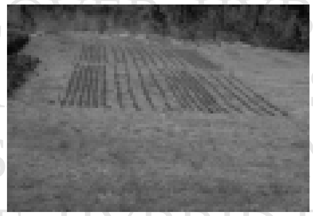

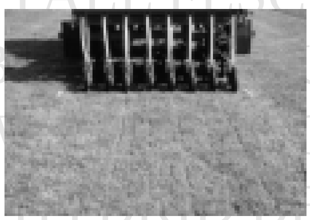

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Extending the Grazing Season:

Growing Annual or Perennial Grasses or Legumes in Mixture with Hybrid Bermudagrass

Cover Photos

From top to bottom:

1. Winter annual legumes in April, which had been sod-seeded into bermudagrass the previous fall.

2. Early spring growth of tall fescue that was seeded into bermudagrass the previous fall.

3. Bermudagrass (center of photo), a warm-season perennial, has gone dormant in November, while tall fescue (foreground), a cool-season grass, is actively growing.

4. Bermudagrass, in September, is ready for no-till seeding of winter annual grasses, legumes, or tall fescue.

5. Winter annual grasses and hairy vetch shown in early April, which had been sod-seeded in the fall into bermudagrass.

6. Cows grazing on bermudagrass in mid-summer.

Extending the Grazing Season: Growing Annual or Perennial Grasses or Legumes in Mixture with Hybrid Bermudagrass

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Contents

Abstract

Hybrid bermudagrass, widely grown in North Carolina, is used for summer grazing and for hay. Frequently, various legumes and grasses are no-till seeded into these bermudagrass sods to extend the grazing season or to provide growing plants to effectively absorb animal waste. The studies described below show the potential productive capacity of combinations of hybrid bermudagrass with different annual or perennial grasses or legumes.

Seeding crimson clover into a sod of hybrid bermudagrass fertilized with 120 pounds of nitrogen per acre resulted in increased annual yields of 4,230 pounds per acre of dry matter compared with bermudagrass alone. The seeding of red clover into bermudagrass resulted in a 4,450-pound increase. A crimson clover–bermudagrass mixture top-dressed with 120 pounds of nitrogen per acre (during the summer) produced an average annual yield of 10,160 pounds of dry matter.

Since crabgrass is equal to or better in quality than bermudagrass, the contribution of crabgrass to the total yield of mixtures is shown in the tables. Yield of the bermudagrass component when not fertilized with nitrogen was low on sandy clay loam soils following all winter annual legumes. Yields ranged from 680 to 2,880 pounds per acre of dry matter.

Combinations of winter rye, or annual ryegrass, with hybrid bermudagrass produced high yields ranging from 8,450 to 14,600 pounds dry matter per acre when receiving annual applications of 420 pounds per acre of nitrogen. The summer production of bermudagrass is reduced more following annual ryegrass than winter rye.

In the first two years of this four-year study, a mixture of ladino clover–tall fescue and hybrid bermudagrass, without nitrogen fertilization, produced as much or more forage as a tall fescue–bermudagrass mixture receiving 200 pounds of nitrogen per acre, in four equal applications of nitrogen (50-50-50-50). Yields of the ladino clover mixture were equal to three of the five 200-pound N treatments in the third year. By the fourth year, the stand and growth of ladino clover were greatly diminished.

In three of the four years a marked increase in yield (1,570 pounds per acre annually) was realized from growing tall fescue and bermudagrass in mixture compared with their performance in pure stand (assuming a 50% acreage of each), using 200 pounds of nitrogen applied in four equal applications.

This study showed there may be advantages to growing tall fescue and bermudagrass in mixture rather than in pure stands.

Study I. No-Till Planting of Legumes or Grasses Into Hybrid Bermudagrass Sods to Extend the Grazing Season

Since hybrid bermudagrass is completely dormant from the first frost in the fall until after corn-planting time in the spring, many farmers seed small grains like winter rye or legumes like crimson clover into the bermudagrass sods to extend the grazing season and to provide growing plants to effectively absorb nutrients applied in animal waste. There is a need to determine the feasibility of seeding different species using different methods of management and fertilization into dormant sods of bermudagrass. Limited information has been published concerning the yield potential of various cool-season species and their effect on the subsequent growth of the associated bermudagrass. Various investigators (references 1, 2, 3, 4, and 5) have described the adaptation, fertilization practices, and performance of different cultivars of winter annual grasses and legumes mostly when seeded on prepared seedbeds or following summer annual grasses.

The primary objective of these experiments was to evaluate the production potential of several different winter annual legumes, and perennial legumes and grasses no-till planted in the late summer or fall into a dormant sod of hybrid bermudagrass, and to determine their residual effect on the summer growth of the bermudagrass.

Legumes Sod-Seeded into Bermudagrass

Experimental Procedures

Six experiments were conducted, each in different years, in which legumes were planted in September into a bermudagrass sod. Experiments 1 and 2 were located at the Piedmont Research Station on a Davidson clay loam; Experiment 3 at the Randleigh Farm (lower Piedmont) on an Appling sandy clay loam; and Experiments 4, 5, and 6 at the Central Crops Research Station on a Cecil sandy clay loam. The soil pH was 6.3 to 6.4 at all sites, or sufficient dolomitic lime was applied 6 months before over-seeding to achieve this level.

The experimental areas were not fertilized with nitrogen after July 1 in the year of no-till planting. Phosphate and potash were applied each year at the time of no-till planting and again in March, according to soil test requirements for the species used. Some treatments received nitrogen variables as indicated in the tables.

The experimental variables consisted of comparisons of production between pure stands of hybrid bermudagrass, either Coastal or Tifton 44, and mixtures of bermudagrass receiving different amounts of nitrogen with various legumes (see tables for listing of treatments and legume cultivars used). The legumes were inoculated prior to planting with the proper strain of *rhizobia*. The various treatments were arranged in a randomized complete block design with four replicates.

The legumes were planted into bermudagrass sods that had been cut to a stubble height of 1 1/2 inches with a flail harvester and the vegetation removed just before planting between September 9 and 14. Plots were 5 by 20 feet with 10-foot alleys for Experiments 1, 2, and 3, and 7 by 20 feet with 20-foot alleys for Experiments 4, 5, and 6. To simulate sowing seeds with a no-till drill, a Ryan power rake was used in Experiments 1, 2, and 3 to make furrows 8 inches apart and about 1/2 inch deep, and a Planet Jr. push-type seeder was used for placing seeds into the "drill" furrow. Rates of planting are noted in the tables. A Tye Pasture Pleaser no-till planter with rows10 inches apart was used for Experiments 4, 5, and 6.

All treatments were cut back to 2 inches at each harvest. Dry matter yields were obtained by mowing a strip 24 inches by 20 feet (Experiments 1, 2, and 3) and 30 inches by 20 feet (Experiments 4, 5, and 6) from each plot and drying the entire sample at 135°F for 48 hours. Visual estimates of percentage yield contributed by each species and of weeds in the mixtures were made by two observers at each harvest. Yields were adjusted for weeds and are reported as weed-free. In Experiments 4, 5, and 6, yields include the crabgrass component since it has good nutritive value and, for the purpose of the grazing animal, it is not considered a weed. Other experiments had less than 10% crabgrass. In some experiments (Experiments 1, 4, 5, and 6), selected treatments, such as red and ladino clovers, were harvested in the second year (see tables). Crimson clover and hairy vetch were not permitted to reseed due to clipping management.

The harvest schedules for the various trials are as follows (all winter annuals were cut at the same date in the spring except in Experiment 3 as noted below):

- Experiment 1: (first year) May 5, June 3, July 11, August 14, and November 13; and (second year) May 5, May 26, July 10, August 7, and September 25.
- Experiment 2: May 2, June 13, July 20, August 21, and October 4.
- Experiment 3: February 23, April 3, April 26, May 18, June 13, July 11, and August 3. Vetch was cut the first four dates; crimson clover April 3 and May 9; arrowleaf clover April 26 and June 13; sub clover April 26 and June 13.
- Experiment 4: (first year) April 24, May 31, July 5, and August 22; and (second year) April 23, May 23, July 1, and August 20.
- Experiment 5: (first year) April 26, May 23, July 16, August 20, and November 26; and (second year) May 30, July 28, and September 26.
- Experiment 6: (first year) April 26, May 30, June 8, and September 26; and (second year) May 12, July 13, and October 9.

