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# Productivity of bermudagrass and fescue pasture combinations for steers with clover or nitrogen fertilization

Ricky Joe Carlisle

To the Graduate Council:

I am submitting herewith a dissertation written by Ricky Joe Carlisle entitled "Productivity of bermudagrass and fescue pasture combinations for steers with clover or nitrogen fertilization." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Plant, Soil and Environmental Sciences.

Henry A. Fribourg, Major Professor

We have read this dissertation and recommend its acceptance:

J. B. McLaren, J. H. Reynolds, J. W. Holloway

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Vice Chancellor
Graduate Studies and Research

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PRODUCTIVITY OF BERMUDAGRASS AND FESCUE PASTURE COMBINATIONS
FOR STEERS WITH CLOVER OR NITROGEN FERTILIZATION

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Ricky Joe Carlisle

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# ABSTRACT

A beef backgrounding pasture experiment was conducted on a Typic Hapludalfs soil to measure forage and steer production from seven (1.2-ha/ experimental unit) pasture treatments: (1) 'Midland' bermudagrass (Cynodon dactylon (L.) Pers.) + Ladino clover (Trifolium repens L.) [Midland + clover]; (2) Midland + 224 kg N/ha [Midland + N]; (3) 0.4 ha Midland + N-0.8 ha of tall fescue (Festuca arundinacea Schreb.) + N [Midland (0.4 ha)-fescue (0.8 ha)]; (4) Midland + fescue + N [Midland + fescue]; (5) Common bermudagrass (Cynodon dactylon var. dactylon) + 224 kg N/ha [Common + N]; (6) Fescue + clover; and (7) Orchardgrass (Dactylis glomerata L.) + clover [Orc. + clover]. The pastures were replicated twice and grazed with a modified put-and-take system. Yearling steers weighing about 230 kg in spring grazed up to 150 days. Forage and steer data were taken every three weeks. A species composition index (SCI) was developed to describe each pasture each time with a unique symbol; it was a sensitive tool for characterizing dynamically changing pasture compositions. Forage consumption was 80% or more of estimated growth, which was 4000 to 8300 kg/ha. Crude protein was sufficient to meet minimum requirements for growing steers. Fescue or clover, which were successfully introduced and maintained in Midland sods, extended the grazing season, and the resulting combinations produced more forage than Midland + N alone.

Stocking rates ranged from four to seven steers/ha. Average daily gains (ADG) were about 475 to 575 g for all treatments except for Orc. + clover (825 g). Productivity ranged between 520 grazing

days/ha/season for Orc. + clover to 1190 for Midland + fescue; most were 730 to 880 grazing days/ha. Daily forage dry matter intake was five to seven kg/steer in all pastures, with intake efficiencies of 9 to 13 kg/kg gain. Beef production was 390, 412, 456, 485, 505, 515, and 720 kg/ha for Fescue + clover, Common + N, Midland (0.4 ha)-fescue (0.8 ha), Midland + clover, Orc. + clover, Midland + N, and Midland + fescue, respectively.

Models were developed to identify concomitant variables such as stocking rate/21-day sampling period, season (spring or summer), year, days/period, crude protein, and precipitation in addition to the classification variables "treatments" or SCI, that could account for variability in the dependent variables. When "treatments" was entered in the model, $R^2$'s of 0.26, 0.43, 0.58, and 0.44 were obtained for forage growth, forage consumption, ADG and beef production, respectively; when SCI was used, they were 0.40, 0.52, 0.68, and 0.55.

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# CHAPTER I

## INTRODUCTION

In the last decade, demand for grain has increased dramatically in the United States and throughout the world. Grain prices have followed demand and increased substantially, dimming prospects for finishing beef cattle on grain. Rising fuel and transportation costs also have increased the expense of shipping cattle to the large feedlots in the United States Midwest. If the conversion rate of grain to meat (nine to one) is considered in conjunction with the factors mentioned above, grain-fed beef shipped from the southeastern United States cannot compete economically with that raised in other regions.

Many investigators in the southeast now advocate that weaned feeder calves be first grazed on good quality pasture to maximize growth and frame development, and then fed grain in confinement for 90 to 120 days. This could result in a lifetime conversion of about two units of grain per unit of meat produced.

Forages are important in the world's food resources. Forages vary tremendously in kind, yield, and quality, but all have one thing in common: little or no value until they are marketed through livestock, because the relatively large amounts of structural carbohydrates forages contain cannot be used directly for human consumption. The success of a beef cattle backgrounding system depends largely on the quantity and quality of forage produced. With the recent practice of delaying the placement of weaned calves in feedlots, the need for information concerning pastures suitable for sustaining weight gains of growing animals has increased.

This experiment was initiated to fill this gap in knowledge. The objectives were to compare forage production and quality, as expressed by average daily gain and beef production/ha, of Midland and Common bermudagrass pastures fertilized with nitrogen to those of Midland pastures overseeded with clover or with fescue; to compare equal areas of Midland overseeded with fescue to separate pastures of the two species; and to further compare those combinations to mixtures of fescue and clover, or orchardgrass and clover.

# CHAPTER II

## REVIEW OF LITERATURE

Bermudagrass (*Cynodon dactylon* (L.) Pers.) is widely distributed throughout the tropical and subtropical regions of the world. In view of the diversity in form and type that exists within these regions, it is now postulated that bermudagrass originated in Africa rather than in India, where there is not much diversity among species (10). Bermudagrass is not native to the United States but its introduction has been recorded as early as 1807. Most farmers in the southeastern United States, concerned with growing cotton and corn, viewed bermudagrass for a long time as a weed, although some pioneer agriculturalists realized its potential importance as a forage (71).

Common bermudagrass (*Cynodon dactylon* var. *dactylon*) is well adapted to the western portion of Tennessee and the southern parts of Middle and East Tennessee. It is the predominant warm-season grass on approximately 200,000 ha in Tennessee and is present on twice that area in the state (25). There are many different ecotypes of common bermudagrass that differ greatly in vigor, growth habit, and forage yield. Established stands are used for pasture rather than for hay, because of the difficulty encountered in mechanically harvesting the short and dense growth. Many of the common bermudagrass ecotypes produce seed throughout the growing season; this makes control of their spreading difficult.

'Coastal' bermudagrass was developed at the Georgia Coastal

Plains Experiment Station in 1938. It is an $F_1$ hybrid between Tift bermudagrass and an introduction from Africa that was selected as the best of 5,000 spaced plants. It is characterized by larger and longer leaves, stems, and rhizomes than those of common bermudagrass (9). It is therefore more suitable for hay where it is well adapted. Coastal produces much more forage than common bermudagrass, and is for the most part sterile. It is resistant to foliage diseases and root knot nematodes (20).

'Midland' bermudagrass is an $F_1$ hybrid between Coastal and a winter-hardy common from Indiana. It is similar to Coastal in most of the good traits that characterize Coastal but is less disease-resistant and yields less in the Coastal Plains states. However, Midland is more winter-hardy and can be successfully grown where Coastal is subject to winterkill (15). Midland has produced as much as Coastal in most cases in Tennessee but has outproduced Coastal where the latter was winter-injured (20). Midland has been reported to be cold resistant in Maryland and throughout the southern regions of Ohio, Indiana, and Illinois (19, 47). Midland starts growth two to three weeks earlier in the spring than common and three to five weeks earlier than Coastal in Tennessee (15, 20). Midland rhizomes tend to be long and straight and do not form as dense a sod as common (15, 32). This characteristic would favor the establishment and maintenance of companion crops such as legumes or other grass species.

Tall fescue (*Festuca arundinacea* Schreb.) is one of the most important grass species in the United States and Tennessee because of its wide adaptation to different soils and climatic conditions. Native to Europe, it was introduced into the United States over a century ago and did not receive much attention until the late 1930's. The use of fescue increased when Oregon released the 'Alta' selection and Kentucky released the natural selection referred to as 'Kentucky 31' (5). Although tall fescue is widely adapted, it grows best in the transition zone between the northern and the southern regions of the eastern United States. Tall fescue is tolerant of both poor drainage and droughty conditions. It can provide adequate forage for grazing animals during the cooler seasons of the year. Forage quality is usually higher when a legume is present as a companion crop and rather close grazing has reduced competition and maintained the grass in a vegetative stage. This allows both species to persist and to make a significant contribution to the total forage production. Forage quality is usually lowest during late spring and summer (5) when the grass is in a reproductive stage or semi-dormant.

Orchardgrass (Dactylis glomerata L.) is another European introduction. It is a long lived perennial where winters are not severe. Orchardgrass is more shade-tolerant than many perennial forage grasses. It was recognized long ago that it had early spring growth and abundant leafy aftermath production (39). It is one of the best cool-season perennial grasses in Tennessee (20), with its range of adaptation extending from the northern United States into Tennessee. It is used for pasture, hay, and seed production. In Tennessee, orchardgrass is primarily used for pasture, usually in mixtures with legumes, but the first spring growth is often cut for hay in East Tennessee. Most of the pasture production occurs in spring and early summer. During years with above average rainfall and below average temperatures, orchardgrass will continue to grow and produce after mid-summer, but hot, dry weather generally leads to a cessation of growth. Pastures grazed then can be severely damaged and yields can be reduced by as much as half in droughty years.

## Effect of Nitrogen Fertilization on Perennial Forage Crops

### Effect on Total Forage Production

Bermudagrass yields have been as high as 15,000 kg of dry matter DM/ha when fertilized with 900 kg N/ha, when adequate moisture was available (11). Midland yields have been reported to range from 9,500 to 24,500 kg DM/ha with varied levels of N fertilization (15, 16). Faix et al. (19) reported total forage DM production of 8,790 to 11,470 kg/ha when fertilized with 150 kg N/ha/year. Fribourg et al. (27) reported yields of 18,000 kg DM/ha/year when Midland was fertilized with 224 kg N/ha at the beginning of the growing season and with 112 kg N/ha after each of the first two or three harvests. Coastal produced 16,600 kg DM/ha when managed in a similar manner. In Oklahoma, Midland with a single application of 150 kg N/ha in the spring produced 15,800 kg DM/ha, while 50 kg N/ha applied at the same time of the year resulted in only 9,830 kg DM/ha (40). Coastal produced 35% more total forage DM than 'Coastcross 1' bermudagrass and 'Pensacola' bahiagrass (*Paspalum notatum* Flugge) (14, 72). Coastal has produced about twice as much DM as Kentucky 31 tall fescue for each increment of N fertilization (112, 224, 448, and 896 kg N/ha) (29).

Fescue is very similar to bermudagrass in its response to N fertilization, but at a lower overall level. As N fertilization is increased so is DM production (29). However, at high rates of N (448 and 896 kg N/ha) severe thinning of the stand can occur (30), especially after summer applications. Nitrogen applied in July resulted in some stand loss later in the year (23). Fescue stands fertilized with 224 kg N/ha had yields of 2,090 kg DM/ha and stands remained in excellent condition (30). A relationship was evident between the higher N fertilization rates and decreased hot water soluble carbohydrate contents of the fescue stubble above the 224 kg N/ha rate. It was postulated that high rates of N applied to freshly defoliated cool-season grasses during hot weather may increase respiration and regrowth demands beyond the photosynthetic capacity of some plants under such physical and environmental conditions. Small amounts of N fertilizer at frequent intervals during late spring and early summer have increased summer DM yields without significant damage to the stand (29, 31, 51). When 50 kg N/ha were applied in March and September, spring DM production was similar to that resulting from a single March application, and fall production was about the same as that from a single fall application (23).

Nitrogen fertilization generally increases the yields of most grasses. Orchardgrass, however, is variable in such responses. In Pennsylvania, orchardgrass was less productive than timothy (*Phleum pratense* L.) when 56 kg N/ha was applied, but when the rate was increased to 112 kg N/ha, the two grasses produced equally (49). Nitrogen fertilization seemed to have its greatest effect on orchardgrass when K fertilizer was applied also (76). Nitrogen fertilization has been shown to increase tillering of orchardgrass (1) and decrease root growth in relation to top growth (76). Nitrogen fertilization rates of 224 to 336 kg N/ha substantially increased orchardgrass production in Tennessee over that obtained from a 112 kg N/ha rate (28). Treatments harvested less frequently had the highest yields but also contained more mature forage. Orchardgrass yields were highest at the 224 kg N/ha rate and when the forage was harvested at a 3.8-cm stubble height. Additional research in Tennessee concurs with earlier findings on N fertilizer rate and harvest stubble height (61). Frequent harvesting at a stubble height of 3.8-cm was the most detrimental to the continued productivity of the orchardgrass stand. Reid et al. (60) reported that rate and source of N had little effect on ad libitum consumption of orchardgrass hays by sheep. Animal preference for the hays, however, declined with increased rates of N fertilization. In contrast, the preference ranking of orchardgrass fertilized at several rates of N was reversed under grazing conditions. Different sources of N affected the attractiveness of the hays but did not significantly modify selection of forage by grazing sheep.

## Effect on Crude Protein

Many investigators have demonstrated an increase in percent CP of Midland with increasing levels of N fertilizer (12, 17, 30, 50, 67). In Maryland, percent CP of Midland was raised from 15.8% with 224 kg N/ha to 24.2% with 896 kg N/ha (17). Midland without N or fertilized with 112 kg N/ha had CP percentages of about 10 which were increased to 18 when 448 kg N/ha or more were used (50). Midland fertilized with 112, 224, and 448 kg N/ha/year resulted in high CP percentages at the start of the grazing season (19, 19, and 24%, respectively) followed by a rapid decrease to early July, and a much slower decrease for the rest of the grazing season (12). Only grass fertilized with 112 kg N/ha was so low in percent CP as to not meet the 10.7% level accepted as minimum for growing-finishing steers weighing 250 kg and gaining 700 g/day (53). It was suggested that three applications of 56 kg N/ha might stabilize the CP percentage and reduce the rapid decline from early spring to mid summer. The increase in percent CP with each level of N was thought to be due to the vegetative stage that is fostered when N fertilization is increased and stocking rate is high enough to prevent accumulation of older leaves and stems. Horn et al. (41) observed that by increasing N fertilization levels on Midland sods the CP concentration of the forage increased and calves grazing selected the forage higher in CP. Fescue CP concentration also increases with each increase of N fertilization. Crude protein was increased from about 12.5% to 17.8% with applications of 50 kg N/ha in spring, summer, and fall (23). It continued to increase as the total N applied exceeded the three 50 kg N/ha applications. Hallock et al. (30) increased CP from 15.8% with 112 kg N/ha to 21.9% with 896 kg N/ha. Severe thinning of fescue stands occurred at 448 to 896 kg N/ha rates (29).

Orchardgrass follows the same trend as fescue and bermudagrass with respect to CP concentration as a result of following N fertilization. Ramage et al. (59) observed that increasing the rate of N fertilization decreased the crude fiber content of orchardgrass but increased its CP percent. Nitrogen rates of 56 kg/ha and 448 kg/ha on orchardgrass pastures produced a three-year average of 5,720 and 9,472 kg DM/ha, respectively; corresponding CP percentages were 12.1 and 19.8. The 112 kg N/ha rate resulted in the greatest yield of DM and CP/kg of N applied. Lewis and Lang (48) also noted increases in CP of orchardgrass with N fertilization.

## Establishment of Annual and Perennial Forages in Bermudagrass Sods

Improving forage production and quality by overseeding annuals and perennials in bermudagrass sods has long been a goal of many investigators. Midland is capable of producing substantial forage yields sufficiently high in quality to result in a high rate of gain by stocker animals for only 60 to 90 days (70). The introduction of other forage species into existing bermudagrass pastures during times of low seasonal production or dormancy can improve overall pasture quality at those times.

Decker et al. (17) noted that the addition of rye (*Secale cereale* L.) a cool-season annual forage, to a Midland sod would slightly increase total forage production and extend the grazing season. Hallock et al. (30) observed a yield depression when rye was overseeded into a Midland sod at low N rates, but this depression was negligible at a higher (896 kg N/ha) level. Even though yield was depressed at the lower rates, the grazing season was extended and more uniform grazing took place. A more desirable yearly distribution of growth from bermudagrass pastures was achieved when the sod was overseeded with rye (63). A study in Maryland compared total forage yields and seasonal distribution of Midland in combination with cool-season annual or cool-season perennial grasses (17). Production was greater for the cool-season annuals-Midland combinations even though the perennials significantly increased total forage yield. This probably occurred because the summers were not hot enough or long enough to cause dormancy of the cool-season perennials. Thus, competition between bermudagrass and perennial cool-season grasses prevented either one from reaching its full yield potential.

When tall fescue was seeded into dormant Coastal in northern Georgia, the fescue persisted and contributed to the total yield of forage at N levels up to 420 kg N/ha/year at a 5-cm stubble height (78). Tall fescue was also competitive at N levels up to 560 kg N/ha/year at a 10-cm stubble height. At higher N levels, fertilization was detrimental to the proportion of fescue in the stand, but higher clipping heights resulted in increased fescue content except at the largest N applications. Although the higher rates of N produced the highest yields the percent fescue in the harvested forage was very small. Midland overseeded with fescue reduced the production of Midland forage to 70% of that when grown alone (25). However, the total yield for the combination was 1.8 ton DM/ha greater than for Midland alone. It was thought that if these stands had been grazed, they would have provided pasture from mid-February through mid-November. When fescue was overseeded in 25-cm rows in a Midland sod harvested four times a year to a stubble height of 5 to 10 cm and fertilized with 200 kg N/ha/year, 1,500 kg DM/ha were produced each harvest period (24). The combination of the two species extended the season of production of the sward from five to nine or ten months/year. Dry matter production increased from 5,800 to 7,150 kg/ha/year.

