

## Chapter 1

# Perennial Ryegrass and Annual Ryegrass Overseeded Bermudagrass Fairway Performance and Post Dormancy Transition as Influenced by Seeding Rate and Trinexapac-ethyl

### Introduction

The acceptance of dormant, non-overseeded bermudagrass (*Cynodon* [L.] Pers.) fairways, especially during spring, is a focus of concern on golf courses throughout the region located in the climatic transition zone between temperate and subtropical climates. Dormant bermudagrass fairways often maintain canopy structure in late fall and early winter prior to becoming matted down and thinned out from the effects of winter traffic. This appears to be more of a problem on the common types of bermudagrass and the coarser textured, winter hardy, improved varieties (e.g., 'Midiron' and 'Vamont') typically used in the colder regions of the transition zone than finer textured cultivars used in the most southern extremes of the country.

Bermudagrass long term persistence, in golf course fairways overseeded with ryegrasses (*Lolium* sp.) for winter quality, can decline if the ryegrasses persist due to cool spring temperatures, using persistent varieties, and management that favors perennial ryegrass. Overseeded perennial ryegrass persistence often results in poor post dormancy (PD) transition from overseeded ryegrass to bermudagrass in the April to June period. This is the main reason why some professional turfgrass managers choose not to overseed bermudagrass fairways in the northern portion of the climatic transition zone. Spring transition in overseeded bermudagrass in extreme southern climates is easier to accomplish due to the typically shorter, more mild winters which are less stressful to bermudagrass while the warmer spring and summer temperatures are more favorable to

perennial ryegrass (*L. perenne*) decline and bermudagrass PD regrowth (Chalmers, 1997). A method for winter overseeding that successfully facilitates reliable transition from overseeded species to bermudagrass each year would enable transition zone golf courses to provide overseeded bermudagrass fairway winter-spring quality, while maintaining a late spring to early fall period of non-delayed, active bermudagrass growth.

In 1990, Gadd reported overseeding with low seeding rates (approximately 224 kg ha<sup>-1</sup>) made for an easier transition the following spring due to the fewer number of plants. However, there is a growing trend in today's turfgrass industry toward higher winter overseeding rates (448 to 896 kg ha<sup>-1</sup>) to respond to clientele demand to improve fall to spring quality. Proponents of using higher rates theorize that increasing the number of plants per square cm could have the potential to delay plant development, help keep blade size and root systems smaller; thus the "weaker" plants could transition out more easily. Landry (1993) stated the increased competition caused by the greater density of cool-season grasses when overseeded at higher rates, tends to prolong the PD transition period. With apparent contradictions regarding seeding rate influence on PD transition, information is needed on the influence of seeding rates used in winter overseeding and its influence on bermudagrass PD transition.

Trinexapac-ethyl (TE) is a plant growth regulator that inhibits giberellin biosynthesis, thus reducing cell elongation and suppressing foliar growth (Abbot et al., 1991). Trinexapac-ethyl is used to reduce mowing frequency and clippings per mowing. The suppression of foliar growth may last from 3 to 6 weeks depending upon grass species treated and application rate.

Information pertaining to the use of TE and its potential influence on PD transition of overseeded bermudagrass turf is lacking. Fall TE use may maintain the overseeded turf in a juvenile state which could facilitate a PD transition from a mixed sward of cool-season and warm-season grasses to a monostand of warm-season grass.

Spring TE use could suppress the overseeded cool-season species providing an opportunity for bermudagrass recovering from winter dormancy to have a more competitive advantage in the regulated overseeded turf enhancing PD transition.

## **Objectives**

The objectives of this study were to:

- 1.) Compare how seeding rates of perennial ryegrass and annual ryegrass overseeded into bermudagrass influence winter-spring turf performance and bermudagrass PD transition.
- 2.) Determine the impact of seasonal TE applications on overseeded perennial ryegrass and annual ryegrass winter-spring turf performance and bermudagrass PD transition.

### **1.1 1997-1998 Field Study**

#### **Materials and Methods**

‘Palmer II’ perennial ryegrass (*L. perenne*) and annual ryegrass (*L. multiflorum*) were overseeded separately in mid-September 1997 at two locations. The overseeded plots were established into ‘Midiron’ bermudagrass maintained as a golf course fairway at the Virginia Tech Turfgrass Research Center in Blacksburg, Virginia and a ‘Brute’ bermudagrass fairway on Boonsboro Country Club near Lynchburg, Virginia. Lynchburg, located in central Virginia at 197.5 meters above sea level, is considered a transition zone climate compared to Blacksburg (634 meters above sea level) which has a cooler transition zone climate.

Treatments at both sites were identical with only the dates of plot overseeding, initial TE treatments, and subsequent TE treatments varying. The study for 1997-1998

consisted of two separate experiments run simultaneously. Each experiment, one using perennial ryegrass and the other using annual ryegrass, had sixteen treatments comprised of two variables and replicated four times. Perennial ryegrass overseeded bermudagrass treatments and annual ryegrass overseeded bermudagrass treatments are listed in Tables 1.1 and 1.2, respectively. Variables included four seeding rates (0, 224, 448, or 896 kg ha<sup>-1</sup>) and four TE regimes (none, fall applied, spring applied, or fall and spring applied). Plot size was 1.2 m x 1.8 m with a total of 128 plots at each location arranged in a randomized complete block design.

### **Blacksburg Location**

The Blacksburg site was a mature stand of 'Midiron' bermudagrass growing on a fine, mixed, mesic Typic Hapludult (Groseclose-Urban Land Complex) with two to seven percent south facing slope at the Virginia Tech Turfgrass Research Center. Initial soil test results (analyzed by the Virginia Tech soil testing laboratory) reported pH = 5.6, P = 39 ppm, K = 86 ppm, Ca = 480 ppm, Mg = 93 ppm. In previous years the site had received little or no supplemental fertilization or irrigation and mowed only once or twice weekly at 2.5 cm with clippings returned.

In August 1997, the site was fertilized with 97.6 kg ha<sup>-1</sup> of urea nitrogen and irrigated to promote bermudagrass quality. Plots were seeded on September 15, 1997 with a Scott's Professional Drop Spreader calibrated separately to deliver 224 kg ha<sup>-1</sup> of annual ryegrass and perennial ryegrass. Additional passes were used to apply seed at 448 or 896 kg ha<sup>-1</sup>. Plots were irrigated twice daily until all seed had germinated. All subsequent irrigation was applied as needed to prevent severe moisture stress. Insecticide for insect control and herbicide for broadleaf weed control were applied when necessary.

Plots were mowed with a reel mower (Toro, Reelmaster 2300-D) at 1.6 cm two to three times per week during maximum growth periods and clippings returned. On

**Table 1.1 1997-1998 Overseeded Perennial Ryegrass Treatments for Blacksburg and Lynchburg field trials.**

<b>Treatment #</b>	<b>Overseeded Species *</b>	<b>Seed Rate †</b>	<b>TE ‡</b>
1	Perennial ryegrass	0	None
2	Perennial ryegrass	224	None
3	Perennial ryegrass	448	None
4	Perennial ryegrass	896	None
5	Perennial ryegrass	0	Fall
6	Perennial ryegrass	224	Fall
7	Perennial ryegrass	448	Fall
8	Perennial ryegrass	896	Fall
9	Perennial ryegrass	0	Spring
10	Perennial ryegrass	224	Spring
11	Perennial ryegrass	448	Spring
12	Perennial ryegrass	896	Spring
13	Perennial ryegrass	0	Fall + Spring
14	Perennial ryegrass	224	Fall + Spring
15	Perennial ryegrass	448	Fall + Spring
16	Perennial ryegrass	896	Fall + Spring

\* 'Palmer II' perennial ryegrass

† Seed rates are kg ha<sup>-1</sup>

‡ Trinexapac-ethyl applied at 0.19 kg a.i. ha<sup>-1</sup>

**Table 1.2 1997-1998 Overseeded Annual Ryegrass Treatments for Blacksburg and Lynchburg Field Trials.**

<b>Treatment #</b>	<b>Overseeded Species</b>	<b>Seed Rate*</b>	<b>TE †</b>
1	Annual ryegrass	0	None
2	Annual ryegrass	224	None
3	Annual ryegrass	448	None
4	Annual ryegrass	896	None
5	Annual ryegrass	0	Fall
6	Annual ryegrass	224	Fall
7	Annual ryegrass	448	Fall
8	Annual ryegrass	896	Fall
9	Annual ryegrass	0	Spring
10	Annual ryegrass	224	Spring
11	Annual ryegrass	448	Spring
12	Annual ryegrass	896	Spring
13	Annual ryegrass	0	Fall + Spring
14	Annual ryegrass	224	Fall + Spring
15	Annual ryegrass	448	Fall + Spring
16	Annual ryegrass	896	Fall + Spring

\* Seed rates are kg ha<sup>-1</sup>

† Trinexapac-ethyl applied at 0.19 kg a.i. ha<sup>-1</sup>

October 13, 1997, the plots were fertilized with 48.8, 7.6, and 10.7 kg ha<sup>-1</sup> of nitrogen (thirty-three percent sulfur coated urea), phosphate, and potash respectively and irrigated. Additional nitrogen from urea was applied on December 2, 1997 (24.4 kg ha<sup>-1</sup>) and May 23, 1998 (73.2 kg ha<sup>-1</sup>). Plots were irrigated immediately following each fertilizer application.

Applications of TE were made to the plots using a compressed air sprayer with a four-nozzle boom designed to cover 1.8 m. The sprayer, equipped with Tee Jet 8003VS nozzle tips, was calibrated to deliver 374 l ha<sup>-1</sup> at 241.4 kpa. Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup> in the following regimes: (1) fall applied (October 29, 1997); (2) spring applied (March 19, 1998 and April 17, 1998); and (3) fall and spring applied (October 29, 1997 + March 19, 1998 + April 17, 1998).

### **Lynchburg Location**

The Lynchburg site was a mature 'Brute' bermudagrass growing on a fine, kaolinitic, thermic Typic Kanhapludult (Cecil fine sandy loam) with seven to fifteen percent south facing slope located on the former number ten fairway of Boonsboro Country Club. Initial soil test results (analyzed by the Virginia Tech soil testing laboratory) reported pH = 5.3, P = 13 ppm, K = 104 ppm, Ca = 612 ppm, Mg = 114 ppm.

Plots were overseeded on September 19, 1997 using the method described for the Blacksburg location. This site was also mowed at 1.6 cm three times weekly with a reel mower (Toro, 6500-D) and clippings returned. On October 20, 1997, the plots were fertilized with 48.8, 7.6, and 10.7 kg ha<sup>-1</sup> of nitrogen (thirty-three percent sulfur coated urea), phosphate, and potash respectively and irrigated. The plot area received a preemergent herbicide application on a fertilizer carrier March 27, 1998. A combination of prodiamine + oxadiazon at 0.4 and 2.2 kg a.i. ha<sup>-1</sup> respectively was applied with 36.6 kg ha<sup>-1</sup> of slowly available methylene urea nitrogen. Plots also received 48.8, 24.4, and

24.4 kg ha<sup>-1</sup> of ammoniacal and urea nitrogen, phosphate, and potash respectively on June 13, 1998.

Trinexapac-ethyl applications were made using the compressed air sprayer as described for the Blacksburg location at 0.19 kg a.i. ha<sup>-1</sup> in the following regimes: (1) fall applied (October 31, 1997 and December 3, 1997); (2) spring applied (March 5, 1998 and April 10, 1998); (3) fall and spring applied (October 31, 1997 + December 3, 1997 + March 5, 1998 + April 10, 1998).

### **Data Recorded**

Observations recorded throughout the duration of this study consisted of visual ratings of overall turfgrass quality, turf color, density, annual bluegrass (*Poa annua*) invasion, and 1998 bermudagrass PD transition. Quality data was recorded on a 1 to 9 scale (1 = brown or dead turf, and 9 = dense, green, uniform turf). A quality rating of 5 would be indicative of acceptable golf course fairway turf. Turf color data was recorded on a 1 to 9 scale (1 = brown turf, and 9 = dark green turf). A color rating of 5 would be indicative of acceptable turf color. Density data was recorded on a 1 to 9 scale (1 = no turf, and 9 = dense, uniform turf). Annual bluegrass invasion was estimated as a percentage of the total plot area. Bermudagrass PD transition was estimated as a percentage of the total plot area that was actively growing, green bermudagrass. Plots at both locations were rated monthly from November 1997 to August 1998 for turf color, density, and overall turf quality. Annual bluegrass invasion was recorded only in May 1998 at both locations. Both research sites were rated bimonthly from May 1998 to August 1998 for bermudagrass PD transition. All data was subjected to analysis of variance (ANOVA) procedures using the SAS (SAS, 1985) system for each day of data collection. Perennial ryegrass and annual ryegrass experiments were analyzed separately.

Treatment means were separated using Tukey's studentized range test at the 0.05 level of probability.

### **1997-1998 Results**

Mean daily temperatures for the months of September, 1997 through August, 1998 compared to the thirty year mean daily normals for both locations demonstrates Lynchburg's warmer climate (Table 1.3). It is important to note temperatures in January and February 1998 as well as May and June 1998 were above normal for both locations. In fact, Blacksburg's mean temperatures in January and February 1998 were above the January and February thirty year normals for Lynchburg.

### **Blacksburg Location**

#### **Perennial Ryegrass Seeding Rate Effects**

Perennial ryegrass PD transition in overseeded bermudagrass was significantly affected by seeding rate (Table 1.4). Full transition is reached when the post dormant bermudagrass population in overseeded plots is not different from the post dormant bermudagrass population in non-overseeded ( $0 \text{ kg ha}^{-1}$ ) plots. Full PD transition from overseeded perennial ryegrass to bermudagrass was not reached in Blacksburg in 1998. Early PD transition ratings ranged from no detectable bermudagrass in the  $896 \text{ kg ha}^{-1}$  plots to 23.4 percent bermudagrass in the non-overseeded ( $0 \text{ kg ha}^{-1}$ ) plots on May 6, 1998. These differences persisted well into August. Final transition ratings on August 10, 1998 observed 96.1 percent bermudagrass in the non-overseeded ( $0 \text{ kg ha}^{-1}$ ) plots compared to only 60.0 percent bermudagrass in the plots overseeded with  $896 \text{ kg ha}^{-1}$ . Perennial ryegrass plots overseeded with  $224 \text{ kg ha}^{-1}$  and  $448 \text{ kg ha}^{-1}$  reduced post

**Table 1.3 Thirty Year Mean Daily Temperature Normals ( ° C) and 1997-1998 Mean Daily Temperatures ( ° C) for Blacksburg and Lynchburg, Virginia\*.**

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<b>Month</b>	<b>Blacksburg Temperatures</b>		<b>Lynchburg Temperatures</b>	
	<b>30-Year Mean Normal</b>	<b>1997-98 Mean Daily</b>	<b>30-Year Mean Normal</b>	<b>1997-98 Mean Daily</b>
Sep	17.3	17.6	20.1	19.0
Oct	11.1	11.2	13.9	12.9
Nov	5.9	3.9	8.7	6.0
Dec	1.0	1.0	3.6	2.9
Jan	-1.0	2.7	1.2	4.6
Feb	0.7	3.6	3.0	5.0
Mar	5.3	4.9	8.0	7.2
Apr	10.7	11.1	13.2	13.0
May	15.4	17.7	17.8	18.8
Jun	19.3	20.4	22.1	22.3
Jul	21.7	22.2	24.2	23.9
Aug	20.9	21.8	23.7	23.4

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\* Data supplied courtesy of National Weather Service, Blacksburg, Virginia.

**Table 1.4 1998 Overseeded Bermudagrass Post Dormancy Transition as Influenced by Fall 1997 Perennial Ryegrass Overseeding Rates in Blacksburg, Virginia.**

Overseeding Rate †	Post Dormancy Transition ‡					
	6 May	19 May	5 June	29 June	21 July	10 Aug.
0	23.4 a*	56.9 a	72.8 a	88.1 a	93.1 a	96.1 a
224	1.2 b	17.2 b	51.3 b	73.8 b	73.8 b	73.8 b
448	0.3 b	13.1 b	41.3 c	67.8 bc	68.4 bc	68.4 bc
896	0.0 b	11.1 b	37.8 c	59.1 c	59.7 c	60.0 c

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Overseeding rates are kg ha<sup>-1</sup>

‡ Post dormancy transition is estimated as a percentage of the total plot area that was actively growing, green bermudagrass.

dormant bermudagrass populations by 23.2 and 28.8 percent, respectively compared to the non-overseeded ( $0 \text{ kg ha}^{-1}$ ) controls.

