# IN SEASON AND TRANSITION PERFORMANCE OF RYEGRASSES AND ROUGHSTALK BLUEGRASS UNDER GOLF COURSE FAIRWAY CONDTIONS

By

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A THESIS PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE

UNIVERSITY OF FLORIDA

2006

This work is dedicated to my family: my mother for her never-ending encouragement and support of my education, my father for teaching me to respect and enjoy life, and to my brother for always being there when I really needed him.

# ACKNOWLEDGMENTS

I would like to thank Dr. Grady L. Miller, chair of my committee, for his support and guidance while I completed this work. I must also thank him for taking a chance on me and allowing me the opportunity to be the resident at the Envirotron Turfgrass Research Facility while pursuing my master's degree. I am also grateful for the help and support of my other committee members Dr. Phil Harmon, Dr. Kevin Kenworthy, and Dr. Carol Stiles.

Also, I would like to thank Jason Haugh and Jan Weinbrecht for their friendship, support, and willingness to help in all aspects of this project. Special thanks go to Todd Wilkinson, Golf Course Superintendent, and his assistant, John Drouse, for their assistance and for use of their facility to conduct this research.

I would also like to thank the National Turfgrass Evaluation program in conjunction with the United States Golf Association and the Golf Course Superintendents Association of America for funding portions of this research.

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of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Master of Science

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August 2006

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Major Department: Environmental Horticulture

Overseeding sports turf areas provides aesthetically pleasing, year-round green turf in southern United States. Turfgrass managers are well aware of the influence that turfgrass selection and climate have on overseeding and the spring transition. Advancements in turfgrass breeding and selection have led to the release of new cultivars for overseeding bermudagrass fairways each year. Turfgrass managers constantly seek un-biased evaluations of these new turfgrasses for overseed applications. The objectives of this study were to evaluate cultivars for overseeding bermudagrass fairways and evaluate spring transition using known modeling techniques. Thirty-one cultivars and blends consisting of perennial ryegrass (*Lolium perenne* L.), intermediate ryegrass (*Lolium hybridum* L.), and roughstalk bluegrass (*Poa trivialis* L.) were overseeded as a randomized complete block design on a bermudagrass (*Cynodon dactylon* x *C. transvalensis* cv. 'TifSport') fairway at the University of Florida Golf Course in Gainesville, FL. The trial was established in early fall of 2004 and terminated in June of

2005, and repeated the following year with cultivars planted in the same location. Percent coverage, overall quality, genetic color, density, texture, and ability to withstand environmental stresses under fairway conditions were evaluated. Multi-variate analysis was used to develop a model based on the 2004-2006 overseed evaluation trial data to determine the appropriate variables for predicting overseed coverage. Historical overseed evaluation data from 2002-2006 were used to evaluate a cumulative growth potential (CGP) model and a ryegrass disappearance (RD) model using graphical and linear regression analysis, respectively. The evaluation of the grasses indicated that perennial ryegrass and ryegrass blends were quicker to establish, provided better cover, color, and turfgrass quality than intermediate ryegrasses and rough stalk bluegrass. Intermediate ryegrass transitioned quickly while maintaining high turf quality. Roughstalk bluegrass was slow to establish and provided poor coverage. Variation in establishment and cover among species also was observed. The Florida Transition Model was derived to describe overseed coverage from average soil temperature and days after seeding. Results indicated that the CGP model could be a valuable tool to turfgrass managers for further understanding the overseeding process. Linear regression of 2002-2006 overseed coverage provided an accurate RD model for the rapidly increasing spring and summer temperatures of FL.

# CHAPTER 1
# INTRODUCTION

In most of the southern United States, overseeding is a common practice used by turfgrass managers to maintain an aesthetically pleasing green turfgrass year-round. Overseeding does more for sports-turf managers than provide year-round beauty. An overseeded turfgrass provides actively growing turf that can withstand traffic, improve playability, and prevent weed invasion better than brown, dormant bermudagrass turf. Actively growing turfgrass in winter months also can increase golf courses profits by increasing the number of rounds played. For these reasons most turfgrass managers sow millions of pounds of seed in the southern region of the United States each fall (Morris, 2004).

Turfgrass managers are aware that the success of overseeding sports turf areas, especially during spring transition, is dependent on the weather and the proper species of overseed. Many other factors including soil and water quality, previous management, and expectations also play a role in the success of the overseeding practice. Turfgrass managers place an emphasis on understanding the climate of their region and making informed decisions when selecting a turfgrass for overseeding.

Overseed selection can be difficult for turfgrass managers. Each year many new cultivars of overseed turfgrasses are released. According to Golf Course Management magazine's 2006 seed update, over fifty turfgrasses are to be released in 2006 (Carson, 2006). Each new cultivar released varies in color, density, texture, vigor, and adaptation to various climates. Thus, it is difficult for turfgrass managers to select the most effective species and cultivar. This quest to improve overseed germplasm has created a need for un-biased evaluation of newly released turfgrasses over a wide range of environmental conditions.

Agronomists and other researchers have developed models that can help turfgrass managers deal with climate influenced events such as the timing of insect infestations, disease epidemics, and weed invasion (Gelernter and Stowell, 2005). However, there have been few models that have helped turfgrass managers to understand the climate influenced phenomena of spring transition.

Because of the need for performance evaluations of new overseed cultivars and the need for additional research on modeling spring transition, two objectives were addresses with this research. The first objective was to evaluate 31 overseed cultivars for fairway use. The second objective was to evaluate models for spring transition.

CHAPTER 2
LITERATURE REVIEW

## Overseeding Culture

Overseeding is the process of seeding onto an existing turfgrass stand. In fall and winter, cool-season turfgrasses are used to provide regenerative growth and green color during the dormant period of warm-season grasses. When temperatures drop below 15.5º C (60º F), bermudagrass shoots quit growing; when temperatures drop below 9.9º C (50º F), bermudagrass loses its green color and enters winter dormancy (McCarty et al., 2001). In much of the southern United States overseeding golf courses provides year round color on fairways, roughs, tees and putting greens.

Common bermudagrass [*Cynodon dactylon* (L.) Pers.] has been used extensively as a soil stabilizer, sports turf, and forage for many years in the southeastern United States (Duble, 1996a). Common bermudagrass is a warm-season perennial species widely adapted to both tropical and subtropical climates. It spreads by stolons and rhizomes and grows best in climates with high temperatures, mild winters, and moderate to high rainfall. The bermudagrass adaptation range extends northward into the transitional zone of the United States where temperatures rarely reach -12.2º C (10º F) (Duble, 1996a).

Hybrid bermudagrasses (*Cynodon dactylon* X *C. transvaalenis* Burtt-Davy) are used widely in warm climates for both fairways and putting green surfaces. When compared with alternative warm-season turfgrasses, hybrid bermudagrass possesses the best overall turfgrass characteristics for fairway use and culture, providing an extremely dense, uniform, playing surface (Beard, 2002). Hybrid bermudagrass can withstand frequent low mowings and recuperates quickly from injury. The most common problems faced by those managing hybrid bermudagrass are thatch accumulation, poor shade tolerance, and a susceptibility to certain pests (Beard, 2002).

Overseeding bermudagrass golf greens and fairways has many advantages. Overseeding provides a more aesthetically pleasing golf course, and the growing turf is more tolerant to golf cart traffic, divots, and weed invasions (Morris, 2004). Many resort courses in the south receive their heaviest play during the fall, winter, and spring; therefore, overseeding can lead to an increase in revenue (McCarty et al., 2001).

Although there are many advantages, overseeding has some disadvantages. Weed pressure can increase because annual bluegrass (*Poa annua* L.) is hard to control when courses are overseeded consecutively for more than a few years (McCarty et al., 2001). Other problems relate to delayed seed germination or distribution during planting and result in clumps of unsightly ryegrass that are difficult to control. The cool-season grasses also can compete aggressively with bermudagrass well into the summer months thus delaying transition, green-up, and fill-in of the bermudagrass (McCarty et al., 2001). Overseeding can lead to an increase in revenue, but estimated costs of overseeding including seed, water, labor and pesticides make up to 20% of an annual budget on southern golf courses (Ostmeyer, 2004). In St. Augustine, Florida, costs may be as high as $45,000 to $50,000 annually to overseed an entire 18-hole golf course (Ostmeyer, 2004).

Turfgrass selection is perhaps the most important step when beginning the overseeding process. Prior to 1960 the most common species used for overseeding was annual ryegrass (*Lolium multiflorum* Lam.). Seeding rates were as high as 480.6 kg $ha^{-1}$

(60 lb 1000 ft$^{-2}$) (Turgeon, 2002). These rates are high by today's standard, but were necessary because of poor quality seed and poor germination among early annual ryegrass cultivars. In addition, annual ryegrass exhibited poor heat tolerance when mowed low and transitioned quickly leaving a poor stand of bermudagrass (Turgeon, 2002). During the 1960's mixtures and blends of seed were used frequently for overseeding (Turgeon, 2002). It was not uncommon to find mixtures and blends of fine fescue (*Festuca* spp.), bentgrass (*Agrostis* spp.), roughstalk bluegrass (*Poa trivialis* L.), Kentucky bluegrass (*Poa pratensis* L.) and perennial ryegrass (*Lolium perenne* L.) (Turgeon, 2002). Mixtures and blends provided enhanced germination, better frost tolerance, greater disease resistance, reduced seeding rates, and smoother transitions than a single cultivar (Turgeon, 2002). Blends and mixtures continue to be popular choices for many turfgrass managers. Advances in breeding programs have provided turfgrass managers with cultivars of turf-type perennial ryegrasses with qualities early annual ryegrasses lacked (Turgeon, 2002). Turf-type overseeding grasses can be defined as cultivars that have greater cold tolerance, wear tolerance, disease resistance, and persistence than non-turf type cultivars (Duble, 1996b). These turf-type cultivars exhibit finer texture, greater density, darker color, and better mowing qualities according to Duble (1996b). The overseeding and transition processes can be facilitated greatly by proper turfgrass selection.

**Annual Ryegrass**

Annual ryegrass has lost importance as an overseed the last two decades due to a coarser, more open, growth habit compared to perennial ryegrasses (McCarty et al., 2001). According to McCarty et al. (2001), annual ryegrass exhibits poor heat and cold tolerance and early death in the spring that leads to poor transition. Unlike some of the heat resistant perennial ryegrasses, annual ryegrass will die quickly with warm spring temperatures leaving thin areas of dormant bermudagrass (Turgeon, 2002). However, annual ryegrass does have some positive characteristics for overseeding. Annual ryegrass is quicker to germinate than other ryegrasses and is acceptable for fairways and less important areas where color is needed (McCarty et al., 2001). This is especially true when budget constraints exist (McCarty at al., 2001). Annual ryegrass is cheaper than perennial ryegrass, and because it is less heat tolerant than perennial ryegrass, it will often transition at a faster rate (Han, 2004).

**Intermediate Ryegrass**

Intermediate ryegrass (*Lolium hybridum* Hausska.) is a hybrid of annual and perennial ryegrasses. Similar to annual ryegrasses, intermediate ryegrasses are quick to germinate but lack heat tolerance (McCarty et al., 2001). They have a medium texture, are lighter green in color, and have reduced shoot growth when compared to other ryegrass species (McCarty et al., 2001). Unlike many of the perennial ryegrasses, intermediate ryegrasses will usually disappear quickly, with increasing temperatures, once bermudagrass begins to grow in the spring (McCarty et al., 2001). Morris (2004) found that intermediate ryegrasses had slightly lower quality ratings than perennial ryegrasses, but they did transition faster in the 1999-2001 National Turfgrass Evaluation Program's on-site fairway trials.

**Perennial Ryegrass**

Traditionally, perennial ryegrass is the preferred grass for overseeding fairways and roughs. Current cultivars germinate quickly, usually 5 to 7 days, and have excellent dark green color, superior texture, and better disease and traffic resistance compared to annual ryegrass (McCarty et al., 2001). Many cultivars of perennial ryegrasses are available for overseeding. Oregon is the world's major producer of cool-season forage and turfgrass seed. Oregon produces almost two-thirds of the total U.S. cool-season grass seed (Young, 1996). Nearly 78,086 ha (192,950 acre) of perennial ryegrass was harvested for seed in Oregon in 2005 (Young, 2005). Average seed yield is 1,555 kg $ha^{-1}$ (1,387 lbs $acre^{-1}$) (Young, 2005).

Most seed produced in the USA is of turf-type cultivars (Young, 1996). A blend of perennial ryegrass cultivars is recommended to provide greater performance over a wide range of conditions (McCarty et al., 2001). Many new turf-type cultivars of perennial ryegrass have improved heat tolerances and are more competitive during spring transition than previously used cultivars (McCarty et al., 2001). Many persist well into May, June, and July (McCarty et al., 2001). In Florida, the recommended seeding rate for perennial ryegrass in fairways is 244 to 732 kg $ha^{-1}$ (5 to 15 lb 1000 $ft^{-2}$) (McCarty et al., 1993).

