CHAPTER IV

# Livestock performance, quality, and productivity of alfalfa-tall fescue mixed stands as compared to N-fertilized tall fescue

**ABSTRACT**

Livestock grazing grass-legume mixtures including stockpiled alfalfa-tall fescue have shown higher performance as compared to livestock on pure grass stands. This experiment was conducted to compare quality, productivity, and livestock performance of alfalfa-endophyte-free tall fescue mixtures to N-fertilized endophyte-free tall fescue. Forty-eight Angus or Angus crossbred steers were rotationally stocked on a four-replicate alfalfa-tall fescue and N-fertilized tall fescue experiment during the late spring, summer, and early autumn of 2002 and 2003. Steers were weighed every 25-32 days. Forage mass measurements were taken from selected alfalfa-tall fescue and pure tall fescue paddocks within each replication before and after each grazing cycle. Quality samples were collected from all paddocks before each grazing cycle. Seasonal forage mass of N-fertilized tall fescue was higher than alfalfa-tall fescue in 2002 at 4497 kg $ha^{-1}$, but similar between these two forage types in 2003. Alfalfa-tall fescue mixtures showed higher crude protein and lower NDF than pure tall fescue in 2002 and 2003, and lower ADF in 2003. Steers grazing N-fertilized tall fescue had higher average daily gains (ADG) from 8 July to 5 August in 2002. In 2003, steers grazing alfalfa-tall fescue had higher ADG from 30 May to 27 June, 27 June to 23 July, and for the season-long average. This experiment showed that both alfalfa-tall fescue and N-fertilized endophyte-free tall fescue can produce productive pastures and high ADG in beef steers in Virginia, but alfalfa-tall fescue has higher quality than N-fertilized tall fescue.

# INTRODUCTION

Alfalfa is the most widely planted forage crop within the United States with 9.7 million hectares in hay production (Natl. Agric. Stat. Serv., 2001). It has high yield potential, high levels of protein, high quality, and broad adaptation (Lacefield et al., 1987). Tall fescue is a cool-season perennial grass and is grown on over 405,000 hectares in Virginia and 14.2 million hectares across the United States (Ball et al., 2003). This grass is used in many areas throughout the United States due to its broad adaptation over a range of environmental and climatic extremes. Tall fescue is often grown alone and fertilized with N because of its spring and early summer production and ability to maintain quality and palatability when stockpiled for winter grazing (Ball et al., 2002).

Alfalfa is commonly grown in mixtures with perennial grasses for pastures. The best mixtures are those that contain a persistent alfalfa cultivar with an adapted grass species that has beneficial characteristics to contribute to the mixture. Alfalfa grown with tall fescue would appear to be an ideal mixture for Virginia and the eastern United States. Alfalfa is a high quality, nutritious legume and tall fescue is a well adapted, persistent grass. Alfalfa-tall fescue mixtures have the same advantages as other legume-grass mixtures such as reduced soil erosion, increased water conservation, greater weed control, and longer term stands than legumes alone (Smith et al., 1992). Alfalfa-tall fescue mixtures have been shown to have longer growing seasons and higher yields than alfalfa or tall fescue grown alone (Hoveland et al., 1995; Smith et al., 1992). Alfalfa usually has higher production during the warmer summer months than tall fescue (Hoveland et al., 1995). The advantage of alfalfa regrowth in the warmer months and increased growth in late autumn and spring of tall fescue creates a longer growing season when the two are mixed. Hoveland et al. (1986) reported that alfalfa-tall fescue mixtures produced higher yields than tall fescue fertilized with up to 269 kg N $ha^{-1}$.

Forage quality and livestock performance is usually higher on legume-tall fescue mixtures, including alfalfa-tall fescue, as compared to pure tall fescue (Allen et al., 1992). Most tall fescue plants are infected with the endophytic fungus *Neotyphodium coenophialum* which produces ergot alkaloids that are toxic to livestock and can cause fescue toxicosis, fescue foot, and fat necrosis (Ball et al., 2002). Interseeding legumes into endophyte-infected tall fescue can alleviate some of the negative effects of the endophyte by diluting ergot alkaloids and increasing animal production (Hoveland, 2003). Petritz et al. (1980) documented that cow weight gain, calf weight gain, and cow conception rate were higher on pastures of endophyte-infected tall fescue with ladino or red clover compared to pure endophyte-infected tall fescue pastures in Indiana. Burns et al. (1973) found that cows grazing endophyte-infected tall fescue with ladino clover had consistently higher gains than those grazing pure endophyte-infected tall fescue. They also reported higher calf gains of cows and calves grazing tall fescue-ladino clover, as compared to tall fescue alone. Allen et al. (1992) obtained higher average daily gains (ADG) for stockers grazing stockpiled alfalfa-endophyte-infected tall fescue mixtures, compared to those stockers grazing N-fertilized stockpiled endophyte-infected tall fescue.

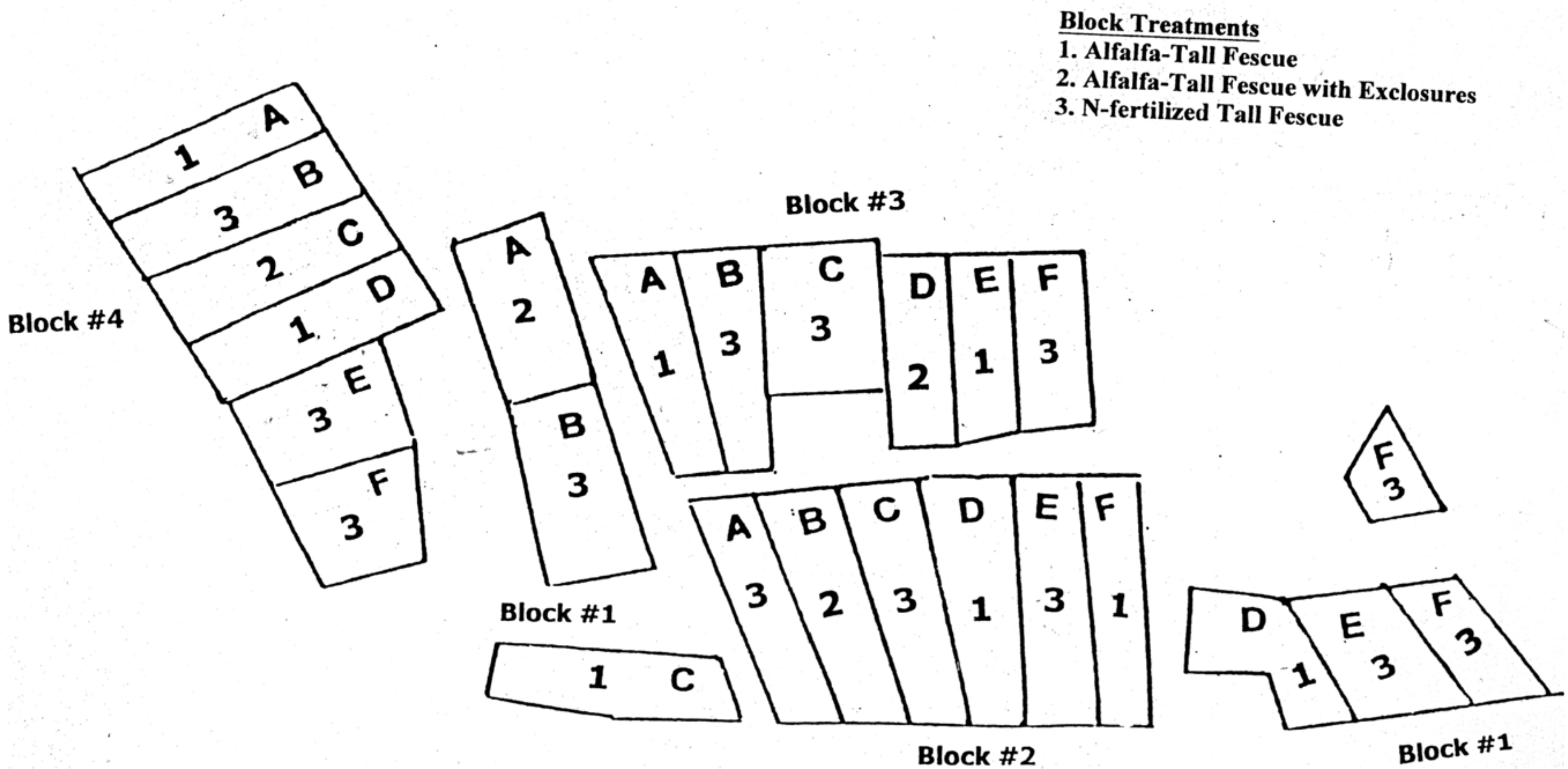
The objective of this experiment was to compare livestock performance, forage quality, and productivity of alfalfa-endophyte-free tall fescue mixtures to N-fertilized endophyte-free tall fescue pastures under rotational stocking during the late spring, summer, and early autumn.

