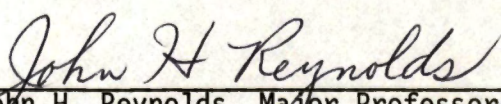
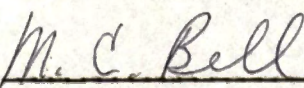
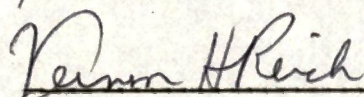


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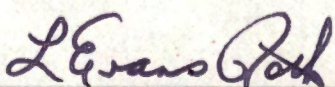
I am submitting herewith a thesis written by Joseph P. Ross entitled "Forage Quality and Yield of Tall Fescue (*Festuca Arundinacea* Schreb.) in Fall Stockpiled Growth and Winter Regrowth." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Plant and Soil Science.


John H. Reynolds, Major Professor

We have read this thesis
and recommend its acceptance:

Accepted for the Council:


Vice Chancellor
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FORAGE QUALITY AND YIELD OF TALL FESCUE (FESTUCA ARUNDINACEA SCHREB.)
IN FALL STOCKPILED GROWTH AND WINTER REGROWTH

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Joseph P. Ross
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ABSTRACT

A two-year experiment was conducted to determine the effects of fall stockpiling and date of removal of the stockpiled forage on the yield and quality of tall fescue stockpiled forage and winter regrowth forage. Tall fescue was stockpiled from August to December, August to January, and August to February, during 1975-1976 and 1976-1977. The forage was removed at the end of these three periods during both years and dry matter yields were determined. Samples were taken for forage quality analyses during October, 1975 and October and November, 1976 without harvesting by mowing and also immediately prior to harvesting the stockpiled forage during December, January, and February of both years. Estimates of the digestibility of the forage were obtained through the in vitro dry matter digestibility (IVDMD) method of Tilley and Terry. Analyses for crude protein (CP), neutral detergent fiber (NDF), water-soluble carbohydrates, K, Mg, Ca, and P provided additional information on the quality of this forage. At the end of the stockpiling periods in which the forage was harvested for yield, two rates of nitrogen fertilization, 0 and 56 kg/ha, were imposed.

Crude protein concentrations and dry matter yields declined as the length of the stockpiling period increased. Water-soluble carbohydrate concentrations in the stockpiled forage increased with the onset of freezing temperatures in the fall and decreased thereafter. In vitro dry matter digestibility percentages declined after December, 1975 and November, 1976, while NDF percentages in this forage increased after

these dates. Increases in water-soluble carbohydrate concentrations were associated with decreases in NDF concentrations and increases in IVDMD percentages. Mineral concentrations were, in general, decreased by increasing the duration of fall stockpiling. Crude protein and Ca concentrations of the stockpiled forage were adequate for a 450 kg dry, pregnant beef cow during both years, as was K during 1975-1976. Potassium levels that were below the NRC requirement for this type of animal occurred in the forage after mid-January, 1977. Phosphorus levels in the forage below the NRC minimum requirement for a 450 kg dry, pregnant beef cow occurred after October, 1975 and November, 1976. Magnesium concentrations of the forage dropped below 0.18 percent after December, 1975 and January, 1977. The quality of stockpiled tall fescue declined earlier in the fall and to a greater extent during the winter of 1976-1977 due to harsher temperature conditions during this period.

Nitrogen fertilizer applications after forage removal significantly increased the CP concentration of the winter regrowth forage. The greatest yield increases due to nitrogen fertilization were noted when the nitrogen was applied at later stockpiled forage removal dates. No significant differences were evident in NDF concentrations during 1976-1977 or IVDMD percentages in either year's winter regrowth due to forage removal dates or nitrogen fertilization. During 1975-1976, neutral detergent fiber percentages were significantly decreased due to nitrogen fertilization. Neutral detergent fiber percentages were significantly lower in the regrowth forage when the stockpiled forage was removed during February of the 1975-1976 season. Nitrogen fertilization did not significantly affect water-soluble carbohydrate

concentrations during either year. Removing the stockpiled forage during December, 1975 significantly decreased the water-soluble carbohydrate concentration of the winter regrowth forage as compared to removing this growth in January or February. Potassium percentages were significantly increased by nitrogen fertilization during both years. Calcium concentrations were significantly decreased by nitrogen fertilization during 1975-1976. Forage removal dates did not significantly affect the mineral concentrations in either year, except K during 1975-1976. Crude protein, Mg, K, and Ca concentrations of the winter regrowth were adequate for a 450 kg lactating beef cow on the harvest date of both years. Phosphorus concentrations of the regrowth forage were slightly below the NRC minimum requirement for this type of animal in both years.

It is suggested that fall-stockpiled tall fescue forage be utilized before January to avoid sizeable reductions in quality, although quality may decline extensively before this time if unfavorable weather conditions occur early in the fall. Nitrogen applications to promote winter regrowth should be made during the late winter in order to avoid losses of nitrogen.

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CHAPTER I

INTRODUCTION

It has been estimated that tall fescue is the dominant grass species in 3-1/2 million acres of pasture in Tennessee. Its efficient production and utilization have become important aspects of beef cattle production. Because of its seasonal growth characteristics, tall fescue production is concentrated during the spring and early fall of the year. Stockpiling tall fescue for use during periods when forage is scarce has been a practice used to reduce the time and labor required by conventional forage harvesting and preservation techniques. It has been estimated that forages accumulated in the fall may extend the grazing season for up to two months of additional grazing (25).

This project was initiated to evaluate the yield and quality of tall fescue stockpiled during the fall for late fall and winter grazing. Winter regrowth following removal of the stockpiled growth was also evaluated for the effects of the removal dates and nitrogen fertilization on yield and quality.

Digestibility was utilized as an estimate of forage quality. Analyses for crude protein, water-soluble carbohydrates, neutral detergent fiber, K, Ca, P, and Mg also provided additional information on the nutritive value of this forage.

CHAPTER II

LITERATURE REVIEW

I. YIELD OF FALL-STOCKPILED FORAGES

Tall fescue was superior to orchardgrass for fall stockpiling in Maryland due to a greater dry matter accumulation of the fescue regardless of the nitrogen level applied (2). This is in contrast to the work of Baker et al. (5) in Great Britain who found that there was little difference in average winter yields between tall fescue and orchardgrass. In the Maryland study, fall-stockpiled tall fescue produced higher dry matter yields at lower soil temperatures than orchardgrass and had a greater growth response to artificially increased soil temperatures. When stockpiled from mid-August, tall fescue produced higher yields than bluegrass in Kentucky at all harvest dates during the fall and winter (22). Tall fescue continued to grow at a significant rate in November at a 100 kg nitrogen/ha level of fertilization. Most researchers agreed that nitrogen applications at the beginning of the stockpiling period in mid-summer provided high yields and quality of stockpiled forages (2,6,14,22).

When fall-stockpiled forages are not utilized by late-fall or early-winter, reductions in dry matter yields occur. From December onward, dry matter yields decreased throughout the remaining part of the winter in tall fescue accumulated during the fall in Kentucky (22).

November and December harvest dates affected spring yields to the greatest extent. Similarly, delaying the harvest date of orchardgrass from mid-December to the end of February when stockpiling from the beginning of August reduced yields by 30 percent in West Scotland (11). When stockpiling from the beginning of September, delaying the harvest as above reduced yields by 55 percent. In West Virginia, delaying harvests from mid-December to mid-January of fall-stockpiled tall fescue decreased yields approximately 10 percent (6). Substantial losses of dry matter occurred in fall-stockpiled tall fescue after December in Missouri (19). Frequency of previous defoliation (4 weeks vs. 8 to 10 weeks) had no effect on the quality and very little effect on the dry matter yield. Dry matter yield began to decline in fall-stockpiled tall fescue in early November when growth ceased after the first week of below freezing average minimum temperatures. Yield of accumulated forage was highly correlated with accumulated precipitation. Archer and Decker (2) noted that the percentage of dead leaves in the sward of tall fescue and orchardgrass stands increased with decreasing temperatures in the fall and as the dead material decomposed during December, the amount of dry matter present decreased.

