineral analysis.

Table 4. Laboratory Analyses

Determination	Method	Authority
Crude protein	Micro kjeldahl (Technicon)	Technicon Industrial
Dry matter	100 C, oven	AOAC
Ash	580 C, Muffle furnace	AOAC
IVDMD	Test tube digestion	Tilley and Terry (1963) modified by Monson, et al. (1969)
Ca, Mg, and K	Atomic Absorption-flame emisson	Isaac and Johnson (1975)
P	Vanadomolybdate method	Fisk and Row (1925)

Laboratory Analyses

All forage samples were analyzed for percentages of field dry matter, crude protein, *in vitro* dry matter digestibility (IVDMD), dry matter on 100-C basis and ash.

Mineral analyses for Ca, Mg, K, and P were run on ten sample dates denoted by '*' in Table 3. Samples from plots in the first replication of the field planting and from the 02 and 20 nitrogen treatments were excluded from the mineral analysis. See Table 3 for sampling dates used in mineral determination.

All values for percentages of crude protein, ash, and Ca, Mg, K, and P were corrected to a 100-C dry matter basis.

Values for percentage of IVDMD were corrected by use of standards for each run. This was done to eliminate animal and ration factors that varied among rumen fluid collections. The formula used to correct IVDMD is as follows:

$$\text{Corrected IVDMD} = \frac{(\text{Sample} - \text{Standard}) \times 100)}{\text{Standard}} + 100$$

Field Design and Statistical Treatment

The study was a split-plot experiment with the cultivars as main-plot treatments and six nitrogen regimes as subplot treatments. There were four replications. Subplots were 6.1 x 1.5m; main plots, 9.0 x 6.1m. Hand samplings and species were considered randomly associated.

RESULTS AND DISCUSSION

The following sampling dates have been seasonally grouped:

Fall Sampling
- September 25
- October 9
- October 23

Spring Sampling
- March 25
- April 12
- April 22
- May 8
- May 19
- May 27

Winter Sampling
- November 12
- December 3
- January 30
- February 19

Summer Sampling
- June 1
- June 28
- August 27

FIELD DRY MATTER (FDM)

Field dry matter percentages varied significantly with species, nitrogen treatments, and sampling dates. All first order interactions were significant. Means for the first order interactions are shown in Tables 5, 6, and 7. Trends are shown graphically in Figures 1, 2, and 3. The analysis of variance is shown in Appendix Table 16.

After first frost, RCG was significantly higher than TF and SB until spring regrowth. Tall fescue was significantly lower in field dry matter than RCG and SB during early winter samplings, as it remained green later in the season. This agreed with results of Bryan et al. (1970) in Iowa, who found that percentage of dry matter increased in RCG over TF after the first series of cold temperatures. Wedin et al. (1966) also in Iowa found that fall dry matter for TF was consistently lower than RCG indicating better "frost tolerance" in TF. The overall trend was for FDM to increase beginning with the fall samplings and advancing

Table 5. Percent Field Dry Matter Content as Affected by Species and Fertilizer Treatment

Species	Fertilizer Treatment					
	00	01	02	10	11	20
Brome	48.47	41.38	38.89	45.56	39.70	41.81
Fescue	44.52	40.20	37.10	43.19	37.68	41.16
Reed Canary	47.46	43.34	41.89	43.99	41.85	43.35

[1]Compare fertilizer treatments within same level of species: LSD .05 = 1.74, LSD .01 = 2.33.

[2]Compare species with same or different fertilizer treatments: LSD .05 = 2.33, LSD .01 = 3.32.

Table 6. Percent Field Dry Matter Content as Affected by Species and Sampling Date

Dates	Species		
	Brome	Fescue	R.C.G.
1	24.96	25.73	26.33
2	39.55	36.40	36.76
3	50.50	42.05	46.28
4	56.72	49.79	50.63
5	56.72	49.47	70.98
6	77.31	70.90	88.43
7	76.94	79.07	96.48
8	35.83	49.14	39.49
9	27.71	32.80	27.28
10	24.25	25.60	23.04
11	26.49	26.57	24.82
12	27.59	26.70	24.18
13	32.73	27.59	24.76
14	33.33	34.41	29.75
15	40.15	33.65	37.30
16	51.36	40.40	51.84

[1]Compare two sampling dates within same species: LSD .05 = 2.60, LSD .01 = 3.42.

[2]Compare two species within same or different sampling dates: LSD .05 = 3.03, LSD .01 = 4.15.

Table 7. Percent Field Dry Matter Content as Affected by Nitrogen Treatment and Sampling Date

Dates	Nitrogen Treatment					
	00	01	02	10	11	20
1	30.76	22.23	19.68	29.63	22.12	29.62
2	44.48	32.52	29.37	45.03	32.12	41.91
3	51.31	43.23	41.17	49.42	44.56	47.98
4	59.13	49.28	42.32	57.35	49.03	57.17
5	65.96	51.68	49.85	68.74	52.96	65.16
6	78.45	79.63	76.79	81.51	76.43	80.49
7	87.87	81.42	77.95	87.73	83.43	86.58
8	56.36	43.13	39.03	39.58	34.63	36.22
9	38.00	32.95	29.38	27.13	25.27	22.88
10	27.66	26.59	25.44	23.60	22.43	20.03
11	28.91	27.85	26.44	25.90	24.29	22.37
12	28.27	27.90	26.65	26.30	24.82	23.02
13	29.13	29.36	29.39	28.27	27.90	26.10
14	35.86	33.72	31.75	32.71	31.22	29.75
15	38.43	37.37	36.28	37.62	36.54	35.95
16	48.53	47.37	47.18	47.45	48.13	48.54

[1]Compare sampling dates within same nitrogen treatment: LSD .05 = 3.68, LSD .01 = 4.84.

[2]Compare nitrogen treatments with same or different sampling dates: LSD .05 = 3.70, LSD .01 = 4.86.

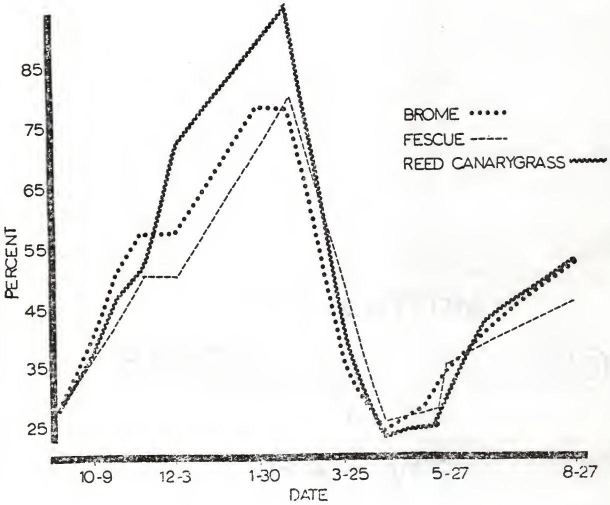

Figure 1. Percent field dry matter content as affected by species and sampling date.

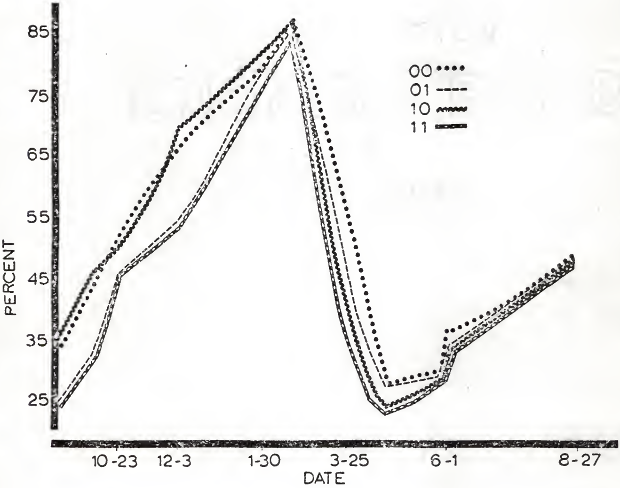

Figure 2. Percent field dry matter content across all species as affected by nitrogen treatment and sampling date.

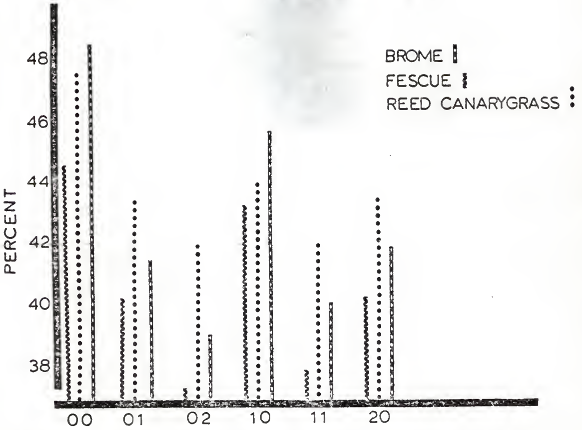

Figure 3. Percent field dry matter content as affected by species and nitrogen treatment.