## MATERIALS AND METHODS

A large interdisciplinary research and education farming system project was conducted from 1989 to 2000 at the Virginia Tech Kentland Farm, Blacksburg. The project compared a conventional to a sustainable crop/livestock system, the current research project was conducted on the crop blocks of the previous project (14.4 ha) on Unison-Braddock soils (deep, well drained, gently sloping to moderately steep soils with a clayey subsoil, formed on old alluvium on stream terraces and alluvial fans) (USDA, 1985). These four blocks were labeled 1, 2, 3, and 4 and provided the four replications for this experiment. Each block contained six paddocks labeled A, B, C, D, E, and F, resulting in a total of 24-0.6 ha paddocks (Fig. 1).

In late September 2000 paddocks 1E, 2A, 3F, and 4E, previously cropped to corn, were planted with 'Triple Crown' alfalfa at 16.8 kg $ha^{-1}$ and endophyte-free 'Forager' tall fescue at 22.4 kg $ha^{-1}$ using a Haybuster no-till drill (Haybuster Agricultural Products, Jamestown, ND). This drill was used for all subsequent planting for this study. Paddocks 1B, 2E, 3B, and 4F (previously corn/wheat) and paddocks 1D, 2F, 3D, and 4A (previously wheat/millet/alfalfa) were also planted with Triple Crown alfalfa at 16.8 kg $ha^{-1}$ and Forager tall fescue at 22.4 kg $ha^{-1}$. Paddocks 1A, 2D, 3A, and 4D (previously alfalfa), 1F, 2B, 3E, and 4C (previously alfalfa/rye-wheat), and 1C, 2C, 3C, and 4B (previously alfalfa/rye) still contained varying amounts of Triple Crown alfalfa from the previous experiment and were all interseeded with Forager tall fescue at a seeding rate of 22.4 kg $ha^{-1}$.

Figure 1. Map of N-fertilized tall fescue and alfalfa-tall fescue paddocks at the Virginia Tech Kentland Farm, Blacksburg, VA.



On 16 Jan. 2001 dairy manure was applied to all 24 paddocks at a rate of 15,132 kg $ha^{-1}$. Due to poor stand establishment and excessive weed growth in 2000, the paddocks planted with alfalfa and tall fescue (1E, 1B, 1D, 2A, 2E, 2F, 3F, 3B, 3D, 4E, 4F, 4A) were sprayed with 2.1 kg a.i. $ha^{-1}$ of glyphosate on 10 Apr. 2001 (Table 1). A follow-up spray of paraquat and AD-Spray 80 Surfactant was applied at 0.47 kg a.i. $ha^{-1}$ and 0.42 kg a.i. $ha^{-1}$ on 11 Apr. 2001 to quickly dessicate green plant material before seeding. These paddocks were then reseeded with Triple Crown alfalfa at 16.8 kg $ha^{-1}$ and Forager tall fescue at 16.8 kg $ha^{-1}$ on 15 Apr. 2001. The remaining 12 paddocks (1A, 1F, 1C, 2D, 2B, 2C, 3A, 3E, 3C, 4D, 4C, 4B) were also planted with Triple Crown alfalfa and Forager tall fescue both at 16.8 kg $ha^{-1}$ on 16 Apr. 2001. Rye was later interseeded into paddocks 1B, 1C, 1D, 1F, 2C, 2D, 2F, 3A, 3C, 3E, 4A, and 4D at 125.5 kg $ha^{-1}$ on 15 Nov. 2001. Nitrogen was applied at 33.6 kg N $ha^{-1}$ to paddocks containing rye on 20 Feb. 2002 followed by grazing with the 48 steers reserved for the current experiment beginning on 22 Mar. 2002.

The experiment was conducted during the late spring, summer, and early autumn of 2002 and 2003. Soil tests were taken in all paddocks and indicated a pH range of 6.4-7.2 with optimum P and K fertility levels for alfalfa growth in 2002 and 2003. All 24 paddocks were harvested for hay between 29 May 2002 and 10 June 2002 (105 round bales). Initial alfalfa plant counts were taken in all paddocks on 16 May 2002 using eight randomly placed 0.25 $m^2$ quadrat samples per paddock. Although alfalfa plant counts can be biased because plants growing close to one another can appear as one crown (Smith and Bouton, 1993), numerous researchers have successfully used plant counts to determine alfalfa persistence (Smith and Bouton, 1993; Bouton and Gates, 2003;

Brummer and Bouton, 1991; Smith et al., 1992). These initial counts were made to determine which paddocks would be designated alfalfa-tall fescue and which paddocks would be pure tall fescue (after spraying to eliminate alfalfa). Alfalfa-tall fescue paddocks were determined by randomly selecting three paddocks per block among those that contained high alfalfa populations. Using this method paddocks 1A, 1C, 1D, 2B, 2D, 2F, 3A, 3D, 3E, 4A, 4C, and 4D were designated alfalfa-tall fescue. The other 12 paddocks were sprayed with Dicamba at 0.28 kg a.i. $ha^{-1}$ and AD-Spray 80 Surfactant at 0.77 kg $ha^{-1}$ on 19 June 2002 to kill alfalfa to produce pure tall fescue stands (Table 1). On 19 June 2002 nitrogen was applied to these 12 pure tall fescue paddocks at 73.1 kg N $ha^{-1}$.

On 3 Apr. 2003 the pure tall fescue paddocks were sprayed with 2,4-D Amine at 1.07 kg a.i. $ha^{-1}$ and Banvel at 0.28 kg a.i. $ha^{-1}$ for weed control (Table 1). The other 12 paddocks containing alfalfa-tall fescue were sprayed with Harmony GT at 0.03 kg a.i. $ha^{-1}$ on 4 Apr. 2003 to suppress thistle and other broadleaf weeds. Nitrogen was applied to the pure tall fescue paddocks on 15 Apr. 2003 at 54.8 kg N $ha^{-1}$. Above average precipitation during the 2003 season caused an excess of forage in the paddocks, therefore hay was harvested from paddocks 1B, 2A, 3B (pure tall fescue) and 1D, 2D, 3E (alfalfa-tall fescue) on 9 June 2003. Eleven round bales were harvested from the pure tall fescue paddocks and eight round bales from the alfalfa-tall fescue paddocks. Hay was also harvested from paddock 4A (alfalfa-tall fescue) and 4B (pure tall fescue) on 23 June 2003 with 139 and 162 square bales harvested, respectively.

Tall fescue in all 24 paddocks was tested for *Neotyphodium coenophialum* endophyte infection on 30 July 2003 to confirm the endophyte-free status of the stands.

Table 1. Pesticides used in establishment and maintenance of alfalfa-tall fescue mixtures and N-fertilized tall fescue at the Virginia Tech Kentland Farm, Blacksburg, VA.

| Pesticide | Rate | Date | Target |
|---|---|---|---|
| | kg a.i. $ha^{-1}$ | | |
| Glyphosate† | 2.1 | 10 Apr. 2001 | eliminate existing stand |
| Paraquat‡ | 0.47 | 11 Apr. 2001 | suppress existing stand |
| AD-Spray 80 Surfactant§ | 0.42<br>0.77 | 11 Apr. 2001<br>19 June 2002 | applied with paraquat and Dicamba |
| Dicamba¶ | 0.28 | 19 June 2003 | alfalfa in pure tall fescue |
| 2,4-D Amine# | 1.07 | 3 Apr. 2003 | weeds in pure tall fescue |
| Banvel¶ | 0.28 | 3 Apr. 2003 | weeds in pure tall fescue |
| Harmony GT£ | 0.03 | 4 Apr. 2003 | thistle, broadleaf weeds |

† isopropylamine salt of N-(phosphonomethyl)glycine
‡ 1,1’-dimethyl-4,4’-bipyridinium dichloride
§ Alkyl aryl polyalkoxylated glycols and derivatives
¶ Dimethylamine salt of 3,6-dichloro-o-anisic acid
# Dimethylamine salt of 2,4-dichlorophenoxyacetic acid
£ Thifensulfuron-methyl Methyl 3-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2 -yl)amino]carbonyl]amino]sulfonyl]-2-thiophenecarboxylate

Twenty tillers were randomly collected from each paddock by walking back and forth across the paddock and cutting tillers at the soil surface with a razor blade (Agrinostics, 2003). The tillers were placed in a plastic zip lock bag and put in a cooler with a small amount of ice until testing. Tall fescue tillers were tested for endophyte infection using a Phytoscreen *Neotyphodium* immunoblot detection kit (Agrinostics, Ltd. Co., Watkinsville, GA). One cross section was cut from 16 different tillers collected from each paddock resulting in a total of 96 tiller cross sections for each block. These 96 cross sections were placed on a nitrocellulose membrane overlaid on an extraction buffer. The assay procedure was then performed according to the Phytoscreen *Neotyphodium* immunoblot detection kit instruction manual (Agrinostics, Ltd., Co., 2003; Hiatt et al., 1999). Endophyte infection was indicated by pink color development where the tiller section was in contact with the membrane through visual assessment in comparison to known checks, therefore the test was somewhat subjective. The pink color was easy to determine for this test and indicated a very low endophyte infection level (0.5%) for the tall fescue stands across all paddocks. Generally, infection levels below 5% are labeled as endophyte-free stands (Ball et al., 2003).