II. DIGESTIBILITY OF FALL-STOCKPILED FORAGES

Baker et al. (5) in Great Britain found that a pasture mixture of S170 tall fescue and S215 meadow fescue accumulated from mid-August to November or December had a higher in vitro dry matter digestibility (IVDMD) percentage than did S143 orchardgrass accumulated during the same period. The fescue plots were grazed better by cattle during the

spring and fall and better live-weight gains were obtained on these plots during late fall. Archer and Decker (2) failed to find consistent differences in quality when fall-stockpiled orchardgrass and tall fescue were compared. Minimum IVDMD levels as determined by the method of Goering and Van Soest were 80 percent for tall fescue and 73 percent for orchardgrass. Soil temperature and nitrogen fertilization had no effect on IVDMD. Orchardgrass was superior to ryegrass and timothy for winter grazing when stockpiled during the fall in Great Britain (10). There was a higher consumption of timothy and ryegrass than orchardgrass with no increase in live-weights of cattle, presumably due to the higher rate of passage of timothy and ryegrass through the digestive tract.

Autumn-accumulated tall fescue usually remains relatively high in digestibility throughout the fall until the onset of freezing temperatures during the late-fall or early-winter. In vitro digestible dry matter percentages decreased significantly throughout the fall for reed canarygrass but remained relatively stable for tall fescue until the latter part of December (26). Tall fescue maintained the same level of soluble carbohydrates during the fall whereas reed canarygrass showed a decline throughout the period. Tall fescue was higher in crude fiber than was reed canarygrass. Kroth et al. (14) found that tall fescue accumulated from June to December had an average IVDMD of 55.6 percent in southwestern Missouri and 51.3 percent in northern Missouri. In Virginia, Brown et al. (9) noted an increase in apparent in vivo dry matter digestibility of tall fescue accumulated for 9 weeks after mid-August, although the increase was not statistically significant.

Soluble carbohydrates increased up to 11 weeks. This increase in soluble carbohydrates with age without an increase in crude fiber and lignin contents may be the reason for the lack of a decrease in dry matter digestibility of fall-stockpiled tall fescue. Soluble carbohydrates may increase in the fall due to a decrease in respiration and tissue synthesis caused by cooler temperatures. Photosynthesis at this time will lead to a greater percentage of soluble carbohydrates being stored rather than utilized. Other researchers have also found the digestibility of fall-stockpiled tall fescue to increase with age, reach a plateau and then decline (8). The percent cellulose and lignin decreased due to a dilution effect from a rise in total nonstructural carbohydrates. The decline may be due to freezing temperatures causing cells to rupture and total nonstructural carbohydrates to leach. Tall fescue contained a greater amount of nonstructural carbohydrates than ryegrass, reed canarygrass, timothy, orchardgrass, redtop, Kentucky bluegrass and smooth brome grass when sampled in October in Pennsylvania (13). Total sugar concentrations of tall fescue increased as autumn advanced and decreased in tall fescue and Kentucky bluegrass from early December onward (22).

Delaying the utilization of fall stockpiled tall fescue later than early winter normally leads to a decline in its digestibility. In West Virginia, delaying harvests of fall-stockpiled tall fescue from mid-December to mid-January decreased IVDMD percentages by 2.8 percent. Total nonstructural carbohydrate concentration changes were variable when harvests were delayed from December to January, but in general were lower in January. Substantial losses of IVDMD also occurred after

December in fall-stockpiled tall fescue in Missouri (19). Loveland (15) in Tennessee noted a decrease in IVDMD after October or early November in fall-stockpiled tall fescue.

Archer and Decker (3) concluded that the percentage of dead leaves in the sward of autumn-accumulated tall fescue and orchardgrass may not provide an adequate means of estimating their digestibility, especially under variable climatic conditions. The IVDMD percentage of the dead leaf fraction, as determined by the method of Goering and Van Soest, was variable during the accumulation period. The neutral detergent fiber (NDF) concentration of the green leaves remained constant during the accumulation period and was not affected by soil temperature or nitrogen level. There was a tendency toward a lower NDF concentration with an increased nitrogen rate. The IVDMD percentage was inversely related to the NDF concentration in all plant fractions. Plant species, nitrogen level or soil temperature did not affect neutral detergent fiber, acid detergent fiber, lignin or silica concentrations of the fall-stockpiled forage to any great extent.

Differing conclusions occur in the literature as to the effect of nitrogen fertilization on the IVDMD of fall-stockpiled forage. Archer and Decker (2) noted that nitrogen fertilization during the late summer had no effect on the IVDMD percentage of fall-stockpiled tall fescue and orchardgrass. Nitrogen fertilization generally increased IVDMD and total nonstructural carbohydrate concentration in fall-stockpiled tall fescue (6). Kroth et al. (14) found that the IVDMD percentage of tall fescue accumulated from June to December in Missouri was significantly increased by August nitrogen applications. When

nitrogen applications were followed by forage harvests within 3 months, the IVDMD percentage was affected.

The relationship between IVDMD and chemical analyses of cell walls and cell contents of autumn-accumulated tall fescue and orchardgrass was studied by Archer and Decker (4). Fiber, lignin, and silica were the three constituents that were most highly correlated with IVDMD and were thus utilized in formulating a prediction equation for estimating IVDMD. Allinson (1), in a growth chamber study, observed that short photoperiods and low temperatures significantly increased IVDMD and decreased cell wall constituents of tall fescue. Cell wall constituents, acid detergent fiber and yield were significantly correlated to IVDMD in both harvests. The first harvest occurred 8 weeks after 6 month-old plants had been cut back to 1.25 cm.

III. PROTEIN IN FALL-STOCKPILED FORAGES

Minimum crude protein levels observed during the fall stockpiling period for orchardgrass and tall fescue in Maryland were 15.2 and 13.5 percent, respectively (2). Soil temperature had no effect on the crude protein concentration of either species. Taylor and Templeton (22) noted that the crude protein concentration of fall-stockpiled tall fescue and Kentucky bluegrass decreased as the season progressed, the green component of the forage usually maintaining a relatively higher concentration than the brown component. Nitrogen fertilization increased crude protein content in both species, with bluegrass having the highest crude protein content during any period observed. The protein concentration of fall-saved tall fescue decreased with age, as

did its digestibility (9). Fall-stockpiled tall fescue was lower in crude protein than was reed canarygrass (26). Nitrogen fertilization during the mid- to late-summer has been shown to increase the crude protein content of fall-saved forages (2,6,11,14,22). Substantial losses of crude protein occurred after December in Missouri in fall-stockpiled tall fescue (19). After growth stopped in November, crude protein losses amounted to 0.1 percent per week.