Results and Discussion—Year 1

Total Yields (Without Crabgrass)

The crimson clover and bermudagrass mixture fertilized with 120 pounds of N yielded as much or more than any other legume combination in five of the six experiments. The yields ranged from 6,790 (Experiment 6, Table 6) to 14,030 (Experiment 2, Table 3) pounds of dry matter per acre. These year-to-year differences were due primarily to variations in winter temperatures and summer rainfall. The average yield for five experiments of this combination was 10,160 pounds of dry matter per acre.

Other combinations that produced well were red clover–bermudagrass (RC+B) with no nitrogen and ladino clover–bermudagrass (LC+B) with no nitrogen. The RC+B mixture yields ranged from 3,900 (Experiment 6, Table 6) to 11,590 (Experiment 2, Table 3) pounds of dry matter per acre. Five of the six experimental combinations of red clover and bermudagrass yielded more than 6,020 pounds of dry matter per acre. The ladino–bermudagrass mixture yielded over 10,000 pounds in the two experiments in which it was included.

The hairy vetch–bermudagrass (HV+B) combination produced similar yields to crimson clover–bermudagrass (CC+B) in one experiment (Experiment 3, Table 5). In three experiments (4, 5, and 6, Table 6), the HV+B treatment yielded 71% as much as the CC+B.

Total Yields (With Crabgrass)

In three experiments (4, 5, and 6, Table 6) crab-grass was invasive and constituted a substantial portion of the total dry matter production. Since crabgrass is of high nutritive value and readily consumed by livestock, it is not considered a weed. Thus, its yields are reported. When evaluating forages such as these for relative value of different combinations for hay, for grazing, or for use for animal waste applications in conjunction with hay or grazing, the crabgrass component should be included and not considered as a "weed." In the bermudagrass–crimson clover mixture with 120 pounds of nitrogen, the crabgrass component yielded 660, 2,810 and 3,500 pounds per acre for Experiments 4, 5, and 6, respectively (Table 6). For the pure stand of bermudagrass top-dressed with 120 pounds of nitrogen, the crabgrass yielded 670, 1,410, and 1,700 pounds per acre, respectively. For each of the above treatments (mixture vs. pure stand) in Experiment 6, the crabgrass contributed more than 30% of the total yield.

Advantages in Total Dry Matter Yield from Adding Legumes

A comparison of the crimson clover–bermudagrass (CC+B) mixture with the pure stand of bermudagrass (B), both receiving 120 pounds of nitrogen per acre during the summer, showed an added advantage of 4,230 pounds of dry matter per acre for CC+B (Experiments 2, 4, 5, and 6; Tables 3 and 6). The total average annual yield was 9,460 pounds for the CC+B and 5,230 pounds for the B treatment. In the CC+B mixture crimson clover averaged 41% of the total mixture for the four experiments. Another advantage for the mixture was the extension of the grazing season into the cool months of the year (Tables 3 and 6). The red clover mixture (RC+B), with *no nitrogen* applied, produced 2,570 pounds more dry matter per acre than the pure stand of bermudagrass (B) receiving 120 pounds of nitrogen in the same experiments. The total average annual yield for the RC+B mixture was 7,800 pounds per acre and 5,230 pounds for the B treatment. In the RC+B mixture, red clover constituted 67% of the total mixture annual yield. In Experiment 1 (Table 1), the RC+B mixture received 120 pounds of nitrogen per acre, and the extra production was 4,450 pounds per acre, compared with B alone plus 120 pounds of nitrogen per acre.

Effects of Seeding Legumes and Summer Applications of Nitrogen on the Bermudagrass Component in the Mixture: Crimson Clover Effects

A comparison between a crimson clover–bermudagrass mixture (CC+B) and a pure stand of bermudagrass (B), both receiving 120 pounds of nitrogen in the summer, showed no differences in the production of bermudagrass (Experiments 2, 4, 5, and 6; Tables 3 and 6). The average annual yields of the bermudagrass were 5,580 and 5,230 pounds per acre for the CC+B and B treatments, respectively.

The CC+B with no nitrogen produced an annual yield of 2,810 pounds per acre of dry matter. These responses indicate low amounts of nitrogen residue from crimson clover when most of the foliage is removed.

Crimson Clover, Hairy Vetch, and Subterranean Clover Effects

Measurements of bermudagrass production following over-seeding of crimson clover, hairy vetch, and subterranean clover (Experiments 2, 4, 5, and 6; Tables 3 and 6), with no nitrogen added to the bermudagrass, showed no differences (except yield for bermudagrass was higher following hairy vetch than sub clover in Experiment 4) in summer production of bermudagrass following these legumes. The legumes varied widely in their production, yet the bermudagrass component produced relatively low yields following all winter annual legumes relative to its production with nitrogen applications. For example, in Experiments 4, 5, and 6 (Table 6), the bermudagrass (without N) following crimson clover yielded from 800 to 2,630 pounds of dry matter per acre; hairy vetch and subterranean clover yielded 680 to 2,880 and 860 to 1,990 pounds of dry matter per acre, respectively (Table 6). Again this indicates relatively low residual nitrogen rates from the stubble and roots of the legumes. Previous studies have suggested a residual nitrogen of about 62 pounds per acre from the above-ground portion of crimson clover that was permitted to reach late bloom. In these studies, the above-ground portion was harvested and removed from the plots, and the below-ground portion plus the stubble would be expected to contain from one-third to one-half as much nitrogen as the tops. Compared with the unfertilized bermudagrass borders in these trials, the bermudagrass was definitely greener in June following the winter annual legumes. However, the legumes that were growing rapidly in April and May competed for light and other growth factors with the bermudagrass, just when it was breaking dormancy.

Seasonal Growth Patterns and Adaptation

Crimson clover and hairy vetch both were making maximum growth in April and were in mid-bloom by April 25. Little growth was made by either species after May 7. Subterranean clover reached its peak of production 10 to 14 days later than crimson clover, and arrowleaf clover was about 3 weeks later than crimson. In these and other studies in North Carolina, arrowleaf clover usually shows low vigor and relatively poor adaptation; however, good results were obtained with Experiment 5 (Table 5). Crimson and hairy vetch are well adapted, but crimson has yielded more than hairy vetch in most situations on clay and sandy clay loams. On some sandy loam soils hairy vetch will be more productive than crimson clover. Subterranean clover volunteered successfully in three (data not presented for one successful volunteer stand) of the six experiments, but yields were low compared with crimson clover. Low yields obtained from subterranean are somewhat deceptive because considerable available growth is below the 2-inch height of the harvest equipment used. Subterranean clover has an advantage in that it will set seed and volunteer even though closely grazed, but it is not dependable as a volunteer reseeding legume. The perennial legumes, ladino and red clover, grew well with bermudagrass and made good growth not only in the cool part of the season but during the summer if moisture was adequate.

Results and Discussion—Year 2

In some experiments selected treatments were harvested in the second growing season to determine the effects of reseeding and persistence. No harvests were made in the second year of treatments with crimson clover, arrowleaf clover, or hairy vetch since they were cut before seedset in the first year. Although subterranean clover was harvested back to 2 inches, it was able to produce seed and volunteer in some years.

Ladino–bermudagrass mixtures in the second year without nitrogen produced 9,200 pounds of dry matter per acre compared with a yield of 9,870 pounds from bermudagrass fertilized with 120 pounds of nitrogen (Experiment 1, Table 1). Very similar results were obtained from Experiment 2 (data not in tables).

In the second year, the red clover–bermudagrass (RC+B) mixtures without nitrogen produced more than 6,500 pounds of dry matter per acre (Table 9); but in Experiment 1 (Table 1), when 120 pounds of nitrogen were added to (RC+B), yields averaged 11,790 pounds per acre (Experiment 1, Table 1). Red clover was the dominant species in the mixture in the second year for all experiments constituting more than 50% of the total yield.

