QUALITY AND YIELD OF TALL FESCUE (*FESTUCA ARUNDINACEA* SCHREB.) AS AFFECTED BY SEASON, LEGUME COMBINATIONS AND NITROGEN FERTILIZATION

by

Edward Barrow Rayburn

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APPROVED:

Dr. R. E. Blaser
Chairman

Dr. S. B. Carr

Dr. J. P. Fontenot

Dr. R. G. Kline

Dr. H. E. White

Dr. D. D. Wolf

Dr. T. B. Hutcheson, Jr.

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Blacksburg, Virginia

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INTRODUCTION

The price squeeze on beef cattle production caused by increased production costs and depressed prices may be a persisting trend because of inflation and an environment of strong consumer concern. Therefore, economical ways of lowering production costs by decreasing input costs or increasing productivity are needed for a competitive beef cattle industry.

Some methods by which cost reduction can be accomplished with forage systems are:

1. increasing forage production from the area being managed without an excessive increase in input costs;
2. increasing the productivity of the livestock grazing the forages; or,
3. managing the pasture and livestock so that labor, machinery, management, and other input costs are reduced.

Increased pasture productivity is achieved by proper lime and fertilizer application and good harvesting systems as well as the introduction of varieties and species of high productive potential and feed value.

Animal output can be increased by genetic selection for highly productive animals. Increasing the feed intake per animal will increase gains and production efficiency since the proportion of feed available for production is increased. This is accomplished by providing more feed per animal to increase dry matter intake (DMI) through selective grazing; by providing feed of a high digestible energy (DE) content; or by incorporating into grass pastures legumes which generally have a higher intake rate by livestock than do grasses. The product of DMI and DE determine the DE intake (DEI). The DEI determines the productivity of the animal as it is limited or accentuated by genetic potential.

Input cost reductions can be made by the addition of legumes to grass pastures to supply nitrogen (N). Properly designed forage systems can reduce costs by balancing the production and utilization of forage so that machine harvest, storage, and feeding requirements are minimized. Methods of deferred grazing are becoming a vital part of forage systems to accomplish this end.

Deferred grazing is the accumulation of forage growth (stockpiling) for use at a season when regrowth of plants is not sufficient to meet the requirements of the livestock. The stockpiling of tall fescue (*Festuca arundinacea* Schreb.) is one method whereby a pasture feed supply can be maintained through the fall and winter season without harvesting, storing, and refeeding.

Tall fescue has the favorable characteristic of providing accumulated growth for winter grazing after freezing weather. This characteristic when used with reasonable rates of N can reduce overwintering costs of a cow or stocker herd by reducing or eliminating the need for winter hay feeding. However, tall fescue has gained disfavor with some farmers due to its low palatability during summer and occasional occurrence of toxicity as reflected in low summer gains, fescue foot, and fat necrosis.

Stockpiling tall fescue earlier in the summer would seemingly make more pasturage available in winter and less in summer, thus appearing to magnify the benefits of tall fescue and minimize its disadvantages in pasture systems. Therefore, experiments were planned to: 1) evaluate the quality of tall fescue as measured by intake and *in vivo* digestibility by sheep in summer (experiment 1) and winter (experiment 2); 2) determine if legume mixtures with tall fescue affect quality (experiment 1); and 3) determine the effect of stockpiling and fertilization dates on yield and yield distribution of tall fescue, and the effect on certain chemical measures of quality (experiment 3).

LITERATURE REVIEW

The biological characteristics of a forage system that determine its economic success are forage production and utilization, relative to land, capital, and labor inputs; and the forage quality, relative to the needs of the livestock being produced.

Forage Production

Forages respond readily to fertilization when the soil has a low fertility status. There are usually quick and apparent responses to N (Mott et al., 1976; Tisdale et al., 1952). Phosphorus (P) and potassium (K) also give responses in many situations (Blaser and Kimbrough, 1968; Lutz et al., 1967). Economics will sometimes not justify fertilization as when animal prices are low relative to the price of fertilizer N. In this case, legumes may serve as a source of N to reduce production costs to give a positive net return. On soils of high fertility, P and K will be justified only at low levels for fertility maintenance or not at all.

Fertilizers have primary effects on yield levels and little effect on forage quality (Blaser, 1964; Blaser et al., 1976), unless the native fertility is limiting levels of P, K, Calcium (Ca), or protein in forage in addition to limiting yields. In cases of low mineral contents in a forage, supplemental mineral feeding would be cheaper than fertilizing unless a fertilizer nutrient concurrently increases production.

Water availability is essential for efficient growth (Blaser et al., 1966) as are suitable light and temperature (Brown et al., 1966;

Blaser et al., 1966; Green, 1974). For a dense plant canopy, photosynthesis increases as light intensity increases. The rate of increase will depend on the species, leaf distribution, leaf area index (LAI), and photorespiration (Brown and Blaser, 1968). As temperatures increase from low to high values, growth of cool season grasses increases and then plateaus as rates of respiration and photorespiration exceed photosynthesis (McKee, 1965). At the onset of cool autumn season temperatures, photosynthesis exceeds respiration, causing sharp increases in total nonstructural carbohydrates (TNC) (Brown et al., 1966; Blaser et al., 1975).

Season of the year also greatly affects yields from temperate region forages (Blaser et al., 1969). The largest production occurs during the mid-spring season, with as much as 50% of the total yield being produced from April through June.

The harvest or grazing managements can greatly affect total yield and yield distribution over the year. Ward and Blaser (1961) showed that regrowth from orchardgrass (Dactylis glomerata L.) was dependent on stubble TNC reserves and residual LAI. Brown and Blaser (1968) discuss how this can be applied to management systems but this is only one of the factors to be considered. Also of importance for consideration in harvest management are basal bud development (Alburquerque, 1967), weed control, and balancing the ratio of grasses and legumes (Johnson, 1970). The efficiency of production varies with harvest management. Blaser et al. (1959) found that yields with grazing were 71-77% of the yields obtained by mowing. They attributed this to frequent and close grazing, with mowing allowing better plant recovery between harvests. Edmond (1958) found that grazing gave lower forage yield than mechanical harvesting because of animals treading on the forage and soil compaction. Van Keuren (1970) recommended strip grazing of deferred growth to reduce wastage and thereby obtain better utilization of feed in winter.

Wilman et al. (1976) found that yields of ryegrass increased as harvesting was delayed up to 14 weeks. Van Keuren (1975) found that tall fescue, orchardgrass, and bluegrass (*Poa pratensis* L.) all made higher total yields with twice-a-year harvests (first cut hay, second deferred grazing). Systems of deferred grazing can also be used to greatly modify the yield distribution so that the forage is available in the field as it is needed by the animal (Van Keuren, 1970 and 1972).

Forage Quality

Forage quality can best be defined as the DEI by ruminants of a forage when fed or grazed *ad libitum* for reasonably long periods. The DEI of a forage will be dependent on the DE concentration in the feed and the DMI by the animal. Crampton et al. (1960) developed this relationship and defined it as the nutritive value index (NVI) of a forage. They reported a high correlation (r = .88 to .94) between the NVI of a forage and the liveweight gains of sheep feeding *ad libitum* on the forage. This definition of forage quality (NVI) includes the effect of factors such as the balance of digestible protein (DP) to metabolizable energy (ME), proper mineral balances, vitamin sufficiency, and presence of toxic substances. The DE concentration of a forage is highly correlated to digestible dry matter (DDM), digestible organic matter (DOM), and total digestible nutrients (TDN) of the forage

(Crampton et al., 1957; Moir, 1961; Rittenhause et al., 1971). The DE is seldom measured but DDM, DOM, or TDN are commonly used in research and practice. Forage DE concentration is mainly affected by species, growth stage, and environment (Blaser, 1964; Blaser et al., 1960; Blaser et al., 1976; Sullivan, 1969; Brown et al., 1963; Minson et al., 1960). Different species may have different digestibilities even at the same growth stage depending on genetic influences affecting the canopy and cellular morphology of the plants. Temperate grasses and legumes decrease in digestibility as they age or approach reproductive status and the stem to leaf ratios increase. In vegetative regrowths, decreases in quality occur with increased age, but they are not dramatic (Reid et al., 1967).

Environment affects DE content by influencing the relative proportions of cell soluble contents (CSC) and cell wall contents (CWC). If the CWC digestibility remains constant as the CSC fraction increases, the DE content will increase since the CSC fraction is near 100% digestible. This is the principle on which the Van Soest summative equation (Goering and Van Soest, 1970; Van Soest, 1965) and other summative equations are based (Sullivan, 1964). Environmental factors (temperature, N, and water) which stimulate growth usually decrease the TNC contents of the temperate forage species (Blaser et al., 1975). Under favorable growth conditions, N fertilizer decreases the TNC but increases crude protein (CP), causing similar CWC:CSC ratios and similar DE for both low and high N fertilization forages.

Forage Intake

Crampton et al. (1960) reported that DMI had a greater influence on the variation in average daily gain (ADG) than the DE content of the feed. Blaser et al. (1960 and 1970) showed that temperate forages, even under good management, were deficient in DEI by showing ADG increases in grazing animals supplemented with grain (energy). Protein content of these forages is usually quite adequate (Crampton et al., 1960). Several extensive reviews have been made of the research work on feed intake (Jones, 1972; Balch and Campling, 1962; Conrad, 1966). Feed intake is influenced by several causative agents arising from the feed, animal, or environmental factors.

Feed Factors: Feed characteristics that influence forage intake are digestibility, rate of digestion, and rate of passage. These are interrelated and species dependent. Digestibility within a species is often correlated with DMI (Hodgson, 1968; Reid, 1973). However, differences in intake among species are not correlated with digestibility when comparing grasses and legumes, or unpalatable species such as tall fescue. The rate of forage digestion and its passage from the rumen have been positively correlated to DMI in ruminants (Campling, 1966; Crampton et al., 1960; Demorquill et al., 1966; Blaxter et al., 1961; Monson et al., 1964). Donefer et al. (1960) found a 12-hour *in vitro* digestion of forages to be highly correlated with DEI and a 48-hour *in vitro* digestion to be highly correlated with *in vivo* DE content. Increased rate of digestion should increase intake if rumen fill is limiting intake. As digestion rate increases there will be a more rapid decrease in the volume of forage in the rumen, thus allowing rapid recurrence of hunger and thus frequent feeding. Butler et al. (1968) and Thornton and Minson (1973) found that this response may occur in sheep since sheep feeding on legume pastures have a more frequent feeding pattern than those feeding on grass pastures. Blaser et al. (1956) showed that cattle grazing legume-grass mixtures had higher ADG than those grazing N fertilized grass. This indicates a greater DEI on the legume-grass pastures.

Fertilization of a forage species under favorable growing conditions usually does not affect DDM or DMI to any great extent directly. Fertilization causes changes in sward species composition by encouraging growth and the competitive ability of certain species. Nitrogen fertilization increases grass growth at the expense of legumes; P, K, and Ca without N increase legumes (Blaser et al., 1976; Templeton and Taylor, 1966; Cooper et al., 1967; Shoop et al., 1961).

Processing of forage by grinding and pelleting increases forage intake over coarse chopping (Campling, 1966; Buckman and Hemken, 1964).

Animal Factors: Animal size is a major factor in feed intake (Crampton, 1960). To account for this, intake is usually expressed as a percent of body weight (% BW) or as grams per metabolic size ($g/w_{kg}^{.75}$).

Production status and age of the ruminant also affects DMI since animals under production stresses such as lactation or growth will consume at higher levels (Arnold, 1975; Arnold and Dalginski, 1963). Breed and sex differences affect DMI due to differences in size and production status (Arnold, 1975; Langland, 1969). Different ruminant species have different intakes of the same forage in pasture situations due to their adaptation for selectivity in feeding habits. Under pasture or range situations, DMI will depend on the types of plant species available, the animal species sharing the pasture, and the degree of competition for forage (Langland and Sanson, 1976; Dusek, 1975; Mott, 1960).

The nutritional status of the ruminant affects DMI. Egan (1965 a, b, c) observed that sheep on a low CP diet would increase intake when given supplemental protein either interintestinally or intravenously, and that this was related to volatile fatty acid (VFA) metabolism. This may be related to the chemostatic principles of regulation and the model of Jones (1970); a low N content in the feed would prevent the body from utilizing VFA in the blood for production, thereby allowing VFA accumulation which would inhibit feed intake.

Environmental Factors: Pasture availability is a major factor affecting forage intake (Mott, 1960). As pasture becomes less available, animals cannot be as selective (Blaser et al., 1976) and will consume less feed per bite (Stobbs, 1973 a, b). Blaser et al. (1960) found that the first cattle grazing a fresh pasture had higher production than second grazers. This was attributed to first grazers selecting forage higher in CP and digestibility and lower in fiber and lignin than last grazers.

High temperature is another environmental factor which inhibits feed intake; however, at low temperatures intake may increase. This may be by means of altering the equilibrium of the chemothermostatic regulating mechanisms. At high ambient temperatures, the body temperature may increase beyond a certain internal temperature "set point" with intake being reduced (Jones, 1977). At low temperatures, the use of blood metabolites for producing heat to maintain body temperature may tend to stimulate appetite.

Protein

Forage CP content has often been related to quality. The CP in productive young temperate forages is usually more than adequate (Crampton, 1960). The CP in grasses increases with N fertilization (Reid et al., 1967) or legume mixtures with the grass. The CP content decreases with advancing maturity (Blaser, 1964; Reid et al., 1967). A high correlation exists between CP and the CP digestion coefficient (French et al., 1957); however, a much better correlation exists between CP and DP (Holter and Reid, 1959).

Management Effect on Forage Quality

The effect of management on forage quality has been reviewed by Blaser et al. (1976). The main effects of management are in controlling growth stage at harvest and in controlling grazing pressure to control selective grazing by the animals. Also, proper fertilization and harvest management to maintain improved grass species and legume-grass mixtures will improve DEI.