IV. MINERALS IN FALL-STOCKPILED FORAGES

Concentrations of mineral elements in fall-stockpiled forages decline during the fall and winter. Pfander and Rubio (20) found that the concentrations of minerals, especially K, declined after January in tall fescue accumulated from spring or August. Potassium levels reached 0.4 percent in March, indicating a deficiency. Ocumpaugh and Matches (19) reported that K concentrations in fall-stockpiled tall fescue forage dropped below the minimum level for ruminants early in January. Balasko (6) noted that, on the average, Mg concentrations of autumn-accumulated tall fescue decreased by one-third between December and January. Nitrogen fertilization increased Mg and decreased Ca concentrations. Potassium fertilization greatly increased the K concentration of the stockpiled forage at all nitrogen levels and decreased the levels of Ca and Mg. Calcium did not show as great a loss between December and January as did the other mineral elements. Phosphorus fertilization increased P concentrations at all nitrogen levels. According to Taylor and Templeton (22), P levels decreased sharply after December in fall-stockpiled tall fescue and bluegrass. Loveland (15)

noted that stockpiling during the months of September, October, and November significantly decreased the K content of tall fescue. Calcium concentrations remained fairly stable throughout the fall. The Mg concentration was variable. Fall stockpiling reduced the P concentration of the forage, but not significantly.

V. SUMMARY

Tall fescue maintains its quality over a longer period of time and produces greater dry matter yields during the autumn-winter seasons than do many forage species. This was true when it was compared to Kentucky bluegrass, reed canarygrass, and orchardgrass, regardless of the level of nitrogen fertilization. Conflicting results as to whether or not tall fescue and orchardgrass differ to any great extent in quality when accumulated during the fall occur in the literature. Tall fescue maintains a higher level of soluble carbohydrates later in the fall than does bluegrass or reed canarygrass. The increase in soluble carbohydrates during the fall in tall fescue may be the reason for the lack of a decrease in IVDMD during this period. Since digestible energy is an important factor limiting the feeding value of many forages, a high level of soluble carbohydrates is a very important aspect of quality. Crude protein concentration of temperate perennial forage species is known to decrease during the fall and winter. Crude protein concentrations of fall-stockpiled reed canarygrass and Kentucky bluegrass were higher than for tall fescue during the fall, while orchardgrass was similar to tall fescue in crude protein concentration. Crude protein concentration of tall fescue remained relatively constant

throughout the winter months after its decline in the fall and has been adequate for over-wintering beef brood cows.

Most data indicate that August is the most desirable time to begin fall stockpiling. Mid-summer applications of nitrogen enhanced fall growth. Fall growth is also related to accumulated precipitation during this period. Nitrogen fertilizer applied during mid-summer increased crude protein concentration of fall-stockpiled tall fescue forage. It was stated that when nitrogen applications preceded harvests by up to three months, crude protein was increased. There are disagreements in the literature as to the effect nitrogen fertilization has on the IVDM percentage of fall-saved tall fescue.

Concentrations of mineral elements in fall-stockpiled tall fescue, in general, decline during the fall and winter. Fall stockpiling decreases the concentrations of K, P, and Mg and to a lesser extent, Ca.

CHAPTER III

MATERIALS AND METHODS

I. FIELD PROCEDURES

This study was conducted on an established stand of Kentucky 31 tall fescue at the Plant and Soil Science Field Research Laboratory, The University of Tennessee, Knoxville. The fescue had been established on a Sequoia silty clay loam soil (clayey, mixed, mesic Typic Hadludults). Treatments were established on 2.1 x 7.6 m plots. The soil test values for K and P were medium. The pH was 6.3.

The experiment was initiated on August 15, 1975, and was repeated beginning August 24, 1976. On the starting date each year, forage was removed from all plots down to a 5 cm stubble and 56 kg nitrogen/ha was applied to all plots in the form of ammonium nitrate. The treatments (duration of the stockpiling periods) are listed in Tables I and II. Samples were taken for forage quality analysis on October 23, 1975, and October 15 and November 9, 1976, without harvesting for yield by mowing. At the end of the other stockpiling periods, the forage was harvested for yield and two rates of nitrogen fertilization, 0 and 56 kg/ha, imposed on the dates listed in Tables III and IV. The winter regrowth was harvested on March 24, 1976, and on April 12, 1977. Between March 24, 1976, and August 24, 1976, forage was harvested at approximately one-month intervals and discarded.

TABLE I
TALL FESCUE STOCKPILING PERIODS DURING 1975-1976

Beginning of Stockpiling Period	Stockpiled Until
August 15	October 23 ^a
August 15	December 11 ^b
August 15	January 14 ^b
August 15	February 10 ^b

^aSampled for forage quality analysis only.

^bSampled for forage quality analysis and harvested for yield.

TABLE II
TALL FESCUE STOCKPILING PERIODS DURING 1976-1977

Beginning of Stockpiling Period	Stockpiled Until
August 24	October 15 ^a
August 24	November 9 ^a
August 24	December 10 ^b
August 24	January 13 ^b
August 24	February 14 ^b

^aSampled for forage quality analysis only.

^bSampled for forage quality analysis and harvested for yield.

TABLE III

TALL FESCUE WINTER REGROWTH PERIODS AND HARVEST
DATES DURING 1975-1976

Regrowth After	N Rate kg/ha	Regrowth Harvested
December 11	0 56	March 24
January 14	0 56	March 24
February 10	0 56	March 24

TABLE IV

TALL FESCUE WINTER REGROWTH PERIODS AND HARVEST
DATES DURING 1976-1977

Regrowth After	N Rate kg/ha	Regrowth Harvested
December 10	0 56	April 12
January 13	0 56	April 12
February 14	0 56	April 12

The portion of the experiment dealing with the duration of fall stockpiling was a randomized complete block design with four replications. For the effects of stockpiling on yield, there were three treatments which were the stockpiling periods in which the forage was harvested by mowing. For the effects of stockpiling on the quality parameters, there were four treatments during 1975-1976 and five treatments during 1976-1977, which included the stockpiling periods when the forage was sampled without harvesting by mowing. The portion of the experiment dealing with winter regrowth consisted of a factorial arrangement of treatments, i.e., nitrogen levels and stockpiled forage removal dates, arranged in a randomized complete block design. Samples for forage quality analysis were taken from plots using hand shears just prior to harvesting stockpiled forage or winter regrowth. Samples were taken at a height of approximately 5 cm. These samples were placed in plastic bags and quick frozen in dry ice in the field. The samples were taken to the laboratory where they were freeze-dried and ground in a Wiley mill to pass a 2 mm screen.

Harvesting at the end of each stockpiling period was done with a rotary mower at a 5 cm stubble height. The area harvested for yield was 4.1 square meters. Winter regrowth was harvested in the same manner. Harvested forage was dried in a forced air drier at 65°C. Dry weights were used in the calculation of yields.

Air temperatures and precipitation were recorded at the Plant and Soil Science Field Research Laboratory. Long-term normals used for comparison were obtained from the Knoxville weather station at McGhee-Tyson Airport.

II. LABORATORY PROCEDURES

The freeze-dried samples were utilized in the determinations of crude protein (CP), in vitro dry matter digestibility (IVDMD), neutral detergent fiber (NDF), water-soluble carbohydrates, K, Mg, Ca, and P.

Estimates of the digestibility of the ground forage material were obtained through the method described by Tilley and Terry (24). Rumen fluid was obtained from three rumen-fistulated sheep that had been fed alfalfa hay prior to and during the period of inoculum collection. The in vitro system consisted of 100 ml plastic centrifuge tubes fitted with Bunsen gas relief valves. One-half gram forage samples were employed. Forty ml of buffer solution were added to each tube in 20 ml portions. Ten ml of strained rumen fluid were added to each tube. Carbon dioxide was passed into the tubes to promote anaerobic conditions. Tubes were stoppered immediately and allowed to incubate in the dark at 39°C for 48 hours. Tubes were swirled during incubation in order to resuspend the substrate. After this incubation period, HgCl_2 was added to stop bacterial action and Na_2CO_3 added to improve sedimentation. All tubes were centrifuged for 15 minutes at 2000 rpm and the supernatant was decanted. Fifty ml of an HCl-pepsin solution were added, in 25 ml portions. Tubes were then incubated without stoppers for 48 hours. Thin asbestos mats were placed in sintered glass crucibles, and they were placed in a muffle furnace at 100°C for one hour and 550°C for two hours, cooled and weighed. After the 48 hour incubation, samples were filtered, dried, and weighed. By subtraction of the original prepared crucible weight, the dry weight of the residue was obtained. In vitro dry matter

digestibility (IVDMD) was then calculated. Tall fescue samples of known in vivo dry matter digestibility were included as checks.