Perennial ryegrass overseeded bermudagrass contributed greatly to increased turf quality during late winter and spring as seeding rates increased (Table 1.5). However, bermudagrass overseeded plots had lower quality when compared to non-overseeded ( $0 \text{ kg ha}^{-1}$ ) plots after June 29, 1998. Mean overseeded plot quality ranged from 6.2 to 6.0 for  $224 \text{ kg ha}^{-1}$  and  $896 \text{ kg ha}^{-1}$  respectively, compared to a mean plot quality of 6.9 for non-overseeded ( $0 \text{ kg ha}^{-1}$ ) plots on August 10, 1998. The interaction between seeding rates and TE application regimes was significant at the 0.05 level of probability for perennial ryegrass overseeded bermudagrass quality on December 2 and December 20, 1997 only. However, the data analysis indicates stronger main effects on both dates as the p values for seed rate and TE main effects were 0.0001 and 0.0001, respectively on both December 2 and December 20, 1997. The p values for seed rate by TE on these dates were 0.0103 and 0.0416, respectively. These temporary interactions were a result of fall applied TE negatively impacting turf density, which is an important component of overall plot quality ratings. Plots receiving fall TE were less dense compared to untreated plots. Plots overseeded with  $224 \text{ kg ha}^{-1}$  contained less plant material than plots overseeded with 448 or  $896 \text{ kg ha}^{-1}$  indicating TE's negative impact on density was amplified in lower seeding rate plots.

Annual bluegrass (*Poa annua*) is the number one cool-season, grassy weed problem on overseeded bermudagrass and previous research has shown that most overseeded species compete well with annual bluegrass (Menn and Beard, 1987; Watschke and Schmidt, 1992). Schmidt and Shoulders (1980) reported perennial ryegrass was quick to establish and competitive to annual bluegrass. There was less annual bluegrass in perennial ryegrass overseeded plots when compared to non-overseeded ( $0 \text{ kg ha}^{-1}$ ) plots on May 19, 1998, regardless of seeding rate (Table 1.6).

**Table 1.5 1997-1998 Overseeded Bermudagrass Fairway Quality as Influenced by Fall 1997 Perennial Ryegrass Overseeding Rates in Blacksburg, Virginia.**

Overseeding Rate †	Turfgrass Quality ‡														
	18 Nov.	2 Dec.	20 Dec.	10 Jan.	10 Feb.	27 Feb.	19 Mar.	31 Mar.	17 Apr.	6 May	19 May	5 June	29 June	21 July	10 Aug.
0	1.0 c*	1.0 c	1.0 c	1.0 c	1.0 c	1.0 d	1.0 c	1.0 d	2.0 c	2.0 c	3.2 b	5.1 b	7.2 NS	6.6 a	6.9 a
224	4.4 b	4.1 b	3.5 b	3.8 b	3.8 b	4.2 c	4.2 c	3.9 c	4.6 b	5.6 b	7.2 a	6.1 a	7.0	6.0 b	6.2 b
448	5.5 a	4.9 a	4.5 a	5.0 a	4.8 a	5.1 b	5.2 a	4.9 b	5.5 a	6.5 a	7.1 a	6.3 a	7.0	6.0 b	6.1 b
896	6.0 a	5.2 a	5.1 a	5.4 a	5.3 a	5.7 a	5.8 a	5.7 a	5.7 a	6.7 a	7.3 a	6.3 a	7.0	6.0 b	6.0 b

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE significant at the 0.05 level of probability on December 2 and December 20, 1997.

† Overseeding rates are kg ha<sup>-1</sup>

‡ Quality data was recorded on a 1 to 9 scale (1 = brown or dead turf, 5 = acceptable golf course fairway turf, and 9 = dense, green, uniform turf).

**Table 1.6 1998 Annual Bluegrass (*Poa annua*) Invasion in Overseeded Bermudagrass as Influenced by Fall 1997 Perennial Ryegrass Overseeding Rates in Blacksburg, Virginia.**

<u>Overseeding Rate †</u>	<u>Annual Bluegrass Invasion ‡</u>
	<u>19 May</u>
0	27.2 b*
224	1.1 a
448	0.3 a
896	0.1 a

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Overseeding rates are kg ha<sup>-1</sup>

‡ Annual bluegrass invasion is estimated as a percentage of the total plot area that was actively growing annual bluegrass.

## Annual Ryegrass Seeding Rate Effects

Influence of annual ryegrass overseeding rate on bermudagrass PD transition was different from that observed in overseeded perennial ryegrass plots. Annual ryegrass overseeded plots had greater post dormant bermudagrass populations than non-overseeded ( $0 \text{ kg ha}^{-1}$ ) plots (Table 1.7). These differences were evident on May 6, 1998 and although not different on May 19, 1998, averaged twelve percent less bermudagrass in non-overseeded ( $0 \text{ kg ha}^{-1}$ ) plots when compared to overseeded plots on June 5, 1998. Final bermudagrass PD transition ratings in overseeded annual ryegrass plots ranged from 96.1 percent bermudagrass in the non-overseeded ( $0 \text{ kg ha}^{-1}$ ) plots to 98.7 percent bermudagrass in plots overseeded at  $896 \text{ kg ha}^{-1}$ . Although only 2.6 percentage points difference, this appeared to be a result of late spring annual bluegrass infestation in the non-overseeded ( $0 \text{ kg ha}^{-1}$ ) plots (Table 1.8) delaying bermudagrass PD transition more than the overseeded annual ryegrass.

Overseeded annual ryegrass plots had greater turf quality with increased seeding rates during the winter and early spring (Table 1.9). However, quality briefly declined once warmer temperatures stimulated bermudagrass PD regrowth (April 17 and May 6, 1998). The steady increase in plot quality observed in all seeding rates after May 6, 1998 reflects the progression of bermudagrass PD regrowth due to the absence of annual ryegrass competition. The quality differences between non-overseeded ( $0 \text{ kg ha}^{-1}$ ) plots and annual ryegrass overseeded plots on July 21, 1998 demonstrates annual ryegrass' ability to reduce or eliminate annual bluegrass competition from bermudagrass PD regrowth. There was one temporary interaction between seeding rates and TE application regimes significant at the 0.05 level of probability for annual ryegrass overseeded bermudagrass quality (April 17, 1998). This was the only date where the p value for TE main effects (0.0364) was significant at the 0.05 level of probability. Otherwise, TE had no effect on overseeded annual ryegrass quality.

**Table 1.7 1998 Overseeded Bermudagrass Post Dormancy Transition as Influenced by Fall 1997 Annual Ryegrass Overseeding Rates in Blacksburg, Virginia.**

Overseeding Rate †	Post Dormancy Transition ‡					
	6 May	19 May	5 June	29 June	21 July	10 Aug.
0	24.1 b*	52.5 NS	74.7 b	90.9 b	95.1 NS	96.1 b
224	35.0 a	50.9	83.1 a	94.4 a	97.3	97.7 ab
448	35.9 a	53.1	86.6 a	95.0 a	97.7	98.1 ab
896	37.2 a	51.3	84.7 a	94.1 a	97.7	98.7 a

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Overseeding rates are kg ha<sup>-1</sup>

‡ Post dormancy transition is estimated as a percentage of the total plot area that was actively growing, green bermudagrass.

**Table 1.8 1998 Annual Bluegrass (*Poa annua*) Invasion in Overseeded Bermudagrass as Influenced by Fall 1997 Annual Ryegrass Overseeding Rates in Blacksburg, Virginia.**

<u>Overseeding Rate †</u>	<u>Annual Bluegrass Invasion ‡</u>
	<u>19 May</u>
0	21.8 b*
224	2.4 a
448	1.9 a
896	1.4 a

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Overseeding rates are kg ha<sup>-1</sup>

‡ Annual bluegrass invasion is estimated as a percentage of the total plot area that was actively growing annual bluegrass.

**Table 1.9 1997-1998 Overseeded Bermudagrass Fairway Quality as Influenced by Fall 1997 Annual Ryegrass Overseeding Rates in Blacksburg, Virginia.**

Overseeding Rate †	Turfgrass Quality ‡														
	18 Nov.	2 Dec.	20 Dec.	10 Jan.	10 Feb.	27 Feb.	19 Mar.	31 Mar.	17 Apr.	6 May	19 May	5 June	29 June	21 July	10 Aug.
0	1.6 c*	1.6 c	1.5 d	1.4 c	1.5 c	1.6 c	1.6 c	1.6 c	2.3 c	2.2 b	3.3 b	5.1 b	7.2 NS	6.7 b	7.4 NS
224	3.8 b	3.8 b	3.3 c	3.1 b	3.2 b	4.1 b	3.7 b	4.1 b	3.0 b	3.1 a	4.2 a	6.1 a	7.7	7.5 a	7.7
448	5.1 a	5.1 a	4.1 b	3.6 ab	3.6 ab	5.0 a	4.7 a	4.8 a	3.5 a	3.3 a	4.4 a	6.1 a	7.4	7.8 a	7.8
896	5.8 a	5.8 a	4.9 a	3.9 a	3.9 a	5.4 a	4.9 a	5.0 a	3.7 a	3.3 a	4.4 a	5.9 a	7.3	7.7 a	7.7

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE significant at the 0.05 level of probability on April 17, 1998.

† Overseeding rates are kg ha<sup>-1</sup>

‡ Quality data was recorded on a 1 to 9 scale (1 = brown or dead turf, 5 = acceptable golf course fairway turf, and 9 = dense, green, uniform turf).

### **Trinexapac-ethyl's Influence on Overseeded Perennial Ryegrass**

Trinexapac-ethyl reduced 1998 bermudagrass PD transition in perennial ryegrass overseeded plots when compared to untreated plots. No reductions occurred in fall only or spring only TE treated plots (Table 1.10). However, a significant reduction in PD transition of perennial ryegrass overseeded bermudagrass plots, was observed in fall + spring TE treatments due to perennial ryegrass persistence. Plots receiving the fall + spring TE applications averaged 12.5 percent less bermudagrass when compared to untreated plots over the final two data observations.

Trinexapac-ethyl applications to overseeded perennial ryegrass had different effects on plot quality when compared to untreated plots (Table 1.11). Spring TE applications had no effects on overseeded perennial ryegrass quality when compared to untreated plots except on May 6, 1998 when spring TE treatments had greater plot quality than untreated plots. However, fall TE applications to overseeded perennial ryegrass reduced overall plot quality when compared to untreated plots. The quality reduction from fall applied TE was observed from November 18, 1997 through February 27, 1998. The fall + spring TE combined treatment also reduced overall plot quality from November 18, 1997 through February 27, 1998 as well as from March 31 through May 6, 1998. The interaction between seeding rates and TE application regimes was significant at the 0.05 level of probability for perennial ryegrass overseeded bermudagrass quality on December 2 and December 20, 1997 only. However, the data analysis indicates stronger main effects on both dates as the p values for seed rate and TE main effects were 0.0001 and 0.0001, respectively on both December 2 and December 20, 1997. The p values for seed rate by TE on these dates were 0.0103 and 0.0416, respectively. These temporary interactions were the result of fall applied TE negatively impacting turf density, which is an important component of overall plot quality ratings. Plots receiving fall TE were less dense compared to untreated plots. Plots overseeded with 224 kg ha<sup>-1</sup> contained less plant material

**Table 1.10 1998 Perennial Ryegrass Overseeded Bermudagrass Post Dormancy Transition as Influenced by Trinexapac-ethyl in Blacksburg, Virginia.**

TE Regime †	Post Dormancy Transition ‡					
	6 May	19 May	5 June	29 June	21 July	10 Aug.
None applied	7.9 NS*	29.7 a	61.3 a	77.8 NS	80.1 a	80.2 a
Fall applied §	4.9	23.4 ab	45.9 b	70.9	72.5 ab	74.4 ab
Spring applied ¶	5.5	24.8 ab	48.1 b	71.3	72.7 ab	73.2 ab
Fall + Spring ¥	6.6	20.3 b	47.8 b	68.8	69.7 b	70.5 b

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Post dormancy transition is estimated as a percentage of the total plot area that was actively growing, green bermudagrass.

§ Fall TE applications were made October 29, 1997.

¶ Spring TE applications were made March 19 and April 17, 1998.

¥ Fall + spring TE applications were made October 29, 1997 + March 19, 1998 + April 17, 1998.

**Table 1.11 1997-1998 Overseeded Perennial Ryegrass Quality as Influenced by Trinexapac-ethyl in Blacksburg, Virginia.**

TE Regime †	Turfgrass Quality ‡														
	18 Nov.	2 Dec.	20 Dec.	10 Jan.	10 Feb.	27 Feb.	19 Mar.	31 Mar.	17 Apr.	6 May	19 May	5 June	29 June	21 July	10 Aug.
None applied	4.6 a*	4.5 a	4.1 a	4.2 a	4.1 a	4.3 a	4.3 NS	4.3 a	4.6 a	5.1 b	6.1 NS	5.8 NS	7.1 NS	6.1 NS	6.3 NS
Fall applied §	4.1 ab	3.4 b	3.0 b	3.4 b	3.4 b	3.8 b	3.9	4.0 ab	4.5 ab	5.1 b	6.0	5.8	7.0	6.0	6.3
Spring applied ¶	4.6 a	4.3 a	4.1 a	4.3 a	4.0 a	4.2 a	4.1	3.8 ab	4.5 ab	5.6 a	6.4	5.9	7.1	6.3	6.3
Fall + Spring ¥	3.6 b	3.0 b	2.9 b	3.3 b	3.4 b	3.8 b	3.8	3.4 b	4.1 b	4.9 b	6.3	6.1	7.1	6.2	6.4

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE significant at the 0.05 level of probability on December 2 and December 20, 1997.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Quality data was recorded on a 1 to 9 scale (1 = brown or dead turf, 5 = acceptable golf course fairway turf, and 9 = dense, green, uniform turf).

§ Fall TE applications were made October 29, 1997.

¶ Spring TE applications were made March 19 and April 17, 1998.

¥ Fall + spring TE applications were made October 29, 1997 + March 19, 1998 + April 17, 1998.

than plots overseeded with 448 or 896 kg ha<sup>-1</sup> indicating TE's negative impact on density was amplified in lower seeding rate plots.

Overseeded perennial ryegrass December through February density was significantly reduced from fall TE treatment (Table 1.12). Overseeded perennial ryegrass treated with TE in the fall + spring also lowered density on March 19, March 31, and April 17, 1998 ratings. The interaction between seeding rates and TE application regimes was significant at the 0.05 level of probability for overseeded perennial ryegrass density on December 20, 1997 and January 10, 1998 only. However, the data analysis indicates stronger main effects on both dates as the p values for seed rate and TE main effects were 0.0001 and 0.0001, respectively on both December 20, 1997 and January 10, 1998. The p values for seed rate by TE on these dates were 0.0198 and 0.0150, respectively. These temporary interactions were the result of fall applied TE negatively impacting turf density. Plots receiving fall TE were less dense compared to untreated plots. Plots overseeded with 224 kg ha<sup>-1</sup> contained less plant material than plots overseeded with 448 or 896 kg ha<sup>-1</sup>, which amplified TE's negative impact on density.