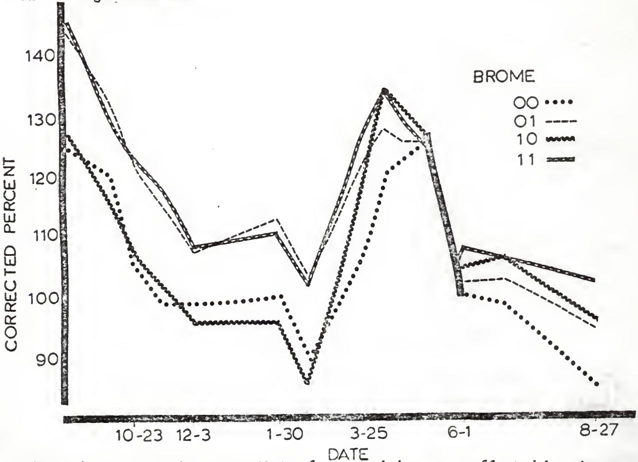

Figure 4. Corrected percent IVDMD for smooth brome as affected by nitrogen treatment, and sampling date.

maturity. Field dry matter began to decrease with spring regrowth and continued downward until late April when it began to increase again as the stem and leaf ratio increased. All species were similar during the spring and summer samplings.

The 02 and 20 nitrogen treatments were lowest in FDM in the fall and spring, respectively. Barth et al. (1959) working with SB and RCG also found that dry matter decreased as nitrogen fertilization increased.

IN VITRO DRY MATTER DIGESTIBILITY (IVDMD)

IVDMD varied significantly among sampling dates, species and nitrogen treatments. All first and second order interactions were highly significant. Means for the second order interactions are shown in Table 8. Characteristics of interactions are apparent in Figures 4, 5, and 6. Analysis of variance is summarized in Appendix Table 17.

Of the three species, RCG has the lowest IVDMD beginning in early November after first frost and until regrowth was sampled in the spring after nitrogen fertilization. This agrees with the findings of Bryan et al. (1970) who indicated that TF was superior in digestibility to RCG during the fall and early winter. It appeared that RCG was adversely affected by low temperatures. After the first series of low temperatures in early November, foliage of RCG became extremely blanched. Tall fescue was slightly higher in IVDMD than SB during winter months indicating better frost tolerance, with respect to maintenance of forage quality. Again this agreed with the findings of Wedin et al. (1966) that TF was high in frost tolerance. Beginning in the spring RCG and SB were similar in IVDMD and both were significantly higher than TF until summer regrowth. Smooth brome was significantly higher than either RCG or TF with RCG significantly higher than TF during the summer.

Table 8. Adjusted Percent IVDMD as Affected by Nitrogen Treatment and Sampling date

Brome Dates	Nitrogen Treatment 1	2	3	4	5	6
1	124.37	144.77	145.11	127.59	145.60	131.87
2	119.96	132.16	135.87	113.63	129.55	117.74
3	105.78	121.02	125.92	106.78	122.72	113.90
4	98.32	115.01	123.53	101.88	118.07	106.29
5	98.28	106.85	108.87	95.58	107.90	103.51
6	99.78	112.33	118.92	95.39	110.09	104.09
7	89.48	102.35	106.44	84.96	101.01	92.47
8	105.16	120.66	126.74	116.91	125.62	126.89
9	119.63	127.39	127.17	133.88	133.48	138.18
10	121.84	124.93	125.46	130.18	128.41	131.93
11	124.40	124.23	124.02	126.45	124.22	126.64
12	115.86	111.52	113.40	115.00	110.56	116.10
13	111.26	105.48	106.43	109.42	103.18	103.76
14	99.50	101.90	106.00	104.05	107.41	112.81
15	98.07	102.01	108.21	105.90	105.90	108.16
16	84.80	93.68	98.06	95.49	101.42	103.30

Fescue Dates	Nitrogen Treatment 1	2	3	4	5	6
1	114.63	134.17	143.69	113.80	135.72	119.57
2	113.04	130.33	134.89	111.95	127.84	113.14
3	109.30	120.87	124.53	107.55	116.90	108.87
4	104.02	115.13	121.95	103.79	114.69	103.72
5	96.14	107.82	115.47	100.40	108.64	100.66
6	102.24	107.04	119.91	101.39	109.83	104.61
7	91.67	98.20	109.72	90.83	102.60	92.19
8	96.68	107.17	111.21	105.34	117.53	113.11
9	106.84	113.09	119.55	127.28	127.72	135.64
10	111.75	110.62	111.67	118.01	117.68	123.81
11	110.85	111.82	113.46	113.05	114.79	117.58
12	108.69	108.28	108.45	111.43	112.83	113.57
13	102.84	99.77	101.17	103.28	104.60	106.71
14	82.58	81.49	82.08	81.49	81.65	84.29
15	77.97	82.98	80.75	77.50	77.98	79.83
16	80.46	79.91	80.14	78.56	75.88	77.08

Table 8. (continued)

Reed Canary	Nitrogen Treatment					
Dates	1	2	3	4	5	6
1	122.16	134.46	141.01	123.05	136.61	123.01
2	114.30	124.61	132.47	117.43	128.33	114.77
3	109.30	116.03	122.50	109.71	117.50	110.33
4	101.61	108.12	113.29	106.40	104.86	102.11
5	92.18	97.05	104.10	89.18	95.74	90.54
6	80.48	83.38	89.90	78.90	79.49	78.72
7	79.05	81.36	86.90	78.43	81.31	79.58
8	85.05	103.84	116.73	117.29	125.49	119.96
9	118.13	127.10	129.32	134.17	134.42	137.32
10	118.88	121.65	123.68	124.91	124.73	128.25
11	120.91	123.67	123.29	123.13	121.61	121.23
12	120.29	119.36	115.81	117.04	113.40	115.35
13	109.95	109.22	107.58	106.89	101.85	102.33
14	93.53	95.86	96.67	97.75	101.61	100.21
15	86.70	87.67	90.43	89.37	88.73	87.71
16	78.91	82.71	82.25	82.10	85.47	84.40

[1]Compare nitrogen treatments within same species with same or different sampling dates: LSD .05 = 6.33, LSD .01 = 8.41.

[2]Compare species with same or different nitrogen treatments and same or different sampling dates: LSD .05 = 6.58, LSD .01 = 8.76.

[3]Compare sampling dates within same nitrogen treatment and same species: LSD .05 = 6.27, LSD .01 = 8.25.

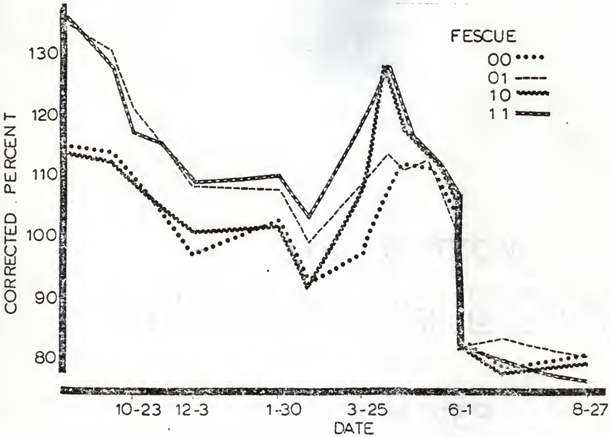

Figure 5. Corrected percent IVDMD of tall fescue as affected by nitrogen treatment, and sampling date.

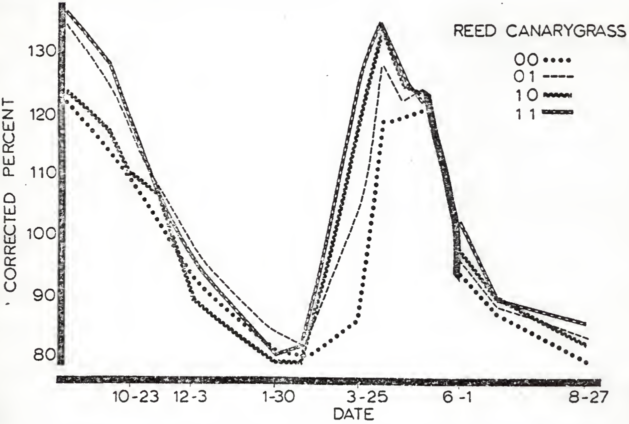

Figure 6. Corrected percent IVDMD of reed canarygrass as affected by nitrogen treatment, and sampling date.

Of the six nitrogen treatments the 00 showed the lowest IVDMD throughout the sampling year. This agreed with work done by Reid et al. (1967), in West Virginia who found that digestible dry matter increased at all sampling dates with increased nitrogen. Kane et al. (1961) also showed that digestibility of forage can be significantly increased by use of nitrogen fertilizer. The 02 treatment had the highest IVDMD through fall and winter, but began to decrease beginning with spring regrowth in March. The 20 treatment was highest in IVDMD for a brief period beginning in early April and extending through the May 8 sampling when plants neared heading and began to increase in stem-leaf ratio. In TF and RCG there was no significant difference among nitrogen treatments during summer samplings. However, in SB all fertilization treatments except 10 were significantly higher in IVDMD than 00 throughout the study. Reid et al. (1967a) in determining digestibilities of summer regrowths of orchardgrass and ryegrass also found digestibilities to be less variable in regrowths than in first growth.

