James B. Beard

PROCEEDINGS OF THE 25TH ANNUAL NORTH CAROLINA TURFGRASS CONFERENCE

Volume VIII

January 7-9, 1987

Winston-Salem, N. C.

Sponsored by

Turfgrass Council of North Carolina

North Carolina State University

North Carolina Agricultural Extension Service

PREFACE

Proceedings of the 25th Annual North Carolina Turfgrass Conference are being provided as a permanent reference to those who attended the conference. The 1987 conference was held at the Benton Convention Center in Winston-Salem, NC, on January 7, 8 and 9. Sessions with general turf topics and concurrent sessions for golf course, lawn care, roadside and low maintenance turf, landscape maintenance, sod, and athletic field topics were scheduled. Workshops on Establishment and Maintenance of Lawns, Turfgrass Diseases, Soil Drainage, and Soil Properties and Testing were held in the afternoon of January 7. The trade show used 40,000 square feet of space. Approximately 1100 people attended the conference.

Special thanks are extended to everyone who helped make this conference successful. Each speaker is to be commended for his excellent presentation and for providing a written summary for the proceedings. The Annual Turfgrass Conference was sponsored by the Turfgrass Council of North Carolina, Inc., North Carolina State University, the North Carolina Agricultural Extension Service and the Piedmont Turfgrass Association. The following committee members contributed to the success of the conference.

CONFERENCE CHAIRMAN - Art Bruneau

PROGRAM COMMITTEE - Leon Lucas, Chairman

Fred Biggers	Art Bruneau	Jack Cox
Joe DiPaola	Bill Johnson	Charles Tomlinson
Fred Miller	Kim Powell	Gary Randolph
Charles Fierke	George Thompson	Bob Tumey

ADVERTISEMENTS AND NEWSLETTER - Art Bruneau

TRADE SHOW COMMITTEE - Bill Riggan, Chairman

Larry Baker	Gary Stafford	Jim Welch
Ed Ancherico	Gary Randolph	R. L. Robertson
Bob Bell		

LOCAL ARRANGEMENTS COMMITTEE - Gene Crews, Chairman

Chuck Dolge	Pat Dolge	Sam Linker
Mark Vaughn	Gary Stafford	Sharon Stafford

PROCEEDINGS EDITORS: L. T. Lucas and A. H. Bruneau, Extension Plant Pathology Specialist - Turf and Extension Crop Science Specialist - Turf, respectively, N. C. State University, Raleigh, N. C., 27695.

Printed in October, 1987

The 1988 North Carolina Turfgrass Conference will be held in Winston-Salem, N. C., on January 6, 7 and 8.

Additional copies of the proceedings are available at $5.00 each from Dr. L. T. Lucas, Department of Plant Pathology, NCSU, Box 7616, Raleigh, N. C. 27695-7616. Make checks payable to The Turfgrass Council of North Carolina.

TABLE OF CONTENTS

PAGE

WATER MANAGEMENT FOR TURFGRASS DROUGHT TOLERANCE

Robert C. Shearman
Department of Horticulture
University of Nebraska
Lincoln, NE 68583-0724

Recent water shortages which occurred in the southeast and the continuing shortages in the arid west have fueled renewed interest in selection of drought resistant turfgrasses and use of cultural practice systems that enhance turfgrass drought avoidance. This interest has stimulated the turfgrass industry and scientific communities to work together to find improved approaches to managing turfs under drought stress.

To manage water for turfgrass drought tolerance, it is important to understand that tolerance is only one of the components involved in turfgrass drought resistance. Turfgrass drought resistance involves drought escape, drought avoidance, and drought tolerance. These components may act alone or in combination to give the plant its ability to withstand drought stress.

Drought Escape. Annual-biotypes of Poa annua are capable of resisting drought through the escape mechanism. These plants germinate, grow, flower, and set viable seed before soil moisture is depleted. Poa annua has a high water use rate when actively growing, but since it completes its life cycle quickly it resists drought stress by escaping it. Escape is not a desirable mechanism for maintenance of turfgrass quality and function. As the annual plants complete their life cycles, their death results in voids that disrupt turfgrass quality and use.

Drought Avoidance. Turfgrasses can resist drought stress through avoidance mechanisms. Drought avoidant turfgrasses are capable of continuing growth and development even though drought stress conditions exist. Mechanisms such as reduced evapotranspiratin, deep root systems, high root/shoot ratios, ability to redistribute roots, reduced radiation absorption, and xeromorphic structures enable the plant to avoid wilt and continue growth. Radiation absorption can be reduced by steepness of the leaf blade angle, lighter color, and leaf hairs. Xeromorphic structures include leaf rolling, wax layers, leaf hairs, and stomatal characteristics.

Turfgrass managers can easily recognize that cultural practices, like mowing, fertilizing, watering, and soil cultivating influence drought avoidance through direct and indirect effects on turfgrass water use and rooting. The role of cultural practices in drought avoidance will be discussed in detail in this article.

Drought Tolerance. Turfgrass plants exhibiting drought tolerance are capable of withstanding low tissue water content for extended periods. Plants may obtain tolerance by maintaining turgor at low water potentials or by surviving severe cell protoplasm desiccation. From a practical standpoint, drought tolerance is a long term exposure and survival mechanism. In many turfgrass situations, tolerance may play a less important role than drought avoidance.

Turfgrasses are often in a position to receive some water either through irrigation or natural precipitation. In these cases drought avoidance mechanisms allow the plants to go longer periods between receiving or requiring additional water. Drought tolerance may not be needed in these situations since the drought stress exposure is not extended. If drought stress is extended (i.e. more than 30 days), drought tolerance mechanisms may be required simply to have turf survival. The most ideal situation would be to use plants and cultural practices that enhance drought avoidance and tolerance.

Reduced Evapotranspiration. Turfgrass water use combines the water lost from the plant and soil through transpiration and evaporation with that required for growth. Only a small portion of the water used is required by the turfgrass plant for growth. Therefore, water use rate is essentially equal to evapotranspiration (ET). ET varies with turfgrass species and cultivar (Tables 1 and 2). In Nebraska studies, Kentucky bluegrass consistently had higher ET rates than the fine-leaved fescues or perennial ryegrass. However, within Kentucky bluegrass, there was a wide variation in ET among cultivars. The variation among cultivars was as wide as that observed between species. This variation means that the opportunity exists for selecting and developing low ET cultivars. Similar trends are apparent within tall fescues with several of the turf-type cultivars having lower ET rates than the forage types.

Turfgrasses with low ET rates tend to be dense, low-growing types with slow vertical extension rates, while those with high ET rates form open stands with upright and rapid vertical growth. Under irrigated conditions, these ET differences are attributed to canopy resistance mechanisms which form natural barriers to water vapor movement in and around the turfgrass canopy. The dense, low-growing stand and reduced vertical extension rate can be manipulated by turfgrass species selection and use of proper cultural practices, such as manipulation of mowing height and frequency. Under well-watered conditions, ET decreases with lower mowing heights and increased mowing frequency.

Turfgrass ET increases with increasing nutrition, particularly as rates exceed the nutritional needs of the plant. ET is higher in potassium-deficient turfs than those receiving adequate potassium. In studies at Nebraska, wilting tendency of Flyking Kentucky bluegrass declined with increasing potassium nutrition ranging from 0 to 8 lbs/1000 sq.ft./growing season, even though soil tests indicated potassium levels were high.

Rooting Responses. Low ET may not be sufficient for a turfgrass to avoid drought stress. The ability to effectively obtain soil moisture is also quite important. Turfgrasses with deep, extensive root systems can draw upon a large volume of soil for water and nutrients. Tall fescue and bermudagrass are excellent examples of grasses with deep, extensive root systems. Tall fescue ranks very high in depth and extent of rooting compared to other cool season turfgrasses (Table 1). Tall fescue is also very drought avoidant, ranking high among warm and cool season species. Turfgrass cultivars differ in depth and extent of rooting (Tables 2 and 3). Some cultivars of Kentucky bluegrass show an ability to redistribute their roots deep in the soil profile, while others tend to concentrate their root development near the sol surface. Touchdown Kentucky bluegrass had 27% of its total root growth located in the subsoil moisture, while Aspen Kentucky bluegrass had only 10% in a drought resistance study conducted in Nebraska. Turfgrasses with deep, extensive root systems and low ET rates are more suited to avoid drought stress than those species with high ET rates and shallow root systems concentrated near the soil surface.

Cultural practices influence the depth, extent, and viability of turfgrass rooting. Rooting depth decreases with reduced mowing heights. Excessive nitrogen fertilization decreases root growth and enhances top growth. Mowing and nutrition are interactive. Low mowing and excessive nitrogen fertilization decrease depth and extent of rooting more than either practiced alone. This situation is true for other cultural practices as well. Turfs receiving light frequent irrigation develop more shallow root systems than those receiving infrequent irrigation. Potassium nutrition increases rooting depth. In a study conducted with Seaside creeping bentgrass, rooting depth and distribution was greater in turfs receiving high potassium and infrequent irrigation. The former turfs had better drought avoidance than the latter, since the deeper root system and reduced ET associated with the high potassium fertilization rate and the infrequent irrigation helped the plants avoid wilt symptoms.

Drought Management. Turfgrass managers must be aware of the potential interaction of cultural practices and turfgrass selection to best manage turfs for drought resistance. Since most turfs receive some irrigation or are grown in areas where rainfall supplements their water needs, drought avoidance enhancement makes sense as an area of concentration to reduce turfgrass water consumption and maintain desired quality and function. In these areas, turfgrass managers should select grasses that form dense, low growing canopies with slow vertical extension rates. These characteristics should be coupled with the ability to develop a deep, extensive root system capable of redistribution during periods of sol moisture depletion. Turfgrass managers need to manipulate cultural practices to enhance the drought avoidance characteristics of the turfgrass species and cultivars selected. For example, mowing high and frequently maintains a deeper root system and a tighter canopy than simply mowing high and infrequently. Turfs with deep root systems and dense turf canopies are generally more drought avoidant.

Our understanding of turfgrass drought resistance is growing. More researchers are emphasizing this subject in their research programs. The United States Golf Association and the Golf Course Superintendents Association of America are jointly sponsoring research projects oriented toward reduction of water and energy consumption by turfs. This research emphasis and support is generating more information for recommendations relating to turfgrass management during drought stress.

Table 1. Relative water use, rooting depth, and drought avoidance of 10 cool-season turfgrasses.

Turfgrass	Water Use	Root Depth	Drought Avoidance
Tall Fescue			
Forage-type	Very high	Very Deep	Very High
Turf-type	Medium-high	Deep	High
Perennial Ryegrass	Medium	Intermediate-Deep	Medium-High
Kentucky Bluegrass	Medium	Intermediate-Shallow	Medium
Creeping Red Fescue	Medium	Intermediate	Medium
Chewings Fescue	Medium-Low	Intermediate	Medium
Hard Fescue	Medium-Low	Intermediate	Medium-Low
Creeping Bentgrass	Medium-High	Intermediate-Shallow	Low
Rough Bluegrass	Medium	Very Shallow	Very Low
Annual Bluegrass	High	Shallow	Very Low

Based on turfgrass evaluations conducted at the University of Nebraska

Table 2. Relative water use, rooting depth, and drought avoidance of Kentucky bluegrass cultivars.

Cultivar Avoidance	Water Use	Rooting Depths	Drought
Touchdown	Low	Very Deep	Excellent
Ram I	Low	Deep	Good-Excellent
Park	Medium	Intermediate	Fair
America	High	Shallow	Poor
Aspen	High	Shallow	Poor

Based on turfgrass evaluations conducted at the University of Nebraska

Table 3. Relative water use, rooting depth, and wilting tendency of tall fescue cultivars grown as turfs under field conditions.

Cultivar	Water Use	Rooting Depth	Wilting Tendency
Rebel	Low	Intermediate-Shallow	High
Adventure	Medium-Low	Deep	Very Low
Houndog	Medium	Intermediate-Deep	Intermediate-Low
Kentucky 31	High	Deep	Low
Kenhy	High	Intermediate Shallow	Very High

Based on turfgrass evaluations conducted at the University of Nebraska

POTASSIUM FERTILIZATION

Robert C. Shearman
Department of Horticulture
University of Nebraska
Lincoln, NE 68583-0724

Potassium is one of sixteen essential elements required by turfgrass plants for proper growth, development, and stress tolerance. Though it is an essential element, potassium is not a constituent of turfgrass tissues. It is found in plants only in the elemental form (K+). K enhances carbohydrate synthesis and translocation, respiration, and uptake of certain other nutrients like nitrogen and magnesium. K has been reported to enhance turfgrass rooting and stress tolerance. Many turfgrass specialists have experimented for years with the potential use of K nutrition to minimize turfgrass stress.

