CHAPTER III

Management of Alfalfa-Tall Fescue Mixed Stands

ABSTRACT

Tall fescue (*Festuca arundinacea* Schreb.) and alfalfa (*Medicago sativa* L.) have many desirable forage qualities, are grown extensively throughout the USA, and combined would make a productive pasture mixture. The objective of this experiment was to determine the effects of defoliation height and frequency on botanical composition and persistence of alfalfa-tall fescue pastures. Six Angus or Angus crossbred steers were rotationally stocked on four 0.6 ha paddocks (replications) for approximately 2 wk grazing periods with 4 wk (short) and 8 wk (long) rest periods in 2002 and 2003. Herbage within wire exclosures was harvested at a 3.8, 7.6, and 12.7 cm defoliation height at each grazing period, separated for botanical composition, and weighed for forage mass. Plant persistence was measured using plant counts, visual percent cover estimation, point quadrat counts, and occupancy counts through both grazing seasons. Twenty alfalfa cultivars were also interseeded into existing tall fescue stands at three locations to evaluate cultivar persistence. In 2002 and 2003 a shorter defoliation height (3.8 cm) favored alfalfa competition in alfalfa-tall fescue mixtures as compared to a taller height (12.7 cm) at two sampling dates. Tall fescue was more competitive at a 12.7 cm defoliation height than a 3.8 or 7.6 cm defoliation height at three sampling dates across years. A long rest period between defoliation maintained alfalfa in the mixed stands better than the short rest period at both sampling dates in 2002. Defoliation height and rest period did not have a consistent effect on alfalfa plant persistence, but tall fescue persistence was higher at the 12.7 cm defoliation height for three sampling dates in 2003. Alfalfa botanical composition and plant persistence decreased to zero during the wet

2003 season, likely due to increased mortality from root and crown diseases and tall fescue competition. Alfalfa cultivars showed no persistence differences, therefore more grazing seasons are required. These results show that under the climatic conditions and management of this experiment defoliation height had only a limited effect on alfalfa competition with tall fescue, but supports previous research that long rest periods benefit alfalfa in mixed stands.

INTRODUCTION

Alfalfa (*Medicago sativa* L.) is one of the most important forages in the United States. It has high yield potential, high levels of protein, high quality, and broad adaptation (Lacefield et al., 1987). Although the majority of alfalfa grown in the USA is managed for hay production, it is also a valuable grazing crop. Most experts recommend that alfalfa for grazing should be managed similar to alfalfa for hay production (Dougherty and Absher, 1987), and grazing studies have confirmed that alfalfa does best under rotational stocking (Allen, 1985). Alfalfa in rotationally stocked pastures has higher quality than under continuous stocking because the plants tend to regrow more uniformly (Popp et al., 2000). Grazing should begin when the alfalfa is in the late bud to early bloom stage and should last no longer than 7 to 10 days (Lacefield et al., 1987). Ideally, alfalfa pastures should not be stocked for short periods (one or two days) except under high stocking densities because selective grazing can occur allowing undesirable weed species to increase (Dougherty and Absher, 1987). Alfalfa should be allowed to rest for approximately 28 to 35 days between grazing cycles (Gerrish, 1997).

Alfalfa is commonly grown in mixtures with perennial grasses for pastures. Alfalfa-grass mixtures have several advantages over pure stands of either grass or alfalfa including alfalfa's nitrogen fixation (Lanyon and Griffith, 1988), increased yield (McCloud and Mott, 1953), longer growing season (Katepa-Mupondwa et al., 2002), reduced soil erosion (Popp et al., 1997), and bloat reduction (Howarth, 1988). Although there are many advantages to growing alfalfa with grass, limitations include competitive interactions between the species. The best mixtures are those that contain a persistent alfalfa cultivar with a grass that has many desirable growth and adaptation characteristics.

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. Unfortunately, tall fescue competes with and reduces the survival of alfalfa, reducing the nutritive value of the mixture (Smith et al., 1992). In early spring and late autumn, tall fescue has vigorous tillering and crown expansion that competes with and shades alfalfa plants reducing photosynthesis and growth. Management is the most effective way to reduce the limitations associated with alfalfa-tall fescue mixtures. Seeding rate, seeding method, and fertilization are all important aspects of alfalfa-tall fescue establishment and maintenance. High tall fescue seeding rates can reduce the number of alfalfa plants and alfalfa yield. Tall fescue is also highly competitive with alfalfa for K (Chamblee and Lovvorn, 1953).

The majority of management research on alfalfa-tall fescue mixtures has been conducted under hay management, but cutting height and frequency studies provide insight for grazing management. Comstock and Law (1948) showed that frequent defoliation of alfalfa-tall fescue mixtures with short rest periods will result in an increased percentage of tall fescue as compared to alfalfa. Blaser et al. (1986) conducted research on regrowth response in alfalfa-orchardgrass mixtures. They observed that close defoliation reduced orchardgrass leaf growth leading to reduced light competition and increased alfalfa growth. Therefore, when the alfalfa-orchardgrass mixture was cut to 3.8 cm alfalfa showed a competitive advantage, but when the mixture was cut to 7.6 cm the orchardgrass had a competitive advantage. Similar results could be predicted in alfalfa-tall fescue mixtures, since tall fescue and orchardgrass have similar morphological characteristics and regrowth patterns.

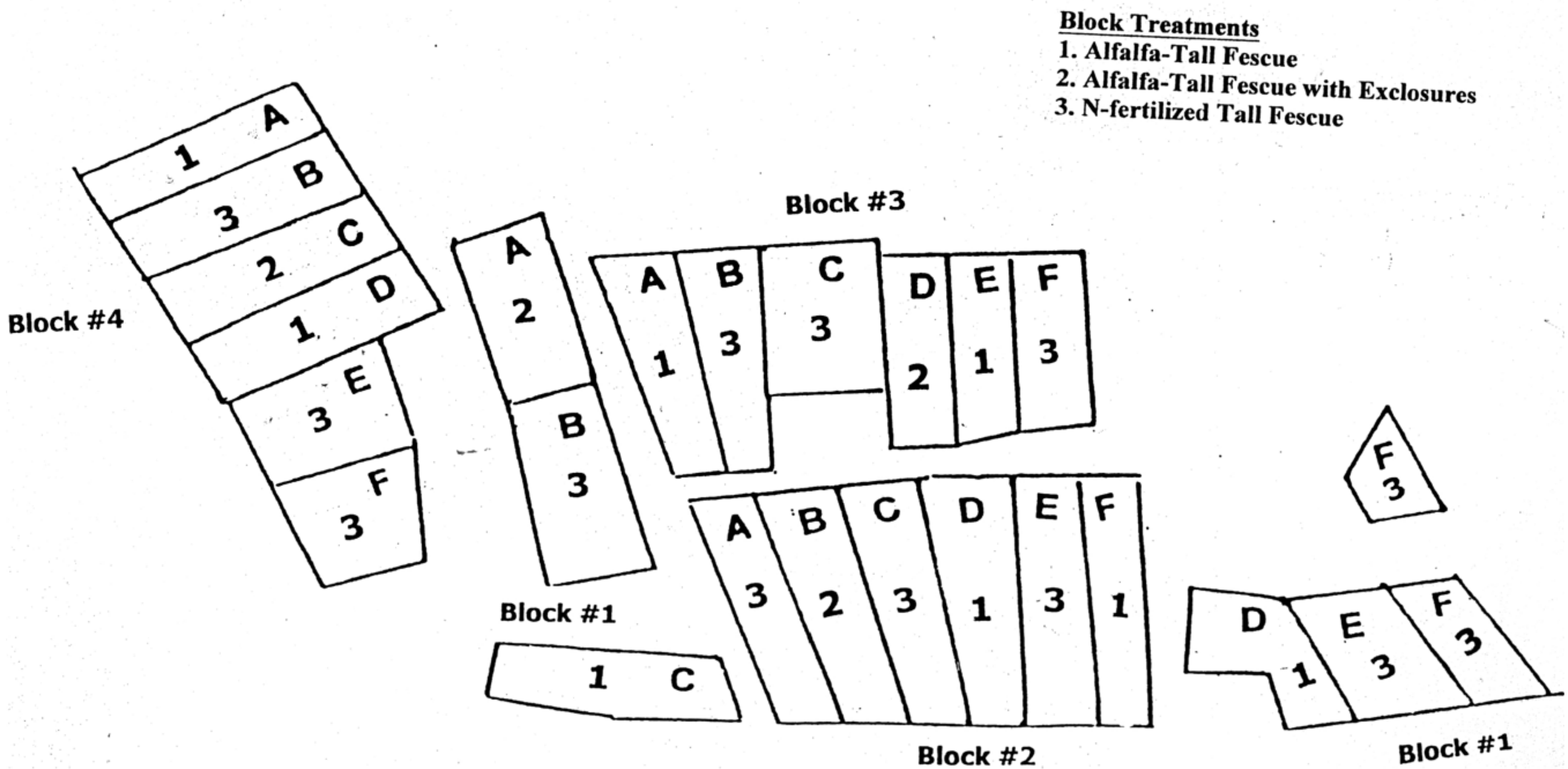
The first step in proper management of alfalfa-tall fescue mixtures is to choose a persistent, grazing-tolerant alfalfa cultivar. Several studies have been conducted to determine grazing-tolerant alfalfa cultivars. Different methods have been employed to evaluate grazing-tolerance in alfalfa including: biweekly clipping (Brummer and Bouton, 1991), frequent and infrequent clipping (Brummer and Bouton, 1992), continuous stocking in pure and mixed stands of alfalfa (Singh, 2000; Smith et al., 1989, 1992, 1993, 2000; Katepa-Mupondwa et al., 2002), and rotational stocking in pure stands of alfalfa (Bouton and Gates, 2003). Alfalfa cultivars tend to be less persistent in mixed stands as compared to pure stands due to competition with the grass species. Tall fescue is especially competitive with alfalfa due to its seasonal growth pattern. Tall fescue reduced the persistence of four alfalfa cultivars tested in the study conducted by Smith et al. (1992) under continuous stocking; even the most persistence cultivars were reduced by the tall fescue. Rotational stocking is the recommended management practice to maintain productivity and persistence of most alfalfa cultivars because it allows alfalfa to have a rest period between defoliation which is important for alfalfa recovery and survival (Dougherty and Absher, 1987). Consequently, combining persistent alfalfa cultivars with tall fescue under rotational stocking would appear to create and maintain a beneficial mixture.

The objective of this research was to determine the effects of defoliation height and frequency on botanical composition and persistence of alfalfa-tall fescue pastures and to determine the persistence of twenty alfalfa cultivars grown in mixed stands with tall fescue under rotational stocking.

MATERIALS AND METHODS

Experiment I. An experiment was conducted at the Virginia Tech Kentland Farm, Blacksburg during the late spring, summer, and early autumn of 2002 and 2003 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). The entire experimental area covered 14.4 ha divided into four blocks of six (0.6 ha) paddocks each (Fig. 1). Three paddocks in each block contained pure tall fescue and three contained an alfalfa-tall fescue mixture. One alfalfa-tall fescue paddock was selected within each block for this experiment, based on alfalfa plant counts and stand uniformity on 16 May 2002. These alfalfa plant counts were taken by counting the number of alfalfa plants contained in a 0.25 m^2 quadrat randomly placed eight times throughout each 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

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



(Smith and Bouton, 1993; Bouton and Gates, 2003; Brummer and Bouton, 1991; Smith et al., 1992). The eight samples were averaged to obtain an overall alfalfa plant count for each paddock. Paddocks labeled 1A, 2B, 3D, and 4C were chosen for this management experiment during the 2002 and 2003 grazing seasons.

In late September 2000 paddocks 1A, 2B, and 4C contained 'Triple Crown' alfalfa from a previous experiment and were interseeded with endophyte-free 'Forager' tall fescue at a seeding rate of 22.4 kg ha^{-1} with a Haybuster no-till drill (Haybuster Agricultural Products, Jamestown, ND). Paddock 3D was planted with Triple Crown alfalfa at 16.8 kg ha^{-1} and endophyte-free Forager tall fescue at 22.4 kg ha^{-1} in late September 2000 with a Haybuster no-till drill. Due to poor establishment, on 10 Apr. 2001 paddock 3D was sprayed with 2.1 kg a.i. ha^{-1} of glyphosate to kill the existing weedy stand. Paraquat and AD-Spray 80 Surfactant were applied at 0.47 kg a.i. ha^{-1} and 0.42 kg a.i. ha^{-1} on this same paddock on 11 Apr. 2001 to dessicate green plant material for planting. Paddock 3D was then seeded with Triple Crown alfalfa at 16.8 kg ha^{-1} and Forager tall fescue at 16.8 kg ha^{-1} on 15 Apr. 2001 with a Haybuster no-till drill. The other three paddocks (1A, 2B, 4C) were interseeded with Triple Crown alfalfa and Forager tall fescue both at 16.8 kg ha^{-1} with the Haybuster no-till drill on 16 Apr. 2001, but with no sod suppression. Soil tests were taken in all paddocks and indicated a pH range of 6.4-7.2 and optimum P and K fertility for alfalfa growth in 2002 and 2003.