Neutral detergent fiber analyses were performed according to the method of Goering and Van Soest (12). Crude protein concentrations were determined after forage samples were digested with concentrated sulfuric acid and 35 percent hydrogen peroxide. The analysis was done with the phenol-hypochlorite reaction in a Technicon Autoanalyzer (23). Water-soluble carbohydrate determinations were performed with anthrone reagent (17). Potassium, Ca, Mg, and P were determined after forage samples were ashed at 500°C for 4 hours, dissolved in 3N HCl and filtered. Potassium and Ca concentrations were determined with a Technicon III dual-channel flame photometer. Magnesium concentrations were determined colorimetrically by the magnesium blue reaction and phosphorus by the ammonium vanadate reaction in the Autoanalyzer. These procedures were discussed by Steckel and Flannery (21). Results are reported for each element on a percent of dry weight basis.

III. STATISTICAL ANALYSES

Analyses of variance were calculated on data for each portion of the experiment within each year. In the first portion of the experiment, the effect of the length of the stockpiling period on dry matter yield (where available), IVDMD, CP, NDF, water-soluble carbohydrates, Ca, K, P, and Mg was evaluated. Analyses of variance were similar for the second portion of the experiment and dealt with the effects of forage removal dates after stockpiling and nitrogen fertilization level on the above mentioned quality parameters and yield.

Procedures of the Statistical Analysis System, developed by Barr and Goodnight (7), were used for the analyses of variance. Duncan's New Multiple Range Test was used for mean separation where F-tests indicated differences among treatments at the .05 level of probability. Comparisons between the two years of yield and quality parameters of fall-stockpiled tall fescue and winter regrowth were made by use of t-Tests. All significant differences reported are at $P \leq .05$.



CHAPTER IV

RESULTS AND DISCUSSION

I. WEATHER CONDITIONS

Near normal temperatures prevailed during the fall and winter of 1975-1976. Minimum temperatures during January averaged approximately 4 degrees below normal at -4°C . Below freezing minimum weekly temperatures occurred during late November, but warmed to above freezing for a week during early December before again dropping below freezing. Weekly minimum temperatures dropped below freezing during the end of the first half of December and remained there until mid-February.

Dry periods during the fall are especially detrimental to stockpiled yields. A two-week dry period occurred during the latter half of August, 1975 during which no precipitation was reported. Only 4 cm of precipitation fell during the month of August which was only half of the normal amount. September's precipitation was 1 cm above normal at 8 cm, while October's was almost 3.5 cm above normal at 10 cm. The month of November received 7 cm of precipitation which was 1.5 cm less than normal. December's precipitation was also below normal by 2 cm at 9 cm. Precipitation during January, 1976 was 2 cm below normal at 10 cm, while February received less than half of the normal amount at 5.5 cm. Thirteen cm of precipitation fell during March, which was 1 cm more than the normal amount.

Fall and winter temperatures of 1976-1977 were generally below the long term average. Minimum temperatures during October, November, and December averaged approximately 4 degrees below normal at 6.8, 0.5, and -3°C , respectively. The January average minimum temperature was 7 degrees below normal at -7.3°C , while only 2 degrees below normal at -1.6°C for February. The March and April average minimum temperatures were above normal. Weekly minimum temperatures dropped below freezing during late October and remained there until late February.

August, 1976 was drier than normal. Precipitation during this month was 5 cm which was more than 3 cm below the long term average. Seven cm of precipitation fell during September, which was near normal, while 13.5 cm fell during October, which was more than twice the normal amount. Precipitation was near normal during November and December at 9 and 11 cm, respectively, even though there were two weeks during November when no precipitation was reported. During January, 6.5 cm of precipitation were reported, which was below the long term average. Only 4 cm of precipitation fell during the month of February, which was approximately half of the average amount for this month. Precipitation during March and April was well above normal. Almost 15.5 cm fell during the first week of April.

II. FIELD OBSERVATIONS

Brown material in stockpiled tall fescue began to increase earlier in the fall of 1976 than during the fall of 1975. There appeared to be a much higher percentage of brown leaves in the stockpiled growth during the December harvest of 1976 than in the same harvest of 1975. By

mid-January of 1977, all of the upper part of the forage was brown in color and there was a small amount of green forage lower in the sward. In mid-January of 1976, only the tallest growth was brown and under this brown material the forage was still green. The stockpiled growth contained a higher proportion of green leaves during February of 1976 than during February of 1977. By February of 1977, the forage appeared to be brown and bleached. After removal of this stockpiled material, the stubble was slightly green.

When examined in mid-January of 1976, plots receiving nitrogen fertilizer in December, 1975 appeared to be slightly greener than those that were not fertilized. A slight amount of regrowth was also noted in these nitrogen fertilized plots. In 1977, no green growth was observed until March in the winter regrowth forage. Plots receiving nitrogen fertilizer after the stockpiled forage was removed were darker green in color when the grass began to grow in March of both years.

III. CRUDE PROTEIN AND YIELD OF THE STOCKPILED FORAGE

Crude protein concentration of the fall-stockpiled grass declined significantly with age until mid-January of both years (Tables V and VI). Between mid-January and February, CP concentration remained relatively stable. Highest concentrations of CP occurred in the October samplings of both years, with a concentration of 28.2 percent in 1975 and 16.5 percent in 1976. Crude protein percentages did not fall below the minimum requirement (5.9 percent) of a 450 kg dry, pregnant beef cow during any period of either year (18).

TABLE V
CRUDE PROTEIN CONCENTRATION AND DRY MATTER YIELD OF TALL FESCUE
FORAGE ACCUMULATED FROM AUGUST 15 DURING 1975-1976

Stockpiled Until	Crude Protein Percent	Dry Matter Yield - kg/ha
October 23	28.2a*	---
December 11	11.4b	951a
January 14	6.9c	743b
February 10	7.2c	676b

*Values followed by the same letter within each column are not significantly different at the .05 level of probability.

TABLE VI
CRUDE PROTEIN CONCENTRATION AND DRY MATTER YIELD OF TALL FESCUE
FORAGE ACCUMULATED FROM AUGUST 24 DURING 1976-1977

Stockpiled Until	Crude Protein Percent	Dry Matter Yield kg/ha
October 15	16.5a*	---
November 9	11.2b	---
December 10	9.7c	867ab
January 13	8.1d	753b
February 14	8.0d	977a

*Values within a column that are followed by the same letter are not significantly different at the .05 level of probability.

Dry matter yields of the stockpiled growth decreased from December until February during 1975-1976, the decrease being significant between December and January (Table V). During 1976-1977, dry matter yields decreased between December and January (Table VI). The increase between January and February was probably due to a slight difference in cutting height at harvest, since no growth was evident during this time. Highest dry matter yields of the accumulated forage occurred in December of 1976 and in February of 1977. Little decay was evident in the accumulated forage in either year.