Three groups of 16 Angus or Angus crossbred steers were placed on paddocks 1D, 2D, and 3E on 6 June 2002 to evenly graze excess forage before the study began. The three groups were consolidated and divided into two groups of 24 steers and moved to paddocks 3B and 4E on 24 June 2002 to graze excess forage. On 27 June 2002 the two groups of steers were divided into four groups of 12 steers and placed in paddocks 1A, 2B, 3D, and 4C. After grazing these four paddocks, the 48 steers were then randomly divided according to weight classification into eight groups of six each to initiate the experiment.

Each group of six was placed on one alfalfa-tall fescue paddock and one pure tall fescue paddock per block, with a total of 12 steers in each block. Steers averaged 357 kg at the initiation of grazing in 2002 and 312 kg in 2003. Grazing for the experiment began on 8 July 2002 and 1 May 2003 and was terminated on 1 Oct. 2002 and 16 Oct. 2003. The grazing season was 12 wk in 2002 and 19 wk in 2003. The steers grazed each paddock to a height of approximately 10 to 12 cm in 2002 and 12 to 15 cm in 2003. Grazing periods on each paddock lasted 1.5 to 2 wk in 2002, with one instance where the grazing period lasted 3 wk due to forage availability. The average grazing period in 2003 was 2 wk. These grazing periods were longer than the suggested 7 to 10 days for alfalfa due to the low stocking rate in each paddock. More steers or smaller paddocks would have allowed the forage to be grazed down in a shorter time period, but this was not possible due to a limited number of animals and fixed paddock sizes. The steers were moved to a new paddock in the same block according to the predetermined cattle movement plan, which illustrates the rotation of the steers among the paddocks in 2002 and 2003 (Tables 2, 3). Paddocks that were harvested for hay on 9 June and 23 June 2003 were not grazed during the first two rotation cycles in 2003. When these paddocks had accumulated sufficient regrowth they were added back into the rotation and the paddock sequence was changed so that steers could graze these paddocks immediately. Those steers grazing alfalfa-tall fescue remained on alfalfa-tall fescue and those grazing pure tall fescue grazed only pure tall fescue paddocks throughout the study. All steers were weighed on 8 July, 5 August, 30 August, and 1 October in 2002 to compare ADG

Table 2. Rotation of steers throughout the alfalfa-tall fescue and pure tall fescue paddocks in 2002 at the Virginia Tech Kentland Farm, Blacksburg, VA.

| | Alfalfa-Tall Fescue Paddocks | | | Tall Fescue Paddocks | | |
|---|---|---|---|---|---|---|
| | C —> | D —> | A | E —> | B —> | F |
| Block 1 | 8 July | 17 July | 30 July | 8 July | 17 July | 30 July |
| | 12 Aug. | 23 Aug. | 3 Sept. | 12 Aug. | 23 Aug. | 3 Sept. |
| | 19 Sept. | | | 19 Sept. | | |
| | F —> | D —> | B | E —> | A —> | C |
| Block 2 | 8 July | 17 July | 30 July | 8 July | 17 July | 30 July |
| | 12 Aug. | 3 Sept. | | 12 Aug. | 3 Sept. | |
| | A —> | E —> | D | F —> | B —> | C |
| Block 3 | 8 July | 17 July | 30 July | 8 July | 17 July | 30 July |
| | 9 Aug. | 20 Aug. | 30 Aug. | 9 Aug. | 20 Aug. | 30 Aug. |
| | 10 Sept. | 24 Sept. | | 10 Sept. | 24 Sept. | |
| | D —> | A —> | C | F —> | B —> | E |
| Block 4 | 8 July | 17 July | 30 July | 8 July | 17 July | 30 July |
| | 12 Aug. | 3 Sept. | | 12 Aug. | 3 Sept. | |

Table 3. Rotation of steers throughout the alfalfa-tall fescue and pure tall fescue paddocks in 2003 at the Virginia Tech Kentland Farm, Blacksburg, VA.

| | Alfalfa-Tall Fescue Paddocks | | | Tall Fescue Paddocks | | |
|---|---|---|---|---|---|---|
| | A ———> | C ———> | D | F ———> | E ———> | B |
| Block 1 | 1 May | 19 May | †Hay | 1 May | 19 May | Hay |
| | 4 June | 19 June | Hay | 4 June | 19 June | Hay |
| | 3 July | | | 3 July | | |
| | ‡D ———> | C ———> | A | ‡B ———> | E ———> | F |
| | 17 July | 28 July | 11 Aug. | 17 July | 28 July | 11 Aug. |
| | 25 Aug. | 3 Sept. | 15 Sept. | 25 Aug. | 3 Sept. | 15 Sept. |
| | 29 Sept. | 10 Oct. | | 29 Sept. | 10 Oct. | |
| | B ———> | F ———> | D | E ———> | C ———> | A |
| Block 2 | 1 May | 19 May | Hay | 1 May | 19 May | Hay |
| | 4 June | 19 June | Hay | 4 June | 19 June | Hay |
| | 3 July | | | 3 July | | |
| | D ———> | F ———> | B | A ———> | C ———> | E |
| | 17 July | 28 July | 18 Aug. | 17 July | 28 July | 18 Aug. |
| | 27 Aug. | 3 Sept. | 15 Sept. | 27 Aug. | 3 Sept. | 15 Sept. |
| | 29 Sept. | 10 Oct. | | 29 Sept. | 10 Oct. | |
| | D ———> | A ———> | E | C ———> | F ———> | B |
| Block 3 | 1 May | 19 May | Hay | 1 May | 19 May | Hay |
| | 4 June | 19 June | Hay | 4 June | 19 June | Hay |
| | 3 July | | | 3 July | | |
| | E ———> | A ———> | D | B ———> | F ———> | C |
| | 17 July | 28 July | 11 Aug. | 17 July | 28 July | 11 Aug. |
| | 25 Aug. | 3 Sept. | 15 Sept. | 25 Aug. | 3 Sept. | 15 Sept. |
| | 29 Sept. | 10 Oct. | | 29 Sept. | 10 Oct. | |
| | C ———> | D ———> | A | E ———> | F ———> | B |
| Block 4 | 1 May | 19 May | Hay | 1 May | 19 May | Hay |
| | 4 June | 19 June | Hay | 4 June | 19 June | Hay |
| | 3 July | | | 3 July | | |
| | A ———> | D ———> | C | B ———> | F ———> | E |
| | 17 July | 28 July | 11 Aug. | 17 July | 28 July | 11 Aug. |
| | 25 Aug. | 3 Sept. | 15 Sept. | 25 Aug. | 3 Sept. | 15 Sept. |
| | 29 Sept. | 10 Oct. | | 29 Sept. | 10 Oct. | |

Table 3. Continued.

† Hay was harvested from these paddocks on 9 June 2003 for blocks 1, 2, 3 and 23 June 2003 for block 4, therefore steers did not graze them during the first two rotations

‡ When the hayed paddocks were added back into the rotation, the paddock sequence changed so that hayed paddocks could be grazed immediately.

between those steers grazing pure tall fescue and the steers grazing alfalfa-tall fescue mixtures. In 2003, the steers were weighed on 1 May, 30 May, 27 June, 23 July, 20 August, 17 September, and 16 October. Paddocks 1B, 1D, 2A, 2D, 3B, 3E, 4A, and 4B were rotary mowed to 12.7 cm after grazing on 1 Aug. 2002 for thistle control. Paddocks 1A, 1F, 2B, 2C, 3C, 3D, 4C, and 4E were also rotary mowed to 12.7 cm after grazing on 12 Aug. 2002.

Detailed mass and species composition measurements were taken on the four alfalfa-tall fescue paddocks (1A, 2B, 3D, and 4C) being concurrently used for a separate exclosure study and four randomly selected pure tall fescue paddocks in the concurrent rotation with the alfalfa-tall fescue paddocks. Tall fescue paddocks were 1F, 2C, 3C, and 4E for the 2002 grazing season and 1F, 2E, 3C, and 4E for 2003. Paddock 2E was used instead of 2C during the first grazing cycle of 2003 due to a concurrent animal intake study conducted on selected steers in 2C. Mass and forage height measurements were taken immediately before and after each grazing period using four randomly placed 0.25 $m^2$ quadrat samples in each paddock. A disk meter was used to measure forage height. It was constructed of a square piece of plexi-glass measuring 0.25 $m^2$ in area and 5 mm in thickness on a piece of PVC pipe 1.27 cm in diameter and 2.44 m long that contained a scale in centimeters to measure forage height. This PVC pipe was surrounded by a PVC pipe 1.91 cm in diameter and 1.22 m long (Vartha and Matches, 1977; Griggs and Stringer, 1988). Height measurements were taken by touching the plexi-glass square of the disk meter to the top of the forage and observing where the top of the outer PVC pipe appeared on the centimeter scale. Percent cover of each species within the sample area was visually estimated. Finally, the sample area was clipped with battery operated Black and Decker hand clippers to 7.6 cm, dried 48 to 72 hours at 60°C, and then weighed. These samples were collected to estimate forage mass before and after grazing and to compare the mass of alfalfa-tall fescue paddocks and pure tall fescue paddocks. Individual height measurements were correlated with forage mass measurements to determine if forage mass could be predicted based on forage height.