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. 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).

Six Angus or Angus crossbred steers grazed the alfalfa-tall fescue paddocks and averaged 357 kg at the initiation of grazing in 2002 and 312 kg in 2003. Grazing 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 were allowed to graze each paddock down to an average of 10 to 12 cm in 2002 and 12 to 15 cm in 2003. Grazing usually lasted about 1.5 to 2 wk in 2002, with the exception of one 3 wk grazing period due to increased forage availability. The average grazing period in 2003 was 2 wk. Grazing periods in both years 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 due to the limited number of animals this was not possible. The steers grazed other alfalfa-tall fescue paddocks when not grazing the four paddocks in this experiment.

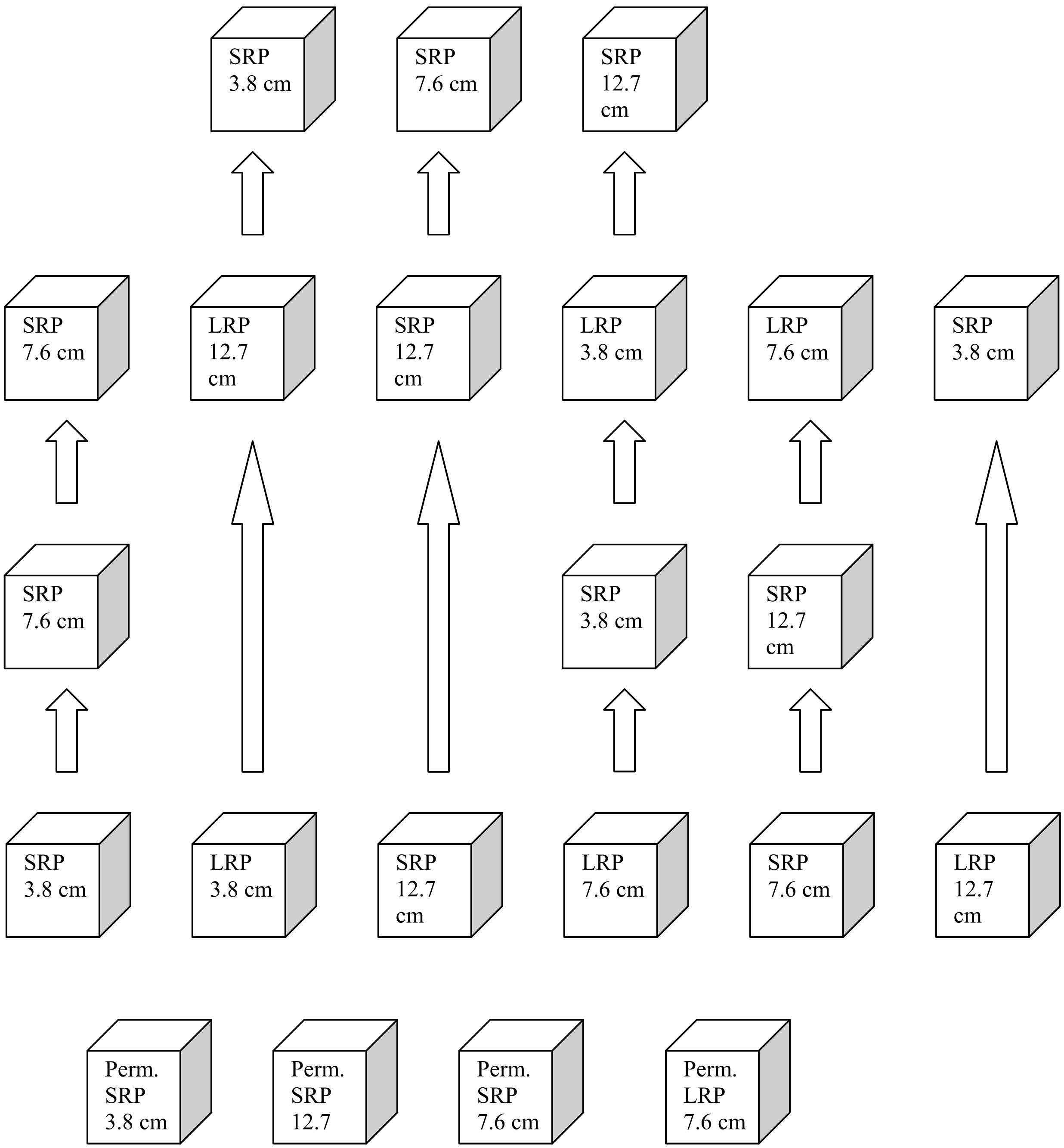
Movable wire exclosures were placed in the four experimental paddocks. Each wire exclosure was 1.3 m tall with three sides measuring 1.6 m wide and a 1.4 m wide gate, all constructed from 4.8 m long cattle panel purchased from the local agricultural supply store. The cattle panel was bent twice to form three equal sides and the gate was cut from another cattle panel. Exclosures were secured with 43.2 cm rebar stakes to exclude grazing. Eight wire exclosures were placed in each paddock in 2002 with an additional two exclosures added in 2003.

Exclosures were used to test the effects of defoliation height, rest period, month, and movement on botanical composition and persistence of alfalfa and tall fescue in the mixtures. Defoliation height effects were tested by clipping forage in the exclosures to 3.8, 7.6, and 12.7 cm. Rest period was the time interval between defoliations, a short and long rest period were used in this experiment. This period averaged one month for short rest period defoliation and two months for long rest period defoliation. Month represented the period between initial clipping to the specified height and subsequent clipping of regrowth after the designated rest period. Movement referred to whether the exclosures remained in the same place (permanent) throughout the season or moved to new locations after one regrowth period. Exclosure movement in one of the four experimental paddocks in 2003 is shown in Fig. 2 and followed the same pattern as 2002.

Six exclosures were moved to new locations after each sampling period to allow the normal defoliation, trampling, and manure effects of cattle on pasture. Three of these

Figure 2. Exclosure movement diagram for paddock 1A during the 2003 season at the Virginia Tech Kentland Farm, Blacksburg, VA.

Perm. = Permanent Exclosure
LRP = Long Rest Period
SRP = Short Rest Period



six exclosures were moved with each grazing period to simulate a short rest period (approximately every 4 wk in 2002 and 5 wk in 2003) and the other three exclosures were moved with every other grazing period to simulate a long rest period (approximately every 8 wk in 2002 and 10 wk in 2003)(Fig. 2). The three short rest period exclosures were clipped to the three defoliation heights (3.8, 7.6, and 12.7 cm), randomly assigned to each exclosure. Exclosures given a long rest period were also randomly assigned the three heights and clipped accordingly. Forage was clipped within each exclosure after being moved 4.6 m forward in the paddock to determine botanical composition, forage mass, and persistence of the mixture after initial clipping. Forage regrowth was then clipped within the exclosure before it was moved again to determine the effects of defoliation height and rest period on botanical composition and persistence. Clipping in the exclosures was conducted on 29 June, 25 July, 30 August, 23 September, 3 October, 22 October, 30 October, and 13 November 2002. Steers were moved at varying rates through the paddocks due to differences in forage regrowth, therefore resulting in staggered harvest dates. In 2003, clipping occurred on 23 April, 21 May, 25 June, 4 August, 10 September, and 17 October. The short rest period was approximately 4 wk in 2002 and 5 wk in 2003 and the long rest period averaged 8 wk in 2002 and 10 wk in 2003. The increased regrowth period under exclosures during 2003 was due to the increased forage availability caused by increased precipitation and the resulting longer grazing periods.

Two of the exclosures remained permanent in 2002 and four remained permanent in 2003. In 2002 both permanent exclosures were clipped to 7.6 cm, one with a short rest period and the other with a long rest period. Three of the permanent exclosures used in

2004 were clipped to the three defoliation heights with a short rest period and the other exclosure was clipped to 7.6 cm with a long rest period. The permanent exclosures were included to observe the effect of exclosure movement on forage regrowth and plant persistence. Permanent exclosures are much simpler to manage experimentally, but do not allow grazing at any point during the season.

The eight exclosures in 2002 provided six exclosures to test the effects of defoliation height, rest interval, and month with exclosure movement and two exclosures to test the effects of rest interval, month, and movement. During 2003 the additional two exclosures provided a measure of defoliation height at the permanent locations. Ideally, 12 exclosures per replication would have been used, but labor constraints for harvesting and separating samples caused this compromise.

Measurements within Exclosures

A 1 m^2 wooden quadrat was placed in each exclosure and the forage contained in the quadrat was clipped with battery operated Black and Decker electric hand clippers to the specified defoliation heights (3.8, 7.6, and 12.7 cm) and placed into a paper bag. After the forage in the 1 m^2 quadrat was clipped to the specified defoliation height, the quadrat was removed and the remaining area in the exclosure was also clipped to the specified height and removed. This procedure was conducted initially when an exclosure was moved to a new location and within the same exclosure a second time following the specified short or long rest period. In other words, clipping occurred twice at each exclosure location to determine the effect of defoliation height during the specified rest period. For permanent exclosures, clipping occurred within the same exclosure area at the specified height and rest period. The clippings from the 1 m^2 quadrat were separated by hand into alfalfa, tall fescue, and weeds and placed in a drier at 60°C for 48 to 72 hours. The dried forage was weighed to obtain the mass of the individual species and total mass.

Approximately 5 to 7 days after each clipping date persistence measurements were taken. The time interval between clipping and measuring persistence allowed some forage regrowth and measurements could be taken more easily and accurately. The 1 m^2 wooden quadrat was again placed within each exclosure location and the number of alfalfa plants contained in the quadrat was counted. Percent cover of alfalfa, tall fescue, and weeds were also visually estimated by the percentage of soil surface that was covered by the different plant canopies. A 1 m^2 point quadrat grid containing 25 points formed from intersecting wires set at 20.3 cm intervals was placed in each of the previous and current exclosure locations (Katepa-Mupondwa et al., 2002). The number of points directly over an alfalfa plant crown or tall fescue plant crown was counted for the basal area estimates. Sixteen squares were formed from the intersecting wire of the point quadrat grid and the number of squares that contained alfalfa plants and tall fescue plants was counted to give an occupancy measurement of each species. All of these measurements were taken to indicate plant persistence in the alfalfa-tall fescue mixture after defoliation to the different heights with the two rest periods.

Changes in alfalfa, tall fescue, and weed botanical composition were calculated to reflect the competitive interaction between alfalfa, tall fescue, and weeds under each treatment. The “percent” change calculation was especially important for the moved exclosures because each exclosure was placed on a new area of the pasture with each movement. It provided a practical means to factor in or adjust for different species composition levels at each new exclosure placement. Percent change values reflect how much species composition increased or decreased under an exclosure from the first defoliation to the second defoliation. These two defoliations occurred at the same height and at a predetermined rest period. Consequently, change in alfalfa, tall fescue, and weed botanical composition showed the effect that defoliation height, rest period, exclosure movement, and month had on alfalfa, tall fescue, and weed composition in a mixed stand.

Alfalfa plant counts and visual percent cover estimates of alfalfa, tall fescue, and weeds were taken at the 2002 exclosure placements 17 April and 10 Nov. 2003 to determine the residual effects of exclosures from the previous year. These plant counts and percent stand estimates also gave an indication of alfalfa or tall fescue winter injury.

Statistical Analysis

The entire experiment was analyzed using the analysis of variance (ANOVA) outline in Table 1. ANOVA was determined using the Statistical Analysis Systems Mixed Procedure (Littell et al., 1996; Bowley, 1999). When variables and interactions were analyzed and found to be not significant ($P < 0.05$), variables were combined and means were analyzed. Treatment means were compared using Fisher's protected least significant difference procedure (SAS, 1990). Pearson's correlation coefficient was used to determine the relationship between alfalfa plant counts, alfalfa percent cover, alfalfa occupancy, and point quadrat measurement. Correlation coefficients were also determined for tall fescue percent cover and tall fescue occupancy.