Turfgrasses require relatively high amounts of K, perhaps even in equal amounts to nitrogen. This is particularly true in relationship to the turfgrass plant's ability to tolerate environmental stress. The term "luxury consumption" has been associated with certain nutrients, like K. It is well established that K can be taken up by plants in excess to the plant's needs for growth and development. Thus, K nutrition levels can be established for pounds of dry matter produced in forages or bushels of grain produced in cereal crops. Turfgrass managers are generally not interested in clipping yields. They are more interested in maintaining adequate growth, recuperative rate, stress tolerance, and playability of the turf than dry matter production. In this regard, turfgrass researchers and managers are being forced to reassess soil and tissue K levels and their critical association with turfgrass nutritional needs.

Recommendations for K fertilization are typically made based on soil tests and their resultant K index values (Table 1). These index values differ slightly with soil testing laboratories and regions. Table 1 gives indices used for Nebraska recommendations. The table is shown to simply indicate the low K levels required to achieve adequate yields compared to soil levels that gave stress tolerance in Kentucky bluegrass and creeping bentgrass studies conducted at the University of Nebraska.

A drought avoidance study involving nitrogen and potassium nutrition interactions was initiated in 1976 on a Kentucky bluegrass turf. This study was terminated in 1985. Soil K levels on the site were slightly in excess of 400 pounds per acre. Turfgrass clippings were removed during the course of the study. K levels ranged from 0 to 8 pounds per 1000 square feet per season in 2 pound increments. At the end of the study, soil K levels in the 0 treatment were 380 pounds per acre, which still rated high on the K index (Table 1). Turfgrass water use decreased with increasing K levels as did turfgrass wilting tendency (Figure 1). Rooting depth and root organic matter production also increased with K levels from 0 to 6 pounds. Recovery from drought injury was also enhanced by K fertilization.

Potassium deficiency symptoms are usually subtle and are not seen as easily or readily as nitrogen deficiency in turf. K deficiency symptoms often are expressed as reduced tolerance to environmental stress and diseases. K deficiencies occur most often on sandy soils that receive frequent or heavy irrigation. Daily irrigation on a Seaside creeping bentgrass green growing on a sand media rootzone resulted in sol K levels that were 20 to 30 percent lower than those of the same turf receiving the same quantity of water but in irrigations applied twice weekly. Potassium content of tissues were similar in trend to those of soil for corresponding irrigation treatments. Soil K levels never exceeded 180 pounds per acre in the sandy media, even with treatments of 8 pounds of K per 100 square feet per season. Levels ranged as low as 30 pounds per acre with the 2 pound treatment applied with frequent irrigation.

Turfgrass wear tolerance increased with increasing K nutrition from 2 to 6 pounds per 1000 square feet per season in the Seaside creeping bentgrass study. A similar response was found for the Kentucky bluegrass study. Earlier research at Michigan State University found increasing turfgrass wear tolerance with K rates ranging from 0 to 8 pounds per 1000 square feet per season on a Toronto creeping bentgrass green growing on a rootzone of 1 peat: 1 soil: 1 sand. In the Seaside creeping bentgrass green study, wilting tendency and water use were found to decrease with additional K. A reduction in pink and gray snowmold activity was found for treatments receiving 4 to 8 pounds of K per 1000 square feet. Desiccation injury declined signficantly for turfs receiving 6 to 8 pounds of K per 1000 square feet. A similar trend was found in the Michigan study which was conducted in 1969.

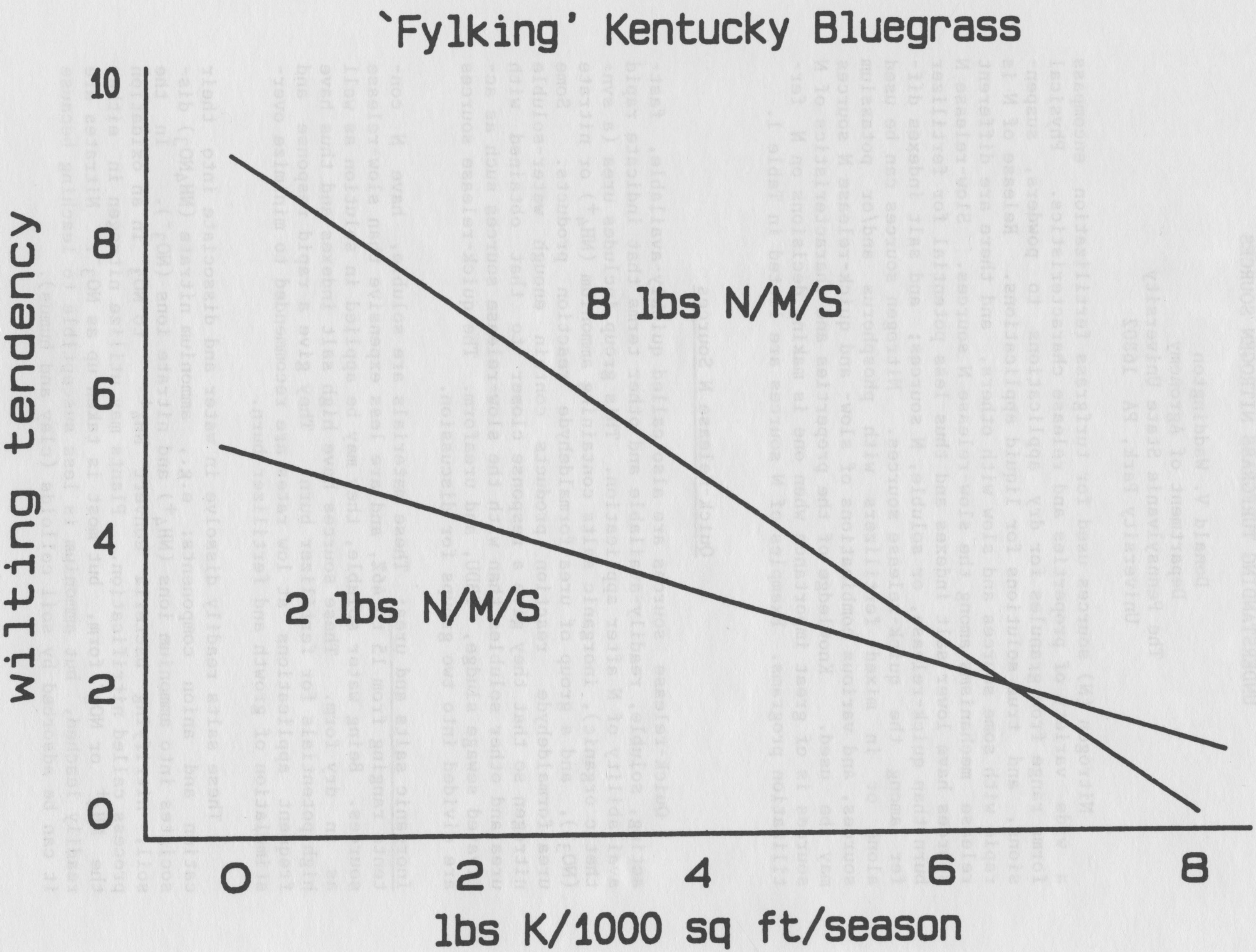
On sandy soils with low water and nutrient retention capabilities, it is best to apply potassium in light, frequent applications rather than infrequent, heavy ones. This procedure ensures more uniform use of the K, rather than allowing it to move rapidly out of the effective rootzone. This situation is particularly the case when frequent irrigation is also required to maintain desire turfgrass quality.

There is growing evidence for the benefits of K nutrition in minimizing turfgrass stress. Turfgrass managers should use this information to help maintain desirable turfgrass quality and playability. K is not a miracle element. It is an essential nutrient and turfgrass managers should keep its role in perspective. Applying excessive amounts in relation to other nutrients may result in severe nutrient imbalance problems. A fair amount of evidence exists to support the use of increased rates that approach ratio of 1 nitrogen: 1 potassium for enhanced stress tolerance. A concerted research effort is being conducted at the University of Nebraska with potassium. This research is being supported in part by a grant from the United States Golf Association Green Section.

Table 1. UN-L Soil Testing Laboratory Potassium Recommendations.

Potassium index (ppm)	Rating
Less than 40	Very low
41 - 74	Low
75 - 124	Medium
125 - 150	High
More than 150	Very High

Figure 1. Wilting tendency of a 'Flyking' Kentucky bluegrass turf influenced by Potassium (K) and nitrogen (N) treatments. Wilting tendency was based on a 0 to 10 rating scale with 0 having no wilt and 10 being 100% wilted turf.



'Fylking' Kentucky Bluegrass
wilting tendency
10
8
6
4
2
0
8 lbs N/M/S
2 lbs N/M/S
0
2
4
6
8
lbs K/1000 sq ft/season

UNDERSTANDING TURFGRASS NITROGEN SOURCES

Donald V. Waddington
Department of Agronomy
The Pennsylvania State University
University Park, PA 16802

Nitrogen (N) sources used for turfgrass fertilization encompass a wide variety of properties and release characteristics. Physical forms range from granules for dry applications to powders, suspensions, and true solutions for liquid applications. Release of N is rapid with some sources and slow with others, and there are different release mechanisms among the slow-release N sources. Slow-release N sources have lower salt indexes and thus less potential for fertilizer burn than quick-release, or soluble, N sources; and salt indexes differ among the quick-release sources. Nitrogen sources can be used alone or in mixed fertilizers with phosphorus and/or potassium sources, and various combinations of slow- and quick-release N sources may be used. Knowledge of the properties and characteristics of N sources is of great importance when one is making decisions on N fertilization programs. Examples of N sources are listed in Table 1.

Quick-Release N Sources

Quick-release sources are also called quickly-available, fast-acting, soluble, readily-available and other terms that indicate rapid availability of N after application. This group includes urea (a synthetic organic), inorganic salts containing ammonium (NH_4^+) or nitrate (NO_3^-), and a group of urea-formaldehyde reaction products. Some urea-formaldehyde reaction products contain enough water-soluble nitrogen so that they give a response closer to that obtained with urea and other solubles than with the slow-release sources such as activated sewage sludge, IBDU, and ureaform. The quick-release sources are divided into two groups for discussion.

Inorganic salts and urea: These materials are soluble, have N contents ranging from 15 to 46%, and are less expensive than slow-release sources. Being water soluble, they may be applied in solution as well as in dry form. These sources have high salt indexes and thus have high potentials for fertilizer burn. They give a rapid response and frequent applications at low rates are recommended to minimize overstimulation of growth and fertilizer burn.

These salts readily dissolve in water and dissociate into their cation and anion components: e.g., ammonium nitrate (NH_4NO_3) dissociates into ammonium ions (NH_4^+) and nitrate ions (NO_3^-). In the soil, nitrifying bacteria convert NH_4^+ to NO_3^- in an oxidation process called nitrification. Plants may utilize nitrogen in either the NH_4^+ or NO_3^- form, but most is taken up as NO_3^-. Nitrates are readily leached, but ammonium is less susceptible to leaching because it can be adsorbed by soil colloids (clay and humus).

Urea is water soluble, and is quickly hydrolyzed (reacts with water) in the presence of adequate moisture and the enzyme urease to form ammonium-N. More than 60% of the applied urea can be expected to hydrolyze in one day, and hydrolysis should be complete in about 7 to 10 days. Under alkaline conditions gaseous loss of N as ammonia may occur from urea and ammonium compounds. This process, called volatilization, is also favored by low soil cation exchange capacity, drying of moist soil, and high temperature. Losses are usually greatest with urea; and on grass areas, losses as high as 30% of the applied N have been reported. Watering-in fertilizer will minimize such losses.