Forage quality samples were taken on all 24 paddocks before each grazing period. The quality samples were collected by walking in a "X" across the paddock, stopping every 30 paces, and taking a grab sample in front of the collector's feet to a height of 10 to 13 cm. Quality samples were dried at 60°C for 48 to 72 hours and ground in a Thomas Wiley Lab Mill Model 4 (Arthur H. Thomas Co., Philadelphia, PA) through a 1 mm mesh screen. Subsamples were weighed and dried at 100° C in a Fisher Scientific Isotemp Model 655G oven (Fisher Scientific Co., LLC, Pittsburgh, PA) overnight then placed in a dessicator for approximately 20 min. to cool. Finally, the subsamples were weighed again to determine dry matter content (AOAC, 2000). These same subsamples were used to determine ash or mineral content by placing in a cool Sybron Thermolyne Furnatrol I muffle furnace (Barnstead/Thermolyne Corp., Dubuque, IA) and allowing it to heat up to 500°C for 1 h then ashing for 2 h at this temperature. After ashing the subsamples were allowed to cool then weighed to calculate percent ash (AOAC, 2000). Neutral detergent fiber (NDF), acid detergent fiber (ADF), lignin, and cellulose were determined using reagents prepared according to Goering and Van Soest (1970) with the Ankom Technology Corp. (1997) method for determining NDF in a Ankom200/220 Fiber Analyzer (Ankom Corp., Fairport, NY). The crude protein in the forage samples was determined according to the AOAC (2000) official method of nitrogen analysis using a PE2410N nitrogen analyzer produced by Perkin Elmer Instruments (Norwalk, CT). An additional ten height measurements were taken before and after each grazing period to determine the average height of the forage in the paddocks and to estimate forage mass using the disk meter.

Alfalfa persistence under grazing was measured on 18 Oct. 2002, 28 March 2003, and 5 Nov. 2003 using eight random 0.25 $m^2$ quadrat samples in all alfalfa-tall fescue paddocks. Alfalfa plant counts and visual percent cover estimates were made at each sample area.

Analysis of variance (ANOVA) was performed on the data using the Statistical Analysis Systems (SAS, 1990) with treatments considered fixed effects and replications random effects. Treatment means for forage mass, quality, and steer performance were compared using Fischer's protected least significant difference procedure. The relationships between paired height measurements and sample mass were determined using linear regressions (SAS, 1990). Correlation between height and mass was determined using $r^2$ values.

## RESULTS AND DISCUSSION

Results from this experiment were analyzed separately for 2002 and 2003 due to highly variable climatic conditions and different grazing season lengths between years.

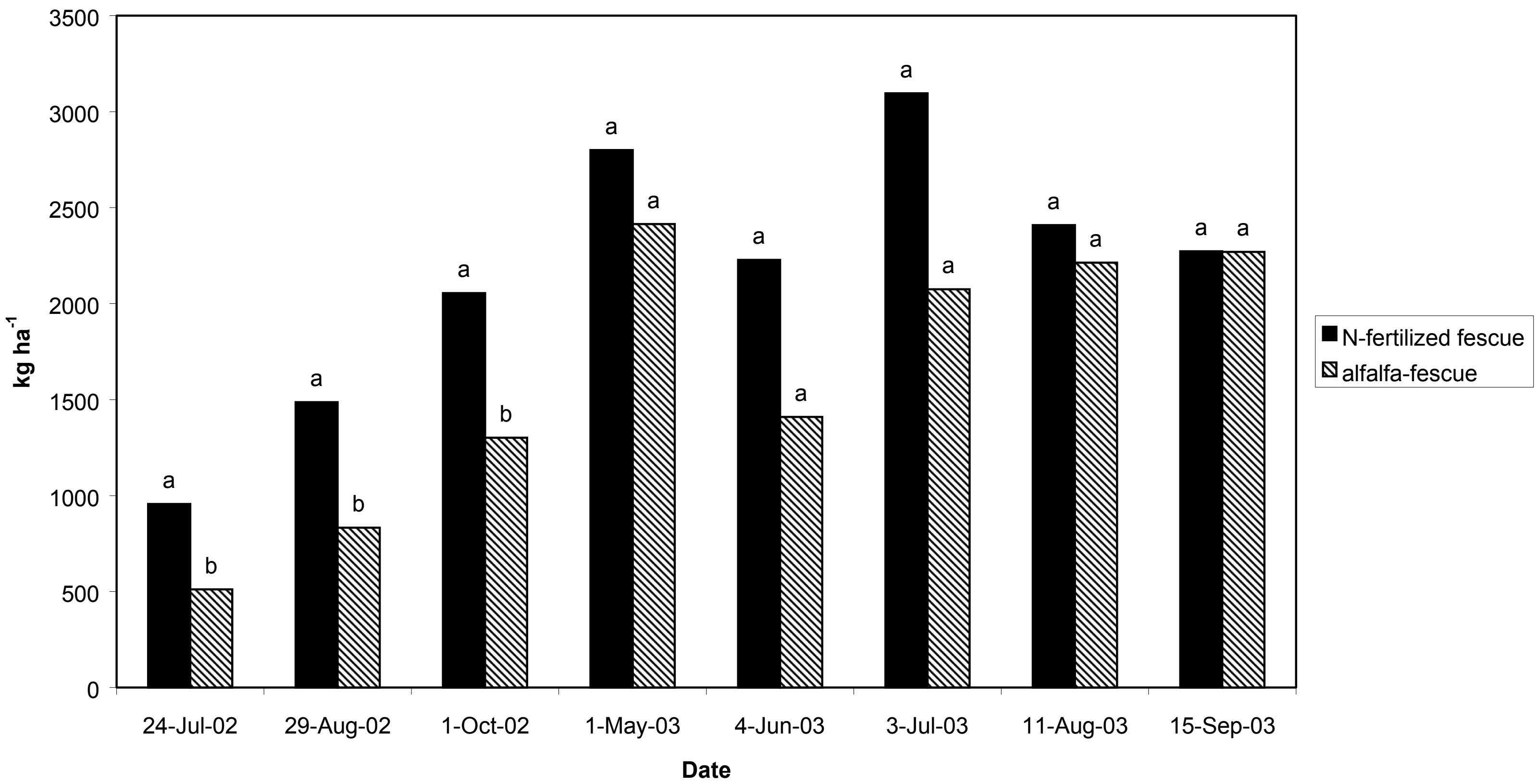
### Forage Mass

Forage mass was estimated from samples harvested in selected N-fertilized tall fescue and alfalfa-tall fescue paddocks at the initiation of grazing and prior to each grazing cycle (Fig. 2). Forage mass samples were collected three times during the abbreviated 2002 grazing season and were lower than expected due to lower-than-average precipitation from April to August (Fig. 3). Forage mass of N-fertilized tall fescue was higher than alfalfa-tall fescue on 24 July 2002 at 956 kg $ha^{-1}$ compared to 512 kg $ha^{-1}$ and on 29 Aug. 2002 at 1487 kg $ha^{-1}$ compared to 833 kg $ha^{-1}$ even though alfalfa was 27% and 51% of the mixed stands on 24 July and 16 Aug. 2002, respectively (Table 4). At the end of the season, 1 Oct. 2002, tall fescue continued to produce more mass (2054 kg $ha^{-1}$) than alfalfa-tall fescue (1302 kg $ha^{-1}$). Spring N fertilization of pure tall fescue was likely a factor in its productivity in comparison to alfalfa-tall fescue which received no N during the dry 2002 season.

Forage mass results in 2002 were surprising because growth of a cool season species like tall fescue is normally suppressed during the summer, especially with below normal precipitation. There were a number of factors that may have influenced forage production during the 2002 grazing season. Tall fescue growth was limited, but alfalfa-tall fescue growth was limited more. Since the 2002 grazing season followed three years of below normal precipitation, subsoil moisture was depleted. Low subsoil moisture reduced the normal competitive advantage alfalfa has during the summer. Tall fescue stands were somewhat open due to the dry conditions during 2002 which allowed crabgrass to invade, making up 10 to 30% of the tall fescue paddocks according to visual estimation from July to September (Table 4). Alfalfa-tall fescue paddocks only contained 8% crabgrass from July to September.