Table 1. Skeletal analysis of variation (ANOVA) with degrees of freedom for Experiment I. Effects of defoliation height and frequency on alfalfa and tall fescue grown in mixed stands at the Virginia Tech Kentland Farm, Blacksburg, VA.

Source of Variation	Degrees of Freedom	
	Short Rest Period	Long Rest Period
Block	3	3
Month	4	1
Error (a)	12	3
Height	2	5
Month x Height	8	5
Error (b)	30	30
Total	59	47
	Short Rest Period (2003)	
Block	3	
Height	2	
Moved Status	1	
Height x Moved Status	2	
Error (a)	15	
Month	4	
Height x Month	8	
Moved Status x Month	4	
Height x Move x Month	8	
Error (b)	72	
Total	119	
	Combined Across Time (Short and Long Rest Periods)	
Blocks	3	
Month	1	
Error (a)	3	
Height	2	
Rest Period	1	
Height x Rest	2	
Height x Month	2	
Month x Rest	1	
Rest x Height x Month	2	
Error (b)	30	
Total	47	

Table 1. Continued.

Source of Variation	Degrees of Freedom
Combined Across Time (Short and Long Rest Periods)	
Blocks	3
Rest Period	1
Moved Status	1
Rest x Moved Status	1
Error (a)	9
Month	1
Rest x Month	1
Moved Status x Month	1
Rest x Move x Month	1
Error (b)	12
Total	31

Experiment II. Twenty alfalfa cultivars were seeded at 13.5 kg ha^{-1} into existing endophyte-infected tall fescue pastures at the Virginia Tech Kentland Farm in Blacksburg, Glade Springs Agricultural Research and Experiment Center (AREC), and Steeles Tavern AREC on 2 April, 5 April, and 29 Mar. 2002 with a 6 ft Great Plains no-till drill (Great Plains Manufacturing, Inc., Salina, KS). Seed was inoculated with *Rhizobium meliloti* and seeded in 1.8 by 6.1 m plots in 19 cm rows in a randomized complete block design with four replications. Blocks were separated by 1.8 m, 2.4 m, and 3.1 m alleys at Steeles Tavern, Blacksburg, and Glade Springs, respectively, and experimental plots were located in paddocks that were 0.19 ha, 0.14 ha, and 0.33 ha in size at Blacksburg, Steeles Tavern, and Glade Springs. The alleys and borders were all planted with 'Ameristand 403T' alfalfa into the existing tall fescue. Lime had been applied to the area where the test was planted at Steeles Tavern at 3,363 kg ha^{-1} on 14 Dec. 2001. Soil fertility of paddocks at all three ARECs was maintained according to soil test recommendations. In 2003, two additional studies containing the same twenty alfalfa cultivars were seeded using the same experimental protocol as 2002 into existing tall fescue pastures at Blacksburg and Steeles Tavern on 3 April and 24 Apr. 2003 to provide additional information and due to unsatisfactory establishment for the 2002 Steeles Tavern experiment. The 2003 Steeles Tavern experiment was seeded into a 0.33 ha paddock and the Blacksburg experiment was seeded into a 0.22 ha paddock.

All sites were prepared for seeding by first grazing then mowing with a lawn mower and spraying paraquat to suppress regrowth of forage before planting. Fertilizer was also applied according to soil test recommendations before planting. Paraquat and surfactant were applied at 0.42 kg ha^{-1} and 0.38 kg a.i. ha^{-1} on the experimental paddock at Glade Springs on 22 Mar. 2002 before seeding (Table 2).

At Steeles Tavern paraquat and surfactant were applied at 0.42 kg ha^{-1} and 0.38 kg a.i. ha^{-1} on 15 Mar. 2002. In 2003, paraquat and surfactant were applied to the new Steeles Tavern experimental site at 0.32 kg a.i. ha^{-1} and 0.38 kg a.i. ha^{-1} on 21 Mar. The paraquat and surfactant application was repeated on 16 Apr. 2003 at the same rates used previously because the forage was not completely killed with the first application due to cool, moist conditions. On 17 Apr. 2003 lime was applied at 4,484 kg ha^{-1}.

Paraquat and surfactant were applied at 0.42 kg a.i. ha^{-1} and 0.38 kg a.i. ha^{-1} at Blacksburg on 19 Mar. 2002. The new Blacksburg experimental site was sprayed with paraquat and surfactant at 0.32 kg a.i. ha^{-1} and 0.38 kg a.i. ha^{-1} on 20 Mar. 2003.

The twenty alfalfa cultivars included in the small plot experiments were 'Alfagraze', '5432', '54V54', 'AmeriStand 403T', 'FK 421', 'Geneva', 'GH 700', 'Haygrazer', 'Hybri 400', 'WL 326 GZ', ZG 0044, ZG 0240 HC, ZG 0240M, ZG 0150A, ZG 0151A, ZG 0152A, ZG 0160A, ZG 0161A, ZG 9910, and ZG 9934. Alfagraze was included as the grazing-tolerant check as per the North Am. Alfalfa Improvement Conf. Standard Test Manual (Bouton and Smith, 1998). Previous research has shown that the dual-purpose cultivar Alfagraze is highly productive and persistent under continuous grazing while maintaining root carbohydrates and residual leaf area (Smith et al., 1989). The winterhardy cultivar 5432 is a standard hay and haylage cultivar and was included as the grazing-intolerant check in this experiment (Bouton and Smith, 1998). Besides the two named cultivar checks, eight other commercial cultivars were included to cover the range of genetic material on the market today. The 54V54 alfalfa has been described as

Table 2. Pesticides used in establishment and maintenance of mixed stands with alfalfa cultivars interseeded into tall fescue at Blacksburg, Glade Springs, and Steeles Tavern.

Pesticide	Rate	Date	Location	Target
	kg a.i. ha^{-1}			
Paraquat‡	0.42	15 Mar. 2002	Steeles Tavern	suppress existing tall fescue stands for interseeding
	0.42	19 Mar. 2002	Blacksburg	
	0.42	22 Mar.2002	Glade Springs	
	0.32	20 Mar. 2003	Blacksburg	
	0.32	21 Mar. 2003	Steeles Tavern	
	0.32	16 Apr. 2003	Steeles Tavern	
AD-Spray 80 Surfactant§	0.38	15 Mar. 2002	Steeles Tavern	applied with paraquat
	0.38	19 Mar. 2002	Blacksburg	
	0.38	22 Mar.2002	Glade Springs	
	0.38	20 Mar. 2003	Blacksburg	
	0.38	21 Mar. 2003	Steeles Tavern	
	0.38	16 Apr. 2003	Steeles Tavern	

‡ 1,1’-dimethyl-4,4’-bipyridinium dichloride
§ Alkyl aryl polyalkoxylated glycols and derivatives

winterhardy, persistent, and disease resistant (Pioneer, 2004). AmeriStand 403T was selected for persistence under intensive grazing and the ability to maintain a healthy crown and root system (North Am. Alfalfa Improvement Conf., 2000a). FK 421 is tolerant of continuous stocking with healthy crowns and roots, but can also be used for hay production (North Am. Alfalfa Improvement Conf., 2002). Geneva was developed for forage yield, persistence, quality, and recovery after cutting (North Am. Alfalfa Improvement Conf., 1998). The GH 700 was selected for its multifoliate characteristic, disease resistance, and high feed value (North Am. Alfalfa Improvement Conf., 2000b). Haygrazer was developed for both hay production and grazing with high yields and persistence (Great Plains Research, 2004). Hybri 400 was the world's first hybrid alfalfa and exhibits high yield and fast recovery after cutting (D&D Seeds, 2004). The alfalfa cultivar WL 326 GZ was selected for persistent under grazing, as well as disease resistance (North Am. Alfalfa Improvement Conf., 1997). The ZG 0044, ZG 0240 HC, ZG 0240M, ZG 0150A, ZG 0151A, ZG 0152A, ZG 0160A, ZG 0161A, ZG 9910, and ZG 9934 were experimental cultivars from ABI, Inc.

Cattle were rotationally stocked in 2002 and 2003 on the five experiments. Grazing duration was short, averaging two to five days, to prevent selective grazing and cattle were allowed to graze the forage down to 7.6 to 10.2 cm. Rest period averaged 30 to 40 days during the grazing season with occasional haying. Due to the growth patterns, grazing behavior, and animal movement experiments were mowed and/or hayed during the 2002 and 2003 seasons as specified in the following paragraphs.

Twenty-two dry beef cows averaging 619 kg were placed on the 2002 Blacksburg experiment 13 May, 11 July, 18 September, and 2 December 2002. In 2003, approximately 20 dry beef cows were placed on the experiment 9 February, 28 April, 22 May, 10 July, and 25 November. The Blacksburg cultivar experiment was rotary mowed after grazing on 17 May and early July of 2002 to obtain consistent defoliation across all plots. In 2003, hay was disc mowed and baled from these plots on 28 May, rotary mowed on 15 July, and disc mowed and baled on 19 September to remove the forage that had accumulated since grazing in July.

Ten to fifteen open cows were placed on the Steeles Tavern experiment on 16 May and 23 May 2002. In 2003, 10 to 15 open cows or heifers were placed on the Steeles Tavern experiment on 17 March, 12 May, 24 June, 6 August, and 24 September. The alfalfa plots at Steeles Tavern were mowed with a lawn mower on a high setting (7.6 cm) on 22 May, 20 June, and 8 August 2002 to even out defoliation of the plots. The plots were also mowed after grazing on 15 May, 27 June, and 1 October 2003. Six to eight steers were placed on the Glade Springs experiment on 28 June, 6 August, and 10 September 2002. Lower animal numbers (weight) resulted in slightly longer grazing periods (5 to 7 days) at Glade Springs in comparison to the other locations. Thistle was spot sprayed in the alfalfa plots at Glade Springs on 18 July 2002. The Glade Springs experiment was also rotary mowed on 5 July, 12 August, and 18 September 2002 to remove plant height variability following grazing.

The alfalfa cultivar experiments planted in 2003 at Blacksburg and Steeles Tavern were also rotationally stocked in 2003 with an average grazing period of two to five days. This second Blacksburg experiment was grazed by 43 cows starting 17 June and 22 cows 30 July and 4 December. The second Blacksburg experiment was also disc mowed and baled on 28 May and 16 Sept. 2003. The second Steeles Tavern experiment was grazed by 10 to 15 cows starting 23 June and 4 August 2003. This experiment was mowed on 2 June, 27 June, and 7 August 2003.

Alfalfa plant counts and visual percent cover estimates were taken in the spring and autumn of 2002 and 2003. A 0.09 m^2 circular ring was randomly placed three times in each plot and the number of alfalfa plants contained in the 0.09 m^2 area was counted. The number of samples taken per plot was increased to four for autumn 2003 to account for increased within plot variation. Overall plant percent cover was visually estimated in each plot by the percentage of soil covered by plant material. Percent cover scores were taken approximately five to seven days after grazing to allow some regrowth and facilitate visual estimates. On 4 June, 7 June, and 14 June 2002 at Blacksburg, Steeles Tavern, and Glade Springs, respectively, alfalfa plant counts and visual estimates of grass percentage were taken for each plot. Alfalfa plant counts and visual estimates of grass and legume percentages were taken again in the autumn of 2002 on 8 October, 9 October, and 17 October at Steeles Tavern, Blacksburg, and Glade Springs. In the spring of 2003 alfalfa plant counts and visual percent cover estimates of grass and alfalfa were taken at Steeles Tavern, Glade Springs, and Blacksburg on 20 May, 4 June, and 10 June, respectively. These same measurements were taken again in the autumn on 20 October and 31 October 2003 at Steeles Tavern and Blacksburg. Alfalfa plant persistence was poor across the entire plot area at Glade Springs, therefore this experiment was terminated in autumn 2003.

ANOVA was performed on the plot means using the Statistical Analysis Systems (SAS, 1990). Cultivar treatments were considered fixed effects and the replications were considered random effects. Cultivar means were compared using the Duncan's Multiple

Range Test procedure due to six and twelve missing plots in the Steeles Tavern and Blacksburg experiments, respectively, planted in 2003 caused by a malfunction of the no-till drill during the seeding of these two tests.