Effect on Animal Performance

Tall fescue and orchardgrass pastures, each containing white clover (Trifolium repens L.) or fertilized with 168 kg/N/year, were compared to Coastal sods overseeded with vetch (Vicia spp. L.) or rye (33). Beef gains averaged 403 and 352 kg/ha/year from fescue and orchardgrass, respectively. Rye or vetch seeded in Coastal sods produced an average of 573 kg beef/ha/year. Total annual gains per animal for tall fescue, orchardgrass, and Coastal were 83, 89, and 95 kg, respectively. Average daily gain (ADG) of the steers did not improve when white clover was included in the orchardgrass sward, but it did increase the ADG on the fescue pastures from 594 to 662 g/day. Stocking rates averaged 5.0, 3.8, and 6.3 steers/ha for fescue, orchardgrass, and Coastal pastures when fall and spring-summer grazing seasons were combined.

To increase the grazing season of bermudagrass-tall fescue pasture combinations, four N applications were made in attempts to maintain a desirable balance between the two species (65). The grazing season was increased by 249 animal grazing days/ha and total gains were increased by 67 to 101 kg beef/ha/year over those obtained when fertilizing with N in June and August for the benefit of bermudagrass alone. Increasing N fertilization rates from 135 to 539 kg N/ha on Midland pastures overseeded with ryegrass (Lolium multiflorum Lam.) increased gains per steer from 105 to 158 kg/ha/year (52). The length of the grazing season was increased by 28 days and steer days/ha increased from 827 to 1,475. The stocking rate for Midland-ladino clover pastures overseeded with rye ranged from 7.4 to 9.9 steers/ha (18). This particular combination produced about 1,010 kg/ha of animal gain.

Tall fescue-ladino clover pastures in a cow-calf grazing experiment in North Carolina produced more gain/calf/season (80 kg) than fescue-ladino clover-Coastal pastures (7). It was noted that gains obtained from Coastal enabled the fescue-clover-bermudagrass treatment to produce gains per season (120 kg) about the same as those from fescue-clover pastures.

## Legumes in Bermudagrass and Other Perennial Sods

Legumes have been used satisfactorily to extend the grazing season, increase forage production, and improve forage quality and use of land resources (42, 46, 77). The grazing season has been extended in both spring and fall with the addition of legumes. Overall forage quality is good during early spring because warm season perennials are still dormant and legumes prosper. The legume is associated with N-fixing bacteria which can produce up to 224 kg N/ha/year (77), thus stimulating earlier bermudagrass growth (37, 38).

### Effect on Total Forage Production

Bermudagrass responds favorably to N fertilization, interplanted winter legumes, and to combinations of these two practices (37). The inclusion of crimson clover (*Trifolium incarnatum* L.) overseeded on Coastal increased total forage production about as much as 67 kg N/ha without the legume. Coastal overseeded in the fall with crimson clover and fertilized with 134 to 168 kg N/ha in early June produced 4,535 to 5,443 kg/ha of forage annually. The same amount of N on Coastal without a legume produced about 3,600 to 4,080 kg/ha of forage. The use of the legume without N resulted in about 3,400 kg of DM/year. Coastal overseeded with either crimson, arrowleaf (Trifolium vesiculosum Savi), red (Trifolium pratense L.), or white clover, produced 13,920, 12,700, 11,250, and 11,425 kg of total forage DM/ha, respectively (77). In the same study Coastal grown alone and fertilized with 224 kg N/ha yielded 8,670 kg/ha. It was noted that the forage produced by the clover-grass mixture was more digestible and its production was better distributed over the season. The inclusion of bigflower vetch (Vicia grandiflora var. kilaibeliana W. Koch.) in Midland and fescue sods increased total DM production more than was obtained from 100 kg N/ha but less than from 200 kg N/ha (68). After crimson or arrowleaf clover had been harvested, Coastal produced about 2,600 kg DM/ha more from the same plots than Coastal receiving 224 kg N/ha without a preceding clover crop (46). Due to competition between the grass and arrowleaf clover a reduction in first-harvest yields was reported. However, the total forage production was 47% higher from the remaining harvest than that from the grass alone fertilized with 224 kg N/ha. A major disadvantage of seeding winter annual legumes is that in years of limited soil moisture, the legume may deplete the moisture available to the bermudagrass, thus delaying or decreasing its growth.

When attempting to maintain legumes in grass sods the levels of available P and exchangeable K in the soil are critical. Rich and Odland (62) observed that reducing the amount of N or P had no significant effect on either the yield or percentage of legumes in the hay. When fertilizer K additions were reduced from 93 to 46 kg/ha, the proportion of legumes was reduced from 50% to 3% and the hay yield lowered from 3,450 kg/ha to 1,825 kg/ha. Potash greatly increased legume yields and percentages in grass-legume mixtures (44). The percentage of legumes was almost doubled in orchardgrass and fescue mixtures containing ladino clover by high K fertilization. Forage yield was increased 62% and 30% in the orchardgrass-ladino clover and fescue-ladino clover mixtures, respectively. The effect of rate and time of N applications on DM yields and clover percentages in a fescue-clover mixture was dramatic (8, 13). Fescue-clover mixtures with 24% clover and no N applied produced 4,930 kg DM/ha. The same mixture fertilized with 56 kg N/ha applied in June yielded 5,150 kg DM/ha with a clover percentage of 21. When 56 kg N/ha were applied in August instead of June, 5,825 kg DM/ha were produced with the same percent clover. Nitrogen rates of 112 kg/ha applied in February or June resulted in decreased DM production and clover percentages. Chamblee et al. (13) found that when no N was applied, 52% clover was present; when 112 kg N/ha were applied, total DM increased but there was only 5% clover.

In Tennessee, fescue fertilized with 67 kg N/ha produced about 3,200 kg DM/ha (21). When ladino clover was added to the fescue without N, DM production increased to 3,500 kg/ha, and to 3,800 kg/ha with the addition of red clover. When ladino and red clovers, and 'Kobe' lespedeza (Lespedeza striata (Thunb.) H. & A.) were all overseeded on a fescue sod, DM yields were about 4,400 kg/ha.

White clover in mixtures of orchardgrass has provided the equivalent in total DM of 168 kg N/ha (74). In contrast, Washko and Pennington (75) obtained higher forage yields from orchardgrass fertilized with 112 kg N/ha than when it was grown with ladino clover.

Effect on Animal Production

Much research has shown that grass-legume mixtures stimulate liveweight gains, animal growth, milk production, or reproduction efficiency above that for grasses fertilized with N (3, 4, 7, 65, 66). Steers grazing orchardgrass or tall fescue fertilized with 240 kg N/ha gained less per day than steers grazing orchardgrass with ladino clover and no N fertilizer (4). Average daily gains per animal were higher (540 g/day) for the orchardgrass-ladino clover mixture and orchardgrass fertilized with N (460 g/day) than for two comparable tall fescue treatments. Tall fescue pastures fertilized with 242 kg N/ha supported the highest carrying capacity per season (411 steer days) while the orchardgrass-legume pastures had the lowest (204 steer days). However, carrying capacity of orchardgrass pastures with N was higher than that for any of the grass-clover mixtures studied. Liveweight gains/ha over a five-year period were 9% higher for the orchardgrass with N pastures than for those grown with clover. Orchardgrass-ladino clover pastures produced about twice as much ADG than Midland pastures fertilized at four different rates of N (0, 112, 224, 448 kg N/ha) (24). Only the Midland with 448 kg N/ha produced more beef/ha than the orchardgrass-ladino clover pasture (705 and 561 kg beef/ha, respectively). The Midland pastures fertilized with the 448 kg N/ha rate resulted in 1,759 animal grazing days/ha while the orchardgrass-ladino clover pastures produced only 590. High et al. (35) and Hobbs et al. (36) reported ADG's of steers grazing orchardgrass-ladino clover pastures as being greater than those of steers grazing fescue. Carrying capacity was higher and steers averaged one-third quality grade higher on the orchardgrass-ladino clover pastures. Fescue-clover pastures with 280 kg N/ha produced 746 grazing days/ha and orchardgrass-clover pastures had highest gains (34).

Winter annual clovers established in Coastal pastures increased the grazing season by 84 to 120 days, improved the quality of available forage, and fixed 84 to 112 kg N/ha in the soil (73). Steers grazing crimson and arrowleaf clovers had ADG of 900 g/day with liveweight gains of about 561 kg/ha. Animal grazing days/ha were 553 for crimson clover and 709 for arrowleaf clover.

Even a slightly larger ADG by cattle grazing pastures with grass-legumes can result in significant beef production. An increased ADG of only 140 g/day can result in an additional 28 kg liveweight gain per animal during a 200-day grazing season (4).

## CHAPTER III

## FORAGE GROWTH AND CONSUMPTION

### Introduction

Midland bermudagrass is well adapted to the mid-southeastern United States (19), produces large amounts of forage (16), grows well in spring and summer, and fills the summer production gap which exists in beef pasture systems when cool-season species are used (24). One of these cool-season grasses, orchardgrass, produces well in spring but often stops growth in early summer. Another cool-season grass, tall fescue, is well adapted in the region (5), produces well in spring and fall, can be stockpiled for winter (54) but is semi-dormant in summer. It has been shown that N fertilization and physiological factors influenced by stage of growth affect productivity and forage quality of these grasses, and that these changes are reflected in animal performance (7). The inclusion of legumes in cool-season sods can result in forage of higher protein content (13) and better animal performance than when clovers are absent. It has been suggested that the overseeding of fescue and clover in bermudagrass sods could lengthen the grazing season (25, 37) and increase forage and animal productivity (26, 78). The high potential productivity of Midland when fertilized with N makes it easy to shift a Midland pasture to a productive hay field with little premeditation, providing flexibility when used in conjunction with pastures of other species.

The objectives of this study were to compare the productivity of

Midland and Common bermudagrass pastures fertilized with N to that of Midland pastures overseeded with clover or with fescue, to compare equal areas of Midland overseeded with fescue to separate pastures of the two species, and to further compare those combinations to mixtures of fescue and clover or orchardgrass and clover.

## Materials and Methods

A grazing experiment was conducted at Ames Plantation, Grand Junction, Tennessee, during 1975, 1976, and 1977 springs and summers. Fourteen 1.2-ha pastures on a Memphis silt loam soil (fine-silty, mixed, thermic, Typic Hapludalfs) were used. Six of these pastures were sods of Midland bermudagrass and two were mixtures of orchardgrass and ladino clover (Orc. + clover) which had been established in 1969 and used in a previous study (24). Two of the six Midland pastures were overseeded each year with 1.4 kg/ha of ladino clover and 5.2 kg/ha of Kobe lespedeza (Midland + clover) in mid-January to February; two others were overseeded in fall 1974 with Kentucky 31 tall fescue drilled in 25-cm rows at 16 kg/ha of seed (Midland + fescue); and the last two were fertilized with 224 kg N/ha/year (Midland + N). Six additional pastures were developed: two consisted of 0.4 ha of Midland + N and 0.8 ha of tall fescue + N [Midland (0.4 ha) + Fescue (0.8 ha)]; two were sods of common bermudagrass fertilized with 224 kg N/ha/year (Common + N); and two were sods of Kentucky 31 tall fescue overseeded with 1.7 kg/ha of ladino clover and 6.7 kg/ha of Kobe lespedeza (Fescue + clover). Bermudagrasses + N were topdressed with $NH_4NO_3$ in three equal installments yearly in late March, May, and early July. In late March each year, 30 kg P/ha and 56 kg K/ha were broadcast on Fescue + clover and Orc. + clover pastures; all other pastures were fertilized with 25 kg P/ha and 95 kg K/ha. In addition, pastures containing fescue received 67 kg N/ha, 15 kg P/ha, and 28 kg K/ha in early September.

The 14 pastures were arranged in a randomized complete block design with two replications of the seven treatments. Yearling beef steers were placed on pastures of each treatment whenever mean height of either fescue or bermudagrass first reached 5 cm, or that of orchardgrass attained 7 cm. A modified put-and-take grazing management system was used to maintain bermudagrass and fescue growth between heights of 5 and 8 cm, and orchardgrass growth between 7 and 14 cm.

Pastures were scored at about 21-day intervals by two or three trained independent observers. Each observer estimated ground cover, botanical composition ($\geq$ 2%), and minimum, maximum and mean heights of each species. In order to characterize each pasture on any observation day by a unique quantifying symbol, a species composition index (SCI) was created. Frequency classes of the botanical composition percentages for each of the four forage species were established. The midpoint value for each species frequency class was used as a component for creating the unique SCI characterizing a pasture. The sequence of range midpoint numbers for orchardgrass-clover-fescue-bermudagrass was arbitrarily selected for the composition of SCI (Table 1). For example, an SCI of 0-15-0-80 describes a pasture with no orchardgrass or fescue, 12% clover and 88% bermudagrass. A pasture with 43% fescue and 57% Midland would be described with an SCI of 0-0-40-60.

TABLE 1. DERIVATION OF COMPONENTS USED IN CREATING THE SPECIES COMPOSITION INDEX (SCI)

| Orchardgrass | | Clover | | Fescue | | Bermudagrass | |
|---|---|---|---|---|---|---|---|
| Frequency Class | First SCI Component | Frequency Class | Second SCI Component | Frequency Class | Third SCI Component | Frequency Class | Fourth SCI Component |
| Percent Botanical Composition | | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1-39 | 20 | 1-9 | 5 | 1-29 | 15 | 1-29 | 15 |
| 40-69 | 60 | 10-19 | 15 | 30-49 | 40 | 30-49 | 40 |
| ≥ 70 | 80 | 20-29 | 25 | 50-69 | 60 | 50-69 | 60 |
| | | 30-39 | 35 | 70-89 | 80 | 70-89 | 80 |
| | | ≥ 40 | 45 | ≥ 90 | 95 | ≥ 90 | 95 |

Although the algebraically possible number of combinations of 4 x 6 x 6 x 6 items could result in 864 different SCI values, the restrictions imposed by the nature of the treatments in the experiments limited the number of meaningful combinations to 180. In fact, 48 SCI combinations occurred throughout the experiment. Thus, the variable SCI could be considered in statistical analyses as a discrete classification variable with 48 possible values, each one characteristic of a specific range of botanical composition.

In the treatments where single grass species were studied [Common + N, Midland + N, Midland (0.4 ha)-fescue (0.8 ha)] SCI values of 0-0-95-0 and 0-0-0-95 were consistently attained. Midland + clover pastures had much clover in 1975 (Figure 1-A). The content gradually declined the next two years, but clover presence was substantial. In the Fescue + clover pastures the low amounts of clover in 1975 had increased the second year and then remained constant (Figure 1-B). The scatter in SCI for Orc. + clover pastures each year reflects the presence of more clover each spring than later in the season (Figure 1-C). In the Midland + fescue pastures, there was more fescue than bermudagrass in 1975 and 1976 (Figure 1-D). There was an equal amount of fescue and bermudagrass during 1977; the SCI values on the diagonal reflect the gradual change from fescue dominance in the spring to bermudagrass preponderance in summer.