<u>Urea-formaldehyde Reactions Products</u>: A well-known urea-formaldehyde fertilizer is ureaform, which is a slow-release source of N with about 70% of the total N being water insoluble. By altering the ratio of urea to formaldehyde, reaction products with considerably less water-insoluble N (WIN) can be produced. The water soluble nitrogen of these products contains compounds such as unreacted urea, methylol urea, and methylene ureas. The amount of each is largely dependent on the urea/formaldehyde ratio and the conditions under which the reaction takes place. These N sources are more expensive than the conventional solubles, but they are safer from the standpoint of fertilizer burn.

Methylol urea is the first compound formed when urea and formaldehyde are chemically combined. As the reaction continues, short-chain and, later, long-chain methylene urea polymers are formed. The short-chain molecules are water soluble and the longer chain molecules are water insoluble. RESI-GROW 4340 and 4341 are clear aqueous solutions containing methylol urea and unreacted, or free, urea, which supplies about 50% of the N. Other water-soluble urea-formaldehyde reaction products are Formolene LU and Nitro-26. They are solutions that contain water soluble methylene ureas and some unreacted urea. About 25 to 30% of the N is from unreacted urea. N-SURE is a solution that differs from the previously mentioned solutions in that it contains N primarily in the forms of triazones and urea. Triazones are cyclic N compounds that form when the fertilizer is manufactured by reacting urea, formaldehyde, and ammonia. Each of these solutions has a lower burn potential than urea, and can be used more safely at higher rates or on heat or water stressed turf. However, turfgrass response to these N sources is similar to but slightly less than that obtained with urea.

FLUF, Homogesol-27, Slo-Release, and RESI-GROW 4318 are flowable urea-formaldehyde reaction products that contain water-insoluble as well as water-soluble methylene ureas. Quick response is obtained with these materials, but the intensity of response is not as great as with urea and the previously discussed solution fertilizers.

Methylene ureas can be made with varying amounts of WIN. We have used a granular material supplied by O. M. Scott & Sons that had 36% of the total N as WIN, and a sprayable material having 30% of the

N as WIN. Such materials can be expected to give a good initial response, but also have a greater residual effect than the soluble materials. The granular product gave turfgrass response similar to that obtained with fertilizers containing 50 and 60% ureaform-N, with the remainder from soluble N sources. Such response more closely followed that from soluble N sources than that from ureaform. Other methylene ureas used by Scotts contain considerably less WIN, but safety is preserved by the presence of soluble, short-chain methylene ureas. Homestead's Homogenite 40 is a granular methylene urea product containing 41% N, with about 27% of the N as WIN.

Slow-Release Nitrogen Sources

Slow-release nitrogen sources, which are also called controlled-release, slowly-available, slow-acting, and insoluble, can be classified according to the method by which the nitrogen is released: (1) microbial activity is required for decomposition and release of N from natural organics and urea-formaldehyde reaction products (ureaform, methylene ureas); (2) low water solubility and a very slow rate of dissolution gives the slow-release characteristic of IBDU; and (3) coatings on soluble N sources act as physical barriers that delay the dissolution of N from sources such as sulfur-coated urea and plastic-coated fertilizers.

Slow-release sources provide a longer duration of N release than the soluble, quick-release sources. They are safe from the standpoint of fertilizer burn (lower salt index), and may be applied at higher rates and with less frequency than soluble sources. The efficiency of some slow-release sources is often low in the first year or two of use. The low efficiency (often expressed as the percentage of the applied N utilized by the plant) and higher cost for N associated with the slow-release sources are reasons that combinations of slow and fast-release N sources are used in many turf fertilizers. A discussion of individual slow-release sources follows:

Natural organics: For the most part, these materials are by-products from the plant and animal processing industries or waste products. Considerable variation exists in the properties of different materials, and even within a given material. The natural organics can be characterized by relatively low N content, the presence of WIN, and N release intermediate between that of soluble N sources and ureaform. Examples include hoof and horn meal, fish scrap and meal, seed meals (cottonseed, linseed, castor pomace), dried manures, activated sewage sludge, and process tankage. Release of N is dependent on microbial activity. Factors influencing release are the chemical composition of the material and environmental conditions that influence microbial activity. Environmental conditions affecting breakdown of natural organics include temperature, soil moisture and oxygen, soil pH, and available minerals. Milorganite is an activated sewage sludge and is the most popular natural organic N source used on turf. Milorganite has been more efficient than several other natural organics in our tests.

Ureaform: Ureaform is made by reacting urea with formaldehyde. Ureaform is not a single compound, but is composed primarily of a mixture of straight-chain polymers. Ureaform contains 38% N and about 70% of this N is water insoluble. Ureaform can be divided into three, almost equal fractions based on solubility. Fraction I is soluble in cold water, and contains unreacted urea and the short-chain methylene ureas: methylene diurea and dimethylene triurea. Availability of N in this fraction is similar to that of soluble sources, but is not as quickly available. Fraction II is made up of slow-release, intermediate length polymers (trimethylene tetraurea and tetramethylene pentaurea). It is insoluble in cold water, but soluble in hot water. Fraction III is insoluble in both hot and cold water and is made up of pentamethylene hexaurea and longer chain polymers. It is the most resistant fraction. In a study by Kaempffe and Lunt (from California) the breakdown of these fractions was studied over a period of 26 weeks. After this time period, 4% of fraction I, 25% of fraction II, and 84% of fraction III remained in the soil. The slow decomposition of fractions II and III accounts for the low efficiency of ureaform in the initial years of use. With continued use and build-up of ureaform, recovery of applied N improves.

According to the Association of American Plant Food Control Officials, ureaform should contain at least 35% N, with at least 60% of the total N being water insoluble N (WIN), and the WIN should have an activitity index (AI) of at least 40%. The AI represents the amount of cold water insoluble N that is soluble in hot water (commercially available material has an AI of about 55%). Nitroform Blue Chip and Powder Blue meet these criteria. Urea-formaldehyde reaction products not falling within these guidelines are referred to by other terms such as methylene urea, methylol urea, and flowable ureaform. By using urea-formaldehyde solutions, ureaform (or methylene ureas) can be made during the manufacture of mixed fertilizers.

Release of N from ureaform is dependent on microbial activity and the same environmental factors that affect release from natural organics also affect release from ureaform. Because of low N recovery (efficiency) in the first years of use, it is usually necessary to use higher rates or supplement ureaform with soluble sources in these years. This low recovery and slow response during cool periods support the concept of fertilization with combinations of ureaform and solubles.

Organiform: Organiform is a N source made by reacting urea and formaldehyde in the presence of a natural organic N source. Organiform contains about 24 to 25% N, of which about 70% is WIN. Organiform LT is a copolymer of leather tankage and methylene ureas, and Organiform SS is a copolymer of sewage sludge and methylene ureas. Release of N is dependent on microbial activity.

We have found these materials to be slower in release and less efficient than Milorganite and Nitroform. Response has improved with continued use. A combination of 50% Organiform N and 50% soluble N greatly exceeded the performance obtained with straight Organiform.

Other urea-formaldehyde reaction products: Although we often think of slow-release N when we hear the term urea-formaldehyde, there are some urea-formaldehyde reaction products that tend to be more quick-release than slow-release. The ratio of urea to formaldehyde used during manufacture affects the amount of WIN in the fertilizer. Ureaform is made using a ratio of about 1.3:1. Other N sources are made using wider ratios (more urea), and the result is lower amounts of WIN. I am not aware of any formal or informal rules that dictate when the term 'slow-release' is justified for an N source with a given amount of WIN. Certainly, confusion can arise when 'slow-release' is used with a material that has less of the total N as WIN than mixed fertilizers containing combinations of slow-release and soluble N such as 50% IBDU or Ureaform N and 50% soluble source N. The characteristics of three urea-formaldehyde reaction products (methylene ureas, methylol urea, and flowable ureaform) were given under the 'Quick-Release N Sources heading. Of these three, the slowest-release of N would occur with methylene ureas having the higher amounts of WIN.

IBDU: IBDU is made by reacting isobutyraldehyde and urea. It contains 31% N, with 90% of the total N being water insoluble in the coarse (0.7 to 2.5 mm) product and 85% being water insoluble in the fine (0.5 to 1.0 mm) product. Release is slow due to low solubility; but once in solution, IBDU is hydrolyzed and releases available nitrogen. Particle size has a large effect on release of N, with smaller particles releasing more quickly. Release also increases with increased soil water content. Release is also affected to some extent by temperature and pH. Hydrolysis is faster under acidic conditions. The rate of release also increases with temperature, but low temperature does not affect IBDU as much as it does those sources dependent on microbial activity for release.

We have observed a 3 to 4 week delay before obtaining response from IBDU applications on Kentucky bluegrass, but not after applications to an aerified and topdressed green. Probably the close contact with wet soil and more liberal irrigation practices enhanced release on the putting green. If the delay in response is considered objectionable, a soluble N source can be used to supplement the IBDU. We have observed early spring greening with IBDU, and N recovery from IBDU exceeded that from ureaform during the initial years of use. We have obtained a quicker response and greater N recovery from fine than coarse IBDU, which has a greater residual effect.

Plastic-coated fertilizer: Sierra Chemical Company uses the Osmocote process to produce plastic-coated fertilizers. In this process, plastic coatings (also called resin or polymeric coatings) are applied to soluble sources of N, P, and K. For release to occur, water passes through the coating and dissolves the fertilizer salt. This causes pressure that swells the capsule, and the dissolved salts diffuse out through enlarged pores in the coating. Different coating thicknesses are used to obtain different release patterns. The thicker the coating, the slower the release. Release increases with increased temperature. If coatings are ruptured or cracked by mechanical damage or due to prolonged, excessive drying, release rate increases. The release rate is not significantly influenced by soil moisture levels (from wilting point to field capacity), volume of water applied, soil pH, or microbial activity. The high cost of these products has been a dominant factor in delaying their acceptance for turf fertilization. They are often used on greenhouse and nursery plants.

Sulfur-coated urea: Sulfur-coated urea (SCU) is made by spraying preheated urea prills or granules with molten sulfur. A sealant, such as wax or a mixture of oil and polyethylene, is often applied to seal pores and imperfections in the sulfur coating. Nitrogen content is usually in the range of 32 to 38% and is dependent on coating thickness (weight). Increasing the thickness decreases the nitrogen content. Smaller particles of urea have a greater surface area than larger particles; thus more sulfur is needed to obtain a given coating thickness on finer particles. This increased sulfur requirement decreases the percent nitrogen in the final product. Nitrogen is released from SCU by degradation of the coating and/or diffusion of soluble nitrogen through pores in the coating. Release rate increases as coating thickness decreases and as temperature increases. The formation of ferrous sulfide on SCU under water-logged conditions slows release of N. As with the plastic coated materials, breakage of the coating increases release. The 7-day dissolution rate in water (laboratory determination) is commonly used to characterize different formulations of SCU. Most commercial products for turf have dissolution rates within the range of 25 to 35%. One product has a rate approaching 65%. These values can be used to roughly estimate the amount of N that will be readily available. The remainder will have some degree of slow release. A much wider range of dissolution rates has been used in experimental SCU. We found a product with an 11% dissolution rate to be somewhat slow for 3 years under our conditions, but it was quite satisfactory in tests conducted in the warmer climate of Alabama. Another experimental SCU had a dissolution rate of 83% and gave results similar to those obtained from soluble sources. Although this material was a SCU, it could hardly be called slow-release. It would, however, offer less potential for fertilizer burn than straight urea.

Particles within an SCU product are not identical. If they were, one might expect all of them to release N at the same time. Quickest release occurs from imperfectly coated particles; particles in which sealant has covered imperfections release N at an intermediate rate; and the greatest delay in release occurs with the thicker coated and more perfectly coated particles having no imperfections. The second class of particles is not present in SCU products manufactured without a sealant. Once release begins from a given particle, it is quite rapid. Thus, the slow-release property of SCU comes from the variability in coatings among the individual particles.

SCU has given good response from two applications per year on Kentucky bluegrass turf, and N recovery has equalled that of soluble N sources. Combinations of SCU and soluble N sources did not give improvement over the performance of SCU alone. The relatively new SCU product of Scotts has a higher dissolution rate than most SCU that we have evaluated. Greater initial response and less residual occurs with this product. Some of the finer SCU materials are suggested for use on putting greens. Breakage could be a problem under these conditions. As much as 20% of applied SCU was picked up at a mowing height of 3/16 inch in a study conducted in England. Mowing without grass catchers would prevent such removal, but breakage could still occur. High rates should be avoided where breakage due to mowing or traffic could occur. The Lesco Elite SCU is finer than the product tested in England, and pick up with it should be minimal.