Subterranean clover volunteered successfully in four of the six experiments. Data are shown in tables for only three experiments (Table 9). The yields of the sub clover were low and ranged from 730 to 2,950 pounds per acre (Table 9).

Summary and Conclusions

- The highest-yielding annual legume combination with bermudagrass fertilized with 120 pounds of nitrogen was the crimson clover mixture in four of the six experiments. Hairy vetch was equal or slightly superior to the crimson clover–bermudagrass mixture in two experiments.
- The crimson clover–bermudagrass mixture with 120 pounds of nitrogen applied to bermudagrass produced an average annual yield of 10,160 pounds of dry matter.
- Red clover and ladino clover produced well with bermudagrass. Red clover mixtures without nitrogen yielded an average of 7,800 pounds per acre, and those with nitrogen yielded 12,380 pounds per acre. Being short-lived perennials (two to three years), these legumes have some advantages.

- Volunteer crabgrass can become an important constituent of legume–bermudagrass mixtures or bermudagrass in pure stands. In three experiments the crabgrass component yielded from 670 to 3,500 pounds per acre in mixture with crimson clover–bermudagrass fertilized with 120 pounds of nitrogen per acre. Crabgrass represented 30% of the total yield in some trials.
- The seeding of crimson clover into a sod of bermudagrass fertilized with 120 pounds of nitrogen resulted in increased annual yields of 4,230 pounds of dry matter per acre when compared with bermudagrass alone. The addition of red clover to bermudagrass fertilized with nitrogen produced a 450-pound increase in dry matter yield and, without nitrogen, a 2,570-pound increase was realized.
- No differences were obtained in the production of bermudagrass without a legume or in its production in mixture with crimson clover when top-dressed with 120 pounds of nitrogen during the summer.
- No differences were found between the legume species in summer production of bermudagrass following the seeding of crimson clover (CC), hairy vetch (HV), or subterranean clover (SC), except the yield of bermudagrass was higher following HV than SC in Experiment 4.
- Yield of the bermudagrass component was low, ranging from 680 to 2,880 pounds per acre of dry matter, following all winter annual legumes tested when no nitrogen was applied, except on a Davidson clay loam. On a Davidson clay loam, the bermudagrass component yields ranged from 3,840 to 3,970 pounds per acre.
- In these and other experiments, arrowleaf clover is about 3 weeks later in maturing in the spring than crimson clover and is not as well adapted as crimson clover.
- Subterranean clover volunteered successfully in four of the six years. Production is relatively low, but it has some merit in that it can be grazed closely in the spring without affecting seed production.

These experiments show that legumes may be effectively used to extend the grazing periods of land established in bermudagrass by several months. The annual and perennial legumes can be grazed from November through May when bermudagrass is dormant with minimum detrimental effects on late spring growth of the grass. Also, some moderate nitrogen release is obtained from the legume which becomes available for grass growth.

Grass and Grass vs. Legume Experiments

Experimental Procedures

Two experiments (Experiments 7 and 8) were conducted, each in different locations and years, in which winter annual grasses or a winter annual legume was seeded in September into a Coastal bermudagrass sod. Experiment 7 was located at the Central Crops Research Station on a Wagram sandy loam, and Experiment 8 was located at the Randleigh Farm (lower piedmont) on an Appling sandy clay loam. The soil pH at both sites was 6.2 to 6.4, and no lime was added. Phosphate and potash were applied each year at the time of over-seeding and annually in March, according to soil test requirements for the species used.

Plot sizes and procedures for planting and harvesting were the same as for Experiments 1, 2, and 3. In this study, the experimental variables consisted of comparisons of production between pure stands of Coastal bermudagrass and mixtures of bermudagrass over-seeded with two winter ryes, two annual ryegrasses, and one winter annual legume, managed to simulate grazing by frequent clipping of the seeded species, or managed for hay (see Tables 10, 11, and 12 for exact variables and footnotes for further explanation including cultivars seeded and nitrogen rates used). In both experiments a split-block design was used with management (“grazing” vs. hay) being used in the whole plot and species and subplots with treatments in a randomized design with four replicates.

The harvest of the "grazing" management treatment in Experiment 7 occurred March 19, April 28, May 8, May 30, June 26, and July 25. No further harvests were made due to extreme drought. The winter rye for hay was not cut until April 15 and the annual ryegrass not until May 15. Harvest for the "grazing" management in Experiment 8 occurred February 23, March 12, April 5, April 30, May 15, June 8, July 1, August 3, and August 28. The winter rye for hay was not cut until April 9 and the annual ryegrass was not cut until May 9. The difference in harvest management between "grazing" and hay was simply an increased harvest frequency for the "grazing" management.

Results and Discussion—Total Yields

Hay Management

Under hay management, the N.C. Abruzzi rye–bermudagrass combination yielded more than annual ryegrass–bermudagrass (see tables for cultivars) in both experiments (Tables 10 and 12). The annual yields of the mixture ranged from 8,450 to 13,660 pounds of dry matter per acre for the commercial ryegrass to 10,030 to 14,600 pounds for the N.C. Abruzzi winter rye. Usually winter rye is more productive than annual ryegrass on sandy soils (see Table 10, hay management), whereas on clay loams or sandy clay loams the reverse is true (see Table 12, hay management). Mixtures of rye and ryegrass with bermudagrass produced yields equal to rye and bermudagrass. These results indicate that combinations of winter rye and annual ryegrass with bermudagrass can produce high tonnages of dry matter and, based on nutrient concentrations, they are capable of taking up large quantities of nutrients from animal-waste applications. Increased annual total yields obtained from N.C. Abruzzi rye–bermudagrass compared with commercial ryegrass–bermudagrass ranged from 940 (Experiment 8) to 1,580 pounds of dry matter (Experiment 7).

Simulated "Grazing" Management vs. Hay Management

A comparison of N.C. Abruzzi rye and commercial ryegrass under hay and "grazing" management (Experiments 7 and 8, Tables 10 and 12) show an average annual total yield of 11,690 for hay and 9,370 for "grazing," which represents an overall difference of 2,320 pounds of dry matter or approximately a 20% reduction in yield for the "simulated grazing" management. However, this system of "simulated grazing" management was lax and did not result in as intensive defoliation as a true grazing system, and only a 20% reduction from the hay management was noted. A more intensive system could easily have resulted in about a 35% reduction. The largest difference in the two systems was a 4,010-pound difference in favor of hay management of the hairy vetch–vitagraze rye–bermuda mixture (Experiment 7, Table 10). To obtain the highest dry matter yield of forages, infrequent defoliation is required for most species. A hay or silage harvest schedule usually results in higher yields of dry matter than grazing. Under "grazing" management, the total yields for all the over-seeded mixtures were the same, except the tetrone ryegrass mixture (Experiment 7), which produced about 12% less than the N.C. Abruzzi rye.

Advantages in Total Yield from Adding Grasses or a Legume

A comparison of the N.C. Abruzzi rye–bermudagrass mixture with a pure stand of bermudagrass, under hay management, showed an average annual added advantage of 4,100 pounds of dry matter (Avg Experiments 7, 8) and, for the commercial ryegrass–bermudagrass, the advantage was 2,840 pounds. Under a "grazing" management, less than 50% of the total hay yield advantage was realized, but the grazing season was extended for several months. Some additional grazing can be realized from November through April or May for most years.

Effect of Seeded Grass or Legume on the Bermudagrass Component in the Mixture

Rye vs. Ryegrass Effects—The summer production of the bermudagrass component was *reduced* under hay management by 1,480 (18.1%) and 4,090 (50.0%) pounds per acre by using the N.C. Abruzzi rye and the commercial ryegrass, respectively, as compared to bermudagrass grown alone (Avg Experiment 7 and 8). Under "grazing" management, the reduction in yields was 1,260 (15.6%) and 2,360 (29.2%), respectively, for the N.C. Abruzzi rye and commercial ryegrass mixtures. Over-seeded winter annual grasses managed for hay are much more competitive with spring bermudagrass growth than the same grasses managed for grazing. The tall-growing, over-seeded species shade the newly developing tillers of bermudagrass and delay their development.