The IVDMD trended downward in all species and nitrogen treatments through the fall with advancing maturity, and through the winter during dormancy. Matches et al. (1973) stockpiling TF in Missouri for winter pasture also found that digestible dry matter decreased in winter. The IVDMD began to increase with spring regrowth. Another general downward trend began in late April, with the increase in stem-leaf ratio and advancement toward heading, and continued through summer regrowth. Crampton et al. (1944) found that the digestibility of pasture herbage followed the leaf-stem ratio closely.

The IVDMD was similar for the 20 and the 11 nitrogen treatment in the spring, and the 02 nitrogen treatment was similar to the 11 treatment in the fall. The 02 and 20 nitrogen treatments were consistently higher than the 01 and 10 nitrogen treatments in season of application. The 180 KgN/ha treatments were more digestible than the 90 KgN/ha treatments indicating more carryover of nitrogen in the heavier rates to the growing season after nitrogen applications. Treatment 10 differed little in IVDMD from the 11 nitrogen treatment during the spring and summer but was slightly lower during fall and winter. The opposite was true for the 01 treatment; IVDMD was slightly lower for 01 than for 11 in the spring and summer, but similar for the two treatments in fall and winter.

CRUDE PROTEIN

Crude protein percentage varied significantly among sampling dates, species, and nitrogen treatments. All first-order and second-order interactions were highly significant. Means for the second-order interactions are shown in Table 9, and the analysis of variance is summarized in Appendix Table 18. Data are presented graphically in Figures 7, 8, and 9.

Tall fescue tended to be lowest in crude protein during the entire year. Smooth brome and RCG were similar during early fall until first series of cold temperatures when RCG became severely blanched. Smooth brome remained higher in crude protein than RCG through the late fall and winter samplings. Beginning with spring sampling and continuing until summer regrowth RCG was higher in crude protein than SB and TF. Smooth brome and RCG were similar during the summer regrowth samplings. Review of the findings of several researchers working in different areas showed considerable disagreement regarding the relative protein contents

Table 9. Percent Crude Protein as Affected by Nitrogen Treatment and Sampling Date

Brome Dates	Nitrogen Treatments 1	2	3	4	5	6
1	15.29	25.78	27.44	15.34	23.53	15.08
2	14.54	22.18	27.01	13.97	21.65	14.86
3	12.60	15.01	18.80	11.03	14.86	11.74
4	9.57	13.25	20.65	9.64	13.97	9.46
5	11.28	15.26	19.32	10.37	13.76	11.11
6	9.91	13.26	15.53	9.12	11.87	10.39
7	10.07	14.00	16.68	9.02	12.30	9.73
8	12.57	17.50	21.35	21.49	26.29	27.77
9	11.91	15.79	17.69	21.55	22.24	28.01
10	13.64	14.65	15.99	19.63	19.17	26.73
11	11.20	11.89	12.35	14.39	14.94	20.38
12	10.45	9.43	10.23	11.22	11.35	15.49
13	9.35	8.46	8.15	9.57	9.54	11.41
14	12.68	13.17	14.79	14.20	15.85	18.32
15	11.85	14.27	11.96	12.29	13.52	14.81
16	7.63	8.11	7.92	8.01	8.75	9.28
Fescue Dates	**Nitrogen Treatments 1**	**2**	**3**	**4**	**5**	**6**
1	11.12	17.84	25.13	10.28	17.97	11.38
2	13.34	16.75	22.29	10.20	16.75	9.83
3	9.87	12.92	16.74	8.87	15.13	8.97
4	8.54	10.24	13.64	7.19	10.52	6.75
5	8.35	10.21	13.45	9.38	10.19	8.05
6	6.69	9.09	11.34	6.58	8.78	6.38
7	7.32	9.03	12.29	7.27	9.34	6.51
8	8.16	9.99	12.65	12.86	16.41	17.43
9	11.03	12.27	15.71	20.20	20.31	25.53
10	12.47	13.20	15.11	18.95	19.56	23.76
11	11.05	11.21	11.85	12.86	13.39	15.26
12	9.84	9.66	10.04	10.35	10.99	13.34
13	9.51	9.11	9.84	9.93	10.30	12.49
14	9.54	9.07	10.44	9.88	10.12	10.92
15	8.89	8.61	9.09	8.14	8.53	8.60
16	6.45	5.97	6.37	5.84	6.08	5.81

Table 9. (continued)

Reed Canary	Nitrogen Treatments					
Dates	1	2	3	4	5	6
1	14.92	22.68	28.58	14.36	24.06	15.70
2	14.51	19.87	24.06	14.40	17.97	14.51
3	11.92	14.50	19.31	11.52	15.58	11.19
4	9.19	11.56	14.80	9.31	11.35	8.78
5	10.66	11.97	14.56	10.08	12.54	9.24
6	9.32	9.55	11.92	8.60	9.64	8.54
7	9.69	10.52	13.82	9.97	10.51	9.68
8	10.33	14.38	20.44	25.50	26.59	30.76
9	18.26	20.11	24.08	25.10	26.95	30.76
10	18.00	19.86	22.81	23.40	24.72	26.58
11	14.95	15.37	17.57	16.45	18.74	21.29
12	12.37	12.33	13.86	13.67	15.14	16.69
13	11.56	11.82	13.41	12.69	13.26	15.63
14	13.90	14.48	15.62	15.20	16.57	19.86
15	12.32	11.54	12.16	11.93	11.33	11.97
16	8.54	8.41	8.53	8.47	8.55	8.28

[1] Compare nitrogen treatments within same species with same or different sampling dates: LSD .05 = 2.11, LSD .01 = 2.87.

[2] Compare species with same or different nitrogen treatments and same or different sampling dates: LSD .05 = 2.15, LSD .01 = 2.88.

[3] Compare sampling dates within same nitrogen treatment and species: LSD .05 = 6.27, LSD .01 = 8.25.

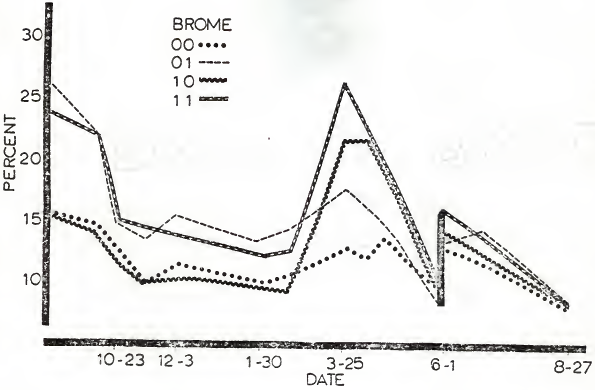

Figure 7. Percent crude protein of smooth brome as affected by nitrogen treatment, and sampling date.

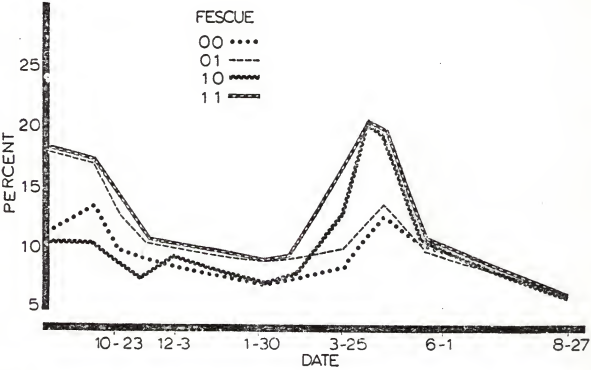

Figure 8. Percent crude protein of tall fescue as affected by nitrogen treatment, and sampling date.

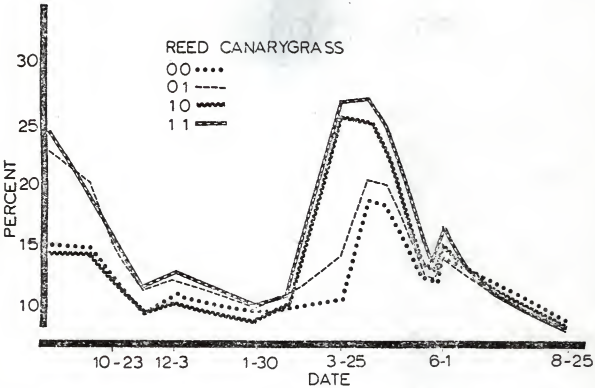

Figure 9. Percent crude protein of reed canarygrass as affected by nitrogen treatment, and sampling date.