Oxamide: Oxamide is a N source that has been known for over sixty years. High production costs have kept it from being produced commercially. A renewed interest in this material as a slow-release N source has resulted in recent studies on turfgrass. Oxamide contains 31.8% N, and the chemical formula is NH_2-CO-CO-NH_2. Release of N is by hydrolysis reactions and more rapid release is favored by finer particle size and warm temperatures. Our results with this material have shown a similarity in response to that obtained with IBDU. We have observed a delay in response following application (especially with larger granule sizes) and adequate release in cold weather to promote good green color. Fine oxamide (less than 0.25 mm) has given quicker response than granular oxamide (1-3 mm), but release from the fine material was slower than with soluble sources.

Melamine: Another older slow-release source that has gained some attention in recent years is melamine. Melamine (2,4,6 triamino-1,3,5-triazine) is a long lasting, insoluble N source containing 66% N. Melamine Chemicals Inc. has combined melamine and urea to produce N fertilizers known as "Super 60" nitrogen fertilizers. Three formulations are currently available and are made by utilizing various ratios of melamine and urea. Ratios of 1:3, 1:1, and 3:1 yield 50-0-0, 55-0-0, and 60-0-0, respectively. The lowest N content (50%) reflects the highest amount of urea used, and this product will give the greatest initial response. The initial response with each is due to the urea component. Melamine begins to release N after a delay of several months. The "Super 60" fertilizers can be applied dry as granules or in water. In fluid applications, the urea dissolves and the melamine is a suspended solid.

Table 1. Typical properties of nitrogen sources used for turfgrass fertilization.

Physical Form	Trade Name	Manu-facturer	Fertilizer Grade	Total N	Water-Insoluble N
				%	%
SOLUBLE SOLIDS					
	Monoammonium phosphate	-	10-50-0	10	0
	Diammonium phosphate	-	18-46-0	18	0
	Ammonium nitrate	-	33.5-0-0	33.5	0
	Ammonium sulfate	-	20-0-0	20	0
	Calcium nitrate	-	15-0-0	15	0
	Sodium nitrate	-	16-0-0	16	0
	Potassium nitrate	-	13-0-44	13	0
	Urea	-	46-0-0	46	0
SLOW-RELEASE SOLIDS					
	Milorganite	1	6-2-0	6	5.5
	Nitroform Blue Chip	2	38-0-0	38	27.0
	IBDU (coarse)	3	31-0-0	31	27.9
	IBDU (fine)	3	31-0-0	31	26.3
	Methylene ureas	4,13	--	38-41	10-14
	Sulfur-coated urea	4,5,6	--	32-38	--
	Plastic-coated fertilizer	7	Variable (See text)		
	Melamine, "Super 60"	8	Variable (See text)		
SOLUTIONS					
	RESI-GROW 4340	9	30-0-0	30	0
	RESI-GROW 4341	9	30-0-2	30	0
	Formolene LU	10	30-0-1	30	0
	N-SURE	11	28-0-0	28	0
	Nitro-26	12	26-0-0	26	0
SUSPENSIONS					
	Homogesol-27	13	27-0-0	27	2.7
	Slo-Release	10	18-0-1	18	4.5
	FLUF	14	18-0-0	18	4.5
	RESI-GROW 4318	9	18-0-0	18	4.5
SPRAYABLE POWDERS					
	Methylene Urea	4	41-0-0	41	12
	Nitroform Powder Blue	2	38-0-0	38	25

Manufacturers

1. Milwaukee Metropolitan Sewerage District
2. NOR-AM Chemical Co.
3. Estech Inc.
4. O. M. Scott & Sons Co.
5. Canadian Industries Ltd.
6. Ag. Industries Mfg.
7. Sierra Chemical Co.
8. Melamine Chemicals Inc.
9. Georgia Pacific Corp.
10. Hawkeye Chemical Co.
11. Arcadian Corp.
12. C. P. Chemical Co.
13. Homestead Corp.
14. W. A. Cleary Chemical Corp.

NEW TECHNOLOGY IN FERTILIZERS

George R. McVey
O. M. Scott and Sons
Marysville, Ohio 43041

Introduction

Nutrient uptake based on plant demand has been a dream for many years. Current technology, based on empirical testing, approaches the optimum release pattern but is far from ideal. Soil temperature, moisture, pH, and type, fertilizer placement, etc. can alter the release of nitrogen from fertilizer made with even the most sophisticated technology. New technology has partially overcome physical and biological stresses, thus making nitrogen release more predictable. Today I will review some of our experiences with the new technologies including altering the molecular chain length and distribution of the methylene ureas, altering coating thickness and chemistry and altering plant growth as a means of increasing nitrogen efficiency. The impact of certain environmental conditions (temperature and leaching) shall be reviewed.

Synchronizing nutrient release with biological demand has a number of advantages.

- Reduction of luxury consumption
- More even distribution of nutrient uptake
- More regulated growth pattern
- Allows for more efficient placement
- Reduction of phytotoxicity
- Increased flexibility for timing the application
- More efficient nitrogen update
- Reduces leaching, volatilization and denitrification

Nutrient Losses

Nutrient losses can reach staggering proportions if the wrong nitrogen source is selected and environmental stresses are excessive. For example, on sandy soils in a heavy thatched turf area, a foliar application of urea applied during high temperatures can be rapidly converted to ammonia (up to 60% loss), which is lost to the atmosphere (volatilization). Leaching of nitrogen can reach 90% while denitrification can go as high as 25%.

With these potential pathways for loss of nitrogen, it is evident that means must be found to reduce these losses so that nitrogen efficiency can be increased.

Methylene Urea

Methylene urea, a class of slow release nitrogen, has been used for over 35 years to reduce nitrogen losses. This technology is certainly not new, but new processing methods have increased the percent of the more biologically active short chain methylene urea. These new formulations induce less surge growth, with release of the nitrogen more consistent from week to week. The increase in nitrogen efficiency is associated with a reduction in leaching as compared to urea and IBDU and volatilization as compared to urea.

Sulfur-Coated Urea

Sulfur coated urea has been commercially available for over 10 years, but research goes back to the early 1960's. Research is still continuing on this process, with new technology suggesting more efficient N sources can be realized.

Coating thickness can alter the release characteristics of SCU. By altering the coating thickness and modifying the sulfur chemistry (patented process) the initial response can be controlled (reduced surge growth) and the residual dramatically extended (75-100%). Early greenhouse and field research suggests that 1/3 - 1/2 as much nitrogen will be required to equal the same performance as that realized with urea. Fertilizer produced by this new technology is less sensitive to soil temperature changes or physical stress during handling. This new technology is also very effective at increasing the residual of potassium.

Turf Growth Regulators and Plant Nutrition

Growth of turf can be dramatically altered by applying certain turf growth regulators (TGR). The typical growth surge associated with a fertilizer application can be negated while the residual growth response is extended. This response is associated with an increase in turf color with a 15% reduction in total clipping yields. These dramatic differences in growth patterns have an impact on the nutritional requirements of the turf.

The percent nitrogen in the leaf tissue is increased up to 100% during the earlier retardation period (first month), however, total nitrogen uptake is reduced up to 50% during the same period. This shift in nitrogen demand provides residual nitrogen for growth during the 2nd & 3rd month following treatment. This is reflected in improved turf color, quality and density during this time period as compared to turf fertilized with nitrogen only. In controlled experiments, turf fertilized with 0.28# N/1000 sq. ft. plus TGR was equal in quality and color but had 2/3rds less clippings as compared to turf fertilized with 1.1# N/1000 sq. ft.

Summary

Nitrogen efficiency is dramatically influenced by environmental conditions. Current technology has reduced vulnerability to the elements, resulting in improved efficiency with reduced loss to the environment. Modifications of existing technology have advanced us ever closer to the 100% efficiency target. Modification of methylene urea and SCU technology are at the cutting edge and promise to provide nitrogen sources that are more efficiently utilized than products now on the market.

PERSONAL FINANCIAL MANAGEMENT

Janice Holm Lloyd, Specialist
Family Reosurce Management
N.C. Agricultural Extension Service
Box 7605 N.C. State University
Raleigh NC 27695-7605

Nita Higginbotham
Area Specialized Agent
Family Resource Management
Money Management Center
1450 Fairchild Drive
Winston-Salem NC 27105

Families at all income levels and in all settings have problems with money management. Even in prosperous times, the major cause of marital discord is disagreement about money management, with many a family spending more than it makes, and countless thousands of families struggling to meet minimum-due payments on too many credit accounts. The current situation affecting North Carolina's farm and rural families magnifies these problems, with the impact reported in increased domestic violence, school problems, alcoholism and depression.

North Carolina also has an unusual number of two-income families who have no immediate financial concerns, but need reliable information about tax and investment issues in order to find their way through the maze of deregulation and reform. And we have a higher than the national average older citizen population, with concerns about their finances while in good health, and a need to plan for the possibility of becoming dependent.

The need for better information at every stage of financial management is universal, as few schools or homes prepare young people adequately for the challenges of responsible decision making. Throughout the state, Extension county advisory councils report that family financial management should receive expanded emphasis. This concern is echoed by state and local financial institutions, credit counseling services, credit bureaus, as well as insurance, real estate and investment firm representatives.

On November 1, 1986, we launched the first Money Management Center in the state, here in Forsyth County, to provide a greatly expanded financial management educational program in cooperation with Agricultural Extension Service staff in neighboring counties. The Area Specialized Agent selected to direct the activities of this center has a strong background both in counseling skills and in teaching all levels of financial management -- from elementary budgeting to saving for and learning how to finance such goals as a house or higher education. She is here today as part of her outreach program, but she also does individual counseling at the County Agriculture Building -- dealing with basic money management procedures as well as complex consumer decisions. Severe credit problems are of course referred to the Consumer Credit Counseling Service, and people needing income assistance are referred to Social Services and other community programs. Requests for advice on specific investment products or legal matters are referred to the appropriate types of advisers. Money Management Centers originated in Mississippi more than a decade ago. One of the most experienced counselors from that program has joined the N.C. staff, and is making our plans for this essential educational service a reality.

What is Personal Financial Management:

All of us are managers--of a business, a hobby, a household and hopefully of our finances. Every aspect of management includes decision making as a part of the process. Decision making is a learned process rooted in the past, carried on in the present and shaping the future. The quality of life of a person, family and a nation depend upon the quality of decisions made. Management is not a set of rigid rules, instead a set of flexible responses or a process which results in goal-directed action in the use of resources to obtain a lifestyle satisfactory to everyone involved. It is an important discipline in the context of business and industry and it should have the same prestige in families.

Financial management is purposeful behavior in allocating money resources to achieve family goals. The key issues for most people are: making more money, getting more for the money you spend, and keeping more of the money you earn. To be successful a plan must be developed then implemented. To accomplish this three-fold task a more detailed analysis of financial planning is necessary. Financial Planning should include:

*Examining one's current financial condition and relating it to one's lifetime and estate goals.
*Identifying the principal hurdles that act as obstacles to achieving one's multiple objectives or goals.
*Objectively selecting and implementing procedural and investment strategies for success.

Goals with a plan bring your dreams closer to reality. Sam Richalson once said; "A goal without a plan to achieve it is only a dream".

How can you make your financial goals or dreams become realities? Following are ten suggestions or steps to success for today's money manager:

*Review your lifestyle and determine where you stand now.
*Know your present net worth in current market values.
*Estimate your income and expenses for the current year.
*Develop a long-range plan (For a lifetime hopefully) based upon your primary objectives and financial goals.
*Make a written plan to improve current spending and be totally committed to the plan.
*Pay yourself first by taking from the top a designated amount for savings and investments.
*Maintain records indicating actual income and expenses on a monthly basis.
*Compare the written plan with actuality each month and modify your plan as needed.
*Get out of debt as soon as possible and stay out if possible - except for your mortgage loan.
*Focus on minimizing your costs and maximizing your returns from your investments.