Seasonal Growth Pattern—Ryegrass reaches its peak about three weeks later than rye and this peak is reached just as bermudagrass is breaking dormancy (Experiment 7, Table 11). Grazing will greatly reduce this problem since light can reach the newly developing tillers.

Hairy Vetch Effects—The yield of bermudagrass associated with a mixture of hairy vetch and Vitagraze rye was similar to the yield in association with only Vitagraze rye (Experiment 7, Table 10). The high levels of nitrogen (210 pounds per acre) applied in the summer probably masked any residual nitrogen effects from the hairy vetch.

Summary and Conclusions

- Mixtures of annual ryegrass or winter rye with bermudagrass produced high yields when managed for hay; the yields of N.C. Abruzzi rye–bermudagrass ranged from 10,030 to 14,600 pounds of dry matter per acre, and yields of commercial annual ryegrass–bermudagrass ranged from 8,450 pounds to 13,660 pounds of dry matter.
- Comparisons of the N.C. Abruzzi rye–bermudagrass mixture with a pure stand of bermudagrass under hay management showed an average annual added advantage of 4,100 pounds of dry matter and for the commercial ryegrass–bermudagrass an advantage of 2,840 pounds.
- These results indicate that combinations of winter rye or annual ryegrass with bermudagrass can serve as a receiver crop for nutrients from animal wastes since high yields would take up high amounts of nutrients.
- Simulated grazing management of the seeded species substantially reduced dry matter production of the mixture as compared with hay management. These reductions averaged 2,320 pounds per acre (20% reduction) (Avg N.C. Abruzzi and commercial ryegrass).
- Under hay management, the summer production of bermudagrass was reduced 50% when associated with annual ryegrass and 18.1% with winter rye.
- Under the "grazing" management, the reductions were 29.2% and 15.6%, respectively.
- Annual ryegrass reaches its peak growth about 3 weeks later than winter rye.
- Yields of winter annuals fluctuate widely from year to year due to temperature and moisture variations. For example, yields of commercial annual ryegrass under hay management ranged during the winters from 4,440 to 9,470 pounds of dry matter per acre.

References

1. Ball, D. M., C. S. Hoveland, and G. D. Lacefield. 1991. *Southern Forages*. Potash and Phosphate Institute, and the Foundation for Agronmic Research, Atlanta, GA.

2. Barnes, R. F, D. A. Miller, and C. J. Nelson. 1995. *Forages.* Vol. I, Fifth Edition, Iowa University Press, Ames, IA.

3. Chamblee, D. S. 1960. *Adaptation and performance of forage species*. Agricultural Experiment Station Bulletin 411.

4. Chamblee, D. S., and J.T. Green, Jr. (ed.). 1995. *Production and Utilization of Pastures and Forages in North Carolina.* North Carolina Agricultural Research Service Technical Bulletin 305.

5. Daniel, D. W., J. P. Mueller, and J. T. Green, Jr. *Forage Crops Variety Testing*. (Published annually by North Carolina Cooperative Extension Service).

6. Rannells, N. N., and M. G. Wagger. 1992. Nitrogen release from crimson clover in relation to plant growth stage and composition. *Agron. J.* 84:424–430.

Table 1. Influence of no-till seeding winter annual or perennial legumes or tall fescue into a bermudagrass sod on total dry matter production of the individual species (Piedmont Research Station, Experiment 1, years 1 and 2).

	YEAR 1					YEAR 2			
	Seeded species		Bermuda-		Legume production	Seeded species		Bermuda-	
Treatments[1]	Legume	Grass	grass (B)	Total	by June 3[2]	Legume	Grass	grass (B)	Total
	pounds per acre				%	pounds per acre			
1. Crimson + bermudagrass (B) 120 N	4,180	—	8,800	12,980	99	—	—	—	—
2. Sub clover + B 120 N	2,890	—	7,090	9,980	76	—	—	—	—
3. Arrowleaf + B 120 N	2,590	—	7,950	10,550	86	—	—	—	—
4. Red clover + B 120 N	9,650	—	3,560	13,210	51	6,130	—	5,660	11,790
5. Ladino + B No N	7,930	—	2,730	10,660	47	4,590	—	4,610	9,200
6. Ladino + Fescue + B No N	7,200	700	2,080	9,980	44	4,340	720	3,760	8,810
7. Bermuda alone 120 N	—	—	8,760	8,760	—	—	—	9,870	9,870
8. Bermuda alone 180 N	—	—	12,170	12,170	—	—	—	11,890	11,890
9. Bermuda + fescue 240 N	—	4,730	4,530	9,260	—	—	3,730	6,930	10,670
LSD[3] (0.05)	1,470	1,330	1,840	1,860	—	690	370	1,510	1,545

[1] Common crimson clover, Mt. Barker subterranean clover, Yuchi arrowleaf clover, Kenland red clover, Tillman ladino clover, and Ky 31 tall fescue were seeded at 25, 27, 14, 15, 5, 15 pounds per acre, respectively, into a sod of Tifton 44 bermudagrass (B) in September. All treatments top-dressed with 120 pounds of nitrogen per acre received 60 pounds about June 1 and again July 15. Treatment 8 received extra 60 pounds on August 15. Treatment 9 received four applications of 60 pounds on March 1, June 1, July 15, and September 1.

[2] For example, 51% of the total production (9,650) for red clover was produced before June 3.

[3] LSD = least significant difference.

Table 2. Influence of no-till seeding a winter annual (crimson clover) or perennial legumes (red and ladino white clovers) into a bermudagrass sod on the seasonal dry matter production of the individual species, Piedmont Research Station, Experiment 1 (Year 1).

	May 5			June 3			July 11			August 14			November 13			Season total		
Treatments[1]	SS	B	Total	SS	B	Total	SS	B	Total	SS	B	Total	SS	B	Total	SS	B	Total
	pounds per acre			pounds per acre			pounds per acre			pounds per acre			pounds per acre			pounds per acre		
1. Crimson + B	4,170	220	4,390	0	750	750	0	2,710	2,710	10	2,260	2,280	0	2,850	2,850	4,180	8,800	12,980
4. Red clover + B	3,000	330	3,330	1,950	490	2,440	1,300	1,300	2,600	660	790	1,450	2,730	650	3,380	9,650	3,560	13,210
5. Ladino + B	1,300	380	1,680	2,460	610	3,070	1,320	670	1,990	570	570	1,140	2,270	500	2,780	7,930	2,730	10,660
7. Bermuda (B)	—	200	200	—	920	920	—	2,630	2,630	—	2,400	2,400	—	2,610	2,610	—	8,760	8,760
LSD[2] (0.05)	680	100	560	230	220	290	220	440	440	250	730	660	680	800	750	1,480	1,840	1,870

[1] SS denotes seeded species, and B is Tifton 44 hybrid bermudagrass. Treatments 1, 4, and 7 received 120 pounds of nitrogen per acre with 60 pounds applied about June 1 and again July 15.

[2] LSD = least significant difference.

Table 3. Influence of no-till seeding winter annual or perennial legumes into a bermudagrass sod on seasonal and total dry matter production of the individual species, Piedmont Research Station, Experiment 2 (Year 1).

Treatments[1]	Seeded species	Bermuda	Total	Legume production by June 13[2]
	— pounds per acre —			%
1. Crimson + B 120 N	4,900	9,130	14,030	100
2. Crimson + B No N	3,970	5,710	9,680	100
3. Hairy vetch 120 N	2,590	9,970	12,560	100
4. Hairy vetch + B No N	3,840	6,620	10,460	100
5. Subclover + B 120 N	640	8,860	9,500	96
6. Red clover + B No N	7,860	3,720	11,590	44
7. Ladino+B No N	5,870	4,140	10,010	36
8. Bermuda alone 120 N	—	8,300	8,300	—
9. Bermuda alone[2] 180 N	—	8,000	8,000	—
LSD[3] (0.05)	1,010	1,210	1,610	

[1] Common crimson clover, common hairy vetch, Mt. Barker subterranean clover, Kenstar red clover, and Regal ladino clover were seeded at 20, 30, 20, 15, and 5 pounds per acre, respectively, into a sod of Tifton 44 bermudagrass (B). All plots receiving 120 pounds of nitrogen received 60 pounds about June 1 and again July 15. Treatment 9 received an extra 60 pounds on August 15.