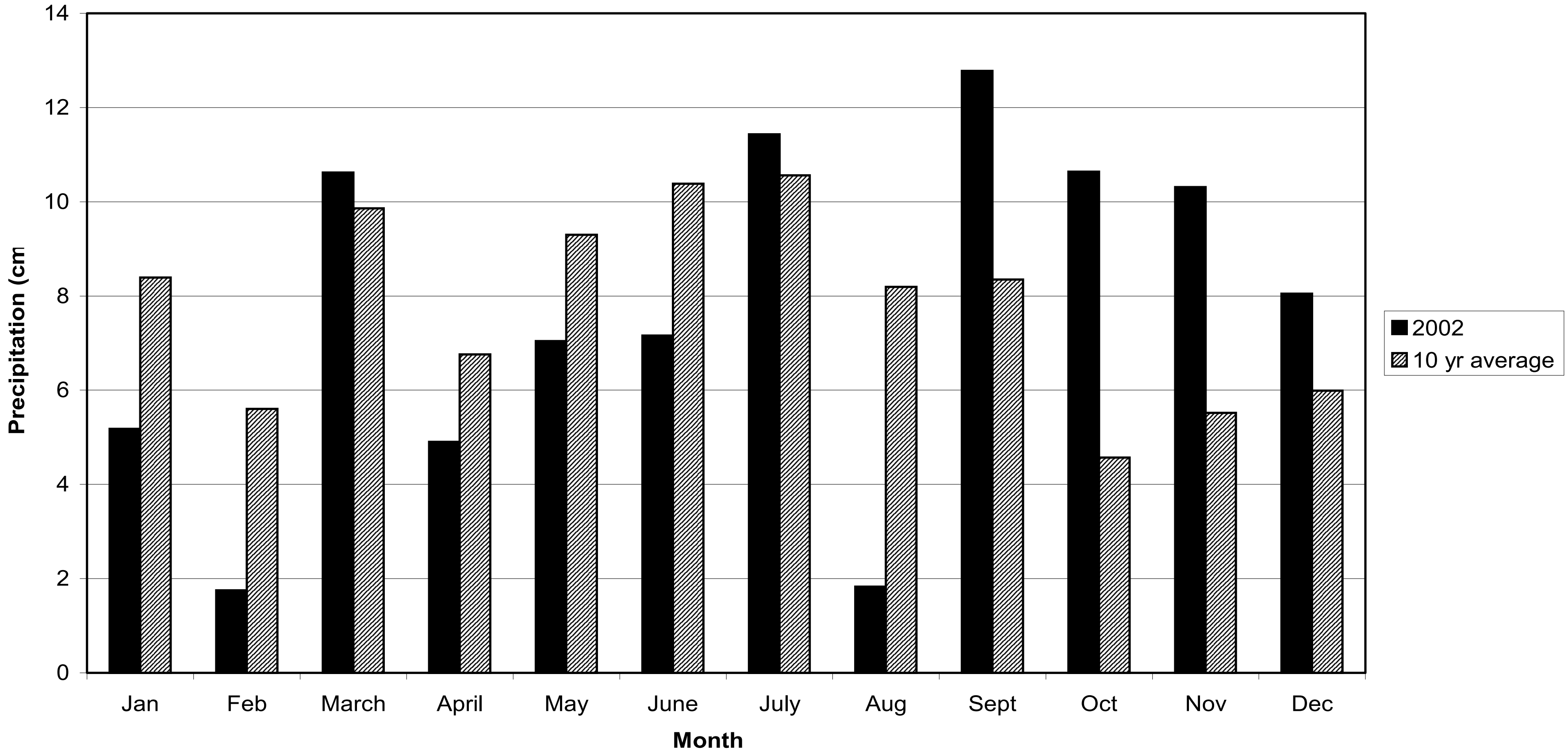
Hoveland et al. (1995) reported a 76% increase in endophyte-free tall fescue yield when N fertilizer was applied in a Georgia study. They also increased yield of alfalfa-tall

Figure 2. Forage mass of N-fertilized tall fescue and alfalfa-tall fescue mixtures in 2002 and 2003 at the Virginia Tech Kentland Farm, Blacksburg, VA.




*Within date, forage mass bars with different letters are significantly different (P < 0.05)

**Figure 3. 2002 Monthly Precipitation**
**Virginia Tech Kentland Farm, Blacksburg, VA.**




***Cumulative annual precipitation in 2002 was 92 cm.**
***The 50 year average annual precipitation for Blacksburg, VA in 2002 (1953-2002) was 102 cm.**

Table 4. Alfalfa, tall fescue, crabgrass, and weed percent ground cover in the alfalfa-tall fescue and pure tall fescue pastures in 2002 at the Virginia Tech Kentland Farm, Blacksburg, VA.

| Forage Type | 24 July | 16 Aug. | 9 Sept. | 1 Oct. |
|---|---|---|---|---|
| | % alfalfa cover | | | |
| Pure fescue | 0.6† | 0.0 | 1.3 | 0.6 |
| Alfalfa-fescue | 26.6 | 51.3 | 10.0 | 29.4 |
| | % fescue cover | | | |
| Pure fescue | 81.6 | 67.8 | 42.5 | 81.3 |
| Alfalfa-fescue | 30.9 | 41.3 | 24.4 | 36.3 |
| | % crabgrass cover | | | |
| Pure fescue | 10.3 | 32.2 | 13.1 | 2.5 |
| Alfalfa-fescue | 8.1 | 7.5 | 8.1 | 5.6 |
| | % weed cover‡ | | | |
| Pure fescue | 4.1 | 0.0 | 1.3 | 0.0 |
| Alfalfa-fescue | 4.4 | 0.0 | 0.0 | 1.9 |

† Percent cover was measured based on vegetative cover vs. bare soil. Plant species included alfalfa, tall fescue, crabgrass, weeds, and annual grasses (data not shown for annual grasses due to very low values).

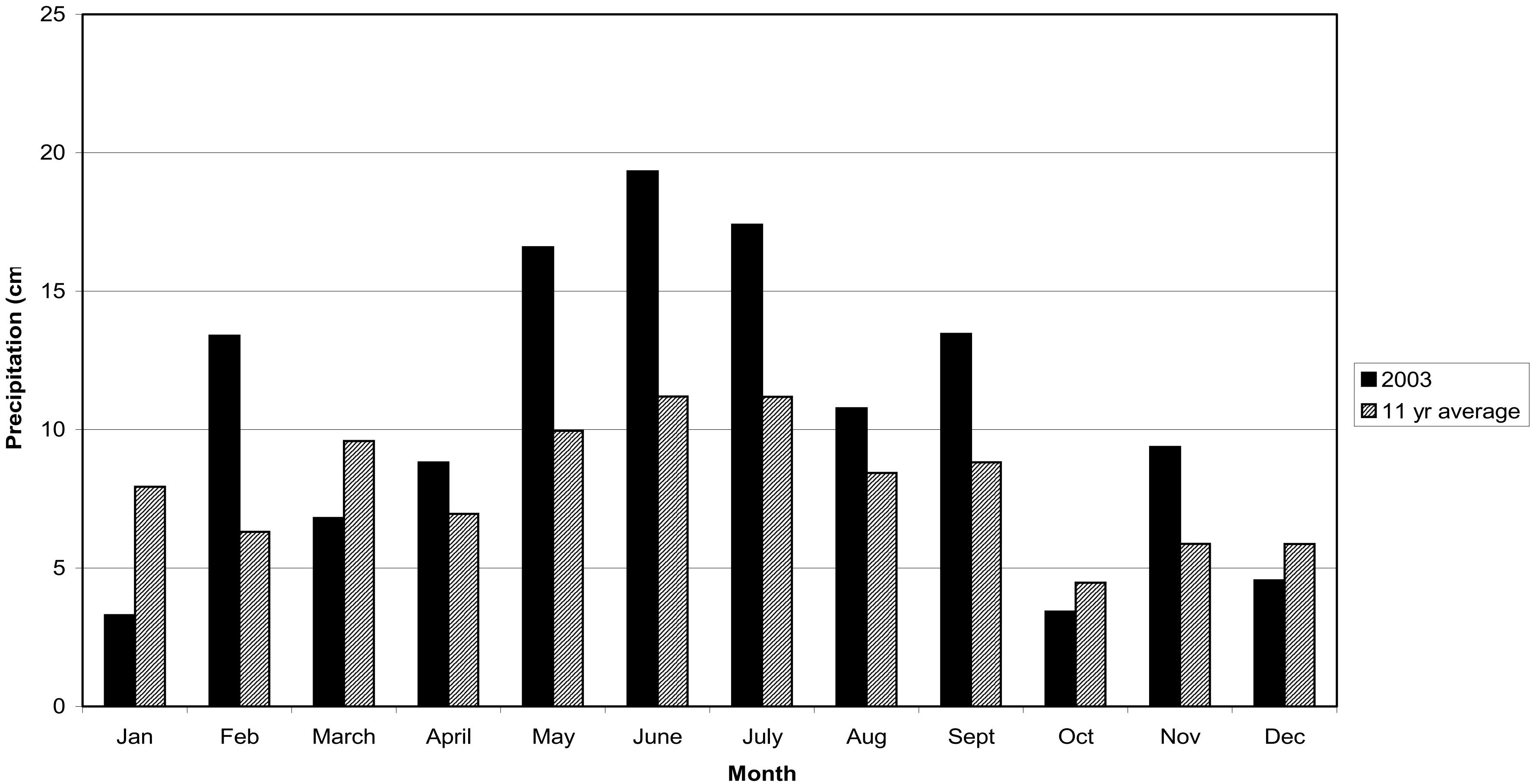
‡ Percent weed cover included redroot pigweed, pepperweed, chickweed, thistle, horsenettle, dandelion, broadleaf plaintain, wild onion, and nimblewill.

fescue mixtures by one-third with N fertilization. In Virginia, Blaser et al. (1986) obtained higher yields with N-fertilized grass as compared to grass-clover pastures without N. Allen et al. (1992) reported higher yields of N-fertilized stockpiled tall fescue than stockpiled alfalfa-tall fescue in northern Virginia. Nitrogen fertilization of grass-legume mixtures is usually not recommended because of the competitive advantage N can provide to the grass component (Blaser et al., 1986), but limited applications have the potential to increase total yield without reducing percent legume.