Success depends on you and your family's reaction to these steps. For some families there are some problems affecting their success. The most frequent problems identified by families recently in Mississippi included:

*Inability to save money
*Inability to buy special things the kids want
*Inability to buy new clothes or new shoes
*Not enough money for dentist, doctor or medicine when needed
*Inability to meet large bills such as insurance premiums and property taxes
*Not enough money to buy food for the entire month
*Not able to keep household equipment in running order
*Getting behind in the rent or house payment

These problems are probably characteristic of most urban families throughout the United States. Some of them often result from mismanagement practices that could be controlled. The most common mismanagement practices that families can control in 1987 include:

*Underestimating expenses
*Overestimating income
*Lack of family communication about money matters
*Lack of financial planning
*Lack of keeping financial records and maintaining a financial office
*Use of money for emotional reasons.

Much is written today about personal financial management compared to a decade ago. There is also the emerging "financial planner" concept sweeping the globe whereby you can go and secure (often for a fee) advice and assistance in personal financial management. From the studies conducted in financial management, there is a need for help with personal consumption problems. The N.C. Agricultural Extension Service recognizes this need and wants to contribute by providing concentrated staffers who will assist with information and knowledge needed for consumers to make wise decisions about financial management strategies. This assistance includes one-on-one confidential consultations for planning and implementing helps to those interested. Following is an example of one tool used by the Money Management Center for your consideration:

ASSESS YOUR FINANCIAL MANAGEMENT PRACTICES

Problem Area	Determine Your Current Level of Success		
	Satisfied	Needs Improving	Plans for Improving
1. Procrastination			
2. Emotional Feelings			
3. Family Communication			
4. Goal Setting			
5. Spending-Savings Plan			
6. Mechanics of Money Management			
7. Discipline Commitment			
8. Decision Making			
9. Investment Knowledge			
10. Protection Program			
11. Credit Management			
12. Retirement and Estate Planning			
13. Attitude			

REMEMBER: IF YOU FAIL TO ACT YOU FAIL TO SUCCEED.

MANAGEMENT OF BENTGRASS GREENS IN THE SOUTH

Charles B. White
Southeastern Director
USGA Green Section
P. O. Box 4213, Campus Station
Athens, Georgia 30605

Management of bentgrass greens in the South has become an issue that has been ever increasing in popularity over the last three years. Bentgrass is being put in areas that three or four years ago would never have been considered for bentgrass whatsoever. Because of this increased popularity of bentgrass in the Southeast, some very specific management practices must be considered before success is complete. Oftentimes, bentgrass has been put into areas with resulting failure - not because of the inability of the grass to withstand the condition but rather the management practices imposed. Therefore, let us take a look at some very basic management practices for bentgrass to insure year round success and maximum playability.

The first program to consider for proper bent management should be an overall cultural program. This should ideally include three aerifications per year. These aerifications should be early April, late May and then again in early September. The April and September aerifications are done with larger tines with heavy topdressing following according to the needs of each individual green site. The late May to early June aerification is done with the small tines and the holes usually 1/4" to 3/8". These holes can be left open or lightly topdressed. This late spring aerification is very important for maximizing the vigor of the bentgrass through the summer stress months. It is also important to remember to always avoid early spring and late fall aerifications because <u>Poa annua</u> invasion is horrendous if these type of aerification programs are practiced. Therefore, aerifications should always be confined to after April 1 and before September 15th to 20th in the Southeast.

Vertical mowings should also be carried out heavily once per year. This is best done immediately prior to the first spring aerification. Heavy vertical mowing with the walking type vertical mower is important to remove grain and puffiness from the bentgrass and also to minimize thatch accumulations and the tendency for horizontal growth. Grooming with the vertical mower on the triplex or walking greens mower units is done weekly in addition to the heavy vertical mowing through the spring and through the fall months. To make cultural management programs complete, light topdressings every third week is most effective for maximizing surface uniformity and putting qualities.

Use of the grooved roller during all the year except for possibly the extreme summer heat months is essential for the best quality bentgrass putting surfaces.

Cutting heights for bentgrass greens is another touchy subject and related to this is the stimpmeter speeds. It is important to remember that ideally for membership play, 8.6 on the stimpmeter is an ideal speed to shoot for. This is very reasonable in terms of golfer consideration and in terms of management. A cutting height that is most helpful for establishing this type of putting green speed and most desirable for the health of the bentgrass should be 3/16" with the grooved rollers. I recommend that general membership clubs maintain 3/16" with the grooved rollers on a year round basis except during the extreme heat of summer, usually from late June until Labor Day. Then many clubs must go to 7/32", but then I suggest going only to 7/32" and not to a full 1/4". At 1/4", bentgrass cannot perform to its best features. Oftentimes, I have recommended that clubs merely change from grooved rollers to solid rollers at this time and leave the same bench setting of 3/16". This is, in effect, raising the cutting height and will provide a more desirable surface uniformity and speed. Try this type operation on your golf course and I think both you and the membership will be happy with the success. Fluctuating cutting heights on a golf course should always be minimized to reduce complaints of the golfers.

In terms of fertilization, basically bentgrass greens in the Southeast should receive approximately 4 to 7 lbs. of nitrogen per 1000 sq. ft. per year depending on the length of the growing season, the construction of the greens and the amount of traffic received. In no instance, however, in the Southeast, should bentgrass putting surfaces or collars receive more than 7 lbs. of nitrogen annually. The bulk of this is put down in the fall, winter and early spring months with minimal amounts applied in the later spring and minimal, if any, applied in the summer months. Soluble applications sprayed on in the spring and summer at 1/10 to 1/8 lb. nitrogen/1000 sq. ft. is an excellent means of stimulating growth and health in the leaf, crown and root regions of the grass without creating over stimulation of the growth curve. Phosphorus, minor nutrients and soil pH adjustments should be made according to annual soil tests. But potassium should be put down on a 1:1 or slightly higher ratio than is the nitrogen. This maximizes heat, drought and wear tolerance as well as root extension.

When discussing soil pH, you should keep bentgrass greens at a soil pH of ideally 5.7 to 5.8. This low pH inhibits Poa annua invasions as much as possible and bentgrass loves acidic growing conditions. At this pH range you do not create nutrient tie up problems as you would with pH's below 5.5. A 6.2 to 6.5 pH is normally the pH range most desirable for turfgrasses but this is not the case for bentgrass putting surfaces or any bentgrass area because of the tendency for Poa annua invasions at this soil pH.

Weed control on bentgrass greens is also a very touchy subject and Poa annua has been controlled with many successful programs. These include preemerge programs of bensulide in the fall and winter as well as postemerge applications of Prograss, Endothall and paraquat on an experimental basis. All have given good success with the proper handling and timing of the materials. These should be experimented with before extensive use is considered. Tupersan, on the other hand, has given excellent control of bermudagrass encroachment into the bentgrass if proper timing and applications are made. The best approach has usually been a full labeled rate of Siduron in the spring and fall following an edging at the desired bentgrass/bermudagrass line. Bermudagrasses are much more easily controlled if they are first severed off from the actual bermuda sod adjacent the bentgrass.

Disease and insect control programs are applied on an as-needed basis with a preventative program usually occurring from June 1 until Labor Day. Minimal water is also a must for good bentgrass greens as bentgrass is often thinned by over watering in the Southeast more commonly than for any other reason. Ideally bentgrass greens should be watered heavily early in the morning every other day and supplement water is applied to hotter areas on strictly a "syringe" basis. Remember that when you are syringing turfgrass, you are wetting only the leaves and the air immediately above the surface - not the soil. This, therefore, does not mean five to seven minutes of water on the greens but rather one to three minutes or only one revolution of the irrigation head. Also, waiting until 1:00 P. M. to syringe is not the best program as you must syringe before the heat completely builds up on the surface to prevent wilting. Again, good management with the above-outlined programs minimizes the need for wetting agents and/or constant syringing during the summer time.

WEED CONTROL ON GOLF GREENS

Wayne Bingham
Professor and Extension Specialist
Weed Science
Virginia Polytechnic Institute & State University
Blacksburg, Virginia 24061

Golf greens are expensive to establish and maintain for a high quality putting surface. The chemical industry has been very supportive in developing herbicides for turfgrasses; however, with high risk, there is more reluctance to provide an EPA labeled product for use on golf greens. More research and experience is necessary for herbicides that are developed for golf greens. Thus, we have several herbicides for crabgrass control in many turfgrass situations but only a few for golf greens.

Crabgrass, goosegrass and annual bluegrass are the important annual grasses requiring herbicides on golf greens. The herbicides for control of these annual grasses include bensulide and bensulide plus oxadiazon for bentgrass golf greens. Bensulide appears excellent for crabgrass control, very poor for goosegrass and variable for annual bluegrass. For goosegrass, a formulation of bensulide plus oxadiazon has been labeled but extra caution and care must be exercised during this use to reduce bronzing, browning and reduced vigor. The management for the bentgrass must be moderate to high to have continuous high quality putting surface. Both of these herbicides have a relatively long residual in soil and do reduce root growth significantly especially at 2 times normal rates.

In addition to preemergence herbicides for crabgrass control, DSMA and MSMA are used at low rates (repeated). Although extremely effective for crabgrass control, the arsenicals are relatively poor for goosegrass control on golf greens.

Ethofumesate (Progress) was recently labeled for annual bluegrass control on bermudagrass, bermudagrass overseeded with perennial ryegrass and perennial ryegrass alone. More recently, Kentucky bluegrass was added to the label. Research on bentgrasses with ethofumesate has been rather extensive and leaves us in a gray zone as far as effectiveness for control of annual bluegrass and also tolerance of the turfgrass. It is rather clear that the amount of control is better with repeated treatments at low rates rather than high rates in one application. The tolerance is variable from place to place and appears to depend on soil conditions. Annual bluegrass control is apparently better in high sand soils and poor in loam or clay soil conditions. Preemergence herbicides (bensulide, bensulide plus oxadiazon and DCPA) are only partially effective for annual bluegrass.

Broadleaf weeds such as white clover, chickweeds and spurges are controlled with mecoprop, dicamba and combination herbicide products. The combination products contain 2,4-D plus mecoprop plus dicamba. For less injury, more mecoprop and less 2,4-D is used in bentgrass formulations.

BLACK LAYER, PYTHIUM ROOT ROT OR SUMMER DECLINE OF BENTGRASS

Leon T. Lucas
Plant Pathology Department
N. C. State University
Raleigh, N. C. 27695

Black layer or Pythium root rot has become a familiar term to many golf course superintendents who are growing bentgrass in recent years. I prefer to call the problem summer decline because I think more than Pythium root rot or black layer is involved in causing the thinning or dying of bentgrass in late summer or early fall. These conditions develop in golf greens that are constructed with large quantities of sand with good drainage and in greens that have poor soil drainage.

Symptoms of summer decline are thinning and poor growth of bentgrass following extended periods of hot weather and too much water in the soil. The grass becomes weak and does not recover very well from the condition. The tops of the plants look normal in early stages of the disease, but the roots are weak or have died and do not grow. The plants continue to die from what looks like dry wilt even with good soil moisture and proper maintenance. Eventually all the grass may die except in recent aerifier holes.

Pythium species are usually isolated from the affected plants which has given the name Pythium root rot. These Pythium species are different from the ones that cause Pythium blight. Pythium blight usually starts as small spots and kills the tops rapidly and spreads quickly over the greens. The root-rot-type fungi have been identified as Pythium graminicola. The fungi have been found in the roots of bentgrass during all times of the year. These fungi apparently do not cause much disease unless the plants are weakened by some other stress. The major stress factor to the roots in summer decline is excessive soil moisture which causes a deficiency of oxygen in the soil. These conditions weaken or kill the roots and then the Pythium root rot type of fungi can kill or prevent new roots from growing. Pythium root rot has been difficult to control with fungicides that can be used to control Pythium blight. The fungi have been isolated and tested against fungicides in the laboratory. The fungi are not sensitive to Subdue, and are not very sensitive to Banol, Alliete and Terraneb SP. These fungi are sensitive to Koban in laboratory tests and this fungicides has given some control on greens.

Too much water and the lack of oxygen in the soil can occur in greens contructed with sand or in poorly drained soil if greens are irrigated too much and during periods of wet weather. Roots in all sand greens are actually growing in the water around the sand particles, and the greens are often too wet although water drains through them rapidly. Nutrients are leached rapidly from the sand resulting in low nutrients levels, especially potassium, which is often associated with summer decline. Phosphorus can also leach through sand and low levels of the nutrient have been found in the high sand content greens. Nutrient levels are usually very low in the top one to two inches of the sand during the summer unless nutrients are applied regularly. I suggest taking soil samples throughout the summer about one to two inches deep because that is the depth of most of the roots on bentgrass during the summer stress period. High soluble salts have been associated with the problem also. As water evaporates from the soil surface, salts may be concentrated around the crowns of the plants. The salts have occurred on poorly drained and well drained greens during dry weather when the greens are allowed to dry to prevent diseases.