IV. NEUTRAL DETERGENT FIBER, WATER-SOLUBLE CARBOHYDRATES, AND IN VITRO DRY MATTER DIGESTIBILITY OF THE STOCKPILED FORAGE

Neutral detergent fiber percentages of the stockpiled growth were greater in harvests later than December of the first year (Table VII). During 1976-1977, NDF decreased significantly between October and November and increased significantly when samples were taken after November (Table VIII). Digestibility also increased slightly between October and November. Neutral detergent fiber percentages were considerably higher in the December and January harvests of 1976-1977 than was observed during 1975-1976, probably due to the leaching of soluble material from plant cells earlier in the season during the second year with lower temperatures. Increases in NDF percentages were associated with reductions in percent IVDMD during both years.

As the length of the stockpiling period was increased, the percentage of water-soluble carbohydrates increased significantly during the fall of 1975, but decreased significantly on all harvests after

TABLE VII

NEUTRAL DETERGENT FIBER, WATER-SOLUBLE CARBOHYDRATES, AND IN VITRO
 DRY MATTER DIGESTIBILITY PERCENTAGES OF TALL FESCUE FORAGE
 ACCUMULATED FROM AUGUST 15 DURING 1975-1976

Stockpiled Until	Neutral Detergent Fiber	Percent	
		Water-Soluble Carbohydrates	IVDMD
October 23	41.9c*	19.8b	80.6a
December 11	40.4c	28.4a	81.3a
January 14	48.5b	23.5ab	75.9b
February 10	55.5a	12.3c	69.8c

*Values followed by the same letter within each column are not significantly different at the .05 level of probability.

TABLE VIII

NEUTRAL DETERGENT FIBER, WATER-SOLUBLE CARBOHYDRATES, AND IN VITRO
 DRY MATTER DIGESTIBILITY PERCENTAGES OF TALL FESCUE FORAGE
 ACCUMULATED FROM AUGUST 24 DURING 1976-1977

Stockpiled Until	Percent		
	Neutral Detergent Fiber	Water-Soluble Carbohydrates	IVDMD
October 15	43.8d*	16.6c	75.5a
November 9	40.6e	34.4a	77.5a
December 10	51.2c	20.5b	66.5b
January 13	58.2b	14.8c	63.8b
February 14	60.6a	9.4d	58.6c

*Values within a column that are followed by the same letter are not significantly different at the .05 level of probability.

December (Table VII). During 1976-1977, a significant increase in water-soluble carbohydrates was noted between October and November (Table VIII). This period between October and November was associated with the onset of below freezing weekly minimum temperatures. The lower temperatures probably promoted a decrease in the respiration of the tall fescue plants and an increase in soluble carbohydrates due to a decrease in carbohydrate utilization for growth. Other researchers have noted this increase in soluble carbohydrates with the onset of freezing temperatures in fall-stockpiled tall fescue (8,9,13,22,26). Some suggest that the digestibility of tall fescue is maintained throughout the fall due to this increase in soluble carbohydrates without an increase in fiber. Soluble carbohydrates were considerably lower on all dates during 1976-1977 than in 1975-1976. Increases in soluble carbohydrates were associated with increases in digestibility.

The IVDMD percentage of fall-stockpiled tall fescue decreased significantly when harvests were delayed later than December, 1975 (Table VII). Between October and December, no significant changes occurred. During 1976-1977, no significant changes in the percent IVDMD occurred between October and November, but a significant decline in digestibility occurred between November and December (Table VIII). No significant changes occurred between December and January, but another significant decrease occurred between January and February. Digestibility of the fall-stockpiled forage was considerably higher during 1975-1976.

V. MINERAL CONCENTRATIONS OF THE STOCKPILED FORAGE

Magnesium percentages of the stockpiled tall fescue decreased throughout the fall and winter (Tables IX and X). They decreased significantly until January of the 1975-1976 season and between November and December of the 1976-1977 season. After January of the first year and December of the second year, Mg percentages continued to decrease slightly. The Mg level in the fall-stockpiled forage did not fall below the NRC minimum requirement (0.10 percent) of a 450 kg dry, pregnant beef cow (18) during the fall and winter of either year. However, for the prevention of grass tetany in lactating beef cows, a higher concentration of Mg in the ration may be necessary both before and after calving. The NRC minimum requirement for Mg for a 450 kg lactating beef cow (18) is 0.18 percent. Stockpiled tall fescue, when grazed by pregnant beef cows as the dominant constituent of their winter ration, may not provide sufficient amounts of Mg to allow for a rapid return of blood serum Mg levels to normal after the stress of calving (21). This could possibly lead to an increased incidence of grass tetany. After calving, blood serum Mg levels returned to normal more rapidly in cows receiving a higher level of supplemental Mg in their diets (21).

Significant decreases in P percentages were seen between all sampling dates up to and including January during the 1975-1976 season (Table IX). Between January and February, the P percentage continued to decline, but not significantly. No significant reductions in percent P were seen between October and November of the 1976-1977 season,

TABLE IX
MINERAL CONCENTRATIONS OF TALL FESCUE FORAGE ACCUMULATED
FROM AUGUST 15 DURING 1975-1976

Stockpiled Until	Percent			
	Mg	P	K	Ca
October 23	.29a*	.27a	3.01a	.60a
December 11	.24b	.17b	2.75a	.68a
January 14	.16c	.11c	1.24b	.44b
February 10	.14c	.09c	1.04b	.44b

*Values followed by the same letter within each column are not significantly different at the .05 level of probability.

TABLE X
MINERAL CONCENTRATIONS OF TALL FESCUE FORAGE ACCUMULATED
FROM AUGUST 24 DURING 1976-1977

Stockpiled Until	Percent			
	Mg	P	K	Ca
October 15	.33a*	.30a	1.99a	.41a
November 9	.27a	.23ab	1.22b	.42a
December 10	.20b	.15b	1.28b	.38a
January 13	.18b	.13b	.87c	.38a
February 14	.17b	.13b	.58c	.36a

*Values within a column that are followed by the same letter are not significantly different at the .05 level of probability.

although the decrease between October and December was significant (Table X). After November, 1976, P concentrations continued to decline to a low of 0.13 percent in February. After October, 1975 and November, 1976, P percentages of the stockpiled forage were below the NRC minimum requirement (0.18 percent) of a 450 kg dry, pregnant beef cow (18). Since the forage was not sampled for analysis in November, 1975, it cannot be determined whether the forage was adequate in P during this time.

Potassium concentrations declined throughout the fall and winter of both years (Tables IX and X). The K levels were considerably higher in the stockpiled forage during 1975-1976 than during the 1976-1977 season. Percentages dropped to a low of 1.04 percent in February, 1976 and 0.58 percent in February, 1977. Significant decreases occurred between December and January of the first year and between October-November and December-January of the second year. The K levels that were below the NRC requirement (0.8 percent) for a 450 kg dry, pregnant beef cow (18) occurred after mid-January, 1977. Ocumpaugh and Matches (19) noted the level of K dropped below the minimum requirement for ruminants early in January in Missouri. Low K levels in the diet may reduce voluntary intake in ruminants (20).

Ca concentrations of the fall-stockpiled forage, in general, declined during the fall and winter of 1976-1977 but were more variable during the fall and winter of 1975-1976 (Tables IX and X). The decline in 1976-1977 was from a high of 0.41 percent in October to a low of 0.36 percent in February. During the fall and winter of 1975-1976, Ca percentages decreased significantly between December and January and

remained constant between January and February. The decrease between December and January amounted to 0.24 percent. Ca levels of the stockpiled forage were sufficient to meet the minimum NRC requirement (0.18 percent) of a 450 kg dry, pregnant beef cow (18) during the fall and winter of both years.