Forage growth and consumption were determined by the cage and strip method (24), using one of each at random for each 0.2 ha. The sampling mower blade was set at a stubble height of 5 cm for sods containing fescue or bermudagrass, and at 8 cm for orchardgrass. Each

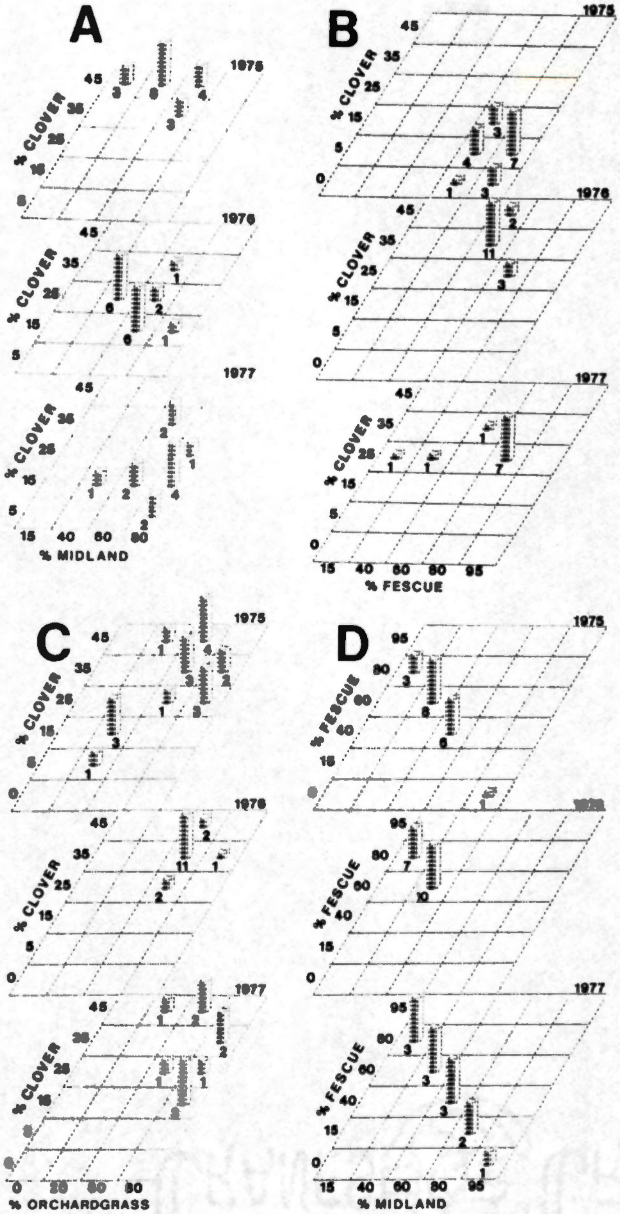


Figure 1. Frequency of occurrence of botanical components in pasture mixtures rated at 21-day intervals, 1975-1977: (A) Midland bermudagrass + clover; (B) Fescue + clover; (C) Orchardgrass + clover; (D) Midland + fescue.

sample was oven-dried at 65 C for 72 hours and weighed. Dried samples from each pasture were composited for cages and strips separately and analyzed for total nitrogen. Total N was determined by the phenolhypochlorite color reaction (69) with a Technicon Autoanalyzer on extracts obtained after digestion with concentrated $H_2SO_4$ and 35% $H_2O_2$. Crude protein (CP) was obtained by multiplying percent N by 6.25. Daily mean air temperature at 2 m above sod and precipitation were measured.

Data were analyzed on a 21-day sampling period basis and also on a cumulative basis for each year and for spring (March-mid June) and summer (mid June-September). Since the seven treatment names do not, both within each year and across years, reflect actual botanical composition and their dynamic changes over time, within seasons, among pastures and treatments, the classification variable "SCI" was used in the statistical analysis instead of the classification variable "treatments." Least-squares means for period and cumulative forage growth, forage consumption, protein content, and length of grazing season were tested for significance ($\alpha$ = 0.05) after removal of the variation due to the effects of year, season, and replication. To compare the seven treatments, the SCI values belonging to a particular treatment were grouped and arranged into the following linear contrasts: (1) Midland (0.4 ha)-fescue (0.8 ha) vs. Midland + fescue, (2) Midland + clover vs. Midland + N, (3) Midland + N vs. Common + N, (4) Orc. + clover vs. the mean of Midland + clover and Fescue + clover, and (5) Midland + clover vs. Fescue + clover.

Computations were done using sequential and partial sums of squares obtained from a General Linear Model analysis (2). Since dates and sampling intervals were not the same from year to year, arithmetic means across years could not be calculated for each sampling date. In order to describe treatment effects from spring to autumn, the cumulative data for all years were fitted to polynomials and are presented graphically. Second degree polynomials were used whenever the partial regression coefficient associated with the cubic term was not significant. When the partial regression coefficient in models including the cubic term was significant, and if its inclusion in the model increased the $R^2$ by at least 0.08, then a third degree polynomial was used. No partial regression associated with quartic terms was significant. The $R^2$'s obtained for cumulative forage growth and consumption ranged between 0.88 and 0.98, except for those associated with Orc. + clover (0.76). The lower $R^2$'s obtained for that treatment were probably due to the greater variability in the pastures with respect to species composition from year to year as orchardgrass was deleteriously affected by hot dry weather.

## Results and Discussion

### The Grazing Season

Grazing for all pastures started on 12 April 1976 and 30 March 1977. In 1975, Orc. + clover grazing started on 24 April, and that of Midland + clover, Midland + fescue, Midland (0.4 ha)-fescue (0.8 ha), and Fescue + clover pastures was started on 27 March (Table 5, Appendix). Grazing of Midland + N and Common + N could not be started until 12 May.

As observed by others (37), the initial introduction of clover in Midland resulted in earlier growth. Over the three years, Midland + fescue, Midland + clover, and Fescue + clover pastures had a spring grazing season of 70 days (Table 2). Orc. + clover pastures were delayed in early spring by nine days, because grass height did not reach 7 cm until that time. The winter dormancy of Midland + N and Common + N sods delayed spring grazing by 15 days. The two Midland-fescue and the Midland + clover treatments had the longest average grazing season, and Midland + N and Fescue + clover grazing seasons were about 15 days less. The Midland + N pastures, delayed in spring by winter dormancy, grew later in summer than the fescue which, starting growth earlier in spring, was semi-dormant in late summer. Orc. + clover had the shortest grazing season due to growth cessation in hot dry weather. This was particularly severe in 1977, when grazing lasted only 99 days, due to below-normal precipitation (154 mm less) and above-normal temperatures (Figure 2). These adverse conditions also affected Fescue + clover sods (110 days grazing). In contrast, 1976 temperatures were about normal and precipitation was 68 mm above normal. In 1975, precipitation was slightly above normal (50 mm) but temperatures were as high as in 1977. Under those conditions of abundant moisture, clover stands in mixtures with the grasses were good.

## Forage Growth and Consumption

Even though no significant differences were noted in forage growth among treatments when comparisons were made on the basis of individual 21-day sampling periods, the cumulative effect of small

TABLE 2. MEAN FORAGE GROWTH AND CONSUMPTION, FORAGE CRUDE PROTEIN, AND GRAZING SEASONS, 1975-1977

| | Treatments | | | | | | |
|---|---|---|---|---|---|---|---|
| Variable | Midland (0.4 ha)-† fescue (0.8 ha)‡ | Midland† + fescue‡ | Common + N† | Midland + N† | Midland + clover | Fescue + clover | Orchardgrass + clover |
| Initial grazing date | April 1§ | April 1 | April 20 | April 20 | April 1 | April 1 | April 11 |
| Spring grazing season, days | 70§ | 70 | 45 | 55 | 70 | 70 | 61 |
| Total grazing season, days | 150§ | 150 | 125 | 135 | 150 | 136 | 123 |
| Spring forage growth, kg/ha | 2960¶ | 4400 | 2000 | 1920 | 2430 | 2480 | 2475 |
| Grazing season forage growth, kg/ha | 5025¶ c | 8320 a | 4965 cd | 5640 b | 5695 b | 3965 d | 4800 cd |
| Spring forage consumption, kg/ha | 2520¶ | 3530 | 1440 | 1355 | 1720 | 2125 | 1720 |
| Grazing season forage consumption, kg/ha | 4850¶ bc | 7900 a | 3965 d | 4885 bc | 5310 b | 3885 d | 4260 cd |
| Forage crude protein, % | 12.2# | 15.2 | 14.2 | 13.5 | 14.0 | 14.4 | 14.9 |

† 224 kg N/ha in 3 equal applications, April-July.

‡ 67 kg N/ha in September.

§ Mean of 2 replications for each of 3 years.

¶ Least squares mean.

# Weighted mean of cage samples, based on forage dry matter growth.

a, b, c, d Values within a row followed by the same latter are not significantly different ($\alpha = 0.05$).

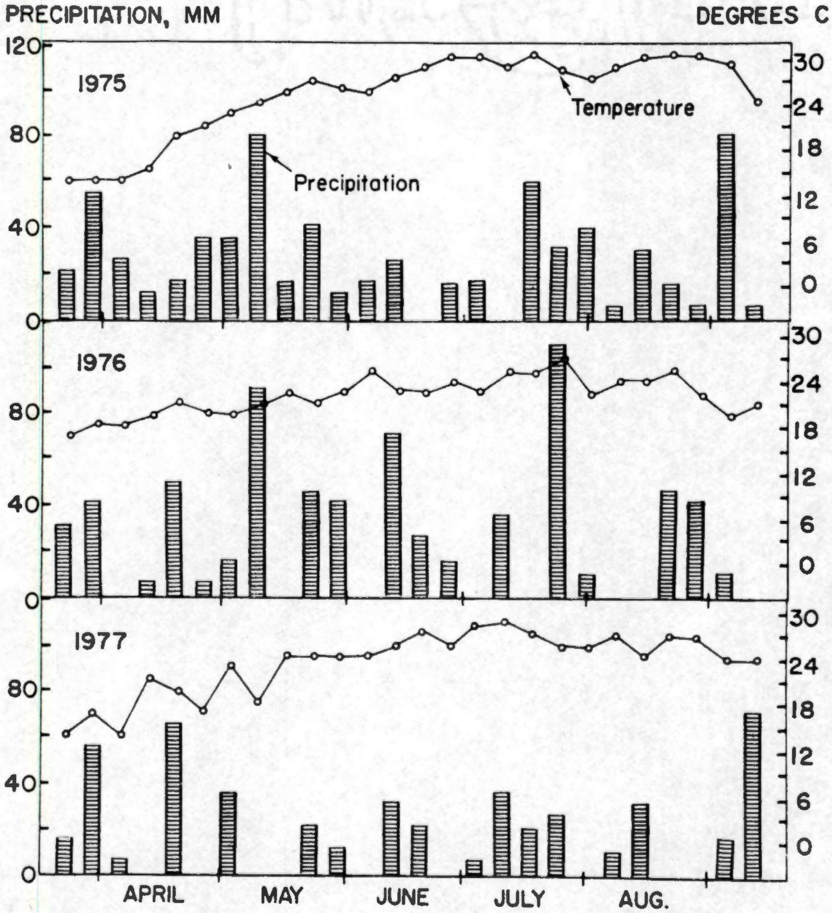


Figure 2. Weekly precipitation and mean air temperature during the 1975-1977 grazing seasons.

differences from period to period resulted, at the end of the grazing season, in significant differences among treatments for cumulative forage growth. This was observed for each year as well as when the years were combined. Since one of the three years was hotter and drier than normal, one had near normal temperatures with slightly above normal precipitation, and the third approximated normal climatic conditions, only the combined data for all years will be presented here (Table 2, Figure 3). More detailed data are available elsewhere (Tables 5, 6, 7, and 8, Appendix). Consideration of the three-year means is also justifiable because, even though there were fluctuations in SCI's from year to year due to varying climatic conditions and stocking rates (Figures 1 and 2), the desired mixtures were maintained within acceptable limits of percent composition throughout the study.

Midland + fescue pastures produced more forage than any other pasture (Figure 3), 43% more in spring and 70% more for the entire grazing season than Midland (0.4 ha)-fescue (0.8 ha). These results obtained under grazing confirm earlier observations in agronomic plots (26, 78), that inclusion of the cool-season fescue in the warm-season bermudagrass is feasible, extends the grazing season of the mixture over that obtained from bermudagrass alone and produces more forage than either species alone during a grazing season. Forage consumption from each pasture treatment was slightly less than growth, indicating that the total number of animals placed in each pasture during each grazing period was generally the number of animals required to consume the usable forage growth occurring within the height criteria set for most species combinations. This was achieved well in the case of

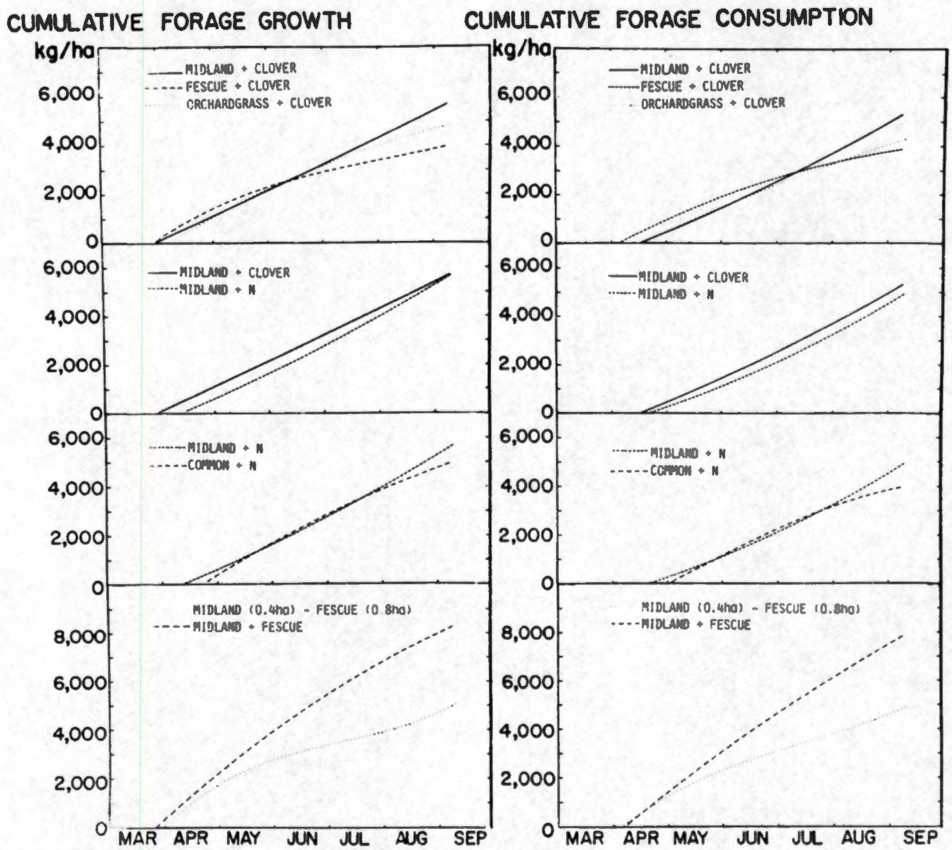


Figure 3. Cumulative forage growth and consumption (least squares three-year means) for seven pasture combinations during the 1975-1977 grazing seasons.

Midland + fescue, where consumption was 56% larger than for Midland (0.4 ha)-fescue (0.8 ha). It was not always feasible to utilize all forage produced on the 0.4 ha Midland, since it was deemed more appropriate to maintain the 0.8 ha fescue in a vegetative stage shorter than 8 cm. If a fescue sod and Midland sod both are to be grazed, area ratios of 2/7 or 1/4 Midland to 5/7 or 3/4 fescue might be more appropriate than the 1/3-2/3 ratio used here. However, this ratio might be satisfactory if hay for winter use was harvested from the Midland sod in spring and early summer.

The two bermudagrasses fertilized with 224 kg N/ha produced about as much forage as they did in the previous study at the N rate (24). Midland started growth about two weeks earlier than common bermudagrass but due to the relatively low N rate, it produced only 9% more yearly forage. Consumption of N-fertilized bermudagrass was related to forage growth, but perhaps summer consumption was accentuated by the leafier growth habit of Midland, since more Midland was consumed than common toward the end of the season. Forage quality of the two grasses, as indicated by CP concentration, was moderate but higher than the minimum requirement (53) of 10.7 or 10.0% for 250-kg or 300-kg steers gaining 700 g/day: the weighted CP for Midland + N was 13.5 and that for Common + N, 14.2%. The difference in CP between the two grasses was probably due to dilution of N recovered in the forage from fertilizer N applied since Midland growth was greater than that of common. It would be expected that much of the fertilizer N applied at this rate would be recovered in forage (27). The Midland + fescue had a 15.2% CP. This higher concentration was probably due to a residual N effect from previous applications.

The inclusion of clover in a Midland sod resulted in spring forage growth sufficient for grazing two weeks earlier than on Midland alone fertilized with N. Earlier spring grazing of Midland + clover to minimize shading of Midland by clover was deemed necessary when there was more than 30% clover stand in the mixture. This earlier grazing allowed the Midland to break dormancy at the same time as Midland growing alone. Total forage growth during the entire grazing season was the same for Midland + clover and Midland + N, indicating that 20 to 35% clover in a Midland sod resulted in the same total forage growth as 224 kg N/ha applied in three equal installments per year. Additional research since this study was terminated indicates that periodic winter topseeding of clover on sods containing less than 10 to 15% clover increases clover stand to 30% or more in the spring following overseeding. Spring forage consumption by steers grazing Midland + clover was about 20% greater than the amount consumed by steers grazing Midland + N. In addition to the larger consumption of Midland + clover forage the CP concentration in Midland + clover (14.0) was consistently higher than that in Midland + N forage (13.5%).