Estimating Forage Quality

Forage researchers have been looking for methods to give better evaluations of forage quality that apply to all species. Two *in vitro* and chemical evaluation systems receiving the most interest in the last few years are the biological rumen analog of Tilley and Terry (1963) and the detergent summative equation of Van Soest (1964). Both systems can give close estimates of DDM of forages, within 3-4 units residual mean square (RMS), but need to be correlated with *in vivo* standards. This is important with the detergent fraction summative equation when investigating forages from different areas or of different genetic materials

(Deinum and Van Soest, 1969). The Tilley and Terry digestion technique is sensitive to length of fermentation and is different for selected groups of grasses (Nelson et al., 1974). A modified Tilley and Terry system can be useful in evaluating the expected intake of forages (Donefer et al., 1960).

Tall Fescue Productivity and Quality

Tall fescue is a productive, widely adapted, temperate region grass which follows the productive characteristics of other temperate grasses as influenced by season, light, fertilization, and harvest (Green, 1974; Van Keuren, 1972; Lechtenburg et al., 1972; Bryant et al., 1975). Tall fescue quality during summer, as measured by animal productivity, is generally not as high as that of bluegrass and orchardgrass. A good deal of work on tall fescue quality has been directed toward isolating the toxic characteristics of tall fescue associated with fescue foot, fat necrosis, and poor animal performance. Fescue foot and fat necrosis are relatively rare occurrences in the mid-Atlantic region and have been studied by Jacobson et al. (1963), Yates et al. (1968), and Williams et al. (1969). These two toxicity problems are accompanied by poor animal performance due to ill health and are considered different than the poor animal performance not associated with obvious toxicity. Bush and Buckner (1973) reviewed these two toxicity problems.

Poor animal performance is a widespread problem and may or may not be the effect of toxicity problems. Chemical analysis of tall fescue indicates its quality to be comparable to bluegrass and orchardgrass; however, the output per head is generally lower for tall fescue than other temperate grasses. The summer carrying capacity is high for tall fescue indicating a low DMI and/or high dry matter production for tall fescue as compared to other pastures (Blaser et al., 1969; Van Keuren, 1972). Bush and Buckner (1968) have shown that alkaloid content in tall fescue parallels the performance of animals during summer. Bush et al. (1970 and 1972) showed that perloline (the predominant alkaloid in tall fescue) decreases the *in vitro* digestion rate of cellulose in forages. Therefore, it could be expected that perloline would decrease DMI of tall fescue. However, Bush and Buckner (1973) have shown that a possible adaptation to perloline occurs in ruminant microbes cultured on tall fescue.

Tall fescue does not appear to have low animal performance problems in winter and can be used very successfully as deferred pasturage for wintering cattle and sheep. When using tall fescue pastures for wintering cows in Virginia and Ohio, winter weight changes and calf birth weights were no different than for a conventional hay feeding system (Van Keuren, 1970; Hammes, 1976). In Virginia, there were lower calf weaning weights when cattle were maintained on a year-around all-tall fescue grazing system as compared with similar management treatments with some bluegrass pasture (Hammes, 1976).

MATERIALS AND METHODS

To accomplish the objectives of this research, three experiments were conducted in 1975 and repeated in 1976.

Experiment 1

The quality of late summer regrowth of Kentucky 31 tall fescue was evaluated when fed alone and in combination with a legume. Digestibility and intake of the grass, the legume, and a 50:50 grass-legume mixture (mix) were evaluated with sheep. In 1976, orchardgrass (*Dactylis glomerata* L.) was included alone and in a mix with the legume for comparison. Procedures followed during the two trials were altered slightly between 1975 and 1976.

Summer 1975: Tall fescue and alfalfa (*Medicago sativa* L.) were evaluated in late summer, 1975. Tall fescue was harvested from an established stand on a Groseclose silt loam (clayey, mixed, mesic, Typic, Hapludult) at the VPI & SU Agronomy Farm, Blacksburg, Virginia. This stand was harvested in July and fertilized in early August with 1121 kg/ha of 10-10-10. The 60-day tall fescue regrowth was 20 cm tall and dormant due to drought. The alfalfa (variety unknown), also grown on a Groseclose silt loam, had about 40 days of regrowth, being in a 10 to 50% bloom stage during the experiment. The alfalfa growth was normal, apparently unaffected by the dry weather.

The tall fescue and alfalfa were harvested once daily in the afternoon with a sickle bar mower, leaving a 3.8 cm stubble. The forage was raked, bagged, and chopped into 7.6 to 10.2 cm lengths with a stationary forage chopper. Part of the forage was then fed at 7:00 P.M.; the rest of the forage was stored loosely in large burlap bags for the 7:00 A.M. feeding. Evenings during the period September 1-20 were sufficiently cool enough to prevent appreciable heating of the loosely stored forage. The mixes were made on a 1:1 wet weight basis. The component forages of the mixed ration were weighed separately for each animal and mixed by hand on a clean concrete floor.

Fifteen crossbred wether sheep (average weight 23.5 kg ± 2.2 s.d.) were blocked by weight and allocated at random to the three forages (five animals/treatment). The sheep were housed in individual box stalls for adjustment to the rations and for determining intake. Forages and water were available at all times. Refusals of 5 to 10% were collected and weighed once daily. Forage before feeding and refusals were subsampled for dry matter (DM) determination. All samples were then oven dried, air equilibrated, and stored for laboratory analysis.

The sheep were moved to metabolism crates for the digestion trial. Feeding practices were continued as before, except that water was available for two 1-hour periods daily while the forages were weighed. The sheep were allowed a 7-day preliminary period before fecal collection. Each ration was fed to a 5 to 10% refusal. Total feces and urine were collected for 5 days. Each wether was weighed at the beginning and end of each phase of the trial, the average weight being used in calculations.

Feces, collected daily, were placed in metal pans and dried in a forced air oven at a maximum temperature of 60°C for 24 hours. Daily collections were composited and stored for each wether in large tin cans. After the experiment, samples were air equilibrated for 2 weeks, weighed, mixed, subsampled, and ground to pass a 1 mm screen. The ground samples were then stored in sealed sample jars for analysis.

Forages were subsampled at each feeding and dried for 24 hours in a forced air oven at 60°C. Refusals were collected once daily and dried. Forage and refusals, allowed to air equilibrate for 2 weeks, were weighed, ground to pass a 1 mm screen and stored in sealed sample bottles.

Total urine collections were made in 15 ml of 1:1 (weight:weight) sulfuric acid and H_2O, plus approximately 500 ml H_2O. Daily collections of urine were diluted to a constant weight, checked for acidity, and a 3% volumetric subsample taken. Subsamples were composited daily for each animal into 1-liter plastic bottles and refrigerated. At the end of the experiment, the samples were mixed, subsampled, and subsamples frozen until analyzed.

Feeds, refusals, and feces were analyzed for proximate fractions, except crude fiber, by AOAC (1970) procedures. Crude fiber was determined by the method of Whitehouse et al. (1949). Urine N was determined by macro-Kieldahl (AOAC, 1970). Neutral and acid detergent fractions were determined by the methods of Goering and Van Soest (1970). Determinations of TNC contents were made by the method of Wolf and Ellmore (1973).

<u>Summer 1976</u>: The 1976 trial was conducted similar to the 1975 trial with the following exceptions. Red clover (<u>Trifolium</u> <u>pratense</u> L., cultivar Kenstar) and the Jackson cultivar of orchardgrass were established in the spring of 1975. Tall fescue was harvested from a different established sod. All plots were located on Groseclose silt loam.

All stands were fertilized according to soil test and extension recommendations. The grasses received 67 kg/ha of N in the spring of 1976. All forages were harvested on 14 June; the regrowths were used for the trial during 12 August and 1 September. All forages had about 60 days of growth. The red clover was in a late bloom to mature stage of flower.

All forages were harvested once daily in the afternoon with a "Carter" flail forage harvester. The mixes (1:1, grass:clover) were based on DM estimates observed in the adjustment phase of the trial under various weather conditions.

Thirty crossbred sheep (average weight 31.8 kg $\pm$ .7 s.d.) were blocked by breed and weight and assigned at random to the five treatments. The digestion trial was conducted with a 7-day adjustment period, a 7-day preliminary, and a 7-day collection period. During the adjustment phase, forage was adjusted to give 550 gms of dry feed (1.7% BW) to the animals daily to avoid refusals. During the trial, wet weight of the forages was adjusted to approximate this intake. However, there were some refusals which were treated as in the 1975 trial. Sheep were allowed 2 hours for each feeding; water was available at all other times. Other procedures were as for the 1975 trial.

At the end of the digestion trial, the sheep were moved to box stalls where they were fed to determine DMI as in the 1975 trial. However, one block of sheep was lost due to injury in transport.

Experiment 2

The quality of stockpiled tall fescue during winter as affected by four dates of accumulation was studied by digestion and intake trials with sheep.

Winter 1975: A well established stand of Ky 31 tall fescue was chosen in the spring of 1975 and fertilized with P and K according to soil tests. This is the same stand used for the summer, 1976, digestion trial. The first growth was cut in June of each year (1975 and 1976). The four stockpiling treatments, allocated at random each year, were accumulating growths from 3 June, 9 July, 5 August, and 15 September in 1975 and 14 June, 15 July, 17 August, and 15 September in 1976. Nitrogen was applied to all plots on 15 August at the rate of 112 kg/ha. In 1975, the forage was harvested with a rotary mower every other day and stored loosely in burlap bags between harvests for feeding. In 1976, forage was harvested every day with a "Carter" flail harvester. Stubble heights were 3.8 cm each year.

Winter 1976: In 1976, the August accumulated tall fescue was evaluated for the feed quality of the top and bottom strata as well as for the entire canopy. About half of the canopy (top growth) was harvested with the flail chopper; a second cut was made to harvest the bottom stratum leaving a 3.8 cm stubble as for the single cutting (whole canopy). Whole, top, and bottom strata of canopies were harvested daily. Sheep allocation, management, feeding, collection, and laboratory methods were as for August, 1976, experiment 1 trial.

Canopy Evaluation: In December of 1976, four 61 X 61 cm quadrats were harvested from each of the four stockpiling treatments. These harvested samples were divided into upper leaf blades and basal strata by harvesting at the top of the stem sheaths to obtain entire upper blades and then cutting to a 1.3 cm stubble to obtain a basal strata of stem-sheaths and some live and dead leaves. The upper leaf blades were divided into apex and basal blades by cutting them into approximately equal portions. The September stockpiled tall fescue leaf stratum was so sparse that it was not divided. The basal stratum was hand separated into stem-sheaths by removing any attached leaf material and all leaf material was then separated into live blades or dead leaves (blades and some sheaths) based on its being green or brown, respectively. Data obtained were DM yield of the canopies, yield distribution over the canopy components, and TNC and CP contents of the canopy components by methods previously discussed. A chlorophyl index (CI) was measured for the whole canopy and for each hand separation. The method used is discussed subsequently in the methods used in experiment 3.

Experiment 3

An established stand of tall fescue on the VPI & SU Agronomy Farm, similar to that in experiment 2, was used in 1975 and 1976 to investigate the influence of four stockpiling dates (mid-June, July, August, and September) and five N fertilizer treatments (no N and 112 kg N/ha applied in mid-June, July, August, or September) on yield and chemical quality of stockpiled tall fescue. The experiment was set up as a 4 X 5 factorial split plot design, harvest dates being the main plots and N application dates as subplots. These subplots were 2.4 X 3.7 meters in size. There were 3 replications. Different tall fescue sods were used in 1975 and 1976.

To obtain different accumulation period lengths, the tall fescue was stockpiled from 3 June, 9 July, 5 August, and 15 September in 1975 and from 14 June, 15 July, 17 August, and 15 September in 1976. The spring growth for all treatments was harvested on the June date. At this date, the June N treatment was applied to one subplot of each main plot. At each harvest which started a subsequent stockpiling treatment, all main plots not yet being accumulated were cut to estimate the summer production from different N fertilization dates. After the harvest, N was applied to a subplot in each stockpiling date main plot.

Winter yields were taken on 13 December 1975, and 13 February 1976, for the 1975-1976 winter season and on 1 December in 1976 for the 1976-1977 season. All harvests were cut to a 3.8 cm stubble height using a Gravely (1975) or Jacobson (1976) mower. All samples were dried in forced hot air, ground to pass a 1 mm screen, and stored for laboratory analysis. Analyses were made for TNC and N as already described.

Chlorophyl Index: A chlorophyl index (CI) was used in lieu of hand separation of live and dead material. A 250 mg sample of material was treated overnight with 20 ml of ethanol, filtered, and colimetric determinations of the extracted pigments made at 522 millimicrons, the absorption peak for the extract. A Bausch and Lomb Spectronic 20 with flow-thru cuvette unit, having a 10 mm path length microcell, was used in these determinations. The chlorophyl index (CI) was calculated by the equation:

$$CI = \frac{\ln t}{\ln T} \qquad [1]$$

Where: CI is the chlorophyl index,

t is the percent light transmittance through the sample extractant, and,

T is the percent light transmittance through a standard sample.

The September stockpiled and N fertilized forage harvested in December, 1975, was chosen as a standard for making comparisons. This tall fescue forage had nearly 100% live leaf material. Single analyses of all forage treatments in each of three replications were extracted.

Spring Stand Density: The effects of the 1975 stockpiling and N fertilization dates on the sod density the following spring (1976) were determined with a point quadrat to ascertain ground cover. If a point touched a tall fescue tiller or part of a tall fescue clone, the area was counted as being part of the sod. Four quadrats of 25 points and 61 X 61 cm in size were taken per plot.

Statistical computations were made by analysis of variance using the statistical analysis systems, SAS .72 and SAS .76, (Barr et al., 1976) on the VPI & SU computer system. Least significant differences ($LSD_{.05}$) were calculated according to Steel and Torrie (1960) for comparisons found to be significantly different. Linear regressions were calculated by least square fit.

RESULTS

Experiment 1

The quality of late summer regrowths of Ky 31 tall fescue and alfalfa were compared alone and in a 50:50 mix in 1975 (Table 1). Due to differences in dry matter, alfalfa constituted 41.9% of the mixed ration dry matter.