[2] For example, 44% of the total production (7,860) for red clover was produced before June 13. Severe drought occurred after August 10 for several weeks.

[3] LSD = least significant difference.

Table 4. Influence of no-till seeding a winter annual (crimson clover) or perennial legumes (red and ladino white clovers) into a bermudagrass sod on the seasonal and total dry matter production of the individual species, Piedmont Research Station, Experiment 2 (Year 1).

Treatments[1]	May 2			June 13			July 20			August 21			October 4			Season total		
	SS	B	Total	SS	B	Total	SS	B	Total	SS	B	Total	SS	B	Total	SS	B	Total
	pounds per acre			pounds per acre			pounds per acre			pounds per acre			pounds per acre			pounds per acre		
1. Crimson + B 120 N	4,900	0	4,900	0	310	310	0	4,480	4,480	0	3,910	3,910	0	430	430	4,900	9,130	14,030
6. Red clover + B No N	1,420	20	1,440	2,020	1,510	3,530	2,840	1,010	3,850	1,190	860	2,050	400	320	720	7,870	3,720	11,590
7. Ladino + B No N	520	20	540	1,600	1,180	2,780	2,570	1,390	3,960	1,110	1,240	2,350	70	310	380	5,870	4,140	10,010
8. Bermuda (B) 120 N	0	10	10	0	460	460	0	4,210	4,210	0	3,260	3,260	0	360	360	0	8,300	8,300
LSD[2] (0.05)																1,010	1,210	1,610

[1] SS denotes seeded species and B is Tifton 44 hybrid bermudagrass. Treatments 1 and 8 received 120 pounds of nitrogen per acre with 60 pounds applied about June 1 and again July 15.

[2] LSD = least significant difference.

Table 5. Influence of no-till seeding a winter annual or perennial legumes into a bermudagrass sod on seasonal dry matter production of the individual species and the percentage of seeded legumes, bermuda and weeds for the June 13 harvest, Randleigh Farm (lower Piedmont), Experiment 3 (Year 1).

Treatments[1]	Dry matter yield			% Yield on June 13[2]		
	Seeded species	Bermuda	Total	Seeded legume	Bermuda	Weeds
	pounds per acre			%		
Crimson + B 220 N	2,960	10,040	13,000	0	90	10
Hairy vetch + B 220 N	4,180	10,070	14,250	2	92	6
Sub clover + B 220 N	2,020	8,100	10,120	54	35	11
Arrowleaf + B 220 N	3,350	7,940	11,290	75	21	4
Red clover + B 220 N	2,830	8,720	11,550	38	60	2
Bermuda alone 220 N	—	10,000	10,000	0	80	20
LSD[3] (0.05)	510	800	1,080			

[1] Dixie crimson clover, common hairy vetch, Mt. Barker subterranean clover, Yuchi arrowleaf, and Chesapeake red clover were seeded at 25, 25, 25, 12, and 15 pounds per acre, respectively, into a sod of Coastal bermudagrass (B). All treatments received 220 pounds of nitrogen per acre: 80 pounds June 1 and July 1 and 60 pounds August 1.

[2] The percentage of crimson clover and hairy vetch were very low on June 13 since both had reached maturity before this date. Weeds at this date were largely broadleaf.

[3] LSD = least significant difference.

Table 6. Influence of no-till seeding a winter annual or perennial legumes into a bermudagrass sod on total production in the first year for each individual species and for the mixture, Central Crops Research Station, Experiments 4, 5, and 6 (Year 1).

Treatments[1]	EXPERIMENT 4				EXPERIMENT 5				EXPERIMENT 6			
	Seeded species	B	Total	Total w/CG[2]	Seeded species	B	Total	Total w/CG[2]	Seeded species	B	Total	Total w/CG[2]
	— pounds per acre dry matter —				— pounds per acre dry matter —				— pounds per acre dry matter —			
1. Crimson + B 120 N	3,260	6,670	9,930	10,600	3,310	3,770	7,080	9,220	4,030	2,760	6,790	10,290
2. Crimson + B No N	3,560	2,630	6,190	6,500	2,800	800	3,600	3,890	3,930	2,120	6,040	7,370
3. Hairy vetch + B No N	1,900	2,880	4,780	5,180	1,920	680	2,600	2,950	2,170	1,690	3,860	5,490
4. Sub clover + B 120 N	1,000	4,970	5,970	6,680	1,910	3,210	5,120	6,770	340	3,680	4,020	6,560
5. Sub clover + B No N	890	1,990	2,880	3,140	3,110	860	3,970	4,330	370	1,870	2,240	3,770
6. Red clover + B No N	5,870	3,840	9,710	10,010	4,630	1,390	6,020	6,570	2,600	1,300	3,900	4,750
7. Bermuda alone 120 N	—	5,050	5,050	5,710	—	3,720	3,720	5,130	—	3,830	3,830	5,530
LSD[3] (0.05)	520	850	1,180	1,200	750	690	1,050	940	580	600	740	1,030

[1] Common crimson clover, common hairy vetch, Mt. Barker subterranean clover, and Kenstar red clover were seeded at 20, 30, 20, and 15 pounds per acre, respectively, into a sod of Coastal bermudagrass (B), Experiment 4, and into Tifton 44 bermudagrass, Experiments 5 and 6. All treatments receiving 120 pounds of nitrogen received 60 pounds about June 1 and another 60 pounds July 15.

[2] Total w/CG denotes total yields including crabgrass.

[3] LSD = least significant difference.

Table 7. Influence of seeding a winter annual (crimson clover) or perennial legume (red clover) into a bermudagrass sod on the seasonal and total dry matter production of the individual species, Central Crops Research Station, Experiment 4 (Year 1).

Treatments[1]	April 24			May 31			July 5			August 17			Season Total		
	SS	B	Total	SS	B	Total	SS	B	Total	SS	B	Total	SS	B	Total
	pounds per acre			pounds per acre			pounds per acre			pounds per acre			pounds per acre		
1. Crimson + B 120 N	3,200	170	3,370	60	360	420	0	2,610	2,610	0	3,530	3,530	3,260	6,670	9,930
6. Red clover + B No N	950	170	1,120	1,930	930	2,860	1,720	1,140	2,860	1,270	1,580	2,850	5,870	3,820	9,690
7. Bermuda (B) 120 N	—	70	70	—	360	360	—	1,950	1,950	—	2,670	2,670	—	5,050	5,050
LSD[2] (0.05)													520	850	1,180

[1] SS denotes seeded species and B denotes Coastal bermudagrass. Treatments 1 and 7 received 120 pounds of nitrogen per acre with 60 pounds applied about June 1 and again July 15.

[2] LSD = least significant difference.

Table 8. Influence of seeding a winter annual (crimson clover) or perennial legume (red clover) into a bermudagrass sod on seasonal and total dry matter production of the individual species, Central Crops Research Station, Experiment 5 (Year 1).

Treatments[1]	April 26			May 23			July 16[2]			August 20			November 26			Season total		
	SS	B	Total	SS	B	Total	SS	B	Total	SS	B	Total	SS	B	Total	SS	B	Total
	pounds per acre			pounds per acre			pounds per acre			pounds per acre			pounds per acre			pounds per acre		
1. Crimson + B 120 N	3,270	0	3,270	40	20	60	0	1,950	1,950	0	1,420	1,420	0	370	370	3,310	3,760	7,070
6. Red clover + B No N	400	0	0	1,410	100	1,510	1,120	270	1,390	560	850	1,410	1,530	170	1,700	4,630	1,390	6,020
7. Bermuda (B) 120 N	—	—	—	—	40	40	—	1,580	1,580	—	1,730	1,730	—	360	360	—	3,720	3,720

[1] SS denotes seeded species and B denotes Coastal bermudagrass. Treatments 1 and 7 received 120 pounds of nitrogen per acre with 60 pounds applied about June 1 and again July 15.

[2] Red clover was cut July 2 in treatment 6.

Table 9. Influence of seeding a winter annual (sub clover) or perennial legume (red clover) into a bermudagrass sod on total production of the individual species in the second year, Central Crops Research Station, Experiments 4, 5, and 6 (Year 2).