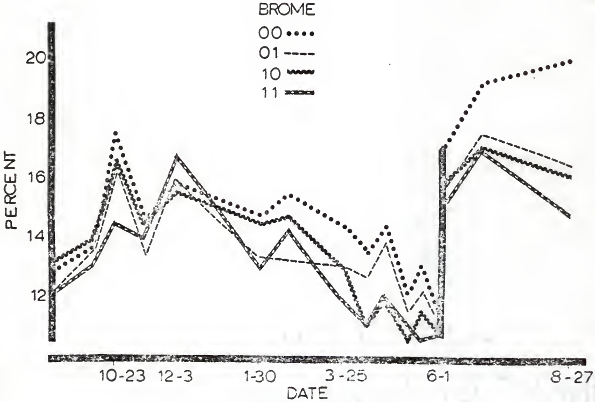

Figure 10. Percent ash of smooth brome as affected by nitrogen treatment, and sampling date.

of these grasses. Sullivan et al. (1956) found canarygrass and tall fescue significantly higher in protein than brome while Lassiter et al. (1956) noted that crude protein percentage of brome was significantly higher than that of Kentucky 31 tall fescue.

Fall and spring crude protein percentage were similar in TF. Smooth brome and RCG were higher in the spring and lower in the fall in crude protein content. This did not agree with findings of Sullivan et al. (1954), who found fall percentages to be higher than spring percentages in brome, tall fescue and reed canarygrass.

As expected, crude protein was increased by nitrogen fertilization in all cultivars. This agreed with the findings of Duell (1960) who studied six cool-season pasture grasses in New Jersey. Duell found that the protein content of all grasses studied increased similarly with each increment of nitrogen fertilizer. In this study, the 02 nitrogen treatment produced the highest crude protein percentage in the fall and winter, and the 20 treatment produced the highest percentages in the spring. Percentage of crude protein during fall and winter was similar with the 00, 10, and 20 treatments. However, the 00 treatment remained low throughout the spring and summer sampling periods, beginning in late March. The 01 treatment was similar to the 11 treatment during fall and winter, until spring regrowth when 11 became significantly higher following spring fertilization and remained so until summer regrowth. The 10 treatment was significantly lower than 11 beginning with fall samplings and until first series of low temperatures when they became similar. Kin Look and MacKenzie (1970), studying the effect of time and rate of nitrogen fertilization in Canada, agreed with this finding. They noted that nitrogen applied prior to growth of a cut increased crude protein percentage significantly regardless of cut.

As expected, the heavier rates of nitrogen produced higher percentages of crude protein in all cultivars during the season of application. The treatment 02 was significantly higher in fall until after the first killing frost, and 20 highest in spring until plants began to increase in stem-leaf ratio and neared heading.

There was a general downward trend in crude protein percentage during the fall and winter sampling periods and a general upward trend beginning with the spring growth after nitrogen fertilization. A general decline began in late April, when plants neared heading.

The first sampling of summer regrowth (6-1) in SB and RCG showed an increase in crude protein percentage over the last three spring samplings. This agreed with the findings of Rhykerd et al. (1966) who reported that nitrogen content of first-cut brome at early heading was considerably lower than the content of an aftermath cutting which consisted entirely of vegetative growth. In all grasses there was a general downward trend beginning in late June (6-28) for the summer sampling period, with no significant difference among fertilizer treatments or grasses. This agreed with the findings of Buckner et al. (1970) and Bird, J. N. (1943) who also noted a summer depression in percent of crude protein.

Crude protein content remained above minimum requirements for lactating and dry beef cows in all nitrogen treatments and cultivars over the entire sampling year. However, crude protein percentage fell below the upper range for lactating cows in TF during the winter and summer sampling periods (Anonymous, 1976).

ASH

Percent ash varied significantly among sampling dates, species, and nitrogen treatments. All first-order and second-order interactions were significant. Means for the second-order interaction are shown in Table 10. The analysis of variance is summarized in Appendix Table 19. Data are presented graphically in Figures 10, 11, and 12.

Smooth brome was generally lower in percent ash than either TF or RCG. This agreed with the findings of Sullivan et al. (1965) who found that smooth brome was significantly lower than tall fescue and reed canarygrass in percent ash in successive cuttings during the growing season. All species were relatively similar during the fall and early winter. Tall fescue tended to contain more ash during the spring and summer than either RCG or SB. Samplings of regrowth during the summer showed a great increase in ash percentage in all species with SB being significantly lower than TF or RCG except in the 00 nitrogen treatment. Minson et al. (1960) noted that in regrowths of orchardgrass and ryegrass, ash contents were increased in successive cuttings.

There was little difference in ash percentage among the fertilization treatments in TF or SB during fall and winter samplings. In RCG, however, the 02 and 11 treatments were significantly lower in ash than 00 and 10 throughout the entire year. The 00 treatment almost always was highest in ash content in RCG and SB. This agreed with the work of Ramage et al. (1958) who found that percent ash was significantly decreased in reed canarygrass and orchardgrass fertilized with nitrogen. In TF there was no significant difference among nitrogen treatments until April when 00 was significantly higher than 20. There was a general

Table 10. Percent Ash as Affected by Nitrogen Treatment and Sampling Date

Brome Dates	Nitrogen Treatments 1	2	3	4	5	6
1	12.79	11.92	11.93	13.06	12.07	12.87
2	13.74	13.42	12.94	13.76	13.00	13.78
3	17.39	16.52	15.59	16.58	14.45	16.42
4	14.62	13.24	12.29	14.41	13.86	13.80
5	15.71	15.86	15.68	15.43	16.64	15.24
6	14.65	13.21	12.63	14.40	12.84	13.41
7	15.35	13.18	13.16	14.60	14.15	13.99
8	14.32	12.98	12.20	12.98	11.77	11.83
9	13.45	12.64	12.16	10.88	11.16	10.56
10	14.26	13.70	12.89	11.93	12.01	11.03
11	11.89	11.57	10.63	10.41	10.85	10.27
12	13.15	12.05	11.10	11.58	10.50	10.56
13	11.39	11.08	11.19	10.80	10.59	10.26
14	16.81	15.57	15.31	15.74	14.92	13.86
15	19.12	17.37	16.45	16.90	16.86	15.93
16	19.82	16.37	15.58	16.00	14.72	14.22

Fescue Dates	Nitrogen Treatments 1	2	3	4	5	6
1	13.27	12.76	12.54	13.29	12.62	12.85
2	12.80	13.63	13.53	13.39	13.75	12.84
3	15.67	16.65	16.83	15.49	17.31	15.22
4	13.88	16.14	15.30	13.31	16.35	13.73
5	16.85	16.89	15.86	15.57	16.59	15.35
6	13.76	15.03	14.77	13.83	14.12	13.79
7	15.69	16.17	15.03	15.67	15.05	13.99
8	14.90	14.78	14.44	14.88	13.91	13.45
9	15.65	14.97	14.97	14.35	13.75	12.32
10	17.40	17.65	17.51	16.72	16.09	14.53
11	16.64	15.33	14.77	14.80	13.86	13.54
12	16.10	15.00	14.82	15.20	13.94	14.05
13	15.63	14.23	14.64	15.58	13.96	13.15
14	19.84	20.15	20.63	20.00	20.62	20.09
15	22.22	22.19	22.67	22.90	22.54	22.36
16	20.28	20.83	20.93	20.43	21.76	19.63

Table 10. (continued)

Reed Canary Dates	Nitrogen Treatments 1	2	3	4	5	6
1	14.97	13.10	11.59	15.18	11.86	13.27
2	15.55	13.78	11.67	14.79	11.97	13.47
3	17.82	16.34	14.01	17.13	14.97	16.22
4	17.73	15.79	13.58	18.44	13.83	16.77
5	17.30	14.71	13.37	18.16	12.43	16.08
6	17.94	17.16	18.79	17.74	16.24	16.61
7	17.11	16.19	14.34	18.68	14.65	16.12
8	17.25	14.36	12.89	14.16	12.57	13.87
9	15.31	13.62	12.55	12.87	11.93	11.81
10	16.10	15.37	13.67	13.98	13.23	12.05
11	15.83	14.28	12.87	13.39	12.59	13.17
12	16.98	15.15	14.16	14.70	13.56	14.39
13	16.39	14.90	13.79	14.43	13.24	14.38
14	21.05	20.35	19.12	19.62	18.54	17.93
15	21.13	21.70	20.43	19.60	19.25	18.97
16	22.18	21.36	19.92	20.98	19.18	18.03

[1]Compare nitrogen treatments within same species with same or different sampling dates: LSD .05 = 1.66.

[2]Compare species with same or different nitrogen treatment and same or different sampling dates: LSD .05 = 1.87, LSD .01 = 2.56.

[3]Compare sampling dates within same nitrogen treatment and species: LSD: .05 = 1.54, LSD .01 = 2.02.