The digestibilities of dry matter (DM), organic matter (OM), and the TDN, and apparent DP contents of the forages differed significantly (Table 2).[1/] These values for tall fescue were substantially lower than for alfalfa. However, the values for the mix were similar to the means of the two component forages. The digestion coefficients of the proximate fractions of these forages were significantly different. The digestion coefficients for crude fiber (CF) and CP of the mix were different from the calculated means of the forages fed alone. The digestion coefficients for ether extract (EE) and nitrogen free extract (NFE) of the mix are not different than the mean of the component forages fed alone. Intake of DM of the three forage rations did not differ significantly when expressed on either a body weight or a metabolic size basis. Intake tended to be higher when part or all of the forage consited of the legume.

The results of the 1976 summer digestion trial (Tables 3 and 4) show that the digestibilities of DM and OM for these rations were significantly different. The values for orchardgrass were generally higher than those for tall fescue or red clover fed alone. The

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[1/]All differences infer significant differences at $P \leq .05$.

Table 1. Chemical characteristics of tall fescue and alfalfa when fed as green chop in September, 1975.[1/]

Constituents	Tall Fescue	Alfalfa
	Proximate Fractions (%)	
Dry Matter	29.6	26.1
Crude Protein	9.9	21.8
Crude Fiber	31.9	22.9
Ether Extract	2.2	1.6
Nitrogen Free Extract	48.8	41.0
Ash	7.3	12.6
	Acid Detergent Fractions (%)	
Cell Wall Contents	71.8	47.6
Acid Detergent Fiber	41.3	34.6
Acid Detergent Lignin	6.9	8.2
Acid Detergent Insoluble Ash	2.2	4.1
	TNC (%)	
	8.6	6.8

[1/]Percentages other than DM are computed on a DM basis.

Table 2. Digestibility, nutrient content, and intake (dry matter basis) of tall fescue and alfalfa alone and in a 50:50 mixture when fed as green chop in September, 1975.

Constituents	Tall Fescue	Fescue-Alfalfa	Alfalfa	$LSD_{.05}$
	Digestion Coefficients (%)			
Dry Matter	35.8	46.9	59.4	4.1
Organic Matter	37.8	49.4	63.5	4.1
Crude Protein	35.5	62.4	76.9	4.0
Crude Fiber	38.4	46.0	55.1	4.4
Ether Extract	-18.5	5.6	18.6	12.9
Nitrogen Free Extract	42.0	49.6	63.9	4.9
	Nutrient Content (%)			
Total Digestible Nutrients	35.3	45.1	54.9	3.5
Digestible Protein	3.5	9.3	16.8	.5
	Intake			
% Body Wt.	1.78	2.19	2.23	NS
$g/wt_{kg}^{.75}$	47.6	58.6	59.1	NS

Table 3. Chemical characteristics of tall fescue, orchardgrass, and red clover when fed as green chop in August, 1976.[1/]

Constituents	Tall Fescue	Red Clover	Orchardgrass
	Proximate Fractions (%)		
Dry Matter	34.6	34.5	33.6
Crude Protein	8.8	13.6	9.3
Crude Fiber	30.0	33.0	34.0
Ether Extract	2.6	1.7	2.6
Nitrogen Free Extract	48.8	45.5	45.7
Ash	9.8	6.2	8.3
	Acid Detergent Fractions (%)		
Cell Wall Contents	66.5	56.9	69.8
Acid Detergent Fiber	41.8	45.0	44.6
Acid Detergent Lignin	6.5	11.4	7.8
Acid Detergent Insoluble Ash	4.7	.4	2.4
	TNC (%)		
	10.8	9.0	8.4

1/Percentages other than DM are computed on a DM basis.

Table 4. Digestibility, nutrient content, and intake (dry matter basis) of tall fescue, orchardgrass, and red clover alone and in 50:50 mixtures of each grass and legume when fed as green chop in August of 1976.

Constituents	Tall Fescue	Tall Fescue-Red Clover	Red Clover	Orchardgrass-Red Clover	Orchardgrass	LSD .05
	Digestion Coefficients (%)					
Dry Matter	54.8	54.6	53.9	56.9	57.0	1.9
Organic Matter	57.5	56.7	55.1	58.0	58.5	1.9
Crude Protein	51.0	51.8	51.9	55.5	53.8	2.8
Crude Fiber	61.0	60.8	58.6	64.9	69.2	2.6
Ether Extract	11.1	19.8	33.6	4.4	-30.1	4.3
Nitrogen Free Extract	59.0	56.7	54.3	56.2	56.6	1.8
	Nutrient Content (%)					
Total Digestible Nutrients	52.2	52.6	52.4	53.9	52.6	NS
Digestible Protein	4.49	5.79	7.07	6.34	5.02	0.3
	Intake					
% Body Wt.	2.26	2.29	2.39	2.46	2.24	NS
$g/wt_{kg}^{.75}$	53.5	54.6	56.3	58.5	53.4	NS
	Nitrogen Balance					
g/day	- .28	- .66	- 1.11	+ .72	- .36	NS

digestibility of the mixes did not differ from the means of the two component forages. The TDN contents of the rations did not differ significantly. The DP contents of the rations were highest for red clover and lowest for tall fescue. Digestion coefficients of the proximate fractions were significantly different. The CP digestion coefficient for the orchardgrass-red clover mix was higher than the mean of the coefficients of the two component forages fed alone. However, when expressed as DP content, there was no difference between the orchardgrass-clover mix and the means of the two component forages. The CP digestion coefficients of tall fescue, red clover, and their mix were lower than that of the orchardgrass-red clover mix. The intake of DM of the five rations were not significantly different. The tall fescue-clover ration contained 49.8% clover and the orchardgrass-clover ration, 49.5% clover.

Experiment 2

The quality of stockpiled tall fescue canopies of different ages obtained by accumulating growths from various dates (June to September) and harvested in December is presented in Tables 5 and 6.

In Vivo Trials: The 1975 digestibilities of DM and OM and the TDN and DP contents of the forages were highest for the three later stockpiling dates (Table 6). The CP was highest in digestibility for the tall fescue accumulated from September. The digestion coefficients of CP, EE, and NFE of tall fescue stockpiled from different dates differed significantly, but those of CF did not. The intake of DM was lowest for the June accumulated tall fescue and increased as the accumulating periods were shortened, with nonsignificant differences between the July and August canopies. There was not sufficient forage for the September

Table 5. Chemical characteristics of stockpiled tall fescue harvested and fed as green chop in December, 1975.[1]

Constituents	Beginning Dates of Stockpiling June	July	August	September
	Proximate Fractions (%)			
Dry Matter	42.5	38.9	37.0	37.2
Crude Protein	10.1	10.8	10.5	13.2
Crude Fiber	22.6	21.7	20.5	18.4
Ether Extract	2.9	3.2	3.1	3.0
Nitrogen Free Extract	49.7	48.6	50.8	49.9
Ash	14.7	15.7	15.1	15.4
	Acid Detergent Fractions (%)			
Cell Wall Content	53.1	50.2	48.2	44.2
Acid Detergent Fiber	30.2	28.3	27.9	25.8
Acid Detergent Lignin	3.6	2.9	3.1	3.0
Acid Detergent Insoluble Ash	2.3	2.4	2.5	3.6
	TNC (%)			
	20.8	23.0	24.4	23.8

[1]Percentages other than DM are computed on a DM basis.

Table 6. Digestibility, nutrient content, and intake (dry matter basis) of stockpiled tall fescue when fed as green chop in December, 1975.

Constituents	Beginning Dates of Stockpiling: June	July	Aug.	Sept.	$LSD_{.05}$
	Digestion Coefficients (%)				
Dry Matter	62.3	66.7	67.4	66.9	2.7
Organic Matter	64.8	69.0	70.1	70.4	2.5
Crude Protein	56.2	60.2	59.3	65.8	2.8
Crude Fiber	61.3	65.7	65.3	65.5	NS
Ether Extract	57.7	62.8	60.9	57.6	2.6
Nitrogen Free Extract	67.5	71.9	74.4	74.0	2.1
	Nutrient Content (%)				
Total Digestible Nutrients	56.9	60.2	61.6	61.6	1.8
Digestible Protein	6.2	7.0	6.7	9.3	.3
	Intake				
% Body Wt.	2.04	2.41	2.52	-- 1/	.29
$g/wt_{kg}^{.75}$	48.6	58.0	61.1	----	7.7
	Nitrogen Balance				
g/day	.84	.93	.85	1.23	.09

1/ Because of a shortage of forage, the intake of the September stockpiling could not be measured.

accumulation period to complete the intake trial.

The 1976 data for a trial similar to that for 1975 appears in Tables 7 and 8. The digestibilities of DM and OM and the TDN contents increased as tall fescue was stockpiled from June to August and decreased for the September accumulated growth. The digestible protein content was not significantly different between stockpiling dates. The digestion coefficients for the proximate fractions followed trends similar to those for digestibilities of DM and OM, values for CP were not significant. The intake of DM was not affected by stockpiling date in 1976.

For August stockpiled growth, the top, bottom, and entire canopies were compared (Table 9). The DM digestibility was highest for the top portion of the canopy; the OM digestibility and TDN content did not differ significantly but followed similar trends. The DP content of the canopy differed significantly, the bottom and entire canopy having lower values than the top. The digestion coefficients for CP and EE differed in the canopy strata. The CP digestion coefficient followed the trend of DM digestion and DP content. Digestion of EE was higher for the entire canopy than for the basal and top portions. Intake of DM did not differ significantly for canopy fractions.

Canopy Evaluation: Yields of DM for the four stockpiling treatments used in 1976 differed, ranging from 5208 kg/ha for June stockpiling to 2191 kg/ha for September stockpiling (Table 10). The percentages of leaf blades in the upper strata and basal materials were similar for canopies accumulated after June, July, and August. In the September stockpiled canopy, upper leaves made up only 33% of the

Table 7. Chemical characteristics of stockpiled tall fescue when harvested and fed as green chop in December, 1976.[1]

Constituents	Beginning Dates of Stockpiling and Canopy Fraction					
	June	July	August			September
	Whole Canopy	Whole Canopy	Whole Canopy	Top Half	Bottom Half	Whole Canopy
	Proximate Fractions (%)					
Dry Matter	42.2	40.5	37.7	41.2	38.0	39.9
Crude Protein	10.1	10.6	10.2	11.3	9.7	10.6
Crude Fiber	19.4	20.8	19.1	20.5	19.7	20.1
Ether Extract	2.5	2.7	3.3	2.7	2.3	2.3
Nitrogen Free Extract	59.8	58.4	59.2	57.8	59.9	58.4
Ash	8.2	7.5	8.2	7.6	8.4	8.6
	Acid Detergent Fractions (%)					
Cell Wall Content	60.8	59.2	55.9	55.0	56.5	54.1
Acid Detergent Fiber	34.4	34.0	32.4	30.1	31.5	30.2
Acid Detergent Lignin	2.7	3.0	2.5	2.3	3.2	3.0
Acid Detergent Insoluble Ash	3.3	2.9	3.0	2.1	3.2	3.5
	TNC (%)					
	14.4	16.6	19.2	18.8	19.0	20.3

1/Percentages other than DM are computed on a DM basis.

Table 8. Digestibility, nutrient content, and intake (dry matter basis) of stockpiled tall fescue when fed as green chop in December, 1976.

Constituents	Beginning Dates of Stockpiling June	July	Aug.	Sept.	LSD .05
	Digestion Coefficients (%)				
Dry Matter	51.0	55.6	60.6	53.8	2.0
Organic Matter	55.0	59.5	64.2	58.2	2.0
Crude Protein	47.3	48.7	49.7	45.0	NS
Crude Fiber	37.1	46.8	49.0	43.2	5.3
Ether Extract	47.7	51.2	61.9	43.6	3.2
Nitrogen Free Extract	62.5	66.3	71.8	66.4	2.5
	Nutrient Content (%)				
Total Digestible Nutrients	52.0	56.7	61.5	54.5	1.9
Digestible Protein	4.8	5.2	5.1	4.8	NS
	Intake				
% Body Wt.	2.60	2.59	2.40	2.59	NS
$g/wt_{kg}^{.75}$	59.6	58.7	53.8	58.4	NS
	Nitrogen Balance				
g/day	- .06	- .58	- .34	- 1.13	.70

Table 9. Digestibility, nutrient content, and intake (dry matter basis) of whole, top, and bottom portions of August stockpiled tall fescue canopies when fed as green chop in December, 1976.

Constituents	Whole Canopy	Top	Bottom	$LSD_{.05}$
	Digestion Coefficients (%)			
Dry Matter	60.6	62.9	60.4	1.8
Organic Matter	64.2	65.5	64.6	NS
Crude Protein	49.7	53.5	49.8	3.0
Crude Fiber	49.0	55.9	50.2	NS
Ether Extract	61.9	50.0	47.2	5.4
Nitrogen Free Extract	71.8	72.0	72.3	NS
	Nutrient Content (%)			
Total Digestible Nutrients	61.5	62.2	60.5	NS
Digestible Protein	5.1	6.1	4.9	.3
	Intake			
% Body Wt.	2.40	2.49	2.47	NS
$g/wt_{kg}^{.75}$	53.8	56.7	56.3	NS
	Nitrogen Balance			
g/day	- .34	- .16	- .27	NS

Table 10. Dry matter yields (kg/ha) and botanical fractions of canopy strata of stockpiled tall fescue harvested in December, 1976.[1/]

Canopy Components	Beginning Stockpiling Date June	July	Aug.	Sept.	LSD .05
	——Total Canopy Yield (kg/ha.)——				
Total Canopy	5208	4467	3432	2191	972
	——Percent of Total Canopy Yield——				
Upper Leaf Blades, Total	51	56	54	33	12
Apex Parts	26	27	25	----	N/A[2/]
Basal Parts	25	28	29	----	N/A
Basal Strata, Total	49	44	47	67	12
Stem Sheaths	8	11	10	10	NS
Live Blades	11	13	15	18	NS
Dead Leaves	30	20	21	39	6

[1/]The forage typifies that used for the 1976 digestion trial.

[2/]Not applicable. The leaf blades were divided into apex and basal parts so that each portion made up approximately 50% of yield.

yield, with the basal strata being correspondingly higher than the other stockpiling dates. The percentages of basal canopy yields of stem sheaths and live blades were similar between dates of stockpiling. The percentages of dead leaves were lowest in July and August stockpiled canopies (20-21%) and highest for the September (39%) stockpiling date. The yields of dead leaf material were not significantly different between July, August, and September (721-893 kg/ha) but were highest for the July stockpiling (1562 kg/ha).