	EXPERIMENT 4				EXPERIMENT 5				EXPERIMENT 6[1]			
Treatments[2]	Seeded species	B	Total	Total w/CG[3]	Seeded species	B	Total	Total w/CG[3]	Seeded species	B	Total	Total w/CG[3]
	pounds per acre of dry matter				pounds per acre of dry matter				pounds per acre of dry matter			
4. Sub clover + B (120 N)	760	—	—	—					2,710	2,320	5,030	7,430
5. Sub clover + B (No N)	730	—	—	—	1,090	—	—		2,950	1,220	4,170	5,980
6. Red clover + B (No N)	5,670	1,230	6,900	7,420	5,680	840	6,520	7,380	4,090	850	4,940	6,600
7. Bermuda alone (120 N)	—	3,570	3,570	6,010							NS	NS

[1] On April 23, Experiment 6 percentage ground cover of sub clover ranged from 30% to 70% with an average cover of 54%. It was harvested May 23.

[2] Crimson clover and hairy vetch were not managed in a manner that would permit volunteer reseeding—or blanks denote no harvest or measurement made.

[3] Total w/CG denotes total yields including crabgrass.

Table 10. Influence of seeding winter annual grasses (rye or ryegrass) or a winter annual legume (hairy vetch) into a bermudagrass sod (B) on seasonal and total dry matter production of the individual species, Central Crops Research Station, Experiment 7.

Treatments[3]	Grazing management[1]					Hay management[2]			
	Seeded species				% of seeded species	Seeded species			
	Legume	Grass	B	Total	yield by May 8	Legume	Grass	B	Total
	pounds per acre					pounds per acre			
1. N.C. Abruzzi rye + B		2,240	5,390	7,630	100		5,050	4,980	10,030
2. Vitagraze rye + B		2,390	5,230	7,620	100		5,510	4,820	10,330
3. Tetrone ryegrass + B		2,480	4,260	6,740	59		3,750	4,150	7,900
4. Common ryegrass + B		2,960	4,350	7,310	71		4,440	4,010	8,450
5. N.C. Abruzzi rye + tetrone + B		2,560	4,980	7,540	90		5,600	4,580	10,180
6. Hairy vetch + B	1,380	—	5,830	7,210	78	2,220	—	5,840	8,060
7. Hairy vetch + vitagraze + B	350	2,360	4,890	7,600	95	770	5,950	4,900	11,620
8. Bermudagrass alone	—	—	6,690	6,690	—	—	—	6,890	6,890
LSD[4] (0.05)		360	780	820		930	910	710	1,100

[1] See Table 11 for grazing management harvest schedule.

[2] Hay management was similar to Experiment 8, Table 12.

[3] N.C. Abruzzi rye, Vitagraze rye, tetrone ryegrass, commercial ryegrass, and common hairy vetch were seeded, respectively, at 120, 120, 25, 25, and 30 pounds per acre into a sod of Coastal bermudagrass in September. Nitrogen was applied to all plots at 330 pounds per acre (except bermudagrass alone), split with 40 pounds at time of seeding, 30 pounds on November 1, 50 on February 1 and April 1, and 80 on June 1 and July 1. Bermudagrass alone received total of 210 pounds split 50pounds in April 1 and 80 pounds in June 1 and July 1.

[4] LSD = least significant difference.

Table 11. Influence of seeding a winter rye or ryegrass into a bermudagrass sod on seasonal and total dry-matter production of the individual species for the "grazing" management, Central Crops Research Station, Experiment 7.

Treatments[2]	March 19			April 25			May 8			May 30			June 26			July 25			Season Total		
	SS	B	Total	SS	B	Total	SS	B	Total	SS	B	Total	SS	B	Total	SS	B	Total	SS	B	Total
	pounds per acre																				
1. Abruzzi rye + B	180	0	180	1,820	0	1,820	240	0	240	0	0	0	0	1,350	1,350	0	4,030	4,030	2,240	5,380	7,620
3. Tetrone ryegrass + B	0	0	0	790	0	90	680	0	680	600	40	640	410	1,060	1,470	0	3,160	3,160	2,480	4,260	6,740
8. Bermudagrass alone	—	0	0	—	0	0	—	0	0	—	560	560	—	2,710	2,710	—	3,420	3,420	—	6,690	6,690
LSD[3] (0.05)																				780	820

[1] SS denotes seeded species, and B denotes bermudagrass.

[2] See Table 10 footnotes for nitrogen applications.

[3] LSD = least significant difference.

Table 12. Influence of seeding winter annual grasses into a bermudagrass sod on total dry matter production of the individual species and on the individual species' contribution to yield on June 5, Randleigh Farm (lower Piedmont), Experiment 8.

Treatments[1]	Dry Matter Yield			% of Yield on June 5		
	Seeded Grass	Bermuda	Total	Seeded Grass	Bermuda	Weeds
	pounds per acre			%		
Hay Management[2]						
N.C. Abruzzi rye + B	6,170	8,430	14,600	15	80	5
Aubade ryegrass + B	9,080	3,270	12,350	88	12	0
Common ryegrass + B	9,470	4,190	13,660	87	12	1
N.C. Abruzzi + Aubade + B	8,320	6,270	14,850	62	37	1
Bermudagrass alone	60	9,480	9,540	0	82	18
Grazing Management[3]						
Abruzzi rye + B	3,350	8,250	11,600	1	89	10
Aubade ryegrass + B	4,110	7,310	11,420	49	51	0
Common ryegrass + B	3,860	7,090	10,950	50	50	0
Abruzzi + Aubade + B	4,380	7,460	11,840	48	51	1
Bermudagrass alone	40	9,470	9,510	0	78	22
LSD[4] (0.05):						
Subplots within main plots	660	820	930			
Subplots different main plots	700	1,470	1,720			

[1] Winter annual grasses were seeded into an established stand of Coastal bermudagrass (B). Rates were the same as Experiment 7, Table 10.

[2] Hay management: Winter annual grasses were cut once in full head (early dough) April 9 for rye and May 9 for rye and ryegrass mixtures.

[3] Grazing management: Winter annual grasses were cut five times between February 23 and May 15. Bermudagrass, both alone and in mixture, was cut on hay schedule for both treatments (hay and grazing). A total of 420 pounds of nitrogen were applied per acre to all treatments (except bermudagrass alone) in seven split applications from time of seeding until August. Sixty pounds were applied at seeding, 40 November 1, 50 February and April 1, 80 June 1 and July 1, and 60 August 1. Bermudagrass alone received the April, June, July, and August applications, totaling 270 pounds per acre.

[4] LSD = least significant difference.

Study II. Growing Tall Fescue and Hybrid Bermudagrass Together in a Mixture Compared with Pure Stands of Each and in Mixture with Ladino Clover

Traditionally, most plantings of tall fescue and hybrid bermudagrass are made in separate fields. Tall fescue plantings on well-drained soils in the coastal plain and piedmont of North Carolina usually go through successional changes that result in mixtures of tall fescue (cool-season perennial grass) and common bermudagrass (warm-season perennial grass). More knowledge is needed concerning the timing and amounts of nitrogen for these types of pastures to maintain maximum yields and distribution of forage growth at high seasonal yields. Primary objectives of this experiment were to determine the feasibility of growing tall fescue and hybrid bermudagrass in a mixture compared with pure stands and to evaluate the influence of several nitrogen fertilization schedules and clover overseeding on the botanical composition and productivity of the mixture.

Experimental Procedures

An experiment was conducted over a four-year period near Raleigh, North Carolina, at the Reedy Creek Road Field Laboratory on a Cecil clay loam. The soil pH was 6.4 when tall fescue and ladino clover were seeded, and no additional limestone was added. Each year in February, 600 pounds of an 0-10-20 fertilizer was applied. Nitrogen was applied as ammonium nitrate at 50 pounds per acre in September to all treatments (except pure stands of bermudagrass) in the year that tall fescue was planted.