Total forage growth during the spring grazing season was similar for Midland + clover, Fescue + clover and Orc. + clover pastures. Orc. + clover grew faster than the other two mixtures since the later spring growth of orchardgrass delayed initial grazing for two weeks after grazing of the other two had started. Forage growth for the entire grazing season was one-third greater for Midland + clover than for Fescue + clover and reflects the vigorous growth of Midland and the summer semi-dormancy of fescue. Orc. + clover forage production was intermediate between those of Midland + clover and Fescue + clover. However, in years of above-normal temperatures and below-normal precipitation, orchardgrass can be expected to stop growth in early summer. Even under normal circumstances, grazing of Orc. + clover should be terminated in late July to early August to preserve the stand for subsequent years. The delay in sampling Orc. + clover pastures, occasioned by the higher stubble heights used, tended to underestimate the early spring growth of orchardgrass. The relatively smaller number of animals used to graze Orc. + clover pastures than Fescue + clover pastures, which was essential to maintain stands for several years (24), also resulted in occasional under-utilization of orchardgrass forage. This tended to overestimate summer orchardgrass growth. Forage consumption was the same for Orc. + clover and Midland + clover in spring. Consumption of Fescue + clover forage from the start of grazing until early July was similar to that of the other two clover-grass mixtures, although grazing of Fescue + clover started earlier and animal consumption was greater in early spring. By the end of the grazing season, more Midland + clover forage had been consumed than from the other two clover-grass mixtures. Forage quality of the grass-legume pastures, as expressed by weighted CP percentages, was relatively high: 14.0, 14.4, and 14.9% for Midland + clover, Fescue + clover and Orc. + clover, respectively. However, the Orc. + clover CP was

15.6% in 1975 and 1976 when SCI's indicated good clover stands, but only 13.5% in 1977 as the stands began to deteriorate.

# CHAPTER IV

# ANIMAL PERFORMANCE

## Introduction

Backgrounding programs involve the retention of weaned calves by feeder-calf producers for variable periods following weaning and before marketing for feedlot placement. A prevalent backgrounding scheme, which is adapted to mid-southeastern United States beef cattle operations, involves spring calves weaned in October, overwintered on harvested forage at nutritional levels sufficient to produce skeletal growth with limited increases in body weight, and grazed in spring and summer on pastures which support rapid animal gains. Detailed information regarding pasture productivity and forage quality of various pasture species and combinations is needed in planning such operations.

Pastures of orchardgrass mixed with ladino clover can support about 2.5 steers/ha in the mid-southeastern United States (34). Pastures of tall fescue with clover can support more animals over a longer grazing season, but forage quality factors and summer semidormancy are conducive to lesser beef production (35). It has been shown that N-fertilized bermudagrass can support six or more steers/ha in spring and summer (24, 67) but low forage quality and intake lead to beef production levels similar to those obtained with fewer animals on orchardgrass-clover. The inclusion of legumes in bermudagrass sods has increased total forage production and quality (46, 68), but management needed for long term maintenance of legumes in the stand under grazing conditions is uncertain.

The objectives of this study were to compare the forage quality, as expressed by average daily gain (ADG) and beef production/ha of Midland and common bermudagrass pastures fertilized with N to that of Midland pastures overseeded with clover or with fescue, to compare equal areas of Midland overseeded with fescue to separate pastures of the two species, and to further compare those combinations to mixtures of fescue and clover or orchardgrass and clover.

## Materials and Methods

Beef steers were backgrounded on different pasture systems during 1975, 1976 and 1977 at Ames Plantation, Grand Junction, Tennessee (Chapter III). The experimental design was a randomized complete block with two replications. Seven treatment combinations were assigned to 1.2 ha pastures: Midland bermudagrass + clover (Midland + clover); Midland bermudagrass + N (Midland + N); 0.4 ha Midland bermudagrass + N plus 0.8 ha of tall fescue + N [Midland (0.4 ha)-fescue (0.8 ha)]; Midland bermudagrass + tall fescue + N (Midland + fescue); Common bermudagrass + N (Common + N); Tall fescue + clover (Fescue + clover); and Orchardgrass + clover (Orc. + clover). A detailed description of these treatments is reported in Chapter III. The grazing season was divided into spring (March to mid-June) and summer (mid-June to September).

A modified put-and-take grazing management system was used. Yearling Angus beef steers were purchased each fall preceding the spring grazing season. They were wintered uniformly on a hay ration to gain about 300 g/head/day. In spring steers weighed 205 to 270 kg for the three years and graded either good or choice. Averages of body weights taken on two consecutive days were used as initial and final weights. Tester animals were selected each year for uniformity of initial weight across pastures and in such a manner that the mean weight did not differ by more than 7 kg from pasture to pasture within a replication. Individual weights of tester animals were taken at about 21-day intervals during the grazing season. Beef production for each period was calculated by multiplying the total number of animal grazing days per weighing period by the ADG of the tester steers. At no time did the steers receive supplemental feed while on pasture, but they all had free access to salt, minerals, water, and artificial shade.

Three tester steers were placed on each pasture in 1975. In 1976 and 1977, four tester steers were used in Common + N pastures, and five in Midland + N pastures. Extra steers were added to any bermudagrass pasture whenever mean growth reached 5 to 8 cm and were removed when mean height was 2.5 cm. Fescue + clover and Orc. + clover pastures were allowed to reach a mean growth of 7 cm and 14 cm, respectively, before extra steers were added. Extra steers were removed when mean grass height was 2.5 cm for Fescue + clover pastures and 5 cm for Orc. + clover pastures. Stocking rate changes were made independently for each pasture according to these criteria, and without regard to the decision deemed appropriate for a pasture of the same treatment in the other replication.

Forage growth, consumption and protein concentration, climatic data, and length of grazing season have been characterized earlier (Chapter III). Stocking rates, grazing days, ADG, and beef/ha were analyzed on a 21-day weighing period basis. Cumulative beef productions per animal and per ha were also considered for each period and season. Data and statistical analysis was done in a manner similar to that used for the forage production data and using the same linear contrasts (Chapter III). Since weighing dates and intervals were not exactly the same from year to year, arithmetic means could not be calculated for grazing days/ha, animal gains and beef production. To describe treatment effects for the grazing season, the cumulative data for the three variables for all years were fitted to polynomials and presented graphically. As discussed earlier for forage growth and consumption (Chapter III), second degree polynomials were used whenever cubic effects were not significant. Otherwise third degree polynomials were used. The models fitted for grazing days/ha had $R^2$'s ranging from 0.91 to 0.99, those for gain ranged between 0.86 and 0.97 and, for beef/ha, between 0.83 and 0.95.

## Results and Discussion

### Stocking Rate

Stocking rates varied between 3.8 and 7.3 steers/ha among treatments across all years (Table 3 and Figure 4). There was considerable variability among years. In 1975, a year with uniform distribution of above-normal precipitation (Figure 2, page 28), an average of 6.1 steers/ha was used for all treatments, with a range of 5.3 to 7.0 steers/ha (Tables 9 and 10, Appendix). In the hot dry 1977 season,

TABLE 3. MEAN ANIMAL PERFORMANCE AND PASTURE PRODUCTIVITY DURING THE 1975-1977 GRAZING SEASONS

| Variable | Treatments | | | | | | |
|---|---|---|---|---|---|---|---|
| | Midland (0.4 ha)-† fescue (0.8 ha)‡ | Midland† + fescue‡ | Common + N† | Midland + N† | Midland + clover | Fescue + clover | Orchardgrass + clover |
| SPRING GRAZING SEASON | | | | | | | |
| Stocking rate, steers/ha | 4.6§ | 7.3 | 4.7 | 5.7 | 3.3 | 4.9 | 3.9 |
| Steer weights and gains | | | | | | | |
| Final weight, kg/steer | 280§ | 275 | 300 | 278 | 290 | 286 | 304 |
| Gain, kg/steer | 60¶ | 55 | 40 | 45 | 65 | 60 | 77 |
| Daily gain, g/steer | 857§ | 786 | 889 | 818 | 929 | 857 | 1262 |
| Grazing and beef production | | | | | | | |
| Animal grazing days/ha | 310¶ | 500 | 200 | 285 | 265 | 340 | 230 |
| Beef production, kg/ha | 355¶ | 495 | 230 | 285 | 300 | 335 | 340 |
| ENTIRE GRAZING SEASON | | | | | | | |
| Stocking rate, steers/ha | 4.6§ | 7.3 | 4.9 | 5.9 | 3.8 | 5.0 | 4.0 |
| Steer weights and gains | | | | | | | |
| Final weight, kg/steer | 301§ | 301 | 320 | 311 | 318 | 284 | 327 |
| Gain, kg/steer | 81¶ c | 81 c | 60 d | 78 cd | ,93 b | 58 d | 100 a |
| Daily gain, g/steer | 514§ b | 476 b | 509 b | 517 b | 576 b | 524 b | 826 a |
| Grazing and consumption and beef production | | | | | | | |
| Animal grazing days/ha | 735¶ | 1190 | 730 | 880 | 750 | 825 | 520 |
| Forage dry matter intake, kg/steer/day | 6.6§ | 6.3 | 5.9 | 4.9 | 6.7 | 4.9 | 7.2 |
| Forage dry matter intake, kg/kg gain | 12.8§ | 13.2 | 11.6 | 9.5 | 11.6 | 9.3 | 8.8 |
| Beef production, kg/ha | 456¶ bc | 720 a | 412 bc | 515 b | 485 bc | 390 c | 505 b |

† 224 kg N/ha in 3 equal applications, April-July.

‡ 67 kg N/ha in September.

§ Mean of 2 replications for each of 3 years.

¶ Least squares mean.

a, b, c, d Values within a row followed by the same letter are not significantly different ($\alpha$ = 0.05).

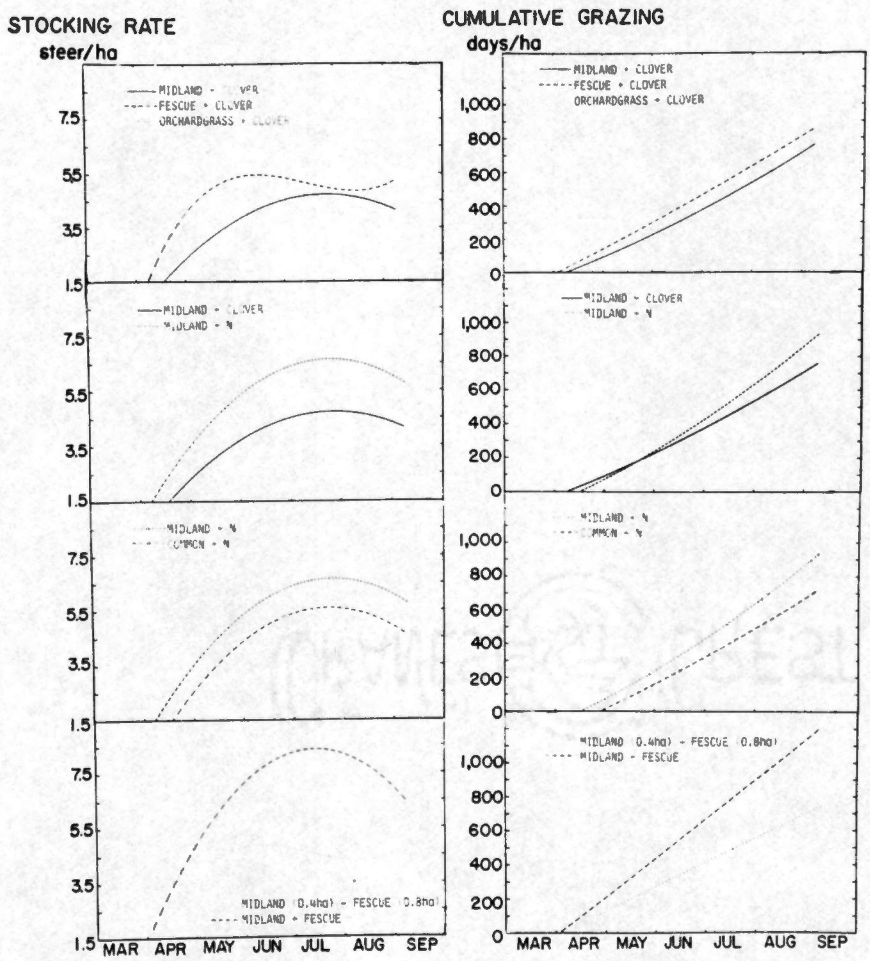


Figure 4. Stocking rate and cumulative grazing days (least squares three-year means) for seven pasture combinations during the 1975-1977 grazing seasons.

average stocking rate was only 4.4 steers/ha. The 1976 average stocking rate was intermediate. Stocking rates were set by the observers at the beginning of each 21-day grazing period, and their judgement was influenced by many factors, such as (1) forage growth and (2) SCI; (3) the desirability of maintaining grass components of the sod in vegetative stages of growth, as guided by the forage height criteria previously set for each species; (4) soil water availability; (5) weather conditions likely to occur during the forthcoming 21-day period; and (6) the probable combined influences of these factors interacting with grazing animals and the forage species. Even though stocking rates were varied by adding or removing extra animals in order to utilize the forage production of each pasture--usually changes consisted of no more than two or three animals per 1.2-ha pasture--stocking rates remained relatively constant during the grazing season after they had been established in spring. Stocking rates for Orc. + clover were reduced in late June and remained constant at 2.5 steers/ha until the grazing season ended.

## Pasture Productivity

Pasture productivity ranged from 675 grazing days/ha for Orc. + clover to 1190 for Midland + fescue (Figure 4). The small number of grazing days for Orc. + clover was a function of both the relatively low stocking rate and the earlier termination of grazing. Midland-fescue pastures were grazed earlier in the spring, later in the fall, and produced more forage (Chapter III). Midland + clover, Midland (0.4 ha)-fescue (0.8 ha) and Common + N pastures produced 55 to 75 more grazing days/ha than Orc. + clover. Midland + N produced 150 grazing days/ha more than Common + N, thus expressing the slightly greater productivity of Midland at a 224-kg N/ha fertilization rate. Fescue + clover was intermediate in productivity between Midland + clover and Midland + N. More detailed information is presented in Tables 9 and 14, Appendix.

Animal Gains

Steers gained an average of 565 g/day over the three-year 138-day average grazing season. Midland + clover steers gained slightly more than this average, and Orc. + clover steers considerably more. The other five treatments resulted in the comparatively low gains of 475 to 524 g/steer/day. Average daily gain for year and periods is presented in the Appendix in Tables 9 and 13. The lowest gains were those of steers grazing Midland + fescue, the pastures which had the largest number of grazing days/ha. It is possible that higher rates of gain per steer would have been obtained if fewer animals had been used. However, previous studies (24) have shown that long-term maintenance of mixtures of fescue and Midland cannot be achieved unless forage growth is kept within narrow height limits; if forage growth is continually less than 5 cm, fescue tends to predominate, and if bermudagrass is allowed to remain much taller than 10 cm, fescue stands deteriorate. Desirable mixtures of the two species were indeed maintained with the management used (Chapter III) and still exist today in another study on the same pastures--at the cost of decreased animal forage selectivity and lower ADG.

The effects of the different pastures on animal gains were reflected in cumulative beef gains over the season (Figure 5). Yearly

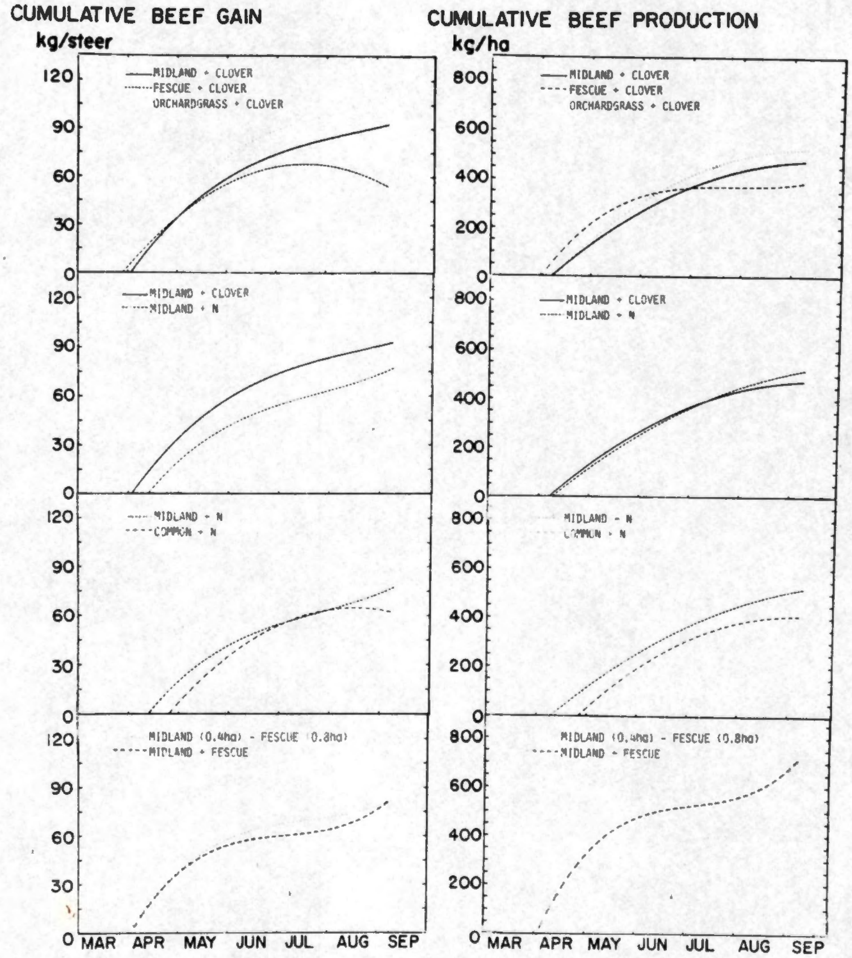


Figure 5. Cumulative beef gain and production (least squares three-year means) for seven pasture combinations during the 1975-1977 grazing seasons.

data and period data/year are presented in the Appendix, Tables 9 and 12. During early spring, daily gains of steers grazing fescue were rapid regardless of whether fescue occurred in mixtures with Midland or with clover. In the Midland + fescue pastures, ADG increased slowly when Midland started to dominate the sward, and again in late summer. When steers had access to Midland and fescue separately, ADG was slightly higher than when Midland unshaded by fescue was available. The earlier break in dormancy of Midland was reflected in slightly earlier gains obtained in Midland + N than in Common + N. The presence of clover has been cited as responsible for better animal gains than when it was absent (7): steers grazing Midland + clover gained 15% more than those grazing Midland + N, thus making up for the lower productivity of the Midland + clover pastures (750 vs. 880 grazing days/ha). The high quality and acceptability of Orc. + clover pastures was evident from the ADG of the small number of steers grazing these pastures. Steers grazing Midland + clover and Fescue + clover pastures had comparable gains in spring. As fescue became semi-dormant in summer, ADG decreased; Midland + clover ADG continued at a lower rate than in spring.