Wetzel and Dernoeden (1994) reported TE applied to perennial ryegrass at 0.29 kg ha<sup>-1</sup> exhibited a darker green color when compared to untreated plots approximately seven weeks after treatment. However, the darker green appearance of TE treated turf did not significantly improve overall turfgrass quality. Spring TE applications to overseeded perennial ryegrass did produce a slightly darker turf color when compared to nontreated (Table 1.13). However, no differences were observed thirty-two days after the final spring TE application. The interaction between seeding rates and TE application regimes was significant at the 0.05 level of probability for overseeded perennial ryegrass color on December 20, 1997 and April 17, 1998 only. However, the data analysis indicates stronger main effects on both dates as the p values for seed rate and TE main effects were 0.0001 and 0.0001, respectively on both December 20, 1997 and April 17, 1998. The p values for seed rate by TE on these dates were 0.0135 and 0.0416, respectively. These temporary interactions were results of fall TE negatively impacting turf

**Table 1.12 1997 - 1998 Overseeded Perennial Ryegrass Density as Influenced by Trinexapac-ethyl in Blacksburg, Virginia.**

TE Regime †	Turfgrass Density ‡								
	20 Dec.	10 Jan.	10 Feb.	27 Feb.	19 Mar.	31 Mar.	17 Apr.	6 May	19 May
None applied	4.1 a*	4.6 a	4.4 a	4.1 ab	4.3 ab	4.4 a	4.8 a	5.2 NS	6.3 NS
Fall applied §	2.8 b	3.6 b	3.3 b	3.9 ab	4.1 ab	3.9 ab	4.6 ab	5.4	6.3
Spring applied ¶	3.8 a	4.2 a	4.1 a	4.3 a	4.4 a	4.0 ab	4.6 ab	5.4	6.2
Fall + Spring ¥	2.4 b	3.4 b	3.4 b	3.8 b	3.9 b	3.8 b	4.2 b	5.1	6.1

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE significant at the 0.05 level of probability on December 20, 1997 and January 10, 1998 only.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Density data was recorded on a 1 to 9 scale (1 = no turf, and 9 = dense, uniform turf).

§ Fall TE applications were made October 29, 1997.

¶ Spring TE applications were made March 19 and April 17, 1998.

¥ Fall + spring TE applications were made October 29, 1997 + March 19, 1998 + April 17, 1998.

**Table 1.13 1997-1998 Overseeded Perennial Ryegrass Color as Influenced by Trinexapac-ethyl in Blacksburg, Virginia.**

TE Regime †	Turfgrass Color ‡										
	18 Nov.	2 Dec.	20 Dec.	10 Jan.	10 Feb.	27 Feb.	19 Mar.	31 Mar.	17 Apr.	6 May	19 May
None applied	5.6 NS*	5.6 a	5.5 a	5.5 NS	5.5 NS	5.7 NS	5.4 NS	6.0 b	5.3 b	6.0 b	7.3 NS
Fall applied §	5.3	5.4 ab	4.9 b	5.4	5.5	5.6	5.4	5.9 b	5.6 b	6.0 b	7.6
Spring applied ¶	5.3	5.4 ab	5.5 a	5.5	5.5	5.6	5.4	6.4 a	6.4 a	6.9 a	7.6
Fall + Spring ¥	5.5	5.1 b	5.1 b	5.4	5.5	5.6	5.4	6.1 ab	6.4 a	7.0 a	7.7

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE significant at the 0.05 level of probability on December 20, 1997 and April 17, 1998.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Turf color data was recorded on a 1 to 9 scale (1 = brown turf, 5 = acceptable turf color for a golf course fairway, and 9 = dark green turf).

§ Fall TE applications were made October 29, 1997.

¶ Spring TE applications were made March 19 and April 17, 1998.

¥ Fall + spring TE applications were made October 29, 1997 + March 19, 1998 + April 17, 1998.

density on December 20, 1997 and spring TE enhancing color on April 17, 1998. Overseeded turf color ratings were affected by fall TE's negative impact on density when lower density plots resulting from lower seeding rates received lower color ratings. Spring TE's impact on color ratings was due to the enhancement of turf color being more noticeable in higher density plots resulting from higher seeding rates.

Trinexapac-ethyl applications had no effect on annual bluegrass invasion in perennial ryegrass overseeded plots compared to untreated plots (Table 1.14).

### **Trinexapac-ethyl's Influence on Overseeded Annual Ryegrass**

Bermudagrass PD transition in overseeded annual ryegrass was not affected by fall only TE while spring only and fall + spring TE did delay PD transition to bermudagrass when compared to nontreated plots (Table 1.15). This reduction in bermudagrass PD transition (7.8 percent and 9.6 percent less bermudagrass when compared to untreated plots in spring TE and fall + spring TE plots, respectively) was observed June 5, 1998, forty-nine days after the final TE application on April 17, 1998. Bermudagrass PD transition in TE treated plots was similar to untreated plots after June 29, 1998.

Trinexapac-ethyl had no effect on overseeded annual ryegrass plot quality (Table 1.16). There was one temporary interaction between seeding rates and TE application regimes significant at the 0.05 level of probability for annual ryegrass overseeded bermudagrass quality (April 17, 1998). This was the only date where the p value for TE main effects (0.0364) was significant at the 0.05 level of probability. Otherwise, TE had no effect on overseeded annual ryegrass quality.

Trinexapac-ethyl affected overseeded annual ryegrass color (Table 1.17). The effect was similar to TE treated overseeded perennial ryegrass. There was one temporary interaction between seeding rates and TE application regimes significant at the 0.05 level of probability for overseeded annual ryegrass color (March 31, 1998). This temporary interaction was the result of

**Table 1.14 1998 Annual Bluegrass (*Poa annua*) Invasion in Perennial Ryegrass Overseeded Bermudagrass as Influenced by Trinexapac-ethyl in Blacksburg, Virginia.**

<u>TE Regime †</u>	<u>Annual Bluegrass Invasion ‡</u>
	19 May
None applied	4.5 NS*
Fall applied §	10.0
Spring applied ¶	6.6
Fall + Spring ¥	7.6

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Annual bluegrass invasion is estimated as a percentage of the total plot area that was actively growing annual bluegrass.

§ Fall TE applications were made October 29, 1997.

¶ Spring TE applications were made March 19 and April 17, 1998.

¥ Fall + spring TE applications were made October 29, 1997 + March 19, 1998 + April 17, 1998.

**Table 1.15 1998 Annual Ryegrass Overseeded Bermudagrass Post Dormancy Transition as Influenced by Trinexapac-ethyl in Blacksburg, Virginia.**

TE Regime †	Post Dormancy Transition ‡					
	6 May	19 May	5 June	29 June	21 July	10 Aug.
None applied	33.4 ab*	64.7 a	86.1 a	94.4 NS	97.8 NS	98.3 NS
Fall applied §	38.8 a	59.1 a	85.3 a	94.1	96.9	97.6
Spring applied ¶	28.1 b	41.6 b	79.4 b	93.4	97.7	98.3
Fall + Spring ¥	31.9 ab	42.5 b	77.8 b	92.5	95.4	96.4

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Post dormancy transition is estimated as a percentage of the total plot area that was actively growing, green bermudagrass.

§ Fall TE applications were made October 29, 1997.

¶ Spring TE applications were made March 19 and April 17, 1998.

¥ Fall + spring TE applications were made October 29, 1997 + March 19, 1998 + April 17, 1998.

**Table 1.16 1997-1998 Overseeded Annual Ryegrass Quality as Influenced by Trinexapac-ethyl in Blacksburg, Virginia.**

TE Regime †	Turfgrass Quality ‡														
	18 Nov.	2 Dec.	20 Dec.	10 Jan.	10 Feb.	27 Feb.	19 Mar.	31 Mar.	17 Apr.	6 May	19 May	5 June	29 June	21 July	10 Aug.
None applied	4.4 NS*	4.3 NS	3.6 NS	3.3 NS	3.3 NS	4.3 NS	4.0 NS	4.1 NS	3.1 ab	3.1 NS	4.3 NS	6.1 a	7.6 NS	7.5 NS	7.8 NS
Fall applied §	4.0	4.1	3.5	3.0	3.0	3.9	3.7	3.9	2.9 b	3.1	4.1	6.1 a	7.7	7.4	7.6
Spring applied ¶	4.1	4.1	3.3	3.1	3.1	4.1	3.8	3.8	3.3 a	2.8	3.9	5.8 ab	7.4	7.6	7.8
Fall + Spring ¥	3.7	3.8	3.4	2.8	2.9	3.8	3.4	3.6	3.2 ab	2.9	4.0	5.3 b	6.8	7.2	7.4

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE significant at the 0.05 level of probability on April 17, 1998.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Quality data was recorded on a 1 to 9 scale (1 = brown or dead turf, 5 = acceptable golf course fairway turf, and 9 = dense, green, uniform turf).

§ Fall TE applications were made October 29, 1997.

¶ Spring TE applications were made March 19 and April 17, 1998.

¥ Fall + spring TE applications were made October 29, 1997 + March 19, 1998 + April 17, 1998.

**Table 1.17 1997-1998 Overseeded Annual Ryegrass Color as Influenced by Trinexapac-ethyl in Blacksburg, Virginia.**

TE Regime †	Turfgrass Color ‡									
	18 Nov.	2 Dec.	20 Dec.	10 Jan.	10 Feb.	27 Feb.	19 Mar.	31 Mar.	17 Apr.	19 May
None applied	5.0 NS*	4.8 ab	5.0 NS	5.3 NS	4.9 NS	5.1 NS	4.3 NS	3.1 ab	3.0 b	2.0 b
Fall applied §	5.3	5.4 a	5.1	5.1	4.9	4.9	4.3	2.9 b	3.3 ab	2.3 b
Spring applied ¶	4.4	4.3 b	4.4	4.8	4.4	4.4	3.7	3.4 a	3.2 ab	4.2 ab
Fall + Spring ¥	5.0	4.9 ab	4.8	4.8	4.6	4.7	3.9	3.4 a	3.4 a	5.7 a

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE significant at the 0.05 level of probability on March 31, 1998.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Turf color data was recorded on a 1 to 9 scale (1 = brown turf, 5 = acceptable turf color for a golf course fairway, and 9 = dark green turf).

§ Fall TE applications were made October 29, 1997.

¶ Spring TE applications were made March 19 and April 17, 1998.

¥ Fall + spring TE applications were made October 29, 1997 + March 19, 1998 + April 17, 1998.

higher annual ryegrass overseeding rates, and the corresponding higher density, amplifying spring TE's enhancement of turfgrass color when compared to lower annual ryegrass overseeding rates.

Trinexapac-ethyl applications had no effect on annual bluegrass invasion in annual ryegrass overseeded plots when compared with untreated plots (Table 1.18).

## **Lynchburg Location**

### **Perennial Ryegrass Seeding Rate Effects**

Overseeded perennial ryegrass PD transition to bermudagrass was significantly affected by seeding rate (Table 1.19). Full PD transition occurs when the post dormant bermudagrass population in overseeded plots is not different from the post dormant bermudagrass population in non-overseeded ( $0 \text{ kg ha}^{-1}$ ) plots. Full PD transition from overseeded perennial ryegrass to bermudagrass did not occur in Lynchburg until mid-August 1998 and only in plots overseeded at  $224 \text{ kg ha}^{-1}$ . Despite overseeded perennial ryegrass delaying PD transition to bermudagrass, differences between seeding rates were slight in Lynchburg. Final PD transition ratings on August 14, 1998 ranged from 94.1 percent bermudagrass ( $448 \text{ kg ha}^{-1}$ ) to 99.3 percent bermudagrass in non-overseeded ( $0 \text{ kg ha}^{-1}$ ) plots. Plots overseeded with  $896 \text{ kg ha}^{-1}$  perennial ryegrass averaged 94.7 percent bermudagrass on August 14, 1998 compared to 60.0 percent bermudagrass in Blacksburg on August 10, 1998.

Seeding rate influence on overseeded perennial ryegrass turf quality was similar to that observed in Blacksburg. Plots overseeded with higher rates of perennial ryegrass increased turf quality from November 24, 1997 to May 28, 1998 (Table 1.20). After June 11, 1998, turf quality differences between the three perennial ryegrass overseeding rates were no longer evident and after July 2, 1998, no turf quality differences existed between perennial ryegrass overseeded plots and non-overseeded ( $0 \text{ kg ha}^{-1}$ ) plots.

**Table 1.18 1998 Annual Bluegrass (*Poa annua*) Invasion in Annual Ryegrass Overseeded Bermudagrass as Influenced by Trinexapac-ethyl in Blacksburg, Virginia.**

<u>TE Regime †</u>	<u>Annual Bluegrass Invasion ‡</u>
	19 May
None applied	4.6 NS*
Fall applied §	8.2
Spring applied ¶	7.6
Fall + Spring ¥	7.1

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Annual bluegrass invasion is estimated as a percentage of the total plot area that was actively growing annual bluegrass.

§ Fall TE applications were made October 29, 1997.

¶ Spring TE applications were made March 19 and April 17, 1998.

¥ Fall + spring TE applications were made October 29, 1997 + March 19, 1998 + April 17, 1998.

**Table 1.19 1998 Overseeded Bermudagrass Post Dormancy Transition as Influenced by Fall 1997 Perennial Ryegrass Overseeding Rates in Lynchburg, Virginia.**

Overseeding Rate †	Post Dormancy Transition ‡					
	<u>12 May</u>	<u>28 May</u>	<u>11 June</u>	<u>2 July</u>	<u>23 July</u>	<u>14 Aug.</u>
0	33.8 a*	59.1 a	73.1 a	87.5 a	96.0 a	99.3 a
224	10.3 b	34.7 b	40.0 b	74.4 b	88.4 b	95.4 ab
448	9.1 b	31.3 bc	38.8 b	68.4 bc	85.6 b	94.1 b
896	7.2 b	28.4 c	37.5 b	60.9 c	86.9 b	94.7 b

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Overseeding rates are kg ha<sup>-1</sup>

‡ Post dormancy transition is estimated as a percentage of the total plot area that was actively growing, green bermudagrass.

**Table 1.20 1997-1998 Overseeded Bermudagrass Fairway Quality as Influenced by Fall 1997 Perennial Ryegrass Overseeding Rates in Lynchburg, Virginia.**

Overseeding Rate †	Turfgrass Quality ‡														
	<u>24 Nov.</u>	<u>3 Dec.</u>	<u>6 Jan.</u>	<u>29 Jan.</u>	<u>26 Feb.</u>	<u>5 Mar.</u>	<u>26 Mar.</u>	<u>10 Apr.</u>	<u>30 Apr.</u>	<u>12 May</u>	<u>28 May</u>	<u>11 June</u>	<u>2 July</u>	<u>23 July</u>	<u>14 Aug.</u>
0	1.0 d*	1.0 d	1.0 c	1.0 d	1.0 d	1.0 c	1.0 c	1.0 d	2.1 c	3.0 d	4.4 c	5.0 b	5.1 NS	6.8 NS	7.3 NS
224	5.6 c	4.8 c	5.4 b	5.1 c	4.7 c	4.1 b	4.2 b	4.1 c	5.6 b	5.3 c	6.4 b	6.4 a	5.7	6.4	6.7
448	6.8 b	5.9 b	6.4 a	5.9 b	5.4 b	4.3 b	5.1 a	4.9 b	6.7 a	6.1 b	6.9 a	6.5 a	5.7	6.4	6.4
896	7.4 a	7.0 a	6.9 a	6.4 a	6.2 a	5.1 a	5.4 a	5.6 a	7.2 a	6.6 a	6.9 a	6.5 a	5.3	6.2	6.4

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Overseeding rates are kg ha<sup>-1</sup>

‡ Quality data was recorded on a 1 to 9 scale (1 = brown or dead turf, 5 = acceptable golf course fairway turf, and 9 = dense, green, uniform turf).

Unlike in Blacksburg, overseeded perennial ryegrass suppression of annual bluegrass invasion was different among seeding rates on May 12, 1998 (Table 1.21). Higher perennial ryegrass seeding rates (448 and 896 kg ha<sup>-1</sup>) reduced annual bluegrass infestation better than the lower seeding rate (224 kg ha<sup>-1</sup>) and non-overseeded (0 kg ha<sup>-1</sup>) bermudagrass.

### **Annual Ryegrass Seeding Rate Effects**

Overseeded annual ryegrass performance in Lynchburg was similar to Blacksburg. Annual ryegrass overseeding rates did not appear to delay PD transition when compared to non-overseeded (0 kg ha<sup>-1</sup>) plots (Table 1.22). Annual ryegrass overseeded plots had larger post dormant bermudagrass populations than non-overseeded (0 kg ha<sup>-1</sup>) plots on May 12, May 18, and June 11, 1998. After July 2, 1998, the average post dormant bermudagrass population in non-overseeded (0 kg ha<sup>-1</sup>) plots was not different from overseeded annual ryegrass plots. Average PD transition ratings on August 14, 1998 ranged from 99.2 percent bermudagrass in non-overseeded (0 kg ha<sup>-1</sup>) plots to 99.9 percent bermudagrass in annual ryegrass plots overseeded at 896 kg ha<sup>-1</sup>. The effect observed in late spring appeared to be due to a strong presence of annual bluegrass in the non-overseeded (0 kg ha<sup>-1</sup>) plots negatively impacting PD transition more than overseeded annual ryegrass (Table 1.23).