VI. CRUDE PROTEIN AND YIELD OF WINTER REGROWTH

During 1975-1976 and 1976-1977, no significant differences in CP concentrations of the winter regrowth were noted due to removing the stockpiled forage at the different dates (Tables XI and XII). When nitrogen fertilizer was applied after forage removal during both years, winter regrowth contained a significantly higher concentration of CP as compared to treatments receiving no nitrogen fertilizer. During 1975-1976, nitrogen fertilization increased the average CP concentration from 13.7 to 16.5 percent, while during 1976-1977, the increase was from 13.5 to 15.0 percent. Higher crude protein concentrations of winter regrowth with nitrogen fertilization were associated with slightly lower NDF and water-soluble carbohydrate concentrations and slightly higher IVDMD concentrations. At harvest, winter regrowth contained an adequate concentration of CP, regardless of treatment, for a 450 kg lactating beef cow in both years (18).

Dry matter yields of winter regrowth during 1975-1976 or 1976-1977 did not vary significantly among dates in treatments receiving no nitrogen fertilizer after stockpiled forage removal (Tables XI and XII). When fertilized with 56 kg N/ha, dry matter yields were greater when the nitrogen was applied at the later stockpiled removal dates.

TABLE XI

CRUDE PROTEIN CONCENTRATION AND DRY MATTER YIELD OF TALL FESCUE WINTER
REGROWTH FORAGE FERTILIZED WITH TWO LEVELS OF N DURING 1975-1976

Regrowth After	N Rate * kg/ha	Crude Protein Percent	Yield kg/ha
December 11	0	13.6bc**	179c
	56	16.3a	485b
January 14	0	14.7b	220c
	56	16.4a	551b
February 10	0	12.9c	237c
	56	16.7a	752a
<u>Date Means</u>			
December 11		15.0a	297b
January 14		15.6a	344b
February 10		14.8a	441a
<u>Nitrogen Means</u>			
	0	13.7b	189b
	56	16.5a	532a

*Nitrogen was applied at the end of the stockpiling period.

**Values within a column in the same section of the table that are followed by the same letter are not significantly different at the .05 level of probability.

TABLE XII

CRUDE PROTEIN CONCENTRATION AND DRY MATTER YIELD OF TALL FESCUE WINTER
REGROWTH FORAGE FERTILIZED WITH TWO LEVELS OF N DURING 1976-1977

Regrowth After	N Rate* kg/ha	Crude Protein Percent	Yield kg/ha
December 10	0	14.0bc**	169c
	56	14.8ab	385b
January 13	0	13.3c	180c
	56	14.6abc	515a
February 14	0	13.2c	164c
	56	15.7a	576a
<u>Date Means</u>			
December 10		14.4a	247a
January 13		13.9a	311a
February 14		14.4a	330a
<u>Nitrogen Means</u>			
	0	13.5b	153b
	56	15.0a	439a

*Nitrogen was applied at the end of the stockpiling period.

**Values within a column in the same section of the table that are followed by the same letter are not significantly different at the .05 level of probability.

This was probably due to the greater length of time available for nitrates to leach from the soil when nitrogen fertilizer was applied earlier in the winter. When nitrogen fertilizer was applied during February, 1976, yield increases were significantly greater than when the same rate of nitrogen had been applied during December or January. When nitrogen was applied during January or February, 1977, the dry matter yields were significantly greater than if applied at the same rate during December. Highest dry matter yields of the winter regrowth forage occurred when nitrogen fertilizer was applied on the February removal dates of 1976 and 1977 with 752 and 576 kg per ha, respectively.

VII. NEUTRAL DETERGENT FIBER, WATER-SOLUBLE CARBOHYDRATES, AND IN VITRO DRY MATTER DIGESTIBILITY IN WINTER REGROWTH

During 1975-1976, nitrogen fertilization significantly decreased the NDF concentrations of winter regrowth (Table XIII). When the stockpiled forage was removed in February, 1976, a significant reduction in NDF concentration compared with December, 1975 and January, 1976 stockpiled removal dates was noted. Nitrogen fertilization had no significant effect on the water-soluble carbohydrate concentration of winter regrowth during 1975-1976 (Table XIII). Removing the stockpiled forage during December, 1975 significantly decreased the water-soluble carbohydrate concentration as compared to removing the stockpiled forage on the later dates. Stockpiled removal dates or nitrogen fertilization did not significantly change the concentration of IVDMD in the regrowth forage of either year or the concentration of NDF and water-soluble carbohydrates during 1976-1977 (Tables XIII and XIV). There were

TABLE XIII

NEUTRAL DETERGENT FIBER, WATER-SOLUBLE CARBOHYDRATES, AND IN VITRO DRY
MATTER DIGESTIBILITY PERCENTAGES OF TALL FESCUE WINTER REGROWTH
FORAGE FERTILIZED WITH TWO LEVELS OF N DURING 1975-1976

Regrowth After	N Rate* kg/ha	Percent		
		Neutral Detergent Fiber	Water-Soluble Carbohydrates	IVDMD
December 11	0	39.5a**	29.2a	81.0a
	56	36.4bc	28.4a	83.9a
January 14	0	37.7b	31.8a	86.2a
	56	35.8c	30.2a	83.0a
February 10	0	37.0bc	31.2a	84.9a
	56	34.2d	30.9a	85.8a
<u>Date Means</u>				
December 11		37.9a	28.8b	82.5a
January 14		36.7a	31.0a	84.6a
February 10		35.6b	31.1a	85.3a
<u>Nitrogen Means</u>				
	0	38.0a	30.7a	84.0a
	56	35.4b	29.8a	84.2a

*Nitrogen was applied at the end of the stockpiling period.

**Values within a column in the same section of the table that are followed by the same letter are not significantly different at the .05 level of probability.

TABLE XIV

NEUTRAL DETERGENT FIBER, WATER-SOLUBLE CARBOHYDRATES, AND IN VITRO DRY
MATTER DIGESTIBILITY PERCENTAGES OF TALL FESCUE WINTER REGROWTH
FORAGE FERTILIZED WITH TWO LEVELS OF N DURING 1976-1977

Regrowth After	N Rate* kg/ha	Percent		
		Neutral Detergent Fiber	Water-Soluble Carbohydrates	IVDMD
December 10	0	47.4a**	19.3a	82.4a
	56	45.0a	19.4a	82.0a
January 13	0	47.9a	18.6a	80.8a
	56	46.5a	17.9a	83.0a
February 14	0	47.7a	20.5a	81.4a
	56	45.6a	19.3a	80.9a
<u>Date Means</u>				
December 10		46.2a	19.3a	82.2a
January 13		47.2a	18.3a	81.9a
February 14		46.6a	19.9a	81.2a
<u>Nitrogen Means</u>				
	0	47.7a	19.5a	81.5a
	56	45.7a	18.8a	81.9a

*Nitrogen was applied at the end of the stockpiling period.

**Values within a column that are followed by the same letter are not significantly different at the .05 level of probability.

trends toward lower NDF and water-soluble carbohydrate percentages with nitrogen fertilization in the regrowth during 1976-1977.

VIII. MINERAL CONCENTRATIONS OF WINTER REGROWTH

Nitrogen fertilization after removing the stockpiled forage had no significant effect on the Mg or P concentrations of the regrowth forage during either year or the Ca concentration during 1976-1977 (Tables XV and XVI). Nitrogen fertilization significantly increased the concentration of K in the winter regrowth during both years from an average of 2.16 to 3.01 percent during 1975-1976 and 1.68 to 1.85 during 1976-1977 (Tables XV and XVI). The Ca concentration was significantly reduced from 0.57 to 0.48 due to nitrogen fertilization after stockpiled forage removal during 1975-1976. Removing the stockpiled forage on different dates during the winter did not significantly affect the concentrations of any mineral except K during 1975-1976. There was a trend toward lower P percentages in the regrowth forage when the stockpiled forage was removed at later dates. The forage contained adequate concentrations of Mg, K, and Ca to meet the NRC minimum requirement (18) for a 450 kg lactating beef cow. Phosphorus concentrations were slightly below the NRC minimum requirement for this animal in the regrowth forage of both years.