When the soil is too wet and the nutrient levels are low during periods of hot weather, the roots will drown and die or become very weak quickly. It is reported in the literature that bentgrass roots do not grow when the soil temperatures are above 80 degrees. It is common to find soil temperatures of more than 90 degrees in the top 2 inches of soil on golf greens during the summer when day time temperatures are in the 90's. The first indication that a problem is developing is a bad odor in the soil. This odor is from anaerobic decomposition of organic matter and the formation of sulfur containing compounds in the soil by microorganisms that can grow at low levels, or lack of, oxygen in the soil. Substances that are produced by these microorganisms may be toxic to the roots of the bentgrass and cause additional damage to the roots.

The black layer that has received much publicity in all sand greens is reported to be composed of sulfur compounds or algae. This layer forms 2 to 3 inches deep in sand greens that remain too wet and can be seen due to the light color of the sand. I think a similiar layer forms in greens that have dark soil or a lot of organic matter but it cannot be seen easily. The bad odor is associated with both types of greens and is caused by anaerobic conditions in the soil. Some algae and bacteria can grow in the anaerobic conditions and the algae may even produce substances that fill the pores in the soil mixtures and reduce drainage. Another factor associated with the problem on older greens is a hardpan that has developed about 3 inches deep in the soil. This layer is apparently caused by aerifyer tines penetrating to this depth and compacting the soil at the tips. The layer prevents the normal movement of water deeper into the soil and may cause the top 3 inches of soil to hold more water than normal. Roots will not grow through this layer easily which results in a shallow root system. Poor air movement around greens is also associated with greens on which the problem first develops.

Since the primary cause of the problem is too much water in the soil, management practices that provide good soil aeration and proper soil moisture will be the best solution. Irrigation pracitices should include hand watering of high dry areas to avoid to much water in lower areas of the greens. Increased aeration can be provided by using proper size sand during construction and top dressing, normal and deep aerification methods as needed and careful management of irrigation water. Summer aerification with small tines and leaving the holes open before the grass begins to decline or when the bad odor is detected in the soil has been the best treatment to prevent the problem or to help the bentgrass recover. Weeds have not been a problem following aerification if the soil cores are removed and a good preemergence herbicide has been used. The new deep aerifyers can be used to break the hardpan layer and help improve drainage deeper into the soil. The fungicides Koban and Fore have helped control the disease in some cases. I suggest using Koban in a Pythium control program to help control Pythium root rot. This fungicide seems to work best when applied in about 5 gallons of water per 1000 square feet and not watering it into the soil. The fungicide Fore has given some control and helps control algae and brown patch which are often associataed with the problem. I suggest fertilization with at least one half pound of potassium and phosphorus per month in the spring, summer and fall if soil tests indicate these nutrients are low. This fertilization program will help to maintain the proper level of potassium and phosphorus in the upper two inches of the soil or sand where most of the roots will be growing during the summer. The amount of potassium added should be based on soil test results to avoid a problem with high soluble salts. Soil tests from soil samples that are taken about 1 1/2 inches deep during the summer are the best to indicate the need for these nutrients. The application of small amounts of nitrogen, less than 1/4 pound per 1000 square feet, has helped some greens recover, especially on very sandy greens.

Improvement of air movement around greens by removing nearby undergrowth or trees has helped reduce the severity of the disease in many cases. The most expensive and possbily the best solution to the problem may be to rebuild the greens to proper specifications. If greens are rebuilt, a management program that emphasizes proper aerification, irrigation and fertilization is still needed to help prevent Phytium root rot, summer decline or black layer whichever you prefer to call it.

SPRING DEAD SPOT RESEARCH

L.B. McCarty and L.T. Lucas
North Carolina State University
Raleigh, NC 27695

Spring Dead Spot (SDS) is the most important disease of bermudagrass in the northern range of its adaptation in the United States and Australia. Previous research has yielded little management and control information for turf growers. Smith and Endo of Australia and California, respectively, have suggested that the organisms Leptosphaeria korrae and L. narmari are involved with SDS. Other organisms have also been reported associated with SDS, thus complicating the identification of the actual causal agent.

SDS control in North Carolina has been obtained following an October - November treatment of benomyl (Tersan 1991) at high rates of 6 to 8 oz. per 1000 ft^2. This is an expensive treatment: therefore, it is usually practiced only on putting greens and tees. The Elanco Company has recently labelled fenarimol (Rubigan) for SDS control with treatment either at 1 oz/1000 ft^2 in September, or 1.5 oz/1000 ft^2 in October, or 2.0 oz/1000 ft^2 in November. It should be noted that at the time of this writing, little university testing has been released to confirm this control.

Due to the delayed winter dormancy of SDS affected bermudagrass and winter-kill-like symptoms of SDS in the spring, some researchers believe that the disease may be predisposing the grass to low temperature kill. Increasing winter hardiness by the use of fungicides and certain fertilization programs may help to prevent this low temperature related damage. The use of higher rates of potassium fertilizers may have reduced the severity of SDS in recent years.

Current Research at NCSU:

A. Isolation Attempts. Previous isolation attempts of the SDS causal agent have been unsuccessful in the southeastern U.S. Due to the reported slow growing nature of Leptosphaeria spp., most isolations are soon contaminated with other organisms. Ideally, selective media would help to suppress these other organisms while allowing the principal fungi to grow. Other researchers have planted wheat in SDS-affected bermudagrass because of wheat's high susceptibility to Leptosphaeria spp. The pathogen actively grows on the wheat roots and then transferred to media for isolation.

Current isolation attempts in NC involve using several selective media that have been reported in the literature as well as several new ones. Isolations are being made from wheat roots, directly from infected bermudagrass roots, and from spores on moist-chamber grown bermudagrass. Three potential organisms have been isolated at NCSU. Pathogenicity of these organisms are currently being tested by inoculating greenhouse-grown Tifway bermudagrass. Several temperature regimes will be used to grow these inoculated plants. If reproducible SDS symptoms result, this will prove if one or more of these isolates are involved with the disease.

B. Fungicide/Fertility Interactions: Due to the previously mentioned belief among some researchers that certain fungicide/fertilizers may reduce SDS-associated low temperature kill, tests have been initiated at the Turf Research Center at NCSU. These tests are in cooperation with Dr. J.M. DiPaola. Tifway bermudagrass was treated with the following:

Fungicide	oz/1000 ft²	Fertilizer	lb ai/1000 ft²
Tersan 1991	8	K_2SO_4	3 + 2
Cleary's 3336	8	SCK	3 + 2
Rubigan	2	KCL	3 + 2
PGR IV	10 oz/A	SCU	1 + 1
Banner	6	Check	---
Prograss	2		
Check	---		

Split fertilizer applications were made in mid-October and mid-November. Fungicides were applied in late October. From these treatments, plugs are taken and placed in a low temperature stress simulator (LTSS) for the following periods, 27 F for 5 h + 23 F for 4 h. The plugs are then placed in a greenhouse for 30 days and regrowth yield weights are recorded. Low temperature runs have been made for late fall and winter periods with an early spring run being planned. Hopefully, results will show whether these fungicides and fertilizers and their interactions are influencing winter survival. Stolon hydration and protein levels are also being studied to see if these are influenced by the chemical treatments and if these relate to low temperature survival.

Other low temperature survival tests are also being conducted monthly on plugs from SDS and non-SDS areas. These plugs are from two golf courses in NC. The objective of this research is to determine if artificially induced low temperatures have any influence on SDS survival throughout the winter months. If the low temperatures induce abnormal kill levels for SDS plugs, this will help researchers determine the importance of the SDS/winter damage interaction.

C. Control. With the introduction of several new fungicides, the potential for a more economical SDS control is being investigated. Three golf courses have been treated with the following:

Treatment	oz/1000 ft²	Fertilizer	lb ai/1000 ft²
Tersan 1991	8	K_2SO^4	3 + 2
Cleary's 3336	8	SCU	1 + 1
Bayleton	4	Check	---
Banner	6		
PGR IV	10 oz/A		
Rubigan (Sep,Oct,Nov)	1,1.5,2		
Prograss	2		
Check	---		

These experiments are located at Walnut Creek CC in Goldsboro, NC, Mr. Lewis Clark, Supt.; Goodyear Golf Club in Danville, VA, Mr. Mark Vaughn, Supt.; and Shoal Creek CC in Birmingham, AL, Mr. Jim Simmons, Supt. Only the October Rubigan treatment was included at Shoal Creek. Fungicides were applied in October while September and October fertilizer treatments were made.

Prograss is a herbicide that was included because it induces early bermudagrass dormance and, thus, may help the grass escape early infection by the SDS pathogen. PGR IV is a root growth promoter which may increase bermudagrass root vigor, thus overcoming disease damage.

These treatments will be evaluated in the spring as new growth resumes. Evaluation will consist of SDS numbers and diameters.

Future Research

Attempts to isolate a causal agent and show pathogenicity will continue using various techniques and selective media. Fungicide control results and interactions with low temperature kill will be evaluated and continued as determined by the researchers involved. If a specific causal agent is found, this will speed up laboratory screening of fungicides for control and allow for studies on disease development and dissemination.

SOIL DRAINAGE

Jerry Queen
Catawba Valley Technical College
Hickory, NC 28601

Soil drainage is not new to the agricultural industry. Records indicate that as early as 400 B.C.,the Egyptians used systems similar to those used today to improve agricultural production. These similar systems were first used in the United States in the mid 1800s to control water movement in New York City's Central Park, successfully draining nearly 900 acres!

Because of the extensive use and construction of large recreational areas, excessive amounts of natural soils are removed, disturbing the natural drainage of the remaining soils. If these conditions remain unchecked, unhealthy turf and eroded conditions will prevail with additional loss of topsoil and plants.

Maintaining a balance between soil minerals, air, and water for ideal plant conditions should represent 50% minerals, 20% air, and 30% water. If excessive amounts of air replace the moisture level, conditions may become too dry for plant life causing the plant to wilt. When these conditions are reversed and there is less air in the soil, an excessive moisture level is produced. Then the soil is too saturated to support healthy plant life. These conditions retard plant growth by excluding air from the root zone and by increasing the environmental conditions for disease organisms such as pythium. Saturated conditions also delay the use of areas for recreational activities and management practices, cause compaction in high traffic areas, and prevent the use of maintenance vehicles such as aerifiers, mowers, and other vehicles.

Waterlogged soils should be artifically drained if they are incapable of adequate internal drainage. If properly designed, a subsurface drainage system benefits the soil and the plant conditions. Well drained soil warms up quicker which allows earlier use. It also speeds up maintenance operations, reduces the possibility of soil erosion, and increases the quality of the air in the soil.

Turfgrass Cultivars

Art Bruneau
North Carolina State University
Raleigh, North Carolina

Planting adapted turfgrass species and cultivars is one of the best ways to insure good turfgrass performance. The turfgrass work group at North Carolina State University has established and maintained a number of turfgrass trials across the state to help determine which grasses are best adapted for the state. The following tables summarize the 1986 results for some of these trials.

TURF-TYPE TALL FESCUES

Tall fescue is the predominant specie grown in North Carolina. Efforts have been underway to develop improved cultivars that possess finer leaf texture, improved disease tolerance and better heat and drought tolerance compared to K-31 tall fescue.

Test locations include Raleigh, Asheville, Charlotte, Goldsboro and Hampstead. The seeding rate was 5 pound per 1000 square feet and clipping height of 2 1/2 inches. Plots in Charlotte, Asheville, Goldsboro and Hampstead were maintained under low maintenance conditions whereas the plots in Raleigh were mowed regularly, watered to prevent drought and fertilized in the spring and fall with a complete fertilizer to total 2 pounds of N per 1000 square feet.

The turf quality performance data for 1986 is presented in Tables 1, 2 and 3. The top performers in Raleigh include Adventure, Apache, Arid, Falcon, Finelawn 1, Finelawn 5GL, Jaguar and Rebel. It is interesting to note that Adventure was the top rated cultivar in earlier studies.