**Roughstalk Bluegrass**

Roughstalk bluegrass is known for having a finer texture and higher density due to a seed count of approximately 8 to 1 by weight when compared to perennial ryegrass (McCarty et al., 2001). Primarily used to overseed greens because of its seed size, in the last five years the National Turfgrass Evaluation Program (NTEP) also has been testing cultivars in fairway situations. Rough stalk bluegrass is generally lighter in color, and slower to establish and develop into a dense stand of turf than ryegrass (Morris, 2004). This slower establishment may limit its use as a stand alone species on fairways (Morris, 2004). Rough stalk bluegrass tolerates poorly drained soils and has good shade tolerance making it a good choice for tree-lined fairways lacking drainage from heavy native soils (McCarty et al., 2001). It is generally quicker to transition in the spring because it has lower heat tolerance than perennial ryegrass (McCarty et al., 2001). However, Morris

(2004) found that in Florida and California trials, roughstalk bluegrass was actually slower to transition than perennial ryegrasses. The quickness of roughstalk bluegrass to transition can leave thin dormant bermudagrass. However, if the roughstalk bluegrass persists, as described by Morris (2004), it may out-compete the underlying bermudagrass.

**Spring Transition**

Turfgrass managers who overseed are well aware of the influence weather can have on the success or failure of overseeding and transition programs (Gelernter and Stowell, 2005). Weather is always the driving force when it comes to the success of overseeding and the spring transition. If cool-season grasses transition too quickly the warm-season grasses may be weak and unsightly. However, if the cool-season grasses persist they compete with the warm-season grasses for vital light, water, and nutrition that are needed for a successful spring transition (Gelernter and Stowell, 2005). This problem can be compounded by long term poly-stands of cool-season and warm-season grasses (Gelernter and Stowell, 2005). Superintendents are constantly looking for better ways to transition from cool-season to warm-season grasses.

Over the past years several cultural methods have been employed to enhance the transition process. It is believed among many superintendents that vertical mowing, aeration, and topdressing lead to a successful transition. However, Mazur and Wagner (1987) reported high-intensity vertical mowing and topdressing for overseeded bermudagrass are not effective in promoting bermudagrass emergence in the spring. In fact, vertical mowing was actually found to delay the emergence of bermudagrass (Mazur and Wagner, 1987; Johnson, 1986). Horgan and Yelverton (2001) found that cultural practices did affect perennial ryegrass coverage, but did not hasten its ultimate disappearance. Also, it was found that plots receiving core cultivation had lower bermudagrass shoot density at the end of the transition period (Horgan and Yelverton, 2001). This was due to the physical removal of bermudagrass shoots and the stress of coring each treatment during the hot summer months (Horgan and Yelverton, 2001).

Selective herbicides have successfully removed cool-season grasses. Chemical transition allows the superintendent to remove cool-season grasses quickly without as much concern for weather related issues, and the bermudagrass does not have to compete for sunlight, water, and nutrients (Gelernter and Stowell, 2005). This allows the bermudagrass a chance to become better established early in the normal growing season. Burt and Gerhold (1970) observed that pronamide [3,5-dichloro-*N*-(1,1-dimethyl-2-propynyl)-benzamide] completely eliminated or injured most cool-season grasses without affecting the warm-season grasses. Sulfonylurea herbicides have made transition more predictable, more manageable, and more beneficial for the growth of bermudagrasses (Gelernter and Stowell, 2005). Umeda and Towers (2004) tested seven different sulfonylurea herbicides for removing cool-season grasses from overseeded bermudagrass. They found applications made at the higher labeled rates effectively removed cool-season grasses from bermudagrass in April and May. The products tested included flazasulfuron[1], foramsulfuron[2], rimsulfuron [N-((4,6-dimethoxypyrimidin-2-yl) aminocoarbonyl)-3-(ethylsulfonyl)-2 pyridinesulfonamide], trifloxysulfuron [2-pyridinesulfonamide,[ N-[[(4,6-dimethoxy-2-pyrimidinyl)amino]carbonyl]-3-(2,2,2-trifluoroethoxy)-,monosodium salt, monohydrate salt, monohydrate]], and chlorsulfuron [2-chloro-N-[(4-methoxy-6-methyl-1,3,5-triazin-2-yl) aminiocarbonyl]

[1] Chemical name protected by U.S. Patent No 5,922,646.

[2] Not currently labeled.

benzenesulfonamide] (Umeda and Towers, 2004).

## Heat Stress and Turfgrass Physiology

In order to fully understand the transition of cool-season to warm-season grasses it is important to understand the physiology of the grasses involved in transition and how they react to light and temperature stress. It was not fully understood why cool-season grasses and warm-season grasses differed in their ability to handle environmental stresses until the Calvin-Benson or C3 and the Hatch and Slack or C4 carbon fixation cycles were discovered in the 1950's and 1960's, respectively (McCarty and Miller, 2002). The discovery of the two carbon fixation methods helped explain why warm-season and cool-season grasses perform differently. The C4 or warm-season grasses are able to withstand higher light intensities and warmer temperatures than C3 grasses (McCarty and Miller, 2002). Warm-season grasses grow best when exposed to full sunlight, because C4 plants exhibit a non-saturated growth curve at light intensities found in nature (McCarty and Miller, 2002). Cool-season grasses become stressed because growth curves plateau at one-half full sunlight (McCarty and Miller, 2002). Once this occurs, photosynthesis decreases and photorespiration increases. In the spring and summer growth of cool-season plant slows because of light saturation and high temperatures. During these periods when temperatures increase bermudagrass metabolism changes and dormancy is broken. Cool-season grasses compete for the sunlight needed by bermudagrass to begin growth in spring. When the cool-season overseeded grasses persist well into spring or summer bermudagrass growth is hindered. A slow transition can lead to bermudagrass death. This is why transition modeling to better understand the role that light and temperature play in spring transition could greatly help turfgrass managers make management decisions.

## Turf Growth and Transition Modeling

### Heat Unit (Degree Day) Modeling

Growing degree days, or heat accumulation units, can be used to measure or predict the effect of temperature on biological processes (Baskerville and Emin, 1969). The heat accumulation concept has been an excellent resource for many agricultural researchers and is commonly used for modeling plant growth (Gbur et al., 1979). Research has shown that understanding the relationship between plant growth and temperature can be helpful for many aspects of agricultural production (Unruh et al., 1996). Degree day models have helped turfgrass managers schedule pesticide applications for insects (Tolley and Robinson, 1986), disease (Danneberger, 1983; Danneberger and Vargas, 1984), and weed control (Throssell et al., 1990). Degree day modeling has been used to time plant growth regulator applications (Danneberger et al., 1987; Branham and Danneberger, 1989).

The correlation between growth and temperature in degree day modeling can predict when plants will germinate, mature, or even die (Mullen, 1996). These events in plant development can be measured in "Heat Units" (Mullen, 1996). A heat unit can be defined as the daily minimum temperature plus the daily maximum temperature minus a previously determined base temperature for the plant species in question (Mullen, 1996). Unruh et al. (1996) defines the base temperature as the temperature above which growth takes place and below which the plant is dormant. Limits are often placed on the daily maximum and minimum temperatures, and these are called "Growing Degree Days" or degree days (Mullen, 1996). Degree day units accumulate over a growing season, and thus provide an index of growth (Mullen, 1996). Degree day modeling has not been applied to the transition of overseeded cool-season grasses.

**Cumulative Growth Potential**

Gelernter and Stowell (2005) condsidered the growth requirements for both warm-season and cool-season turfgrasses and developed a model to help understand and explain the variable nature of overseeding programs. The model is based on cumulative growth potential which is a concept to help illustrate the interaction between weather and turf performance (Gelernter and Stowell, 2005). Like degree day modeling the cumulative growth potential model takes into account temperature data. The growth potential is calculated by the following equation:

$$GP = 100\left[\frac{1}{e^{\left[\frac{1}{2}\left[\frac{(obsT - optT)}{sd}\right]^2\right]}}\right] \qquad \text{[eq. 1]}$$

Where GP = growth potential; obsT = observed temperature (C); optT = optimal temperature (C); sd = standard deviation of the distribution (sd warm-season turf = 12; and sd cool-season turf = 10), and e = natural logarithm base (Gelernter and Stowell, 2005).

According to Gelernter and Stowell (2005), when the growth potential is at 100% the turfgrass has reached its optimal growth because temperatures are ideal for the particular turf species. Turf growth is still generally good until 50% because stress is minimal (Gelernter and Stowell, 2005). Once the growth potential falls below 50% the growth is limited, and as it nears 0% growth is halted (Gelernter and Stowell, 2005). The percent growth potential can be graphed over time and by overlapping the graphs of warm-season and cool-season turfgrasses a model can be constructed for a growing season including the transition periods of overseeded bermudagrass.

**Percent Ryegrass Disappearance**

Horgan and Yelverton (2001) found that increased relative humidity and air temperature in Raleigh, NC, accelerate natural ryegrass disappearance. Using two cultivars of perennial ryegrasses, ‘Derby Supreme’ and ‘Gator’, it was found that percent ryegrass disappearance could be modeled with linear regression over two growing seasons (Horgan and Yelverton, 2001). In finding that both relative humidity and air temperature were significant in the disappearance of ryegrass, it was noted also that there was no difference between the heat tolerance of the two varieties (Horgan and Yelverton, 2001). The equations used to model the disappearance of the ryegrasses were as follows:

$$RD = -37.01+3.41(airT) \quad [eq. 2]$$

and

$$RD = -274.7+4.31(RH) \quad [eq. 3]$$

Where RD = ryegrass disappearance; airT = air temperature (C); and RH = relative humidity (Horgan and Yelverton, 2001).

## National Turfgrass Evaluation Program

The National Turfgrass Evaluation Program, commonly referred to as NTEP, is designed to coordinate uniform evaluation trials of turfgrass varieties and promising selections in the United States and Canada (Morris and Shearman, 2000). The world-wide turfgrass community has relied heavily on the evaluation of information collected and summarized by NTEP since the early 1980’s. NTEP is a partnership between the USDA’s Agricultural Research Service, land-grant universities, and turfgrass seed companies (Morris and Shearman, 2000). NTEP is sponsored by the National Turfgrass Federation and the United States Department of Agriculture (Morris and Shearman, 2000). In most cases, NTEP evaluation trials are one of the first steps a new cultivar, blend, or mixture will go through before being released on the market. New turfgrasses should be well adapted for their intended applications. To accomplish this goal NTEP has designed trials to collect unbiased cultivar data using very consistent methods over a large range of environmental conditions.

## Turfgrass Evaluation Methods

### Visual Evaluation of Turfgrasses

The evaluation of turfgrasses is a difficult and complex issue (Shearman, 1998). Unlike agricultural crops, it is unreasonable to evaluate turfgrasses using methods such as a measure of yield or nutritive value (Shearman, 1998). Turfgrass quality is a subjective measure based on visual estimates of aesthetic qualities such as genetic color, stand density, leaf texture, uniformity, smoothness, and growth habit (Shearman, 1998). Trained observers can indeed effectively discern slight differences in turfgrasses using a visual rating system (Karcher et al., 2001; Karcher and Richardson, 2003; Shearman, 1998). Shearman (1998) and NTEP have created the following guidelines and suggestions for the evaluation of turfgrasses.

### General Methods

Visual ratings require consistency to ensure merit. One person should take the data for a study over the entire duration of a study. Before taking data, a study should be observed. The investigator should walk around the treatments and identify the range of differences that occur. This process allows the investigator to establish a rating range each time treatments are evaluated and keeps the ratings consistent. NTEP protocol suggests turfgrasses are rated on a one to nine scale and should only be rated in whole numbers. Ideally, evaluations should be made between mid-morning to early afternoon, when shadows and reflections are minimal. (Shearman, 1998)

### Turfgrass Quality

Quality ratings take into account the functional and aesthetic aspects of turfgrass. They are based on a combination of color, density, uniformity, texture, and disease or environmental stress. Quality is based on nine being the best and one being the poorest. Quality values of nine are generally reserved for a perfect or ideal grass, while a rating of six is generally considered an acceptable turf. Investigators must keep this in mind when rating turfgrasses. (Shearman, 1998)

### Genetic Color

Genetic color reflects the inherent color of a genotype. The visual rating is a one to nine scale, one being light green and nine being dark green. Chlorosis and browning from necrosis are not part of genetic color. Color charts, including Munsell Color Charts for Plant Tissue (GreTagMacbeth LLC, New Windsor, NY), are useful in describing turfgrass color and help in maintaining consistent visual color ratings. (Shearman, 1998)

### Turfgrass Density

Turfgrass density is a visual estimate of living plants or tillers per unit area. Dead patches in turf are excluded. A visual rating scale of one to nine is used and nine equals maximum density. Turfgrass density can be measured quantitatively by counting shoots in a specified area. However, this process is extremely time consuming and labor intensive. Visual density ratings are highly correlated to counts and require less time and labor. (Shearman, 1998)

### Percent Living Ground Cover

Percent living ground cover is based on the surface area covered by the originally planted species. Expressed from zero to100%, it is generally used to measure damage caused by insects, disease, environmental stresses and weed infestation. Ratings taken over a season enable tracking of turfgrass response to various stresses during the growing season. (Shearman, 1998)

**Turfgrass Texture**

Turfgrass texture is a measure or estimate of leaf width. The visual rating of texture is based on a one to nine scale with one equaling coarse and nine equaling fine. Visual estimate of texture is difficult and less than precise. However, actual physical measurement is tedious, time consuming and labor intensive. Care must be taken to measure leaves of similar age and stage of development. Visual ratings of texture can successfully separate cultivars within species. Actual visual estimations of texture should be completed when the turfgrass is actively growing and not under stress. (Shearman, 1998)

**Digital Image Analysis**

Color is a key component of the aesthetic properties of turfgrass and a good indicator of water and nutrient stress (Beard, 2002). Digital analysis has been shown to quantify color differences among standard Munsell Plant Tissue color chips, zoysiagrass and creeping bentgrass receiving various N fertility treatments, and bermudagrass varying in genetic color (Karcher and Richardson, 2003). A Dark Green Color Index DGCI was created from the hue, saturation, and brightness values obtained from digital image color analysis for comparison with values from subjective visual ratings. DGCI variance is significantly lower than the variance when compared to visual ratings of genetic color (Karcher and Richardson, 2003). The accuracy of digital image analysis allows turfgrass researchers to record reflected turfgrass color on a standardized scale rather that using arbitrary color values (Karcher and Richardson, 2003). This enables valid comparisons of color data to be made across researchers, locations, and years.