Beef Production

Midland + fescue produced the most beef/ha even though animal gains were less on those pastures than on Midland + clover and Orc. + clover pastures (Figure 5). The high beef production on Midland + fescue--over 700 kg beef/ha--was achieved with substantially more animals/ha and with a longer grazing season than on the other treatments

(Tables 9 and 15, Appendix). The combination of Midland and fescue in separate pastures produced much less beef/ha with the same animal gain/ha than when the two species were in the same sod. Thus, the flexibility in management resulting from two separate pastures, one of which could have been used for hay production, was achieved by decreasing total beef production.

The greater productivity of Midland + N than of Common + N pastures was reflected by the 25% greater beef production. Total beef production was the same for Midland + clover and Midland + N; thus the managerial and economic aspects of maintaining clover in bermudagrass sods by means of pH adjustments, P and K fertilization, periodic overseedings, inoculating and grazing control must be weighed against the managerial aspects and increasing costs of N fertilizer utilization.

Beef production from Fescue + clover was less than from Midland + clover. Although this may be related to the smaller forage production from fescue than from Midland, it could be ascribed also to some of the negative factors that have been suggested as being responsible for poor animal performance on fescue pastures, such as high alkaloid content (23) or the presence of fungi (43, 55) which do not result in visible phytosymptoms. Individual animal gains on the Orc. + clover pastures were high enough to result in larger beef production/ha from those pastures than from either Fescue + clover or Midland + clover pastures, even though grazing days/ha were least on Orc. + clover.

Estimated Forage Dry Matter Intake

During the entire grazing season, steers grazing Orc. + clover pastures had higher daily forage DM intake (7.2 kg/steer) than steers grazing other combinations. The efficiency of this consumption was the highest among the treatments studied, since only 8.8 kg of DM intake were needed for 1.0 kg of gain. These two values together further describe the high quality of the Orc. + clover pastures. Steers grazing Midland + clover pastures had an estimated intake of 0.5 kg/steer/day less than those on Orc. + clover, followed in decreasing order by steers grazing the Midland-fescue combinations. The lowest quality pastures, as evidenced by DM intake, were those of N-fertilized bermudagrasses and Fescue + clover. However, feed efficiency was about 2 kg greater for Fescue + clover and Midland + N than for Common + N. The lack of grazing selectivity imposed on the steers by the manner in which the Midland + fescue pastures were managed is reflected in the low efficiency of over 13 kg intake/kg of gain.

General Discussion

Forage production and quality, and animal performance from Orc. + clover, Fescue + clover and Midland + N pastures in this study were similar to those measured previously in the region (24, 34). Previously at this location (24) Midland + N pastures had a greater productivity than that reported here (1290 vs. 880 grazing days/ha). However, ADG was 36% greater and beef production/ha 41% greater in this study than in the previous one. This increased performance over time may have been due to more favorable environmental conditions, fortuitous circumstances, or a better ability of the experimenters to control forage utilization. Pasture productivity of Orc. + clover was 14% greater in the present study than in the earlier one; ADG and beef production/ha were almost identical.

When 224 kg N/ha were applied to sods of common or Midland bermudagrasses, little difference in forage productivity was observed but quality tended to be slightly higher for Midland. As measured by the steers, pasture productivity was greater on Midland than on common, even though ADG was about the same. Consequently, total beef production/ha was 25% greater on Midland + N than on Common + N.

The overseeding of tall fescue in Midland bermudagrass sods, which had been successfully accomplished earlier in small plots and where desired mixtures were compatible for several years when forage growth was carefully regulated (26), was successfully accomplished in this grazing study. The species composition index (SCI) developed in the course of this investigation (Chapter III) was a useful tool for reflecting the botanical makeup of a pasture where two or more species occurred in ratios fluctuating over time. Pastures where Midland and fescue mixtures occurred had large productivity. Intake of the relatively low quality forage was good; thus, although ADG was only about 475 g/steer, beef production was over 700 kg/ha.

The use of different pastures in a forage system can be valuable for the producer. The attempt in this study at such a system for the early spring to fall grazing season did not perform up to its potential. The 0.4 ha pasture of Midland produced more forage than could be utilized well by grazing. Its area was too large, relative to the 0.8

ha of fescue, since hay production was not practiced. In a commercial enterprise, the larger field sizes which would be practicable could provide greater flexibility in forage production and management, with separate pasture and hay fields of fescue and/or Midland.

Ladino clover was successfully established and maintained in Midland sods. Control of potentially excessive grass heights was essential in maintaining 20 to 35% clover in the stands. Occasional winter overseedings of clover may be necessary to insure continued presence of sufficient legumes in the stand. Forage growth and consumption were the same on Midland pastures with clover as on Midland pastures fertilized with 224 kg N/ha. Pasture productivity was 17% greater on Midland + N than on Midland + clover, but ADG was 11% less on Midland + N. Consequently total beef production was about the same.

Tall fescue pastures are widespread in the region and the presence of clover can provide even better pastures in spring and autumn. The semi-dormancy of fescue in summer limits its value for backgrounding operations. Pasture productivity, ADG and beef production from the Fescue + clover pastures were similar to those reported earlier (7, 34). Midland + clover pastures resulted in 25% more beef/ha than Fescue + clover pastures over the March to September grazing season. Producers who desire to background steers during those months might find that two pastures, one of fescue with clover and one of Midland with clover, might be of greater value than relying on only one kind of pasture.

# CHAPTER V

# FACTORS CONTRIBUTING TO VARIABILITY IN FORAGE GROWTH AND CONSUMPTION, AND ANIMAL PERFORMANCE

## Introduction

Grazing experiments are notoriously difficult and expensive to conduct. Sufficient replication of experimental units (pastures) and numbers of sampling units (animals) to increase power of statistical tests (56) is often unaffordable. After considerable time and effort have been expended, the data obtained can often be reduced to one or two small tables. Even though this may be an outcome which is satisfactory for the practical utilization of the results by cattle producers, it often leaves the experimenter frustrated, because reasons for effects and consequences of interactions are not easy to explore or explain. The difficulties are aggravated by the inherent variability within such experiments--among animals, soil types and topography, and pasture components. It is often necessary that the results of treatment effects in a grazing study be considerably different in order for statistical tests--rendered insensitive by the uncontrolled variability and insufficient replication--to be able to differentiate among treatments.

A pasture changes dynamically with time. Even when a pasture is comprised of a uniform stand of a single species or cultivar managed uniformly, the physiological status of the plant and nutritional value or acceptability of the forage to the grazing animal will change throughout the season. This problem is compounded when the pasture treatment in an experiment is designed to represent a mixture of two or more species which form a combination deemed desirable for the grazing animal. For example, pastures of two different treatments named X and Y might be represented as containing $X_1$ and $Y_1$ forage (species, amounts, etc. . . .) at the start of the grazing season. After some time (one month, one week, one day) the two pastures will contain $X_2$ and $Y_2$ forage, where $X_1 \neq X_2 \neq Y_1 \neq Y_2$. At the end of the grazing season, the pastures will contain $X_t$ and $Y_t$ forage, where t is the last sampling. To represent each of the two vectors $X_1, X_2, . . .,$ $X_t$ and $Y_1, Y_2, . . ., Y_t$ by treatment labels such as fescue + clover or orchardgrass + clover can be a misleading simplification, since the combined effects of the factors affecting forage growth and consumption, and animal performance over time affect the two pastures differently.

Since different values of the classification variable "treatments" are deceptive for characterizing pasture conditions at different or even the same observation times, it can be argued instead that the treatments were applied in order to generate diverse forage conditions measured over time through observations of plant characteristics and animal performance.

Forage growth and consumption (Chapter III) and animal gains and production (Chapter IV) were estimated in a beef steer backgrounding experiment concurrently with several environmental, plant and animal characteristics. These concomitant variables were related to the effects of the pasture systems on the dependent variables. The intent of this paper is to evaluate approaches that consider the species composition of pastures from time to time and that were useful in explaining up to two-thirds of the total variability encountered among the dependent variables.

## Materials and Methods

A beef steer backgrounding experiment with seven pasture systems in a randomized complete block design with two replications was conducted under a modified put-and-take system for three years. The seven 1.2-ha pasture combinations were: (1) Midland bermudagrass + Ladino clover; (2) Midland + 224 kg N/ha; (3) 0.4 ha Midland + N plus 0.8 ha of tall fescue + N; (4) Midland + fescue + N; (5) Common bermudagrass + N; (6) Fescue + clover; and (7) Orchardgrass + clover. Detailed methods, plant growth and consumption, and animal data have been reported in Chapters III and IV. Forage growth and consumption were estimated by a strip-and-cage method with sampling at about 21-day intervals during spring (March-June) and summer (June-September). At each observation date, several variables were measured for each pasture: (1) dry matter forage yield from cages and (2) strips; (3) visual estimates of the contribution of each forage species to the stand and composition of each pasture; (4) height of each species in each pasture; (5) daily precipitation and (6) mean air temperature; and (7) stocking rate. Samples were analyzed for (8) crude protein (CP) percentage in forage from cages and (9) from strips. From these measurements, other data (57) were calculated: (10) forage growth and (11) consumption; and (12) number of days/grazing period.

It has been suggested that factor analysis can be used to achieve statistical simplicity and help as a screening device in the selection of some variates from a larger set (22). A factor analysis was done separately for forage growth and forage consumption, using the methods and general criteria described by Fribourg and Creel (2, 22). Six factor loadings were retained from the analysis. One described forage growth, involving several variables related to pasture growth and precipitation. The second represented grazing pressure, and included number of days/period and number of animal grazing days. The third combined seasonal effects over time and their interaction with forage plants and grazing animals, including temperature. The other three were all descriptive of the species composition of the pasture from time to time during the season: one for clover, another for fescue, and the third for the other forage grasses used (orchardgrass and bermudagrasses). Using three out of six factor loadings for the characterization of the botanical composition of these pastures over time appeared to be lacking in parsimony. To obviate this difficulty, the species composition index (SCI) was created (Chapter III). It characterized each pasture on each rating day by a unique symbol which combined botanical composition values for the forage species studied into a discrete classification variable with 48 possible values. The factor analysis was useful in highlighting the effects of botanical composition and initiating the creation of the SCI. After SCI was substituted for botanical composition data, the number of independent variables remaining was small. Subsequent analyses were made with multiple regression using a General Linear Model procedure (2).

Animal weights were measured at intervals of about 21 days, usually 19 to 23. Occasionally, periods were as short as two weeks, or lasted more than one month. From the tester steer weights, the number of grazing animals (tester steers + extra steers) during each grazing period, and the forage growth and consumption data, other variables were calculated: (13) number of grazing days/grazing period; (14) average daily gain (ADG); (15) beef gain/ha; and (16) total beef production/ha.

Univariate multiple regression models were developed for the dependent variables: forage growth, forage consumption, animal gain, and beef production. Concomitant variates affecting forage growth and consumption were included in the models for animal gain and beef production. The total number of observations was 320. Concomitant variables were arranged in an order which made biological sense, or which first considered variates which are easier or cheaper to obtain than others. For example, year, season, days/period were entered ahead of crude protein concentrations. Concomitant variables were retained in the models for subsequent analysis when the partial regression coefficient associated with a variable was significant at $\alpha = 0.05$. In the final models, variates accounting for the most variability were entered first and significant variables accounting for the least variability were entered last. The percentage of the total variability associated in the model with each concomitant variate was calculated from the sequential sum of squares of the final model. Main effects only were used. Even though interactions might have led to larger coefficients of determination, the difficulties in interpretation that would arise from their use engendered that decision.

## Results and Discussion

### Forage Growth

Variability in forage growth was associated with variability in precipitation and crude protein, and to a lesser extent with the effects of stocking rate, year, and temperature (Table 4). Season (spring or summer) and days/period were not significant variates. When "treatments" was used in the model, that variable accounted for less than one-third of the variability than was described by the variable "SCI". However, CP helped explain slightly more of the total variability when "treatments" was used than when "SCI" was utilized. The SCI was a more descriptive tool than "treatments" for characterizing the nature of each pasture at each sampling date. Stocking rate effects were small in both analyses. The SCI reflected botanical changes in the pastures occasioned by grazing animals. "Treatments" or "treatments" plus CP did not reflect the changes as well. It is understandable that precipitation and temperature should both affect forage growth. The year effect may reflect interactions between environmental conditions and forage plants which were not entered in the model, or subtle unobserved forage differences from year to year due to the aging of the stands.

### Forage Consumption

Forage consumption was related mostly to CP in the forage, i.e., forage quality. It was also related to precipitation, even though

TABLE 4. SIGNIFICANT CONCOMITANT VARIATES ASSOCIATED WITH VARIABILITY IN FORAGE GROWTH AND CONSUMPTION, AVERAGE DAILY GAIN AND BEEF PRODUCTION, OF SEVEN PASTURE COMBINATIONS STUDIED FOR THREE GRAZING SEASONS

| | Concomitant variables | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dependent variable | Treat-ment | Species compos-tion index (SCI) | Stocking rate/ period | Season (spring or sum-mer | Year | Days/ period | Forage consump-tion/ period | Forage crude protein during period | Precipi-tation during period | Mean tem-perature for period | $R^2$ |
| | $^{\Delta}R^2$ (x 100) from sequential addition of variate | | | | | | | | | | |
| Using "Treatments" to describe pasture conditions period: | | | | | | | | | | | |
| Forage growth | 6.6* | N.A. | 1.4* | | 1.9* | | N.A. | 7.0* | 8.6* | 1.0* | 0.265 |
| Forage consumption | 7.2* | N.A. | 1.8* | | 1.2* | | N.A. | 26.9* | 6.0* | | 0.431 |
| Average daily gain | 3.7* | N.A. | 27.4* | 22.3* | 2.8* | 1.6* | 0.5* | | | | 0.583 |
| Beef production | | N.A. | 17.1* | 12.2* | 5.0* | 9.5* | | | | | 0.438 |
| Using "SCI" to describe pasture conditions period: | | | | | | | | | | | |
| Forage growth | N.A. | 21.4* | 1.3* | | 2.0* | | N.A. | 5.5* | 8.4* | 0.9* | 0.395 |
| Forage consumption | N.A. | 21.0* | 1.5* | | 2.7* | | N.A. | 20.8* | 6.0* | | 0.520 |
| Average daily gain | N.A. | 28.0* | 17.6* | 19.1* | 2.0* | 0.4* | 0.5* | | | | 0.676 |
| Beef production | N.A. | 24.2* | 10.4* | 10.0* | 3.3* | 6.1* | 0.7* | | | | 0.547 |

N.A. = not applicable.

* = significant, $\alpha$ = 0.05.

stocking rate and year effects were significant. Season, days/period and temperature were not significant. As in the case of forage growth, SCI accounted for three times as much variability as "treatments." When SCI was used, CP was equally useful in explaining total variation, but to a lesser extent than when "treatments" was used. Crude protein in the forage samples and SCI were very important in reflecting differing consumptions of forage in the many different pasture conditions to which the steers were exposed. Although temperature in the locale of this study was significant in influencing forage growth, it was not significant in affecting the consumption of that forage by Angus steers.

Animal Gains

The average daily gain of growing steers is often considered to be the best measure of forage quality. However, stocking rate can affect both animal performance and pasture productivity (6) since stocking rates that result in maximum animal performance, beef production, and forage productivity, are not generally the same. The results obtained in this study, therefore, were conditioned by the animal grazing management schemes used (Chapters III, IV) which were set to maintain the pasture species in vegetative stages of growth for as long as possible without deleterious effects on the stands. In one of the seven pasture systems used, where fescue occurred in mixture with Midland, grazing selectivity was impeded by the management required to maintain the mixture and resulted in lower animal performance (Chapter IV).