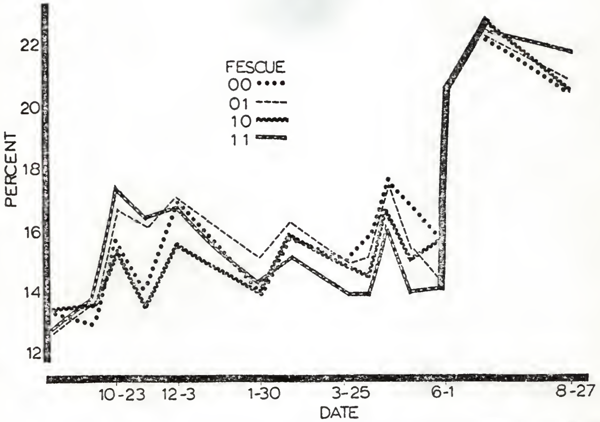

Figure 11. Percent ash of tall fescue as affected by nitrogen treatment, and sampling date.

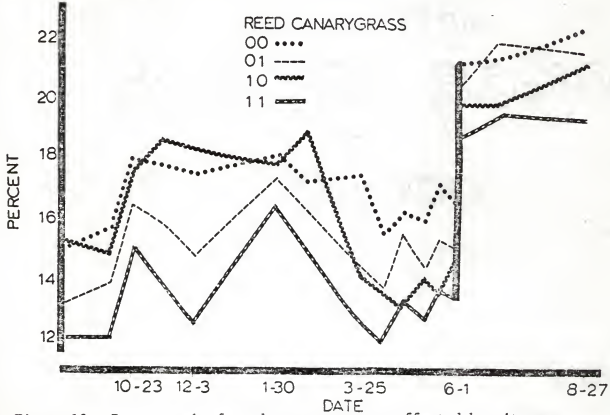

Figure 12. Percent ash of reed canarygrass as affected by nitrogen treatment, and sampling date.

tendency for fertilization treatments to be lower in ash content during the season of application. Thus, 02 had the lowest ash content in the fall while 20 had the lowest content in the spring. Otherwise, there seemed to be little pattern to changes in ash content. The literature presents conflicting data on the effects of season and nitrogen treatment on ash content. Woelfel et al. (1960) reported that ash content of timothy increased slightly with nitrogen application. However, Ramage et al. (1958) found that percentage ash was significantly decreased in reed canarygrass and orchardgrass fertilized with nitrogen.

In this study the most noticeable change in ash content was in summer regrowth when the percentage rose significantly in all nitrogen treatments and grasses. Minson et al. (1960) also found that the ash content of cool-season-grass regrowth increased during the summer.

MINERALS

Calcium

Calcium content varied significantly with species, nitrogen treatment and sampling date. The species by sampling date interaction was also highly significant. Means for the first order interaction (C x T) and means for nitrogen treatments are shown in Tables 11 and 12. The analysis of variance is summarized in Appendix Table 20. Data are presented graphically in Figure 13.

Among grasses, SB was significantly higher in calcium during the fall and early winter samplings than either TF or RCG. Smooth brome and TF were similar in calcium content throughout the spring and summer regrowth sampling periods. Reed canarygrass was significantly lower in calcium than either TF or SB for most of the sampling year.

Table 11. Percent Calcium as Affected by Species and Sampling Date

Date	Species		
	Brome	Fescue	Reed Canary
3	.714	.548	.559
4	.650	.482	.452
5	.632	.509	.373
6	.634	.446	.351
7	.576	.459	.344
8	.508	.468	.290
10	.467	.494	.366
12	.409	.359	.418
14	.472	.451	.322
16	.722	.685	.512

[1]Compare two sampling dates within same species LSD .05 = .054, LSD .01 = .072.

[2]Compare two species with same or different sampling date: LSD .05 = .063, LSD .01 = .079.

Table 12. Percent Calcium as Affected by Nitrogen Treatment

	Nitrogen Treatment			
	00	01	10	11
Fertilizer means	.507	.488	.492	.469

[1]Compare nitrogen treatment means: LSD .05 = .017, LSD .01 = .023.

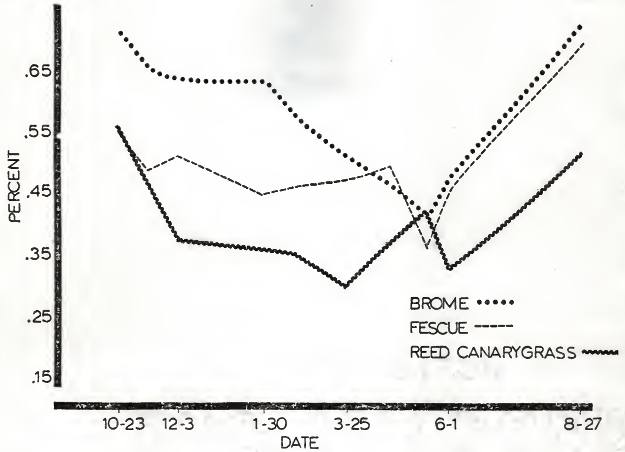

Figure 13. Percent calcium as affected by species and sampling date.

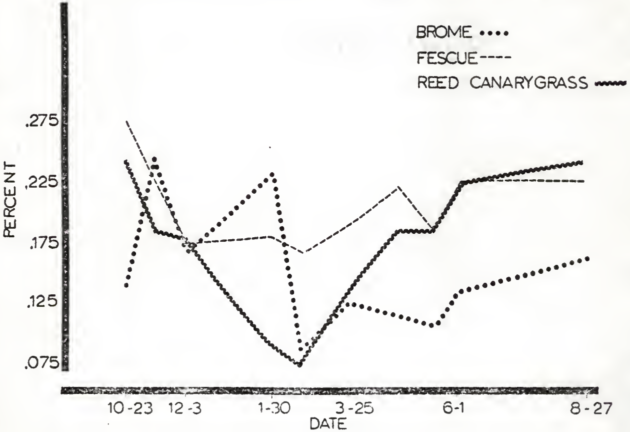

Figure 14. Percent magnesium as affected by species and sampling date.

Nitrogen fertilization tended to lower calcium content. The 11 nitrogen treatment was significantly lower in calcium percentage than all other nitrogen treatments. There was no significant difference between the 01 and 10 nitrogen treatments. The 00 nitrogen treatment was significantly higher in calcium than the 10 and 11 treatments. Literature reports on the effect of nitrogen fertilizer on calcium are conflicting, but studies have generally shown calcium to be increased or unaffected by applied nitrogen. Reid et al. (1967b and 1970) in West Virginia, reported that higher levels of nitrogen fertilizer generally were associated with an increased concentration of Ca in cool-season-grasses. In another study, Reid et al. (1966) found that higher levels of nitrogen fertilization had no uniform effect on Ca content of forage.

Concentrations of calcium tended to be lower in mature plants. This agreed with the findings of Whitehead et al. (1966) and Loneragan et al. (1968) who reported that concentrations of calcium were higher in young plant tissue than in mature plant tissue. In this study a general decline was noted beginning with fall samplings in SB and RCG. Tall fescue varied little in calcium content during the fall. There was a significant increase in calcium content of all species on the final sampling date (8-27) during summer regrowth.

All species were above the calcium requirements for dry, pregnant cows (Anonymous, 1976) during all seasons, and all grasses ranged near the upper end of the range for lactating cows. Means of fertilizer treatments across all grasses and dates, were in all cases, above the highest requirements for lactating cows.

Magnesium

Magnesium content varied significantly with sampling date and species but not with nitrogen treatment. The species by sampling date interaction was significant. Means for the first order interaction (C x T) are shown in Table 13. The analysis of variance is summarized in Appendix Table 21. Data are shown graphically in Figure 14.

Magnesium content of SB fluctuated greatly during the fall and winter but showed no general trend. However, beginning with the spring samplings, magnesium content of SB decreased slightly and showed an upward trend during the summer regrowth. Smooth brome maintained the lowest magnesium content of the three grasses during spring and summer. Tall fescue fluctuated the least of the species across all dates and maintained more stability in magnesium content during the winter sampling period. Reed canarygrass generally was lower than TF through winter and early spring. Reed canarygrass showed a general increase in magnesium beginning with the spring samplings and continuing through summer regrowth. Tall fescue and RCG were similar during the late May and summer regrowth, while SB was relatively low during that period.

Fall samplings generally were higher in magnesium than the winter samplings. There tended to be a downward trend throughout the fall which continued through the winter. This agreed with the findings of Reid et al. (1970) and Russell et al. (1954) who found that magnesium was leached from plant tissue during the winter. An upward trend began in spring samplings which peaked intermediately before plants began to greatly increase in stem-leaf ratio. Whitehead (1966) found that in grasses magnesium generally tended to be lower in concentration in mature plant

Table 13. Percent Magnesium as Affected by Species and Sampling Date

Date	Species		
	Brome	Fescue	Reed Canary
3	.134	.272	.239
4	.242	.216	.183
5	.166	.170	.175
6	.228	.176	.085
7	.088	.164	.073
8	.121	.187	.133
10	.116	.218	.182
12	.103	.184	.180
14	.131	.223	.218
16	.168	.221	.239

[1]Compare two sampling dates within the same species LSD .05 = .089, LSD .01 = .118.

[2]Compare two species with same or different sampling date: LSD .05 = .087, LSD .01 = .116.

tissue than in young plant tissue although peak values sometimes occurred at intermediate stages of growth. In this study summer regrowth samplings showed an increase in magnesium content. This agreed with the work of Reid et al. (1970) who found that magnesium generally was lower in first growth than in regrowth.