# CHAPTER 3
# AN EVALUATION OF TURFGRASSES FOR OVERSEEDING BERMUDAGRASS FAIRWAYS

## Introduction

In the southern United States overseeding bermudagrass fairways is a common practice. Overseeding provides an aesthetically-pleasing and functional playing surface during winter months when temperatures drop below 9.9ºC (50ºF), and bermudagrass has lost its green color due to winter dormancy (McCarty and Miller, 2002). The actively growing turfgrass provided by overseed is more tolerant of traffic, divoting, and weed invasions than dormant bermudagrass (Morris, 2004). Having overseeded turf can add to a golf course's revenue by increasing the number of rounds played during cooler months (Morris, 2004). However, overseeding can add significant costs to a golf course's budget (McCarty et al., 2001). Costs include seed, water, labor, and pesticides and make up to 20% of an annual budget on southern golf courses (Ostmeyer, 2004). Another disadvantage of overseeding is that the persistence of overseeded turfgrasses into late spring and summer months can have detrimental effects on the underlying bermudagrass as they compete for light, moisture, and nutrients (Gelernter and Stowell, 2005). Thus, transition, bermudagrass green-up, and fill-in are delayed (McCarty et al., 2001). This problem can be combated with the proper selection of overseed species and cultivars.

Turfgrass managers desire grasses that establish quickly, provide excellent playability, transition appropriately, require fewer inputs, and are aesthetically pleasing. Breeding programs have led to the release of many new overseed cultivars each year.

The quest to improve turfgrass performance under stressful environmental conditions requires breeding and selecting new germplasm. In addition to breeding and selection of new cultivars, each year seed companies formulate new mixtures and blends. Timely testing of new cultivars, blends, and mixtures over a range of environmental conditions by university scientists provides an un-biased evaluation to the breeder and end-user. The objective of this study is to evaluate the suitability of the commercially available species, cultivars, and blends included in the 2004-2006 National Turfgrass Evaluation Program (NTEP) on-site fairway overseed trials for the north central region of Florida.

## Materials and Methods

Thirty-one entries were established at the University of Florida Golf Course in Gainesville, FL during fall of 2004 and 2005 (Appendix A). Entries included 17 perennial ryegrasses (*Lolium perenne* L.), eight perennial ryegrass blends, four roughstalk bluegrasses (*Poa trivialis* L.), and two intermediate ryegrasses (*Lolium hybridum* Hausska.). The fairway site was selected with the aid of the superintendent to ensure that plots would receive uniform sunlight and wear. The University of Florida Golf Course staff provided daily maintenance for the plots. Fertilization, irrigation, mowing, and pesticide regimes were applied as determined by the superintendent to provide typical golf course conditions.

Prior to planting, the number of seeds $g^{-1}$ for each cultivar was determined by weighing 100 fully developed seed to the nearest mg. The number of seeds $g^{-1}$ was then calculated. This procedure was completed in three replications for each cultivar. Germination tests were completed in germination chambers (Stults Scientific Engineering Corp., Springfield, IL). Ten seeds were germinated at 21 ºC (70 ºF) with 5 mL of water and germination paper in the bottom of Petri dishes. Germination percentages were calculated from this information and the procedure was completed in four replications for each cultivar.

The fairway was scalped to 0.95 cm (0.375 in) from 1.14cm (0.45 in) three days prior to overseeding in 2004 and no seedbed preparation occurred in 2005. The plots were seeded on 18 Oct. 2004 and 25 Oct. 2005 with the 31 entries. Ten days after seeding the plots were mowed at 1.14 cm (0.45 in). Plots were mowed at this height three times per week for the remainder of the study. Plots were 1.5 m by 6.1 m (5 ft by 20 ft) and arranged in a randomized complete block design with three replications. Entries were seeded onto a 'TifSport' bermudagrass (*Cynodon dactylon* X *C. transvaalenis* Burtt-Davy) fairway with a drop spreader (The Andersons Company, Maumee, OH) at rates of 392.3 kg $ha^{-1}$ (350 lbs $acre^{-1}$) for ryegrass species and blends, and 224.2 kg $ha^{-1}$ (200 lbs $acre^{-1}$) for roughstalk bluegrass. Because overseeding grasses provide a temporary playing surface during the fall, winter, and spring and are reseeded each year cultivars were seeded in the same plots for two consecutive years (fall 2004 and fall 2005) to prevent un-germinated seed from emerging in the plot of a different cultivar the following year. The 31 entries tested were NTEP solicited grasses from sponsoring companies and commercially available cultivars and blends. Experimental entries that were soon to be commercially available (before the end of the testing cycle) also were permitted.

The first fertilization occurred on 1 Nov. 2004 with a 6-2-3 biosolid at a N rate of 17 kg $ha^{-1}$ (15.2 lbs $acre^{-1}$). The second fertilization occurred on 15 Dec. 2004 with a 15-5-10 granular fertilizer at a N rate of 42 kg $ha^{-1}$ (37.5 lbs $acre^{-1}$). On 30 Jan. the plots were fertilized at a N rate 0.65 kg $ha^{-1}$ (0.58 lbs $acre^{-1}$) with liquid 7-0-0 with Fe and Mg as a supplement. The final fertilization occurred on 23 May with a sulfur coated urea (28-0-0) at a N rate of 244 kg ha$^{-1}$ (217.7 lbs acre$^{-1}$). The plots received no pesticides during the 2004-2005 trial.

During the second year the first fertilization occurred on 6 Dec. 2005 with a 21-0-0 liquid supplemented with Mn at a N rate of 68 kg ha$^{-1}$ (60.7 lbs acre$^{-1}$). On 3 Jan. 2006 the trial was fertilized with at 28-0-0 slow release material at a N rate of 3.25 kg ha$^{-1}$ (2.9 lbs acre$^{-1}$). The next fertilization occurred on 17 Jan with IBDU (31-0-0) at a N rate of 69.5 kg ha$^{-1}$ (62 lbs acre$^{-1}$). The final fertilization occurred on 14 Mar. with a N rate using 14-0-14 plus oxadiazon [2-tert-butyl-4-(2,4-dichloro-5-isopropoxyphenyl)-Δ-1, 3, 4-oxidiazon-5-one] at 39.2 kg ha$^{-1}$ (35 lbs acre$^{-1}$). The oxidaizon was delivered at a rate of 2.69 kg a.i. ha$^{-1}$ (2.4 lbs a.i. acre$^{-1}$) The plots were also slit injected with fipronil [5-amino-1-(2,6-dichloro-4-(trifluoromethyl)phenyl)-4-((1,R,S,)-(trifluoromethyl)sulinyl) - 1-H-pyrazole-3-carbonitrile] on 29 Apr. at a rate of 0.028 kg a.i. ha$^{-1}$ (0.025 lbs a.i. acre$^{-1}$) for the preventative control of mole crickets (*Scapteriscus* spp.).

Data collected included visual estimates of percent establishment (weekly for first six weeks after seeding), turfgrass quality (weekly during the fall transition, winter and spring transition), genetic color (every other week during the winter and spring transition), percent cover (twice weekly during the winter and spring transition), texture (weekly during early spring period), and density (weekly during early spring period). Disease incidence was evaluated counting necrotic spots (centers) in each plot. NTEP Turfgrass Evaluation Guidelines (Shearman, 1998) were followed for all visual ratings.

Dark Green Color Index (DGCI) values were obtained (once during the winter period) using digital images and the DGCI calculation (Karcher and Richardson, 2003).

*In situ* shear strength measurements (kg force) were determined using a Clegg Shear tester (Dr. Baden Clegg Pty. Ltd., St. Jolimont, WA) with the insertion of a 49mm wide paddle, 40mm into the soil profile. Weather data was mined from the Florida Automated Weather Network (FAWN) weather station in Citra, FL (FAWN, 2006). The soil temperatures were measured daily 10 cm below the soil surface at the Citra location and then the data was computed to provide average weekly soil temperatures.

For analysis all measurements and visual ratings were statistically analyzed as a main-effects model using SAS proc GLM (SAS Institute, 1999). For those traits measured multiple times during the trial the repeated measures were analyzed as split plots in time. Therefore, when the interaction of cultivar × year was significant years were analyzed separately. Least significant differences (LSD) at $P < 0.05$ was used to compare cultivar means, whereas contrasts were used to compare species differences.

## Results and Discussion

Seeds $g^{-1}$, as described in Table 3-1, showed that ryegrass species did not vary among species, cultivars, and blends. Roughstalk bluegrass species did exhibit significant variation ($P < 0.05$). Germination rates varied between species and cultivars (Table 3-1).

Temperatures were average compared to historical data for north central FL. However, above average warm temperatures were recorded in early January during the 2004-2005 study (Figures 3-1 & 3-2). Frosts occurred in both years of the trial. April, May, and June were hot dry months for much of Florida.

Table 3-1 Germination and seed count data for each of the cultivars in the evaluation.

| Cultivar | Species | Germination* | Count* |
|---|---|---|---|
| | | ----%---- | Seeds $g^{-1}$ |
| MTV-124 | Perennial ryegrass | 100 a | 554 d |
| Top Hat | Perennial ryegrass | 100 a | 527 d |
| RAM-100 | Roughstalk bluegrass | 98 ab | 4,929 a |
| OSC 116 | Perennial ryegrass | 98 ab | 586 d |
| RAD-OS3 | Intermediate ryegrass | 98 ab | 442 d |
| Flash II | Perennial ryegrass | 97 ab | 547 d |
| Overseeding Eagle Blend | Ryegrass blend | 97 ab | 547 d |
| PRS2 | Perennial ryegrass | 97 ab | 559 d |
| OSC108 | Perennial ryegrass | 95 abc | 543 d |
| Champion GQ | Ryegrass blend | 95 abc | 613 d |
| Covet | Perennial ryegrass | 95 abc | 583 d |
| Futura 2500 | Ryegrass blend | 95 abc | 557 d |
| League Master | Ryegrass blend | 95 abc | 518 d |
| Magnum Gold | Ryegrass blend | 95 abc | 651 d |
| ProSelect | Ryegrass blend | 95 abc | 591 d |
| Winterplay | Roughstalk bluegrass | 95 abc | 4,552 c |
| Marvelgreen Supreme | Ryegrass blend | 94 abcd | 640 d |
| STP | Perennial ryegrass | 94 abcd | 630 d |
| Playmate | Ryegrass blend | 94 abcd | 576 d |
| Colt | Roughstalk bluegrass | 94 abcd | 4,791 ab |
| PR 17 | Perennial ryegrass | 94 abcd | 535 d |
| CRR | Perennial ryegrass | 94 abcd | 625 d |
| IS-IR3 | Intermediate ryegrass | 93 bcd | 452 d |
| IS-OS | Perennial ryegrass | 93 bcd | 482 d |
| OSC110 | Perennial ryegrass | 93 bcd | 510 d |
| Starlite | Roughstalk bluegrass | 93 bcd | 4,587 bc |
| Pick SD | Perennial ryegrass | 91 bcd | 561 d |
| Charger | Perennial ryegrass | 91 bcd | 473 d |
| OS | Perennial ryegrass | 89 cde | 511 d |
| BMX 020383 | Perennial ryegrass | 88 de | 536 d |
| ALS2 | Perennial ryegrass | 83 e | 533 d |

*Means followed by the same letter are not significantly different at the 0.05 level.