The experimental variables consisted of a group of independent comparisons designed to evaluate and compare (a) monocultures of Forager tall fescue and Tifton 44 bermudagrass with the mixture of the two, (b) the rate and timing of nitrogen application on botanical composition and yield of the tall fescue–bermudagrass mixture, (c) the influence of tall fescue row spacing (10- and 20-inch rows) in mixture with bermudagrass on botanical composition and yield, and (d) a three-component mixture of hybrid bermudagrass, tall fescue, and Regal ladino clover with nitrogen-fertilized monocultures and the tall fescue–bermudagrass mixture (see Table 13 for listing of all comparisons). The 14 treatments were arranged in a randomized, complete block design with four replicates. Tall fescue was planted at 14 pounds per acre in 10-inch rows in all treatments except one. In that case, tall fescue was seeded in 20-inch rows at 7 pounds per acre. All seedings were made September 4 into a well-established sod (three years old) of hybrid bermudagrass, previously defoliated to 2 inches. In the ladino clover mixture the clover was seeded at 5 pounds per acre at the same date. A Tye Pasture Pleaser no-till planter was used for seeding tall fescue and ladino clover by making eight rows per plot spaced 10 inches apart. Plots were 7 by 20 feet with a 6-foot alley between replicates. The drill was adjusted to make a furrow about 3/4 inch deep which resulted in the seed being covered with about 1/2 inch of soil. The bermudagrass sod was not fertilized with nitrogen after July 1 in the year that tall fescue was seeded to prevent excessive competition.

All treatments were cut from 5 to 8 inches back to 2 inches throughout the growing season. Dry matter yields were obtained by mowing a strip 2 1/2 by 20 feet from each plot and drying the entire sample at 135°F for 48 hours. Visual estimates of percentage yield contribution by each species and of the weeds in the mixtures were made by two observers at each harvest. Yields were adjusted for weeds and reported as weed-free.

Results and Discussion

The data were analyzed and are presented by year because of several significant year by treatment interactions. A mixture of ladino clover, tall fescue, and bermudagrass (treatment 11, Table 1), without nitrogen fertilization, produced as much or more dry herbage as any of the tall fescue–bermudagrass mixtures (treatments 1 through 5) receiving 200 pounds of nitrogen per acre in the first two years. Yields of this mixture without nitrogen were also equal to three of the five nitrogen treatments in the third year. But by the fourth year, the stand and yield of the ladino clover were greatly diminished as ladino clover usually persists as a perennial about three years on adapted soils in North Carolina (reference 1). In the fourth year the ladino clover–grass mixtures produced only 2,550 pounds per acre compared with 8,760 from a mixture of tall fescue–bermudagrass receiving 200 pounds of nitrogen (treatment 4, Table 1). It should be noted that in the first three years of this study, the ladino–tall fescue mixture produced an average yield of almost four tons (7,990 pounds) per acre of dry matter.

During the four years of this trial, tall fescue was usually the dominant species present until late in the fourth season. For example, in treatment 3 (Table 13), tall fescue constituted 58%, 58%, 76%, and 74% of the harvested yield in 1988, 1989, 1990, and 1991, respectively, with the balance being hybrid bermudagrass. Near the end of the fourth growing season (August 15, Table 13), bermudagrass constituted from 45% to 61% of the harvested yield in the tall fescue–bermudagrass mixture treatments.

Both the pure stands of tall fescue (treatment 14) and hybrid bermudagrass (treatment 13), and several other treatments (references 1, 2, 3, 4, and 5) in the study, received 200 pounds of nitrogen per acre. A comparison between a mixture of fescue and bermudagrass receiving 200 pounds of nitrogen in two split applications (treatment 4) will be made with each species grown in pure stands. In this comparison, assume that 1/2 acre of tall fescue and 1/2 acre of hybrid bermudagrass were grown in separate pastures and compared with the production from 1 acre of a mixture of the same two grasses (treatment 4). In three of the four years, a marked increase in yield (1,570 pounds per acre) was realized from growing these plants in mixture rather than pure stand. The increases averaged 1,380, 1,130, and 2,210 pounds per acre for 1988, 1989, and 1991, respectively.

In addition to the increase obtained in weed-free forage, there were fewer weeds, particularly winter and summer annual weeds, present in the mixtures. Pure stands of bermudagrass were more prone to invasion of annual weeds than tall fescue. Studies in Tennessee (reference 2) show that the combination of the two species Kentucky 31 tall fescue and Midland bermudagrass, compared with bermudagrass alone, increased dry matter production by 1,704 pounds per acre and extended the grazing season from 5 to 9 or 10 months. Tall fescue production alone was not determined in these studies. Excellent stands of tall fescue were maintained in the Tennessee studies when 170 pounds of nitrogen per acre were applied annually in four equal amounts. When applications of 340 or 510 pounds of nitrogen were made per acre, tall fescue stands were reduced in half. Other workers (reference 3) evaluated a mixture of tall fescue and Coastal bermudagrass as affected by nitrogen fertilization and height of clip and concluded that N fertilization at high levels (higher than 225 pounds per acre) decreased the tall fescue content relative to bermudagrass and that higher clipping (4 vs. 2 inches) increased the tall fescue content of the mixture.

No obvious stand loss or direct damage to tall fescue grown in mixture with bermudagrass was noted in this study from the nitrogen applications made during the summer months. Treatments 1, 2, and 3 each received 200 pounds of nitrogen split four times, giving 50 pounds per acre each applied at varying dates (Table 13). Delaying application one month from June 1 to July 1 (treatment 2 vs. 1) or from April 15 to May 15 (treatment 1 vs. 3) resulted in small differences in total yields (Table 13) only in one year. Yields of individual species were not consistently affected by a delay of one of the 50-pound increments from June 1 to July 1. A delay from April 15 to May 15 (treatment 1 vs. 3) in application of one of the 50-pound increments resulted in an increase in the bermudagrass component in two of the four years and no change in two years; however, tall fescue yields were deceased in one of the four years by the delay. A 1-month forward shift in two different months (treatment 2 vs. 3) resulted in a substantial shift in the production of the bermudagrass component (Table 14), and the addition of an extra 50 pounds of nitrogen in July (treatment 7) resulted in a 910-pound increase in the bermudagrass portion (treatment 3 vs. 7; see Table 14).

A comparison of treatments 2 and 4 (Table 13) shows advantages or disadvantages of applying 200 pounds of nitrogen per acre to a mixture of tall fescue–bermudagrass split into either two (treatment 4) or four (treatment 2) applications. In two (1988, 1991; Table 13) of the four years, total yield advantages were realized from the two-way split compared with four. No differences were obtained in two years. The average increased yield for the two-way split for those two years was 1,420 pounds per acre. In one year (1988), this increase was largely due to an increase in the tall fescue component and in another year (1991) to the bermudagrass component.

The addition of an extra 50-pound increment of nitrogen above 200 pounds per acre (four-way split) resulted in increased yields of the total tall fescue–bermudagrass mixture. Adding the extra 50 pounds in May (treatment 3 vs. 6) produced an average annual increase of 878 pounds per acre, and the addition in July (treatment 3 vs. 7) resulted in a 1,070 increase. These increases were largely the result of improved yields from the bermudagrass component.

The application of only 100 pounds of nitrogen per acre in two splits, February 15 and August 15 (treatment 9), resulted in much lower yields than 200 pounds applied in four splits—February 15, May 15, July 1, and August 15 (treatment 3)—the annual yields for four years being 7,500 and 4,310, respectively, for treatments 3 and 7 (Table 13).

Planting tall fescue into bermudagrass in 20-inch-spaced rows rather than 10 inches (treatment 3 vs. 12, Table 13) resulted in lower total mixture yields averaging 950 pounds per acre in two of the four years, while no differences were obtained in the other two years. In each year the tall fescue component yield was decreased by wide spacing, whereas the bermudagrass was increased in three of the four years (Table 13).