RESULTS AND DISCUSSION

Experiment I. Results from this experiment are presented separately for 2002 and 2003 due to highly variable climatic conditions and different grazing season lengths between years.

Alfalfa Mass and Total Mass Production

Forage production in 2002 and 2003 is presented based on total mass harvested only from the 7.6 cm short rest period under exclosures (kg ha^{-1}) and the alfalfa proportion of the total (Table 3, 4). The remainder of the total was mostly tall fescue, although a certain proportion was comprised of annual grasses and broadleaf weeds (Table 5). It is important to note that forage mass production represents the regrowth that occurred during the short rest period between the initial clipping and the second clipping for each harvest date. Under the permanent exclosures forage mass over harvest dates represents the cumulative production for the season since the exclosures were always clipped to 7.6 cm. Only the 7.6 cm height was used since desired utilization height was 7.6 to 10.1 cm.

During 2002 there was a significant month effect for alfalfa and total mass. There was a rest x month interaction only for alfalfa mass which was due to a significant rest effect on 30 Oct. 2002, when the long rest period produced more alfalfa mass (803 kg

Table 3. Alfalfa and total biomass production (alfalfa, tall fescue, annual grasses, weeds) from alfalfa-tall fescue pastures clipped at 7.6 cm from wire exclosures compared across the 2002 season at the Virginia Tech Kentland Farm, Blacksburg, VA.

Yield	25 July	30 Aug.	3 Oct.	30 Oct.
	kg ha^{-1}			
Alfalfa	557a	220b	477a	17c
Total	971a	630b	1164a	339c

F probability of main effects and interactions	Alfalfa	Total
Move	NS	NS
Month	*	*
Move x month	NS	NS
Rest	NS	NS
Rest x move	NS	NS
Rest x month	*	NS
Rest x move x month	NS	NS

* Significant at P < 0.01; NS = non-significant.

† Within row, means followed by the same letter are not significantly different based on Fisher's protected LSD (P < 0.05).

Table 4. Alfalfa and total biomass production (alfalfa, tall fescue, annual grasses, weeds) from alfalfa-tall fescue pastures clipped at 7.6 cm from wire exclosures compared across the 2003 season at the Virginia Tech Kentland Farm, Blacksburg, VA.

Yield	21 May	25 June	4 Aug.	10 Sept.	17 Oct.
			kg ha^{-1}		
Alfalfa	228a	299a	90b	9b	0b
Total	2059b	2170ab	2537a	2008b	525c

F probability of main effects and interactions	Alfalfa	Total
Move	NS	NS
Month	*	*
Move x month	NS	NS
Rest	NS	NS
Rest x move	NS	NS
Rest x month	NS	*
Rest x move x month	NS	NS

* Significant at P < 0.01; NS = non-significant

† Within row, means followed by the same letter are not significantly different based on Fisher's protected LSD (P < 0.05).

Table 5. Alfalfa, tall fescue, and weed botanical composition from alfalfa-tall fescue pastures clipped at 7.6 cm from wire exclosures during the 2002 and 2003 seasons at the Virginia Tech Kentland Farm, Blacksburg, VA.

	2002				
	2 July	25 July	30 Aug.	3 Oct.	30 Oct.
	%				
Alfalfa	75.5a†	58.1a	28.8b	42.6b	3.4c
Fescue	20.6d	37.8c	63.1b	52.3bc	96.6a
Weeds	3.9a	4.1a	8.1a	5.1a	0.0a

	2003					
	23 Apr.	21 May	25 June	4 Aug.	10 Sept.‡	17 Oct.§
	%					
Alfalfa	50.1a	10.9bc	11.1b	4.4bc	0.4c	0c
Fescue	48.9b	87.8a	88.6a	85.4a	89.2a	89.0a
Weeds	1.0b	1.2b	0.3b	10.0a	4.0ab	0.0b

† Within in a row, means followed by the same letter are not significantly different based on Fisher's protected LSD ($P < 0.05$).

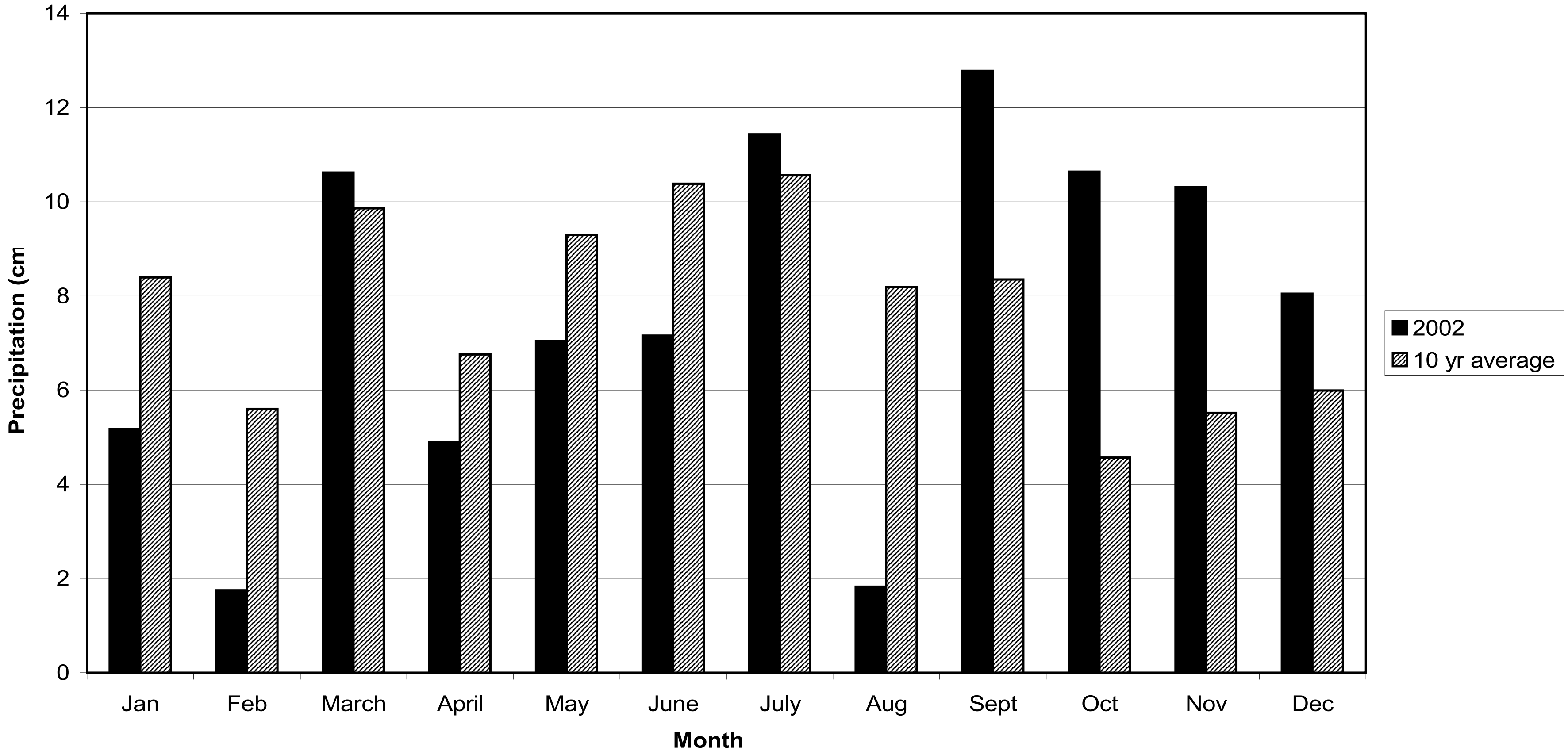
‡ On 10 Sept. alfalfa-tall fescue samples also contained 2% crabgrass and 4.4% dead plant material (mostly tall fescue).

§ On 17 Oct. alfalfa-tall fescue samples also contained 11% dead plant material (mostly tall fescue).

ha^{-1}) than the short rest period (492 kg ha^{-1}). Since the interaction was created at only one harvest date and move was not significant across the season, results for alfalfa mass were combined for the permanent and moved exclosures and shown only for the short rest period (Table 3). Short rest period results most closely represent the mass available to the steers, since a short rest period was used in the actual steer rotation. In the absence of interactions total mass was combined across exclosure movement and are presented for the short rest period for each harvest date. In 2003, there was a month effect on alfalfa and total mass production. There was a rest x month interaction for total mass, but when rest period was compared for total mass for the periods May to June and August to September there were no significant differences between the two rest periods. Therefore, mass results were combined across exclosure movement and are shown for the short rest period (Table 4).

Alfalfa and total mass decreased throughout the 2002 season with the exception of an increase during September (as indicated by the 3 October harvest) (Table 3). The seasonal decrease follows a typical cool season production pattern and the September increase was most likely caused by cooler temperatures and September rainfall of 12.8 cm (Fig. 3). August and October alfalfa and total mass production was lowest for the season. The low mass in August can be explained by the low total precipitation during the month (1.8 cm) and the cumulative effect of three dry years on subsoil moisture. Precipitation was higher in October (10.6 cm), but air temperature decreased from September to October (19.3 to 12.6 °C). Alfalfa was well below its maximum growth temperature of 27°C by October (McKenzie et al., 1988). Additionally, fall dormancy is initiated with decreasing photoperiod and temperatures below 15.5°C (Schonhorst et al.,

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.**

1957). Total mass production during October would likely have been higher with the addition of a late summer N application, since it was composed mainly of tall fescue (Table 5).

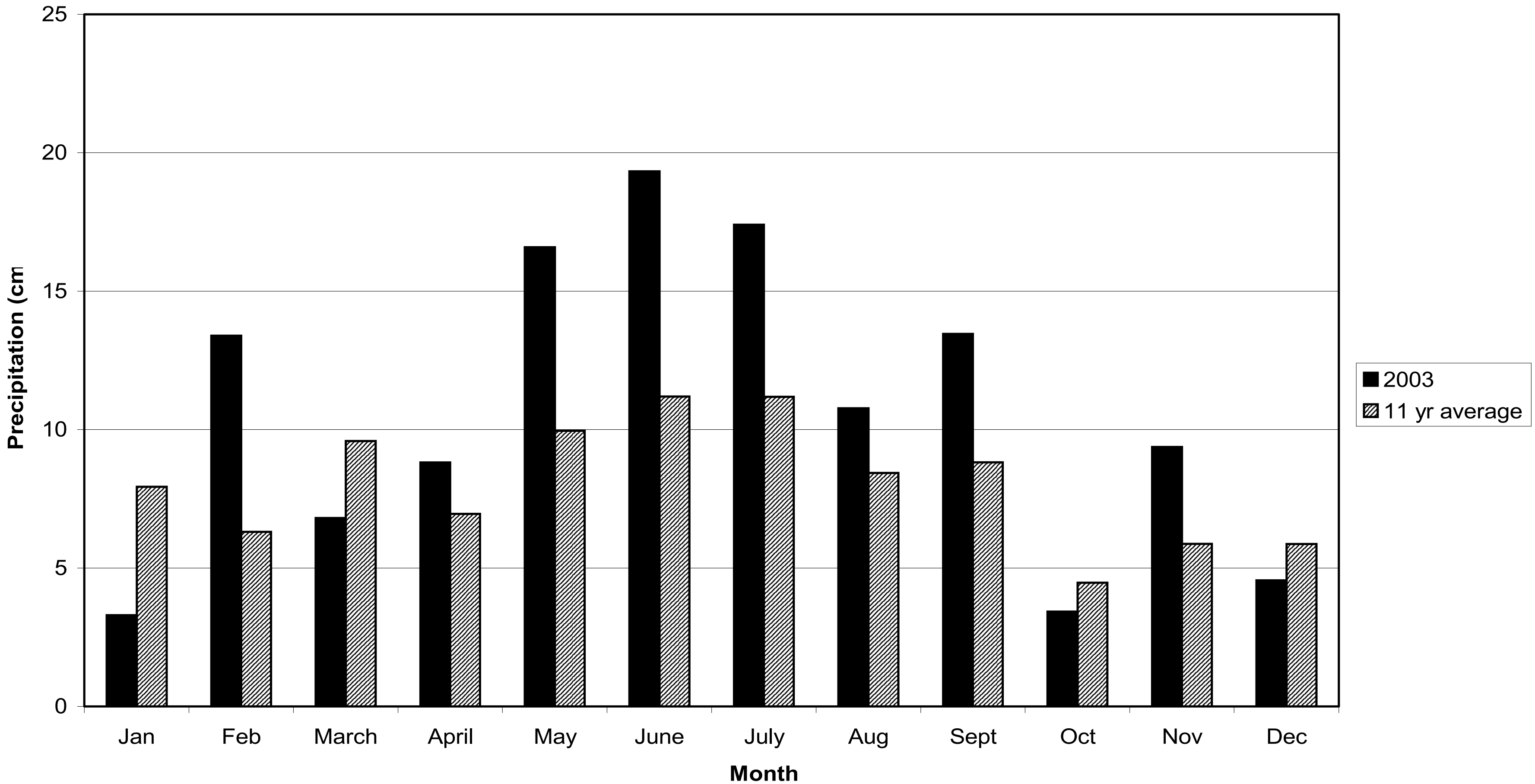
Alfalfa mass production decreased during 2003 with the highest mass at the beginning of the season in May and June (Table 4). The largest decrease in alfalfa mass occurred during July and there was no alfalfa under the exclosures by the end of the season. Precipitation remained high during May, June, and July (16.6, 19.3, and 17.4 cm, respectively, Fig. 4) with temperatures averaging 18.5 °C during this summer period, creating an ideal environment for tall fescue growth as reflected by the high mass production comprised almost entirely of tall fescue (Table 5) (Cooper and Tainton, 1968)(cited by Burns and Chamblee, 1979).