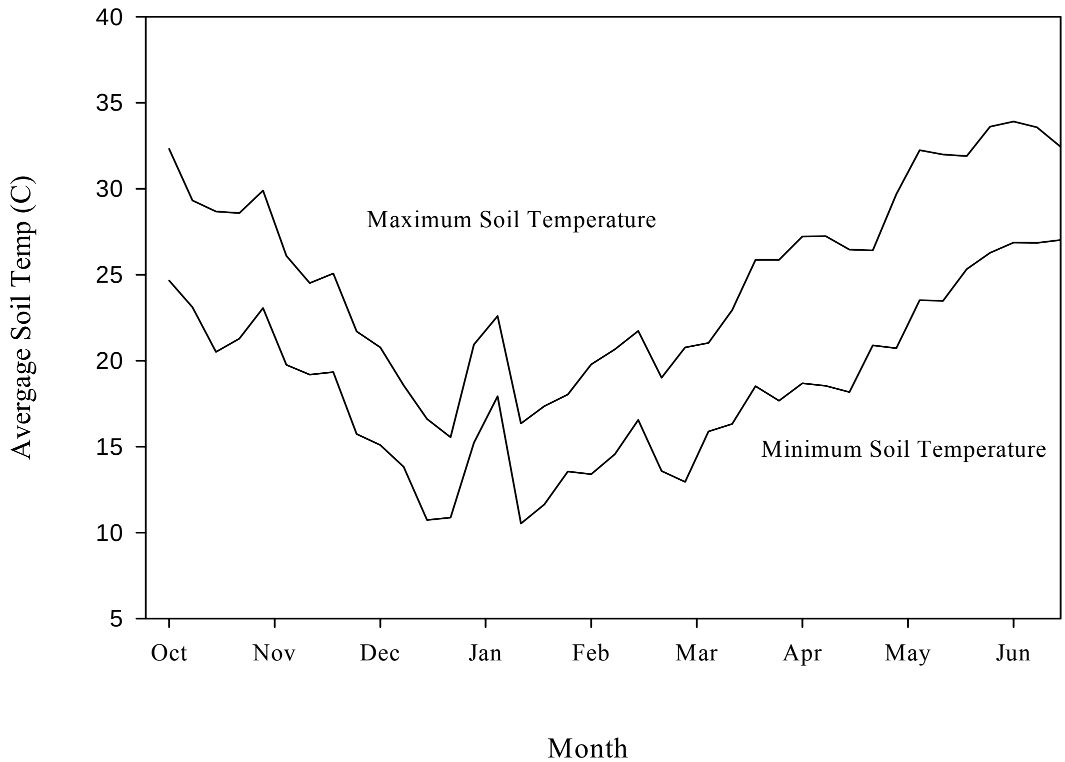


Figure 3-1. Average weekly soil temperatures taken 10cm below soil surface for the 2004-2005 evaluation.

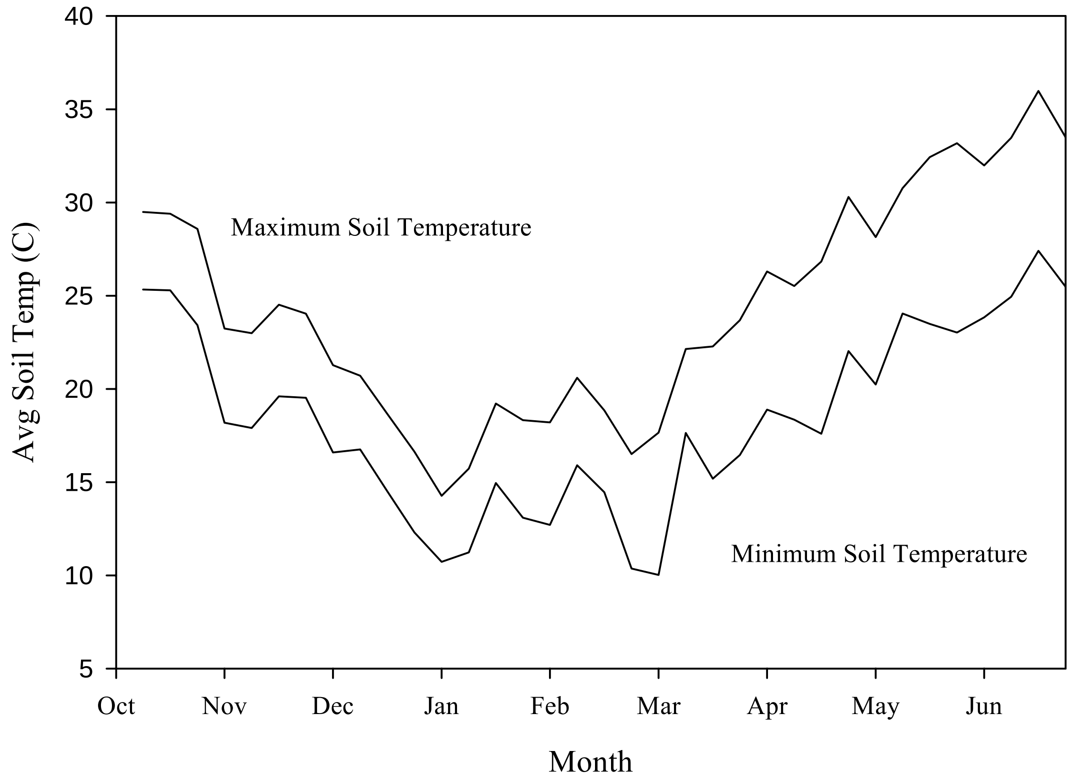


Figure 3-2. Average weekly soil temperatures taken 10cm below surface for the 2005-2006 evaluation.

### 2004-2005 Turf Establishment, Quality, and Transition Performance

A cultivar by year interaction was observed for both cover and quality ratings when the data was analyzed (Table 3-2). Therefore, the data was analyzed and discussed separately for cover and quality among individual growing seasons. Establishment at four weeks after (18 Nov. 2004) seeding ranged from 23 to 48% in the field study (Table 3-3). With the exception of ‘PR 17’ the ryegrasses were more established than roughstalk bluegrass entries. Although it should be noted that differences were not always significant between ryegrasses and roughstalk bluegrass entries.

Table 3-2 Mean square from combined analyses of variance for cover and quality ratings of the cool-season overseed turfgrasses from the 2004-2005 and 2005-2006 growing seasons.

| | | Mean Square | |
|---|---|---|---|
| Source of Variation | df | Cover | Quality |
| Cultivar, C | 30 | 4801.5** | 63.2** |
| Year, Y | 1 | 613.3** | 1.2 |
| C x Y | 30 | 357.4** | 3.6** |
| Rep, R | 2 | 188.9** | 3.7** |
| Date(Y) | 81 | 57820.9** | 19.1** |
| Error | 7718 | 36.7 | 0.4 |
| CV, % | | 11.2 | 9.2 |
| Mean | | 54.3 | 6.8 |
| Species, S | 3 | 40836.6** | 300.5** |
| Blend vs Perennial rye, PR | 1 | 2033.6** | 9.4** |
| Intermediate rye vs PR | 1 | 1902.2* | 6.5** |
| PR vs Roughstalk bluegrass | 1 | 105478.3** | 794.5** |

*, ** Indicates significance at 0.05 and 0.01 level, respectively.

Table 3-3 Percent cover of overseeded grasses four and six weeks after seeding for the 2004-2005 trial.

| Cultivar | Species | Overseed Cover 18 Nov 04 | Overseed Cover 2 Dec 04 |
|---|---|---|---|
| | | ----------%---------- | |
| Magnum Gold | Ryegrass blend | 48 a | 70 a |
| OSC110 | Perennial ryegrass | 47 ab | 65 ab |
| OSC108 | Perennial ryegrass | 47 ab | 66 ab |
| Flash II | Perennial ryegrass | 47 ab | 63 abc |
| Charger | Perennial ryegrass | 47 ab | 57 abcde |
| Champion GQ | Ryegrass blend | 47 ab | 60 abcd |
| STP | Perennial ryegrass | 45 ab | 62abc |
| ProSelect | Ryegrass blend | 43 ab | 60 abcd |
| MTV-124 | Perennial ryegrass | 43 ab | 63 abc |
| Marvelgreen Supreme | Ryegrass blend | 43 ab | 60 abcd |
| CRR | Perennial ryegrass | 43 ab | 63 abc |
| Playmate | Ryegrass blend | 42 abc | 65 ab |
| Pick SD | Perennial ryegrass | 42 abc | 55 bcde |
| Overseeding Eagle Blend | Ryegrass blend | 42 abc | 63 abc |
| OS | Perennial ryegrass | 42 abc | 63 abc |
| Futura 2500 | Ryegrass blend | 42 abc | 53 cde |
| Covet | Perennial ryegrass | 42 abc | 63 abc |
| Top Hat | Perennial ryegrass | 40 abcd | 62 abc |
| PRS2 | Perennial ryegrass | 40 abcd | 53 cde |
| OSC 116 | Perennial ryegrass | 40 abcd | 57 abcde |
| IS-OS | Perennial ryegrass | 40 abcd | 58 abcd |
| IS-IR3 | Intermediate ryegrass | 40 abcd | 57 abcde |
| ALS2 | Perennial ryegrass | 40 abcd | 53 cde |
| RAD-OS3 | Intermediate ryegrass | 38 abcde | 57 abcde |
| BMX 020383 | Perennial ryegrass | 38 abcde | 53 cde |
| League Master | Ryegrass blend | 37 abcde | 57 abcde |
| Colt | Roughstalk bluegrass | 32 cdef | 53 cde |
| Starlite | Roughstalk bluegrass | 30 def | 43 ef |
| RAM-100 | Roughstalk bluegrass | 28 ef | 47 def |
| PR 17 | Perennial ryegrass | 28 ef | 43 ef |
| Winterplay | Roughstalk bluegrass | 23 f | 38 f |

* Means followed by the same letter are not statistically different at the 0.05 level.

Six weeks after establishment the ryegrasses and blends exhibited good coverage, (53 to 70%) the exception again being ‘PR 17’ (43%, Table 3-3). Similar to the 4-week establishment ratings the ryegrass entries and blends had higher establishment ratings. Again, not all differences were significant ($P < 0.05$, Table 3-3). The quality ratings at this time showed similar results as coverage with the roughstalk bluegrasses and ‘PR 17’ having the lowest quality ratings (Table 3-4). This trend of roughstalk bluegrasses and ‘PR 17’ having lower cover and quality ratings continued until late February. In March there was less than 10% difference between coverage ratings for all entries. The majority of the perennial ryegrasses and ryegrass blends still exhibited the best coverage (≥75%), but the roughstalk bluegrasses and intermediate ryegrasses had good coverage, between 60 and 75%. Thirty of the grasses exhibited minimally acceptable quality ratings greater than six (Table 3-4). The roughstalk bluegrass ‘Colt’ had the poorest quality rating, 4.7 (Table 3-4).

During early May and throughout the transition period, the time when ryegrasses begin to fade due to heat stress, ‘LeagueMaster’ and ‘Playmate’, perennial ryegrass blends, exhibited the highest cool-season grass coverage at 35% (Data not shown). They also exhibited mean quality ratings greater than or equal to 6.0 throughout the transition period (Table 3-4). Other plots exhibiting high overseed coverage above 33%, good bermudagrass densities, and quality ratings in mid May included the perennial ryegrasses ‘PRS 2’, ‘OSC 108’, ‘OSC110’, ‘PickSD’, and the ryegrass blends ‘ProSelect’ and ‘Futura 2500’. These grasses may be the appropriate choice when turf managers desire predominately cool-season grass to persist into spring and then transition abruptly. Roughstalk bluegrasses, the intermediate ryegrass ‘RAD-OS3’, and ‘PR 17’ exhibited less than 28%, coverage and high bermudagrass coverage through the transition period. However, ‘RAD-OS3’ exhibited a greater average quality rating than others during this period (Table 3-4). As temperatures increased in June most of the grasses had transitioned to the point that there were no statistical differences in coverage (Data not shown) and very little difference in quality. By the end of June all entries had completely transitioned leaving all plots with 100% bermudagrass coverage and quality ratings greater than or equal to 7.0 (1 to 9 scale) with the exception of 'Colt' (6.7, Table 3-4).