As has been reported by others (58) stocking rate had profound effects on ADG. However, stocking rate did not fluctuate widely from period to period (Chapter IV) and was determined primarily by forage availability and the perceived needs for long-term sod maintenance as determined for each pasture independently. Thus any advantage or disadvantage resulting from stocking rate was a consequence of the state of an individual pasture. In this study, stocking rate and season of the year were important in accounting for variability in pasture quality, as reflected by the ADG of the tester steers. This relationship was accentuated by the inclusion in the study of such diverse pastures as orchardgrass with clover, and fescue or bermudagrass fertilized with N and without an associated legume. Although the variable "season" was not significant in explaining forage growth and consumption, it was important in explaining variability in the two animal-response dependent variables. "Season" incorporated into one variable the combined effects of precipitation and temperature and their interaction, as they affected forage CP, growth and consumption, thus emphasizing the decreases in ADG and beef production often noted from spring into summer. The variable "treatments," although significant, accounted for less than 4% of the total variation in ADG. The variable SCI accounted for seven times as much variability, at the expense of a lesser reliance on stocking rate and season effects in that model. The effect of season was important because orchardgrass + clover pastures initiated growth earlier in spring than those of bermudagrasses, and ADG of steers grazing grass pastures without clover in late summer was often negligible.

Beef Production

The variable "treatments" was not significant in explaining variation in beef production among pastures, even though beef production ranged from a low of 390 to 720 kg/ha. When SCI was used, it explained one-fourth of the variability in beef production. Although this phenomenon cannot be used for justifying the selection of specific pasture systems in a commercial enterprise, it does highlight the paramount importance of the species composition of pastures.

Stocking rate and season of the year were also important in explaining variability in beef production, just as they were in accounting for variations in ADG. The relatively large effects of days per period were probably related to the cases beyond the control of the experimenters when the three-week observation periods were substantially shorter or longer than 21 days. On four occasions, periods were only two weeks long, and on three occasions, four to five weeks long; there was a total of 28 observation periods during the three-year study. Year effects accounted for more variability in beef production than they did for the other dependent variables. This may have been due to the fact that different sets of cattle were used each year. Average daily gain was not affected as much as beef production by different sets of cattle from year to year, since ADG is more sensitive to stocking rate effects than is beef production. Tester steers were carefully allotted among pastures so that uniform lots were apportioned among them; extra steers were somewhat more variable, and a greater variability among them from one year to the next may have contributed also to the year effect.

The same significant concomitant variables explained variability in both ADG and beef production, but the $R^2$ for ADG was 0.13 larger than the 0.55 obtained for beef production. Average daily gain was used as a dependent variable rather than animal gains/period because animal scientists and the public are accustomed to using ADG for expressing animal response to forage quality. Average daily gain is calculated by dividing gain/period by number of days/period. However, stocking rate/period was a significant and relatively large concomitant variable. The number of days in a period enters into the calculations for both the dependent variable ADG and the concomitant variable stocking rate/period. Under such conditions, where there is double use of the number of days/period, it should not be surprising that the model for ADG has a larger $R^2$ than that for beef production. If number of days/period could be omitted from at least one side of the equation, it is probable that the concomitant variables would explain about the same amount of variability in both animal gains and beef production.

CHAPTER VI

# SUMMARY

A grazing experiment was conducted 80 km east of Memphis, Tennessee from 1975 through 1977 on a fine-silty, mixed, thermic, Typic Hapludalfs, to evaluate productivity and quality of seven pasture combinations for growing beef steers. The 1.2 ha pastures were: 'Midland' bermudagrass (*Cynodon dactylon* (L.) Pers.) + Ladino clover (*Trifolium repens* L.) [Midland + clover]; Midland + 224 kg N/ha [Midland + N]; 0.4 ha Midland + N plus 0.8 ha tall fescue + N (*Festuca arundinacea* Schreb.) [Midland (0.4 ha)-fescue (0.8 ha)]; Midland + overseeded fescue + N [Midland + fescue]; Common bermudagrass (*Cynodon dactylon* L. var. *dactylon*) + 224 kg N/ha [Common + N]; Fescue + clover; and Orchardgrass (*Dactylis glomerata* L.) + clover [Orc. + clover]. Pastures were replicated twice and grazed using a modified put-and-take system where orchardgrass was maintained between heights of 7 and 14 cm, and the other grasses between 5 and 8 cm. Forage growth and consumption were determined by the cage-and-strip method and visual estimates of species composition of each pasture were made at about 21-day intervals. The species composition index (SCI) was developed to describe each pasture at each observation time with a unique symbol. The SCI was found to be a sensitive tool for characterizing dynamically changing pasture compositions.

Grazing season ranged from 123 for Orc. + clover to 150 days in pastures where both cool- and warm-season species occurred. Forage

growths were about 4000 kg/ha for Fescue + clover; 4900 kg/ha for Orc. + clover, Common + N, and Midland (0.4 ha)-fescue (0.8 ha); 5670 kg/ha for Midland + N and Midland + clover; and 8300 kg/ha for Midland + fescue. Estimated forage consumption was 80% or more of the estimated forage growth of each pasture. Forage quality, as reflected by crude protein (12.2 to 15.2%) was sufficient for meeting the minimum requirements for growing 250-kg steers.

Stocking rates were four steers/ha for Midland + clover and Orc. + clover; about five steers/ha for Midland (0.4 ha)-fescue (0.8 ha), Common + N and Fescue + clover; six steers/ha for Midland + N and over seven for Midland + fescue. Average daily gains (ADG) were about 475 to 575 g/day for all treatments except for Orc. + clover where ADG was 825 g/day. Pasture productivity ranged between 520 grazing days/ha for Orc. + clover to 1190 for Midland + fescue; the productivity of the other pastures was between 730 and 880 grazing days/ha. Daily forage dry matter (DM) intake was five to seven kg/steer/day in all pastures. Steers grazing Orc. + clover, Fescue + clover, and Midland + N pastures had the best feed efficiency (8.8, 9.3, and 9.5 kg/kg gain, respectively) while the steers on the other treatments needed 11 to 13 kg DM/kg gain. Beef production was 390, 412, 456, 485, 505, 515, and 720 kg/ha for Fescue + clover, Common + N, Midland (0.4 ha)-fescue (0.8 ha), Midland + clover, Orc. + clover, Midland + N, and Midland + fescue, respectively.

Forage production and quality, and animal performance of Orc. + clover, Fescue + clover and Midland + N pastures were similar in this study to those measured previously in the region (24, 34). Previously at this location (24) Midland + N pastures had a greater productivity than that reported here (1290 vs. 880 grazing days/ha); however, ADG was 36% greater and beef production/ha 41% greater in this study than in the previous one. This increased performance over time may have been due to more favorable environmental conditions, fortuitous circumstances, or a better ability of the experimenters to control forage utilization. Pasture productivity of Orc. + clover was 14% greater in the present study than in the earlier one; ADG and beef production/ha were almost identical.

When 224 kg N/ha were applied to sods of common or Midland bermudagrasses, little difference in forage productivity was observed but quality tended to be slightly higher for Midland. As measured by the steers, pasture productivity was greater on Midland than on common, even though ADG was about the same. Consequently, total beef production/ha was 25% greater on Midland + N than on Common + N.

The maintenance of tall fescue in Midland bermudagrass sods was carefully accomplished in this grazing study. Pastures where Midland and fescue mixtures occurred were very productive. Intake of the relatively low quality forage was good; thus, although ADG was only about 475 g/steer, beef production was over 700 kg/ha.

The use of different pastures in a forage system can be valuable for the producer. The attempt in this study at such a system for the early spring to fall grazing season did not perform as well as had been expected. The 0.4 ha pasture of Midland produced more forage than could be utilized well by grazing since hay production was not practiced and was too large relative to the 0.8 ha of fescue. In a commercial enterprise, the larger field sizes which would be practicable could provide greater flexibility in forage production and management with separate dual-purpose pasture and hay fields of fescue and Midland.

Ladino clover was successfully established and maintained in Midland sods, and control of potentially excessive heights was essential in maintaining 20 to 35% clover in the stands. Occasional winter over-seedings of clover may be necessary to insure continued presence of adequate legumes in the stand. Forage growth and consumption were the same on Midland pastures with clover as on Midland pastures fertilized with 224 kg N/ha. Total productivity was 17% greater on Midland + N than on Midland + clover, but ADG was 11% less on Midland + N. Consequently total beef production was the same.

Tall fescue pastures are widespread in the region and the presence of clover can provide even better pastures in spring and autumn. The semi-dormancy of fescue in summer limits its value for ongoing backgrounding operations. Pasture productivity, ADG and beef production from the Fescue + clover pastures in this study were very similar to those reported in earlier studies. Midland + clover pastures resulted in 25% more beef/ha than Fescue + clover pastures over the March to September grazing season. Producers who desire to background steers during those months might find that two pastures, one of fescue with clover and one of Midland with clover, could be of greater value than either pasture alone.

The traditional classification variable "treatments," used to describe seven differently managed pasture combinations of different forage species, was compared to SCI. Models were developed to identify the concomitant variables, in addition to "treatments" or SCI, that could account for variability in forage growth and consumption, ADG and beef production. Variability in forage growth could be accounted for by precipitation, mean air temperature, forage crude protein, year effects and stocking rate, in addition to "treatments" or SCI. Forage consumption variability depended on the same factors, excluding temperature, Average daily gains and beef production could be explained by seasonal and yearly effects, stocking rate, forage consumption, and length of grazing period, in addition to "treatments" or SCI. When "treatments" was entered in the model, coefficients of determination of 0.26, 0.43, 0.58, and 0.44 were obtained for forage growth, forage consumption, ADG and beef production, respectively; when SCI was used, the $R^2$'s were 0.40, 0.52, 0.68, and 0.55.

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APPENDIX

# APPENDIX

TABLE 5. YEARLY FORAGE GROWTH AND CONSUMPTION, FORAGE CRUDE PROTEIN, INITIAL GRAZING DATE, AND GRAZING SEASONS, 1975-1977

| | | Treatments | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Variable | Year | Midland (0.4 ha)-† fescue (0.8 ha)‡ | Midland† + fescue‡ | Common + N† | Midland + N† | Midland + clover | Fescue + clover | Orchardgrass + clover |
| Initial grazing date | 1975 | March 27§ | March 27 | May 12 | May 12 | March 27 | March 27 | April 24 |
| | 1976 | April 12 | April 12 | April 12 | April 12 | April 12 | April 12 | April 12 |
| | 1977 | March 30 | March 30 | March 30 | March 30 | March 30 | March 30 | March 30 |
| | Mean | April 1 | April 1 | April 20 | April 20 | April 1 | April 1 | April 11 |
| Length of spring grazing season, days | 1975 | 77§ | 77 | 31 | 31 | 77 | 77 | 49 |
| | 1976 | 61 | 61 | 61 | 61 | 61 | 61 | 61 |
| | 1977 | 74 | 74 | 43 | 74 | 74 | 74 | 74 |
| | Mean | 70 | 70 | 45 | 55 | 70 | 70 | 61 |
| Length of grazing season, days | 1975 | 165§ | 165 | 119 | 119 | 165 | 165 | 137 |
| | 1976 | 134 | 134 | 134 | 134 | 134 | 134 | 134 |
| | 1977 | 153 | 153 | 123 | 123 | 153 | 110 | 99 |
| | Mean | 150 | 150 | 125 | 135 | 150 | 136 | 123 |
| Forage growth, kg/ha | 1975 | 5882§ | 10280 | 4725 | 5835 | 7440 | 5662 | 3447 |
| | 1976 | 2320 | 6485 | 5415 | 4272 | 5075 | 2925 | 5800 |
| | 1977 | 5825 | 6450 | 4277 | 4767 | 3062 | 1600 | 1937 |
| Least squares | mean | 5025 c | 8320 a | 4965 cd | 5640 b | 5695 b | 3965 d | 4800 cd |
| Forage consumption, kg/ha | 1975 | 5600§ | 9290 | 3392 | 4905 | 6535 | 5415 | 4370 |
| | 1976 | 2645 | 6415 | 4767 | 3977 | 4582 | 2977 | 5125 |
| | 1977 | 5397 | 5987 | 3457 | 3920 | 2580 | 1520 | 1332 |
| Least squares | mean | 4850 bc | 7900 a | 3965 d | 4885 bc | 5310 b | 3885 d | 4260 cd |
| Weighted forage crude protein, % | 1975 | 13.1¶ | 15.9 | 16.2 | 15.7 | 18.2 | 13.8 | 15.6 |
| | 1976 | 12.1 | 16.6 | 15.1 | 12.9 | 12.6 | 16.4 | 15.6 |
| | 1977 | 11.6 | 13.3 | 11.3 | 12.1 | 11.3 | 13.2 | 13.5 |
| | Mean | 12.2 | 15.2 | 14.2 | 13.5 | 14.0 | 14.4 | 14.9 |

† 224 kg N/ha in 3 equal applications, April-July.

‡ 67 kg N/ha in September.

§ Mean of 2 replications.

¶ Weighted mean cage samples, based on forage dry matter growth.

a, b, c, d Values within a row followed by the same letter are not significantly different ($\alpha = 0.05$).

TABLE 6. FORAGE GROWTH AT INDIVIDUAL SAMPLING DATES, 1975-1977

| Year | Sampling date | Season | Treatments | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Midland (0.4)-† fescue (0.8 ha)‡ | Midland† + fescue‡ | Common + N† | Midland + N† | Midland + clover | Fescue + clover | Orchardgrass + clover |
| | | | kg/ha | | | | | | |
| 1975 | March 27 | Spring | 368§ | 792 | --- | --- | 622 | 628 | --- |
| | April 28 | Spring | 1925 | 1752 | --- | --- | 1478 | 2112 | 932 |
| | May 16 | Spring | 878 | 1255 | 995 | 1045 | 60 | 1212 | 675 |
| | May 27 | Spring | 682 | 932 | 160 | 322 | 1180 | 312 | 628 |
| | June 11 | Spring | 468 | 1232 | 232 | 1405 | 408 | 455 | 498 |
| | June 30 | Summer | 182 | 1500 | 522 | 590 | 1298 | 350 | 695 |
| | July 15 | Summer | 308 | 632 | 308 | 648 | 325 | 282 | 510 |
| | Aug. 14 | Summer | 622 | 1065 | 1302 | 1050 | 998 | 195 | 702 |
| | Sept. 08 | Summer | 450 | 1118 | 1205 | 775 | 1072 | 115 | 768 |
| 1976 | April 12 | Spring | 115 | 432 | --- | --- | --- | 235 | --- |
| | April 27 | Spring | --- | --- | 817 | 902 | 1015 | --- | 610 |
| | May 20 | Spring | 585 | 1232 | 992 | 422 | 460 | 568 | 1315 |
| | June 01 | Spring | 500 | 785 | 250 | 105 | 38 | 260 | 708 |
| | June 21 | Summer | 252 | 1488 | 815 | 942 | 1127 | 780 | 1450 |
| | July 07 | Summer | 425 | 1138 | 1390 | 732 | 1280 | 530 | 858 |
| | Aug. 03 | Summer | 148 | 1078 | 190 | 820 | 822 | 470 | 860 |
| | Aug. 23 | Summer | 295 | 332 | 960 | 348 | 332 | 82 | --- |
| 1977 | March 30 | Spring | 282 | 850 | --- | --- | --- | 108 | 315 |
| | May 03 | Spring | 2208 | 2610 | 482 | 185 | 210 | 672 | 1300 |
| | May 24 | Spring | 252 | 1338 | 1250 | 652 | 688 | 322 | 322 |
| | June 24 | Summer | 908 | 575 | 968 | 1258 | 795 | 302 | --- |
| | July 07 | Summer | --- | --- | --- | --- | --- | 105 | --- |
| | July 18 | Summer | --- | --- | --- | --- | --- | 385 | --- |
| | Aug. 01 | Summer | 1312 | 1078 | 1332 | 2430 | 908 | --- | --- |
| | Aug. 30 | Summer | 862 | --- | 245 | 242 | 462 | --- | --- |

† 224 kg N/ha applied in 3 equal applications, April-July.

‡ 67 kg N/ha in September.

§ Mean of 2 replications.