The TNC content of the whole canopies increased from 13.3 and 14.9% in June and July stockpiled forage to 22.3 and 18.1% in August and September stockpiled forages (Table 11). The differences in TNC between upper blades for the accumulation dates were not significant. However, for the apex and basal parts of blades, the August growth was significantly higher in TNC than the June or July growths. There was a trend for the basal parts of blades to have a higher TNC content than the apex portion, but this was not significant. For all materials in the basal canopy strata, the TNC content increased from June growth (12.2%) to the July, August, and September growths which were similar (20.8-21.5%). The stem sheaths were highest in TNC in the June, July, and August stockpiled growths (31.0-36.8%), with a trend to decrease with age. The lowest TNC values occurred with the September stockpiled forage (25.8%). The live blades in the basal parts of canopies were lowest in TNC when stockpiled from June and July. The TNC values increased for August with sharp increases for September stockpiled tall fescue. The TNC concentrations for dead leaves increased from June through August growths, with no further change for September stockpiled

Table 11. Total nonstructural carbohydrates (% of dry matter) of botanical fractions of stockpiled tall fescue harvested in December, 1976.[1/]

Canopy Components[2/]	Beginning Stockpiling Dates June %	July %	Aug. %	Sept. %	$LSD_{.05}$
Total Canopy	13.3	14.9	22.3	18.1	5.9
Upper Leaf Blades, Total	15.6	15.4	20.1	20.6	NS
Apex Parts	14.1	15.0	19.2	----	3.4
Basal Parts	15.9	16.2	22.9	----	2.1
Basal Strata, Total	12.2	21.2	21.5	20.8	6.7
Stem Sheaths	31.0	33.1	36.8	25.8	8.4
Live Blades	23.9	23.5	26.5	35.7	2.0
Dead Leaves	4.0	7.3	9.5	8.8	1.9

[1/] The forage typifies that used for the 1976 digestion trial.

[2/] $LSD_{.05}$ between strata means = 3.0.

forage.

There was no significant stockpiling treatment effect on the CP content of the whole canopy growths (Table 12). For leaf blades, including apex or basal fractions, the CP content tended to be highest in the July and September stockpiled tall fescue. For the basal parts of canopies, only the dead leaves showed a treatment effect on CP content; June and July growths were lower than August and September growths.

The CI of the whole canopy, leaf blades, and apex aprts of blades were not affected by stockpiling treatments (Table 13). The basal parts of blades displayed a significant increase in CI from June (29%) to July and August (41%). The basal strata had a progressive CI increase from June (16%) through September (24%). The stem sheaths and dead leaves from the basal strata showed a similar trend. When averaging all stockpiling dates, the blades were higher in CI than stem sheaths. The basal strata live blades had a higher CI than the other botanical components.

Experiment 3

The effect of four canopy accumulation periods, five N fertilizer treatments and two winter harvesting dates on yield and chemical quality of tall fescue were studied.

Winter Yield: The winter, 1975-1976, DM yields were significantly affected by N fertilization and stockpiling date treatments (Table 14). Yields decreased as stockpiling dates were delayed. When averaging yields for stockpiling dates, the highest yield was obtained with September N fertilization. However, there was a highly significant

Table 12. Crude protein content (% of dry matter) of botanical fractions of stockpiled tall fescue harvested in December, 1976.[1/]

Canopy Components[2/]	Beginning Stockpiling Dates June %	July %	Aug. %	Sept. %	LSD .05
Total Canopy	8.4	8.5	8.0	8.6	NS
Upper Leaf Blades, Total	9.0	11.1	9.6	10.7	1.5
Apex Parts	8.7	10.9	9.6	----	1.4
Basal Parts	8.6	10.5	9.4	----	1.2
Basal Strata, Total	6.9	7.2	8.0	8.3	NS
Stem Sheaths	8.0	7.3	7.1	9.0	NS
Live Blades	9.9	10.8	9.1	9.8	NS
Dead Leaves	5.8	5.5	7.1	7.9	1.5

[1/]The forage typifies that used for the 1976 digestion trial.

[2/]$LSD_{.05}$ between strata means = NS.

Table 13. Chlorophyl index of botanical fractions of stockpiled tall fescue harvested in December, 1976.[1]

Canopy Components[2]	Beginning Stockpiling Dates: June	July	Aug.	Sept.	$LSD_{.05}$
Total Canopy	23	32	28	26	NS
Upper Leaf Blades, Total	30	38	35	40	NS
Apex Parts	26	36	31	--	NS
Basal Parts	29	41	41	--	6
Basal Strata, Total	16	18	22	24	4
Stem Sheaths	13	16	16	22	8
Live Blades	42	39	43	47	NS
Dead Leaves	7	9	9	12	2

[1] The forage typifies that used for the 1976 digestion trial.

[2] $LSD_{.05}$ between upper and basal strata means = 4.6.

Table 14. Dry matter yields (kg/ha) of stockpiled tall fescue harvested in December, 1975, and February, 1976.

112 kg Nitrogen/ha Application Dates	1975 Stockpiling Date[1] June	July	Aug.	Sept.	Avg.
	December Harvest[2]				
No Nitrogen	2956	1121	880	521	1369[3]
June	4864	2599	1177	793	2358
July	4393	3031	1666	698	2448
Aug.	3752	2973	1627	967	2330
Sept.	3971	2947	2295	2021	2808
Avg.[4]	3987	2534	1529	1000	2263
	February Harvest				
No Nitrogen	2039	565	354	138	773[5]
June	2422	956	471	208	1014
July	3161	2494	733	252	1660
Aug.	3079	1715	777	306	1469
Sept.	3345	1824	1392	858	1855
Avg.[6]	2810	1511	745	353	1355

[1] The following interactions were statistically significant at $P \leq .01$: stockpiling date X fertilization date, (S X F), fertilization date X harvest date, (F X H), and (S X F X H).

[2] Harvest dates were significantly different at $P \leq .01$.

[3] $LSD_{.05} = 232$

[4] $LSD_{.05} = 208$

[5] $LSD_{.05} = 362$

[6] $LSD_{.05} = 341$

interaction between stockpiling dates and N fertilization. The highest yield for a given stockpiling date generally occurred when the date of applying N was similar to the stockpiling date. When harvest was delayed from December to February, there was a 60% loss in DM yield. The February DM yields (DM_{Feb}, kg/ha) were highly correlated to the December DM yields (DM_{Dec}) (r^2 = .90, n = 30) as described by the equation:

$$DM_{Feb} = .774\ DM_{Dec} - 396. \qquad [2]$$

The 1976 stockpilings were harvested only in December. Again, DM yield decreased (Table 15) as stockpiling was delayed from June to August and the trend continued, nonsignificantly, into September. When averaging all stockpiling dates, yields increased as N fertilization was delayed from June, peaking with the July and August applications. The September and August fertilization dates yields were similar. There was a strong interaction between stockpiling and fertilization dates.

Summer Yield: The monthly summer production of tall fescue (Table 16) was highest with N fertilization applied in June and July in both years. In 1975, but not in 1976, yields (averaged over all N fertilizer treatments) decreased progressively with later harvests. Fertilizing with N caused production to peak in the month after N was applied. In the August N fertilizer treatment, a bimodal curve was produced by combining the higher production of early summer in the July harvest and the N stimulating effects in the August harvest.

Table 15. Dry matter yields (kg/ha) of stockpiled tall fescue harvested in December, 1976.

112 kg Nitrogen/ha Application Dates	1976 Stockpiling Date[1/] June	July	Aug.	Sept.	Avg.
No Nitrogen	2899	1837	923	447	1526[2/]
June	4297	2863	843	377	2095
July	4852	3688	1263	591	2598
Aug.	3705	3461	1911	848	2481
Sept.	3551	2831	1506	1083	2244
Avg.[3/]	3861	2936	1289	669	2189

[1/] The stockpiling date X fertilization date interaction was significant at $P \leq .01$.

[2/] $LSD_{.05} = 305$

[3/] $LSD_{.05} = 1333$

Table 16. Summer monthly dry matter yields of tall fescue (kg/ha).[1]

112 kg Nitrogen/ha Application Dates	Harvest[2] July	Aug.	Sept.	Avg.
	1975			
No Nitrogen	873	219	96	396[3]
June	2129	601	146	958
July	873	949	607	810
Aug.	873	219	381	491
Avg.[4]	1187	496	308	663
	1976			
No Nitrogen	649	366	439	485[5]
June	1398	891	401	897
July	649	1029	681	787
Aug.	649	366	985	667
Avg.[6]	836	663	626	708

[1] First cutting dry matter yields were taken in June and are omitted. In 1975, they yielded 4994 kg/ha.

[2] All interactions were significant at $P \leq .01$ level.

[3] $LSD_{.05} = 167$

[4] $LSD_{.05} = 137$

[5] $LSD_{.05} = 360$

[6] NS

Total Yield: Excluding the spring growth harvested in June, the total DM yields generally decreased as stockpiling dates were delayed when averaging all N treatments (Table 17). When averaging stockpiling dates, the yields were highest for the June and July dates of applying N and lowest for August N applications. There was no stockpiling date X fertilizer date interaction.

Total Nonstructural Carbohydrates (TNC): The TNC contents of tall fescue harvested in winter (Tables 18 and 19) were significantly affected by stockpiling date, fertilization date, and harvest date. When averaging dates of N application, TNC contents increased as stockpiling was delayed from June to September. When averaging over stockpiling dates, TNC contents were similar for June and July dates of applying N; thereafter they increased. Over all treatments, the TNC content decreased 47% as harvest was delayed from December to February. February TNC content (TNC_{Feb}) was correlated to December TNC content (TNC_{Dec}) (r^2 = .77, n = 30) and is described by the equation:

$$TNC_{Feb} = .502\ TNC_{Dec} + 1.49 \qquad [3]$$

There was a stockpiling date by fertilization date interaction in harvests in December, 1975, but not in the February or December, 1976, harvests.

The yield of TNC in the winter season (Tables 20 and 21) decreased as stockpiling was delayed and increased as N fertilization was delayed. Over all treatments, the TNC yield decreased by 64% as harvest was delayed from December to February. February TNC yield (TNC_{Feb}, kg/ha)

Table 17. Total dry matter yields (kg/ha) for various stockpiling dates of tall fescue harvested monthly until stockpiling and then cut in December (the spring growths of all treatments harvested in June are excluded).

112 kg Nitrogen/ha Application Dates	Stockpiling Dates[1/] June	July	Aug.	Sept.	Avg.
	1975				
No Nitrogen	2956	1994	1970	1708	2155[2/]
June	4864	4728	3907	3669	4292
July	4393	3905	3925	3564	3947
Aug.	3752	3846	2870	2591	3265
Sept.	3971	3820	3538	3359	3671
Avg.[3/]	3985	3658	3242	2978	3466
	1976				
No Nitrogen	2899	2487	1939	1902	2306[4/]
June	4297	4260	3131	3066	3688
July	4852	4337	2922	2950	3766
Aug.	3705	4110	2926	2935	3419
Sept.	3551	3481	2522	2537	3023
Avg.[5/]	3861	3735	2687	2678	3241

[1/] Interactions were not significant in 1975 or 1976.

[2/] $LSD_{.05} = 349$

[3/] $LSD_{.05} = 352$

[4/] $LSD_{.05} = 364$

[5/] $LSD_{.05} = 880$

Table 18. Total nonstructural carbohydrates (% of dry matter) of stockpiled tall fescue harvested in December, 1975, and February, 1976.

112 kg Nitrogen/ha Application Dates	1975 Stockpiling Dates[1/] June %	July %	Aug. %	Sept. %	Avg. %
	December Harvest[2/]				
No Nitrogen	15.9	19.1	19.6	19.6	18.5[3/]
June	14.7	18.0	21.2	22.8	19.2
July	16.5	18.2	21.3	23.1	19.8
Aug.	18.5	20.3	22.9	27.1	22.2
Sept.	20.3	23.3	27.2	30.5	25.3
Avg.[4/]	17.2	19.8	22.4	24.6	21.0
	February Harvest				
No Nitrogen	9.3	9.2	10.3	9.8	9.7[5/]
June	9.5	10.3	10.9	12.0	10.7
July	10.5	10.9	12.6	12.7	11.7
Aug.	12.0	12.3	13.7	13.5	12.9
Sept.	13.0	14.0	17.2	16.8	15.3
Avg.[6/]	10.9	11.4	12.9	13.0	11.2

[1/] Interactions significant, $P \leq .01$: S X F, S X H, F X H.

[2/] Harvest dates were significantly different at $P \leq .01$.

[3/] $LSD_{.05} = 0.9$

[4/] $LSD_{.05} = 1.2$

[5/] $LSD_{.05} = 0.7$

[6/] $LSD_{.05} = 0.9$

Table 19. Total nonstructural carbohydrates (% of dry matter) of stockpiled tall fescue harvested in December, 1976.

112 kg Nitrogen/ha Application Dates	1976 Stockpiling Dates[1/] June %	July %	Aug. %	Sept. %	Avg. %
No Nitrogen	12.2	15.4	16.9	16.5	15.2[2/]
June	11.8	15.9	17.7	16.8	15.6
July	13.2	16.1	19.1	19.3	16.9
Aug.	17.0	19.1	22.5	26.1	21.1
Sept.	16.6	19.7	25.1	28.0	22.3
Avg.[3/]	14.1	17.2	20.2	21.3	18.2

[1/]Interactions were not significant.

[2/]$LSD_{.05}$ = 1.8

[3/]$LSD_{.05}$ = 2.6

Table 20. Total nonstructural carbohydrate yields (kg/ha) of stockpiled tall fescue harvested in December, 1975, and February, 1976.

112 kg Nitrogen/ha Application Dates	1976 Stockpiling Date[1/] June	July	Aug.	Sept.	Avg.
	December Harvest[2/]				
No Nitrogen	467	215	171	103	239[3/]
June	709	467	250	182	402
July	726	544	358	161	447
Aug.	694	604	370	263	483
Sept.	806	691	622	615	683
Avg.[4/]	680	503	354	264	451
	February Harvest				
No Nitrogen	189	52	37	13	73[5/]
June	230	94	52	26	101
July	335	266	89	31	180
Aug.	370	211	105	41	182
Sept.	437	254	239	145	269
Avg.[6/]	313	176	104	52	160

[1/] All interactions were significant at $P \leq .01$.