Table 3-4 Quality ratings of overseeded grasses for the 2004-2005 season.

| | Quality Rating | | | | | |
|---|---|---|---|---|---|---|
| Cultivar | 6 Dec 04 | 24 Mar 05 | 5 May 05 | 16 May 05 | 6 Jun 05 | 23 Jun 05 |
| Flash II | 7.0 a | 7.7 ab | 7.0 a | 7.2 a | 7.0 a | 7.3 ab |
| Magnum Gold | 7.0 a | 7.7 ab | 6.7 ab | 6.7 abcd | 7.0 a | 7.7 a |
| OSC116 | 7.0 a | 7.3 abc | 6.7 ab | 6.5 abcd | 7.0 a | 7.3 ab |
| ProSelect | 6.7 ab | 6.7 bcd | 6.3 abc | 6.5 abcd | 6.7 ab | 7.0 ab |
| OSC108 | 6.7 ab | 7.3 abc | 6.7 ab | 6.8 abc | 6.7 ab | 7.0 ab |
| Top Hat | 6.7 ab | 6.7 bcd | 6.3 abc | 6.3 bcd | 6.7 ab | 7.3 ab |
| OSC110 | 6.7 ab | 7.7 ab | 6.3 abc | 6.8 abc | 6.7 ab | 7.0 ab |
| Champion GQ | 6.3 abc | 7.0 abcd | 6.7 ab | 6.8 abc | 6.3 abc | 7.3 ab |
| MTV-124 | 6.3 abc | 8.0 a | 7.0 a | 7.0 ab | 6.3 abc | 7.3 ab |
| Overseeding EB | 6.3 abc | 7.0 abcd | 6.7 ab | 6.7 abcd | 6.3 abc | 6.3 b |
| CRR | 6.3 abc | 7.0 abcd | 6.3 abc | 6.7 abcd | 6.3 abc | 7.7 a |
| MG Supreme | 6.3 abc | 7.3 abc | 6.3 abc | 6.5 abcd | 6.3 abc | 7.0 ab |
| League Master | 6.3 abc | 7.3 abc | 6.7 ab | 6.8 abc | 6.3 abc | 6.7 ab |
| IS-OS | 6.3 abc | 6.7 bcd | 6.0 bc | 6.5 abcd | 6.3 abc | 7.0 ab |
| Covet | 6.3 abc | 7.0 abcd | 6.7 ab | 6.7 abcd | 6.3 abc | 7.0 ab |
| STP | 6.3 abc | 7.0 abcd | 6.0 bc | 6.5 abcd | 6.3 abc | 7.3 ab |
| Playmate | 6.0 abcd | 7.7 ab | 6.7 ab | 6.8 abc | 6.0 abcd | 7.3 ab |
| PRS2 | 6.0 abcd | 6.3 dc | 5.7 cd | 6.5 abcd | 6.0 abcd | 6.3 b |
| Futura 2500 | 6.0 abcd | 7.0 abcd | 6.7 ab | 6.8 abc | 6.0 abcd | 6.7 ab |
| Pick SD | 6.0 abcd | 7.3 abc | 6.7 ab | 7.0 ab | 6.0 abcd | 6.7 ab |
| BMX 020383 | 5.7 bcde | 6.7 bcd | 7.0 a | 7.0 ab | 5.7 bcde | 7.0 ab |
| RAD-OS3 | 5.7 bcde | 6.7 bcd | 6.0 bc | 6.7 abcd | 5.7 bcde | 7.0 ab |
| ALS2 | 5.3 cde | 6.3 bcd | 6.0 bc | 6.5 abcd | 5.3 cde | 7.0 ab |
| OS-IR3 | 5.3 cde | 7.0 abcd | 6.3 abc | 7.0 ab | 5.3 cde | 7.7 a |
| OS | 5.0 def | 6.7 bcd | 6.3 abc | 6.8 abc | 5.0 def | 7.3 ab |
| Charger | 4.7 efg | 6.3 dc | 6.7 ab | 6.8 abc | 4.7 efg | 6.7 ab |
| Starlite | 4.0 fgh | 6.0 d | 6.3 abc | 6.2 cd | 4.0 fgh | 7.0 ab |
| RAM-100 | 4.0 fgh | 7.0 abcd | 6.0 bc | 6.2 cd | 4.0 fgh | 7.7 a |
| PR 17 | 3.7 gh | 6.3 cd | 5.7 cd | 6.7 abcd | 3.7 gh | 7.0 ab |
| Winterplay | 3.7 gh | 6.3 cd | 6.0 bc | 6.2 cd | 3.7 gh | 7.3 ab |
| Colt | 3.0 h | 4.7 e | 5.0 d | 6.0 d | 3.0 h | 6.7 ab |

* Means followed by the same letter are not statistically different at the 0.05 level.

**2005-2006 Turf Establishment, Quality, and Transition Performance**

During the second year of the study the coverage again varied between the ryegrasses and the roughstalk bluegrasses. Most of the ryegrasses exhibited good establishment coverage during the first four weeks after planting (Table 3-5). The roughstalk bluegrasses were again much slower to establish than the most of the ryegrasses. The top performers included ‘Charger’, ‘Pick SD’, and ‘ProSelect’ (Table 3-5). The perennial ryegrass ‘PR 17’ was slow to establish as in the previous year; however, it was not different from other poorer performing ryegrasses at the $P < 0.05$ level. The roughstalk bluegrasses establishment coverage ranged from 7 to 18% below the poorest ryegrass coverage four weeks after seeding (Table 3-5).

At six weeks after establishment the roughstalk bluegrasses were still different from other entries ($P < 0.05$). The top performers at six weeks included ‘Playmate’ and ‘BMX 020383’. Roughstalk bluegrasses were still 14 to 28% less than the other grasses (Table 3-5). This trend continued well into March as in year one of the trial. In early quality ratings the roughstalk bluegrasses and the perennial ryegrass ‘PR 17’ rated the poorest in quality.

In mid April and early May the perennial ryegrasses ‘Playmate’, ‘PickSD’, and the ryegrass blend ‘Champion GQ’ had the highest overall cover ratings as transition began. They also exhibited mean quality ratings of 6.0 on the 1 to 9 scale and were not different ($P < 0.05$ level) from the majority of the other ryegrasses (Table 3-6). The roughstalk bluegrasses did however perform much better during the transition period with mean quality ratings ranging from 6.3 to 7.0 (Table 3-6). The roughstalk bluegrasses ranged in coverage from 30 to 35% with good bermudagrass density (Table 3-5). The intermediate ryegrass ‘RAD-OS3’ exhibited the lowest cover in early May at 30%, but ranked the highest in quality at the $P < 0.05$ level. By early June all of the grasses had completed transition leaving 100% bermudagrass cover and average quality ratings of 7.0 on a 1 to 9 scale.

Table 3-5 Percent cover of overseeded grasses four and six weeks after seeding for the 2005-2006 trial.

| Cultivar | Species | Overseed Cover 22 Nov 05 | Overseed Cover 1 Dec 05 |
|---|---|---|---|
| | | ----------%---------- | |
| Charger | Perennial ryegrass | 53 a | 53 abc |
| Pick SD | Perennial ryegrass | 52 a | 57 ab |
| ProSelect | Ryegrass blend | 52 a | 57 ab |
| BMX 020383 | Perennial ryegrass | 50 ab | 58 a |
| Playmate | Ryegrass blend | 50 ab | 58 a |
| Champion GQ | Ryegrass blend | 48 abc | 53 abc |
| CRR | Perennial ryegrass | 48 abc | 53 abc |
| MTV-124 | Perennial ryegrass | 48 abc | 55 abc |
| Overseeding Eagle Blend | Ryegrass blend | 48 abc | 55 abc |
| Futura 2500 | Ryegrass blend | 47 abc | 53 abc |
| League Master | Ryegrass blend | 47 abc | 57 ab |
| Magnum Gold | Ryegrass blend | 47 abc | 55 abc |
| RAD-OS3 | Intermediate ryegrass | 47 abc | 50 abc |
| STP | Perennial ryegrass | 47 abc | 57 ab |
| Top Hat | Perennial ryegrass | 47 abc | 55 abc |
| ALS2 | Perennial ryegrass | 45 abc | 57 ab |
| Flash II | Perennial ryegrass | 45 abc | 53 abc |
| Marvelgreen Supreme | Ryegrass blend | 45 abc | 53 abc |
| OSC 116 | Perennial ryegrass | 45 abc | 55 abc |
| OSC108 | Perennial ryegrass | 45 abc | 53 abc |
| OSC110 | Perennial ryegrass | 45 abc | 53 abc |
| Covet | Perennial ryegrass | 43 abcd | 53 abc |
| IS-OS | Perennial ryegrass | 43 abcd | 48 bc |
| OS | Perennial ryegrass | 43 abcd | 55 abc |
| PRS2 | Perennial ryegrass | 43 abcd | 52 abc |
| IS-IR3 | Intermediate ryegrass | 40 bcd | 52 abc |
| PR 17 | Perennial ryegrass | 38 cd | 47 c |
| Winterplay | Roughstalk bluegrass | 33 d | 33 d |
| Colt | Roughstalk bluegrass | 18 e | 18 e |
| RAM-100 | Roughstalk bluegrass | 17 e | 22 e |
| Starlite | Roughstalk bluegrass | 15 e | 18 e |

* Means followed by the same letter are not statistically different at the 0.05 level.

Table 3-6 Quality ratings of overseeded grasses for the 2005-2006 season.

| | Quality Rating | | | | | |
|---|---|---|---|---|---|---|
| Cultivar | 12 Dec 05 | 13 Mar 06 | 2 May 06 | 16 May 06 | 23 May 06 | 7 Jun 06 |
| Flash II | 6.7 a | 7.0 ab | 7.0 a | 7.2 a | 7.0 a | 7.0 a |
| Magnum Gold | 6.0 a | 7.0 ab | 6.7 ab | 6.7 abcd | 7.0 a | 7.0 a |
| OSC116 | 6.7 a | 7.0 ab | 6.7 ab | 6.5 abcd | 6.7 ab | 7.0 a |
| ProSelect | 6.3 ab | 7.0 ab | 7.0 a | 6.5 abcd | 7.0 a | 7.0 a |
| OSC108 | 6.0 a | 7.0 ab | 6.7 ab | 6.8 abc | 6.8 ab | 7.0 a |
| Top Hat | 6.0 a | 7.0 ab | 6.7 ab | 6.3 bcd | 6.8 ab | 7.0 a |
| OSC110 | 5.7 a | 7.0 ab | 7.0 a | 6.8 abc | 6.7 ab | 7.0 a |
| Champion GQ | 6.3 a | 7.0 ab | 6.7 ab | 6.8 abc | 6.8 ab | 7.0 a |
| MTV-124 | 6.3 ab | 7.0 ab | 7.0 a | 7.0 ab | 7.0 a | 7.0 a |
| OEB | 6.3 a | 7.0 ab | 7.0 a | 6.7 abcd | 6.8 ab | 7.0 a |
| CRR | 6.3 a | 7.3 a | 6.7 ab | 6.7 abcd | 6.8ab | 7.0 a |
| MG Supreme | 6.3 a | 7.3 a | 6.7 ab | 6.5 abcd | 6.7 ab | 7.0 a |
| League Master | 6.3 a | 7.0 ab | 7.0 a | 6.8 abc | 6.8 ab | 7.0 a |
| IS-OS | 5.7 a | 7.0 ab | 7.0 a | 6.5 abcd | 6.8 ab | 7.0 a |
| Covet | 6.0 a | 7.0 ab | 6.7 ab | 6.7 abcd | 6.7 ab | 7.0 a |
| STP | 6.3 a | 7.0 ab | 7.0 a | 6.5 abcd | 6.8 ab | 7.0 a |
| Playmate | 6.0 a | 7.3 a | 7.0 a | 6.8 abc | 7.0 a | 7.0 a |
| PRS2 | 6.0 a | 7.0 ab | 7.0 a | 6.5 abcd | 6.7 ab | 7.0 a |
| Futura 2500 | 6.0 a | 7.0 ab | 7.0 a | 6.8 abc | 6.8 ab | 7.0 a |
| Pick SD | 6.3 a | 7.0 ab | 7.0 a | 7.0 ab | 6.8 ab | 7.0 a |
| BMX 020383 | 6.3 a | 7.0 ab | 7.0 a | 7.0 ab | 7.0 a | 7.0 a |
| RAD-OS3 | 6.0 a | 7.0 ab | 7.0 a | 6.7 abcd | 6.8 ab | 7.0 a |
| ALS2 | 6.0 a | 7.0 ab | 7.0 a | 6.5 abcd | 6.8 ab | 7.0 a |
| OS-IR3 | 6.3 a | 7.0 ab | 7.0 a | 7.0 ab | 7.0 a | 7.0 a |
| OS | 6.3 a | 7.0 ab | 6.7 ab | 6.8 abc | 6.8 ab | 7.0 a |
| Charger | 6.0 a | 7.3 a | 6.7 ab | 6.8 abcd | 6.8 ab | 7.0 a |
| Starlite | 3.7 b | 6.7 bc | 6.7 ab | 6.2 cd | 6.3 bc | 7.0 a |
| RAM-100 | 4.0 b | 6.7 bc | 7.0 a | 6.2 cd | 6.3 bc | 7.0 a |
| PR 17 | 6.0 a | 7.0 ab | 6.7 ab | 6.7 abcd | 6.5 ab | 7.0 a |
| Winterplay | 4.0 b | 6.7 bc | 6.7 ab | 6.2 cd | 6.5 ab | 7.0 a |
| Colt | 3.7 b | 6.3 c | 6.3 b | 6.0 d | 5.8 c | 7.0 a |

* Means followed by the same letter are not statistically different at the 0.05 level.

**2004-2006 Overseed Density and Texture**

Density was analyzed and discussed separately by year because a cultivar by year interaction was again observed. Perennial ryegrass and ryegrass blends exhibited the highest values for density during both years, but were different from one another at the 95% probability level (Table 3-7). Contrast analyses by species indicated perennial ryegrasses and roughstalk bluegrasses were not different in density at the $P < 0.05$ level (Table 3-7). This was probably due to the high seed count per unit weight of the roughstalk bluegrasses, and the coarseness of perennial ryegrass leaves. Perennial ryegrasses and intermediate ryegrasses were different at the $P < 0.05$ level (Table 3-7). This could possibly be explained by the coarser leaf blades that intermediate ryegrasses possess. The second year of the trial had greater average density ratings than year one. However, this variation could likely be due to the higher N rate applied during year two of the study. Specific cultivar texture performance can be referenced in Appendix B.