Overseeded annual ryegrass plot winter-spring quality was similar to that observed in Blacksburg. Annual ryegrass overseeded plots had higher turf quality ratings with increased seeding rates (Table 1.24). However, these differences between annual ryegrass seeding rates were no longer evident once bermudagrass began PD regrowth and all the annual ryegrass seemed to thin out at the same time.

### **Trinexapac-ethyl's Influence on Overseeded Perennial Ryegrass**

Trinexapac-ethyl's effect on PD transition from overseeded perennial ryegrass to bermudagrass was different from the Blacksburg study. No differences were observed in PD

**Table 1.21 1998 Annual Bluegrass (*Poa annua*) Invasion in Overseeded Bermudagrass as Influenced by Fall 1997 Perennial Ryegrass Overseeding Rates in Lynchburg, Virginia.**

<u>Overseeding Rate †</u>	<u>Annual Bluegrass Invasion ‡</u>
	<u>12 May</u>
0	32.8 c*
224	8.1 b
448	4.1 ab
896	2.3 a

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Overseeding rates are kg ha<sup>-1</sup>

‡ Annual bluegrass invasion is estimated as a percentage of the total plot area that was actively growing annual bluegrass.

**Table 1.22 1998 Overseeded Bermudagrass Post Dormancy Transition as Influenced by Fall 1997 Annual Ryegrass Overseeding Rates in Lynchburg, Virginia.**

Overseeding Rate †	Post Dormancy Transition ‡					
	12 May	28 May	11 June	2 July	23 July	14 Aug.
0	36.9 NS*	58.1 b	77.8 b	91.3 NS	97.3 NS	99.2 NS
224	39.1	64.1 ab	85.3 a	92.5	98.2	99.4
448	39.1	65.6 a	86.9 a	91.9	97.8	99.3
896	35.9	69.1 a	88.1 a	90.6	98.4	99.9

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Overseeding rates are kg ha<sup>-1</sup>

‡ Post dormancy transition is estimated as a percentage of the total plot area that was actively growing, green bermudagrass.

**Table 1.23 1998 Annual Bluegrass (*Poa annua*) Invasion in Overseeded Bermudagrass as Influenced by Fall 1997 Annual Ryegrass Overseeding Rates in Lynchburg, Virginia.**

<u>Overseeding Rate †</u>	<u>Annual Bluegrass Invasion ‡</u>
	<u>12 May</u>
0	29.1 c*
224	14.1 b
448	12.6 b
896	5.9 a

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Overseeding rates are kg ha<sup>-1</sup>

‡ Annual bluegrass invasion is estimated as a percentage of the total plot area that was actively growing annual bluegrass.

**Table 1.24 1997-1998 Overseeded Bermudagrass Fairway Quality as Influenced by Fall 1997 Annual Ryegrass Overseeding Rates in Lynchburg, Virginia.**

Overseeding Rate †	Turfgrass Quality ‡														
	24 Nov.	3 Dec.	6 Jan.	29 Jan.	26 Feb.	5 Mar.	26 Mar.	10 Apr.	30 Apr.	12 May	28 May	11 June	2 July	23 July	14 Aug.
0	1.0 d*	1.0 d	1.0 d	1.0 d	1.0 c	1.0 c	1.0 c	1.0 c	2.1 c	3.0 b	4.5 a	4.9 NS	5.7 NS	7.2 NS	7.4 NS
224	3.2 c	3.4 c	3.8 c	3.2 c	2.9 b	3.4 b	3.3 b	3.5 b	3.2 b	3.6 a	4.0 ab	4.7	5.3	7.4	7.6
448	4.4 b	4.0 b	4.4 b	3.8 b	3.2 b	3.5 b	3.6 b	3.8 ab	3.7 a	3.8 a	3.6 b	4.6	4.9	6.9	7.3
896	5.6 a	4.8 a	5.0 a	4.1 a	3.9 a	4.0 a	4.0 a	4.0 a	4.0 a	3.9 a	3.6 b	4.4	4.6	7.1	7.6

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Overseeding rates are kg ha<sup>-1</sup>

‡ Quality data was recorded on a 1 to 9 scale (1 = brown or dead turf, 5 = acceptable golf course fairway turf, and 9 = dense, green, uniform turf).

transition ratings in TE treated plots compared to nontreated plots after the initial rating on May 12, 1998 (Table 1.25). Final observations on August 14, 1998 only ranged from 93.9 percent bermudagrass in TE fall + spring treated plots to 96.8 percent bermudagrass in the untreated control.

The TE influence on overseeded perennial ryegrass plot quality was also different than TE effects observed in Blacksburg. Trinexapac-ethyl applications had no effect on overall turf quality from November 1997 through August 1998 (Table 1.26). The significant reduction in overseeded perennial ryegrass density that was observed in Blacksburg, during the winter months in fall TE treated plots was not observed in Lynchburg. Overseeded perennial ryegrass turf density was only reduced in fall TE treated plots on March 5, 1998 (Table 1.27).

Overseeded perennial ryegrass treated with fall TE had slightly greater turfgrass color throughout the winter months, however these differences were not statistically significant (Table 1.28). Overseeded perennial ryegrass treated with spring TE did have darker color observed April 30 and May 12, 1998. However, these differences were no longer evident by May 28, 1998. Trinexapac-ethyl applications had no effect on annual bluegrass invasion of overseeded perennial ryegrass compared to untreated plots (Table 1.29).

### **Trinexapac-ethyl's Influence on Overseeded Annual Ryegrass**

Trinexapac-ethyl did not influence bermudagrass PD transition in overseeded annual ryegrass (Table 1.30). Also, TE had no effect on overseeded annual ryegrass quality (Table 1.31) nor on overseeded annual ryegrass density (Table 1.32). Applications of TE did not influence overseeded annual ryegrass color (Table 1.33). Trinexapac-ethyl applications had no effect on annual bluegrass invasion of overseeded annual ryegrass compared to untreated plots (Table 1.34).

**Table 1.25 1998 Perennial Ryegrass Overseeded Bermudagrass Post Dormancy Transition as Influenced by Trinexapac-ethyl in Lynchburg, Virginia.**

TE Regime †	Post Dormancy Transition ‡					
	12 May	28 May	11 June	2 July	23 July	14 Aug.
None applied	18.4 a*	40.0 NS	48.1 NS	73.1 NS	90.4 NS	96.8 NS
Fall applied §	15.6 ab	40.0	48.8	73.1	89.4	96.6
Spring applied ¶	12.8 ab	38.4	49.1	73.4	90.4	96.2
Fall + Spring ¥	13.4 b	35.0	43.4	71.6	86.7	93.9

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Post dormancy transition is estimated as a percentage of the total plot area that was actively growing, green bermudagrass.

§ Fall TE applications were made October 31 and December 3, 1997.

¶ Spring TE applications were made March 5 and April 10, 1998.

¥ Fall + spring TE applications were made October 31 + December 3, 1997 + March 5 + April 10, 1998.

**Table 1.26 1997-1998 Overseeded Perennial Ryegrass Quality as Influenced by Trinexapac-ethyl in Lynchburg, Virginia.**

TE Regime †	Turfgrass Quality ‡														
	24 Nov.	3 Dec.	6 Jan.	29 Jan.	26 Feb.	5 Mar.	26 Mar.	10 Apr.	30 Apr.	12 May	28 May	11 June	2 July	23 July	14 Aug.
None applied	5.3 NS*	4.6 NS	5.0 NS	4.6 NS	4.4 NS	3.7 NS	3.8 NS	3.9 NS	5.3 NS	5.1 NS	6.3 NS	5.9 NS	5.4 NS	6.4 NS	6.7 NS
Fall applied §	5.1	4.7	4.8	4.5	4.2	3.6	3.8	3.8	5.3	5.2	6.0	6.0	5.3	6.4	6.8
Spring applied ¶	5.3	4.8	4.9	4.6	4.6	3.7	3.9	3.9	5.4	5.3	6.1	6.1	5.4	6.3	6.7
Fall + Spring ¥	5.2	4.7	5.1	4.6	4.2	3.5	4.1	4.0	5.5	5.4	6.4	6.3	5.8	6.7	6.6

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Quality data was recorded on a 1 to 9 scale (1 = brown or dead turf, 5 = acceptable golf course fairway turf, and 9 = dense, green, uniform turf).

§ Fall TE applications were made October 31 and December 3, 1997.

¶ Spring TE applications were made March 5 and April 10, 1998.

¥ Fall + spring TE applications were made October 31 + December 3, 1997 + March 5 + April 10, 1998.

**Table 1.27 1998 Overseeded Perennial Ryegrass Density as Influenced by Trinexapac-ethyl in Lynchburg, Virginia.**

TE Regime †	Turfgrass Density ‡									
	6 Jan.	29 Jan.	26 Feb.	5 Mar.	26 Mar.	10 Apr.	30 Apr.	12 May	28 May	11 June
None applied	4.9 NS*	4.8 NS	4.5 NS	3.8 ab	4.1 NS	4.6 NS	5.5 NS	5.1 NS	6.2 NS	6.4 NS
Fall applied §	4.8	4.7	4.3	3.6 b	4.2	4.6	5.6	5.4	6.1	6.3
Spring applied ¶	4.8	4.9	4.4	4.0 a	4.0	4.7	5.4	5.5	6.0	6.4
Fall + Spring ¥	4.6	4.8	4.3	4.1 a	4.2	4.6	5.6	5.4	6.4	6.6

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Density data was recorded on a 1 to 9 scale (1 = no turf, and 9 = dense, uniform turf).

§ Fall TE applications were made October 31 and December 3, 1997.

¶ Spring TE applications were made March 5 and April 10, 1998.

¥ Fall + spring TE applications were made October 31 + December 3, 1997 + March 5 + April 10, 1998.

**Table 1.28 1997-1998 Overseeded Perennial Ryegrass Color as Influenced by Trinexapac-ethyl in Lynchburg, Virginia.**

TE Regime †	Turfgrass Color ‡										
	24 Nov.	3 Dec.	6 Jan.	29 Jan.	26 Feb.	5 Mar.	26 Mar.	10 Apr.	30 Apr.	12 May	28 May
None applied	5.4 NS*	5.4 ab	5.3 NS	5.1 NS	4.4 NS	4.6 NS	4.3 NS	5.1 NS	6.3 b	6.2 c	7.0 NS
Fall applied §	5.5	5.7 a	5.3	5.4	4.6	4.9	4.5	5.1	6.2 b	6.3 bc	7.0
Spring applied ¶	5.3	5.3 b	5.3	5.1	4.4	4.7	4.4	5.4	6.8 a	6.7 ab	7.3
Fall + Spring ¥	5.5	5.4 ab	5.2	5.2	4.5	4.8	4.6	5.4	7.0 a	6.8 a	7.3

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Turf color data was recorded on a 1 to 9 scale (1 = brown turf, 5 = acceptable turf color for a golf course fairway, and 9 = dark green turf).

§ Fall TE applications were made October 31 and December 3, 1997.

¶ Spring TE applications were made March 5 and April 10, 1998.

¥ Fall + spring TE applications were made October 31 + December 3, 1997 + March 5 + April 10, 1998.

**Table 1.29 1998 Annual Bluegrass (*Poa annua*) Invasion in Perennial Ryegrass Overseeded Bermudagrass as Influenced by Trinexapac-ethyl in Lynchburg, Virginia.**

<u>TE Regime †</u>	<u>Annual Bluegrass Invasion ‡</u>
	<u>12 May</u>
None applied	11.7 NS*
Fall applied §	11.8
Spring applied ¶	12.0
Fall + Spring ¥	11.9

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Annual bluegrass invasion is estimated as a percentage of the total plot area that was actively growing annual bluegrass.

§ Fall TE applications were made October 31 and December 3, 1997.

¶ Spring TE applications were made March 5 and April 10, 1998.

¥ Fall + spring TE applications were made October 31 + December 3, 1997 + March 5 + April 10, 1998.

**Table 1.30 1998 Annual Ryegrass Overseeded Bermudagrass Post Dormancy Transition as Influenced by Trinexapac-ethyl in Lynchburg, Virginia.**

TE Regime †	Post Dormancy Transition ‡					
	12 May	28 May	11 June	2 July	23 July	14 Aug.
None applied	42.5 NS*	63.8 NS	84.7 NS	90.6 NS	97.7 NS	99.2 NS
Fall applied §	40.3	66.3	84.7	92.2	98.5	99.9
Spring applied ¶	33.8	62.8	83.8	91.9	97.5	99.3
Fall + Spring ¥	34.4	64.1	85.0	91.6	98.0	99.4

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Post dormancy transition is estimated as a percentage of the total plot area that was actively growing, green bermudagrass.

§ Fall TE applications were made October 31 and December 3, 1997.

¶ Spring TE applications were made March 5 and April 10, 1998.

¥ Fall + spring TE applications were made October 31 + December 3, 1997 + March 5 + April 10, 1998.

**Table 1.31 1997-1998 Overseeded Annual Ryegrass Quality as Influenced by Trinexapac-ethyl in Lynchburg, Virginia.**

TE Regime †	Turfgrass Quality ‡														
	24 Nov.	3 Dec.	6 Jan.	29 Jan.	26 Feb.	5 Mar.	26 Mar.	10 Apr.	30 Apr.	12 May	28 May	11 June	2 July	23 July	14 Aug.
None applied	3.5 NS*	3.3 NS	3.6 NS	2.8 NS	2.8 NS	2.9 NS	2.9 NS	3.0 NS	3.3 NS	3.5 NS	3.9 NS	4.6 NS	5.4 NS	7.1 NS	7.4 NS
Fall applied §	3.7	3.3	3.8	3.1	2.8	3.1	3.1	3.1	3.2	3.7	4.1	4.7	5.4	7.4	7.6
Spring applied ¶	3.3	3.3	3.4	3.0	2.6	2.9	2.9	3.1	3.2	3.6	3.9	4.7	5.2	7.1	7.5
Fall + Spring ¥	3.7	3.3	3.4	3.1	2.8	2.9	3.0	3.0	3.3	3.6	3.9	4.6	4.6	7.0	7.3

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Quality data was recorded on a 1 to 9 scale (1 = brown or dead turf, 5 = acceptable golf course fairway turf, and 9 = dense, green, uniform turf).

§ Fall TE applications were made October 31 and December 3, 1997.

¶ Spring TE applications were made March 5 and April 10, 1998.

¥ Fall + spring TE applications were made October 31 + December 3, 1997 + March 5 + April 10, 1998.

**Table 1.32 1998 Overseeded Annual Ryegrass Density as Influenced by Trinexapac-ethyl in Lynchburg, Virginia.**

TE Regime †	Turfgrass Density ‡									
	6 Jan.	29 Jan.	26 Feb.	5 Mar.	26 Mar.	10 Apr.	30 Apr.	12 May	28 May	11 June
None applied	3.5 NS*	3.3 NS	3.6 NS	3.4 NS	3.6 NS	4.0 NS	4.2 NS	3.9 NS	3.8 NS	4.9 NS
Fall applied §	3.6	3.3	3.7	3.5	3.8	3.7	4.3	3.8	4.1	5.1
Spring applied ¶	3.4	3.2	3.5	3.4	3.6	4.1	4.4	3.8	3.9	5.1
Fall + Spring ¥	3.8	3.2	3.8	3.3	3.8	3.8	4.4	3.7	3.9	4.8

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Density data was recorded on a 1 to 9 scale (1 = no turf, and 9 = dense, uniform turf).

§ Fall TE applications were made October 31 and December 3, 1997.

¶ Spring TE applications were made March 5 and April 10, 1998.

¥ Fall + spring TE applications were made October 31 + December 3, 1997 + March 5 + April 10, 1998.