<u>Alfalfa Botanical Composition</u>

Alfalfa botanical composition represents the alfalfa portion of the samples harvested from the wire exclosures. The alfalfa portion of the samples harvested at the 7.6 cm height showed similar trends in 2002 as the alfalfa mass discussed previously. There was a decrease in alfalfa botanical composition across the season with an increase during September (Table 5), likely caused by an increase in precipitation during the month (Fig. 3). Unlike the alfalfa mass data, alfalfa composition for 3 Oct. 2002 was not significantly higher than alfalfa composition on 30 Aug. 2002. Lower temperatures and decreasing photoperiod caused the significant reduction in percent alfalfa during October (Table 5).

The high alfalfa composition on 23 Apr. 2003 (50.1%) indicated that the low composition during the autumn of 2002 was not due to plant mortality, but was solely a

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.**

reflection of fall dormancy. Adequate spring moisture (Fig. 4), optimum temperatures, and the resulting low evapotranspiration greatly benefited alfalfa spring growth (Daigger et al., 1970). Alfalfa botanical composition declined during the remainder of the 2003 season likely due to the favorable conditions for tall fescue growth. Tall fescue is usually most competitive with alfalfa during the spring and late autumn when it has vigorous tillering and crown expansion (Smith et al., 1992). These results show that tall fescue was able to out-compete alfalfa even during the summer months, when alfalfa is expected to have better performance. Above average precipitation during the summer months contributed to the decrease in alfalfa because waterlogged soils can cause root and crown diseases to develop, while livestock grazing and equipment on saturated soils damage the alfalfa crowns and roots by trampling and soil compaction (Gerrish, 1997). Reduced alfalfa growth also allowed the tall fescue plants to dominate. These results are similar to those reported by Smith et al. (1992) where tall fescue reduced the persistence and botanical composition of all alfalfa cultivars in their study. Chamblee and Lovvorn (1953) also reported that tall fescue suppressed alfalfa growth by shading the crown buds, inhibiting elongation, and increasing alfalfa mortality.

Grazing management of the paddocks also likely contributed to the decline in alfalfa composition. Steers were not allowed to graze the paddocks down as closely as would be desired for alfalfa due to the high production of forage in all paddocks. Grazing periods were also longer than suggested for alfalfa management in 2003 due to the high forage availability. Steers were rotated before the forage was grazed down to the desired height to maintain forage quality in all of the paddocks. Alfalfa-tall fescue mixtures had a 4 to 5 wk rest interval between grazing. Hoveland et al. (1995) showed that alfalfa was reduced in their mixtures when cut at 3 and 4 wk intervals as compared to a 6 wk interval. They were able to maintain alfalfa in their alfalfa-tall fescue mixtures by seeding the grazing-tolerant Alfagraze cultivar (Smith et al., 1989) with endophyte-free 'AU Triumph'. Additionally, Triple Crown used in this research has not been shown to be grazing-tolerant, further contributing to the depletion of alfalfa in these mixed stands. Alfalfa botanical composition also declined in the permanent exclosures which were not affected by grazing management, therefore climatic conditions in 2003 were mostly responsible for the decline in alfalfa.

Tall Fescue Botanical Composition

Tall fescue botanical composition reported on a percent basis represents the tall fescue portion of the samples harvested from the wire exclosures. Tall fescue composition harvested at the 7.6 cm height showed the opposite trend than that of alfalfa composition in 2002 (Table 5). Tall fescue composition increased as the season progressed with a slight decrease for the month of September. Increased precipitation during September (Fig. 3) encouraged alfalfa growth which led to a subsequent decrease in the composition of tall fescue in the mixture. Precipitation remained above average for October 2002, but temperatures became cooler (12.6 °C) creating an ideal atmosphere for tall fescue growth resulting in a large increase in tall fescue botanical composition (Table 5).

Tall fescue contributed almost one-half of the botanical composition of the alfalfa-tall fescue mixtures early in the second grazing season, 23 Apr. 2003 (Table 5). Adequate spring moisture created an almost perfect mixture of 50% alfalfa and 50% tall fescue at this date. The percent botanical composition of tall fescue in the mixtures increased throughout the rest of the 2003 season due to above average precipitation from May through September coupled with moderate temperatures (Fig. 4). Average monthly air temperatures for the 2003 season were close to or in the range of 20 to 25°C, where maximum tall fescue growth occurs (Cooper and Tainton, 1968)(cited by Burns and Chamblee, 1979). Tall fescue prefers to have adequate moisture and soils with a heavy to medium texture (Buckner and Cowan, 1973), which is characteristic of Unison-Braddock soils. Tall fescue is also able to tolerate waterlogging, while alfalfa growth declines under these conditions.

Weed Botanical Composition

Weeds in the alfalfa-tall fescue pastures were annuals such as crabgrass (*Digitaria* sanguinalis), redroot pigweed (*Amaranthus retroflexus*), pepperweed (*Lepidium virginicum*), and chickweed (*Stellaria media*); biennials such as thistle (*Cirsium arvense*); and perennials such as horsenettle (*Solanum carolinense*), dandelion (*Taraxacum officinale*), broadleaf plaintain (*Plantago major*), wild onion (*Allium validum*), and nimblewill (*Muhlenbergia schreberi*). Weed botanical composition remained low for 2002 (Table 5). Weed botanical composition increased during July in 2003 likely due to a slight decrease in precipitation (19.33 to 17.40 cm) and an increase in temperature (18.85 to 21.29 °C). The botanical composition of weeds in the alfalfa-tall fescue mixtures decreased to zero by October 2002 and 2003. Temperatures dropped during this month, increasing or maintaining tall fescue and decreasing weeds. There was also 2% crabgrass and 4.4% dead plant material comprised mostly of tall fescue on 10 September 2003 and 11% dead plant material on 17 October 2003 this resulted from an accumulation of mature plant material caused by optimum growing conditions and the subsequent death of underlying tall fescue.

Alfalfa Botanical Composition Change

There was a significant defoliation height and month effect on the change in alfalfa botanical composition for 2002 and 2003 when calculated for the short rest period (Table 6). The combined effect of exclosure movement and height could be determined in 2003 with the addition of the 3.8 and 12.7 cm defoliation heights to the permanent exclosures. Although there was no move effect in 2003, there was a significant move x month interaction, and graphical analysis indicated that the interaction occurred in July (data not shown). Therefore, permanent and moved exclosure results were analyzed separately for 2003.

The results for change in alfalfa botanical composition for the moved exclosures showed that alfalfa was more competitive ($P < 0.07$) when defoliated to 3.8 cm than 12.7 cm during July 2002 (Table 6). A similar result occurred under the permanent exclosures in May 2003, where the 12.7 cm defoliation height caused a larger decrease in alfalfa composition than either the 3.8 or 7.6 cm heights. Alternatively, the composition of alfalfa increased when defoliated to 12.7 cm in September 2003 while the 3.8 and 7.6 cm height caused alfalfa to decrease, but these changes were small due to the low amounts of alfalfa in the mixtures at the end of the 2003 season. The July 2002 and May 2003 results cited above parallel the findings of Blaser et al. (1986), where they demonstrated that alfalfa is able to remain competitive in a mixture with orchardgrass if defoliated to 3.8 cm, but orchardgrass has a competitive advantage at a 7.6 cm defoliation height. The partial defoliation of alfalfa that occurs at taller defoliation heights (e.g., 7.6 and 12.7 cm)

Table 6. Influence of defoliation height on change in alfalfa botanical composition under short rest period exclosures in alfalfa-tall fescue pastures in 2002 and 2003 at the Virginia Tech Kentland Farm, Blacksburg, VA.

Stubble Height	2002 July	2002 Aug.	2002 Sept.	2002 Oct.	2003 May	2003 June	2003 July	2003 Aug.	2003 Sept.
	% Change†								
Moved Exclosures									
3.8 cm	-7.5a§	-31.9a	18.3a	-42.8a	-33.0a	4.3a	-0.3a	-1.9a	-0.6b‡
7.6 cm	-17.3ab	-33.4a	13.8a	-39.2a	-39.2a	4.3a	-8.0a	-4.0a	-0.4b
12.7 cm	-25.8b	-49.5a	6.6a	-43.7a	-38.7a	-1.0a	-2.8a	-3.0a	0.4a
Permanent Exclosures									
3.8 cm	—¶	—	—	—	-24.6a‡	7.1a	-12.7a	-3.6a	-0.1a
7.6 cm	—	—	—	—	-28.3a	8.6a	-11.2a	-3.1a	-0.5a
12.7 cm	—	—	—	—	-45.8b	5.2a	-12.7a	-3.4a	-0.2a

F probability of main effects and interactions	2002	2003
Height	*	*
Month	**	**
Height x month	NS	NS
Move	N/A	NS
Move x month	N/A	**
Height x move	N/A	NS
Height x move x month	N/A	NS

*,** Significant at $P < 0.05$ and $P < 0.01$, respectively; NS = non-significant.

† % Alfalfa Change = (Alfalfa Wt. 2nd Harvest/Total Yield 2nd Harvest)*100 – (Alfalfa Wt. 1st Harvest/Total Yield 1st Harvest)*100

‡ Within date, means followed by the same letter are not significantly different based on Fisher's protected LSD ($P < 0.05$).

§ Within date, means followed by the same letter are not significantly different based on Fisher's protected LSD ($P < 0.07$).

¶ Defoliation height not included in treatments for permanent exclosures in 2002.

produces new stem growth from axillary buds, which suppresses regrowth from crown buds and results in weak branches and reduced yield (Dougherty and Absher, 1987).

The effect of rest period on change in alfalfa botanical composition was compared at the 7.6 cm defoliation height, because permanent long rest period exclosures only included the 7.6 cm defoliation height due to limited time and labor. There was a significant rest period and month effect for change in alfalfa composition in both 2002 and 2003 (Table 7). The effect of exclosure movement was also significant in 2003. The permanent and moved exclosure results were combined for 2002 and analyzed over the two rest periods. The 2003 results only compared the effect of rest period from the moved exclosures. The permanent exclosure results were not reported because there was no rest period effect on change in alfalfa botanical composition.

In Table 7 change in alfalfa botanical composition was presented over a two month time period since the long rest period was included. Change in alfalfa botanical composition under the short rest period was calculated by comparing the composition at the beginning of the two month period for the short rest period exclosures to composition at the end of the two month period under these same short rest period exclosures. In 2002 there was a larger decrease in alfalfa composition from the beginning of July to the end of August with the short rest period than the long rest period (Table 7). Similarly, from September to the end of October 2002 there was a 26% decrease in alfalfa composition with the short rest period, but no decrease under the long rest period. During 2003, with high rainfall and strong fescue competition alfalfa composition decreased equally for both rest periods during May to June and July to August. Results for 2002 suggest that a longer rest period may be more favorable for maintaining alfalfa in alfalfa-tall fescue

Table 7. Influence of rest period on change in alfalfa botanical composition clipped at 7.6 cm under exclosures in alfalfa-tall fescue pastures in 2002 and 2003 at the Virginia Tech Kentland Farm, Blacksburg, VA.†

Rest Period	2002		2003	
	July - Aug.	Sept. – Oct.	May - June	July – Aug.
	% Change‡			
Short	-46.7b§	-26.2b	-47.5a	-8.5a
Long	-11.8a	0.2a	-40.1a	-10.7a

F probability of main effects and interactions	2002	2003
Rest	**	NS
Month	**	**
Rest x month	NS	NS
Move	NS	NS
Move x month	NS	*
Move x rest	NS	NS
Move x rest x month	NS	*

*,** Significant at P < 0.05 and P < 0.01, respectively; NS = non-significant.