Texture ratings were analyzed across years because there was no cultivar by year interaction. There were differences in average texture between species at the 95% probability level (Table 3-7). Perennial ryegrass and the ryegrasses blend were not different at the $P < 0.05$ level. Intermediate ryegrasses were different from the perennial ryegrasses, and exhibited lower texture ratings than all of the other species. Intermediate ryegrasses had mean texture ratings below 6.8. The roughstalk bluegrasses in the trial exhibited the highest texture ratings averaging above 7.4, and with ‘RAM-100’ having the highest average texture rating.

Table 3-7 Mean square from combined analyses of variance for density and texture ratings of the cool-season overseed turfgrasses for 2004-2005 and 2005-2006.

| | | Mean Square | |
|---|---|---|---|
| Source of Variation | df | Density | Texture |
| Cultivar, C | 30 | 0.64** | 6.41 |
| Year, Y | 1 | 7.75** | 61.83** |
| C x Y | 30 | 0.68** | 4.80 |
| Rep, R | 2 | 8.80** | 6.04 |
| Date(Y) | 5 | 1.98** | 16.89 |
| Error | 650 | 0.52 | 2.77 |
| CV, % | | 7.37 | 38.53 |
| Mean | | 7.05 | 7.19 |
| Species, S | 3 | 1.75** | 33.13* |
| Blend vs Perennial rye, PR | 1 | 1.97** | 0.21 |
| Intermediate rye vs PR | 1 | 1.19* | 52.41** |
| PR vs Roughstalk bluegrass | 1 | 0.86 | 48.85* |

*, ** Indicates significance at 0.05 and 0.01 level, respectively.

**Visual and Digital Color Analysis**

The highest visual color ratings were the perennial ryegrasses and ryegrass blends in both years. The data was again analyzed separately due to a cultivar by year interaction for both methods of measuring color. The perennial ryegrass ‘Pick SD’ was rated higher than all of the grasses for its deep dark green color, with a color rating of 8.1 in the 2004-2005 season and 8.2 2005-2006 season (Appendix C). The roughstalk bluegrasses ‘RAM-100’, ‘Colt’, and ‘Winterplay’ exhibited the poorest color in the first year. Perennial ryegrasses ‘Charger’, ‘PR 17’, and the intermediate ryegrass ‘RAD-OS3’ also exhibited color ratings of less than 6.0. In 2005-2006 the rough bluegrasses exhibited color ratings below 6.0. Digital color evaluations for the first and second year provided different results between trial years at $P < 0.05$ (Table 3-8). This was probably due to the grasses responding to the higher N rates of the 2005-2006 growing season. ‘PickSD’,‘MTV-124’, ‘BMX 020383’, ‘Playmate’, and ‘Futura 2500’ performed the best in both years of DGCI evaluation.

Table 3-8 Mean square from combined analyses of variance for color analysis using visual ratings and digital analysis of DGCI.

| | | Mean square | |
|---|---|---|---|
| Source of Variation | df | Visual Color | DGCI |
| Cultivar, C | 30 | 28.88** | 0.0001** |
| Year, Y | 1 | 3.74** | 0.0029** |
| C x Y | 30 | 1.96** | 0.1896* |
| Rep | 2 | 0.52 | 0.0005 |
| Date(Y) | 13†, - | 4.99** | - |
| Error | 1394†,185‡ | 0.50 | 0.02 |
| CV, % | | 7.21 | 4.11 |
| Mean | | 6.87 | 0.43 |
| Species, S | 3 | 22.66** | 45.58** |
| Blend vs Perennial rye, PR | 1 | 10.55** | 4.17* |
| Intermediate rye vs PR, | 1 | 43.07** | 2.03 |
| PR vs Roughstalk bluegrass | 1 | 557.56** | 113.10** |
| Error | 1372 | 0.64 | 0.02 |
| CV, % | | 9.20 | 4.80 |

*, ** Indicates significance at 0.05 and 0.01 level, respectively.
†, ‡ values for visual color and DGCI respectively

The digital image analysis verified that the roughstalk bluegrasses had the poorest color, followed by the intermediate ryegrasses during both seasons. Specific color performance for each cultivar can be referenced in Appendix C.

**Disease Incidence**

During the 2004-2005 trial there was an outbreak of apparent dollar spot symptoms on some of the plots. Small circular, sunken, straw colored patches were observed. The roughstalk bluegrasses ‘RAM-100’, ‘WinterPlay’, ‘Colt’, and the perennial ryegrass ‘PR 17’ had the highest incidence of spots averaging at least 24 dollar spot centers for each of these entries. These cultivars had much greater dollar spot incidence than the rest of the cultivars in the study at the 95% probability level. There were no disease symptoms during the 2005-2006 trial as indicated by the years being different in Table 3-9. This was probably due to the dry year and higher N fertility.

Table 3-9 Mean square from analysis of variance for dollar spot centers during 2004-2005 growing season.

| Source of Variation | df | Mean Square Dollar Spot Centers |
|---|---|---|
| Cultivar, C | 30 | 1724.41** |
| Date (Year), D (Y) | 1 | 939.38 |
| Rep | 2 | 64.65 |
| C x D (Y) | 30 | 1044.10* |
| Error | 185 | 523.58 |
| CV, % | | 277.71 |
| Mean | | 8.24 |

*, ** Indicates significance at 0.05 and 0.01 level, respectively.

**Shear Strength**

*In situ* shear strength data indicated that there was no difference among entries or years (Table 3-10). This was most likely due to the late season April testing of the shear strength in the 2004-2005 season, as the bermudagrass had already started rooting.

Table 3-10 Mean square from analysis of variance for *in situ* shear strength (kg force) for both years.

| | | Mean square |
|---|---|---|
| Source of Variation | df | Shear Value |
| Cultivar, C | 30 | 230.80 |
| Rep | 2 | 509.63 |
| Year, Y | 1 | 294.39 |
| C x Y | 30 | 201.58 |
| Error | 185 | 0.64 |
| CV, % | | 18.28 |
| Mean | | 76.74 |

* Indicates significance at $P \geq 0.05$

## Conclusions

This study further indicated that perennial ryegrass and ryegrass blends provide quick establishment, better coverage, and higher quality turf than roughstalk bluegrass. Perennial ryegrass entries and blends provided the highest coverage and quality ratings during the transition period further illustrating the persistent nature of perennial ryegrasses to heat stress during transition. Intermediate ryegrasses provided less coverage than perennial ryegrasses during the transition period, yet maintained high overall plot quality. The intermediate ryegrasses transitioned faster allowing greater bermudagrass densities during the spring transition period, indicating that it may be the most appropriate choice for turfgrass managers who wish to maintain good quality and provide less competition for the underlying bermudagrass. Roughstalk bluegrasses are much slower to germinate and often took most of the season to establish. The roughstalk bluegrasses had low percent coverage and the poorest quality ratings during the spring reaffirming that the species may not be an appropriate choice for use as a stand-alone species for overseeding fairways. Both methods for evaluating color indicated that perennial ryegrass had the darkest green color followed by intermediate ryegrass and roughstalk bluegrass, respectively. With the many different qualities that overseeding

0species possess, turfgrass managers should take great care to seek out un-biased evaluations of seed cultivars to make the most appropriate selection for their particular needs.

Turfgrass managers must also be aware of variability within species. The perennial ryegrasses and ryegrass blends varied among cultivars within species with respect to establishment, color, quality, density, and cover. There is less variability among cultivars within the roughstalk bluegrass species. The variation within species is less than that observed between species, but it can influence the success of transition.

# CHAPTER 4
# AN EVALUATION OF THREE MODELS TO PREDICT TURFGRASS OVERSEED TRANSITION

## Introduction

Turfgrass managers who overseed are well aware of the influence weather can have on the success or failure of overseeding and transition programs (Gelernter and Stowell, 2005). Weather, especially temperature, is always the driving force when it comes to the success of overseeding and spring transition. If cool-season grasses transition too quickly the warm-season grasses may be weak and unsightly. However, if the cool-season grasses persist, they compete with the warm-season grasses for light, water, and nutrition that are needed for spring green-up (Gelernter and Stowell, 2005). When cool-season grasses are left to transition naturally, the bermudagrass growing season can be limited to less than nine weeks (Howard, 2006). Periods of less than 16 weeks for bermudagrass to recuperate and repair from overseeding are not adequate (Howard, 2006). Thus, over multiple shortened growing seasons bermudagrass will not endure (Howard, 2006). Turfgrass managers are continuously seeking ways to better understand climate and its effect on overseeding, spring transition, and bermudagrass health.

A mathematical model can be used to better understand the spring transition. Mathematical models have been used to comprehend many aspects of turfgrass culture. Models have been developed to help turfgrass managers develop pesticide spray schedules for insects (Tolley and Robinson, 1986), diseases (Danneberger, 1983; Danneberger and Vargas, 1984), weeds (Throssell et al., 1987), and timing of plant growth regulator applications (Danneberger et al., 1987; Branham and Danneberger, 1989). However, few models have been developed to better explain spring transition. The cumulative percent growth potential model mathematically explains the overseeding process and spring transition (Gelernter and Stowell, 2005). The growth potential model compares observed temperatures with optimum temperatures for growth of warm and cool season grasses to predict the potential growth over a season (Gelernter and Stowell, 2005). Another model is a percent ryegrass disappearance model (Horgan and Yelverton, 2001). Horgan and Yelverton (2001) found that a linear regression can be used to better understand the relationship between temperature and relative humidity in the disappearance of ryegrass during spring transition. The object of this study was to evaluate spring transition data using these known models and modeling techniques.

## Materials and Methods

### Turf and Weather Data Sets

Percent coverage and ryegrass disappearance data were obtained from four growing seasons for overseed evaluation trials and National Turfgrass Evaluation Program (NTEP) on-site fairway overseed evaluations completed in Gainesville, FL from 2002 to 2004 and from 2004 to 2006, respectively. The trials evaluated up to five species of cool season grasses to be commercially marketed as overseed for bermudagrass sports turf. The only data used from these trials were the percent coverage data. Cool-season grass disappearance was calculated from this data. Weather data was mined from the Florida Automated Weather Network (FAWN) weather station in Citra, FL. The data mined included average daily soil temperatures and average daily air temperatures. The soil temperatures were measured 10 cm below the soil surface and air temperatures were measured 60 cm above the soil surface (FAWN, 2006). The daily averages were used to generate average weekly and average monthly temperatures. These data were used to evaluate the three models for predicting spring transition.

**Florida Turfgrass Transition Model**

A transition model was developed using NTEP on-site evaluation coverage data from consecutive overseeding trials (2004-2005 and 2005-2006). The variables, average weekly air temperature, average weekly soil temperature, and days after seeding (DAS), were evaluated using multivariate analysis proc STEPWISE (SAS Institute, 1999) to determine which variables were most appropriate for use in the model.

**Cumulative Growth Potential and Ryegrass Disappearance Models**

The two models used for comparison were previously published models that describe overseed performance and spring transition. The cumulative growth potential (CGP) model has been extensively used by the Pace Turfgrass Research Institute of San Diego, CA (Gelernter and Stowell, 2005). The CGP growth potential model was used to calculate the growth potential of warm and cool-season grasses using the following equation and average monthly soil temperature data for each of the four years:

$$\mathrm{GP} = 100\left[\frac{1}{e^{\left[\frac{1}{2}\left[\frac{(\mathrm{obsT}-\mathrm{optT})}{\mathrm{sd}}\right]^2\right]}}\right] \qquad \text{[eq. 1]}$$

Where GP = growth potential; obsT = observed temperature (C); optT = optimal temperature (31.1°C for warm-season turf and 20°C for cool-season turf); sd = standard deviation of the distribution (sd warm-season turf = 12; and sd cool-season turf = 10), and e = natural logarithm base (Gelernter and Stowell, 2005). In this study, average monthly coverage data, for the two consecutive years of the NTEP trials, were compared with the growth potential curves calculated for each year to determine the appropriateness of the CGP model for overseed performance and transition using SigmaPlot (SPSS Inc., 2002).

The ryegrass disappearance (RD) model was postulated to describe the transition of ryegrass in Raleigh, NC (Horgan and Yelverton, 2001):

RD = -37.01+3.41(airT) [eq. 2]

Where RD = ryegrass disappearance and airT = air temperature (C) (Horgan and Yelverton, 2001). The $r^2$ value for the goodness of fit about the Horgan and Yelverton (2001) data was 0.51. In this study, the actual ryegrass disappearance data that was previously calculated from the four years of cover data were subjected to the RD model equation and the relative fit of the RD model was determined using SigmaPlot (SPSS Inc., Chicago, IL). Linear regression was used to determine a Florida Ryegrass Disappearance (FRD) model based on weekly air temperature and the Florida coverage data from 2002-2006. The FRD model was then subjected to each of the individual growing seasons to determine the fit of the model using SigmaPlot (SPSS Inc., Chicago, IL).