All grasses generally maintained adequate magnesium percentages for dry pregnant cows. Smooth brome and RCG, however, fell below the upper end of the range in late winter samplings (1-30 and 2-19). Smooth brome was generally inadequate for lactating cows during the entire sampling year, while TF and RCG were below requirements (Anonymous, 1976) only during the winter samplings.

Potassium

Potassium content varied significantly with sampling date, species and nitrogen treatment. All first-order, and second-order interactions were significant. Means for the second-order interaction are shown in Table 14. The analysis of variance is summarized in Appendix Table 27. Graphs are shown in Figures 15, 16, and 17.

Reed canarygrass was significantly lower in potassium than other species during the fall and winter samplings. Smooth brome and TF were similar during these periods. However, SB and RCG were similar in potassium content during the spring and summer while TF was significantly lower than the other species during that period.

Nitrogen fertilization was generally associated with higher levels of potassium. This agreed with the findings of several researchers. Reid et al. (1970), Hojjati et al. (1977) and Reid et al. (1965) all reported significant increases in potassium content with increasing nitrogen rate.

Table 14. Percent Potassium as Affected by Nitrogen Treatment, and Sampling Date

Brome Dates	Nitrogen Treatment 1	2	3	4
3	2.126	4.139	2.176	4.151
4	1.104	1.970	1.175	2.639
5	0.437	1.352	0.450	1.258
6	1.048	0.970	0.311	0.886
7	0.564	0.690	0.310	0.631
8	0.689	2.075	1.397	2.444
10	2.441	2.614	2.876	3.084
12	2.133	1.839	2.355	2.223
14	1.540	1.906	1.863	2.119
16	1.142	1.335	1.495	1.869
Fescue Dates	**Nitrogen Treatment 1**	**2**	**3**	**4**
3	2.406	3.062	1.377	3.203
4	1.253	1.931	0.846	2.088
5	0.528	1.177	0.601	1.567
6	0.487	1.044	0.843	0.797
7	0.365	0.432	0.363	0.791
8	0.450	0.822	0.708	1.291
10	1.895	1.733	2.616	2.571
12	1.650	1.644	2.090	2.047
14	1.149	0.922	1.302	1.379
16	0.809	0.718	0.631	0.743
Reed Canary Dates	**Nitrogen Treatment 1**	**2**	**3**	**4**
3	1.674	2.432	1.628	2.598
4	1.064	1.553	1.046	1.246
5	0.285	0.466	0.286	0.356
6	0.129	0.235	0.110	0.256
7	0.128	0.156	0.099	0.174
8	0.751	1.271	2.469	2.928
10	2.524	2.730	3.230	3.293
12	2.193	2.332	2.625	2.703
14	1.589	1.828	1.685	1.955
16	1.211	1.240	1.261	1.198

[1]Compare nitrogen treatments within same species with same or different sampling dates: LSD .05 = .529, LSD .01 = .679.

[2]Compare species with same or different nitrogen treatments and same or different sampling dates: LSD .05 = .433, LSD .01 = .577.

[3]Compare sampling dates within same nitrogen treatment and species: LSD .05 = .416, LSD .01 = .548.

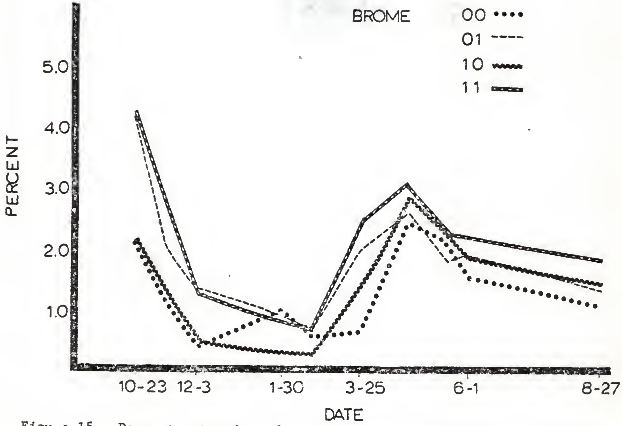

Figure 15. Percent potassium of smooth brome as affected by nitrogen treatment, and sampling date.

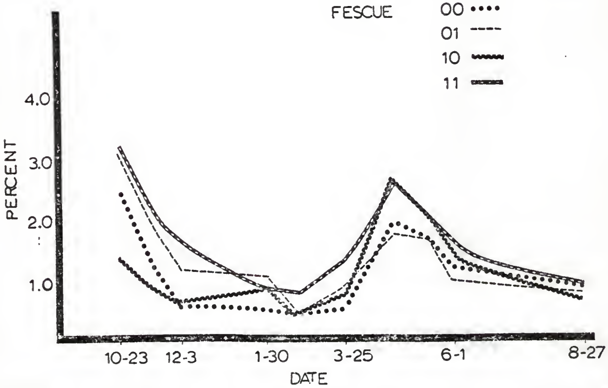

Figure 16. Percent potassium of tall fescue as affected by nitrogen treatment, and sampling date.

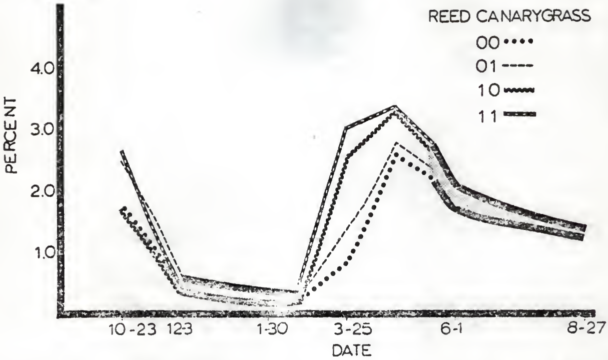

Figure 17. Percent potassium of reed canarygrass as affected by nitrogen treatment, and sampling date.

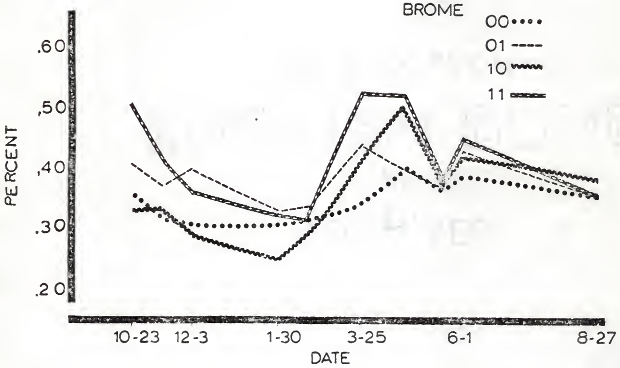

Figure 18. Percent phosphorus of smooth brome as affected by nitrogen treatment, and sampling date.

Potassium was significantly higher during the fall and winter in plots receiving fall-applied nitrogen. There was little difference among nitrogen treatments during late winter samplings (1-30 and 2-19). However, during the spring sampling period, the 00 nitrogen treatment was significantly lower in potassium in SB and RCG than other nitrogen treatments while the 11 nitrogen treatment was significantly higher in the two grasses than other nitrogen treatments. During summer regrowth there were no significant differences among the nitrogen treatments.

There was a general downward trend in potassium during the fall, with advancing maturity, and through the winter. That agreed with the findings of Reid et al. (1970) and Russell et al. (1954) who showed a regular decline as potassium was leached during the winter from plant tissue. In this study an upward trend was noted beginning with the spring samplings (3-25), and a general decline began in late April (4-22), as stem-leaf ratio increased, and continued through the summer regrowth period. That agreed with the findings of Whitehead (1966) who concluded that potassium was lower in concentration in mature plant tissue although peak values may occur at intermediate growth stages.

Tall fescue and SB generally maintained adequate concentrations of potassium during the entire sampling year, for both dry, pregnant and lactating cows. However, RCG fell below requirements for both groups of cows during the winter samplings.

Phosphorus

Phosphorus content varied significantly with sampling date but not with species or nitrogen treatment. All first-order and second-order interactions were highly significant. Means for the second-order interaction are shown in Table 15. The analysis of variance is summarized in Appendix Table 23. Graphs are shown in Figures 18, 19, and 20.

Table 15. Percent Phosphorus as Affected by Nitrogen Treatment, and Sampling Date

Brome	Nitrogen Treatments			
Dates	1	2	4	5
3	.353	.400	.326	.496
4	.312	.364	.328	.403
5	.296	.390	.283	.353
6	.294	.323	.246	.314
7	.310	.333	.283	.306
8	.331	.435	.412	.519
10	.395	.391	.498	.514
12	.355	.359	.366	.368
14	.382	.424	.417	.448
16	.349	.349	.374	.346
Fescue	**Nitrogen Treatments**			
Dates	1	2	4	5
3	.452	.373	.381	.359
4	.340	.313	.357	.305
5	.319	.316	.334	.319
6	.298	.290	.268	.268
7	.314	.279	.283	.259
8	.320	.353	.359	.389
10	.495	.448	.402	.385
12	.415	.315	.290	.276
14	.495	.455	.402	.363
16	.542	.538	.477	.413
Reed Canary	**Nitrogen Treatments**			
Dates	1	2	4	5
3	.514	.453	.358	.407
4	.394	.334	.355	.281
5	.267	.247	.247	.230
6	.207	.236	.167	.235
7	.178	.202	.181	.200
8	.331	.372	.463	.559
10	.463	.435	.482	.512
12	.406	.379	.434	.384
14	.522	.454	.431	.423
16	.541	.480	.468	.412

[1]Compare nitrogen treatments within same species with same or different sampling dates: LSD .05 = .067, LSD .01 = .089.