**Table 1.33 1997-1998 Overseeded Annual Ryegrass Color as Influenced by Trinexapac-ethyl in Lynchburg, Virginia.**

TE Regime †	Turfgrass Color ‡								
	24 Nov.	3 Dec.	6 Jan.	29 Jan.	26 Feb.	5 Mar.	26 Mar.	10 Apr.	30 Apr.
None applied	3.8 NS*	4.3 NS	4.8 a	3.3 NS	2.7 NS	3.1 NS	2.9 ab	3.4 NS	4.4 NS
Fall applied §	4.3	4.4	4.6 ab	3.5	2.7	3.2	2.8 b	3.5	4.4
Spring applied ¶	3.8	4.3	4.4 b	3.3	2.5	3.1	3.2 a	3.7	4.8
Fall + Spring ¥	3.9	4.4	4.8 a	3.5	2.8	3.2	3.1 ab	3.6	4.8

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Turf color data was recorded on a 1 to 9 scale (1 = brown turf, 5 = acceptable turf color for a golf course fairway, and 9 = dark green turf).

§ Fall TE applications were made October 31 and December 3, 1997.

¶ Spring TE applications were made March 5 and April 10, 1998.

¥ Fall + spring TE applications were made October 31 + December 3, 1997 + March 5 + April 10, 1998.

**Table 1.34 1998 Annual Bluegrass (*Poa annua*) Invasion in Annual Ryegrass Overseeded Bermudagrass as Influenced by Trinexapac-ethyl in Lynchburg, Virginia.**

<u>TE Regime †</u>	<u>Annual Bluegrass Invasion ‡</u>
	<u>12 May</u>
None applied	17.6 NS*
Fall applied §	12.9
Spring applied ¶	17.4
Fall + Spring ¥	13.7

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Annual bluegrass invasion is estimated as a percentage of the total plot area that was actively growing annual bluegrass.

§ Fall TE applications were made October 31 and December 3, 1997.

¶ Spring TE applications were made March 5 and April 10, 1998.

¥ Fall + spring TE applications were made October 31 + December 3, 1997 + March 5 + April 10, 1998.

## 1997-1998 Conclusions

Blacksburg's cooler climate at 634 meters above sea level is not as favorable for bermudagrass growth when compared to Lynchburg's warmer climate. Conversely, it is a more favorable climate for cool-season grasses. However, the above normal temperatures during the winter months and PD transition period at both locations should have led to minimal, if any winter injury of bermudagrass and favored earlier than normal post dormant bermudagrass regrowth at both locations.

Annual ryegrass does not persist well into spring, acting more as a short-lived, heat sensitive winter annual. Therefore annual ryegrass does favor quicker PD transition to bermudagrass than the 'Palmer II' perennial ryegrass. The persistence of perennial ryegrass makes PD transition to bermudagrass much more difficult, even in years that would seem to favor bermudagrass PD regrowth. However, annual ryegrass' contribution to overseeded turf quality, declines during the late winter and spring, even at the higher seeding rates (448 and 896 kg ha<sup>-1</sup>). Trinexapac-ethyl failed to enhance late winter and spring overseeded annual ryegrass turf quality in either location. Therefore, annual ryegrass remains an unacceptable choice for winter overseeding since it declines or transitions out of the stand prior to significant post dormant bermudagrass regrowth.

Gadd (1990) stated the trend toward lower seeding rates was related to the theory that fewer plants provided less competition and made for an easier transition. The current trend toward increased overseeding rates is attributed to the theory, that higher seeding rates leads to a better bermudagrass PD transition. Landry (1993) stated the increased competition caused by the greater density of cool-season grasses when overseeded at higher rates, tends to increase PD transition time. Higher seeding rates (448 and 896 kg ha<sup>-1</sup>) of 'Palmer II' perennial ryegrass did not enhance bermudagrass PD transition over the lower seeding rate (224 kg ha<sup>-1</sup>) at either location. In fact, the higher seeding rates of perennial ryegrass hindered PD transition when compared to the lower seeding rates at Blacksburg. This result would be somewhat expected

since Blacksburg's climate is naturally cooler and thus favors perennial ryegrass persistence. Although PD transition was reduced in plots overseeded with higher perennial ryegrass rates than the lower rate in Lynchburg, this effect was insignificant among the three seeding rates. This suggests higher perennial ryegrass overseeding rates may not have an effect on PD transition in warmer transition zone climates or in years that weather conditions favor early PD transition. Non-overseeded ( $0 \text{ kg ha}^{-1}$ ) bermudagrass in both locations was slow to transition, taking until mid-summer (late-July or early-August) to reach at least ninety percent bermudagrass plot coverage.

The higher perennial ryegrass overseeding rates did enhance fairway turf quality over lower seeding rates in both locations. However, turf quality can decline once bermudagrass begins to exit winter dormancy and high amounts of perennial ryegrass persist, as was the case in Blacksburg. This is largely a result of a non-uniform turf canopy. Higher annual ryegrass overseeding rates did not enhance PD transition. However, higher seeding rates of annual ryegrass led to a greater post dormant bermudagrass population in overseeded plots than non-overseeded plots in both locations. This effect shows the influence annual bluegrass invasion in non-overseeded bermudagrass can have on PD transition. Menn and Beard (1987) stated annual bluegrass was the number one cool-season, grassy weed problem on winter overseeded bermudagrass. Their research conducted in Texas in the mid-1980's showed higher overseeding rates of perennial ryegrass rarely produced a problem with annual bluegrass invasion on bermudagrass putting greens. Plots overseeded with both annual ryegrass and perennial ryegrass were able to prevent significant annual bluegrass invasion and subsequently the higher seeding rates were more effective than lower seeding rates in preventing annual bluegrass from invading the turfgrass canopy. Larger percentages of bermudagrass were present in plots overseeded with annual ryegrass when compared to non-overseeded plots. Plots not overseeded at either location had significantly greater amounts of annual bluegrass present, which competed with bermudagrass PD regrowth.

Post dormancy transition from overseeded perennial ryegrass to bermudagrass was not improved in either location from TE applications. Although transition ratings were for the most part unaffected, somewhat lower post dormant bermudagrass populations were in treated plots. This suggests TE applications made to overseeded perennial ryegrass may negatively impact PD transition to bermudagrass. Post dormancy transition from overseeded annual ryegrass to bermudagrass in Blacksburg and Lynchburg was not enhanced with TE applications.

Trinexapac-ethyl did not enhance overseeded perennial ryegrass quality in either location. Although TE negatively impacted turf quality in Blacksburg and not Lynchburg in fall treated plots, this may have occurred due to Blacksburg's cooler climate. This effect of fall TE suggests six weeks after overseeding might be too early to apply TE at  $0.19 \text{ kg a.i. ha}^{-1}$  to perennial ryegrass in cooler climates. Spring TE applications may darken overseeded turf color, but do so without enhancing turf quality.

## **1.2 1998-1999 Field Study**

### **Materials and Methods**

'Palmer II' perennial ryegrass was overseeded in September 1998 at the same Blacksburg and Lynchburg locations used the previous year. The perennial ryegrass was overseeded only into plots, which had been overseeded the previous year with annual ryegrass. Plots previously overseeded with perennial ryegrass in September 1997 were not overseeded nor treated in 1998 and were merely observed for 1997 seeded perennial ryegrass carry over into fall and early winter 1998.

Treatments at both sites were identical with only the dates of plot overseeding, initial TE treatments, and subsequent TE treatments varying. The experiment consisted of sixteen treatments comprised of two variables and replicated four times (Table 1.35). Variables included: perennial ryegrass seeding rate (not seeded, 224, 448, or  $896 \text{ kg ha}^{-1}$ ); and four

**Table 1.35 1998-1999 Overseeded Perennial Ryegrass Treatments for Blacksburg and Lynchburg field trials.**

<b>Treatment #</b>	<b>Overseeded Species *</b>	<b>Seed Rate †</b>	<b>TE ‡</b>
1	Perennial ryegrass	0	None
2	Perennial ryegrass	224	None
3	Perennial ryegrass	448	None
4	Perennial ryegrass	896	None
5	Perennial ryegrass	0	Fall
6	Perennial ryegrass	224	Fall
7	Perennial ryegrass	448	Fall
8	Perennial ryegrass	896	Fall
9	Perennial ryegrass	0	Spring
10	Perennial ryegrass	224	Spring
11	Perennial ryegrass	448	Spring
12	Perennial ryegrass	896	Spring
13	Perennial ryegrass	0	Fall + Spring
14	Perennial ryegrass	224	Fall + Spring
15	Perennial ryegrass	448	Fall + Spring
16	Perennial ryegrass	896	Fall + Spring

\* 'Palmer II' perennial ryegrass

† Seed rates are kg ha<sup>-1</sup>

‡ Trinexapac-ethyl applied at 0.19 kg a.i. ha<sup>-1</sup>

different TE regimes (none, fall applied, spring applied, or fall and spring applied). Plot size was 1.2 m x 1.8 m with a total of sixty-four plots at each location arranged in a randomized complete block design.

### **Blacksburg Location**

The Blacksburg site was a mature stand of 'Midiron' bermudagrass growing on a fine, mixed, mesic Typic Hapludult (Groseclose-Urban Land Complex) with two to seven percent south facing slope at the Virginia Tech Turfgrass Research Center. In August 1998, the site was fertilized with 73.2 kg ha<sup>-1</sup> of urea nitrogen and irrigated. On August 25, 1998, the site was core aerified with a vertical operating hollow tine aerifier (Ryan, GA 30) using 1.3 cm open spoon tines and 6.4 cm spacing. The cores were broken apart by dragging a metal, mesh-like mat across the site. The site was fertilized with 12.2, 24.4, 73.2, and 24.4 kg ha<sup>-1</sup> of urea and ammoniacal nitrogen, phosphate, potash, and iron respectively on September 4, 1998 and immediately irrigated. Fenarimol was applied at 1.5 kg a.i. ha<sup>-1</sup> on September 10, 1998.

Designated plots were overseeded on September 18, 1998 with the same method used in 1997 and irrigated twice daily until all seed had germinated. All subsequent irrigation was applied as needed to prevent severe moisture stress. Insecticide for insect control and herbicide for broadleaf weed control were applied when necessary.

Mowing height for the Blacksburg location in 1998-1999 was the same as in 1997-1998; 1.6 cm two to three times a week with a reel mower (Toro, Reelmaster 2300-D) and clippings returned. A second application of 12.2, 24.4, 73.2, and 24.4 kg ha<sup>-1</sup> of urea and ammoniacal nitrogen, phosphate, potash, and iron respectively was made to the site on October 26, 1998 and irrigated. The plots were fertilized with 73.2 kg ha<sup>-1</sup> urea nitrogen (polymer coated) on May 31, 1999 and July 9, 1999 and immediately irrigated.

Trinexapac-ethyl applications were made to the plots using a compressed air sprayer as in 1997-1998 and applied at 0.19 kg a.i. ha<sup>-1</sup> in similar regimes but more frequently in 1998-1999

when compared to 1997-1998: (1) none; (2) fall applied (November 4, 1998; December 2, 1998; and January 13, 1999); (3) spring applied (March 5, 1999; April 2, 1999; and May 7, 1999); and (4) fall and spring applied (November 4, 1998 + December 2, 1998 + January 13, 1999 + March 5, 1999 + April 2, 1999 + May 7, 1999).

### **Lynchburg Location**

The Lynchburg site was a mature 'Brute' bermudagrass growing on a fine, kaolinitic, thermic Typic Kanhapludult (Cecil fine sandy loam) with seven to fifteen percent south facing slope located on the former number ten fairway of Boonsboro Country Club. On September 11, 1998 fertilizer was applied at 12.2, 24.4, 73.2, and 24.4 kg ha<sup>-1</sup> of urea and ammoniacal nitrogen, phosphate, potash, and iron respectively. Fenarimol was applied at 1.5 kg a.i. ha<sup>-1</sup> on September 11, 1998.

Plots were overseeded on September 25, 1998 with the same method used in 1997 and received a daily irrigation cycle until all seed had germinated. Subsequent irrigation was applied as needed to prevent severe moisture stress.

Mowing height and frequency was the same in 1998-1999 as in 1997-1998. On October 30, 1998, plots were fertilized with 12.2, 24.4, 73.2, and 24.4 kg ha<sup>-1</sup> of urea and ammoniacal nitrogen, phosphate, potash, and iron respectively and irrigated. The plot area received a preemergent herbicide application that consisted of a fertilizer component on April 8, 1999. The herbicide, oxadiazon was applied at 3.4 kg a.i. ha<sup>-1</sup> and the fertilizer carrier supplied 36.6 kg ha<sup>-1</sup> of slowly available methylene urea nitrogen.

Trinexapac-ethyl applications were applied as they were in the 1997-1998 at 0.19 kg a.i. ha<sup>-1</sup> in similar regimes but more frequently in 1998-1999 when compared to 1997-1998: (1) none; (2) fall applied (November 5, 1998; December 4, 1998; and January 14, 1999); (3) spring applied (March 5, 1999; April 2, 1999; and May 3, 1999); and (4) fall and spring applied

(November 5, 1998 + December 4, 1998 + January 14, 1999 + March 5, 1999 + April 2, 1999 + May 3, 1999).

### **Data Recorded**

Observations recorded throughout the duration of this study again consisted of visual ratings of overall turfgrass quality, turf color, density, residual or carry-over 1997 overseeded perennial ryegrass, annual bluegrass (*Poa annua*) infestations, and bermudagrass PD transition. Quality data was recorded on a 1 to 9 scale (1 = brown or dead turf, and 9 = dense, green, uniform turf). A rating of 5 would be indicative of acceptable golf course fairway turf. Turf color data was recorded on a 1 to 9 scale (1 = brown turf, and 9 = dark green turf). A rating of 5 would be indicative of acceptable turf color for a golf course fairway. Density data was recorded on a 1 to 9 scale (1 = no turf, and 9 = dense, uniform turf). Residual or carry-over 1997 overseeded perennial ryegrass was estimated, as a percentage of perennial ryegrass from the 1997 overseeding present in the plot after bermudagrass had become dormant. This observation was only recorded in those plots overseeded with perennial ryegrass in the previous year. Annual bluegrass infestation was estimated as a percentage of the total plot area. Bermudagrass PD transition was estimated as a percentage of the total plot area that was actively growing, green bermudagrass. Plots at both locations were rated monthly from November 1998 to August 1999 for turf color, density, and overall turf quality. Residual or carry-over 1997 overseeded perennial ryegrass was recorded only in November 1998 at both locations. Annual bluegrass infestation was only recorded in April 1999 at both locations. The plots at both locations were rated bimonthly from April 1999 to August 1999 for bermudagrass PD transition. All data collected was subjected to analysis of variance (ANOVA) procedures using the SAS (SAS, 1985) system for each day of data collection. Treatment means were separated using Tukey's studentized range test at the 0.05 level of probability.

## **1998-1999 Results**

Mean daily temperatures for the months of September, 1998 through August, 1999 compared to the thirty year mean daily normals for both locations demonstrates that climatic conditions for both locations were similar to the previous year. Both locations experienced above normal temperatures throughout the winter (December, January, and February) and summer (July and August) months, while temperatures were well below normal during the month of March (Table 1.36).

### **Blacksburg Location**

Tables 1.37 and 1.38 depict the influence of 1997 seeding rates and TE respectively, on the residual perennial ryegrass population from the September 1997 overseeding. Residual perennial ryegrass is that which failed to transition out from overseeded plots in the first year post dormancy period. There were no differences in the amount of residual perennial ryegrass between the three overseeding rates (224, 448, and 896 kg ha<sup>-1</sup>). All three seeding rates had between 55.6 percent (224 kg ha<sup>-1</sup>) and 59.7 percent (448 kg ha<sup>-1</sup>) residual perennial ryegrass from the September 1997 overseeding. All plots treated with TE had significantly more residual perennial ryegrass than untreated plots, although there were no differences between TE treatments. This may be due to TE aiding in perennial ryegrass survival through the unseasonably warm Blacksburg summer of 1998.