† Results at 7.6 cm defoliation height combined from moved and permanent exclosures.

‡ % Change = (Alfalfa Wt. 2^{nd} Harvest/Total Yield 2^{nd} Harvest)*100 – (Alfalfa Wt. 1^{st} Harvest/Total Yield 1^{st} Harvest)*100

§ Within date, means followed by the same letter are not significantly different based on Fisher's protected LSD (P < 0.05).

mixtures. Hoveland et al. (1995) had similar results in their study to determine the effects of different management strategies on Alfagraze alfalfa-tall fescue mixtures. The alfalfa component of their mixtures was reduced when the mixtures were harvested at 3 and 4 wk intervals, when compared to a 6 wk interval. These results seem to confirm the conclusions of Hoveland et al. (1995) which proposed that a long rest period is favorable for a grazing-tolerant alfalfa cultivar such as Alfagraze (Bouton and Smith, 1998) and cultivars like Triple Crown that have not been selected for grazing tolerance. Longer rest periods should maintain alfalfa composition in alfalfa-tall fescue mixtures better than shorter rest periods with any alfalfa cultivar since alfalfa's crown and taproot have a longer recovery period and time to develop new crown buds (Dougherty and Absher, 1987).

Tall Fescue Botanical Composition Change

Change in tall fescue botanical composition was calculated on the same basis as change in alfalfa botanical composition. In 2002, there was a height ($P < 0.06$) and month effect on change in tall fescue composition (Table 8). As with change in alfalfa composition change, change in tall fescue botanical composition was not analyzed for exclosure movement in 2002 for the short rest period since heights were not part of the permanent exclosure treatments. In 2003 there was a month effect, move effect, and a height x month interaction for change in tall fescue botanical composition.

Tall fescue was more competitive with alfalfa when the mixtures were defoliated to 12.7 cm as compared to 3.8 cm in July 2002 in the moved exclosures and May 2003 in the permanent exclosures (Table 8). Interestingly, the 3.8 cm stubble height was more favorable for tall fescue in September 2003 compared to 7.6 and 12.7 cm. In July 2002

Table 8. Influence of defoliation height on change in tall fescue botanical composition under short rest period exclosures in alfalfa-tall fescue pastures in 2002 and 2003 at the Virginia Tech Kentland Farm, Blacksburg, VA.

Stubble Height	2002				2003				
	July	Aug.	Sept.	Oct.	May	June	July	Aug.	Sept.
	% Change†								
Moved <u>Exclosures</u>									
3.8cm	7.9b‡	17.8a	-15.0a	46.0a	30.9a	-5.6a	-3.1a	-0.3a	-6.6a
7.6cm	17.2ab	11.8a	-10.8a	44.4a	38.9a	-5.0a	-3.2a	3.9a	-0.2a
12.7cm	25.9a	45.8a	-6.4a	42.2a	37.4a	-0.1a	-3.7a	-24.5a	21.7a
Permanent <u>Exclosures</u>									
3.8cm	—¶	—	—	—	26.4b	-7.1a	1.8a	-3.7a	19.8a
7.6cm	—	—	—	—	25.5b	3.8a	9.1a	0.6a	5.2b
12.7cm	—	—	—	—	46.5a	0.9a	11.8a	2.4a	0.5b

F probability of main effects and interactions	2002	2003
Height	NS§	NS
Month	**	**
Height x month	NS	*
Move	N/A	**
Move x month	N/A	NS
Height x move	N/A	NS
Height x move x month	N/A	**

*,** Significant at $P < 0.05$ and $P < 0.01$, respectively; NS = non-significant.
† % Fescue Change = (Fescue Wt. 2nd Harvest/Total Yield 2nd Harvest)*100 – (Fescue Wt. 1st Harvest/Total Yield 1st Harvest)*100
‡ Within date, means followed by the same letter are not significantly different based on Fisher's protected LSD ($P < 0.05$).
§ Height significant based on ($P < 0.06$).
¶ Defoliation height not included in treatments for permanent exclosures in 2002.

and September 2003 these changes in tall fescue composition corresponded to the changes that occurred in alfalfa botanical composition (Table 6), when tall fescue increased by a larger amount, alfalfa decreased by a larger amount. These results suggest that closer defoliation heights can reduce the competitiveness of tall fescue when mixed with alfalfa. Smith et al. (1973) had similar results in their study where tall fescue was nearly eliminated when cut twice to 4 cm as compared to 10 cm in alfalfa-tall fescue mixtures. Research conducted by Blaser et al. (1986) revealed that orchardgrass was able to dominate in mixtures with alfalfa when defoliated to 7.6 cm, while in the current study tall fescue showed the potential to dominant at a taller defoliation height of 12.7 cm. Close defoliation heights remove a larger portion of tall fescue plant material, which results in a longer time period for regrowth, especially during warmer summer months when tall fescue regrowth is slower (Wolf et al., 1979). Taller defoliation allows more tall fescue leaf material to remain in the stand.

When the change in tall fescue botanical composition was compared among the three defoliation heights and the short and long rest periods, there was a height, month, and rest effect in both 2002 and 2003 (Table 9). Change in tall fescue botanical composition for the short rest period was calculated on the same basis as change in alfalfa botanical composition by comparing tall fescue compositions at the beginning and end of the two month period under the short rest period exclosures. Defoliation height results showed similar trends as compared under only the short rest period only (Table 8). The 12.7 cm height was more favorable for tall fescue growth as compared to the 3.8 cm height with a short rest period during the July to August period in 2002 (Table 9). Rest period also had an influence on the amount of tall fescue in each sample. A 7.6 and

Table 9. Influence of defoliation height and rest period on change in tall fescue botanical composition under exclosures in alfalfa-tall fescue pastures in 2002 and 2003 at the Virginia Tech Kentland Farm, Blacksburg, VA.

Rest Period	Stubble Height	2002 July – Aug.	2002 Sept. - Oct.	2003 May - June	2003 July – Aug.
		% Change†			
Short	3.8 cm	23.5bc‡	31.0a‡	47.5a§	-11.4ab§
	7.6 cm	47.3ab	33.6a	48.5a	-12.2ab
	12.7 cm	54.2a	35.8a	46.8a	-5.5a
Long	3.8 cm	3.1c	-6.9b	23.0b	-26.0abc
	7.6 cm	0.1c	-3.2b	40.6ab	-35.4c
	12.7 cm	15.6c	4.2b	50.0a	-29.5bc

F probability of main effects and interactions	2002	2003
Height	**	*
Month	**	**
Height x month	NS	NS
Rest	**	**
Rest x month	NS	NS
Height x rest	NS	NS
Height x rest x month	NS	NS

*,** Significant at P < 0.05 and P < 0.01, respectively; NS = non-significant.

† % Change = (Fescue Wt. 2nd Harvest/Total Yield 2nd Harvest)*100 – (Fescue Wt. 1st Harvest/Total Yield 1st Harvest)*100

‡ Within date, means followed by the same letter are not significantly different based on Fisher's protected LSD (P < 0.05).

§ Within date, means followed by the same letter are not significantly different based on Fisher's protected LSD (P < 0.08).

12.7 cm defoliation height with a short rest period increased composition of tall fescue to a greater extent than all three heights with a long rest period for July to August 2002. In the period from September to October 2002 the short rest period caused an increase in fescue composition under all heights, while the long rest period actually caused fescue composition to decrease when defoliated to 3.8 and 7.6 cm. In 2003 defoliation to 3.8 cm with a long rest period for May to June had a lower ($P < 0.08$) increase in tall fescue as compared to all other heights and rest period combinations except 7.6 cm with a long rest period. In July to August 2003 tall fescue composition decreased by a larger ($P < 0.08$) amount when defoliated to 12.7 cm with a long rest period compared to the same height with a short rest period.

These results parallel the conclusions made from the change in alfalfa botanical composition results with the two rest periods (Table 7). A long rest period was more favorable for maintaining alfalfa in alfalfa-tall fescue mixtures, while a short rest period increased the competitiveness of tall fescue. Comstock and Law (1948) also reported higher percentages of Alta tall fescue when alfalfa-Alta fescue mixtures were frequently clipped as compared to rotationally clipped. Smith et al. (1973) reported that the tall fescue portion of their alfalfa-tall fescue mixtures was nearly eliminated when harvested at a 4 cm stubble height twice annually, but those mixtures harvested at this same height three and four times annually maintained tall fescue composition. A shorter rest period may be even more important for endophyte-free tall fescue, such as Forager, because it is less competitive than endophyte-infected tall fescue resulting in smaller plants and lower yield (Hill et al., 1991, 1998). Past and current research shows that a shorter rest period and taller defoliation height will increase tall fescue botanical composition especially when these two management techniques are combined.

Weed Botanical Composition Change

There was no height effect on change in weed botanical composition for the short rest period exclosures except in October 2002 when the 12.7 cm defoliation height had an increase in weed percentage (Table 10). Changes in weed botanical composition can be compared to changes in alfalfa and tall fescue botanical composition (Tables 6, 8). Weeds made up the portion of botanical composition not accounted for by alfalfa, tall fescue, or annual grasses. In August 2002 alfalfa botanical composition decreased for all heights, but tall fescue botanical composition did not increase by similar amounts. The increase in weed botanical composition in August 2002 resulted from the weed encroachment into the area vacated by alfalfa that was not occupied by tall fescue (Table 10). In July 2003 both alfalfa and tall fescue botanical composition decreased in the moved exclosures with a concurrent increase in weed composition. Crabgrass and dead plant material (mostly tall fescue) increased at the end of the 2003 season and made up the part of botanical composition not attributed to alfalfa, tall fescue, or weeds in both the moved and permanent exclosures.

Alfalfa Persistence

Alfalfa persistence was measured using the following four stand monitoring techniques: 1) plant number, 2) alfalfa visual percent cover, 3) alfalfa occupancy, and 4) alfalfa basal area (point quadrat). Plant counts and percent cover are easy to measure and are often used to determine alfalfa persistence, but are subjective. Percent occupancy is an objective measurement that indicates the distribution of species in an area and is a

Table 10. Influence of defoliation height on change in weed botanical composition under short rest period exclosures in alfalfa-tall fescue pastures in 2002 and 2003 at the Virginia Tech Kentland Farm, Blacksburg, VA.

Stubble	2002				2003				
Height	July	Aug.	Sept.	Oct.	May	June	July	Aug.	Sept.
	% Change†								
Moved Exclosures									
3.8cm	-0.4a‡	14.2a	-3.4a	-3.1b	2.0a	1.3a	3.0a	0.3a	-0.7a
7.6cm	0.1a	21.6a	-3.0a	-5.1b	0.2a	0.7a	9.7a	1.4a	-4.0a
12.7cm	-0.1a	3.8a	-0.3a	1.5a	1.3a	0.6a	5.4a	4.3a	-7.2a
Permanent Exclosures									
3.8cm	—§	—	—	—	0.3a	2.6a	0.4a	-0.7a	-3.0a
7.6cm	—	—	—	—	2.8a	-1.0a	0.9a	-0.1a	-2.8a
12.7cm	—	—	—	—	-0.7a	0.8a	0.6a	1.6a	-0.6a

† % Fescue Change = (Weeds Wt. 2nd Harvest/Total Yield 2nd Harvest)*100 – (Weeds Wt. 1st Harvest/Total Yield 1st Harvest)*100

‡ Within date, means followed by the same letter are not significantly different based on Fisher's protected LSD ($P < 0.05$).

§ Defoliation height not included in treatments for permanent exclosures in 2002.

useful technique for species like alfalfa plants that have small crowns, but high aboveground growth. Point quadrat measurements are also objective and provide non-biased percent cover estimates, but was the most time consuming measurement of the four. All monitoring techniques provided valid measures of alfalfa persistence, with the exception of alfalfa basal area. This technique was poorly correlated with the other measures (data not shown) and the small basal percent cover values limited its usefulness as a valid indicator of alfalfa stand persistence.