TABLE 7. FORAGE CONSUMPTION AT INDIVIDUAL SAMPLING DATES, 1975-1977

| Year | Sampling date | Season | Treatments: Midland (0.4 ha)-† fescue (0.8 ha)‡ | Midland† + fescue‡ | Common + N† | Midland + N† | Midland + clover | Fescue + clover | Orchardgrass + clover |
|---|---|---|---|---|---|---|---|---|---|
| | | | kg/ha | | | | | | |
| 1975 | March 27 | Spring | 0 | 0 | --- | --- | 0 | 0 | --- |
| | April 28 | Spring | 1245§ | 1560 | --- | --- | 175 | 1670 | 0 |
| | May 12 | Spring | --- | --- | --- | --- | --- | --- | --- |
| | May 16 | Spring | 1072 | 1085 | 0 | 0 | 580 | 1447 | 562 |
| | May 27 | Spring | 715 | 580 | 622 | 608 | 692 | 562 | 410 |
| | June 11 | Spring | 500 | 1600 | 390 | 1360 | 1410 | 322 | 952 |
| | June 30 | Summer | 445 | 1565 | 490 | 835 | 1572 | 635 | 1040 |
| | July 15 | Summer | 442 | 872 | 328 | 372 | 407 | 272 | 632 |
| | Aug. 14 | Summer | 690 | 1080 | 992 | 1075 | 1157 | 332 | 437 |
| | Sept. 08 | Summer | 490 | 948 | 570 | 655 | 540 | 172 | 260 |
| 1976 | April 12 | Spring | 0 | 0 | --- | --- | --- | 0 | --- |
| | April 27 | Spring | --- | --- | 0 | 0 | 0 | --- | 0 |
| | May 20 | Spring | 640 | 1380 | 1212 | 958 | 957 | 690 | 767 |
| | June 01 | Spring | 442 | 840 | 500 | 235 | 205 | 227 | 1005 |
| | June 21 | Summer | 585 | 1362 | 860 | 665 | 980 | 755 | 1227 |
| | July 07 | Summer | 202 | 702 | 1005 | 602 | 1052 | 615 | 887 |
| | Aug. 03 | Summer | 405 | 1468 | 418 | 892 | 887 | 570 | 1120 |
| | Aug. 23 | Summer | 370 | 662 | 772 | 625 | 500 | 120 | 117 |
| 1977 | March 30 | Spring | 0 | 0 | --- | --- | --- | 0 | 0 |
| | May 03 | Spring | 1812 | 2348 | 0 | 0 | 0 | 625 | 795 |
| | May 24 | Spring | 615 | 1028 | 775 | 600 | 575 | 250 | 372 |
| | June 24 | Summer | 885 | 978 | 908 | 1028 | 827 | 410 | --- |
| | July 07 | Summer | --- | --- | --- | --- | --- | 165 | 165 |
| | July 18 | Summer | --- | --- | --- | --- | --- | 305 | --- |
| | Aug. 01 | Summer | 1155 | 1410 | 1392 | 1662 | 685 | --- | --- |
| | Aug. 30 | Summer | 930 | 225 | 382 | 630 | 492 | --- | --- |

† 224 kg N/ha applied in 3 equal applications, April-July.

‡ 67 kg N/ha in September.

§ Mean of 2 replications.

TABLE 8. FORAGE CRUDE PROTEIN AT INDIVIDUAL SAMPLING DATES, 1975-1977

| | | | Treatments | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Sampling date | Season | Midland (0.4 ha)-† fescue (0.8 ha)‡ | Midland† + fescue‡ | Common + N† | Midland + N† | Midland + clover | Fescue + clover | Orchardgrass + clover |
| | | | | | % CP | | | | |
| 1975 | April 28 | Spring | 13.70§ | 15.10 | --- | --- | 18.15 | 12.80 | --- |
| | May 12 | Spring | --- | --- | --- | --- | --- | --- | --- |
| | May 16 | Spring | 8.70 | 14.40 | --- | --- | 9.30 | 11.75 | 14.15 |
| | May 27 | Spring | 11.65 | 16.30 | 16.75 | 19.30 | 19.00 | 12.65 | 15.00 |
| | June 11 | Spring | 14.15 | 16.50 | 19.30 | 16.40 | 22.90 | 16.75 | 16.40 |
| | June 30 | Summer | 14.65 | 15.95 | 15.95 | 12.50 | 19.35 | 15.35 | 15.95 |
| | July 15 | Summer | 13.50 | 17.40 | 17.35 | 16.65 | 21.10 | 14.70 | 17.35 |
| | Aug. 14 | Summer | 18.50 | 17.35 | 16.15 | 15.25 | 20.85 | 18.50 | 16.40 |
| | Sept. 08 | Summer | 16.50 | 15.20 | 14.70 | 14.95 | 16.60 | 18.10 | 6.95 |
| 1976 | May 20 | Spring | 9.30 | 14.90 | 13.50 | 13.30 | 5.95 | 14.20 | 14.65 |
| | June 01 | Spring | 11.60 | 19.60 | 18.95 | 9.50 | 15.60 | 17.85 | 17.05 |
| | June 21 | Summer | 14.10 | 17.90 | 17.70 | 15.55 | 17.30 | 17.15 | 16.35 |
| | July 07 | Summer | 13.55 | 16.00 | 14.00 | 13.05 | 14.40 | 17.55 | 17.10 |
| | Aug. 03 | Summer | 12.30 | 15.50 | 20.90 | 11.65 | 11.70 | 18.10 | 14.60 |
| | Aug. 23 | Summer | 11.65 | 16.60 | 11.30 | 12.20 | 11.00 | 13.65 | 11.15 |
| 1977 | May 03 | Spring | 10.35 | 13.50 | --- | --- | --- | 14.85 | 14.30 |
| | May 24 | Spring | 10.95 | 10.89 | 11.90 | 11.10 | 10.70 | 12.50 | 12.55 |
| | June 24 | Summer | 14.40 | 14.75 | 13.90 | 16.00 | 12.85 | 14.90 | 14.90 |
| | July 07 | Summer | --- | --- | --- | --- | --- | --- | 13.70 |
| | July 18 | Summer | --- | --- | --- | --- | --- | 14.40 | --- |
| | Aug. 01 | Summer | 12.50 | 14.75 | 9.65 | 11.10 | 11.05 | --- | --- |
| | Aug. 30 | Summer | 12.10 | 13.25 | 9.55 | 11.15 | 10.20 | --- | --- |

† 224 kg N/ha applied in 3 equal applications, April-July.

‡ 224 kg N/ha in September.

§ Composite of 6 cage samples in each of 2 replications.

TABLE 9. YEARLY ANIMAL PERFORMANCE AND PASTURE PRODUCTIVITY, 1975-1977

| Variable | Year | Treatments: Midland (0.4 ha)-† fescue (0.8 ha)‡ | Midland† + fescue‡ | Common + N† | Midland + N† | Midland + clover | Fescue + clover | Orchardgrass + clover |
|---|---|---|---|---|---|---|---|---|
| Stocking rate, steers/ha§ | 1975 | 5.3 | 6.9 | 6.3 | 7.0 | 5.3 | 6.0 | 5.7 |
| | 1976 | 3.8 | 7.2 | 4.3 | 5.8 | 3.8 | 5.4 | 3.5 |
| | 1977 | 4.8 | 7.9 | 4.0 | 5.0 | 2.4 | 3.6 | 2.9 |
| | Mean | 4.6 | 7.3 | 4.9 | 5.9 | 3.8 | 5.0 | 4.0 |
| Steer weights, kg¶ | 1975 | 291 | 306 | 315 | 325 | 319 | 273 | 314 |
| | 1976 | 291 | 289 | 320# | 290†† | 308 | 300 | 346 |
| | 1977 | 323 | 309 | 327# | 318†† | 327 | 279 | 322 |
| | Mean | 301 | 301 | 320 | 311 | 318 | 284 | 327 |
| Steer gains, kg¶ | 1975 | 77 | 92 | 64 | 69 | 106 | 67 | 101 |
| | 1976 | 51 | 48 | 69# | 38†† | 51 | 60 | 93 |
| | 1977 | 105 | 87 | 56# | 104†† | 108 | 59 | 100 |
| Least squares mean | | 81 c | 81 c | 60 d | 78 cd | 93 b | 58 d | 100 a |
| Daily steer gains, g¶ | 1975 | 472 | 558 | 549 | 583 | 646 | 408 | 735 |
| | 1976 | 385 | 302 | 519# | 286†† | 379 | 447 | 696 |
| | 1977 | 685 | 567 | 458# | 683†† | 703 | 717 | 1018 |
| | Mean | 514 b | 476 b | 509 b | 517 b | 576 b | 524 b | 826 a |
| Animal grazing days/ha§ | 1975 | 883 | 1237 | 686 | 878 | 1005 | 966 | 656 |
| | 1976 | 554 | 1195 | 729 | 869 | 604 | 726 | 568 |
| | 1977 | 636 | 989 | 564 | 842 | 445 | 394 | 285 |
| Least squares mean | | 735 | 1190 | 730 | 880 | 750 | 825 | 520 |
| Forage dry matter intake, kg/steer/day§ | 1975 | 6.3 | 7.5 | 4.9 | 5.6 | 6.5 | 5.6 | 6.7 |
| | 1976 | 4.8 | 5.4 | 6.5 | 4.6 | 7.6 | 4.1 | 9.0 |
| | 1977 | 8.5 | 6.1 | 6.1 | 4.7 | 5.8 | 4.3 | 4.7 |
| | Mean | 6.6 | 6.3 | 5.9 | 4.9 | 6.7 | 4.9 | 7.2 |
| Forage DM intake, kg/kg gain§ | 1975 | 13.4 | 13.5 | 9.0 | 9.6 | 10.0 | 13.7 | 8.9 |
| | 1976 | 12.3 | 17.9 | 12.6 | 16.0 | 20.0 | 9.2 | 13.0 |
| | 1977 | 12.4 | 10.7 | 13.4 | 6.8 | 8.3 | 6.1 | 4.6 |
| | Mean | 12.8 | 13.2 | 11.6 | 9.5 | 11.6 | 9.3 | 8.8 |
| Beef production, kg/ha§ | 1975 | 478 | 801 | 458 | 593 | 777 | 459 | 630 |
| | 1976 | 245 | 286 | 440 | 252 | 228 | 394 | 395 |
| | 1977 | 590 | 806 | 309 | 644 | 323 | 301 | 361 |
| Least squares mean | | 456 cd | 720 a | 412 d | 515 c | 485 c | 390 cd | 505 b |

† 224 kg N/ha in 3 equal applications, April–July.

‡ 67 kg N/ha in September.

§ Mean of 2 replications.

¶ Mean of 3 tester steers in each of 2 replications, except # 4 tester steers, †† 5 tester steers.

a, b, c, d Values within a row followed by the same letter are not significantly different ($\alpha$ = 0.05).

TABLE 10. STOCKING RATES AT INDIVIDUAL STOCKING DATES, 1975-1977

| | | | Treatments | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Stocking date | Season | Midland (0.4 ha)-† fescue (0.8 ha)‡ | Midland† + fescue‡ | Common + N† | Midland + N† | Midland + clover | Fescue + clover | Orchardgrass + clover |
| | | | steers/ha | | | | | | |
| 1975 | March 27 | Spring | 0.0 | 0.0 | --- | --- | 0.0 | 0.0 | --- |
| | April 24 | Spring | --- | --- | --- | --- | --- | --- | 0.0 |
| | April 28 | Spring | 4.3§ | 5.4 | --- | --- | 3.0 | 4.6 | 5.3 |
| | May 16 | Spring | 5.3 | 6.4 | 7.4 | 7.4 | 4.0 | 5.9 | 5.5 |
| | May 27 | Spring | 5.7 | 6.7 | 7.4 | 7.4 | 4.6 | 6.3 | 5.7 |
| | June 11 | Spring | 5.5 | 6.9 | 6.2 | 7.0 | 5.8 | 6.5 | 6.5 |
| | June 30 | Summer | 5.6 | 7.1 | 5.7 | 6.6 | 6.4 | 6.5 | 6.6 |
| | July 15 | Summer | 5.5 | 7.5 | 5.6 | 6.1 | 6.2 | 6.3 | 6.0 |
| | Aug. 14 | Summer | 5.4 | 7.4 | 5.7 | 6.7 | 6.1 | 6.0 | 4.9 |
| | Sept. 08 | Summer | 5.3 | 7.5 | 5.7 | 7.4 | 6.1 | 5.8 | 4.8 |
| 1976 | April 12 | Spring | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | April 27 | Spring | 3.3 | 6.1 | 3.3 | 4.9 | 3.3 | 4.9 | 2.5 |
| | May 20 | Spring | 3.6 | 6.7 | 3.7 | 5.2 | 3.5 | 5.2 | 3.0 |
| | June 01 | Spring | 3.9 | 7.2 | 4.2 | 5.6 | 3.6 | 5.5 | 3.3 |
| | June 07 | Spring | --- | 7.1 | --- | --- | --- | --- | --- |
| | June 21 | Summer | 4.1 | 8.4 | 4.6 | 6.0 | 3.8 | 5.7 | 3.5 |
| | July 07 | Summer | 4.1 | 4.4 | 4.8 | 6.2 | 3.8 | 5.9 | 3.8 |
| | Aug. 03 | Summer | 4.1 | 8.8 | 5.2 | 6.4 | 4.4 | 5.7 | 4.5 |
| | Aug. 23 | Summer | 4.1 | 8.9 | 5.4 | 6.5 | 4.5 | 5.4 | 4.2 |
| 1977 | March 30 | Spring | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | May 03 | Spring | 5.0 | 8.6 | 3.3 | 4.7 | 2.0 | 3.9 | 2.8 |
| | May 24 | Spring | 5.3 | 8.6 | 3.5 | 4.7 | 2.2 | 3.7 | 3.0 |
| | June 24 | Summer | 4.8 | 8.1 | 4.2 | 5.0 | 2.6 | 3.5 | 3.0 |
| | July 07 | Summer | --- | --- | --- | --- | --- | 3.1 | 2.9 |
| | July 18 | Summer | --- | --- | --- | --- | --- | 3.6 | --- |
| | Aug. 01 | Summer | 4.1 | 7.0 | 4.9 | 5.2 | 2.7 | --- | --- |
| | Aug. 30 | Summer | 4.1 | 6.5 | 4.6 | 5.5 | 2.9 | --- | --- |

† 224 kg N/ha in 3 equal applications, April-July.

‡ 67 kg N/ha in September.

§ Mean of 2 replications.

TABLE 11. STEER WEIGHTS AT INDIVIDUAL WEIGHING DATES, 1975-1977

| | | | Treatments | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Weighing date | Season | Midland (0.4 ha)-† fescue (0.8 ha)ǂ | Midland† + fescueǂ | Common + N† | Midland + N† | Midland + clover | Fescue + clover | Orchardgrass + clover |
| | | | kg/steer | | | | | | |
| 1975 | March 27 | Spring | 213§ | 214 | --- | --- | 213 | 206 | --- |
| | April 24 | Spring | --- | --- | --- | --- | --- | --- | 214 |
| | April 28 | Spring | 248 | 245 | --- | --- | 237 | 247 | 224 |
| | May 12 | Spring | --- | --- | 250 | 255 | --- | --- | --- |
| | May 16 | Spring | 261 | 264 | 254 | 259 | 261 | 261 | 261 |
| | May 27 | Spring | 266 | 272 | 264 | 270 | 265 | 266 | 270 |
| | June 11 | Spring | 273 | 278 | 276 | 288 | 282 | 266 | 277 |
| | June 30 | Summer | 279 | 284 | 291 | 306 | 299 | 263 | 284 |
| | July 15 | Summer | 278 | 285 | 299 | 309 | 298 | 260 | 291 |
| | Aug. 14 | Summer | 278 | 296 | 301 | 313 | 307 | 259 | 301 |
| | Sept. 08 | Summer | 291 | 306 | 315 | 325 | 319 | 273 | 314 |
| 1976 | April 12 | Spring | 239 | 249 | 250¶ | 252# | 257 | 240 | 253 |
| | April 27 | Spring | 256 | 267 | 272¶ | 269# | 279 | 265 | 276 |
| | May 20 | Spring | 277 | 281 | 294¶ | 283# | 295 | 289 | 312 |
| | June 01 | Spring | 284 | 285 | 306¶ | 286# | 300 | 297 | 329 |
| | June 07 | Spring | --- | 298 | --- | --- | --- | --- | --- |
| | June 21 | Summer | 290 | 292 | 326¶ | 288# | 308 | 303 | 341 |
| | July 07 | Summer | 294 | 289 | 325¶ | 289# | 311 | 300 | 344 |
| | Aug. 03 | Summer | 291 | 290 | 318¶ | 290# | 314 | 303 | 349 |
| | Aug. 23 | Summer | 291 | 289 | 320¶ | 290# | 308 | 300 | 346 |
| 1977 | March 30 | Spring | 218 | 222 | --- | 213# | 219 | 223 | 220 |
| | April 30 | Spring | --- | --- | 270¶ | --- | --- | --- | --- |
| | May 03 | Spring | 281 | 275 | 277¶ | 261# | 264 | 259 | 286 |
| | May 24 | Spring | 292 | 277 | 296¶ | 273# | 286 | 277 | 303 |
| | June 24 | Summer | 308 | 286 | 321¶ | 291# | 304 | 289 | 322 |
| | July 07 | Summer | --- | --- | --- | --- | --- | 314 | 322 |
| | July 18 | Summer | --- | --- | --- | --- | --- | 279 | --- |
| | Aug. 01 | Summer | 324 | 312 | 331¶ | 320# | 330 | --- | --- |
| | Aug. 30 | Summer | 323 | 309 | 327¶ | 318# | 327 | --- | --- |

† 224 kg N/ha in 3 equal applications, April-July.

ǂ 67 kg N/ha in September.

§ Mean of 3 tester steers in each of 2 replications, except ¶ 4 tester steers, # 5 tester steers.