### **Perennial Ryegrass Seeding Rate Effects**

Post dormancy transition from overseeded perennial ryegrass to bermudagrass was reduced as a result of overseeding (Table 1.39). Full PD transition is indicated when the post dormant bermudagrass population in overseeded plots equals the post dormant bermudagrass population in non-overseeded (0 kg ha<sup>-1</sup>) plots. A full transition from overseeded perennial ryegrass to bermudagrass was not achieved in Blacksburg in 1999. Plots overseeded with

**Table 1.36 Thirty Year Mean Daily Temperature Normals ( ° C) and 1998-1999 Mean Daily Temperatures ( ° C) for Blacksburg and Lynchburg, Virginia\*.**

<b>Month</b>	<b>Blacksburg Temperatures</b>		<b>Lynchburg Temperatures</b>	
	<b>30-Year Mean Normal</b>	<b>1998-1999 Mean Daily</b>	<b>30-Year Mean Normal</b>	<b>1998-1999 Mean Daily</b>
Sep	17.3	20.2	20.1	22.0
Oct	11.1	12.4	13.9	13.9
Nov	5.9	6.8	8.7	8.4
Dec	1.0	3.7	3.6	5.5
Jan	-1.0	2.3	1.2	3.7
Feb	0.7	2.7	3.0	4.6
Mar	5.3	3.7	8.0	5.9
Apr	10.7	12.1	13.2	13.4
May	15.4	15.3	17.8	17.2
Jun	19.3	19.8	22.1	21.1
Jul	21.7	23.5	24.2	25.4
Aug	20.9	21.2	23.7	24.0

\* Data supplied courtesy of National Weather Service, Blacksburg, Virginia.

**Table 1.37 Fall 1998 Residual Perennial Ryegrass in Overseeded Bermudagrass as Influenced by 1997 Perennial Ryegrass Overseeding Rates in Blacksburg, Virginia.**

<b>Overseeding Rate †</b>	<b>Residual Perennial Ryegrass ‡</b>
	<i>27 Nov.</i>
224	55.6 NS*
448	59.7
896	57.5

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Overseeding rates are kg ha<sup>-1</sup>

‡ Residual perennial ryegrass is a November 1998 estimation of the percentage of the total plot area that was non-transitioning perennial ryegrass overseeded September 1997.

**Table 1.38 Fall 1998 Residual Perennial Ryegrass in 1997 Overseeded Bermudagrass as Influenced by Trinexapac-ethyl in Blacksburg, Virginia.**

<u>TE Regime †</u>	<u>Residual Perennial Ryegrass ‡</u>
	<u>27 Nov.</u>
None applied	44.2 b*
Fall applied §	60.4 a
Spring applied ¶	62.9 a
Fall + Spring ¥	60.9 a

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Residual perennial ryegrass is a November 1998 estimation of the percentage of the total plot area that was non-transitioning perennial ryegrass overseeded September 1997.

§ Fall TE applications were made October 29, 1997.

¶ Spring TE applications were made March 19 and April 17, 1998.

¥ Fall + spring TE applications were made October 29, 1997 + March 19, 1998 + April 17, 1998.

**Table 1.39 1999 Overseeded Bermudagrass Post Dormancy Transition as Influenced by Fall 1998 Perennial Ryegrass Overseeding Rates in Blacksburg, Virginia.**

Overseeding Rate †	Post Dormancy Transition ‡								
	<u>23 Apr.</u>	<u>6 May</u>	<u>21 May</u>	<u>4 June</u>	<u>19 June</u>	<u>9 July</u>	<u>23 July</u>	<u>6 Aug.</u>	<u>18 Aug.</u>
0	8.4 a*	11.9 a	50.9 a	59.7 a	67.8 a	69.4 a	70.9 a	86.9 a	91.3 a
224	2.2 b	3.3 b	20.6 b	32.5 b	41.6 b	42.8 b	40.0 b	51.6 b	63.1 b
448	1.8 b	2.1 b	15.6 c	30.0 b	36.9 b	35.3 bc	32.8 c	39.4 c	44.7 c
896	0.9 b	2.0 b	10.9 c	22.2 c	25.0 c	26.6 c	25.3 d	28.1 d	36.3 c

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE was significant at the 0.05 level of probability on June 4, June 19, and July 9, 1999 only.

† Overseeding rates are kg ha<sup>-1</sup>

‡ Post dormancy transition is estimated as a percentage of the total plot area that was actively growing, green bermudagrass.

perennial ryegrass experienced much less bermudagrass development when compared to non-overseeded plots. Final PD transition ratings on the Blacksburg site ranged from 36.3 percent bermudagrass in the 896 kg ha<sup>-1</sup> plots to 91.3 percent bermudagrass in the non-overseeded (0 kg ha<sup>-1</sup>) plots on August 18, 1999. There were also significant differences in transition among seeding rates. Plots overseeded with 224 kg ha<sup>-1</sup> transitioned to bermudagrass better than plots overseeded with higher rates (448 and 896 kg ha<sup>-1</sup>) throughout the transition period. The highest seeding rate (896 kg ha<sup>-1</sup>) consistently had the least amount of bermudagrass development throughout the recording period. The interaction between seeding rates and TE application regimes was significant at the 0.05 level of probability on June 4, June 19, and July 9, 1999. However, the data analysis indicates stronger main effects on these dates as the p values for seeding rate main effects were 0.0001 for all three dates and the p values for TE main effects were 0.0001, 0.0006, and 0.0001 for all three dates, respectively. The p values for the temporary seed rate by TE interaction on June 4, June 19, and July 9, 1999 were 0.0010, 0.0044, and 0.0235, respectively. These temporary interactions were a result of spring TE's positive influence on overseeded perennial ryegrass transition to bermudagrass. Spring TE briefly enhanced bermudagrass PD transition compared to fall or fall + spring TE. This effect was most evident in plots overseeded with lower rates of perennial ryegrass than higher rates.

Table 1.40 depicts the influence of perennial ryegrass overseeding rates on overseeded bermudagrass winter-spring quality. The increased seeding rates resulted in better plot quality during the fall, winter, and early spring months. There were no differences in plot quality between 448 and 896 kg ha<sup>-1</sup> overseeded plots after May 21, 1999. By June 4, 1999, there were no differences in plot quality between 224, 448, and 896 kg ha<sup>-1</sup> overseeded plots. Overseeded perennial ryegrass plots had lower plot quality compared to non-overseeded (0 kg ha<sup>-1</sup>) plots after August 6, 1999. The interaction between seeding rates and TE application regimes was significant at the 0.05 level of probability on December 20, 1998 and March 5, 1999. However, the data analysis indicates stronger main effects on both dates as the p values for the seed rate

**Table 1.40 1998-1999 Overseeded Bermudagrass Quality as Influenced by Fall 1998 Perennial Ryegrass Overseeding Rates in Blacksburg, Virginia.**

Overseeding Rate †	Turfgrass Quality ‡												
	27 Nov.	20 Dec.	5 Mar.	2 Apr.	23 Apr.	6 May	21 May	4 June	19 June	9 July	23 July	6 Aug.	18 Aug.
0	1.0 d*	1.1 d	1.0 d	2.0 d	2.3 d	2.6 d	4.1 c	4.6 b	5.5 b	6.1 b	6.1 b	7.0 a	6.6 a
224	3.4 c	3.5 c	3.9 c	4.4 c	4.8 c	5.4 c	7.4 b	7.6 a	6.9 a	6.8 a	6.8 a	6.6 b	5.7 b
448	4.4 b	4.2 b	4.7 b	5.2 b	6.0 b	6.0 b	7.9 a	7.9 a	6.9 a	6.8 a	6.9 a	6.9 ab	5.2 bc
896	5.6 a	5.0 a	5.5 a	5.8 a	6.8 a	6.6 a	7.9 a	7.8 a	7.0 a	6.6 a	6.9 a	6.9 ab	4.8 c

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE significant at the 0.05 level of probability on December 20, 1998 and March 5, 1999 only.

† Overseeding rates are kg ha<sup>-1</sup>

‡ Quality data was recorded on a 1 to 9 scale (1 = brown or dead turf, 5 = acceptable golf course fairway turf, and 9 = dense, green, uniform turf).

and TE main effects were 0.0001 and 0.0001, respectively December 20, 1998 and March 5, 1999. The p values for the seed rate by TE interaction on each date were 0.0001 and 0.0014, respectively. These temporary interactions were similar to those observed for the same variables in Blacksburg in 1997-1998; a result of fall TE negatively impacting density, an important component of overall quality. Fall TE plots were less dense than untreated plots. This effect was greater in plots overseeded with lower seeding rates. Plots overseeded with 224 kg ha<sup>-1</sup> contained less plant material than plots overseeded with 448 or 896 kg ha<sup>-1</sup> indicating TE's negative impact on density was amplified in lower seeding rate plots.

Annual bluegrass (*Poa annua*) invasion was significantly reduced in perennial ryegrass overseeded plots compared to non-overseeded (0 kg ha<sup>-1</sup>) plots (Table 1.41). Non-overseeded (0 kg ha<sup>-1</sup>) plots averaged 11.7 percent annual bluegrass compared to a trace (0.9 percent) in plots overseeded with 896 kg ha<sup>-1</sup>. Less annual bluegrass invasion was observed with overseeding although no differences were observed. The interaction between seeding rates and TE application regimes was significant at the 0.05 level of probability on April 23, 1999. This interaction was a result of fall TE negatively impacting turf density, indicating the more open turf canopy was less likely to impede annual bluegrass from invading a more dense turf canopy.

### **Trinexapac-ethyl's Influence on Overseeded Perennial Ryegrass**

Trinexapac-ethyl had a similar influence on 1999 bermudagrass PD transition as in 1998 (Table 1.42). Fall only TE applications exhibited less bermudagrass at times than the untreated plots. However, spring only TE applications were usually not different than the untreated. Plots receiving TE in the fall and spring combined had less bermudagrass develop than in untreated plots. Fall + spring TE treated plots averaged 15.2 percent less bermudagrass than untreated plots on the August 18, 1999 rating. The interaction between seeding rates and TE application regimes was significant at the 0.05 level of probability on June 4, June 19, and July 9, 1999. However, the data analysis indicates stronger main effects on these dates as the p values for

**Table 1.41 1999 Annual Bluegrass (*Poa annua*) Invasion in Overseeded Bermudagrass as Influenced by Fall 1998 Perennial Ryegrass Overseeding Rates in Blacksburg, Virginia.**

<u>Overseeding Rate †</u>	<u>Annual Bluegrass Invasion ‡</u>
	23 Apr.
0	11.7 b*
224	2.3 a
448	1.9 a
896	0.9 a

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE was significant at the 0.05 level of probability.

† Overseeding rates are kg ha<sup>-1</sup>

‡ Annual bluegrass invasion is estimated as a percentage of the total plot area that was actively growing annual bluegrass.

**Table 1.42 1999 Perennial Ryegrass Overseeded Bermudagrass Post Dormancy Transition as Influenced by Trinexapac-ethyl in Blacksburg, Virginia.**

TE Regime †	Post Dormancy Transition ‡								
	23 Apr.	6 May	21 May	4 June	19 June	9 July	23 July	6 Aug.	18 Aug.
None applied	3.7 NS*	4.5 NS	29.4 a	41.3 a	48.1 a	49.7 a	43.1 ab	58.1 a	63.8 a
Fall applied §	3.3	5.0	20.0 b	32.8 b	39.1 bc	40.0 b	42.8 ab	49.7 b	55.8 ab
Spring applied ¶	3.1	4.7	29.7 a	42.8 a	46.9 ab	50.6 a	44.7 a	50.6 ab	61.8 ab
Fall + Spring ¥	3.2	5.1	19.1 b	27.5 c	37.2 c	33.8 b	38.4 b	47.5 b	54.1 b

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE was significant at the 0.05 level of probability on June 4, June 19, and July 9, 1999 only.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Post dormancy transition is estimated as a percentage of the total plot area that was actively growing, green bermudagrass.

§ Fall TE applications were made November 4, December 2, 1998, and January 13, 1999.

¶ Spring TE applications were made March 5, April 2, and May 7, 1999.

¥ Fall + spring TE applications were made November 4, 1998 + December 2, 1998 + January 13, 1999 + March 5, 1999 + April 2, 1999 + May 7, 1999.

seeding rate main effects were 0.0001 for all three dates and the p values for TE main effects were 0.0001, 0.0006, and 0.0001 for all three dates, respectively. The p values for the temporary seed rate by TE interaction on June 4, June 19, and July 9, 1999 were 0.0010, 0.0044, and 0.0235, respectively. These temporary interactions were the result of spring TE's positive influence on overseeded perennial ryegrass transition to bermudagrass. Spring TE briefly enhanced bermudagrass PD transition compared to fall or fall + spring TE. This effect was most evident in plots overseeded with lower rates of perennial ryegrass.

The effects of TE on plot quality were similar to those observed in 1997-1998. Spring TE treatment did not differ from the untreated control for the entire ten-month data collection period (Table 1.43). Fall TE applications reduced overall plot quality from November 27, 1998 through March 5, 1999 when compared to the untreated plots. Fall + spring applied TE also reduced plot quality on May 6, 1999 as well as during the November 27 through March 5 period. The interaction between seeding rates and TE application regimes was significant at the 0.05 level of probability on December 20, 1998 and March 5, 1999. However, the data analysis indicates stronger main effects on both dates as the p values for the seed rate and TE main effects were 0.0001 and 0.0001, respectively December 20, 1998 and March 5, 1999. The p values for the seed rate by TE interaction on each date were 0.0001 and 0.0014, respectively. These temporary interactions were again similar to those observed for the same variables in Blacksburg in 1997-1998; a result of fall TE negatively impacting density, an important component of overall quality. Fall TE plots were less dense than untreated plots. This effect was greater in plots overseeded with lower seeding rates. Plots overseeded with 224 kg ha<sup>-1</sup> contained less plant material than plots overseeded with 448 or 896 kg ha<sup>-1</sup> indicating TE's negative impact on density was amplified in lower seeding rate plots.

Overseeded perennial ryegrass density ratings were lower in fall TE treated plots when compared to the untreated (Table 1.44). This effect persisted well into May. The same effect was evident in fall + spring TE treated plots over the same period. Spring TE treatments had no

**Table 1.43 1998-1999 Overseeded Perennial Ryegrass Quality as Influenced by Trinexapac-ethyl in Blacksburg, Virginia.**

TE Regime †	Turfgrass Quality ‡												
	27 Nov.	20 Dec.	5 Mar.	2 Apr.	23 Apr.	6 May	21 May	4 June	19 June	9 July	23 July	6 Aug.	18 Aug.
None applied	3.8 a*	4.2 a	4.3 a	4.5 ab	5.2 NS	5.5 a	6.9 NS	6.9 NS	6.4 NS	6.3 b	6.6 NS	6.8 NS	5.6 NS
Fall applied §	3.3 b	2.8 b	3.1 b	4.2 ab	4.7	5.0 ab	6.8	7.1	6.5	6.7 ab	6.8	7.0	5.5
Spring applied ¶	3.9 a	4.3 a	4.3 a	4.6 a	5.3	5.3 ab	6.8	7.0	6.7	6.3 b	6.6	6.9	5.6
Fall + Spring ¥	3.4 b	2.6 b	3.4 b	4.1 b	4.7	4.8 b	6.8	6.9	6.7	6.8 a	6.8	6.7	5.6

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE significant at the 0.05 level of probability on December 20, 1998 and March 5, 1999 only.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Quality data was recorded on a 1 to 9 scale (1 = brown or dead turf, 5 = acceptable golf course fairway turf, and 9 = dense, green, uniform turf).

§ Fall TE applications were made November 4, December 2, 1998, and January 13, 1999.

¶ Spring TE applications were made March 5, April 2, and May 7, 1999.

¥ Fall + spring TE applications were made November 4, 1998 + December 2, 1998 + January 13, 1999 + March 5, 1999 + April 2, 1999 + May 7, 1999.