Turfgrass quality ratings of all cultivars in the low maintenance trial at Asheville can be considered minimally acceptable. Many of the cultivars performed similar to K-31 at low maintenance trials in Asheville, Charlotte and Goldsboro.

Adventure, Clemfine, Falcon, Olympic and Rebel outperformed K-31 at Hampstead in a sandy, shady location. The mixtures of tall fescue with Kentucky bluegrass and hard fescue outperformed monostands of the tall fescue cultivars. These differences were not as evident in the shade trial in Raleigh. The moderating effect of shade cover, good air movement, high tree canopy, proper management practices and no traffic are some of the reasons for the persistence of the cool season grasses at Hampstead.

FINE-LEAF FESCUES

Fine-leaf fescue, a generic term to include chewings, creeping red and hard fescues have been evaluated in Raleigh since 1978. A national fine-leaf fescue trial was established during the Fall of 1983 and included 46 cultivars. The cultural procedures were the same as the tall fescue trials. In addition, this trial was established near Asheville in 1983 under minimum maintenance. Table 4 summarizes the 1986 results for the trials located in Asheville and Raleigh.

For many years, the fine-leaf fescues have performed poorly in the Raleigh area, becoming thin and clumpy in a short time. Several of the varieties in the national test have followed this trend especially the chewings and creeping red fine fescues. However, many of the newer entries have excellent stands after three years. The top performer in Raleigh was Spartan hard fescue whereas SR 3000 hard fescue was the best performer in Asheville under minimum maintenance conditions. Overall, the hard fescues have outperformed both the creeping red and chewings fescues whereas the chewings fescues have performed better than the creeping red fescues.

PERENNIAL RYEGRASSES

A national perennial ryegrass trial was seeded in the Fall of 1982 at 5.5 pounds pure live seed per 1000 square feet. The 53 entries in this trial are being maintained at a 2 inch cutting height and receive 2 pounds N per 1000 square feet per year as split applications of one pound in September and February. Table 5 summarizes the turf quality scores for 1986.

The top performing perennial ryegrass cultivars are Citation II, All *Star and Pennant. It should be noted that cultivar performance can fluctuate dramatically within a growing season. Ryegrass cultivars have been thinned in the summer due to high temperatures and disease and recover remarkably fast in the Fall as temperatures cool.

Use of blends and mixtures is encouraged whenever possible to insure good performance over a wide range of conditions. Contact your local agricultural extension office for assistance in determining which blend or mixture would perform best in your area.

Table 1.

National Tall Fescue Trial, 1984-1986.

Entry[1]	Turf Quality[2] Asheville	Raleigh
Finelawn 5GL	5.2	7.6
Rebel	5.2	7.4
Jaguar	5.1	7.4
Apache	5.0	7.6
Arid	5.0	7.6
Olympic	5.0	7.2
Ky31	4.9	6.5
Maverick	4.9	7.1
Tempo	4.9	7.1
Clemfine	4.8	7.2
Brookston	4.7	7.2
Chesapeake	4.7	6.7
Falcon	4.7	7.4
Johnstone	4.7	6.9
Adventure	4.6	7.6
Finelawn I	4.6	7.3
Houndog	4.6	7.2
Kenhy	4.6	5.8
Mustang	4.6	6.9
Barcel	4.5	6.3
Bonanza	4.5	7.1
Williamette	4.5	7.1
LSD	0.5	0.3

1 Seeded 9/83 at 5 lbs/M.
2 Turf quality on a 1 to 9 scale, 9=best, 5=minimally acceptable.

Table 2.

Turf Type Tall Fescue Trial, 1986.

Entry[1]	Turf Quality[2] Charlotte	Goldsboro	Hampstead 1985	Hampstead 1986	Hampstead '85+'86
Ky31	5.8	4.0	5.0	5.0	5.0
Mustang	5.4	4.6	---	---	---
Finelawn I	5.3	4.8	---	---	---
Jaguar	5.2	4.1	---	---	---
Rebel	5.1	4.0	5.3	6.2	5.5
Apache	5.1	4.7	---	---	---
Astro	5.1	3.7	---	---	---
Falcon	4.9	4.6	5.4	5.5	5.5
Cimarron	4.7	4.7	---	---	---
Mohave	4.4	4.4	5.6	6.1	5.8
Olympic	4.3	4.3	5.2	6.0	5.4
LSD	1.2	2.1	0.4	0.6	0.3

[1] Charlotte and Goldsboro trials were seeded on 10/85 at 5 lbs/M and maintained under low conditions. Hampstead was seeded on 10/84 at 5 lbs/M.

[2] Turf quality on a 1 to 9 scale, 9=best and 5=minimally acceptable.

Table 3.

Tall Fescue Cultivar Performance under Shade 1986, Raleigh, NC.

Entry[1]	Turf Quality[2] 1985	1986
Rebel	6.7	6.5
Reb/Kbl/GL/Penn 80/5/5/10	6.0	6.0
Reb/Kbl/GL 90/5/5	6.0	6.0
Reb/Kbl/GL/Reliant 80/5/5/10	5.9	6.2
Falcon/Kbl 80/20	5.8	5.3
Ky31/GL/NW/Kbl	5.7	5.7
Ky31/GL/NW/Kbl	5.6	5.7
Reb/Kbl/GL	5.6	6.2
Houndog	5.3	5.7
Rebel/Kbl 90/10	5.3	5.7
Falcon	5.3	7.2
Houndog/Kbl 80/20	5.0	6.0
Rebel/Kbl 80/20	5.0	5.7
Ky31/Kbl 80/20	4.8	5.5
Reb/Kbl/GL/EN 80/5/5/10	4.7	4.8
Ky31/Kbl/GL 80/10/10	4.7	5.0
Ky-31	4.6	5.7
Ky31/NW/CR/CH/CA	4.4	4.7
BR/VI/BAN/JAM/BIL	4.2	5.2
Ky31/Kbl 90/10	4.2	5.3
Ky31/Kbl/GL 90/5/5	4.1	4.5
LSD	NS	2.5

[1] Seeded 10/21/82 at 5 lbs/M. Mean irradiance at noon $Em^{-2}S^{-1}$.

[2] Turf quality on 1 to 9 scale, 9=best, 5=minimally acceptable.

BAN=Banner, BIL=Biljart, BR=Bristol, CA=carpetgrass, CH=Chewings fescue, CR=creeping red fescue, EN=Ensylva, GL=Glade, JAM=Jamestown, Kbl=Kenblue, NW=Newport, Penn=Pennlawn, Reb=Rebel, VI=Victa.

Table 4.

NATIONAL FINELEAF FESCUE TRIAL 1984-1986.

ENTRY[1]	TURF QUALITY ASHEVILLE	TURF QUALITY RALEIGH
ST-2 HF (SR 3000)	(6.3)	6.4
Spartan HF	6.2	(7.4)
Reliant HF	6.1	6.7
Biljart HF	5.9	5.3
Enjoy CH	5.9	5.5
Scaldis HF	5.9	6.8
Center CH	5.7	5.3
Waldina HF	5.7*	5.9
Aurora HF	5.6	6.5
Jamestown CH	5.4*	5.4
Victory (CF-2) CH	5.4	6.2
Highlight CH	5.3	4.5
Waldorf CH	5.2*	5.8
Checker CH	5.0	5.4
Pennlawn CR	5.0	5.0
Banner CH	4.9	5.3
Ensylva CR	4.9	5.1
Shadow CH	4.9	5.7
Koket CH	4.8	5.0
Flyer CR	4.6*	5.8
Ruby CR	4.6	5.1
Atlanta CH	4.5*	5.3
Boreal CR	4.5	5.5
Wintergreen CR	4.5*	3.6
LSD	0.4	0.4

[1] Seeded 10/83 at 5 lbs/M.

[2] Turf Quality on a 1 to 9 scale, 9=best, 5=minimally acceptable. Velvetgrass infested, reseeded '85.

[3] ()=highest value for given parameter.

* Special Note

Table 5.

National Perennial Ryegrass Evaluation Trial, 1984-1986, Raleigh, NC

Entry[1]	Turf Quality[2] Nov 84	Sep 85	Dec 86	Mean
Citation II	6.0	6.0	6.7	6.6
Allstar	6.0	7.0	6.3	6.6
Pennant	5.3	6.0	7.0	6.6
Blazer	5.0	5.7	4.7	6.3
Delray	5.0	5.6	6.0	6.3
Premier	5.7	7.0	5.7	6.3
Birdie II[3]	5.3	5.7	6.3	6.2
Gator	5.3	6.0	6.0	6.2
Palmer	4.7	5.0	6.3	6.1
Dasher	5.0	6.3	6.0	6.1
Birdie II	4.3	6.3	6.3	6.1
Allstar[3]	6.7	4.3	5.7	6.0
Prelude	6.0	4.3	6.3	6.0
Derby	4.7	5.7	6.0	6.0
Ranger	4.7	4.7	5.0	6.0
Regal	5.0	5.3	4.3	6.0
Pennfine	4.7	5.3	6.3	6.0
Cowboy	6.3	5.7	6.3	5.9
Ovation	5.3	4.3	5.3	5.9
Manhattan II	5.3	6.3	6.7	5.9
Barry	4.0	4.3	6.0	5.8
Elka	4.0	5.0	6.3	5.7
Citation	3.7	4.3	4.7	5.5
Omega	4.0	4.7	6.0	5.5
Tara	4.7	3.0	5.3	5.5
Goalie	4.7	5.3	4.3	5.4
Manhattan	4.3	4.0	4.3	5.4
Crown	4.7	3.7	4.0	5.3
Diplomat	3.7	4.7	5.0	5.3
Fiesta	4.7	4.0	5.3	5.3
Yorktown II	3.7	3.3	3.7	5.3
Barclay	4.0	3.3	3.7	4.7
Caravelle	3.3	4.0	4.3	4.6
Linn	3.0	3.0	3.0	4.1
LSD	1.8	3.1	NS	0.5

[1] Seeded 10/82 at 9 lbs/M.
[2] Turf quality on a 1 to 9 scale, 9=best, 5=minimally acceptable.
[3] Sample received direct from seed producers.

TURF MANAGEMENT UNDER SHADE

Arthur H. Bruneau
North Carolina State University
Raleigh, NC 27695

Turfgrass, trees and shrubs are highly desirable in most landscapes because of their aesthetic charm and functional value. Plants are used for noise abatement, air purification, cooling, traffic control, as well as reduction of glare and temperature extremes. Frequently all three groups of plants grow in close association with one another in the landscape. According to a recent survey conducted by the North Carolina Crop Reporting Service, nearly 61% of the homeowners believed they had heavy to moderate shade.

Unfortunately, as most turf managers can attest, growing turfgrasses in the presence of trees and shrubs can be a formidable task since each plant group competes with the other for light, water and nutrients essential for growth and survival. In some instances, the difficulty of growing turf in the shade is associated with the desired effects of trees. When trees and shrubs are used to provide screening and privacy, they determine wind direction and control and reduce solar radiation which is often detrimental to the growth of turfgrasses. Even so, there are certain steps that managers can take to optimize the performance of turf growing in shaded sites.

PROBLEMS ASSOCIATED WITH SHADE

Tree leaves can substantially reduce the amount of sunlight reaching the turfgrass underneath the canopy. Light which does pass through the canopy is often of poor quality and inefficient for photosynthesis. Plants growing in very dense shade typically use more energy than manufactured. Plant food reserves are drained and plants weakened.

The degree of density varies with the characteristics of the trees grown, their location in reference to one another, and the season. Maples, oaks and beeches are examples of trees possessing dense canopies that intercept most of the light. Some evergreens such as firs and spruces have very dense canopies but affect small areas of turf because of their narrow canopy. Other trees such as pines, poplars, ash and birch produce more open shade compared to maples and oaks. Areas with trees closely spaced or with an understory cast a very dense shade. Leafless deciduous hardwood trees can block out nearly one-half (50%) of the sunlight while the same trees in full leaf can block nearly 95% of the sunlight.

Roots of trees and shrubs also compete with turfgrasses for nutrients and water. Shallow rooted trees such as willows, maples and beeches are very competitive with turfgrasses. Most of the feeder roots of shade trees growing in clay soil are in the upper 8 inches of soil where you will also find most turfgrass roots.