In 2003, there were no significant differences between N-fertilized tall fescue and alfalfa-tall fescue forage mass estimates (Fig. 2). Numerically, forage mass estimates for tall fescue were higher on 4 June and 3 July, but stand variability and the low sample number used for mass estimation likely contributed to the lack of significance. Overall, forage mass was higher for both stands in 2003 over 2002. High precipitation was the most important factor (Fig. 4), but in May tall fescue yield also benefited from a 15 April N application and mixed stands contained a high proportion of alfalfa at 35% cover (Table 5).

Nitrogen-fertilized tall fescue and alfalfa-tall fescue forage mass were similar by the end of the 2003 season (Fig. 2). Alfalfa percent cover was drastically reduced during this season with only 4% remaining on 11 Aug. and 0.4% on 15 Sept (Table 5). There were 17 alfalfa plants $m^{-2}$ in the alfalfa-tall fescue paddocks on 28 Mar. 2003, but on average only 1 alfalfa plant $m^{-2}$ remained in the mixed paddocks on 5 Nov. 2003. Estimates of percent ground cover on 1 May 2003 showed that tall fescue made up 39% of the alfalfa-tall fescue paddocks. This percentage had increased to 63% cover by 11 Aug. 2003. Alfalfa declined in the alfalfa-tall fescue paddocks due to a combination of

**Figure 4. 2003 Monthly Precipitation**
**Virginia Tech Kentland Farm, Blacksburg, VA.**




***Cumulative annual precipitation in 2003 was 127 cm.**
**** The 51 year average annual precipitation for Blacksburg, VA (1953-2003) was 103 cm.**

Table 5. Alfalfa, tall fescue, and weed percent ground cover in the alfalfa-tall fescue and pure tall fescue pastures in 2003 at the Virginia Tech Kentland Farm, Blacksburg, VA.

| Forage Type | 1 May | 19 June | 11 Aug. | 29 Sept. |
|---|---|---|---|---|
| | % alfalfa cover | | | |
| Pure fescue | 0.3 | 0.0 | 0.0 | 0.0 |
| Alfalfa-fescue | 35.3 | 9.6 | 3.9 | 0.4 |
| | % fescue cover | | | |
| Pure fescue | 75.3 | 64.7 | 68.4 | 56.9 |
| Alfalfa-fescue | 38.8 | 48.8 | 62.5 | 54.4 |
| | % weed cover† | | | |
| Pure fescue | 1.9 | 0.9 | 5.9 | 0.9 |
| Alfalfa-fescue | 1.6 | 0.3 | 3.4 | 0.3 |

† Percent weed cover included all weed species and crabgrass. No individual species had a major contribution, so overall average was shown.

factors including favorable conditions for tall fescue growth during 2003. Moderate temperatures and above average precipitation allowed tall fescue to become the dominant species in the alfalfa-tall fescue mixtures. In addition, alfalfa plant mortality may have been inevitable in 2003 as higher than normal alfalfa stand losses occurred in hayfields across Virginia due to root and crown diseases caused by waterlogged soils. For example, a 90% stand loss was observed in a three year old alfalfa variety test on a sandy loam soil at the Southern Piedmont Agricultural Research and Experiment Station, Blackstone, VA (Smith, pers. comm., 2004).

Grazing management in 2003 also likely contributed to the decline in alfalfa botanical composition and plant mortality. Steers were not allowed to graze the paddocks as closely as recommended for alfalfa-grass mixtures (Blaser et al., 1986) due to set steer numbers and high forage production in all paddocks. There were only three paddocks per treatment in each block and below optimum stocking rate in 2003. Steers were rotated before the forage was grazed down to the desired 7.6 cm height to limit grazing period length to 2 to 2.5 wk and to maintain forage quality in subsequent paddocks. Consequently, grazing periods were longer than the 7 to 10 days recommended for alfalfa management (Lacefield et al., 1987), especially in 2003, due to the high forage availability. Alfalfa-tall fescue mixtures had an average 4 to 5 wk rest interval between grazing due to the limited three paddock rotation. Hoveland et al. (1995) showed that alfalfa persistence was reduced in their mixtures when cut at 3 and 4 wk intervals as compared to a 6 wk interval.

Alfalfa cultivar choice also potentially contributed to the depletion of alfalfa in the mixed stands. Triple Crown was used in this research but it has not been shown to be grazing-tolerant. In similar research in Georgia (Hoveland et al., 1995) mixed alfalfa-tall fescue stands were maintained by seeding the grazing-tolerant Alfagraze cultivar (Smith et al., 1989) with endophyte-free 'AU Triumph' tall fescue.

Forage Height to Forage Mass Relationship

Forage height measurements and forage mass values for the 0.25 $m^2$ samples were grouped across forage type (N-fertilized tall fescue and alfalfa-tall fescue) and sampling date for regression analysis in each year. The purpose was to determine the relationship between forage height and forage mass measurements and to decide if forage mass could be accurately predicted based on forage height. Height measurements showed a wide range over forage type and year. In 2002 the pure tall fescue heights ranged from 14 to 37 cm and alfalfa-tall fescue ranged from 11 to 33 cm. In 2003 stand height ranged between 16 and 60 cm for pure tall fescue paddocks and 12 to 50 cm for alfalfa-tall fescue paddocks. Forage height and mass values were first correlated across all sampling dates and forage types in 2002 and in 2003 but showed a poor relationship with $r^2$ values of 0.42 in 2002 and 0.37 in 2003. Forage height and mass values were then correlated for each forage type separately across all sampling dates in each year and showed a good relationship for alfalfa-tall fescue in 2002 ($r^2$ = 0.73), but low $r^2$ values for pure tall fescue in 2002 ($r^2$ = 0.19), alfalfa-tall fescue in 2003 ($r^2$ = 0.37), and pure tall fescue in 2003 ($r^2$ = 0.34). Regression analysis between height and forage mass was then separated by forage type and sampling date due to these low correlations and the wide range of stand heights for pure tall fescue and alfalfa-tall fescue.

The $r^2$ values obtained from regression analysis were highly variable across sampling dates. Alfalfa-tall fescue tended to have higher $r^2$ values with 0.56 to 0.85 in

2002 and 0.00 to 0.85 in 2003 in comparison to N-fertilized tall fescue with $r^2$ ranging from -0.16 to 0.32 in 2002 and -0.07 to 0.70 in 2003. Alfalfa-tall fescue $r^2$ values were likely higher due to the alfalfa component and lower percent ground cover of the mixture. In previous research, alfalfa had a high correlation ($r^2$ = 0.79 to 0.87) between forage height and dry matter yield (Griggs and Stringer, 1988). Michalk and Herbert (1977) also compared pasture height to yield using linear regression in low-density alfalfa-based pastures and showed there was a high correlation ($r^2$ = 0.82) between the two measurements. Several studies have concluded that the disk meter does not accurately predict forage mass when used on pastures with an accumulation of plant material (Vartha and Matches, 1977; Douglas and Crawford, 1994). Nitrogen-fertilized tall fescue paddocks contained more forage than alfalfa-tall fescue mixtures as evidenced by the forage mass for the two types of paddocks (Fig. 2).

Measurement procedures probably contributed the most to the large variation and low $r^2$ values in this experiment. Plant height was determined by touching the disk meter to the top of the plants instead of measuring bulk-height. This method did not consistently predict mass in this experiment, though past experiments have shown plant height was well correlated to forage mass in low-density pure stands of alfalfa (Griggs and Stringer, 1988; Michalk and Herbert, 1977). Many researchers have used disk meters to take bulk-height readings by dropping the disk meter from a specified height onto the forage and compressing the forage under the disk (Vartha and Matches, 1977; Baker et al., 1981; Douglas and Crawford, 1994; Bransby et al., 1977). This type of disk meter reading takes into account the bulk density of the forage. The plant height measurements in this experiment did not reflect the density of the forage or percent ground cover in the

0.25 $m^2$ area. Other researchers have used a shorter clipping height when harvesting forage mass samples. Most researchers have tried to clip as close to ground level as possible or to a short stubble height such as 3 cm (Vartha and Matches, 1977; Douglas and Crawford, 1994; Bransby et al., 1977; Rayburn and Rayburn, 1998). A 7.6 cm stubble height was used in this experiment because it was the desired grazing height.