**Table 1.44 1998-1999 Overseeded Perennial Ryegrass Density as Influenced by Trinexapac-ethyl in Blacksburg, Virginia.**

TE Regime †	Turfgrass Density ‡							
	27 Nov.	20 Dec.	5 Mar.	2 Apr.	23 Apr.	6 May	21 May	4 June
None applied	3.9 a*	4.3 a	4.4 a	5.3 a	5.8 a	5.9 a	7.1 a	7.4 NS
Fall applied §	3.3 b	3.1 b	3.3 b	4.4 b	4.8 b	5.2 b	7.0 ab	7.5
Spring applied ¶	3.9 a	4.4 a	4.3 a	5.0 a	5.3 ab	5.8 ab	7.0 ab	7.6
Fall + Spring ¥	3.3 b	2.9 b	3.4 b	4.3 b	4.8 b	5.3 ab	6.8 b	7.6

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE was significant at the 0.05 level of probability on November 27, December 20, 1998 and March 5, 1999 only.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Density data was recorded on a 1 to 9 scale (1 = no turf, and 9 = dense, uniform turf).

§ Fall TE applications were made November 4, December 2, 1998, and January 13, 1999.

¶ Spring TE applications were made March 5, April 2, and May 7, 1999.

¥ Fall + spring TE applications were made November 4, 1998 + December 2, 1998 + January 13, 1999 + March 5, 1999 + April 2, 1999 + May 7, 1999.

effect on turfgrass density. The interaction between seeding rates and TE application regimes was significant at the 0.05 level of probability on November 27, December 20, 1998 and March 5, 1999. However, the data analysis indicates stronger main effects on these dates as the p values for seed rate and TE main effects were 0.0001 and 0.0001, respectively on all three dates. The seed rate by TE interaction p values on November 27, December 20, 1998 and March 5, 1999 were 0.0036, 0.0002, and 0.0153, respectively. These temporary interactions were similar to those observed for the same variables in Blacksburg in 1997-1998; a result of fall TE negatively impacting density. Fall TE plots were less dense than untreated plots. This effect was greater in plots overseeded with lower seeding rates. Plots overseeded with 224 kg ha<sup>-1</sup> contained less plant material than plots overseeded with 448 or 896 kg ha<sup>-1</sup> indicating TE's negative impact on density was amplified in lower seeding rate plots.

Spring only TE's effect on turfgrass color was somewhat erratic (Table 1.45). On April 2, 1999 spring TE treated plots exhibited inferior color when compared to untreated plots. Three weeks later (April 23, 1999) spring TE treated plots displayed superior color when compared to untreated plots. The darkest turfgrass color was observed April 2, 1999 through June 19, 1999 in plots receiving fall + spring TE applications. Plots receiving fall only TE displayed a decline in turfgrass color on December 20, 1998. This effect was also noticed in the fall + spring TE treated plots. The interaction between seeding rates and TE application regimes was significant at the 0.05 level of probability on December 20, 1998 and May 6, 1999. These temporary interactions were similar to those observed for the same variables in Blacksburg in 1997-1998. The interactions indicate the effects of fall applied TE on lower seeding rates (December 20, 1998) and spring applied TE on higher seeding rates (May 6, 1999). Color ratings were affected by fall TE's negative impact on density due to lower color ratings in less dense plots resulting from lower seeding rates. Spring TE's impact on color ratings was due to the enhancement of turf color being more noticeable in higher density plots resulting from higher seeding rates.

**Table 1.45 1998-1999 Overseeded Perennial Ryegrass Color as Influenced by Trinexapac-ethyl in Blacksburg, Virginia.**

TE Regime †	Turfgrass Color ‡								
	<u>27 Nov.</u>	<u>20 Dec.</u>	<u>5 Mar.</u>	<u>2 Apr.</u>	<u>23 Apr.</u>	<u>6 May</u>	<u>21 May</u>	<u>4 June</u>	<u>19 June</u>
None applied	5.2 NS*	4.2 a	5.5 NS	6.0 b	6.4 c	6.2 d	6.3 c	6.8 b	6.6 b
Fall applied §	5.1	2.8 b	5.5	6.4 ab	6.8 b	6.5 c	7.0 b	6.9 b	6.8 ab
Spring applied ¶	5.1	4.1 a	5.5	4.9 c	7.8 a	7.3 b	7.6 a	7.1 a	6.8 ab
Fall + Spring ¥	5.1	2.9 b	5.5	6.6 a	7.9 a	7.7 a	7.8 a	7.5 a	7.1 a

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE significant at the 0.05 level of probability on December 20, 1998 and May 6, 1999 only.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Turf color data was recorded on a 1 to 9 scale (1 = brown turf, 5 = acceptable turf color for a golf course fairway, and 9 = dark green turf).

§ Fall TE applications were made November 4, December 2, 1998, and January 13, 1999.

¶ Spring TE applications were made March 5, April 2, and May 7, 1999.

¥ Fall + spring TE applications were made November 4, 1998 + December 2, 1998 + January 13, 1999 + March 5, 1999 + April 2, 1999 + May 7, 1999.

All plots treated with TE in the spring (spring only TE and fall + spring TE) had smaller populations of annual bluegrass when compared to untreated or fall only TE treated plots, although differences were small (Table 1.46). The interaction between seeding rates and TE application regimes was significant at the 0.05 level of probability on April 23, 1999. This interaction was a result of fall TE negatively impacting turf density, indicating the more open turf canopy was less likely to impede annual bluegrass from invading a more dense turf canopy.

### **Lynchburg Location**

Tables 1.47 and 1.48, respectively depict the influence of 1997 seeding rates and TE, respectively on November 1998 residual perennial ryegrass contribution from the September 1997 overseeding. Residual perennial ryegrass is that which failed to transition out from overseeded plots in the first year post dormancy period. There were no differences in the residual perennial ryegrass populations between the three overseeding rates (224, 448, and 896 kg ha<sup>-1</sup>). Amounts of residual perennial ryegrass were low (less than 10 percent) when compared to the Blacksburg site. There were no residual perennial ryegrass population differences between TE treated plots and untreated plots.

### **Perennial Ryegrass Seeding Rate Effects**

Bermudagrass PD transition was reduced by overseeding for the second consecutive year (Table 1.49). Full bermudagrass PD transition is indicated when the post dormant bermudagrass population in overseeded plots is not different from the post dormant bermudagrass population in non-overseeded (0 kg ha<sup>-1</sup>) plots. Full PD transition from overseeded perennial ryegrass to well developed bermudagrass was not achieved in Lynchburg until late-July 1999 in plots overseeded with 224 kg ha<sup>-1</sup> and late-August 1999 in plots overseeded with 448 kg ha<sup>-1</sup>. Perennial ryegrass overseeded plots had less bermudagrass development than non-overseeded (0 kg ha<sup>-1</sup>) plots throughout the PD transition period. However, these differences were not evident in the 224 and

**Table 1.46 1999 Annual Bluegrass (*Poa annua*) Invasion in Perennial Ryegrass Overseeded Bermudagrass as Influenced by Trinexapac-ethyl in Blacksburg, Virginia.**

<b>TE Regime †</b>	<b>Annual Bluegrass Invasion ‡</b>
	<u>23 Apr.</u>
None applied	4.7 b*
Fall applied §	6.2 b
Spring applied ¶	3.9 ab
Fall + Spring ¥	2.0 a

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE was significant at the 0.05 level of probability.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Annual bluegrass invasion is estimated as a percentage of the total plot area that was actively growing annual bluegrass.

§ Fall TE applications were made November 4, December 2, 1998, and January 13, 1999.

¶ Spring TE applications were made March 5, April 2, and May 7, 1999.

¥ Fall + spring TE applications were made November 4, 1998 + December 2, 1998 + January 13, 1999 + March 5, 1999 + April 2, 1999 + May 7, 1999.

**Table 1.47 Fall 1998 Residual Perennial Ryegrass in Overseeded Bermudagrass as Influenced by 1997 Perennial Ryegrass Overseeding Rates in Lynchburg, Virginia.**

<u>Overseeding Rate †</u>	<u>Residual Perennial Ryegrass ‡</u>
	<u>19 Nov.</u>
224	7.6 NS*
448	6.9
896	9.1

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Overseeding rates are kg ha<sup>-1</sup>

‡ Residual perennial ryegrass is a November 1998 estimation of the percentage of the total plot area that was non-transitioning perennial ryegrass overseeded September 1997.

**Table 1.48 Fall 1998 Residual Perennial Ryegrass in 1997 Overseeded Bermudagrass as Influenced by Trinexapac-ethyl in Lynchburg, Virginia.**

<u>TE Regime †</u>	<u>Residual Perennial Ryegrass ‡</u>
	<u>19 Nov.</u>
None applied	8.2 NS*
Fall applied §	6.7
Spring applied ¶	8.2
Fall + Spring ¥	8.4

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Residual perennial ryegrass is a November 1998 estimation of the percentage of the total plot area that was non-transitioning perennial ryegrass overseeded September 1997.

§ Fall TE applications were made October 31 and December 3, 1997.

¶ Spring TE applications were made March 5 and April 10, 1998.

¥ Fall + spring TE applications were made October 31 + December 3, 1997 + March 5 + April 10, 1998.

**Table 1.49 1999 Overseeded Bermudagrass Post Dormancy Transition as Influenced by Fall 1998 Perennial Ryegrass Overseeding Rates in Lynchburg, Virginia.**

Overseeding Rate †	Post Dormancy Transition ‡								
	<u>21 Apr.</u>	<u>3 May</u>	<u>20 May</u>	<u>3 June</u>	<u>18 June</u>	<u>6 July</u>	<u>22 July</u>	<u>4 Aug.</u>	<u>20 Aug.</u>
0	8.8 a*	15.0 a	25.0 a	68.1 a	79.7 a	75.0 a	87.4 a	94.7 a	98.3 a
224	4.8 b	6.6 b	15.3 b	38.8 b	55.9 b	58.4 b	72.2 ab	84.4 ab	94.1 ab
448	4.1 b	5.9 b	13.8 b	32.8 b	54.1 b	52.8 b	65.9 b	76.3 b	92.6 ab
896	3.7 b	6.9 b	11.6 b	33.8 b	49.4 b	48.8 b	63.6 b	74.4 b	90.4 b

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Overseeding rates are kg ha<sup>-1</sup>

‡ Post dormancy transition is estimated as a percentage of the plot area that was actively growing, green bermudagrass.

448 kg ha<sup>-1</sup> overseeded plots by the final rating on August 20, 1999. Only plots overseeded with 896 kg ha<sup>-1</sup> had significantly less bermudagrass than non-overseeded (0 kg ha<sup>-1</sup>) plots on August 20, 1999; 90.4 percent versus 98.3 percent, respectively.

Overseeding improved fairway turf quality similar to the effect noticed in Blacksburg both in 1997-1998 and 1998-1999. Plots overseeded with higher rates of perennial ryegrass had greater turf quality when compared to non-overseeded (0 kg ha<sup>-1</sup>) plots and among seeding rates (Table 1.50). Turfgrass quality differences due to seeding rates were no longer evident by April 21, 1999. By July 6, 1999 overseeded perennial ryegrass plots, regardless of seeding rate, had significantly lower plot quality when compared to non-overseeded (0 kg ha<sup>-1</sup>) plots for the remainder of the recording period. This effect, not evident in Lynchburg in 1997-1998, was due to the rapid, late season decline of persistent perennial ryegrass, which exposed a thin, poorly developed bermudagrass turf canopy causing non-uniform turf conditions. The interaction between seeding rates and TE application regimes was significant at the 0.05 level of probability on March 5, May 3, and June 18, 1999 only. However, on March 5 the p values for seed rate and TE main effects were 0.0001 and 0.0001, respectively compared to the p value for the temporary seed rate by TE interaction (0.0201). On May 3, 1999, the p values for seed rate and TE main effects were 0.0001 and 0.0127, respectively compared to the p value for the temporary seed rate by TE interaction (0.0446). On June 18, 1999 there was no TE main effect (p value = 0.1315) while the seed rate main effect p value = 0.0143 compared to the seed rate by TE interaction p value = 0.0252. The temporary interaction on March 5 resulted from fall TE's effect in reducing turf density, especially in plots overseeded with lower rates. Turf quality enhancement from spring applied TE, recorded on May 3 and June 18, appeared to be due to spring or fall + spring TE treated plots exhibiting increased tolerance to the April 8 preemergent herbicide application of oxadiazon at 3.4 kg a.i. ha<sup>-1</sup>. This was not a factor in 1998 when prodiamine + oxadiazon at 0.4 and 2.2 kg a.i. ha<sup>-1</sup>, respectively was used. Loss in quality in non spring treated plots

**Table 1.50 1998-1999 Overseeded Bermudagrass Quality as Influenced by Fall 1998 Perennial Ryegrass Overseeding Rates in Lynchburg, Virginia.**

Overseeding Rate †	Turfgrass Quality ‡												
	<u>19 Nov.</u>	<u>14 Jan.</u>	<u>5 Mar.</u>	<u>2 Apr.</u>	<u>21 Apr.</u>	<u>3 May</u>	<u>20 May</u>	<u>3 June</u>	<u>18 June</u>	<u>6 July</u>	<u>22 July</u>	<u>4 Aug.</u>	<u>20 Aug.</u>
0	1.1 c*	1.0 d	1.0 c	2.1 d	1.4 b	3.1 b	3.8 b	4.0 c	6.1 ab	5.3 a	5.9 a	7.1 a	7.4 a
224	3.1 b	3.9 c	4.4 b	5.1 c	4.9 a	5.4 a	5.4 a	6.1 a	6.7 a	4.9 ab	4.8 b	5.6 b	6.5 b
448	3.6 a	4.9 b	5.5 a	5.9 b	5.3 a	5.3 a	5.1 a	5.5 ab	6.1 ab	4.4 b	4.3 b	5.3 b	6.2 b
896	4.0 a	5.6 a	5.8 a	6.6 a	5.4 a	5.3 a	4.9 a	4.8 b	5.8 b	4.4 b	4.2 b	5.3 b	6.1 b

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE significant at the 0.05 level of probability on March 5, May 3, and June 18, 1999 only.

† Overseeding rates are kg ha<sup>-1</sup>

‡ Quality data was recorded on a 1 to 9 scale (1 = brown or dead turf, 5 = acceptable golf course fairway turf, and 9 = dense, green, uniform turf).

appeared related to oxadiazon phytotoxicity to the overseeded perennial ryegrass and the effect was most evident in the low seeding rate.

Annual bluegrass (*Poa annua*) invasion was significantly reduced in perennial ryegrass overseeded plots compared to non-overseeded ( $0 \text{ kg ha}^{-1}$ ) plots (Table 1.51). Non-overseeded ( $0 \text{ kg ha}^{-1}$ ) plots contained 42.8 percent annual bluegrass cover compared to a trace (1.1 percent) in plots overseeded with  $896 \text{ kg ha}^{-1}$ . Although less annual bluegrass invasion was observed with overseeding rates, there were no differences among the three seeding rates. The interaction between seeding rates and TE application regimes was significant at the 0.05 level of probability on April 2, 1999. This interaction, similar to observed in Blacksburg on April 23, 1999, was a result of fall TE negatively impacting turf density, indicating the more open turf canopy was less likely to impede annual bluegrass from invading a more dense turf canopy.

### **Trinexapac-ethyl's Influence on Overseeded Perennial Ryegrass**

The influence of TE on bermudagrass PD transition was different than observed in Blacksburg for the second consecutive year. Spring only TE treated plots had less bermudagrass than untreated plots on June 3, June 18 and August 4, 1999 (Table 1.52). Fall + spring TE treated plots had less bermudagrass than untreated plots on June 3, 1999. There were no differences in TE treated versus untreated plots at any other time. By the final transition rating on August 20, 1999; there were no differences between TE treatment regimes, as all regimes had over ninety percent bermudagrass cover.

The TE effect on turfgrass quality of overseeded perennial ryegrass was different than what was observed in Lynchburg in 1997-1998. Fall applied TE did reduce plot quality during the winter months when compared to untreated plots (Table 1.53). Plots receiving spring only TE did exhibit greater quality than untreated during the spring months but this effect was no longer noticeable by June 18, 1999. Untreated plots exhibited greater plot quality than spring TE treated over the final three rating periods (July 22, August 4, and August 20, 1999) while fall TE

**Table 1.51 1999 Annual Bluegrass (*Poa annua*) Invasion in Overseeded Bermudagrass as Influenced by Fall 1998 Perennial Ryegrass Overseeding Rates in Lynchburg, Virginia.**

<u>Overseeding Rate †</u>	<u>Annual Bluegrass Invasion ‡</u>
	<u>2 Apr.</u>
0	42.8 b*
224	2.8 a
448	2.0 a
896	1.1 a

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE was significant at the 0.05 level of probability.