[2/] Harvest dates were significantly different at $P \leq .01$.

[3/] $LSD_{.05} = 40$

[4/] $LSD_{.05} = 55$

[5/] $LSD_{.05} = 38$

[6/] $LSD_{.05} = 29$

Table 21. Total nonstructural carbohydrate yields (kg/ha) of stockpiled tall fescue harvested in December, 1976.

112 kg Nitrogen/ha Application Dates	1976 Stockpiling Dates[1] June	July	Aug.	Sept.	Avg.
No Nitrogen	353	271	161	81	216[2]
June	489	438	149	64	285
July	604	569	240	118	383
Aug.	582	634	410	217	461
Sept.	537	533	368	295	433
Avg.[3]	512	490	266	155	355

[1] The stockpiling date X fertilization date interaction was significant at $P \leq .01$

[2] $LSD_{.05} = 81$

[3] $LSD_{.05} = 122$

was linearly correlated to December TNC yield (TNC_{Dec}) ($r^2 = .85$, $n = 30$) and was described by the equation:

$$TNC_{Feb} = .518\ TNC_{Dec} - 73. \qquad [4]$$

The double logarithmic linear regression showed a better relationship ($r^2 = .94$, $n = 30$) and was described by the equation:

$$\ln TNC_{Feb} = 1.59 \ln TNC_{Dec} - 4.671 \qquad [5]$$

or

$$TNC_{Feb} = .00937\ TNC_{Dec}^{1.59} \qquad [6]$$

Crude Protein (CP): The CP content of stockpiled tall fescue in both years was significantly influenced by dates of stockpiling, N fertilization, and harvest date. For averages across factorial treatments, CP content increased with delayed stockpiling and delayed N fertilization in the 1975-1976 winter season (Table 22). The loss of CP content between December and February harvests (when averaged over all other treatments) was 0.5 units. The CP contents in February (CP_{Feb}) and December (CP_{Dec}) were correlated ($r^2 = .98$, $n = 30$) as expressed by the equation:

$$CP_{Feb} = 1.03\ CP_{Dec} - .83 \qquad [7]$$

In December, 1976 (Table 23), the forage CP content generally increased with delayed N fertilization; delays in stockpiling dates tended to

Table 22. Crude protein contents (% of dry matter) of stockpiled tall fescue harvested in December, 1975, and February, 1976.

112 kg Nitrogen/ha Application Dates	Stockpiling Date[1/] June %	July %	Aug. %	Sept. %	Avg. %
	December Harvest[2/]				
No Nitrogen	9.3	9.0	10.0	11.4	9.9[3/]
June	8.2	8.9	8.8	11.2	9.3
July	9.7	9.5	10.2	10.7	10.0
Aug.	9.7	10.6	10.6	10.9	10.4
Sept.	12.0	13.6	14.3	15.5	13.9
Avg.[4/]	9.8	10.3	10.8	11.9	10.7
	February Harvest				
No Nitrogen	8.9	8.7	9.7	10.3	9.4[5/]
June	7.9	8.1	8.3	10.8	8.7
July	8.9	9.5	9.5	9.7	9.4
Aug.	9.2	10.3	9.7	10.0	9.8
Sept.	11.3	13.3	14.2	15.3	13.5
Avg.[6/]	9.2	10.0	10.3	11.2	10.2

1/The stockpiling date X fertilization date interaction was significant at $P \leq .05$.

2/Harvest dates were significantly different at $P \leq .01$.

3/$LSD_{.05} = 0.5$

4/$LSD_{.05} = 0.3$

5/$LSD_{.05} = 0.5$

6/$LSD_{.05} = 0.3$

Table 23. Crude protein contents (% of dry matter) of stockpiled tall fescue harvested in December, 1976.

112 kg Nitrogen/ha Application Dates	1976 Stockpiling Dates[1]				
	June	July	Aug.	Sept.	Avg.
No Nitrogen	7.4	8.4	8.8	9.2	8.4[2]
June	8.2	8.4	8.8	9.4	8.7
July	9.2	9.1	8.5	9.8	9.2
Aug.	9.9	11.0	10.7	11.0	10.6
Sept.	10.2	12.2	13.7	13.9	12.5
Avg.[3]	9.0	9.8	10.1	10.6	9.9

[1] The stockpiling date X fertilization date interaction was significant at $P \leq .01$.

[2] $LSD_{.05} = 0.6$

[3] $LSD_{.05} = NS$

increase the CP contents as in 1975, but were not significant.

The CP yields (Tables 24 and 25) in the stockpiled forage decreased with delaying stockpiling dates and increased with delayed N fertilization for all harvests in both years. When averaged over stockpiling and N fertilization dates, the CP yield was 43% less in the February than in the December harvest. The CP yield in February (CPY_{Feb}, kg/ha) was closely correlated to the December yield (CPY_{Dec}) (r^2 = .90, n = 30) as described by the equation:

$$CPY_{Feb} = .758\ CPY_{Dec} - 44. \qquad [8]$$

Chlorophyl Index (CI): The relative chlorophyl content in stockpiled tall fescue during two years (Tables 26 and 27) increased with delayed stockpiling dates and delayed N fertilization dates, when averaged over factorial treatments. When averaging stockpiling and fertilization dates, CI decreased by 76% between the December and February harvests in the 1975-1976 season. The CI values in February (CI_{Feb}) and December (CI_{Dec}) were correlated (r^2 = .803, n = 30) as described by the equation:

$$CI_{Feb} = .285\ CI_{Dec} - 2.6 \qquad [9]$$

Spring Stand Density: Stockpiling tall fescue from different dates had no effect on sod density the following spring (Table 28). Fertilizing with N increased the subsequent spring sod density. When averaged over stockpiling dates, the sod cover increased from 35% with June N

Table 24. Crude protein yields (kg/ha) of stockpiled tall fescue harvested in December, 1975, and February, 1976.

112 kg Nitrogen/ha Application Dates	1975 Stockpiling Dates[1/] June	July	Aug.	Sept.	Avg.
	December Harvest[2/]				
No Nitrogen	272	102	89	59	130[3/]
June	394	231	104	89	205
July	428	288	171	74	241
Aug.	363	314	171	105	239
Sept.	479	401	327	314	380
Avg.[4/]	388	268	173	128	239
	February Harvest				
No Nitrogen	179	49	36	15	69[5/]
June	194	77	38	22	83
July	282	240	67	25	154
Aug.	280	177	74	30	140
Sept.	377	244	197	132	239
Avg.[6/]	262	158	83	45	137

[1/] All interactions were significant at $P \leq .01$.

[2/] Harvest dates were significantly different at $P \leq .01$.

[3/] $LSD_{.05} = 30$

[4/] $LSD_{.05} = 40$

[5/] $LSD_{.05} = 30$

[6/] $LSD_{.05} = 40$

Table 25. Crude protein yields (kg/ha) of stockpiled tall fescue harvested in December, 1976.

112 kg Nitrogen/ha Application Dates	1976 Stockpiling Dates[1] June	July	Aug.	Sept.	Avg.
No Nitrogen	223	160	84	45	161[2]
June	370	245	76	36	182
July	455	342	109	62	242
Aug.	377	389	207	96	267
Sept.	363	347	210	155	269
Avg.[3]	358	297	137	78	217

[1]The stockpiling date X fertilization date interaction was significant at $P \leq .01$.

[2]$LSD_{.05} = 34$

[3]$LSD_{.05} = 146$

Table 26. Chlorophyl indices of stockpiled tall fescue harvested in December, 1975, and February, 1976.

112 kg Nitrogen/ha Application Dates	1975 Stockpiling Dates[1/] June	July	Aug.	Sept.	Avg.
	December Harvest[2/]				
No Nitrogen	36	38	42	42	40[3/]
June	31	40	42	51	41
July	40	45	48	52	46
Aug.	44	49	56	57	52
Sept.	64	78	89	100	83
Avg.[4/]	43	50	56	61	52
	February Harvest				
No Nitrogen	10	7	8	5	8[5/]
June	9	9	8	8	9
July	12	10	11	8	10
Aug.	13	13	12	10	12
Sept.	19	22	25	25	23
Avg.[6/]	13	13	13	11	12

[1/] All interactions were significant at $P \leq .05$.

[2/] Harvest dates were significantly different at $P \leq .01$.

[3/] $LSD_{.05} = 4$

[4/] $LSD_{.05} = 4$

[5/] $LSD_{.05} = 2$

[6/] $LSD_{.05} = 2$

Table 27. Chlorophyl indices of stockpiled tall fescue harvested in December, 1976.

112 kg Nitrogen/ha Application Dates	1976 Stockpiling Dates[1/]				
	June	July	Aug.	Sept.	Avg.
No Nitrogen	16	23	23	21	21[2/]
June	16	21	23	19	20
July	20	25	24	25	23
Aug.	25	37	34	36	33
Sept.	30	39	43	45	39
Avg.[3/]	21	29	29	29	27

[1/] Interactions were not significant.

[2/] $LSD_{.05}$ = 2.9

[3/] $LSD_{.05}$ = NS

Table 28. The March, 1976, sod density (% ground cover) of tall fescue as affected by the 1975 stockpiling treatments.

112 kg Nitrogen/ha Application Dates	1975 Stockpiling Dates[1/] June	July	Aug.	Sept.	Avg.
No Nitrogen	33	20	27	25	27[2/]
June	34	33	36	37	35
July	44	37	49	33	41
Aug.	39	39	43	43	41
Sept.	51	53	63	66	57
Avg.[3/]	40	36	44	40	40

[1/]Interactions were not significant.

[2/]$LSD_{.05}$ = 8

[3/]$LSD_{.05}$ = NS

fertilization to 57% with September N fertilization.

DISCUSSION

Summer Digestion Trials

Experiments were conducted to measure the digestiblity and intake of tall fescue in summer, alone and when combined with a legume, and in winter when accumulated for different lengths of time. The growth and chemical composition of stockpiled tall fescue as influenced by date of applying N and length of accumulation period were also investigated.

In this study, the digestible components of the summer grown tall fescue forages were not significantly affected by mixing grasses and legumes. The inhibitors of digestibility were probably caused by normal forage components such as lignin rather than toxic substances such as perloline in tall fescue forage. If a toxic substance was present, its site of inhibition was apparently within the forage and not dispersed into the rumen fluid. Otherwise, such a substance could be expected to reduce the digestibility of the legume components in the mix, unless there was an interaction with the legume to reduce the activity which would elevate the tall fescue digestibility. There was a slight but not a statistically significant increase in digestibility of the mix in these trials (Table 29). Monson and Reid (1968) found that the *in vitro* DDM of mixes was depressed from the weighted mean of the components when mixing late or early cut grasses with early cut legumes but that the *in vitro* DDM was increased from the component means when grasses were mixed with late cut birdsfoot trefoil (*Lotus corniculatus* L.). The biological influence on DDM of botanical mixtures may

Table 29. Weighted average digestibilities and nutrient contents of the components of grass-legume mixtures compared to the observed digestibilities of the mixes.[1]

Constituent	Summer 1975 Fescue/Alfalfa Weighted Average	Summer 1975 Fescue/Alfalfa Observed	LSD .05	Summer 1976 Fescue/Clover Weighted Average	Summer 1976 Fescue/Clover Observed	Summer 1976 Orchardgrass/Clover Weighted Average	Summer 1976 Orchardgrass/Clover Observed	LSD .05
	Digestion Coefficients (%)							
Dry Matter	45.7	46.9	4.1	54.4	54.6	55.6	56.9	1.9
Organic Matter	48.6	49.4	4.1	56.3	56.7	56.8	58.0	1.9
Crude Protein	52.8	62.4	4.0	51.4	51.8	52.9	55.5	2.8
Crude Fiber	28.6	46.0	4.4	59.8	60.8	64.0	64.9	2.6
Ether Extract	- 3.0	5.6	12.9	22.3	19.8	1.4	4.4	4.3
Nitrogen Free Extract	51.2	49.6	4.9	56.7	56.7	55.4	56.2	1.8
	Nutrient Content (%)							
Total Digestible Nutrients	43.5	45.1	3.5	52.3	52.6	53.2	53.9	NS
Digestible Protein	9.1	9.3	0.5	5.8	5.8	5.7	6.3	0.3

[1]Dry matter basis.

need critical evaluation. Even small differences that are not statistically significant may be biologically important to improve production efficiency. Based on data published by the NRC (1970), it is estimated that a one unit increase in TDN, from 60 to 61%, would cause a .04 kg increase in daily gains for a 318 kg steer consuming forage at 2.5% of its body weight (Table 30). At the difference levels shown in Table 29, this could mean a 10.1 to 53.8 kg increase in beef production per hectare on improved pastures. At 18.1 cents per kg, this amounts to $8.89 to $47.42 increased net income per hectare. These small daily gain increases could also elevate the carcass grade and value per kg.

The advanced age of summer forages, other than the alfalfa in 1975, elevated CWC and acid detergent lignin (ADL) contents, thereby reducing the digestibility. The ADL in the legumes did not reduce digestibility in proportion to its content since in legumes, lignin is concentrated in stems and is low in the leaves (Johnson et al., 1962; Tomlin et al., 1965). The CP trends were similar to CWC and ADL. Digestibility of CF was lower in the legumes than in grasses in both years. The CP, DP, and TDN contents of these mature summer regrowth forages, other than the 1975 tall fescue, were suitable for dry cow maintenance (NRC, 1970). The low tall fescue digestibility in 1975 was likely due to advanced age causing high CWC and associated lignin and low soluble components associated with the warm season and advanced age (Ward and Blaser, 1961).

In the 1976 trial, DDM values were highly significant, but TDN values did not differ among forages. This ambiguity may be attributed to forage and fecal OM content. The fecal OM contents from the rations were tall fescue, 84.7%; red clover, 91.4%; and orchardgrass, 88.5%.