[2]Compare species with same or different nitrogen treatments and same or different sampling dates: LSD .05 = .079, LSD .01 = .110.

[3]Compare sampling dates within same nitrogen treatment and species: LSD .05 = .065, LSD .01 = .086.

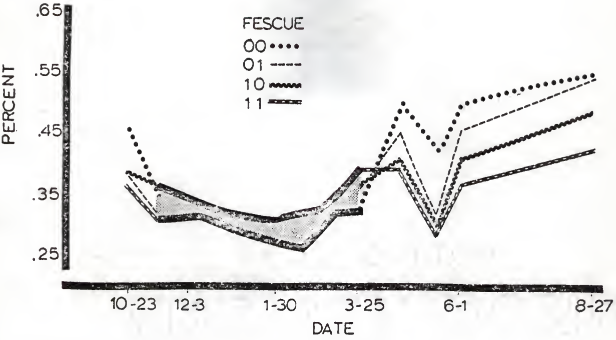

Figure 19. Percent phosphorus of tall fescue as affected by nitrogen treatment, and sampling date.

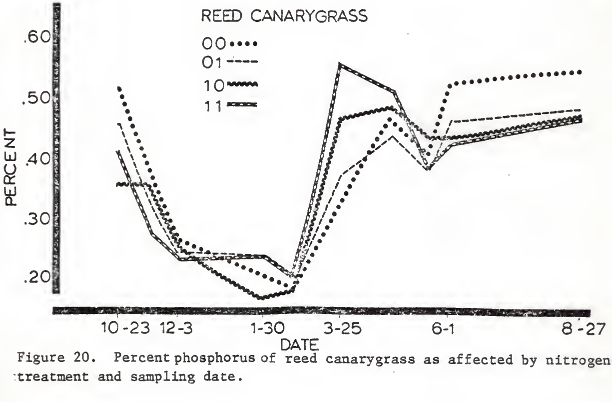

Figure 20. Percent phosphorus of reed canarygrass as affected by nitrogen treatment and sampling date.

Smooth brome and TF were similar during fall and winter samplings with SB being only slightly higher than TF. Reed canarygrass was significantly lower than other species during the winter samplings beginning 12-3. Of the three grasses, reed canarygrass maintained the highest phosphorus content during the spring samplings and into the summer regrowth. Tall fescue generally had the lowest content during the spring samplings, but increased considerably during summer regrowth.

During early fall, in SB, samplings from the 00 treatment were lower in phosphorus than those from the 11 treatment. In RCG, during the same period, phosphorus was significantly higher in the samplings from the 00 treatment than in those from the 11 treatment. There was no consistent effect of nitrogen fertilizer on phosphorus. This agreed with the findings of several researchers.

With advancing maturity in the fall, and continuing throughout the winter, there was a general downward trend in phosphorus content. Reid et al. (1970) and Russell et al. (1954) noted this trend and suggested that phosphorus, like potassium, was leached from plant tissue during winter months. A general upward trend began with the spring samplings and leveled off in late April (4-22) as the stem-leaf ratio increased. Thomas et al. (1952) reported that levels of phosphorus decreased with the age of plant. In this study, phosphorus began to increase in May (5-19) and continued increasing through the summer regrowth in RCG and TF. That agreed with the findings of Reid et al. (1966) who noted that orchardgrass aftermath cut in late July in West Virginia increased in phosphorus content as compared with first-cut grass in mid May. However, SB showed a slight decline in phosphorus during this period.

Phosphorus percentages of TF and SB were above the requirements for dry pregnant cows and above the lower end of the range for lactating cows through the entire sampling year. The same was true for RCG except that it became sub minimal in phosphorus content in the late winter samplings in the 00 and 10 nitrogen treatments (Anonymous, 1976).

SUMMARY AND CONCLUSIONS

Field Dry Matter

Reed canarygrass was adversely affected by low temperatures and therefore was higher in FDM during the winter than were SB and TF. Tall fescue was lower in FDM during early winter samplings as it was more frost tolerant and remained green longer. All species were similar in FDM during the summer samplings. FDM increased as stem to leaf ratio increased. As nitrogen fertilizer increased, FDM decreased.

IVDMD

Low temperatures depressed digestibility with RCG being the most adversely effected and TF the most "frost tolerant" species. High temperatures during the summer caused a decline in IVDMD; however, digestibilities were less variable among species and nitrogen treatments during the summer. Digestibility was increased with the use of nitrogen fertilizer. Forages receiving 180 Kg/ha of nitrogen were more digestible during the season following application than were those receiving 90 Kg/ha, indicating a greater carryover of nitrogen. The IVDMD decreased as the grasses approached maturity.

Crude Protein

Tall fescue maintained the lowest percent crude protein throughout the sampling year. Smooth brome contained the highest percent crude protein through late fall and winter while RCG was highest in the spring. Nitrogen fertilizer applied prior to a growing season significantly increased the crude protein content in all species. Crude protein declined as the stem to leaf ratio increased. Crude protein content of all three species at heading was lower than the first aftermath cutting which consisted entirely of vegetative growth. Crude protein decreased during summer regrowth with no significant differences among fertilizer treatments. Crude protein remained above minimum requirements for lactating and dry beef cows in all nitrogen treatments and species throughout the sampling year.

Ash

Smooth brome was generally lower in percent ash than TF or RCG throughout the year. All species were similar during the fall and early winter. Tall fescue contained a greater percentage of ash during the spring and summer with summer samplings showing a large increase in percent ash in all species and nitrogen treatments. There was a general tendency for nitrogen fertilizer to lower percent ash during the season of application. The no-nitrogen treatment generally was highest in percent ash in SB and RCG. There seemed to be little pattern to the changes in ash content.

Minerals

Calcium--Reed canarygrass was generally lower in Ca content throughout the entire sampling year than TF or SB. Smooth brome contained the highest percent Ca during the fall and early winter. Nitrogen treatments tended to adversely affect Ca content with the no-nitrogen treatment significantly highest in percent Ca. Concentrations of Ca tended to be lower in mature plants. All species were above the requirements for dry pregnant cows during all seasons, and all species ranged near the upper end of the range for lactating cows.

Magnesium--Tall fescue was higher in percent Mg than RCG and maintained more stability in Mg content during the winter samplings than SB which fluctuated greatly. Smooth brome contained the lowest percent Mg during the spring and summer. Nitrogen treatments had no significant effect on Mg content. Mature plants contained lower concentrations of Mg thanyoung, with peak values occuring at intermediate stages of growth. Summer regrowth samplings contained higher percentages of Mg.

All species maintained adequate amounts of Mg for dry pregnant cows except during the late winter samplings when SB and RCG fell below the upper end of the range. Smooth brome was generally inadequate for lactating cows throughout the sampling year while TF and RCG were below these requirements only during winter samplings.

Potassium--Reed canarygrass contained the lowest percent K during the fall and winter samplings. Tall fescue was significantly lower in percent K during the spring and summer than RCG and SB. Nitrogen fertilizer was generally associated with higher levels of K concentrations. Percent K was significantly higher during the fall and winter in plants receiving fall applied nitrogen. Percent K showed a regular decline into fall and winter. Percent K was also lower in concentration in mature plants although peak values occured at intermediate growth stages. Tall fescue and SB maintained adequate amounts of K throughout the sampling year for both pregnant and lactating cows. However, RCG fell below requirements for both groups of cows during the winter months.

Phosphorus--Reed canarygrass was significantly lower in percent P during the winter samplings but contained the highest P content during the spring samplings. Reed canarygrass and TF increased in P content during summer regrowth while SB showed a slight decline. Nitrogen fertilization had no consistent effect on P content.

Phosphorus showed a regular decline into the winter season, and it also decreased with advancing maturity. Percent P in TF and SB were above the requirements for dry pregnant cows and above the lower end of the range for lactating cows throughout the year. The same can be said for RCG except it did become subminimal in the late winter in P.

All grasses studied were well suited for grazing during the growing season in the spring and fall. However, TF and SB seem better suited for a winter grazing program because these grasses maintained a higher percentage of crude protein and IVDMD during the winter months than RCG. Tall fescue and SB also maintained adequate amounts of Ca, K, and P for dry pregnant cows during the winter months while RCG fell below these requirements. In addition, TF also maintained adequate amounts of Mg for dry pregnant cows while both SB and RCG fell below these requirements.