Many experiments relating disk meter bulk-height to forage mass have reported high $r^2$ values. Baker et al. (1981) had a $r^2$ value of 0.82, similar to the $r^2 = 0.83$ reported by Douglas and Crawford (1994) and correlation coefficients ($r = 0.79$ to 0.94) reported by Bransby et al. (1977). Other researchers have obtained lower $r^2$ values, such as Vartha and Matches (1977) with $r^2$ ranging from 0.09 to 0.84 and Rayburn and Rayburn (1998) with a $r^2$ value of 0.52.

Forage Quality

Percentage dry matter, ash, crude protein, and fiber content were determined for samples collected at the initiation of grazing and at the beginning of each grazing cycle in each paddock in 2002 (Table 6). Ash provided a measure of mineral content and these results showed higher percent ash for N-fertilized tall fescue than alfalfa-tall fescue on 9 Aug. 2002. Alfalfa-tall fescue mixtures contained a higher percentage of crude protein than N-fertilized tall fescue on 17 July, 30 August, 3 October, and for the season-long average in 2002. Allen et al. (1992) reported a higher crude protein content in stockpiled alfalfa-tall fescue mixtures (24%) as compared to stockpiled N-fertilized tall fescue (13%). McCloud and Mott (1953) found that legumes in mixtures, such as alfalfa, increased the protein of the grass component as well.

Table 6. Percent dry matter, ash, crude protein, and fiber of N-fertilized tall fescue and alfalfa-tall fescue mixtures in 2002 at the Virginia Tech Kentland Farm, Blacksburg, VA.

| Date | DM | Ash† | CP† | NDF† | ADF† | Cellulose† | Lignin† |
|---|---|---|---|---|---|---|---|
| | % | | | | | | |
| 17 July 2002 | | | | | | | |
| Fescue‡ | 91.7a¶ | 9.7a | 17.8a | 50.3a | 26.2a | 2.3a | 0.1a |
| Alf-Fes§ | 91.0a | 9.9a | 23.7b | 33.6b | 20.8a | 3.9b | 0.2a |
| 9 Aug. 2002 | | | | | | | |
| Fescue | 90.9a | 9.9a | 16.0a | 49.7a | 25.3a | 2.7a | 0.2a |
| Alf-Fes | 90.8a | 9.3b | 18.1a | 45.8a | 24.8a | 3.5b | 0.2a |
| 20 Aug. 2002 | | | | | | | |
| Fescue | 93.1a | 9.5a | 14.6a | 54.6a | 27.6a | 4.1a | 0.2a |
| Alf-Fes | 93.3a | 9.2a | 15.1a | 46.1b | 25.5a | 4.1a | 0.1a |
| 30 Aug. 2002 | | | | | | | |
| Fescue | 92.4a | 9.7a | 13.6a | 60.7a | 29.9a | 6.5a | 0.9a |
| Alf-Fes | 92.1a | 8.8a | 16.4b | 55.2b | 27.7a | 6.3a | 0.5a |
| 3 Oct. 2002 | | | | | | | |
| Fescue | 92.7a | 11.6a | 22.4a | 45.2a | 23.2a | 4.1a | 1.1a |
| Alf-Fes | 93.2a | 12.2a | 27.1b | 42.5a | 23.0a | 4.1a | 1.4a |
| Season Long | | | | | | | |
| Fescue | 92.4a | 10.6a | 18.3a | 50.8a | 25.8a | 4.3a | 0.7a |
| Alf-Fes | 92.5a | 10.4a | 21.7b | 45.0b | 24.3a | 4.5a | 0.7a |

† Ash, CP (crude protein), NDF (neutral detergent fiber), ADF (acid detergent fiber), cellulose, and lignin on a dry matter basis.

‡ Represents pure tall fescue stands.

§ Represents alfalfa-tall fescue mixtures.

¶ Within each date and quality component pair, means followed by the same letter are not significantly different based on Fisher's protected LSD ($P < 0.05$).

In 2002 NDF was higher for N-fertilized tall fescue than alfalfa-tall fescue on 17 July, 20 August, 30 August, and for the season-long average (Table 6). Grasses have higher total cell wall content (NDF) than legumes due to greater amounts of hemicellulose (Van Soest, 1985). Lower NDF translates to a faster rate of fiber digestion by ruminant livestock, which usually leads to higher intake (Ball et al., 2002). Cellulose content was higher for the alfalfa-tall fescue mixtures than N-fertilized tall fescue on 17 July and 9 August 2002, which is unusual because cellulose is usually higher in grasses (Van Soest, 1985).

Percentage dry matter, ash, crude protein, and fiber content were determined for samples collected at the initiation of grazing and before each grazing cycle in each paddock in 2003 as in 2002 (Table 7). In 2003, alfalfa-tall fescue samples contained a higher percentage of crude protein than pure tall fescue on 30 April, 18 June, 2 July, 16 July, 25 August, 29 September, and for the season-long average. The ash component of alfalfa-tall fescue was higher than N-fertilized tall fescue on 30 April and 16 July 2003. On 30 April, 19 May, 18 June, 16 July, 28 July, 25 August, 29 September, and for the season-long average in 2003 NDF percentages for N-fertilized tall fescue were higher than alfalfa-tall fescue indicating a slower fiber digestion rate and lower intake. Nitrogen-fertilized tall fescue also showed higher ADF values for samples collected on 30 April, 28 July, 25 August 2003, and for the season-long average. Higher ADF indicates lower forage digestibility (Ball et al., 2002).

The 2003 results indicated that the quality of the alfalfa-tall fescue mixtures was still higher than N-fertilized tall fescue despite the loss of alfalfa composition throughout the season. The slow release of N from decaying alfalfa roots and crowns in the mixed

Table 7. Percent dry matter, ash, crude protein, and fiber of N-fertilized tall fescue and alfalfa-tall fescue mixtures in 2003 at the Virginia Tech Kentland Farm, Blacksburg, VA.

| Date | DM | Ash† | CP† | NDF† | ADF† |
|---|---|---|---|---|---|
| | % | | | | |
| 30 Apr. 2003 | | | | | |
| Fescue‡ | 96.1a¶ | 7.6a | 22.6a | 46.3a | 22.9a |
| Alf-Fes§ | 95.5a | 8.9b | 28.1b | 35.7b | 19.5b |
| 19 May 2003 | | | | | |
| Fescue | 93.0a | 9.1a | 15.5a | 59.6a | 32.1a |
| Alf-Fes | 93.0a | 9.2a | 18.5a | 54.6b | 31.4a |
| 30 May 2003 | | | | | |
| Fescue | 90.5a | 8.8a | 14.1a | 61.8a | 32.7a |
| Alf-Fes | 90.7a | 14.2a | 17.1a | 56.9a | 32.2a |
| 18 June 2003 | | | | | |
| Fescue | 90.7a | 9.4a | 17.4a | 55.9a | 30.6a |
| Alf-Fes | 90.5a | 9.1a | 20.2b | 48.0b | 27.0a |
| 2 July 2003 | | | | | |
| Fescue | 91.5a | 10.4a | 18.2a | 54.9a | 33.1a |
| Alf-Fes | 91.1a | 10.6a | 22.8b | 49.2a | 27.9a |
| 16 July 2003 | | | | | |
| Fescue | 90.8a | 10.7a | 19.5a | 43.1a | 22.3a |
| Alf-Fes | 90.8a | 9.1b | 20.6b | 35.5b | 20.3a |
| 28 July 2003 | | | | | |
| Fescue | 92.6a | 10.2a | 17.7a | 46.6a | 23.8a |
| Alf-Fes | 92.4a | 9.9a | 18.8a | 42.2b | 22.1b |
| 11 Aug. 2003 | | | | | |
| Fescue | 91.9a | 9.5a | 18.6a | 50.8a | 25.7a |
| Alf-Fes | 92.6a | 8.6a | 20.3a | 46.9a | 24.2a |
| 25 Aug. 2003 | | | | | |
| Fescue | 91.6a | 9.8a | 17.9a | 50.3a | 26.0a |
| Alf-Fes | 91.4a | 9.5a | 21.2b | 46.1b | 24.4b |
| 3 Sept. 2003 | | | | | |
| Fescue | 92.2a | 10.0a | 19.8a | 55.8a | 29.4a |
| Alf-Fes | 92.3a | 10.3a | 21.8a | 55.4a | 28.7a |

Table 7. Continued

| Date | DM | Ash† | CP† | NDF† | ADF† |
|---|---|---|---|---|---|
| | % | | | | |
| 15 Sept. 2003 | | | | | |
| Fescue | 95.7a | 9.5a | 19.6a | 56.8a | 29.3a |
| Alf-Fes | 95.9a | 9.5a | 20.5a | 55.6a | 28.7a |
| | | | | | |
| 29 Sept. 2003 | | | | | |
| Fescue | 96.1a | 8.8a | 16.8a | 56.0a | 29.0a |
| Alf-Fes | 95.9a | 8.8a | 18.7b | 53.1b | 27.5a |
| | | | | | |
| 10 Oct. 2003 | | | | | |
| Fescue | 95.9a | 9.1a | 18.7a | 48.6a | 24.4a |
| Alf-Fes | 96.1a | 8.8a | 18.5a | 48.6a | 24.9a |
| | | | | | |
| Season Long | | | | | |
| Fescue | 93.0a | 9.5a | 18.2a | 52.8a | 27.8a |
| Alf-Fes | 92.9a | 9.7a | 20.5b | 48.3b | 26.1b |

† Ash, CP (crude protein), NDF (neutral detergent fiber), and ADF (acid detergent fiber) presented on a dry matter basis.