Table 30. The influence of feed total digestible nutrient (TDN) content and dry matter intake (DMI) on the estimated average daily gains (ADG) of a 318 kg growing steer.[1/]

TDN (% Dry Matter)	DMI (% Body Weight)	ADG (kg)
60	2.5	.53
61	2.5	.57
60	2.6	.58
61	2.6	.62
50	2.5	.17
51	2.5	.20
50	2.6	.20
51	2.6	.23

Increase in ADG (kg) With Increase in TDN and DMI

TDN Level	TDN % + 1 unit	DMI + .1 unit
60	+ .04	.05
50	.04	.03

[1/]ADG estimated by relations published by NRC, 1970.

The lack of absorption or the intestinal excretion of ash constitutents increases fecal dry matter, thereby decreasing DDM as compared to DOM. The higher OM of red clover forage also caused an increase in the organic proximate fractions of the clover, thus raising its relative TDN content. The differences in TDN may also be attributed, in part, to the higher DP and DEE of red clover and low DEE of orchardgrass.

The lack of significance in DMI may be due to the high variability of intake. Confidence intervals ($T_{.05}$ X s.e.) of the mean intakes ranged from 4.4 to 10.0 g/w$^{.75}$ for the 1976 trial. Using the variance of the intake in this trial, it was calculated that nine animals per treatment would be needed to estimate a true difference in intake of $\pm$ 5 g/w$^{.75}$ ($\pm$ .2% BWI).

Winter Digestion Trials

The increase in digestibility of tall fescue as accumulation is delayed was related to increases in the soluble fraction of the forage. When *in vivo* DDM was correlated with the soluble and insoluble fractions of the forage (Table 31), the regressions were significant. Brown et al. (1960) found a similar increase in DDM with increased TNC content as stockpiled tall fescue grew from mid-August through fall to December. Balasko (1977) found that N fertilization increased TNC and *in vitro* DDM of tall fescue stockpiled from August and harvested in December. The September stockpiled forages were quite low in DDM compared to the June, July, and August stockpilings and caused the high RMS as shown by the reduction of RMS when these two feeds were excluded. Table 32 shows that the high ratio of ADL plus acid detergent insoluble ash (ADIA) to acid detergent fiber (ADF) in the September forage may account

Table 31. Correlations of soluble and insoluble cell fractions with *in vivo* digestible dry matter (DDM) of stockpiled tall fescue.

Fraction Regressed Against in vivo DDM	r^2	Residual Mean Square	Significance
	All Samples (n = 10)		
Total Nonstructural Carbohydrates	.73	9.6	**[1/]
Crude Protein	.17	30.5	NS
Digestible Protein	.59	14.9	**
Total Nonstructural Carbohydrates + Crude Protein	.73	9.9	**
Total Nonstructural Carbohydrates + Digestible Protein	.78	8.1	**
Cell Wall Content	.69	11.3	**
Acid Detergent Fiber	.68	11.7	**
	September Samples Excluded (n = 8)		
Total Nonstructural Carbohydrates	.93	2.6	**
Crude Protein	.08	31.9	NS
Digestible Protein	.72	9.8	**
Total Nonstructural Carbohydrates + Crude Protein	.97	1.1	**
Total Nonstructural Carbohydrates + Digestible Protein	.93	2.6	**
Cell Wall Content	.92	3.0	**
Acid Detergent Fiber	.93	2.6	**

[1/] Significant at $P \leq .01$.

Table 32. Ratios of acid detergent lignin (ADL) to acid detergent fiber (ADF), and ADL plus acid detergent insoluble ash (ADIA) to ADF in stockpiled tall fescue.

Stockpiling Treatment		ADL / ADF	ADL + ADIA / ADF
		—1975 Feed Samples—	
June		.119	.195
July		.102	.187
Aug.		.111	.201
Sept.		.116	.256
		—1976 Feed Samples—	
June		.078	.174
July		.088	.174
Aug.	Whole Canopy	.077	.170
	Top	.076	.146
	Bottom	.102	.203
Sept.		.099	.209

for this. Tall fescue is known to accumulate silica in its cell wall structure as well as lignin, and these constituents cause decreases in cell wall digestibility. The high ratio of ADL plus ADIA to ADF in the August, 1976, basal part of the canopy is probably due to soil contamination since there was no noticeable reduction in in vivo DDM.

When the September stockpilings are excluded, the sum of TNC and CP gave the best correlation with in vivo DDM and the lowest RMS. The CWC and ADF contents were highly correlated to DDM but gave RMS over 2 times as large. It can be inferred from these results that management treatments and environmental conditions which increase the cell soluble fraction of accumulated tall fescue will give proportional increases in digestibility as long as the CWC digestibility is not reduced.

The August whole canopy and top and bottom growths have small but important differences in quality. When first and last grazing accumulated tall fescue, there would also be the effect of yield, canopy structure, and availability affecting selective grazing which would allow first grazers to consume more DM of a slightly higher digestibility than last grazers. Intake of DM in 1975 followed a trend similar to the increase in DDM. If intake is affected by digestibility in accumulated tall fescue, concomitant small increases in digestibility and intake could cause considerable increase in animal growth even though differences are not statistically significant.

The quality of tall fescue in winter was affected by length of stockpiling periods and by when it was harvested in winter.

In 1975, the digestibility of June stockpiled tall fescue was depressed relative to shorter accumulation periods. In 1976, digestibility increased as stockpiling was delayed from June to July and August but then decreased when delayed into September. In 1975, hard frosts did not occur until early December; no visual browning of the forage occurred until after the digestion trial had started. During the 1975 trial, there was insufficient rain to accelerate weathering of the accumulated growth. During the fall of 1976, there was a temperature decline to -7°C in October, causing severe frost damage to all tall fescue stockpiling dates, especially noticeable in November. Also, there was considerable rain and snow during the trial period which probably accentuated weathering. These combined factors caused low TNC and digestibilities in 1976 as compared to 1975. The work of Brown et al. (1960) shows that as tall fescue is stockpiled from August, DDM increases with age and then decreases with the onset of freezing weather. Early harvesting of the 1976 canopies before freezing and weathering should have increased digestibilities. In both years, the peak DDM and TDN occurred with August stockpiling. During 1975, the TDN and DP contents of all but the June accumulated tall fescue were of suitable quality for growing steers gaining at a low rate (NRC, 1970). In 1976, the TDN and DP contents in the July and August growths were suitable for growing steers but the June and September growths were considered too low.

The continual decline of DM yield as stockpiling is delayed from June to September is not offset by increased quality. The TDN yields would be 2708, 2533, 2110, and 1194 kg/ha , respectively, from the June through September canopies. Decreases in the leaf percentage and total yield for September stockpiled growth indicates that there would probably be a low intake from this treatment due to poor availability and lack of selective grazing.

The September stockpiled canopy growth had a reduction in TNC content probably due to TNC utilization for regrowth and a lack of sufficient leaf regrowth and time for photosynthesis to restore high levels of TNC. The high TNC content in the live material from the basal strata of August and September stockpilings is probably also due to the short canopies allowing more light penetration to increase photosynthesis. This is also indicated by the increase of CI in the basal strata with delayed stockpiling dates. The live material in lower strata of older canopies would be less efficient in photosynthesis due to age and increased shading by the larger quantity of upper canopy growth, causing the reduced TNC content. Frost damage of the upper leaf strata reduced their CI while the lower leaf strata maintained a higher CI since they were protected from frost and bleaching by the upper leaves. The dead material in the basal strata had a lower TNC in older canopies probably due to longer weathering than that in younger canopies. The differences in CP of the leaf blades is attributed to the older age of the June growth. The difference in CP content of the dead material may be due to dates of N application. All dead material in the August and September forage was regrowth after the N fertilization in August, thus, increasing the N content before death while the June and July forages had appreciable growth and leaf senescence before N application.

Summer vs Winter Quality

The neutral detergent cell solubles are highly correlated with the sum of TNC and CP in all seasons (winter $r^2 = .98$, summer $r^2 = .95$, combined r^2 = .86). The low digestibility of summer as compared to the winter harvested tall fescue can be largely attributed to the lower cell soluble concentrations and the higher ADL/ADF ratio. The readily digestible cell contents and the expected digestibility of CWC was highest for winter forage. The higher temperatures in summer can increase the ratio of respiration to photosynthesis when conditions for growth are favorable such that TNC content is reduced (Greene, 1975; Blaser et al., 1966).

Predicting in vivo DDM with the Van Soest Summative Equation

The Van Soest summative equation (Goering and Van Soest, 1970) was used to predict DDM from the detergent fractions of all forages and a correlation was made comparing this prediction to the observed *in vivo* DDM. The correlation was significant but low (r^2 = .257, n = 15) and the RMS was large (47.1). For the range of forages used (35.8 to 67.4% DDM) this is unsatisfactory. The summative equation overestimated DDM apparently by overestimating the digestibility of the CWC, expecially for stockpiled tall fescue which had predicted DDM 10 to 20 units above the *in vivo* DDM.

Predicting Digestible Protein of Tall Fescue

The digestion coefficient for CP over all trials and forages was correlated to CP content (r^2 = .73, n = 18). However, the better correlation of CP vs DP of the forages (r^2 = .97) suggests its use for predicting DP. When only tall fescue forages were used, this correlation was (r^2 = .86, n = 14), and the residual mean square was low (.35). This low correlation may be attributed to the small range of CP contents (from 8.8 to 14.1%) in the tall fescue forage. For tall fescue in spring, summer, and fall seasons at different N rates and locations (Brown et al., 1963; Reid et al., 1967; and Bryant et al., 1970), the correlation of CP to DP in dried forage is high (r^2 = .98, n = 50, RMS = .48) as described by the equation:

$$DP = .980\ CP - 3.83 \qquad [10]$$

When including data from these experiments, the RMS was increased (.59) but the coefficient of determination was unchanged (.98) indicating only a small divergence of these data from that reported previously. The equation became:

$$DP = .999\ CP - 4.22 \qquad [11]$$

Small Plots

When developing a forage management plan such as stockpiling tall fescue, several considerations should be stressed.

1. What affect will management plans have on the total yield, yield distribution, and quality of the forage?
2. What total yield, yield distribution, and quality is needed for the class of livestock being managed in the enterprise?
3. What biological and economic compromises can and need to be made between forage yield, distribution, and quality?

Total yield and the December yield of accumulated forage were both highest from June and July stockpiled and N fertilized tall fescue in the two years of this study. However, with such early accumulation dates, the summer pasturage would be greatly reduced. Corespondingly, more summer pasturage becomes available as stockpiling is delayed, but total yields, and especially winter yields, would be reduced.

The loss of yield and quality was of considerable magnitude as utilization is shifted from December to February. Some loss in forage yield may be justified due to the high alternative cost of harvesting and feeding hay instead of pasturing livestock during winter. Also, winter tall fescue pasture can provide a healthier late winter calving area than a dry lot, which may justify delayed usage of the pasture. The best returns from accumulated tall fescue will be realized by utilizing it in late autumn or early winter when its quality is best. Stored feed should be reserved for adverse weather and late winter feeding.

Quality of stockpiled tall fescue (CP and TNC) increases as stockpiling and fertilization are delayed, but the potential winter yield decreases. Management for high yields for winter grazing require long growth periods. In the old forage, more of the carbohydrates are metabolized into CWC and as this fibrous fraction increases, the TNC and CP contents are diluted. The low TNC and CP contents do not indicate a net loss of these fractions since the TNC and CP yields are highest with early fertilization and stockpiling.

The _in vivo_ trials showed that July, August, and September stockpiled and August fertilized tall fescue gave adequate levels of TDN and CP for growing beef cattle and all treatments gave feed suitable for dry cows (NRC, 1970). Since fertilization earlier than August decreased TNC and CP contents, some decreases could be expected in TDN. However, since average TNC content was reduced (averaged over stockpiling dates) 4 units (3 in 1975 and 5.5 in 1976) as fertilization was shifted from August to June and CP changed only 1.5 units (1 in 1975 and 2 in 1976), digestibility would only change 2.5 units. This assumes complete digestion of these soluble fractions and 50% digestion of the remaining material. As simultaneous changes occur in stockpiling and fertilization dates, TNC can be reduced 15 units and CP can be reduced up to 7 units as dates are shifted from September back to June. Thus, for the June stockpiled and fertilized growth, TNC and CP levels in December may be so low that TDN values would be suboptimal for growth, and may or may not be satisfactory for maintaining spring calving cows during the autumn season without substantial weight loss.

The best time to stockpile tall fescue for late fall or early winter grazing depends on the acreage of tall fescue suitable for stockpiling, the quantity and yield distribution of other forages on the farm or in storage, and the restraints on quality imposed by the livestock which will graze the accumulated growth. Stockpiling as early as July gives high winter and total yields and good quality feed when fertilized in August. When stockpiling earlier than July, a decrease in quality can be expected. By utilizing the growth at its optimum quality, nutrient intake may be kept high.

September stockpiling did not improve quality in the in vivo digestion trials. September stockpiled small plot yields and quality were not greatly different than August stockpiled growths except for TNC content. September stockpiling appears undesirable because drought and early freezes could result in greater proportional yield losses than from earlier stockpiling. There may also be a reduction in intake of September stockpiled tall fescue due to the short and thinner canopy structure. Thus, July and August would be the most generally desirable dates to stockpile tall fescue with June and September being useful but less desirable alternatives.

Fertilization with N gave the highest total yield with June and July applications. Highest winter yields were obtained by applying the N fertilizer just after the harvest which starts the accumulation period. The actual effect in a given year will depend on the availability of soil moisture at the time of and shortly after application, and on fall temperatures. At current prices, it may be more economical to use legume-tall fescue mixtures to reduce N fertilization costs. However, stockpiled tall fescue has a higher value than does summer pasture due to lack of other pasturage and high cost of alternative feeding systems, and, N fertilization will often be economical if the tall fescue stand is deficient in legumes. Best returns from N fertilization may be with management aimed at getting high winter yields rather than high total yields.

Interrelations of CP, TNC, and CI

In the small plot samples, CP, TNC, and CI were highly correlated at all harvests (Table 33). There were significant differences in these correlations between harvests, except for the December CP vs TNC correlation; therefore, the two years data have been pooled.