Height had no effect on alfalfa persistence under the moved cages in 2002, therefore only the 7.6 cm defoliation height was compared among the two types of exclosures. There was a rest effect and a rest x move interaction for alfalfa plant counts in 2002. In 2002, there was also a move x month interaction for alfalfa occupancy. Since there was no move effect with any measurement of stand persistence, all results were presented on permanent exclosures (Table 11). Permanent exclosures provided several experimental advantages over moved exclosures. They allowed repeated defoliation to the same specified height throughout the season, a controlled rest period, and a short simulated grazing period. Therefore, permanent exclosures may be the most valid technique to accurately compare stand differences within a season. Grazing effect on stand persistence is also important to evaluate, but this creates additional variability. Analysis over seasons could not be performed because permanent exclosures were placed on a new area in 2003 to prevent confounding data based on the previous year's treatments.

In 2002, a rest effect only occurred on 4 September when alfalfa plant numbers were higher at 7.6 cm with a short rest period as compared to the long rest period (data

Table 11. Alfalfa persistence under permanent exclosures in alfalfa-tall fescue pastures defoliated to 7.6 cm in 2002 and 2003 at the Virginia Tech Kentland Farm, Blacksburg, VA.

Year	8 July† (2 May)	30 July (1 July)	4 Sept. (8 Aug.)	7 Oct. (22 Sept.)	5 Nov. (30 Oct.)
			plants m^{-2}		
2002	33a‡	33a	31a	28a	19.3b
2003	14a	13a	8b	3c	0c
			% alfalfa cover		
2002	23.8a	23.8a	16.3b	15.0b	12.5b
2003	10a	5.5b	5.3b	1.5bc	0.0c
			% alfalfa occupancy		
2002	95.3a	89.1a	81.3a	76.6	82.8a
2003	68.8a	43.8b	26.6bc	10.9cd	0.0d

† Represents sampling dates in 2002 and dates in parentheses are 2003 sampling dates

‡ Within in a row, means followed by the same letter are not significantly different based on Fisher's protected LSD ($P < 0.05$).

not shown). Therefore, data was only shown at the 7.6 cm defoliation height and with a short rest period (Table 11). Additionally, there were more sampling dates under the short rest period as compared to the long rest period, which gives a better indication of alfalfa persistence throughout the season. Moved exclosures had similar alfalfa persistence to permanent exclosures at the 7.6 cm defoliation height and short rest period with 33 alfalfa plants, 22.5% cover, and 82.8% occupancy on 8 July 2002. On 5 Nov. 2002 moved exclosures contained 19.3 alfalfa plants, 9% alfalfa cover, and 81.3% occupancy.

In 2002, rest period did not have a consistent effect on the persistence of alfalfa as measured by alfalfa plant counts, visual estimates of alfalfa percent cover, or alfalfa occupancy percentages. However, alfalfa percent cover estimates taken on 17 Apr. 2003 from these 2002 exclosure areas showed that a long rest period maintained higher alfalfa cover (25%) overwinter than those with a short rest period (8.8%). Alfalfa plant counts were similar for the short (16 plant m^{-2}) and long rest period (18 plants m^{-2}). These results show that alfalfa was more persistence through the winter and into early spring when given a long rest period between defoliations in the previous spring, summer, and early autumn. Longer rest periods allow for greater accumulation of carbohydrates in the alfalfa plants due to longer periods of photosynthesis than shorter rest periods. Large amounts of carbohydrates are stored in the plant for later use and are extremely important for survival throughout the winter when alfalfa is dormant in the upper South. Higher carbohydrate reserves translate to less winter injury with higher plant persistence and yield the following spring (Ball et al., 2002).

Within permanent exclosures, there was no height or rest effect for any stand measurement in 2003 (height not available for 2002) with the exception of higher stand occupancy at 12.7 cm on 2 May 2003 (Table 11). Alfalfa persistence had a slight decline during the 2002 season, and a dramatic decline in 2003. This decline was also seen in the 7.6 cm short rest period moved exclosures with 15 plants, 11.3% cover, and 73.4% occupancy on 2 May 2002 and 0 plants, 0% cover, and 0% occupancy on 30 Oct. 2003. These trends were similar to the alfalfa mass and alfalfa botanical composition results over the two years.

Since alfalfa persistence declined in the permanent exclosures which were not affected by grazing management, climatic conditions in 2003 were mostly responsible for the decline in alfalfa. The above average precipitation and moderate temperatures during the summer of 2003 allowed tall fescue to become the more dominant species in the mixed stand, decreasing alfalfa persistence to zero by 30 Oct. 2003. Waterlogged soils can also cause root and crown diseases to develop in alfalfa, while livestock grazing and equipment on saturated soils damage the alfalfa crowns and roots by trampling and soil compaction (Gerrish, 1997). The low precipitation and lower temperatures at the end of the 2003 season resulted in decreased persistence of alfalfa with tall fescue. Alfalfa plant counts and percent cover in the sample areas where the exclosures were located during 2002 had also decreased to zero when measured on 10 Nov. 2003.

Correlation coefficients between alfalfa plant counts, percent alfalfa cover, and alfalfa occupancy percentage were all highly significant for 2002 and 2003 (Table 12). Coefficients were between 0.52 and 0.74 in 2002, and 0.85 to 0.86 in 2003. Alfalfa plant counts and alfalfa occupancy measurements were most closely related in 2002. These

Table 12. Pearson's correlation coefficients for alfalfa plant counts, visual estimates of alfalfa percent cover, and alfalfa occupancy measurements for 2002 and 2003 at Virginia Tech Kentland Farm, Blacksburg, VA.

Correlation Variables	2002	2003
count : % cover	0.54**	0.86***
count : % occupancy	0.74***	0.86***
% cover : % occupancy	0.52**	0.85***

,* Correlation coefficients significant at $P < 0.01$ and $P < 0.001$, respectively (n = 32, 2002; n = 84, 2003).

correlations showed that the subjective measurement of visual alfalfa percent cover was an accurate predictor of alfalfa plant counts and alfalfa occupancy. These results confirm the previous research findings of Smith et al. (1989), who reported high correlations between visual estimate of percent cover and alfalfa plant counts. Alfalfa plant counts, visual estimates of percent cover, and occupancy measurements all provide accurate indications of alfalfa persistence in mixtures with tall fescue under varying management practices. Therefore, visual estimates of percent cover can be considered an accurate substitute for the more time consuming measurements, such as plant counts and occupancy ratings.

Tall Fescue Persistence

Exclosure movement had no effect on tall fescue persistence in 2002 or 2003. Since the sample areas in the permanent exclosures were defoliated to the specified height and rest period at every harvest date, they provided the most accurate results for the effects of defoliation height and rest period on tall fescue persistence throughout the season (Table 13, 14). There was no rest period effect on tall fescue percent cover in 2002, therefore results at the 7.6 cm defoliation height and short rest period were compared by date (Table 14). There was a significant height effect on tall fescue percent cover under the short rest period in 2003, therefore these results were compared between heights (Table 13).

Tall fescue percent cover was higher with the 12.7 cm defoliation height as compared to the 3.8 cm height on 8 August ($P < 0.06$), 22 September, and 30 October ($P < 0.06$) in 2003 (Table 13). These results parallel the change in tall fescue botanical

Table 13. Influence of defoliation height on tall fescue persistence under permanent exclosures in alfalfa-tall fescue pastures in 2003 at the Virginia Tech Kentland Farm, Blacksburg, VA.

Stubble Height	2003				
	2 May	1 July	8 Aug.	22 Sept.	30 Oct.
	% fescue cover				
3.8 cm	37.5a†	45.0a	37.5a‡	30.0a†	41.3a‡
7.6 cm	45.0a	53.8a	47.5ab	46.3b	55.0ab
12.7 cm	51.3a	45.0a	52.5b	53.8b	58.8b

† Within date, means followed by a different letter are significantly different based on Fisher's protected LSD ($P < 0.01$).

‡ Within date, means followed by a different letter are significantly different based on Fisher's protected LSD ($P < 0.06$).

Table 14. Tall fescue persistence under permanent exclosures in alfalfa-tall fescue pastures defoliated to 7.6 cm in 2002 at the Virginia Tech Kentland Farm, Blacksburg, VA.

Stubble	2002				
Height	8 July	30 July	4 Sept.	7 Oct.	5 Nov.
	% fescue cover				
7.6 cm†	27.5a	32.5a	41.3a	38.8a	23.8a

† Within in a row, means followed by the same letter are not significantly different based on LSD (0.05).

composition results (Table 8) and reinforce the concept that taller defoliation heights increase the competitiveness of tall fescue.

Moving the exclosures in 2002 had a significant effect on tall fescue percent cover estimated for these same exclosure areas on 17 Apr. 2003. Unlike alfalfa persistence, percent cover of tall fescue was not influenced by rest period indicating that higher carbohydrate accumulation before winter was more important for alfalfa. The exclosures that remained permanent throughout the 2002 season had an average of 55% tall fescue cover the following spring on 17 Apr. 2003. Tall fescue percent cover values remained constant in 2002 (Table 14), but were lower than the tall fescue botanical composition results (Table 5). The visual estimates took into account the amount of bare ground in the sample area, which was not represented in botanical composition measurements.

In conclusion for Experiment I, alfalfa was more competitive with tall fescue when defoliated to 3.8 cm as compared to 7.6 or 12.7 cm in some instances, and alternatively tall fescue was more competitive when defoliated to 12.7 cm. A long rest period between defoliation helped maintain alfalfa in the mixed stands better than the shorter rest period, which tended to favor tall fescue competition. Although these results confirm previous recommendations that short defoliation and longer rest periods favor alfalfa composition in most alfalfa-grass mixtures, they were not consistent enough to become formal recommendations for alfalfa-tall fescue management. Defoliation height and rest period did not have a consistent effect on alfalfa persistence as measured by alfalfa plant counts, visual estimates of alfalfa percent cover, or alfalfa occupancy during 2002 and 2003. Tall fescue percent cover was higher with the 12.7 defoliation height for three sampling dates in 2003. When botanical composition and plant persistence results were combined for this experiment, the following management recommendations from previous research appears valid, but cannot be confirmed. Alfalfa-tall fescue paddocks should be managed with stocking rates sufficient to graze closely (3.8 cm) in 7 to 10 days with a 35 to 42 day rest period. Climate throughout the season and management had a major influence on the alfalfa mass, total mass, alfalfa botanical composition, and tall fescue botanical composition of samples harvested from the wire exclosures.

Experiment II. Results from this experiment are presented separately for 2002 and 2003 due to highly variable climatic conditions and different grazing season lengths between years.

Glade Springs Alfalfa Grazing Experiment

Alfalfa plant counts at the Glade Springs AREC are not shown for Hybri 400 and ZG 0240HC cultivars because seeder malfunction resulted in extremely low alfalfa emergence. There were no differences in alfalfa plant counts with initial measurements on 14 June 2002 (Table 15) indicating uniform seeding across the plots and replications. Tall fescue percent cover averaged 42% across all plots on 14 June 2002.

Competition from tall fescue increased throughout the season (42 to 64%) likely contributing to the lower alfalfa plant counts for 17 Oct. 2002 (Table 15). There were only a few differences in plant counts between cultivars by autumn 2002 when 5432 had lower plant numbers than ZG 0160A and Haygrazer. The hay-type cultivar 5432 was expected to have low persistence since it was the grazing-intolerant check in the study (Smith and Bouton, 1998).

Table 15. Alfalfa plant counts of cultivars seeded on 5 Apr. 2002 in mixed stands with tall fescue under rotational stocking at the Virginia Agricultural Experiment Center, Glade Springs, VA.

Cultivar	2002		2003
	14 June	17 Oct.	4 June
	plants m^{-2}		
ZG 0151A	29a†	7abc	6a
ZG 0240M	26a	9abc	5ab
ZG 0152A	21a	5abc	5ab
403T	17a	3bc	4ab
Alfagraze	13a	10ab	4ab
ZG 0161A	26a	7abc	2ab
ZG 9934	26a	5abc	2ab
FK 421	22a	6abc	2ab
5432	23a	2c	1ab
GH700	16a	3bc	1ab
ZG 0044	23a	5abc	1ab
Haygrazer	23a	10ab	1ab
ZG 0160A	17a	12a	1ab
ZG 0150A	15a	8abc	1ab
Geneva	19a	3bc	1ab
326GZ	28a	5abc	0b
ZG 9910	18a	5abc	0b
54V54	18a	7abc	0b
Hybri 400‡	—	—	—
ZG 0240HC‡	—	—	—

† Within date, means followed by the same letter are not significantly different based on Duncan's Multiple Range Test (α = 0.05).
‡ Data not shown due to a seeding error in these plots.