Fertilization with nitrogen prior to any growing season tended to increase the digestibility and crude protein content of the grass. Therefore, a fall application of nitrogen is suggested for winter grazing to increase the quality of the grass. The smaller nitrogen treatments (90 Kg/ha) are recommended because they were more economical and generally met the nutritional requirements of the beef cow as well as the 180 Kg/ha nitrogen treatments.

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APPENDIX

Table 16. AOV Summary for Field Dry-Matter Content of Three Grasses Under Six Nitrogen Treatments

Source of Variation	df	MS	F
Replications (R)	3	181.18	9.47*
Cultivars (C)	2	897.55	
C x R (Error a)	6	94.70	
Fertilizer (F)	5	1546.94	64.46**
F x C	10	72.11	3.00**
F x R x C (Error b)	45	23.99	
Sampling Date (T)	15	24764.67	1175.71**
F x T	75	167.72	7.96**
C x T	30	718.13	34.09**
F x C x T	150	22.41	1.06
Residual error (Error c)	810	21.06	

*Significant at .05

**Significant at .01

Table 17. AOV Summary for IVDMD of Three Grasses Under Six Nitrogen Treatments

Source of Variation	df	Ms	F
Replications (R)	3	307.57	48.31**
Cultivars (C)	2	7229.43	
C x R (Error a)	6	149.61	
Fertilizer (F)	5	2664.35	144.45**
F x C	10	63.86	3.46**
F x R x C (Error b)	45	18.44	
Sampling Date (T)	15	14119.43	690.83**
F x T	75	287.47	14.06**
C x T	30	943.62	46.16**
F x C x T	150	34.26	1.67**
Residual error (Error c)	810	20.43	

**Significant at .01.

Table 18. AOV Summary for Crude Protein Content of Three Grasses Under Six Nitrogen Treatments

Source of Variation	df	Ms	F
Replications (R)	3	19.98	
Cultivars (C)	2	1465.13	70.94**
C x R (Error a)	6	20.65	
Fertilizer (F)	5	553.32	88.44**
F x C	10	9.54	1.53
F x R x C (Error b)	45	6.25	
Sampling Date (T)	15	1092.49	590.16**
F x T	75	100.64	54.36**
C x T	30	56.69	30.62**
F x C x T	150	3.95	2.13**
Residual error (Error c)	810	1.85	

**Significant at .01.

Table 19. AOV Summary for Ash Content of Three Grasses Under Six Nitrogen Treatments

Source of Variation	df	Ms	F
Replications (R)	3	45.088	
Cultivars (C)	2	647.11	19.75**
C x R (Error a)	6	32.76	
Fertilizer (F)	5	93.65	31.35**
F x C	10	21.09	7.06**
F x R x C (Error b)	45	2.99	
Sampling Date (T)	15	353.82	288.83**
F x T	75	2.72	2.22**
C x T	30	30.98	25.29**
F x C x T	150	2.16	1.76**
Residual error (Error c)	810	1.22	

**Significant at .01.

Table 20. AOV Summary for Calcium Content of Three Grasses Under Four Nitrogen Treatments

Source of Variation	df	MS	F
Replications (R)	2	.0129	
Cultivars (C)	2	.9686	82.97**
C x R (Error a)	6	.0116	
Fertilizer	3	.0216	7.43**
F x C	6	.0015	.51
F x R x C (Error b)	18	.0029	
Sampling Date (T)	9	.2414	53.13**
F x T	27	.0068	1.49
C x T	18	.0380	8.36**
F x C x T	54	.0040	.88
Residual error (Error c)	216	.0045	

**Significant at .01.

Table 21. AOV Summary for Magnesium Content of Three Grasses Under Four Nitrogen Treatments

Source of Variation	df	MS	F
Replications (R)	2	0.0032	
Cultivars (C)	2	0.0899	20.37**
C x R (Error a)	6	0.0044	
Fertilizer	3	0.0065	0.63
F x C	6	0.0106	1.03
F x R x C (Error b)	18	0.0103	
Sampling Date (T)	9	0.0406	3.30**
F x T	27	0.0076	0.62
C x T	18	0.0222	1.80*
F x C x T	54	0.0098	0.80
Residual error (Error c)	216	0.0123	

*Significant at .05.
**Significant at .01.

Table 22. AOV Summary For Potassium Content of Three Grasses Under Four Nitrogen Treatments

Source of Variation	df	MS	F
Replications (R)	2	0.1448	
Cultivars (C)	2	4.7499	79.32**
C x R (Error a)	6	0.0598	
Fertilizer	3	6.6200	54.45**
F x C	6	.4590	3.77*
F x R x C (Error b)	18	0.1215	
Sampling Date (T)	9	22.6523	339.64**
F x T	27	0.9335	13.99**
C x T	18	1.4060	21.08**
F x C x T	54	0.1992	2.98**
Residual error (Error c)	216	0.0666	

*Significant at .05.
**Significant at .01.

Table 23. AOV Summary for Phosphorus Content of Three Grasses Under Four Nitrogen Treatments

Source of Variation	df	MS	F
Replications (R)	2	.0073	
Cultivars (C)	2	.0006	0.04
C x R (Error a)	6	.0152	
Fertilizer	3	.0048	1.78
F x C	6	.0241	8.87**
F x R x C (Error b)	18	.0027	
Sampling Date (T)	9	.1902	116.83**
F x T	27	.0090	5.58**
C x T	18	.0244	14.99**
F x C x T	54	.0032	2.01**
Residual error (Error c)	216	.0016	

**Significant at .01.

SEASONAL CHANGES IN QUALITY OF THREE COOL SEASON PERENNIAL GRASSES

by

HARRIET JEAN MUNCRIEF

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In the past few years cow calf operators have been turning to forages as a potential year-round feed for cows. More information is needed on the year-round feeding potential of many forages. In eastern Kansas, development of effective forage utilization systems requires a greater knowledge of the nutritional value of cool-season perennial grasses.

The objectives of this study were to determine: (1) seasonal changes in forage quality as determined by crude protein and in vitro dry matter digestibility, (2) and seasonal changes in mineral content of P, Mg, K, and Ca in forages.

The study was conducted on the Agronomy Farm at Manhattan, Kansas. Three cultivars, Achenbach smooth brome, Kentucky 31 tall fescue and Ioreed reed canarygrass were selected from a larger management study and were subjected to six nitrogen treatments, including a no-nitrogen treatment.

To determine forage quality and mineral content, hand clipped samples were taken sixteen times over a period of one year.

Tall fescue was the most frost tolerant cultivar and maintained the highest IVDMD during the winter samplings. Reed canarygrass was adversely affected by cold temperatures and maintained the lowest IVDMD during the winter. Digestibility and crude protein increased with the use of nitrogen fertilizer. Both digestibility and crude protein decreased with advance toward maturity. Tall fescue maintained the lowest crude protein percentage throughout the year; smooth brome was highest during the fall and early winter. With both IVDMD and crude protein content there was less variability among grasses and among nitrogen treatments in summer aftermath samplings than in forage sampled before the spring harvest and during the fall before the first series of cold temperatures.

Reed canarygrass generally was lower in Ca content throughout the entire sampling year than either smooth brome or tall fescue. Smooth brome was highest in percent Ca during fall and early winter samplings. Nitrogen treatments tended to adversely affect Ca content. Calcium concentrations also tended to decline as plants matured.

Tall fescue was higher in Mg content than reed canarygrass and maintained more stability than smooth brome during the winter samplings. Smooth brome contained the lowest Mg percentage during spring and summer. Applied nitrogen had no effect on Mg content. Magnesium concentrations declined as plants matured.

Reed canarygrass contained the lowest percentage of K of the three grasses during fall and winter. Tall fescue was significantly lower than reed canarygrass and smooth brome during the spring and summer. Nitrogen fertilizer was generally associated with higher levels of K. Percentage of K was lower in mature plants.

Reed canarygrass was significantly lower in P content during winter samplings but contained the highest P content during the spring. Tall fescue contained the lowest percentage of P during summer regrowth. Nitrogen fertilizer had no consistent effect on P content. Phosphorus content tended to decrease with advancing maturity.

All grasses studied were well suited for grazing during the growing seasons in the spring and fall. However, tall fescue and smooth brome seem better suited for a winter grazing program because these grasses maintained a higher percentage of crude protein and IVDMD during the winter months than reed canarygrass. Tall fescue and smooth brome also maintained adequate amounts of Ca, K and P for dry pregnant cows during the winter months while reed canarygrass fell below these requirements. In addition, tall fescue also maintained adequate amounts of Mg for dry pregnant cows while both smooth brome and reed canarygrass fell below these requirements.

Fertilization with nitrogen prior to any growing season increased the digestibility and crude protein content of the grass. For winter grazing a fall application is suggested to increase the quality of the grass. The nitrogen treatments of 90 Kg/ha as opposed to 180 Kg/ha were more feasible due to costs and because the larger nitrogen treatments did not increase the quality parameters significantly above the lesser treatments when applied in the same season, to make the economical.