† Overseeding rates are kg ha<sup>-1</sup>

‡ Annual bluegrass invasion is estimated as a percentage of the total plot area that was actively growing annual bluegrass.

**Table 1.52 1999 Perennial Ryegrass Overseeded Bermudagrass Post Dormancy Transition as Influenced by Trinexapac-ethyl in Lynchburg, Virginia.**

<u>TE Regime †</u>	<u>Post Dormancy Transition ‡</u>								
	<u>21 Apr.</u>	<u>3 May</u>	<u>20 May</u>	<u>3 June</u>	<u>18 June</u>	<u>6 July</u>	<u>22 July</u>	<u>4 Aug.</u>	<u>20 Aug.</u>
None applied	5.2 NS*	8.8 NS	19.7 NS	50.0 a	67.2 a	64.7 NS	76.9 NS	89.6 a	95.7 NS
Fall applied §	4.2	8.4	16.8	46.9 ab	61.6 ab	56.6	72.5	82.4 ab	94.3
Spring applied ¶	5.5	8.8	14.4	38.4 b	53.1 b	54.4	65.3	73.6 b	90.9
Fall + Spring ¥	6.4	8.4	14.7	38.1 b	57.2 ab	59.4	74.4	84.2 ab	94.4

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE NS.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Post dormancy transition is estimated as a percentage of the total plot area that was actively growing, green bermudagrass.

§ Fall TE applications were made November 5, December 4, 1998, and January 14, 1999.

¶ Spring TE applications were made March 5, April 2, and May 3, 1999.

¥ Fall + spring TE applications were made November 5, 1998 + December 4, 1998 + January 14, 1999 + March 5, 1999 + April 2, 1999 + May 3, 1999.

**Table 1.53 1998-1999 Perennial Ryegrass Overseeded Bermudagrass Quality as Influenced by Trinexapac-ethyl in Lynchburg, Virginia.**

TE Regime †	Turfgrass Quality ‡												
	19 Nov.	14 Jan.	5 Mar.	2 Apr.	21 Apr.	3 May	20 May	3 June	18 June	6 July	22 July	4 Aug.	20 Aug.
None applied	3.1 NS*	4.0 ab	4.3 b	5.0 ab	4.4 NS	4.7 ab	4.6 b	4.8 b	6.1 NS	4.8 NS	5.4 a	6.6 a	6.9 a
Fall applied §	2.9	3.6 bc	3.9 c	4.9 ab	4.3	4.5 b	4.5 b	4.7 b	6.1	4.6	4.7 ab	5.8 ab	6.5 ab
Spring applied ¶	3.1	4.3 a	4.7 a	5.1 a	4.4	5.2 a	5.4 a	5.8 a	6.6	4.8	4.4 b	5.3 b	6.0 b
Fall + Spring ¥	2.8	3.5 c	3.9 c	4.6 b	3.9	4.6 ab	4.7 ab	5.1 ab	5.9	4.9	4.8 ab	5.6 ab	6.8 ab

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE significant at the 0.05 level of probability on March 5, May 3, and June 18, 1999 only.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Quality data was recorded on a 1 to 9 scale (1 = brown or dead turf, 5 = acceptable golf course fairway turf, and 9 = dense, green, uniform turf).

§ Fall TE applications were made November 5, December 4, 1998, and January 14, 1999.

¶ Spring TE applications were made March 5, April 2, and May 3, 1999.

¥ Fall + spring TE applications were made November 5, 1998 + December 4, 1998 + January 14, 1999 + March 5, 1999 + April 2, 1999 + May 3, 1999.

treated and fall + spring TE treated plots had quality ratings closely similar to both the untreated and spring TE treated plots. The interaction between seeding rates and TE application regimes was significant at the 0.05 level of probability on March 5, May 3, and June 18, 1999. However, on March 5 the p values for seed rate and TE main effects were 0.0001 and 0.0001, respectively compared to the p value for the temporary seed rate by TE interaction (0.0201). On May 3, 1999, the p values for seed rate and TE main effects were 0.0001 and 0.0127, respectively compared to the p value for the temporary seed rate by TE interaction (0.0446). On June 18, 1999 there was no TE main effect (p value = 0.1315) while the seed rate main effect p value = 0.0143 compared to the seed rate by TE interaction p value = 0.0252. The temporary interaction on March 5 resulted from fall TE's effect in reducing turf density, especially in plots overseeded with lower rates. Turf quality enhancement from spring applied TE, recorded on May 3 and June 18, appeared to be due to spring or fall + spring TE treated plots exhibiting increased tolerance to the April 8 preemergent herbicide application of oxadiazon at 3.4 kg a.i. ha<sup>-1</sup>. This was not a factor in 1998 when prodiamine + oxadiazon at 0.4 and 2.2 kg a.i. ha<sup>-1</sup>, respectively was used. Loss in quality in non spring treated plots appeared related to oxadiazon phytotoxicity to the overseeded perennial ryegrass and the effect was most evident in the low seeding rate.

In 1997-1998, the TE effect on turfgrass density in fall TE treated plots in Blacksburg was not evident in Lynchburg. However, the TE effect noticed in Blacksburg in 1997-1998 was observed in Lynchburg in 1998-1999. Plots receiving any TE in the fall had lower turfgrass density ratings when compared to untreated plots (Table 1.54). This effect did subside and was no longer evident by April 21, 1999. Spring applied TE had no influence on overseeded turfgrass density when compared to untreated plots. The interaction between seeding rates and TE application regimes was significant at the 0.05 level of probability on January 14 and March 5, 1999. However, the data analysis indicates stronger main effects on these dates as the p values for seed rate and TE main effects were 0.0001 and 0.0001, respectively on both dates compared to the p values for the temporary seed rate by TE interaction (0.0002 and 0.0153, respectively).

**Table 1.54 1998-1999 Overseeded Perennial Ryegrass Density as Influenced by Trinexapac-ethyl in Lynchburg, Virginia.**

TE Regime †	Turfgrass Density ‡							
	<u>19 Nov.</u>	<u>14 Jan.</u>	<u>5 Mar.</u>	<u>2 Apr.</u>	<u>21 Apr.</u>	<u>3 May</u>	<u>3 June</u>	<u>18 June</u>
None applied	3.0 ab*	4.0 a	4.1 ab	5.0 a	4.4 NS	5.0 ab	4.9 ab	5.1 NS
Fall applied §	2.9 b	3.3 b	3.7 c	4.4 b	4.3	4.9 b	4.6 b	4.8
Spring applied ¶	3.3 a	4.1 a	4.3 a	4.8 a	4.5	5.6 a	5.8 a	5.6
Fall + Spring ¥	2.8 b	3.1 b	3.9 bc	4.3 b	4.1	5.1 ab	5.1 ab	5.1

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE was significant at the 0.05 level of probability on January 14 and March 5, 1999 only.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Density data was recorded on a 1 to 9 scale (1 = no turf, and 9 = dense, uniform turf).

§ Fall TE applications were made November 5, December 4, 1998, and January 14, 1999.

¶ Spring TE applications were made March 5, April 2, and May 3, 1999.

¥ Fall + spring TE applications were made November 5, 1998 + December 4, 1998 + January 14, 1999 + March 5, 1999 + April 2, 1999 + May 3, 1999.

These temporary interactions were the result of fall TE negatively impacting turf density and the effect is most noticeable with lower seeding rates.

Fall TE applications did not influence turfgrass color when compared to the untreated plots (Table 1.55). Plots receiving any spring TE (spring only and fall + spring) did exhibit a darker color than untreated control from April 21 through June 18, 1999. The interaction between seeding rates and TE application regimes was significant at the 0.05 level of probability on April 2 and April 21, 1999. These temporary interactions were the result of spring TE's enhancement of turf color being amplified by the larger turfgrass population in plots overseeded with higher rates.

Trinexapac-ethyl's influence on annual bluegrass invasion was similar to the effect observed in Blacksburg. Fall + spring TE treated plots exhibited less annual bluegrass compared to untreated plots (Table 1.56). Fall only TE or spring only TE treatments were not different from the fall + spring TE application regime nor from untreated plots. The interaction between seeding rates and TE application regimes was significant at the 0.05 level of probability on April 2, 1999. This interaction was a result of fall TE negatively impacting turf density, making the more open turf canopy less likely to impede annual bluegrass from invading than a more dense turf canopy.

### **1998-1999 Conclusions**

The second year of the study had weather similar to that observed in 1997-1998, with temperatures above normal in both locations throughout the winter months then dropping below normal during March and returning above normal during the summer months. Again, the above normal winter temperatures should have led to minimal, if any winter injury of bermudagrass and favored earlier than normal PD bermudagrass development and transition at both locations. The months of May and June 1999 were cooler in Blacksburg than in 1998, and may have led to the weaker recovery of bermudagrass observed on that site in 1998-1999.

**Table 1.55 1998-1999 Overseeded Perennial Ryegrass Color as Influenced by Trinexapac-ethyl in Lynchburg, Virginia.**

TE Regime †	Turfgrass Color ‡								
	19 Nov.	14 Jan.	5 Mar.	2 Apr.	21 Apr.	3 May	20 May	3 June	18 June
None applied	5.0 b*	4.3 NS	5.0 NS	5.1 b	5.4 b	5.1 b	5.6 b	6.3 b	6.5 b
Fall applied §	5.4 a	4.1	5.3	6.1 a	6.5 ab	5.2 b	5.6 b	6.3 b	6.7 ab
Spring applied ¶	5.1 ab	4.4	5.1	5.4 ab	7.1 a	6.3 a	6.9 a	7.3 a	6.8 a
Fall + Spring ¥	5.3 ab	4.1	5.2	5.9 a	7.2 a	6.3 a	6.8 a	7.2 a	6.9 a

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE significant at the 0.05 level of probability on April 2 and April 21, 1999 only.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Turf color data was recorded on a 1 to 9 scale (1 = brown turf, 5 = acceptable turf color for a golf course fairway, and 9 = dark green turf).

§ Fall TE applications were made November 5, December 4, 1998, and January 14, 1999.

¶ Spring TE applications were made March 5, April 2, and May 3, 1999.

¥ Fall + spring TE applications were made November 5, 1998 + December 4, 1998 + January 14, 1999 + March 5, 1999 + April 2, 1999 + May 3, 1999.

**Table 1.56 1999 Annual Bluegrass (*Poa annua*) Invasion in Perennial Ryegrass Overseeded Bermudagrass as Influenced by Trinexapac-ethyl in Lynchburg, Virginia.**

<u>TE Regime †</u>	<u>Annual Bluegrass Invasion ‡</u>
	<u>2 Apr.</u>
None applied	16.3 b*
Fall applied §	10.8 ab
Spring applied ¶	12.6 ab
Fall + Spring ¥	9.1 a

\* Means in the same column followed by the same letter are not significantly different according to Tukey's studentized range test at the 0.05 level of probability. NS, not significant at the 0.05 level of probability. Seed rate x TE was significant at the 0.05 level of probability.

† Trinexapac-ethyl was applied at 0.19 kg a.i. ha<sup>-1</sup>

‡ Annual bluegrass invasion is estimated as a percentage of the total plot area that was actively growing annual bluegrass.

§ Fall TE applications were made November 5, December 4, 1998, and January 14, 1999.

¶ Spring TE applications were made March 5, April 2, and May 3, 1999.

¥ Fall + spring TE applications were made November 5, 1998 + December 4, 1998 + January 14, 1999 + March 5, 1999 + April 2, 1999 + May 3, 1999.

The residual perennial ryegrass population that carried over from the September 1997 overseeding to November 1998 in Blacksburg demonstrates that Blacksburg is not a particularly favorable climate for complete PD transition from the overseeded perennial ryegrass to bermudagrass. Over fifty percent residual perennial ryegrass remained in plots one year old. This reduced the amount of bermudagrass present (less than fifty percent) in plots overseeded with 448 and 896 kg ha<sup>-1</sup>. Therefore it is obvious that overseeding bermudagrass in Blacksburg leads to a significant reduction to the bermudagrass sward over time. The Lynchburg location was more successful than Blacksburg in reducing perennial ryegrass carryover and transitioning back to bermudagrass. Yet full PD transition did not occur till August each year. Bermudagrass overseeding can be done in Lynchburg's climate without threat of severe bermudagrass stand reductions. However, 1998 and 1999 were warmer than normal years. Results in normal or cooler than normal years would likely be more similar to results in 1998 and 1999 in Blacksburg. These studies used 'Palmer II' perennial ryegrass for overseeding. This is an improved type of perennial ryegrass that would be somewhat persistent which could have played a role in delaying bermudagrass PD transition or being overly competitive with the bermudagrass in Blacksburg or Lynchburg.

Higher perennial ryegrass seeding rates did enhance fairway turf quality for the second consecutive year over lower seeding rates and non-overseeded turf at both locations. However, turf quality declines, compared to the non-overseeded turf, once bermudagrass PD regrowth is complete and great amounts of perennial ryegrass persist. The theory behind higher seeding rates enhancing spring transition of overseeded bermudagrass was not evident in the results of this research. For the second consecutive year, higher seeding rates (448 and 896 kg ha<sup>-1</sup>) of perennial ryegrass hindered transition when compared to lower seeding rates (224 kg ha<sup>-1</sup>) at either location. However, Lynchburg's climate was more conducive to overseeding bermudagrass with perennial ryegrass at higher seeding rates. In 1997-1998, no transition differences between seeding rates occurred in Lynchburg and only the highest seeding rate (896

kg ha<sup>-1</sup>) displayed a reduction in PD transition in 1998-1999. However, the weather conditions throughout both years of this study were above normal and conducive to bermudagrass growth and development. For years in Lynchburg when weather conditions are less favorable to bermudagrass, but more favorable to perennial ryegrass growth, steps would need to be taken to encourage the transition from overseeded species back to bermudagrass. Non-overseeded (0 kg ha<sup>-1</sup>) bermudagrass in both locations was slow to transition, taking until mid-summer (early to mid-August) to reach levels of at least ninety percent bermudagrass.

After two years of this study, overseeding bermudagrass with perennial ryegrass was able to provide enough competition to reduce annual bluegrass competition. All three seeding rates used in this research were effective in keeping annual bluegrass invasion to a minimum at both locations. If a bermudagrass turf is not overseeded, then herbicides must be used to control annual bluegrass. The amounts of annual bluegrass present in non-overseeded (0 kg ha<sup>-1</sup>) plots was enough to compete with bermudagrass during PD regrowth.

Trinexapac-ethyl use did not enhance transitional decline of perennial ryegrass overseeded bermudagrass and may actually enhance perennial ryegrass persistence. Although the use of TE in certain application regimes did not negatively affect transition when compared to untreated turf, the use of TE in the spring of the year should be used with caution. There was less bermudagrass present in TE treated plots than in untreated. According to Fry and Jiang (1998), TE has the potential to enhance the drought tolerance response of perennial ryegrass when favorable temperatures exist for growth. As a result, TE applications to reduce perennial ryegrass clipping production may inadvertently reduce the turf's water requirements. If true, spring TE use on overseeded perennial ryegrass may in fact make it more difficult for high temperatures and dry conditions to injure perennial ryegrass which normally aids overseeded bermudagrass PD transition. This should raise awareness to professional turfgrass managers that may be using TE in the spring of the year on overseeded perennial ryegrass to reduce mowing requirements. These applications may in fact be leading to a reduced or delayed, if only slightly,

PD transition back to bermudagrass. Although spring TE applications may darken turfgrass color, it does so without significantly improving turfgrass quality. Therefore, with the potential hindrance to bermudagrass PD transition with spring TE applications, TE should not be solely used solely for enhancing turfgrass color.

As concluded in 1997-1998, fall TE applications at  $0.19 \text{ kg a.i. ha}^{-1}$  to overseeded perennial ryegrass should be avoided. The cool fall conditions, along with the juvenile state of the perennial ryegrass are hindrances in the development of the overseeded turfgrass canopy. The thin turfgrass stand does not have adequate density to provide an acceptable overseeded turf.

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