IX. GENERAL DISCUSSION

The yields of stockpiled tall fescue were not high in either year and were not significantly different when compared between years (Appendix, Table XVII). The soil on which the forage was grown was not

TABLE XV
MINERAL CONCENTRATIONS OF TALL FESCUE WINTER REGROWTH FORAGE
FERTILIZED WITH TWO LEVELS OF N DURING 1975-1976

Regrowth After	N Rate* kg/ha	Percent			
		Mg	P	K	Ca
December 11	0	.23a**	.24a	2.05e	.53ab
	56	.23a	.25a	2.45c	.48b
January 14	0	.24a	.24a	2.22d	.57a
	56	.24a	.24a	2.68b	.48b
February 10	0	.21a	.23a	2.23d	.53ab
	56	.24a	.25a	2.89a	.48b
<u>Date Means</u>					
December 11		.23a	.24a	2.25a	.51a
January 14		.24a	.24a	2.45a	.53a
February 10		.23a	.24a	2.56a	.51a
<u>Nitrogen Means</u>					
	0	.23a	.24a	2.17b	.54a
	56	.23a	.24a	2.67a	.48b

*Nitrogen was applied at the end of the stockpiling period.

**Values within a column in the same section of the table that are followed by the same letter are not significantly different at the .05 level of probability.

TABLE XVI
MINERAL CONCENTRATIONS OF TALL FESCUE WINTER REGROWTH FORAGE
FERTILIZED WITH TWO LEVELS OF N DURING 1976-1977

Regrowth After	N Rate* kg/ha	Percent			
		Mg	P	K	Ca
December 10	0	.22a**	.27a	1.64a	.35a
	56	.23a	.24a	1.79a	.36a
January 13	0	.23a	.26a	1.67a	.36a
	56	.23a	.24a	1.92a	.35a
February 14	0	.23a	.26a	1.73a	.39a
	56	.24a	.23a	1.84a	.34a
<u>Date Means</u>					
December 11		.23a	.26a	1.72a	.36a
January 13		.23a	.25a	1.80a	.35a
February 14		.23a	.24a	1.79a	.37a
<u>Nitrogen Means</u>					
	0	.22a	.26a	1.68b	.37a
	56	.23a	.24a	1.85a	.35a

*Nitrogen was applied at the end of the stockpiling period.

**Values within a column in the same section of the table that are followed by the same letter are not significantly different at the .05 level of probability.

a highly productive soil but was a typical location where a permanent pasture might exist in east Tennessee. Yields could have possibly been increased by a higher level of nitrogen fertilizer (2,14,22). Yield increases induced by a higher rate of nitrogen could have produced a greater loss of this increased yield later in the winter due to a greater degree of tissue decomposition in the growth low in the canopy (6).

Weather conditions during the fall and winter are probably the most important factor influencing the yield and quality of fall-stockpiled forages. Below freezing temperatures arriving early during the stockpiling period cause growth to cease earlier in some years, reducing yields. The growth period of fall-stockpiled tall fescue was probably shortened during 1976-1977, as compared to 1975-1976, due to the earlier arrival of freezing temperatures during the fall of 1976 (Appendix, Table XVIII). However, dry matter yields in December, 1976 were only slightly higher than in December, 1975. Yields were almost equal between years for the stockpiling period ending during January. When dry matter yields of the regrowth forage were compared between years (Appendix, Table XVII), no significant differences were noted.

A lack of adequate precipitation during the period when the forage is actively growing also promotes yield reductions (22), while rainfall after the forage has stopped growing promotes a higher degree of leaching of soluble carbohydrates, protein, and minerals from the senescing forage. Precipitation during August was below normal during both years (Appendix, Table XIX). A 2-week dry period occurred during the latter half of August, 1975. A greater amount of precipitation

fell during the fall of 1976 than during the same period of 1975. The precipitation during October, 1976 was nearly twice the normal amount for this month. Even though the growth of tall fescue was probably decreased earlier during the fall of 1976 by lower temperatures, the higher precipitation that fell during the fall of this year when temperatures were favorable for growth probably resulted in dry matter yields by December of both years only differing by 84 kg/ha. Precipitation during December and January of 1975-1976 was lower than that for the same months during 1976-1977. The greater reduction in the percentage of protein, carbohydrates, and minerals during 1976-1977 may have occurred from a greater amount of cell rupture due to the greater severity and lengths of freezes during this period. A probable increase in forage weathering due to greater amounts of precipitation during December and January of 1976-1977 may have also occurred.

The stockpiled forage maintained a significantly higher level of quality, as indicated by IVDMD, during 1975-1976 than during 1976-1977 (Appendix, Table XVII). Freezing temperatures occurred earlier in the fall during 1976-1977 which permitted more tissue senescence and more time for the leaching of soluble substances from the accumulated forage. Furthermore, the monthly precipitation during November and December, 1975 was lower than that for the same months during 1976, which probably decreased forage weathering during the first year, increasing the percent IVDMD of the forage. The slightly higher CP concentration in the stockpiled forage during October, 1975 was probably due to a higher proportion of green leaves in the sward due to milder temperatures. Higher NDF percentages in January and February, 1977 were

probably the result of a greater degree of forage weathering which may have removed more cell solubles from the forage due to the harsher environmental conditions during this period.

The trend for the water-soluble carbohydrate concentration of fall-stockpiled tall fescue is in agreement with the results obtained by Brown et al. (9), who found the soluble carbohydrate concentration of fall-stockpiled tall fescue to reach a peak of 29.2 percent in late October. The IVDMD percentages of the stockpiled forage in October of both years were higher than those obtained by Brown et al. (9) using in vivo techniques. Ocumpaugh and Matches (19) noted trends similar to those found here for the percent IVDMD and CP in fall-stockpiled tall fescue. Crude protein and P levels found here during the winter were lower here than those obtained by Taylor and Templeton (22). Archer and Decker (2) found CP levels in December in fall-stockpiled tall fescue that were higher than those obtained here, but they applied nitrogen fertilizer in September. Neutral detergent fiber percentages during the fall and early winter were higher (3), especially during the early and mid-fall, than those found in this study.

Dry matter yields of the winter regrowth were similar between 1975-1976 and 1976-1977, even though the forage was harvested later in the season during 1976-1977. Neutral detergent fiber concentrations were significantly lower in the regrowth forage during 1975-1976 than during 1976-1977 (Appendix, Table XVII), due to the 1977 regrowth harvest being closer to heading of the forage. Water-soluble carbohydrate percentages were significantly higher during 1975-1976 (Appendix, Table XVII), again due to the forage being

harvested before visible reproductive growth. In vitro dry matter digestibility percentages did vary significantly between years in the regrowth forage (Appendix, Table XVII).

In vitro dry matter digestibility percentages of the winter regrowth forage from both years were not greatly different from forage stockpiled until December, 1975 or November, 1976. Winter regrowth had a higher level of quality than stockpiled forage harvested in December, January, or February. Crude protein concentrations in winter regrowth were higher than in the stockpiled forage from all treatments with the exception of forage stockpiled until October of both years.

Magnesium concentrations of the winter regrowth did not vary greatly from those of the stockpiled forage accumulated until December. Phosphorus concentrations were higher in the regrowth forage than in the forage stockpiled until December. Potassium and Ca concentrations of the stockpiled and regrowth forage varied greatly between years, both being greater in the forage during 1975-1976.