## Results and Discussion

### Soil Temperature and Days After Seeding Variables

The hypothesis was that overseed coverage and transition performance could best be modeled using soil temperature and the amount of time after seeding. The multi-variate analysis determined that soil temperature and days after seeding provided the highest correlation for a two-variable model. The analysis of variance provided an $R^2$ value of 0.54, the highest for the two variable models. The equation of the model for dependent variable cover with soil temperature and days after seeding as the independent variables was:

$$OC = 134.46 + 0.16(DAS) - 04.74(soilT)^2 \qquad \text{[eq. 3]}$$

Where OC = overseed cover; DAS = days after seeding; and soilT = average weekly soil temperature. The $R^2$ value of the analysis indicates that 54% of the variability of OC can be accounted for by the variability in DAS and soilT. Therefore, the model does predict OC, but not very well. This indicates that more research is needed to determine what variables are most attributable to OC. Further research should possibly focus on temperature stress, relative humidity, disease stress, shading, solar radiation, moisture, and environmental stresses (e.g. traffic and divoting) to determine a model with a higher probability for predicting OC and spring transition.

**Growth Potential Model**

Graphical comparison of the growth potential, calculated using the CGP model (Gelernter and Stowell, 2005), and actual percent coverage showed that the actual cover for warm and cool-season grasses were less that the percent growth potential (Figure 4-1). The growth potential portrays a visually accurate slope of establishment and dormancy of cool-season and warm-season grasses, respectively (Figure 4-1), indicating that the time for establishment could be achieved as reported by Gelernter and Stowell (2005). During periods of establishment and dormancy, the CGP model showed fluctuation in the percent growth potential based on temperature that is not reflected in the actual cover (Figure 4-1). While these fluctuations due to temperature cannot be accounted for in the average monthly cover data, they may enable turfgrass managers to determine when established stands of cool-season turf may be experiencing stress. However, additional research would be needed to determine if these fluctuations could indicate plant stress. The actual percent cover data lags behind the disappearance of ryegrass and the re-emergence of warm-season grass from dormancy (Figure 4-1). This may make it difficult for turfgrass managers to precisely identify when to spray a herbicide to hasten the spring transition process. However, as reported by Gelernter and Stowell (2005) the CGP model is a valuable aid in determining when there may be a need to spray a transition hastening herbicide so warm-season grasses have adequate time, 16 weeks (Howard, 2006), to recuperate after the spring transition based on visual comparison of CGP and actual cover data (Figure 4-1).

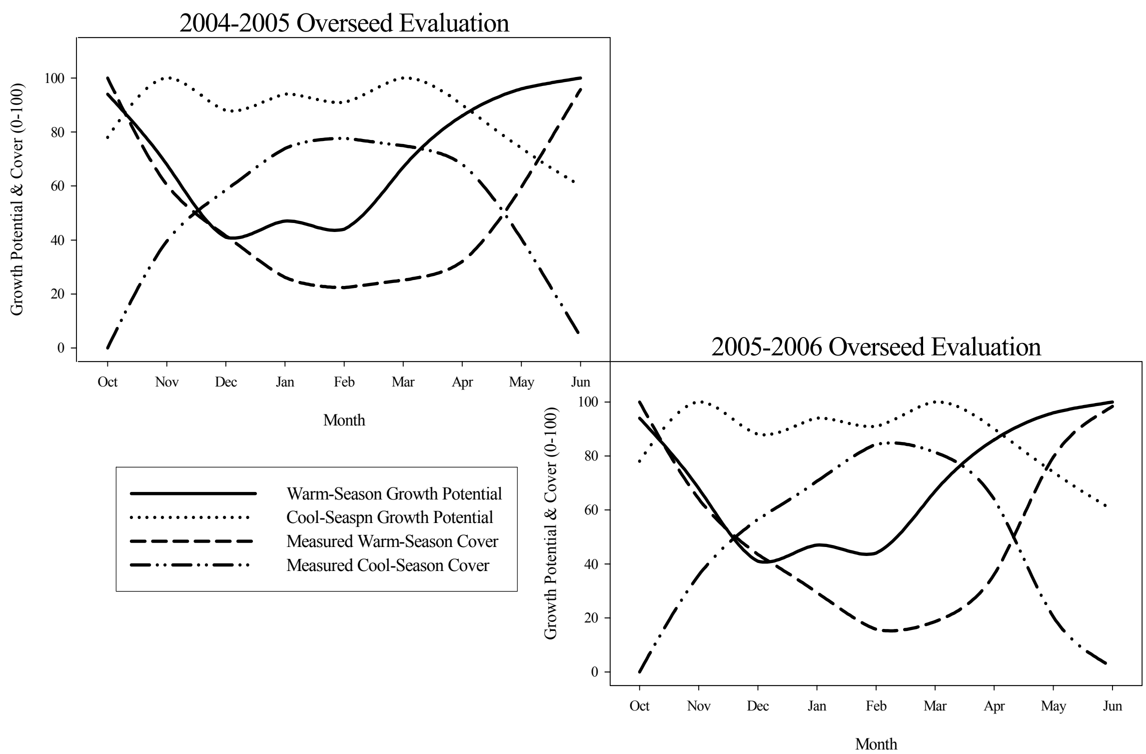


Figure 4-1. Graphical comparison of Percent Growth Potential (Gelernter and Stowell, 2005) and actual percent cover data from two years of overseed evaluation trials.

**Ryegrass Disappearance**

The regression line that Horgan and Yelverton (2001) proposed for ryegrass disappearance did fit the data for each of the four years of overseed trials (Table 4-1).

Table 4-1 Comparison of $r^2$ values for Ryegrass Disappearance (RD) Model (Horgan and Yelverton, 2001) and the Florida Ryegrass Disappearance Model (FRD) for 2002-2006 overseeding coverage for Gainesville, FL.

| | $r^2$ Value | |
|---|---|---|
| Overseed Coverage | RD Model | FRD |
| 2002-2003 Cover Data | 0.53* | 0.54 |
| 2003-2004 Cover Data | 0.41* | 0.78 |
| 2004-2005 Cover Data | 0.31* | 0.59 |
| 2005-2006 Cover Data | 0.18* | 0.66 |
| 2002-2006 Cover Data | 0.34* | 0.59 |

* Indicates significance of RD Model (Horgan and Yelverton, 2001) at $P < 0.05$

However, when compared to the Florida Ryegrass Disappearance Model (FRD) determined through linear regression of each of the four years of data, the Horgan and Yelverton RD model had less slope and lower $r^2$ values for the coverage data (Figure 4-2). The same results were found when the Horgan and Yelverton (2001) model was fit to all transition data from the growing seasons of 2002-2006 (Figure 4-3). This could possibly be explained by higher relative humidity in Florida and most importantly more rapid rate of temperature increase in the spring in Gainesville, FL than in Raleigh, NC. The equation for the Florida Ryegrass Disappearance may more appropriately be:

$$FRD = -96.66 + 6.61(airT) \qquad \text{[eq. 4]}$$

Where FRD = ryegrass disappearance (0-100%); airT = air temperature (C). This model allows for a more appropriate fit, $r^2 = 0.59$, in Gainesville, FL with its rapidly increasing temperatures during the spring and early summer.

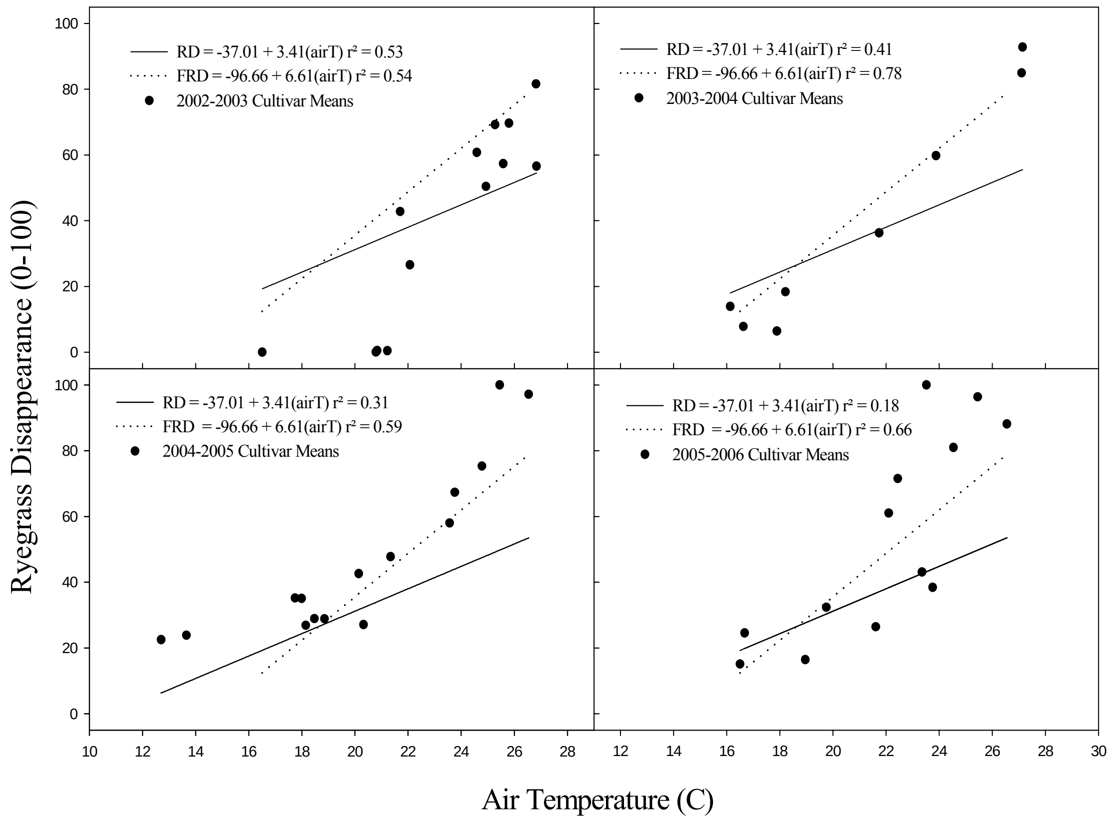


Figure 4-2 Graphical comparison of Ryegrass Disappearance (RD) Model (Horgan and Yelverton, 2001) and Florida Ryegrass Disappearance (FRD) Model for average cover data from four consecutive years of overseed trials.

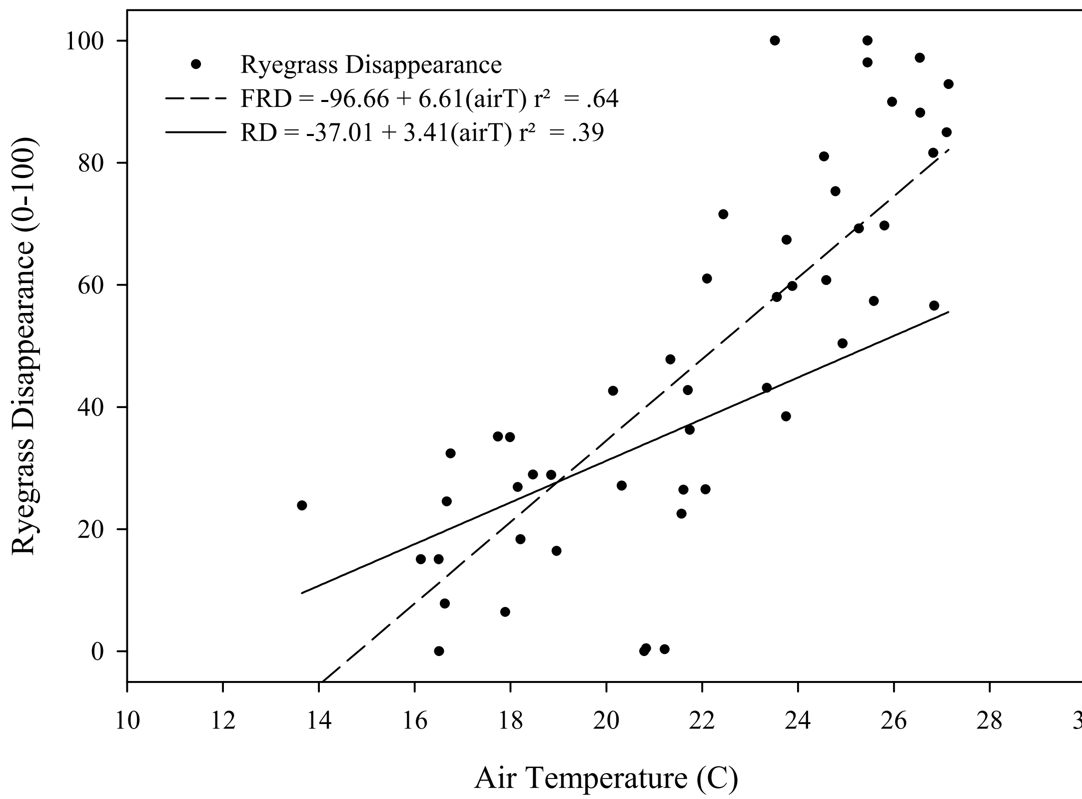


Figure 4-3 Comparison of RD model (Horgan and Yelverton, 2001) and Florida Ryegrass Disappearance Model (FRD) for average cover data from four growing seasons (2002-2006).