TABLE 12. STEER GAINS AT INDIVIDUAL WEIGHING DATES, 1975-1977

| Year | Weighing date | Season | Treatments | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Midland (0.4 ha)-† fescue (0.8 ha)ǂ | Midland† + fescueǂ | Common + N† | Midland + N† | Midland + clover | Fescue + clover | Orchardgrass + clover |
| | | | kg/steer | | | | | | |
| 1975 | March 27 | Spring | 0 | 0 | -- | -- | 0 | 0 | -- |
| | April 24 | Spring | -- | -- | -- | -- | -- | -- | -- |
| | April 28 | Spring | 35§ | 30 | 0 | 0 | 24 | 40 | 10 |
| | May 16 | Spring | 13 | 19 | 4 | 4 | 24 | 15 | 37 |
| | May 27 | Spring | 4 | 8 | 10 | 11 | 4 | 4 | 9 |
| | June 11 | Spring | 7 | 6 | 12 | 17 | 16 | 0 | 7 |
| | June 30 | Summer | 6 | 6 | 14 | 18 | 16 | -2 | 8 |
| | July 15 | Summer | -1 | 1 | 8 | 3 | 0 | -4 | 7 |
| | Aug. 14 | Summer | 0 | 10 | 2 | 4 | 8 | 0 | 9 |
| | Sept. 08 | Summer | 13 | 11 | 13 | 12 | 12 | 14 | 13 |
| 1976 | April 12 | Spring | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | April 27 | Spring | 16 | 17 | 21¶ | 18# | 22 | 24 | 23 |
| | May 20 | Spring | 20 | 14 | 22¶ | 14# | 16 | 24 | 36 |
| | June 01 | Spring | 7 | 4 | 12¶ | 3# | 5 | 8 | 17 |
| | June 07 | Spring | -- | 16 | -- | -- | -- | -- | -- |
| | June 21 | Summer | 6 | -1 | 20¶ | 2# | 8 | 6 | 12 |
| | July 07 | Summer | 3 | 0 | 0¶ | 0# | 3 | -3 | 2 |
| | Aug. 03 | Summer | -3 | -1 | -7¶ | 0# | 3 | 3 | 5 |
| | Aug. 23 | Summer | 0 | 0 | 1¶ | 0# | -6 | -3 | -3 |
| 1977 | March 30 | Spring | 0 | 0 | -- | 0# | 0 | 0 | 0 |
| | April 30 | Spring | -- | -- | 0¶ | -- | -- | -- | -- |
| | May 03 | Spring | 63 | 53 | 6¶ | 47# | 44 | 36 | 64 |
| | May 24 | Spring | 10 | 2 | 18¶ | 11# | 22 | 18 | 17 |
| | June 24 | Summer | 16 | 10 | 26¶ | 17# | 18 | 12 | 19 |
| | July 07 | Summer | -- | -- | -- | -- | -- | 2 | 0 |
| | July 18 | Summer | -- | -- | -- | -- | -- | 13 | -- |
| | Aug. 01 | Summer | 16 | 25 | 9¶ | 29# | 22 | -- | -- |
| | Aug. 30 | Summer | -1 | -3 | -4¶ | -2# | -2 | -- | -- |

† 224 kg N/ha in 3 equal applications, April-July.

ǂ 67 kg N/ha in September.

§ Mean of 3 tester steers in each of 2 replications, except ¶ 4 tester steers, # 5 tester steers.

TABLE 13. STEER AVERAGE DAILY GAINS AT INDIVIDUAL WEIGHING DATES, 1975-1977

| Year | Weighing date | Season | Treatments: Midland (0.4 ha)-† fescue (0.8 ha)‡ | Midland† + fescue‡ | Common + N† | Midland + N† | Midland + clover | Fescue + clover | Orchardgrass + clover |
|---|---|---|---|---|---|---|---|---|---|
| | | | g/steer | | | | | | |
| 1975 | March 27 | Spring | 0 | 0 | --- | --- | 0 | 0 | --- |
| | April 24 | Spring | --- | --- | --- | --- | --- | --- | 0 |
| | April 28 | Spring | 1101§ | 946 | --- | --- | 765 | 1264 | 2438 |
| | May 12 | Spring | --- | --- | 0 | | --- | --- | --- |
| | May 16 | Spring | 729 | 1082 | 946 | 1014 | 1341 | 831 | 2074 |
| | May 27 | Spring | 415 | 708 | 946 | 1014 | 354 | 424 | 804 |
| | June 11 | Spring | 467 | 413 | 831 | 1167 | 1112 | -25 | 458 |
| | June 30 | Summer | 322 | 309 | 753 | 874 | 862 | -107 | 404 |
| | July 15 | Summer | -111 | 127 | 549 | 225 | -15 | -231 | 483 |
| | Aug. 14 | Summer | -90 | 349 | 81 | 131 | -16 | -2 | 299 |
| | Sept. 08 | Summer | 513 | 438 | 540 | 474 | 495 | 567 | 540 |
| 1976 | April 12 | Spring | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | April 27 | Spring | 1055 | 1119 | 1360¶ | 1107# | 1371 | 1546 | 992 |
| | May 20 | Spring | 892 | 608 | 958¶ | 608# | 695 | 1053 | 1562 |
| | June 01 | Spring | 633 | 361 | 989¶ | 274# | 413 | 667 | 1460 |
| | June 07 | Spring | --- | 318 | --- | --- | --- | --- | --- |
| | June 21 | Summer | 292 | -250 | 996¶ | 104# | 422 | 290 | 595 |
| | July 07 | Summer | 233 | 143 | -40¶ | 0# | 163 | -200 | 163 |
| | Aug. 03 | Summer | -109 | -13 | 77¶ | 45# | 120 | 136 | 200 |
| | Aug. 23 | Summer | 9 | -34 | 86¶ | 0# | -308 | -154 | -140 |
| 1977 | March 30 | Spring | 0 | 0 | --- | 0# | 0 | 0 | 0 |
| | April 30 | Spring | --- | --- | 0¶ | --- | --- | --- | --- |
| | May 03 | Spring | 1868 | 1564 | 1634¶ | 1407# | 1307 | 1060 | 1911 |
| | May 24 | Spring | 502 | 75 | 888¶ | 545# | 1064 | 849 | 837 |
| | June 24 | Summer | 515 | 324 | 824¶ | 567# | 590 | 397 | 604 |
| | July 07 | Summer | --- | --- | --- | --- | --- | 354 | -29 |
| | July 18 | Summer | --- | --- | --- | --- | --- | 323 | --- |
| | Aug. 01 | Summer | 440 | 674 | 249¶ | 785# | 665 | --- | --- |
| | Aug. 30 | Summer | -59 | -113 | -136¶ | -74# | -90 | --- | --- |

† 224 kg N/ha in 3 equal applications, April-July.

‡ 67 kg N/ha in September.

§ Mean of 3 tester steers in each of 2 replications, except ¶ 4 tester steers, # 5 tester steers.

TABLE 14. PASTURE PRODUCTIVITY FOR INDIVIDUAL STOCKING PERIODS, 1975-1977

| | | | Treatments | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Stocking date | Season | Midland (0.4 ha)-† fescue (0.8 ha)‡ | Midland† + fescue‡ | Common + N† | Midland + N† | Midland + clover | Fescue + clover | Orchardgrass + clover |
| | | | animals x days grazing/ha | | | | | | |
| 1975 | March 27 | Spring | 0 | 0 | --- | --- | 0 | 0 | --- |
| | April 24 | Spring | --- | --- | --- | --- | --- | --- | 0 |
| | April 28 | Spring | 137§ | 171 | --- | --- | 96 | 148 | 21 |
| | May 12 | Spring | --- | --- | 0 | 0 | --- | --- | --- |
| | May 16 | Spring | 127 | 148 | 29 | 30 | 104 | 148 | 99 |
| | May 27 | Spring | 82 | 91 | 81 | 82 | 82 | 91 | 68 |
| | June 11 | Spring | 77 | 118 | 76 | 99 | 163 | 106 | 121 |
| | June 30 | Summer | 116 | 147 | 95 | 114 | 165 | 123 | 131 |
| | July 15 | Summer | 71 | 148 | 77 | 68 | 80 | 77 | 49 |
| | Aug. 14 | Summer | 148 | 218 | 183 | 237 | 170 | 148 | 64 |
| | Sept. 08 | Summer | 124 | 195 | 144 | 247 | 144 | 124 | 101 |
| 1976 | April 12 | Spring | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | April 27 | Spring | 53 | 99 | 53 | 79 | 53 | 79 | 40 |
| | May 20 | Spring | 87 | 164 | 91 | 125 | 84 | 126 | 77 |
| | June 01 | Spring | 59 | 109 | 69 | 84 | 49 | 74 | 49 |
| | June 07 | Spring | --- | 184 | --- | --- | --- | --- | --- |
| | June 21 | Summer | 95 | 310 | 115 | 140 | 82 | 125 | 85 |
| | July 07 | Summer | 66 | 158 | 92 | 112 | 66 | 105 | 79 |
| | Aug. 03 | Summer | 111 | 133 | 177 | 189 | 162 | 140 | 179 |
| | Aug. 23 | Summer | 82 | 192 | 132 | 140 | 108 | 76 | 58 |
| 1977 | March 30 | Spring | 0 | 0 | --- | 0 | 0 | 0 | 0 |
| | April 30 | Spring | | | 0 | --- | --- | --- | --- |
| | May 03 | Spring | | 294 | 13 | 161 | 69 | 134 | 94 |
| | May 24 | Spring | | 180 | 73 | 100 | 52 | 71 | 69 |
| | June 24 | Summer | | 223 | 152 | 175 | 107 | 98 | 95 |
| | July 07 | Summer | --- | --- | --- | --- | --- | 45 | 26 |
| | July 18 | Summer | --- | --- | --- | --- | --- | 46 | --- |
| | Aug. 01 | Summer | 100 | 177 | 224 | 214 | 109 | --- | --- |
| | Aug. 30 | Summer | 119 | 114 | 102 | 191 | 107 | --- | --- |

† 224 kg N/ha in 3 equal applications, April-July.

‡ 67 kg N/ha in September.

§ Mean of 2 replications.

TABLE 15. BEEF PRODUCTION FOR INDIVIDUAL WEIGHING PERIODS, 1975-1977

| Year | Weighing date | Season | Treatments | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Midland (0.4 ha)-† fescue (0.8 ha)‡ | Midland† + fescue‡ | Common + N† | Midland + N† | Midland + clover | Fescue + clover | Orchardgrass + clover |
| | | | kg/ha | | | | | | |
| 1975 | March 27 | Spring | 0 | 0 | --- | --- | 0 | 0 | --- |
| | April 24 | Spring | --- | --- | --- | --- | --- | --- | 0 |
| | April 28 | Spring | 184§ | 197 | --- | --- | 92 | 227 | 62 |
| | May 12 | Spring | --- | --- | 0 | 0 | --- | --- | --- |
| | May 16 | Spring | 113 | 195 | 34 | 36 | 172 | 149 | 250 |
| | May 27 | Spring | 41 | 78 | 94 | 100 | 35 | 46 | 66 |
| | June 11 | Spring | 43 | 56 | 77 | 140 | 222 | -2 | 70 |
| | June 30 | Summer | 45 | 54 | 87 | 121 | 173 | -17 | 67 |
| | July 15 | Summer | -9 | 22 | 53 | 17 | -3 | -29 | 27 |
| | Aug. 14 | Summer | -16 | 93 | 18 | 36 | 6 | -1 | 21 |
| | Sept. 08 | Summer | 77 | 105 | 94 | 142 | 80 | 85 | 64 |
| 1976 | April 12 | Spring | 0 | 0 | 0¶ | 0# | 0 | 0 | 0 |
| | April 27 | Spring | 67 | 128 | 87¶ | 108# | 90 | 148 | 47 |
| | May 20 | Spring | 93 | 121 | 105¶ | 91# | 71 | 161 | 146 |
| | June 01 | Spring | 44 | 47 | 83¶ | 27# | 25 | 60 | 87 |
| | June 07 | Spring | --- | 67 | --- | --- | --- | --- | --- |
| | June 21 | Summer | 36 | -94 | 139¶ | 15# | 42 | 43 | 63 |
| | July 07 | Summer | 19 | 27 | -4¶ | 1# | 13 | -25 | 16 |
| | Aug. 03 | Summer | -15 | 4 | 16¶ | 8# | 22 | 24 | 44 |
| | Aug. 23 | Summer | 1 | -8 | 13¶ | 0# | -36 | -17 | -10 |
| 1977 | March 30 | Spring | 0 | 0 | --- | 0# | 0 | 0 | 0 |
| | April 30 | Spring | --- | --- | 0¶ | --- | --- | --- | --- |
| | May 03 | Spring | 390 | 554 | 26¶ | 276# | 110 | 159 | 218 |
| | May 24 | Spring | 78 | 27 | 79¶ | 63# | 67 | 72 | 74 |
| | June 24 | Summer | 76 | 88 | 153¶ | 119# | 76 | 47 | 69 |
| | July 07 | Summer | --- | --- | --- | --- | --- | 23 | 30 |
| | July 18 | Summer | --- | --- | --- | --- | --- | 49 | --- |
| | Aug. 01 | Summer | 54 | 142 | 68¶ | 203# | 87 | --- | --- |
| | Aug. 30 | Summer | -8 | -11 | -17¶ | -17# | -17 | --- | --- |

† 224 kg N/ha in 3 equal applications, April-July.

‡ 67 kg N/ha in September.

§ Mean of 3 tester steers in each of 2 replications, except ¶ 4 tester steers, # 5 tester steers.

TABLE 16. NUMBER OF DAYS PER WEIGHING PERIOD, 1975-1977

| Year | Weighing date | Season | Treatments | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Midland (0.4 ha)-† fescue (0.8 ha)‡ | Midland† + fescue‡ | Common + N† | Midland + N† | Midland + clover | Fescue + clover | Orchardgrass + clover |
| 1975 | March 27 | Spring | 0 | 0 | -- | -- | 0 | 0 | -- |
| | April 24 | Spring | -- | -- | -- | -- | -- | -- | 0 |
| | April 28 | Spring | 32§ | 32 | -- | -- | 32 | 32 | 4 |
| | May 12 | Spring | -- | -- | 0 | 0 | -- | -- | -- |
| | May 16 | Spring | 18 | 18 | 4 | 4 | 18 | 18 | 18 |
| | May 27 | Spring | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| | June 11 | Spring | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | June 30 | Summer | 19 | 19 | 19 | 19 | 19 | 19 | 19 |
| | July 15 | Summer | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Aug. 14 | Summer | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| | Sept. 08 | Summer | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| 1976 | April 12 | Spring | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | April 27 | Spring | 16 | 16 | 16 | 16 | 16 | 16 | 16 |
| | May 20 | Spring | 23 | 23 | 23 | 23 | 23 | 23 | 23 |
| | June 01 | Spring | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| | June 21 | Summer | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| | July 07 | Summer | 16 | 16 | 16 | 16 | 16 | 16 | 16 |
| | Aug. 03 | Summer | 27 | 27 | 27 | 27 | 27 | 27 | 27 |
| | Aug. 23 | Summer | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| 1977 | March 30 | Spring | 0 | 0 | -- | 0 | 0 | 0 | 0 |
| | April 30 | Spring | -- | -- | 0 | -- | -- | -- | -- |
| | May 03 | Spring | 34 | 34 | 4 | 34 | 34 | 34 | 34 |
| | May 24 | Spring | 21 | 21 | 21 | 21 | 21 | 21 | 21 |
| | June 24 | Summer | 31 | 31 | 31 | 31 | 31 | 31 | 31 |
| | July 07 | Summer | -- | -- | -- | -- | -- | 14 | 14 |
| | July 18 | Summer | -- | -- | -- | -- | -- | 12 | -- |
| | Aug. 01 | Summer | 38 | 38 | 38 | 38 | 38 | -- | -- |
| | Aug. 30 | Summer | 29 | 29 | 29 | 29 | 29 | -- | -- |

† 224 kg N/ha in 3 equal applications, April-July.

‡ 67 kg N/ha in September.

§ Mean of 2 replications.

## VITA

Ricky Joe Carlisle was born August 20, 1954, in Memphis, Tennessee, to Mr. and Mrs. Tate C. Carlisle, Jr. He was reared on a livestock and row crop farm near Bolton, Mississippi. He attended Raymond High School and was graduated in 1972.

In June 1972, he entered Hinds Junior College, Raymond, Mississippi for one year. He transferred to Mississippi State University as a sophomore in August 1973, and completed the Bachelor of Science degree in Animal Science in December 1976. After completing this degree, he accepted the position of Research Assistant with the Department of Agronomy, Mississippi Agricultural and Forestry Experiment Station with primary responsibilities in forage research. He completed the Master of Science degree in December 1978. In March 1979, he accepted the position of Research Assistant with the Department of Plant and Soil Science, The University of Tennessee, Institute of Agriculture, Knoxville. He pursued a Doctorate of Philosophy degree with a major in Plant and Soil Science (Crop Physiology and Ecology) and a minor in Animal Nutrition for which he is now a candidate.

The writer is a member of Gamma Sigma Delta, American Society of Agronomy, and Crop Science Society of America.

He married the former Linda Katherine Ross in August 1976.