‡ Represents pure tall fescue stands.

§ Represents alfalfa-tall fescue mixtures.

¶ Within each date and quality component pair, means followed by the same letter are not significantly different based on Fisher's protected LSD ($P < 0.05$).

stands most likely helped maintain crude protein even as alfalfa percentage declined. Above average rainfall during the season increased the growth of tall fescue and a low stocking rate resulted in tall fescue being at a more mature stage than originally planned. Nutritive quality declines with maturity in most forages (Van Soest, 1985). The high quality of alfalfa was able to offset the lower quality of tall fescue in the alfalfa-tall fescue mixtures.

<u>Animal Performance</u>

Animal performance of steers grazing N-fertilized tall fescue and alfalfa-tall fescue mixtures in 2002 is shown in Table 8. Steers grazing N-fertilized tall fescue had higher ADG from 8 July to 5 August 2002. Although gain was only significant on 5 August, performance trended higher for steers grazing N-fertilized tall fescue than steers grazing alfalfa-tall fescue in 2002. Compared to past legume-tall fescue research (Allen et al., 1992; Burns et al., 1973; Blaser et al., 1956) these results were surprising, but they indicate the advantage of endophyte-free in comparison to endophyte-infected tall fescue. Previous research by Hoveland et al. (1983) in an Alabama study showed higher ADG for cattle grazing an endophyte-free Kentucky 31 stand and higher total beef production per hectare than cattle grazing a heavily infected Kentucky 31 stand. ADG was high for both stands in 2002 (Table 8) with the exception of 1 October indicating that either stand type could be recommended for stockers.

Additional factors likely contributed to the slightly higher ADG for pure tall fescue in 2002. Even with the dry conditions, N-fertilized tall fescue was able to produce higher forage mass than alfalfa-tall fescue (Fig. 2). Higher forage mass meant there was more available forage for the steers on N-fertilized tall fescue than the alfalfa-tall fescue

Table 8. Animal performance of steers grazing N-fertilized tall fescue and alfalfa-tall fescue mixtures in 2002 at the Virginia Tech Kentland Farm, Blacksburg, VA.

| Item | Tall Fescue | | Alfalfa- Tall Fescue | SE |
|---|---|---|---|---|
| | —— kg —— | | | |
| Weight 1, 8 July | 356 | | 358 | 4.35 |
| Weight 2, 5 Aug. | 380 | | 378 | 4.25 |
| ADG, 28d | 0.87 | * | 0.72 | 0.04 |
| Weight 3, 30 Aug. | 404 | | 400 | 4.29 |
| ADG, 25d | 0.96 | | 0.87 | 0.06 |
| Weight 4, 1 Oct. | 407 | | 403 | 5.13 |
| ADG, 32d | 0.08 | | 0.10 | 0.07 |
| Total ADG, 85d | 0.60 | | 0.53 | 0.03 |

* Indicates a significant difference in ADG between tall fescue and alfalfa-tall fescue during this grazing period according to Fisher's protected LSD ($P < 0.05$).

mixtures. Crabgrass emerged in the paddocks during 2002 due to the warm, dry conditions. Many of the pure tall fescue paddocks contained 3 to 30% crabgrass according to visual estimation throughout the season, while the alfalfa-tall fescue paddocks only contained 6 to 8% crabgrass (Table 4). The contribution of high quality crabgrass may help explain the higher ADG of the tall fescue steers in 2002 (Ball et. al., 2002).

Steer performance in 2003 reflected the benefits of alfalfa-tall fescue mixtures (Table 9). Steers grazing alfalfa-tall fescue mixtures showed higher ADG than steers grazing N-fertilized tall fescue for the period from 30 May to 27 June and 27 June to 23 July. Season-long ADG was also higher for steers on alfalfa-tall fescue as compared to steers grazing N-fertilized tall fescue. Allen et al. (1992) reported higher ADG for stockers grazing stockpiled alfalfa-endophyte-infected tall fescue as compared to stockpiled N-fertilized endophyte-infected tall fescue. Forage mass was similar for N-fertilized tall fescue and alfalfa-tall fescue in 2003 (Fig. 2), therefore the alfalfa component in the alfalfa-tall fescue mixtures may have been responsible for the increase in steer gain. Alfalfa-tall fescue mixtures showed higher crude protein, lower NDF, and lower ADF on various sampling dates and for the season-long average (Table 7). As mentioned previously, lower NDF means the rate of fiber digestion will be faster which usually leads to higher intake and lower ADF corresponds to higher digestibility (Ball et al., 2002). Legumes are recognized as having higher digestion rates than grasses leading to faster passage rates through the rumen, higher forage intake and increased daily gain (Blaser et al., 1986). Blaser et al. (1956) obtained higher ADG on ladino clover-orchardgrass and ladino-endophyte-infected tall fescue mixtures than both pure grass

Table 9. Animal performance of steers grazing N-fertilized tall fescue and alfalfa-tall fescue mixtures in 2003 at the Virginia Tech Kentland Farm, Blacksburg, VA.

| Item | Fescue | | Alfalfa-Fescue | SE |
|---|---|---|---|---|
| | ——— kg ——— | | | |
| Weight 1, 1 May | 305 | | 318 | 2.83 |
| Weight 2, 30 May | 336 | | 355 | 3.21 |
| ADG, 29d | 1.06 | | 1.26 | 0.07 |
| Weight 3, 27 June | 344 | | 373 | 4.72 |
| ADG, 28d | 0.30 | * | 0.67 | 0.11 |
| Weight 4, 23 July | 362 | | 396 | 4.00 |
| ADG, 26d | 0.69 | * | 0.89 | 0.06 |
| Weight 4, 20 Aug. | 382 | | 414 | 4.27 |
| ADG, 54d | 0.70 | | 0.75 | 0.03 |
| Weight 5, 17 Sept. | 405 | | 436 | 4.72 |
| ADG, 28d | 0.81 | | 0.80 | 0.04 |
| Weight 6, 16 Oct. | 424 | | 458 | 5.30 |
| ADG, 29d | 0.64 | | 0.77 | 0.05 |
| Total ADG, 168d | 0.70 | * | 0.84 | 0.03 |

* Indicates a significant difference in ADG between tall fescue and alfalfa-tall fescue during these two grazing periods and for the total season according to Fisher's protected LSD ($P < 0.05$).

stands fertilized with N. Pure grass stands fertilized with N generally have lower quality than grass-legume mixtures (Blaser et al., 1956).

In conclusion, climatic conditions and management had large effects on forage mass, quality, and steer performance of N-fertilized endophyte-free tall fescue and alfalfa-endophyte-free tall fescue mixtures over the 2002 and 2003 grazing seasons. Nitrogen fertilization increased the mass of pure tall fescue over alfalfa-tall fescue under the climatic conditions of 2002. Limited N fertilization could be considered for alfalfa-tall fescue mixtures to increase forage mass.

These experimental results suggest that plant height is not a valid measurement to predict forage mass in alfalfa-tall fescue or pure tall fescue. Bulk-height using a disk meter should provide more accurate predictions, but previous research indicates neither method is suited for pastures with an excessive accumulation of mature plant residues caused by undergrazing and trampling (Vartha and Matches, 1977). The consistent high quality of the alfalfa-tall fescue mixtures in this experiment agrees with the literature, but quality was not consistent with higher animal gain. The addition of alfalfa to tall fescue stands should not be detrimental to the stand, but may not always translate into improved gain. Both alfalfa-tall fescue and N-fertilized endophyte-free tall fescue have potential to produce high ADG in beef steers.

Climatic conditions optimum for tall fescue growth was the most likely factor causing alfalfa decline in alfalfa-tall fescue mixtures in 2003, but grazing management may have been an additional factor reducing alfalfa competition. Future studies should have stocking rate high enough to graze down the pastures in 7 to 10 days. Additionally, a grazing-tolerant alfalfa cultivar should be interseeded with tall fescue to increase alfalfa competition.  Endophyte-free tall fescue appears to have similar performance to alfalfa-tall fescue, but alfalfa-tall fescue provided higher quality and a more consistent increase in ADG.

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