The high positive correlation between CP and TNC in winter accumulated tall fescue may be caused by N fertilization increasing the photosynthetic activity of the canopy (Green, 1975) while the cool fall

Table 33. Correlation coefficients and regressions between crude protein (CP), total nonstructural carbohydrates (TNC), and chlorophyl index (CI) of stockpiled tall fescue.

Harvest Date	r^2	n	Regression
	CP vs TNC		
Dec. 1975 + Dec. 1976	.69	60	TNC = 1.95 CP - 0.5
Feb. 1976	.73	30	TNC = .98 CP + 2.1
	CP vs CI		
Dec. 1975	.92	30	CI = 9.09 CP -45.1
Feb. 1976	.74	30	CI = 2.49 CP -13.1
Dec. 1976	.90	30	CI = 4.75 CP -19.7
	TNC vs CI		
Dec. 1975	.74	30	CI = 3.91 TNC -30.0
Feb. 1976	.70	30	CI = 2.11 TNC -13.1
Dec. 1976	.78	30	CI = 1.78 TNC - 5.3
All Data Pooled	.76	90	CI = 3.43 TNC -28.0
	.84	90	ln CI = 2.094 ln TNC -2.653 or CI = .0704 TNC 2.094

temperatures prevent proportionate increases in growth (Brown et al., 1960). The December harvests did not differ even though there was more dead material in the December, 1976, harvest. This may be due to both lower TNC and CP contents in the 1976 harvest. This may indicate that the initial CP loss is from the cell sap and is in conjunction with early TNC loss. By February, TNC losses in the forages were high and those for CP small. The additional loss of TNC is probably due to the loss of cell contents from freezing and cell rupture, leaching by rain and snow, and through metabolic activity within the cells by the plant or microbes; whereas, part of the protein fraction is combined in cell membranes and would not be as readily soluble in water and subject to leaching as the TNC fraction.

The correlation between CP and CI was quite high but was dependent on weather damage as is pointed out by the different regressions for each harvest. The N status of the plant would affect the CI by altering the concentration of chlorophyl, thus increasing photosynthesis, and by its effect on resistance to freeze damage. There were increases in TNC with N fertilization; also, an increase in tissue potassium occurs with N fertilization (Balasko, 1977; Hojjate et al., 1977) both of which may increase the resistance to freezing injury. The different harvests constitute different CP vs CI populations, but when regressed on a double logarithmic model, the increased r^2 value indicates that they may comprise a biological continuum.

Research Needs

For the optimum development of forage systems using tall fescue, several problems must be addressed and associated questions answered.

1. June stockpiled tall fescue produces high total and winter forage yields, but quality may be too low, except for maintaining dry cows. The *in vivo* digestibility of June stockpiled and fertilized tall fescue should be measured, and a field evaluation made of the suitability of this stockpiling treatment for maintaining dry cows and over-wintering stocker cattle.
2. The effect of accumulated canopy yield and availability on selective grazing and DMI should be quantified. As tall fescue accumulates longer, more growth is available and larger mouthfuls can be taken by the cattle, but age and quality are negatively correlated and may interact with pasture availability.
3. The use of legumes for supplying N for accumulating tall fescue canopies should be evaluated. What quantity of legume is needed in a stand for maximum forage production? What effect does the legume have on the N status of the grass portion of the stand? In an accumulating canopy of tall fescue and legumes, what percent of the stand needs to be legumes to make N fertilization unprofitable? What effect are legumes going to have on the DMI from accumulated tall fescue canopies, the digestibility of the DM consumed, and what is the change in this effect with canopy defoliation? What changes in quality occur in legumes with advancing age in the fall and what is the effect of cooler fall weather on the quality of the legume at a given age?
4. An economic analysis of tall fescue management systems should

be made by linear programming methods to evaluate the quantity of fescue pastures most profitable on farms differing in proportions of soil suited for crops (corn, soybeans, and alfalfa) and pasture, with cattle making use of crop residues and stockpiled tall fescue for winter feed. What effect does the cropping system have on optimum stockpiling dates and utilization periods? What is the value of tall fescue pasture in winter under these different farm situations, and what rate of N fertilization should be used? How does N fertilization compare to using legumes to supply the N for accumulating tall fescue? What are the effects of changing prices of cattle, crops, and N on these relationships? These types of analyses are the best means of making recommendations at the farm level since the interactions of resources available determine the optimum economic approach to livestock production.

SUMMARY

Experiments were conducted to measure the digestibility and intake of summer growth of tall fescue and orchardgrass alone and with legumes and of tall fescue canopies accumulated for various periods and evaluated in winter. The growth and chemical composition of tall fescue as influenced by dates of applying N and length of accumulation period were also investigated.

When grass and legume forages were mixed, digestibility of the mixes did not differ significantly from the means of digestibilities of the component forages. Nonsignificant increases in digestibility occurred which could have meaningful economic influences on production efficiency. These consistent, small, nonsignificant increases in digestibilities of mixes over the components indicate a possible biological interaction between forages in a mix. A more critical evaluation is needed since the sheep sample size was too small to evaluate statistical differences at levels that may be biologically important.

Canopies of tall fescue accumulated and used in summer had variable quality. When low quality tall fescue was mixed with a young legume, the mix quality was improved. Red clover of an age comparable to the tall fescue had a similar digestibility and a slightly higher but not significant DM intake; the resulting mix was not improved.

The results of the winter feeding trials and the analyses of the forage samples from small plots indicate that July and August stockpiling may give the best compromise between yield and quality. These treatments give high winter yields of adequate quality and are not

subject to the reduction of quality associated with the longer June accumulation interval or the risk of low yields by delaying stockpiling until September. Accumulated tall fescue canopies have maximum quality before frost kills the leaves since freezing weather and precipitation will cause a decline in TNC and *in vivo* DDM..

When stockpiling tall fescue with N fertilizer, the N should be applied as soon as possible after the harvest which starts the accumulation period, if maximum winter yields are to be obtained. The accumulation period yield will be influenced by the availability of soil moisture and rainfall after N application. Fertilization with N increased the yield and quality of stockpiled tall fescue. Quality increase was due to increasing CP and TNC contents and reduced injury from cold weather. The DP content of tall fescue is related to its CP content and can be accurately predicted by a linear regression.

LITERATURE CITED

Alburquerque, H. E. 1967. Leaf area, age and carbohydrate reserves in the regrowth of tall fescue (Festuca arundinacea Schreb.) tillers. Ph.D. Thesis. Va. Polytechnic Inst. and State Univ., Blacksburg, Va.

Alburquerque, H. E. 1967. Leaf area index, light penetration, and carbohydrate reserves during growth of Kentucky 31 tall fescue (Festuca arundinacea Schreb.). M.S. Thesis. Va. Polytechnic Inst. and State Univ., Blacksburg, Va.

Arnold, G. W. 1975. Herbage intake and grazing behavior in ewes of four breeds at different physiological states. Aust. J. Agr. Res. 26:1017-1024.

Arnold, G. W. and M. L. Dudzinski. 1963. The use of faecal nitrogen as an index for estimating the consumption of herbage by grazing animals. J. Agr. Sci. 61:33-43.

A.O.A.C. 1970. Official methods of analysis (11th Ed.) of the Association of Official Agricultural Chemists. Washington, D.C.

Balasko, J. A. 1977. Effects of N, P, and K fertilization on yield and quality of tall fescue forage in winter. Agron. J. 69:425-428.

Barr, A. J., J. H. Goodnight, J. P. Sall, J. T. Helwig. 1976. A user's guide to SAS .76. SAS Inst. Inc., Raleigh, N.C. 329 p.

Blaser, R. E. 1964. Symposium on forage utilization: effects of fertility levels and stage of maturity on forage nutritive value. J. Anim. Sci. 23:246-252.

Blaser, R. E. and E. L. Kimbrough. 1968. Potassium nutrition of forage crops with perennials in the role of potassium in agriculture. 423-445.

Blaser, R. E., R. H. Brown, and H. T. Bryant. 1966. The relationship between carbohydrate accumulation and growth of grasses under different microclimates. Proc. 10th Internat. Grassl. Congr. p. 147-150.

Blaser, R. E., H. T. Bryant, C. Y. Ward, R. C. Hammes, Jr., R. C. Carter, and N. H. MacLeod. 1959. Symposium on forage evaluation: VII. Animal performance and yields with methods of utilizing pasturage. Agron. J. 51:238-242.

Blaser, R. E., R. C. Hammes, Jr., H. T. Bryant, W. A. Hardison, J. P. Fontenot, and R. W. Engel. 1960. The effect of selective grazing on animal output. Proc. 8th Internat. Grassl. Congr. p. 601-606.

Blaser, R. E., W. C. Stringer, E. B. Rayburn, J. P. Fontenot, R. C. Hammes, Jr., and H. T. Bryant. 1976. Increasing digestibility and intake through management of grazing systems. Proc. Southern Reg. Forage Fed Beef Res. Workshop, New Orleans, La. October, 1975.

Blaser, R. E., R. C. Hammes, Jr., H. T. Bryant, C. M. Kincaid, W. H. Skrdla, T. H. Taylor, and W. L. Griffith. 1956. The value of forage species and mixtures for fattening steers. Agron. J. 48: 508-513.

Blaxter, K. L., F. W. Wainman, and R. S. Wilson. 1961. The regulation of food intake in sheep. Anim. Prod. 3:51-61.

Brown, R. H. and R. E. Blaser. 1968. Leaf area index in pasture growth. Herb. Abs. 38:1-9.

Brown, R. H., R. E. Blaser, and H. L. Dunton. 1966. Leaf area index and apparent photosynthesis under various microclimates for different pasture species. Proc. 10th Internat. Grassl. Congr. p. 108-113.

Brown, R. H., R. E. Blaser, and J. P. Fontenot. 1963. Digestibility of fall grown Kentucky 31 fescue. Agron. J. 55:321-324.

Buchman, D. T. and R. W. Hemken. 1964. Ad libitum intake and digestibility of several alfalfa hays by cattle and sheep. J. Dairy Sci. 47:861-864.

Burdick, D. and J. T. Sullivan. 1963. Ease of hydrolysis of the hemicelluloses of forage plants in relation to digestibility. J. Anim. Sci. 22:444-447.

Bush, L. P. and R. C. Buckner. 1973. Tall fescue toxicity in antiquality components of forages. Matches, A. G. (ed.) CSSA Sp. Pub. No. 4. 140 p.

Bush, L. P., C. Streeter, and R. C. Buckner. 1970. Perloline inhibition of in vitro ruminant cellulose digestion. Crop Sci. 10:108-109.

Bush, L. P., J. A. Boling, G. Allen, and R. C. Buckner. 1972. Inhibitory effects of perloline to rumen fermentation in vitro. Crop Sci. 12:277-279.

Butler, G. W., A. L. Rae, and R. W. Bailey. 1968. Influence of pasture species on aspects of animal production. Agr. Sci. (July, 1968).

Campling, R. C. 1966. The voluntary intake of conserved grass by cattle. Proc. 9th Internat. Grassl. Congr. p. 903-905.

Chacon, E. and T. H. Stobbs. 1976. Influence of progressive defoliation of a grass sward on the eating behavior of cattle. Aust. J. Agr. Res. 27:709-727.

Chalnpa, W. V., J. L. Cason, and B. R. Baumgardt. 1961. Nutritive value of reed canarygrass as hay when grown with various nitrogen levels. J. Dairy Sci. 44:874-878.

Collins and J. A. Balasko. 1975. Yield and quality components of tall fescue (Festuca arundinacea Schreb.) in winter. Agron. Abs. An. Meeting ASA, CSSA, SSSA. 1975:105.

Cooper, R. B., R. E. Blaser, and R. H. Brown. 1967. Potassium nutrition effects on net photosynthesis and morphology of alfalfa. Proc. SSSA. 31:231-235.

Crampton, E. W., E. Donefer, and L. E. Lloyd. 1960. The nutritive value index of forages. Proc. 8th Internat. Grassl. Congr. p. 462-466.

Crampton, E. W., L. E. Lloyd, and V. G. MacKay. 1957. The calorie value of TDN. J. Ani. Sci. 16:541-545.

Deinum, B. and P. J. Van Soest. 1969. Prediction of forage digestibility from some laboratory procedures. Neth. J. Agr. 17:119-127.

Demarquilly, C., J. M. Boissau, and G. Caylle. 1966. Factors affecting the voluntary intake of green forage by sheep. Proc. 9th Internat. Grassl. Congr. p. 899-885.

Donefer, E., E. W. Crampton, and L. E. Lloyd. 1960. Prediction of the nutritive value index of a forage from in vitro rumen fermentation data. J. Anim. Sci. 19:545-552.

Dusek, G. L. 1975. Range relations of mule, deer, and cattle in prairie habitat. J. Wildl. Mangt. 39:605-616.

Edmond, D. B. 1958. The influence of treading on pasture - a preliminary study. New Zealand J. of Agr. Res. 1:319-328.

Egan, A. R. 1965a. Nutritional status and intake regulation in sheep. II. The influence of sustained duodenal infusions of casein or urea upon voluntary intake of low protein roughages by sheep. Aust. J. Agr. Res. 16:451-462.

Egan, A. R. 1965b. Nutritional status and intake regulation in sheep. III. The relationship between improvement of nitrogen status and increase in voluntary intake of low protein roughages by sheep. Aust. J. Agr. Res. 16:463-472.

Egan, A. R. 1965c. Nutritional status and intake regulation in sheep. IV. The influence of protein supplements upon acetate and propionate tolerance of sheep fed on low quality chaffed oaten hay. Aust. J. Agr. Res. 16:473-483.

French, M. H., J. Glover, and D. W. Duthie. 1957. The apparent digestibility of crude protein by the ruminant. II. The general equation and some of its implications. J. Agr. Sci. 486, 379-383.

Goering, H. K. and P. J. Van Soest. 1970. Forage fiber analysis (apparatus, reagents, procedures, and some applications). U.S.D.A. Agr. Handbook. No. 379. 20 p.

Green, J. T., Jr. 1974. Accumulating canopies of tall fescue (Festuca arundinacea Schreb.) as influenced by nitrogen and cutting management. Ph.D. Thesis, Va. Polytechnic Inst. and State Univ., Blacksburg, Va.