Alfalfa persistence continued to decline throughout the winter and into the spring of 2003, as evidenced by the low alfalfa plant counts for 4 June 2003 and high average tall fescue percent cover of 98.1% (Table 15). ZG 0151A had 6 plants m^{-2} which was higher than 326GZ, ZG 9910, and 54V54 with 0 plants m^{-2}. Alfalfa persistence was so low for all cultivars that it cannot be concluded that ZG 0151A has a definite advantage over 326GZ, ZG 9910, and 54V54. Low alfalfa persistence, high tall fescue competition, and poor land conditions resulted in the termination of this test after the 4 June 2003 measurements.

2002 Blacksburg Alfalfa Grazing Experiment

Initial plant counts taken on 4 June 2002 on the 2002 experiment at the Kentland Farm, Blacksburg showed differences among cultivars (Table 16). ZG 9910 had higher alfalfa plant counts than nine other cultivars and ZG 0161A had more plants than 4 other cultivars. There were no differences in tall fescue percent cover between alfalfa cultivar plots (data not shown), which averaged 69%, therefore tall fescue competition cannot explain initial stand differences between alfalfa cultivars. The variation in initial alfalfa plant counts most likely occurred due to differences in plant emergence. Smith et al. (1992) also reported a variation in alfalfa cultivar plant counts in mixed stands with tall fescue at the initiation of their experiment in Georgia, but large differences in stand persistence after two years of grazing negated the slight initial differences.

Alfalfa plant counts measured on 9 Oct. 2002 showed few differences between cultivars (Table 16). ZG 0240HC had higher alfalfa plant numbers than ZG 0152A, Hybri400, ZG 0151A, and Geneva. The higher plant counts for ZG 0240HC as

Table 16. Alfalfa plant counts of cultivars seeded on 2 Apr. 2002 in mixed stands with tall fescue under rotational stocking at the Virginia Tech Kentland Farm, Blacksburg, VA.

Cultivar	2002		2003	
	4 June	9 Oct.	10 June	31 Oct.
	plants m^{-2}			
ZG 0161A	74ab†	25ab	16ab	25a
ZG 0240M	52abcd	28ab	17ab	24ab
ZG 9934	54abcd	28ab	10b	22ab
ZG 0152A	56abcd	21b	13b	22ab
ZG 0044	44bcd	23ab	17ab	20ab
5432	46bcd	26ab	21ab	19ab
Alfagraze	46bcd	27ab	14ab	18ab
Haygrazer	33d	24ab	23ab	18ab
ZG 0160A	57abcd	22ab	17ab	18ab
326GZ	61abcd	27ab	23ab	18ab
Hybri400	41cd	17b	17ab	17ab
GH700	63abcd	24ab	15ab	17ab
ZG 0240HC	64abcd	39a	29a	16ab
ZG 0150A	65abc	30ab	25ab	15ab
403T	57abcd	28ab	16ab	13ab
ZG 9910	77a	24ab	15ab	13ab
ZG 0151A	34d	19b	19ab	11ab
FK421	37cd	31ab	14ab	11ab
54V54	47bcd	23ab	22ab	11ab
Geneva	46bcd	22b	19ab	9b

† Within date, means followed by the same letter are not significantly different based on Duncan's Multiple Range Test ($\alpha = 0.05$).

compared to ZG 0152A and ZG 0151A may be attributed to the lower tall fescue percent cover of ZG 0240HC (66.3%) than ZG 0152A (76.3%) and ZG 0151A (78.8%).

By 10 June 2003 only ZG 0240HC showed higher counts than ZG 9934 and ZG 0152A, by 31 Oct. 2003 only ZG 0161A had higher plant counts than Geneva (Table 16). Alfalfa plant counts declined over the two years of this study partly due to the competition of tall fescue which made up an average of 29% of the plots by 31 Oct. 2003. High rainfall and waterlogged soils also contributed to plant mortality. The major source of alfalfa plant decline though was red and white clover percent cover which increased from an average of less than 5% on 4 June 2002 to 55% by 31 Oct. 2003. The excessive volunteer clover in the plots was surprising since none had been planted in this area for over five years, but not unlike what occurred for many producers. Temperatures during the summer of 2003 were near or in the range of maximum red clover growth which occurs between 21 to 24°C (Smith et al., 1985). Red and white clovers also prefer adequate moisture conditions and can tolerate wet conditions better than alfalfa (Ball et al., 2002). Above average precipitation during the summer of 2003 created optimum conditions for clover growth and increased competition for alfalfa.

<u>2003 Blacksburg Alfalfa Grazing Experiment</u>

Alfalfa cultivars seeded on 3 Apr. 2003 for the 2003 Kentland Farm, Blacksburg experiment into existing endophyte-infected tall fescue stands had similar initial alfalfa plant counts on 10 June 2003 (Table 17). Tall fescue percent cover averaged 71% on 10 June. There were no cultivar differences on 31 Oct. 2003 with an average tall fescue percent cover of 57% and 22% red and white clover. Tall fescue percent cover decreased

Table 17. Alfalfa plant counts of cultivars seeded on 3 Apr. 2003 in mixed stands with tall fescue under rotational stocking at the Virginia Tech Kentland Farm, Blacksburg, VA.†

Cultivar	2003	
	10 June	31 Oct.
	plants m^{-2}	
ZG 9934	38a‡	31a
Alfagraze	37a	22a
326GZ	37a	24a
5432	36a	23a
ZG 0151A	36a	24a
Geneva	36a	23a
ZG 9910	34a	23a
ZG 0152A	34a	26a
54V54	34a	24a
ZG 0240HC	34a	31a
ZG 0044	33a	24a
GH700	33a	23a
ZG 0150A	31a	32a
FK 421	28a	26a
Haygrazer	27a	22a
ZG 0160A	27a	26a
Hybri 400	27a	21a
ZG 0240M	27a	25a
403T	27a	23a
ZG 0161A	27a	20a

† A seeding error led to 12 missing plots in this test.

‡ Within date, means followed by the same letter are not significantly different based on Duncan's Multiple Range Test ($\alpha = 0.05$).

from spring to autumn 2003, likely as a result of clover competition under the favorable clover growing conditions. Alfalfa also declined in the plots due to aggressive clover growth and waterlogged soils. At least one more grazing season will be required for this test.

2002 Steeles Tavern Alfalfa Grazing Experiment

There were no cultivar differences in alfalfa plant counts measured at the Steeles Tavern AREC on 7 June 2002 (seeded on 29 Mar. 2002) (Table 18). This trend continued throughout the 2002 grazing season and no differences were observed on 8 Oct. 2002 when tall fescue percent cover was 80%. Large percentages of tall fescue in the plots left small areas for alfalfa growth. Differences in alfalfa plant persistence began to occur between cultivars by spring 2003. The FK 421 had higher alfalfa plant counts than ZG 0240M, ZG 9934, and 403T on 20 May 2003. These same differences were not present in the autumn of 2003 when FK 421 and ZG 0152A had higher alfalfa plant counts than Hybri 400. On average tall fescue represented 62% of the experiment plots with 28.6% occupied by red and white clover on 20 Oct. 2003. Tall fescue and clover were competition for the alfalfa cultivars in this experiment resulting in low alfalfa plant counts by autumn 2003. As stated previously, high moisture conditions in 2003 benefited tall fescue and clover and were detrimental to alfalfa in waterlogged soils.

2003 Steeles Tavern Alfalfa Grazing Experiment

The alfalfa cultivar experiment seeded on 15 Apr. 2003 at the Steeles Tavern AREC had similar results as the experiment seeded in 2003 at Kentland. Only two alfalfa cultivars had different alfalfa plant counts on 12 June 2003 with Hybri 400 having more alfalfa plants than GH700 (Table 19). There were no differences in cultivar persistence

Table 18. Alfalfa plant counts of cultivars seeded on 29 Mar. 2002 in mixed stands with tall fescue under rotational stocking at the Virginia Agricultural Experiment Center, Steeles Tavern, VA.

Cultivar	2002		2003	
	7 June	8 Oct.	20 May	20 Oct.
	plants m^{-2}			
FK 421	41a†	24a	17a	8a
ZG 0152A	31a	22a	11ab	8a
Geneva	43a	13a	13ab	6ab
ZG 0150A	35a	8a	6ab	5ab
ZG 0240M	50a	13a	5b	5ab
326GZ	52a	13a	12ab	5ab
ZG 9934	40a	14a	5b	5ab
ZG 0160A	44a	20a	10ab	4ab
54V54	29a	14a	6ab	4ab
Alfagraze	52a	10a	8ab	4ab
ZG 0240HC	33a	24a	15ab	3ab
ZG 0161A	46a	15a	6ab	3ab
ZG 0151A	44a	12a	13ab	3ab
Haygrazer	36a	15a	10ab	3ab
ZG 0044	31a	13a	14ab	3ab
GH700	35a	11a	14ab	3ab
403T	33a	14a	5b	3ab
5432	48a	8a	10ab	2ab
ZG 9910	41a	14a	12ab	2ab
Hybri 400	45a	13a	9ab	1b

† Within date, means followed by the same letter are not significantly different based on Duncan's Multiple Range Test ($\alpha = 0.05$).

Table 19. Alfalfa plant counts of cultivars seeded on 24 Apr. 2003 in mixed stands with tall fescue under rotational stocking at the Virginia Agricultural Experiment Center, Steeles Tavern, VA.†

Cultivar	2003	
	12 June	20 Oct.
	plants m^{-2}	
Hybri 400	87a‡	22a
ZG 0160A	80ab	23a
ZG 9934	80ab	18a
Alfagraze	80ab	22a
ZG 0150A	77ab	27a
FK 421	72ab	23a
326GZ	69ab	23a
ZG 0151A	68ab	20a
ZG 0240M	67ab	16a
403T	67ab	20a
ZG 0240HC	67ab	30a
Geneva	66ab	21a
54V54	62ab	31a
ZG 0161A	57ab	31a
ZG 9910	57ab	20a
ZG 0152A	56ab	28a
ZG 0044	55ab	22a
Haygrazer	52ab	20a
5432	52ab	31a
GH700	49b	20a

† A seeding error led to six missing plots in this test.
‡ Within date, means followed by the same letter are not significantly different based on Duncan's Multiple Range Test ($\alpha = 0.05$).

by 20 Oct. 2003. The plots contained an average of 49% tall fescue and 42% red and white clover leaving only a small amount of area for alfalfa. High precipitation in 2003 also decreased alfalfa persistence in this experiment due to waterlogged soils and increased tall fescue and clover growth.

In conclusion for Experiment II, definite alfalfa cultivar recommendations for endophyte-infected tall fescue pastures cannot be made based on the current results from these five experiments. Initial alfalfa plant numbers after seeding were below the 90 plants m^{-2} that are recommended as initial alfalfa stands for standardized testing of cultivar grazing tolerance (Bouton and Smith, 1998), but the standard test guidelines were developed based on pure stands of alfalfa cultivars and not mixed stands. Tall fescue is very competitive during the spring when these cultivar tests were seeded due to vigorous tillering and crown expansion. Although initial tall fescue growth was suppressed by paraquate, regrowth shaded the alfalfa plants and likely reduced growth (Smith et al., 1992) and may have resulted in lower alfalfa plant numbers. Most experiments had a decline in initial alfalfa plant counts over the grazing seasons, which was to be expected since alfalfa plant density normally declines throughout the life of a stand as certain plants die and others increase in size due to natural competition (Smith and Bouton, 1993). Tall fescue and clover most likely had an influence on alfalfa plant survival, but cannot fully explain the observed differences in alfalfa persistence among cultivars due to a lack of consistent trends between alfalfa plant counts and percent cover estimates of tall fescue and clover. Some variation in grazing may have occurred, but all possible efforts were made to maintain heavy stocking on the plots to insure all plants were equally and uniformly exposed to grazing stress. Since the grazing-tolerant (Alfagraze) and grazing-intolerant (5432) checks did not separate in any of the experiments for alfalfa plant persistence, additional grazing seasons will be required for these experiments to determine persistence differences among the twenty cultivars (Bouton and Smith, 1998).

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