**Conclusions**

Modeling of overseed and transition can be provided via many methods and can serve as valuable aids to turfgrass managers. A model for overseed coverage was determined through multi-variate analysis with average weekly soil temperature and days after seeded. The model was:

$$OC = 134.46 + 0.16(DAS) - 04.74(soilT)^2 \qquad \text{[eq. 3]}$$

Where OC = percent overseed coverage; DAS = days after seeding; and soilT = average weekly soil temperature. Based on the predictive capacity ($R^2$), this model is similar to the one reported by Horgan and Yelverton (2001), but accounts for overseed coverage based on soil temperature and days after seeding. Further research should be conducted to ascertain a model with higher predictive probabilities.

Based upon visual estimation, the CGP model can be a valuable aid to turfgrass managers for predicting when to seed, when establishment will occur, and if there is a need to chemically transition (Gelernter and Stowell, 2005). However, it may prove difficult to determine an exact date to spray a transition aid based on the growth potential of the warm-season and cool-season grasses.

The FRD model that was created using the 2002-2006 coverage data fit each of the individual years better than the Horgan and Yelverton (2001) RD model. The FRD model provides a better account of Florida ryegrass disappearance. The FRD model is as follows:

$$FRD = -96.66 + 6.61(airT) \qquad [eq. 4]$$

Where FRD = ryegrass disappearance (0-100%); airT = air temperature (C).

These models can be used as an aid for turfgrass managers. However, because it is difficult to accurately model all of the aspects of overseed performance and transition over a wide area such as the southern United States, more research needs to be conducted on the most appropriate models and model inputs, so an even better understanding of overseeding culture can be obtained.

# CHAPTER 5
# SUMMARY AND CONCLUSIONS

University overseeding trial evaluations can result in valuable, unbiased overseed cultivar performance evaluation, thus, providing turfgrass managers with a wealth of knowledge when choosing a species or cultivar for overseeding.

Turfgrass managers must be familiar with their particular needs when selecting a species or cultivar for overseeding. Knowing how a species or cultivar will perform under regional conditions can enable a turf manager to select the appropriate cultivar allowing for a successful overseeded winter period. An evaluation of 31 National Turfgrass Evaluation Program (NTEP) solicited grasses for overseeding fairways was discussed in Chapter Three. The following results were obtained:

- Perennial ryegrass and ryegrass blends are quicker to establish, provide better coverage, and higher quality turf stands than roughstalk bluegrass. Perennial ryegrasses have a darker green color than intermediate ryegrasses and roughstalk bluegrasses.

- Intermediate ryegrass transitions quicker than perennial ryegrass, perennial ryegrass blends, and roughstalk bluegrass allowing for greater bermudagrass densities in early spring. Intermediate ryegrass maintains higher quality than roughstalk bluegrasses and similar quality to perennial ryegrass during the spring transition.

- Roughstalk bluegrass is slow to establish, has less coverage than perennial ryegrass, and provides a lower quality turfgrass than perennial ryegrass under golf course fairway conditions

- Top performing cultivars for establishment were the perennial ryegrasses: ‘OSC108’, ‘OSC110’, ‘PickSD’, ‘Flash II’, and ‘Charger’; and the perennial ryegrass blends: ‘ProSelect’, ‘Magnum Gold’, and ‘Champion GQ’.

- Top performing cultivars for density were the perennial ryegrasses: ‘Flash II’ and ‘Magnum Gold’; and the roughstalk bluegrass ‘RAM-100’.

- The cultivar ‘PickSD’ had the darkest green color.

There are few models available to help predict overseed performance and transition. Existing models for overseed performance and spring transition can provide valuable knowledge to turfgrass managers about some aspects of overseeding culture. These include establishment prediction, need for chemical aid for transition to bermudagrass, and regional ryegrass disappearance. Evaluation of two existing models and known modeling techniques were used to better understand overseed performance and spring transition in Chapter Four. The following results were obtained:

- A model for overseed coverage based on the independent variables average weekly soil temperature and days after seeding was determined through multivariate analysis. The model is $OC = 134.46 + 0.16(DAS) – 04.74(soilT)^2$.

- The Cumulative Growth Potential model (Gelernter and Stowell, 2005) can be a valuable tool for turfgrass managers for understanding the role of temperature in overseeding practices.

- The Ryegrass Disappearance model (Horgan and Yelverton, 2001) is not appropriate for Gainesville, FL due to its rapidly increasing temperatures during the transition period. A ryegrass disappearance model equivalent to Horgan and Yelverton’s (2001) Ryegrass Disappearance model was successfully developed for Gainesville, FL. The model is $FRD = -96.66 + 6.61(airT)$.

# APPENDIX A
# 2004-2006 ON-SITE TESTING GRASSES, SPECIES, AND COMPOSITION

Table A-1 On-Site testing grasses, species, and composition

| Entry | Name | Species or Composition |
|---|---|---|
| 1 | Charger | Perennial ryegrass |
| 2 | Winterplay | Roughstalk bluegrass |
| 3 | ProSelect | 40% Jet, 40% Sonata, 20% Integra P. ryegrass blend |
| 4 | Marvel Green Supreme | 40% Palmer IV, 40% Prelude IV, 20% Sunkissed P. ryegrass blend |
| 5 | ALS2 | Perennial ryegrass |
| 6 | PRS2 | Perennial ryegrass |
| 7 | Overseeding Eagle Blend | 33% Greenville, 33% ProSport, 34% Pacesetter P. ryegrass blend |
| 8 | Futura 2500 | 30% Blazer 4 P. ryegrass, 30% Sunshine P. ryegrass, 40% Pick Lh A-00 Intermediate ryegrass |
| 9 | Pick SD | Perennial ryegrass |
| 10 | Playmate | 50% Headstart 2, 50% Pick HS-01-09 P. ryegrass blend |
| 11 | BMX 020383 | Perennial ryegrass |
| 12 | RAD-OS3 | Intermediate ryegrass |
| 13 | RAM-100 | Roughstalk bluegrass |
| 14 | IS-OS | Perennial ryegrass |
| 15 | Top Hat | Perennial ryegrass |
| 16 | IS-IR3 | Intermediate ryegrass |
| 17 | Champion GQ | 34% SR 4550, 33% SR 4420, 33% SR 4220 P. ryegrass blend |
| 18 | Magnum Gold | 34% Peregrine, 33% Hawkeye, 33% Penguin P. ryegrass blend |
| 19 | Flash II | Perennial ryegrass |
| 20 | MTV-124 | Perennial ryegrass |
| 21 | OS | Perennial ryegrass |
| 22 | STP | Perennial ryegrass |
| 23 | PR 17 | Perennial ryegrass |
| 24 | Starlite | Roughstalk bluegrass |
| 25 | CRR | Perennial ryegrass |
| 26 | League Master | 40% Ringer, 20% Omega 2, 20% 04-BRE, 20% 04-BEN P. ryegrass blend |
| 27 | OSC110 | Perennial ryegrass |
| 28 | OSC108 | Perennial ryegrass |
| 29 | Covet | Perennial ryegrass |
| 30 | OSC116 | Perennial ryegrass |
| 31 | Colt | Roughstalk bluegrass |

APPENDIX B
DENSITY RATINGS FOR 2004-2005 AND 2005-2006 GROWING SEASONS

Table B-1 Density ratings for 2004-2005 and 2005-2006 growing seasons.

| | Density Rating* | |
|---|---|---|
| Cultivar | 2004-2005 | 2005-2006 |
| Magnum Gold | 7.4 a | 7.3 abc |
| Flash II | 7.3 ab | 7.4 a |
| Playmate | 7.3 ab | 7.3 abc |
| Champion GQ | 7.3 ab | 6.9 dc |
| MTV-124 | 7.2 abc | 7.0 bcd |
| Overseeding Eagle Blend | 7.2 abc | 7.1 abcd |
| PickSD | 7.2 abc | 7.2 abc |
| OSC110 | 7.1 abcd | 7.3 abc |
| BMX 020383 | 7.1 abcd | 7.1 abcd |
| League Master | 7.0 abcd | 7.2 abc |
| ProSelect | 7.0 abcd | 7.3 ab |
| Marvelgreen Supreme | 7.0 abcd | 7.1 abcd |
| Charger | 7.0 abcd | 7.3 abc |
| IS-OS | 7.0 abcd | 7.1 abcd |
| RAM-100 | 6.9 abcd | 7.4 a |
| Futura 2500 | 6.9 abcd | 7.3 abc |
| ALS2 | 6.9 abcd | 7.0 bcd |
| Top Hat | 6.9 abcd | 7.2 abc |
| Covet | 6.9 abcd | 7.3 abc |
| OS-IR3 | 6.9 abcd | 7.1 abcd |
| Starlite | 6.9 abcd | 7.1 abcd |
| OSC108 | 6.8 abcd | 7.1 abcd |
| PRS2 | 6.8 bcd | 7.1 abcd |
| CRR | 6.8 bcd | 7.2 abc |
| Winterplay | 6.8 bcd | 7.2 abc |
| OSC116 | 6.7 dc | 7.1 abcd |
| RAD-OS3 | 6.7 dc | 6.8 d |
| STP | 6.7 dc | 7.2 abc |
| OS | 6.7 dc | 7.1 abcd |
| PR 17 | 6.6 d | 6.9 dc |
| Colt | 5.7 e | 7.4 a |

*Means followed by the same letter are not significantly different at the 0.05 level.

APPENDIX C
CULTIVAR VISUAL AND DGCI COLOR MEANS

Table C-1 Visual and DGCI color ratings for both growing seasons.

| | Visual Color* | | DGCI Color* | |
|---|---|---|---|---|
| Cultivar | 2004-2005 | 2005-2006 | 2004-2005 | 2005-2006 |
| PickSD | 8.1 a | 8.2 a | 0.42 ab | 0.51 a |
| MTV-124 | 7.8 ab | 7.8 b | 0.43 a | 0.49 abc |
| Playmate | 7.7 ab | 7.7 b | 0.41 bcde | 0.49 abc |
| Champion GQ | 7.7 ab | 7.3 cdef | 0.41 bcd | 0.49 abc |
| Marvelgreen Supreme | 7.6 bc | 7.3 cde | 0.42 abc | 0.48 abcd |
| Flash II | 7.4 bcd | 7.4 cd | 0.40 efghij | 0.47 bcdef |
| Magnum Gold | 7.4 bcde | 7.1 efgh | 0.41 bcdefg | 0.47 bcde |
| OSC116 | 7.4 bcde | 7.3 cdefg | 0.39 ghij | 0.48 bcd |
| BMX 020383 | 7.3 cdef | 7.5 c | 0.41 bcd | 0.49 ab |
| Futura 2500 | 7.3 cdef | 7.3 cdef | 0.41 bcdef | 0.49 abc |
| ProSelect | 7.2 cdefg | 7.2 defgh | 0.40 defghi | 0.47 bcde |
| Overseeding Eagle Blend | 7.2 cdefg | 7.2 defg | 0.40 defghi | 0.45 defg |
| ALS2 | 7.1 defgh | 7.3 cdef | 0.40 defghi | 0.46 cdef |
| OSC108 | 7.1 defgh | 7.1 fgh | 0.40 defghi | 0.46 bcdef |
| PRS2 | 7.1 defgh | 7.2 defgh | 0.40 bcdefgh | 0.47 bcde |
| CRR | 7.0 efgh | 7.2 defg | 0.40 defghi | 0.48 bcd |
| League Master | 7.0 efgh | 7.0 gh | 0.40 defghi | 0.46 bcdef |
| Covet | 7.0 efgh | 7.1 fgh | 0.39 hij | 0.47 bcd |
| STP | 7.0 efgh | 7.1 efgh | 0.39 fghij | 0.47 bcde |
| OSC110 | 7.0 fgh | 7.1 fgh | 0.40 defghi | 0.47 bcde |
| OS | 6.9 fghi | 7.2 defg | 0.40 defghi | 0.46 bcdef |
| IS-OS | 6.8 ghij | 7.0 hi | 0.40 bcdefghi | 0.44 efg |
| Top Hat | 6.7 hij | 6.6 jk | 0.40 fghij | 0.43 gh |
| Starlite | 6.5 ij | 5.3 m | 0.39 defghij | 0.43 gh |
| OS-IR3 | 6.4 j | 6.7 ij | 0.40 bcdefghi | 0.45 defg |
| RAD-OS3 | 6.0 k | 6.3 l | 0.39 ij | 0.45defg |
| Charger | 5.9 k | 6.4 kl | 0.40 cdefghi | 0.44 fg |
| PR 17 | 5.9 k | 7.3 cde | 0.39 jk | 0.47 bcdef |
| RAM-100 | 5.1 l | 5.2 mn | 0.35 l | 0.39 i |
| Winterplay | 4.7 l | 5.2 mn | 0.35 l | 0.40 hi |
| Colt | 4.1 m | 5.0 n | 0.37 kl | 0.38 i |

*Means followed by the same letter are not significantly different at the 0.05 level.

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Asa Joel High grew up in Bradenton, Florida. He graduated from Manatee High School in 2000, and enrolled at the University of Florida. After graduating from U.F. with a B.S. in agricultural operations management in 2004, he began working at Haile Plantation Golf and Country Club in Gainesville. After his summer on the golf course he returned to U.F. to pursue a Master of Science in turfgrass science. Upon graduating in July of 2006, Asa will be interning at the Augusta National Golf Club in Augusta, Georgia, so that he may pursue a career as a golf course superintendent.