Hammes, R. C. 1976. Beef cow and calf performance on year-round grazing systems. N. Va. Forage Conf. N. Va. For. Res. Sta., Middleburg, Va. March 11, 1976.

Hannaway, D. B. and J. H. Reynolds. 1976. Seasonal changes in minerals, protein, and yield of tall fescue forage as influenced by nitrogen and potassium fertilization. Tenn. Farm and Home Sci. 14-17.

Hodgson, J. 1968. The relationship between the digestibility of a sward and the herbage consumption of grazing calves. J. Agr. Sci. 70:47-51.

Hojjati, S. M., W. C. Templeton, Jr., and T. H. Taylor. 1977. Changes in chemical composition of Kentucky bluegrass and tall fescue herbages following N fertilization. Agron. J. 69:264-268.

Holter, J. A. and J. T. Reid. 1959. Relationship between the concentrations of crude protein and apparently digestible protein in forages. J. Anim. Sci. 18:1339-1349.

Jacobson, D. R., S. B. Carr, R. H. Hutton, R. C. Buckner, A. P. Gordon, D. R. Dowden, and W. M. Miller. 1970. Growth, physiological responses, and evidence of toxicity in yearling dairy cattle grazing grasses. J. Dairy Sci. 53:575-587.

Jacobson, D. R., W. M. Miller, D. M. Seatn, S. G. Yates, H. L. Tookey, and I. A. Wolff. 1963. Nature of fescue toxicity and progress toward identification of the toxic entity. J. Dairy Sci. 46: 416-422.

Johnson, J. T. 1970. Influence of stocking rates on the production of Kentucky bluegrass-white clover pastures. Ph.D. Thesis. Va. Polytechnic Inst. and State Univ., Blacksburg, Va.

Johnson, R. R., B. A. Dehority, J. L. Parsons, and H. W. Scott. 1962. Discrepancies between grasses and alfalfa when estimating nutritive value from in vitro cellulose digestibility by rumen microorganisms. J. Anim. Sci. 21:892-896.

Jones, G. M. 1972. Chemical factors and their relation to feed intake regulation in ruminants: a review. Can. J. Anim. Sci. 52:207-239.

Langlands, J. P. 1969. Studies on the nutritive value of the diet selected by grazing sheep. IV. Variation in the diet selected by sheep differing in age, breed, sex, strain, and previous history. Anim. Prod. 11:369-379.

Langlands, J. P. and J. Sanson. 1976. Factors affecting the nutritive value of the diet and the composition of rumen fluid of grazing sheep and cattle. Aust. J. Agr. Res. 27:691-707.

Lutz, J. A., Jr., H. M. Camper, P. T. Gish, G. D. Jones, R. D. Sears, and M. T. Carter. 1967. Response of crops to phosphate fertilizers in Virginia. Va. Polytechnic Inst. and State Univ. Res. Div. Bull. 11. 36 p.

McKee, William Henry, Jr. 1965. The effect of high nitrogen fertilization and management practices on yield and stand reduction of cool season grasses. Ph.D. Thesis. Va. Polytechnic Inst. and State Univ., Blacksburg, Va.

Minson, D. J., C. E. Harris, W. F. Raymond, and R. Milford. 1964. The digestibility and voluntary intake of S-22 and H-1 ryegrass, S-170 tall fescue, 548 timothy, S-215 meadow fescue and germinal cocksfoot. J. Brit. Grassl. Soc. 19:298-305.

Minson, D. J., W. F. Raymond, and C. E. Harris. 1960. VIII. The digestibility of S37 cocksfoot, S23 ryegrass, and S24 ryegrass. J. British Grassl. Soc. 15:174-180.

Moir, R. J. 1961. A note on relationships of DDM and DE. Aust. J. Exp. Agr. Anim. Husbandry. 1:24-26.

Monson, W. G. and J. T. Reid. 1968. In vitro and in vivo digestibility and ad libitum intake of mechanical mixtures of forages. Agron. J. 60:610-612.

Mott, G. O. 1960. Grazing pressure and the measurement of pasture production. Proc. 8th Internat. Grassl. Cong. p. 606-611.

National Research Council. Committee on Animal Nutrition. 1970. Nutrient requirements of domestic animals. No. 4. Nutrient requirements of beef cattle. Nat. Acad. of Sci. Wash., D.C. 55 p.

Nelson, B. D., C. R. Montgomery, and P. E. Schilling. 1974. The effects of fermentation time on the *in vivo/in vitro* relationship. Ann. Prog. Rpt. S. E. La. Dairy and Pasture Exp. Sta. p. 144-154.

Raymond, W. F. and C. R. W. Spedding. 1965. Nitrogenous fertilizer and the feed value of grass. European Grassl. Fed. Proc. Wageningen, 151-165.

Reid, R. L., B. Clark, and G. A. Jung. 1964. Studies with sudangrass. II. Nutritive evaluation by in vivo and in vitro methods. Agron. J. 56 (6):537-542.

Reid, R. L., E. K. Odhuba, and G. A. Jung. 1967. Evaluation of tall fescue under different fertilization treatments. Agron. J. 59: 265-271.

Rittenhouse, L. R., C. L. Streeter, and D. C. Clunton. 1971. Estimating digestible energy from digestible dry and organic matter in diets of grazing cattle. J. Range Mangt. 24:73-75.

Shoop, G. J., C. R. Brooks, R. E. Blaser, and G. W. Thomas. 1961. Differential responses of grasses and legumes to liming and phosphorus fertilization. Agron. J. 53:111-115.

Steel, R. G. D. and J. H. Torrie. 1960. Principles and procedures of statistics. McGraw-Hill Book Comp. Inc. 481 p.

Stobbs, T. H. 1973. The effect of plant structure on the intake of tropical pastures. I. Variation in the bite size of grazing cattle. Aust. J. Agr. Res. 24:809-819.

Stobbs, T. H. 1973b. The effect of plant structure on the intake of tropical pastures. II. Differences in sward structure, nutritive value, and bite size of animals grazing *setania anceps* and *chloris gazana* at various stages of growth. Aust. J. Agr. Res. 24:821-824.

Sullivan, J. T. 1969. Chemical composition of forages with reference to the needs of the grazing animal (a review of recent research findings). USDA-ARS. ARS 34-107, 113 p.

Sullivan, J. T. 1964. The chemical composition of forages with relation to digestibility by ruminants. USDA-ARS. ARS 34-62, 58 p.

Taylor, T. H. and W. C. Templeton, Jr. 1976. Stockpiling Kentucky bluegrass and tall fescue forage for winter pasturage. Agron. J. 68:235-239.

Templeton, W. C., Jr. and T. H. Taylor. 1966. Some effects of nitrogen, phosphorus, and potassium fertilization on botanical composition of a tall fescue-white clover sward. Agron. J. 58:569-572.

Thornton, R. F. and D. J. Minson. 1973. The relationship between apparent retention time in the rumen, voluntary intake, and apparent digestibility of legume and grass diets in sheep. Aust. J. Agr. Res. 24:889-898.

Tilley, J. M. A. and R. A. Terry. 1963. A two stage technique for the in vitro digestion of forages. J. Brit. Grassl. Soc. 18:104-111.

Tisdale, S. L., W. L. Nelson, C. D. Welch, W. V. Chandler, W. G. Woltz, J. M. Carr, H. J. Evans, W. H. Rankin, and W. W. Woodhouse, Jr. 1952. Sources of nitrogen in crop production. N. C. Agr. Exp. Sta. Tech. Bull. No. 96. 63 p.

Tomlin, D. C., R. R. Johnson, and B. A. Dehority. 1965. Relationship of lignification to in vitro cellulose digestibility of grasses and legumes. J. Anim. Sci. 24:161-165.

Van Keuren, R. W. 1972. All season forage systems for beef cow herds. Proc. 27th Soil Cons. Soc. Amer. 39-44.

Van Keuren, R. W. 1970. Symposium on pasture methods for maximum production in beef cattle. Pasture methods for maximizing beef cattle production in Ohio. J. Anim. Sci. 30:138-142.

Van Keuren, R. W. and C. F. Parker. 1974. In field forage conservation for wintering sheep in midwestern United States. Proc. 12 Internat. Grassl. Congr. p. 736-740.

Van Soest, P. J. 1968. Structural and chemical characteristics which limit the nutritive value of forages. Amer. Soc. Agron. Spec. Pub. 13, p. 63-76.

Van Soest, P. J. 1965. Symposium on factors influencing the voluntary intake of herbage by ruminants. Voluntary intake in relation to chemical composition and digestibility. J. Anim. Sci. 24:834.

Van Soest, P. J. 1964. Symposium on nutrition and forage and pastures: New chemical procedures for evaluating forages. J. Anim. Sci. 23: 838-845.

Van Soest, P. J. and L. A. Moore. 1965. New chemical methods for analysis of forages for the purpose of predicting nutritive value. Proc. 9th Internat. Grassl. Congr. p. 785-789.

Van Soest, P. J., R. H. Wine, L. A. Moore. 1966. Estimation of true digestibility of forages by the in vitro digestion of cell walls. Proc. 10th Internat. Grassl. Congr. 438-441.

Ward, C. Y. and R. E. Blaser. 1961. Carbohydrate food reserves and leaf area in regrowth of orchardgrass. Crop Sci. 1:366-370.

Wasko, J. B. and L. F. Marriott. 1960. Yield and nutritive value of grass herbage as influenced by nitrogen fertilization in the Northeastern United States. Proc. 8th Internat. Grassl. Congr. p. 137-141.

Whitehouse, D., A. Zarow, and H. Shay. 1945. Rapid method of determining crude fiber in distillers dried grains. J. Assoc. Off. Agr. Chem. 28:147-152.

Williams, D. J., D. E. Tyler, and E. Papp. 1969. Abdominal fat necrosis as a herd problem in Georgia cattle. J. Amer. Vet. Med. Ass. 154:1017-1021.

Wilman, D., B. M. Ojuederie, and E. O. Asare. 1976. Nitrogen and Italian ryegrass. 3. Growth up to 14 weeks: yields, proportions, digestibilities, and nitrogen contents of crop fractions, and tiller populations. J. British Grassl. Soc. 31:73-79.

Wolf, D. D. and T. L. Ellmore. 1973. Total nonstructural carbohydrates in forages by semiautomatic analysis. Can. J. Plant Sci. 53:551-552.

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QUALITY AND YIELD OF TALL FESCUE (*FESTUCA ARUNDINACEA* SCHREB.) AS AFFECTED BY SEASON, LEGUME COMBINATIONS AND NITROGEN FERTILIZATION

by

Edward Barrow Rayburn

(ABSTRACT)

Quality and availability of tall fescue (*Festuca arundinacea* Schreb.) accumulated for fall and winter pasture was influenced by starting dates of accumulation, season of growth, and by the addition of legumes.

In 1975 and 1976, 60-day regrowths of tall fescue were evaluated (*in vivo*) for summer quality when fed alone and in 50:50 grass-legume mixtures to sheep. In 1975, 40-day old alfalfa (*Medicago sativa* L.) growth and in 1976, 60-day old red clover (*Trifolium pratense* L.) growth were used as legume treatments. In 1976, 60-day old orchardgrass (*Dactylis glomerata* L.) regrowth was fed alone and in a clover mix for comparison. Tall fescue was accumulated from mid-June, July, August, and September, fertilized with 112 kg N/ha in August, and fed in December to determine the effect of stockpiling date on *in vivo* quality. The effect of stockpiling date and N fertilization on yield, yield distribution, and chemical quality of fescue in winter were studied.

The total digestible nutrient (TDN) content of tall fescue in summer was variable between years (35.3% in 1975 and 52.2% in 1976). Alfalfa (54.9% TDN) was higher in digestibility in 1975 than tall

fescue, but red clover (52.6% TDN) and orchardgrass (52.6% TDN) were similar to tall fescue in 1976. There were no significant differences in intake of the forages. There was a consistent, nonsignificant increase in the digestibility of grass-legume mixes over the average digestibilities of the component feeds.

The digestibilities of either summer grown tall fescue forage were considerably lower than those of the stockpiled tall fescue forages if accumulated from July, August, or September (60.2, 61.6, 61.6% TDN, respectively). June stockpiled forage (56.9% TDN) was lower in digestibility than the other stockpiling treatments but higher than for the summer grown tall fescue. In 1975, the DM intake (% body-weight) of accumulated forage increased as stockpiling was delayed (June, 2.04%; July, 2.41%; and August, 2.52%). In 1976, the digestibilities of all stockpilings were lower than in 1975. Digestibility increased as the accumulation periods were shortened from June to August (June, 52.0%; July, 56.7%; and August, 61.5% TDN) and then decreased for the shortest accumulation period (September, 54.5% TDN). The 1976 August accumulated growth was divided into top and bottom canopy strata; these strata (62.2 and 60.5% TDN, respectively) did not differ significantly in digestibility from the whole canopy (61.5% TDN). Intake in 1976 was not significantly affected by stockpiling periods or canopy strata.

The digestible protein (DP) content of tall fescue for all summer and winter treatments was highly correlated to the crude protein (CP) content.

There was a decrease in December dry matter (DM) yields as stockpiling and N fertilization was delayed from June to September. Generally, the best yield response for winter grazing occurred when N was applied at the date of stockpiling. Total yields decreased as stockpiling and fertilizaiton was delayed. The highest total yields were obtained by fertilizing with N in June or July. Regrowth yields during summer were highest from early harvests but the yield distribution was shifted by N fertilization.

The winter quality of accumulated tall fescue increased as yields decreased with delaying dates of stockpiling and fertilization. Total nonstructural carbohydrates (TNC as % of DM) increased from 14.7 to 30.5% in 1975 and from 11.8 to 28.0% in 1976; CP content increased from 8.2 to 15.5% in 1975 and from 8.2 to 13.9% in 1976 when stockpiling and fertilization were delayed from June to September. However, the yield of TNC and CP decreased as DM yield decreased. The relative chlorophyl content increased in canopies with delayed stockpiling and fertilization. Fertilization with N increased forage quality and resistance to early winter freezing. Yield and quality of tall fescue in February was lower than but highly correlated to the December yield and quality.