Tall fescue stockpiled during the fall and utilized by December would be of sufficient quality for dry, pregnant beef cows. When utilized by December, the CP, Mg, Ca, and K levels of the forage should be adequate but the P level may be borderline for the dry pregnant beef cow and inadequate for a lactating beef cow. At this time, stockpiled tall fescue contained a high level of IVDMD. After December, P levels decreased to levels that were inadequate for a dry, pregnant beef cow. Winter regrowth forage contained an adequate concentration of CP, Mg, K, and Ca, but phosphorus concentrations were borderline for a lactating beef cow. The regrowth forage contained a

high level of IVDMD. Regrowth forage may be well suited for lactating beef cows after early spring calving, with phosphorus supplementation. In vitro dry matter digestibility percentages indicated that fall-stockpiled tall fescue should contain an adequate percentage of total digestible nutrients for a dry, pregnant beef cow, and winter regrowth should be adequate in this respect for a lactating beef cow.

CRANES  CREST

CHAPTER V

SUMMARY AND CONCLUSIONS

The yield and quality of fall-stockpiled tall fescue forage and winter regrowth were determined during the course of a two-year-study. During both years, tall fescue was stockpiled from August to December, August to January, and August to February. At the beginning of the stockpiling period in August, nitrogen fertilizer was applied at a rate of 56 kg nitrogen/ha. Dry matter yields declined after December. Crude protein concentrations declined from October to January, but remained fairly constant between January and February. Neutral detergent fiber percentages increased after December, 1975 and November, 1976. Water-soluble carbohydrate percentages increased between October and December, 1975 and between October and November, 1976, and declined thereafter. In vitro dry matter digestibility percentages declined after December, 1975 and November, 1976. Increases in IVDMD percentages were associated with increases in water-soluble carbohydrate percentages and decreases in NDF percentages. In general, mineral concentrations declined throughout the fall and winter. The Ca concentration did not decrease as greatly as did the concentrations of the other mineral elements determined. Phosphorus levels in the forage below the NRC minimum requirement for a 450 kg dry, pregnant beef cow occurred after October, 1975 and November, 1976. Potassium levels in the forage dropped below the NRC minimum requirement for a 450 kg dry, pregnant beef cow after

January, 1977. Crude protein and calcium levels in the forage remained above the NRC minimum requirement for this type of animal during the fall and winter of both years as did K during 1975-1976. Magnesium concentrations of the forage dropped below 0.18 percent after December, 1975 and January, 1977.

At the end of the stockpiling periods, the forage was removed and two levels of nitrogen fertilization were imposed: 0 and 56 kg nitrogen/ha. Winter regrowth was harvested on March 24, 1976, and April 12, 1977. Nitrogen fertilization increased the CP concentrations and yield of winter regrowth as compared to treatments receiving no nitrogen. Nitrogen fertilization on the later stockpiled removal dates produced the highest dry matter yields of the regrowth forage. Nitrogen fertilization did not significantly affect NDF percentages during 1976-1977 or water-soluble carbohydrate or IVDMD percentages in either year. Significantly lower NDF percentages were observed with nitrogen fertilization in 1975-1976. Removing the stockpiled forage at later dates during the winter significantly increased the water-soluble carbohydrate concentration of winter regrowth in 1975. No significant changes in mineral concentrations of the winter regrowth were seen due to stockpiled removal dates except K during 1975-1976. Nitrogen fertilization significantly influenced the concentrations of K during both years and Ca during 1975-1976. During both years, the winter regrowth forage contained adequate concentrations of CP, Mg, K, and Ca for a 450 kg lactating beef cow. Phosphorus concentrations were slightly below the NRC minimum requirement for this animal in the regrowth forage of both years.

Temperatures during the fall and winter of 1976-1977 were more severe than during 1975-1976. Weekly minimum temperatures during 1976-1977 fell below freezing almost a month earlier than during 1975-1976. This may account for the lower quality of the stockpiled forage during 1976-1977 due to the greater time period for leaching of soluble cell contents to take place after freezing occurred.

If the quality of the forage is important, it is suggested that the stockpiled forage be utilized before January. Weather conditions during the late fall and early winter will largely determine the length of time the forage may be left standing in the field before appreciable decreases in yield and quality occur. Nitrogen applications in the form of ammonium nitrate to promote winter regrowth should be made during late winter in order to avoid losses of nitrogen.



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APPENDIX

TABLE XVII

COMPARISONS BETWEEN YEARS OF YIELD AND QUALITY PARAMETERS OF
FALL-STOCKPILED TALL FESCUE AND WINTER REGROWTH

Parameters Compared	Stockpiled Forage	Winter Regrowth
Yield	ns ^a	ns
Crude Protein	ns	ns
Neutral Detergent Fiber	ns	*
Water-Soluble Carbohydrates	ns	*
<u>In Vitro</u> Dry Matter Digestibility	*	*
Mg	ns	ns
Ca	*	*
P	ns	ns
K	*	*

^ans = values not significantly different at the .05 level of probability.

*Values significantly different at the .05 level of probability.

TABLE XVIII

AVERAGE DAILY MAXIMUM AND MINIMUM TEMPERATURES AND NORMAL DAILY MAXIMUM
AND MINIMUM TEMPERATURES DURING FALL STOCKPILING
AND WINTER REGROWTH PERIODS

Month	Year	Degrees Celsius							
		Average Daily		Normal Daily		Average Daily		Normal Daily	
		Maximum Temperature	Minimum Temperature	Maximum Temperature	Minimum Temperature	Maximum Temperature	Minimum Temperature	Maximum Temperature	Minimum Temperature
August	1975	31.4	30.7	20.5	19.5				
September		25.8	27.8	15.2	16.2				
October		21.2	22.1	9.9	10.0				
November		16.5	14.9	3.7	4.1				
December		10.5	9.9	-0.5	0.6				
January	1976	6.5	9.4	-4.0	0.1				
February		16.2	11.1	1.8	0.8				
March		17.6	15.8	5.2	4.1				
August		29.9	30.7	17.8	19.5				
September		25.5	27.8	14.1	16.2				
October	1977	18.1	22.1	6.8	10.0				
November		11.8	14.9	0.6	4.1				
December		9.0	9.9	-3.0	0.6				
January		1.9	9.4	-7.3	0.1				
February		12.0	11.1	-1.6	0.8				
March		19.0	15.8	6.4	4.1				
April		23.9	26.5	10.4	13.8				

TABLE XIX

TOTAL MONTHLY AND NORMAL TOTAL MONTHLY PRECIPITATION DURING FALL
STOCKPILING AND WINTER REGROWTH PERIODS

Month	Year	Centimeters	
		Total Monthly Precipitation	Normal Total Monthly Precipitation
August	1975	4.1	8.2
September		8.3	7.1
October		10.2	6.8
November		7.4	9.0
December		9.1	11.4
January	1976	9.8	11.9
February		5.5	12.0
March		13.3	12.3
August		5.0	8.2
September		7.3	7.1
October	1977	13.5	6.8
November		8.8	9.0
December		11.2	11.4
January		6.5	11.9
February		3.9	12.0
March		15.4	12.3
April		17.7	9.2

VITA

Joseph P. Ross was born in Arlington, Virginia, on August 22, 1952. He is the son of Joseph and Raetta Ross. He attended elementary and high school in Lower Burrell, Pennsylvania, before his family's relocation brought him to Maryville, Tennessee, in 1968. He graduated from Maryville High School in June, 1970. That same month, he entered Tennessee Technological University in Cookeville, Tennessee, and in December, 1973, received the Bachelor of Science degree with distinction in Agronomy.

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He is married to the former Teresa Diane Price of Oak Ridge, Tennessee. They have two children, Jennifer Anne and Jason Patrick.