Summary and Conclusions

- A mixture of ladino clover, tall fescue, and hybrid bermudagrass without nitrogen fertilization produced as much, or more, forage as a tall fescue–bermudagrass mixture receiving 200 pounds of nitrogen per acre in split applications (4) in the first two years of this four-year study. Yields of the ladino clover mixture were equal to three of the five 200-pound treatments in the third year. By the fourth year the stand and growth of ladino clover was greatly diminished.
- Tall fescue was the dominant species in the tall fescue–bermudagrass mixture top-dressed with nitrogen until the end of the fourth year when bermudagrass showed dominance in some treatments.
- There were more weeds present in the pure stands, particularly winter annuals in the bermudagrass, than in the mixtures of tall fescue–bermudagrass.
- The seasonal productivity of the individual species (tall fescue and bermudagrass) was affected by timing and amounts of nitrogen fertilization. For example, delaying from April 15 to May 15 and from June 1 to July 1

the application of a 50-pound increment of nitrogen resulted in an increase of 920 pounds per acre in summer production of bermudagrass.

- Although some advantages of shifts in seasonal production of individual species were realized by using four equal applications (50-50-50-50) to apply 200 pounds of nitrogen for the season, a two-way split (100-100) produced higher total yields in two of the four years and similar yields in the other two years.
- Application of 250 pounds of nitrogen per acre in four applications (100 pounds plus three applications of 50 pounds) compared with 200 pounds per acre (four applications of 50 pounds) produced average annual increases ranging from 880 pounds per acre (extra 50 pounds in May) to 1,070 (extra 50 pounds in July).
- Planting tall fescue into bermudagrass in 20-inch, rather than 10-inch, spaced rows resulted in lower total mixture yields in two of the four years, due mainly to a decrease in the tall fescue component.
- Assuming equal acreage of pure stands of tall fescue and bermudagrass compared to the two in mixture, a marked increase in yield (1,570 pounds per acre, annually) was realized in three of the four years from the mixture compared with their yield in pure stand when fertilizing with 200 pounds of nitrogen per acre applied in four equal applications. Thus, some advantage may be realized from growing tall fescue and bermudagrass in mixture rather than in pure stands.

References

1. Chamblee, D. S., J. T. Green and J. C. Burns. 1995. Principal forages of North Carolina. pp. 25–47. *In:* D. S. Chamblee and J. T. Green (eds.). *Production and utilization of pastures and forages in North Carolina.* North Carolina Technical Bulletin 305, Raleigh: NC: North Carolina State University.

2. Fribourg, H. A. and J. R. Overton. 1979. Persistance and productivity of tall fescue in bermudagrass sods subjected to different clipping measurements. *Agron. J.* 71:620–624.

3. Wilkinson, S. R., L. F. Welch, G. A. Hillsman and W. A. Jackson. 1968. Compatibility of tall fescue and Coastal bermudagrass as affected by nitrogen fertilization and height of clip. *Agron. J* 60:359–362.

Table 13. Dry matter yields of tall fescue and hybrid bermuda grown in mixture with different nitrogen fertilization schemes compared with pure stands of each and in a mixture with ladino clover.[1]

Treatment, application dates	1988			1989			1990			1991			Botanical composition (8/15/91)		
	Fes.	Ber.	Total	Fes.	Ber.	Total	Fes.	Ber.	Total	Fes.	Ber.	Total	Fes.	Ber.	Lad.
	pounds per acre			pounds per acre			pounds per acre			pounds per acre			%		
							Fescue/bermuda (10” rows)								
1. 15 15 1 15 Feb. Apr. Jul. Aug. 50 50 50 50	4,910	3,370	8,280	5,400	2,950	8,350	5,250	1,400	6,650	6,020	1,070	7,090	53	47	
2. 15 15 1 15 Feb. Apr. Jun. Aug. 50 50 50 50	4,800	3,180	7,980	5,360	2,430	7,790	5,060	940	6,000	5,890	1,450	7,340	55	45	
3. 15 15 1 15 Feb. May Jul. Aug. 50 50 50 50	4,680	3,440	8,120	4,680	3,410	8,090	4,820	1,520	6,340	5,470	1,960	7,430	49	51	
4. 15 — 1 — Feb. — Jun. — 100 — 100 —	6,020	3,370	9,390	4,860	3,310	8,170	4,350	1,450	5,800	5,820	2,940	8,760	45	55	
5.[2] — — 1 15 — — Jun. Aug. — — 100 100	5,630	4,290	9,920	3,470	3,600	7,070	3,430	1,710	5,140	3,740	2,740	6,480	41	59	
6. 15 15 1 15 Feb. May Jul. Aug. 50 100 50 50	4,950	4,170	9,120	5,260	3,850	9,110	5,080	1,490	6,570	5,470	3,230	8,700	42	58	
7. 15 15 1 15 Feb. May Jul. Aug. 50 50 100 50	5,190	4,602	9,790	4,930	4,640	9,570	4,770	2,180	6,950	5,400	2,580	7,980	39	61	
8. 15 15 1 15 Feb. May Jul. Aug. 100 50 50 50	6,370	3,860	10,230	5,330	3,320	8,650	6,120	1,310	7,430	5,900	1,960	7,860	47	53	

Table 13 (continued)

Treatment	1988			1989			1990			1991			Botanical composition (8/15/91)		
	Fes.	Ber.	Total	Fes.	Ber.	Total	Fes.	Ber.	Total	Fes.	Ber.	Total	Fes.	Ber.	Lad.
	pounds per acre			pounds per acre			pounds per acre			pounds per acre			%		
9. 15 — — 15 Feb. May Jul. Aug. 50 — — 50	3,170	1,830	5,000	2,770	1,200	3,970	2,750	560	3,310	4,140	820	4,960	47	53	
10.[2] — 15 1 — — May Jul. — — 50 50 —	4,220	2,840	7,060	2,980	3,160	6,140	2,530	1,420	3,950	2,340	1,450	3,790	44	56	
Fescue/bermuda/clover (10” rows)															
11. Fes. Lad. Clov. (No nitrogen) (Ladino-yield)	430 L = (6,800)	2,150	9,380	2,060 L = (5,350)	1,590	9,000	1,830 L = (2,940)	820	5,590	1,400 L = (590)	560	2,550	34	40	26
Fescue/bermuda (20” rows)															
12. 15 15 1 15 Feb. May Jul. Aug. 50 50 50 50	2,170	5,010	7,180	3,910	4,380	8,290	3,160	2,240	5,400	4,600	2,280	6,880	42	58	
Bermuda alone															
13. — 15 1 — — Apr. Jul. — — 100 100 —	0	6,980	6,980	0	7,820	7,820	0	5,950	5,950	0	5,520	5,520	0	100	
Fescue alone															
14. 15 — — 15 Feb. — — Aug. 100 — — 100	9,050	0	9,050	6,260	0	6,260	6,800	0	6,800	7,590	0	7,590	100	0	
Assume 1/2 acreage of ber./1/2 fes.:			8,010			7,040			6,380			6,555			
LSD[3] 0.05	450	460	641	550	450	740	550	190	610	550	360	690			

[1] Cutting arrangement: All treatments cut from 5 to 8 inches back to 2 inches throughout the growing season. All treatments except 13 and 14 were mixtures of tall fescue and hybrid bermudagrass.

[2] Applied 50 pounds of nitrogen February 15 first year *only* to treatments 5 and 10 to ensure good initial stands.

[3] LSD = least significant difference.

Table 14. Seasonal dry matter yields of hybrid bermudagrass and tall fescue grown in mixture with varying times of application and amounts of nitrogen.[1]

Treatments[2], application dates					Up to May 26		May 27 through Aug. 26		After Aug. 26		Seasonal yields		
					Fes.	Ber.	Fes.	Ber.	Fes.	Ber.	Fes.	Ber.	Total
					pounds per acre								
2.	15 Feb. 50	15 Apr. 50	1 Jun. 50	15 Aug. 50	3,360	320	1,360	1,220	560	450	5,280	1,990	7,270
3.	15 Feb. 50	15 May 50	1 Jul. 50	15 Aug. 50	2,780	350	1,500	1,720	640	520	4,920	2,590	7,510
7.	15 Feb. 50	15 May 50	1 Jul. 100	15 Aug. 50	2,600	380	1,790	2,600	680	520	5,070	3,500	8,570

[1] Yields are average of four years and dates are approximate.

[2] Nitrogen was applied annually at rates shown. For example, treatment 2 received an annual total of 200 pounds of nitrogen per acre split into four equal applications at dates noted.

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