It is known that some plants exude substances which can be toxic to other plants. Competition extends beyond the drip zone since tree roots can be found a considerable distance beyond this point. The reduction of light quantity and quality as well as the competitive nature of trees and shrubs for nutrients and water produce succulent, weak turfgrass plants which are slow to establish, susceptible to environmental stress, and unable to withstand traffic compared to plants grown in full sunlight. Turfgrasses growing in the presence of shade trees have an erect growth habit and reduced root and shoot density; long, thin leaves, tillers, stolons and rhizomes; high tissue moisture content; thin, weak cell walls; and shorter roots.

Environmental conditions associated with shade are conducive to disease development. Moderating temperatures and increases in relative humidity, caused by poor wind movement and reduced solar radiation, result in foliage remaining wet for extended periods of time. The presence of undergrowth, trees in close proximity to one another and low hanging limbs can greatly diminish wind movement. Although dew formation occurs less frequently in shaded sites compared to sunny locations, the duration is longer since the trees hinder drying. Wet foliage encourages disease infestations. This is especially true where soils are poorly drained. Weak, spindly plants are more susceptible to disease infection.

STRATEGIES FOR MANAGING TURFGRASSES IN THE SHADE

MODIFYING THE ENVIRONMENT. Turfgrasses will not grow in very heavy shade. If an area gets less than 50 % open sunlight or less than four hours of sunlight per day, there is usually too much shade for adequate turfgrass performance. Selective removal of trees, better referred to as shade removal, should be considered especially if existing trees are too closely spaced and their removal will not detract from the existing landscape. Use of ground covers such as ivy, liriope and pachysandra as well as pine bark and needles, crushed stone and woodchips should be considered as an alternative when shade is excessive. These ground covers are more attractive than thin turf. Ground covers, rather than turfgrasses, should be considered when shade exceeds 50%. They make good plantings on steep slopes or other inaccessible areas and complement the home lawn and landscape when properly selected and maintained. A publication, Ground Covers for North Carolina, AG-75, can be obtained from your County Extension office for helpful suggestions.

Removing the lower limbs of existing trees to a height of six feet and removal of unnecessary undergrowth will greatly enhance wind movement and reduce the potential of disease infection. Selective pruning of limbs from the crown of the tree will open the canopy and allow for more light infiltration. Removal of dead and diseased limbs can enhance the health and appearance of the tree provided pruning is done selectively and with care. Severe pruning should be avoided. Root pruning of tree roots will also aid in turfgrass performance; however, care must be taken not to seriously injure desirable trees. Maples, beeches and certain evergreens are very sensitive to extensive root pruning.

Proper tree selection and placement can help minimize turf loss. Trees that possess dense canopies and/or shallow root systems such as the willow, popular, ash and certain maples should be avoided in favor of more desirable species such as oaks, sycamores and elms. Contact your local Extension agent for a list of shade trees that perform best in your location.

GRASS SELECTION. Use of shade tolerate grasses can greatly enhance turfgrass performance in the shade. Research shade trials in North Carolina show that mixtures of "turf-type" tall fescue in combination with shade tolerant cultivars of Kentucky bluegrass such as 'Glade' (80%:20% by weight) are the best choices where cool season grasses can be grown (see Table 1). The addition of a fine fescue, specifically a cultivar of hard fescue such as 'Reliant', has proven beneficial in areas scheduled to receive little or no maintenance. In this instance, an 80% tall fescue/10% Kentucky bluegrass/10% hard fescue mixture by weight seeded at 6 pounds per 1000 sq. ft. would be the best choice. Other fine fescues such as the creeping and chewings fescues that perform well under low light intensities in other areas of the country are thinned by disease in North Carolina. Perennial ryegrass and 'Sabre' Poa trivialis have also performed poorly in shade trials in North Carolina.

St. Augustinegrass has proven to be the most shade tolerant of the warm season grasses followed closely by zoysiagrass. Zoysiagrasses, both Emerald and Meyer, are more widely used in North Carolina because of their superior cold tolerance compared to St. Augustinegrass. Centipedegrass and bahiagrass will perform well under light pine tree shade but are not as shade tolerant as St. Augustinegrass and Zoysiagrass. Bermudagrass is the least shade tolerant of the turfgrasses and should not be considered when shade is present.

CULTURAL PRACTICES. Keep in mind that shade tolerant grasses still prefer sunny locations. There is less room for error on the part of the manager because the turf being grown in the shade is often weaker compared to turf grown in full sun. Cultural practices must be altered to help insure survival and enhance turf performance.

Mow grasses at the top of their recommended mowing height range to enhance deeper rooting and allow for maximum foliage necessary for the manufacture of food. This is demonstrated in Table . Mixtures containing tall fescue should be mowed 4 inches high and St. Augustinegrass and bahiagrass mowed at 3 inches high. Centipedegrass and zoysiagrass should be mowed at 1 to 1-1/4 inches high. Mow frequently enought so that you are not removing more than 1/3 of the foliage at one time.

Turf in the shade should be fertilized at the same time and rate as that schedule for turf grown in the sun. The uptake of nutrients by trees and shrubs compensates for the low fertilization requirements associated with grasses growing in the shade. Turf fertilization is not harmful to trees and shrubs and may actually prove to be beneficial. Fertilizers associated with turf such as 12-4-8 and 16-4-8 can be used to meet the requirements of trees and shrubs precluding the possibility of a nutrient deficiency. (This can be confirmed by submitting a soil sample to the NCDA Soil Testing Lab in Raleigh.) Tree fertilization recommendations that exceed turfgrass recommendations as far as rate and timing should be either soil injected or drill cored. This will reduce the amount of area affected and minimize the potential for turf injury or loss. Keep track of the total amount of fertilizer applied to a given area so that you don't exceed the total recommended amount for any plant. This may occur in situations where different parties are responsible for trees, shrubs and turf and communication is less than ideal.

Turf should be watered infrequently and deeply to encourage deep rooting of trees and turf, reduce soil compaction and minimize the time interval that the foliage is wet. Wet foliage is conducive to disease development. Water in the early morning hours if at all possible to remove dew from the foliage and enhance drying of the foliage.

WEED CONTROL

Mosses, green plants with leaves arising from all sides of a central axis, are very competitive in cool, moist, shaded locations such as the north side of buildings and wooded areas. Conditions favoring the growth of mosses are low fertility, poorly drained soils, high soil acidity, excessively wet soils, soil compaction, excessive thatch or a combination of these factors that add up to thin weak turf. Physical or chemical removal will only be temporary unless growing conditions are improved. Following the turf management recommendations discussed in this article will help. Moss can be controlled with copper or ferrous sulfate sprayed at 5 ounces per 1,000 square feet in 4 gallons of water. Applying concentrated amounts (10 ounces per 1,000 square feet) of ferrous ammonium sulfate to the moss spots when the moss is damp offers another means of control. An application of 5 to

10 pounds of ground limestone per 1,000 square feet prior to reseeding will help to inactivate the copper sulfate that may be toxic to seedlings. Physical removal of the moss by raking may be needed to allow for recovery.

Crabgrass and goosegrass need high light intensity in order to germinate. For this reason, the use of preemergence herbicides is not required in heavily shaded areas. Care should be taken when applying broadleaf week controls since some herbicides such as dicamba can cause injury to trees and shrubs either from root uptake or spray drift. Read and follow label directions.

Table 1. Turf quality evaluations for cool season turfgrasses grown under shaded conditions in Raleigh, NC

Entry	1983	1984	1985	1986
Rebel	6.7	7.1	6.7	6.5
80 Rebel/10 Kenblue/ 10 Glade	6.6	6.8	5.6	6.2
80 Rebel/20 Kenblue	6.4	5.6	5.0	5.7
K31	6.3	5.3	4.6	5.7
Bluegrass/Fine Fescue*	5.7	4.7	4.2	5.2
LSD	0.3	0.6	NS	2.5

*Bristol Kentucky bluegrass; Banner, Jamestown and Biljart fescue.

Table 2. Influence of cutting height on the turf quality of cool turfgrasses grown under shaded conditions.

Cultivar		Cutting height 6.4 cm	3.8 cm
Rebel/Kenblue/Glade/Reliant	(80/5/5/10)	7.3	6.9
Rebel/Kenblue/Glade	(90/5/5)	7.0	6.5
Rebel Tall Fescue		7.0	6.5
Rebel/Kenblue/Glade/Pennlawn	(30/5/5/10)	7.0	6.4
Rebel/Kenblue/Glade	(80/10/10)	6.9	6.3
LSD		0.4	

*Turf quality ratings on a 1 to 9 scale, with 9 = best.

TRANSPLANTING BERMUDAGRASS SOD DURING THE DORMANT SEASON

J. M. DiPaola, D. L. Rose, D. C. Smith and W. B. Gilbert
North Carolina State University, Raleigh, NC

In much of the southern United States construction projects are completed throughout the year. New homes and businesses that open during the winter could benefit from the availability of bermudagrass sod. The use of sod during the off-season would control the mud and dust around buildings and enhance their use. The harvest, transport and installation of dormant bermudagrass sod would also extend the producer's production period.

Bermudagrass survival when transplanted during the off-season is dependent upon overcoming several obstacles including, winter desiccation, low temperature injury and traffic damage. Desiccation is a substantial problem because dormant transplanted sod has a restricted root system for an extended period. The warm, dry winds of late-winter and early-spring increase the draw of water from the turfgrass shoots. The combination of low soil temperatures and a limited sod root system impairs the plant's ability to supply adequate water to the shoot despite the demand resulting from warmer air temperatures and wind.

Low temperature kill of bermudagrass dormant sod would tend to be more visible and injurious than that of well established turf. New bermudagrass sod lacks rhizome development to any significant depth in the soil. The presence of rhizomes insulated within the soil beneath a turf can permit bermudagrass recovery following the exposure of crowns and stolons to lethal low tempertures. In a similar manner, dormant sod lacks deep rhizomes for recovery from traffic damage.

Sod producers often rely on the rhizomes that remain after harvest for the re-establishment of the bermudagrass field. Removal of sod during the late-fall and winter period would expose the remaining rhizomes to lower soil temperatures because the insulating effects of the sod were removed at harvest. The remaining bare soil surface is also an ideal setting for the development of many winter weeds. As one might expect, the risks of dormant sodding are increased for locations closest to the northern extremes of bermudagrass adaptation.

Studies were initiated during 1984 at the North Carolina State University Turf Field Center (Raleigh, NC) to determine the feasibility of transplanting dormant bermudagrass sod. Efforts were particularly directed toward assessing the impact of installation timing, and chemical and cultural treatments on the survival and knitting of sod transplanted during the off-season.

Cultural and chemical treatments applied prior to harvest to enhance rooting included potassium fertilization and applications of the plant hormone indole butyric acid (IBA). Gibberellic acid (GA), another plant hormone, was used to prolong fall color retention, while raised mowing height was included to minimize winter desiccation and low temperature injury. Treatments at or after sod harvest included the use of the antitranspirant abscisic acid (ABA) to reduce desiccation; IBA, potassium and increased sod harvest depth to promote root growth; and annual ryegrass overseeding to help anchor the sod and provide increased insulation. Sods were harvested and transplanted approximately monthly from September through March. Both Tifgreen and Tifway bermudagrasses were studied.

To determine the degree of establishment and knitting of the dormant transplanted sod, a metal frame was placed beneath each sod installation plot. Sod root strength was determined the following spring by measuring the force needed to pull each frame (with the sod above) from the soil. Rooting depth was taken as the distance from the metal frame to the point of breakage following each sod pull.

Despite exposure to record low temperatures in Raleigh (-8°F, January 1985), all sod survived dormant transplanting. Turf survival was equivalent among cultural and chemical treatments included in this study. However, less healthy stands of bermudagrass may well experience injury, while these well maintained turfs survived.

Bermudagrass spring greenup was influenced by the date of sod transplanting. Sod transplanted in early-fall (September and October) was first to greenup, while that harvested in late-fall (November and December) were last (Table 1). This response was transitory, as most plots were of equal turf quality by mid-May. Root strength was weakest for late-fall harvested sod. Some rooting of early-fall transplants had occurred and may have contributed to their improved spring performance compared to sod installed later in the fall. Tifgreen spring greenup preceded that of Tifway bermudagrass, otherwise Tifgreen bermudagrass responses were similar to that of Tifway.

Spring root strength (June) following late season sod installation was best for early-fall harvest dates that had achieved some knitting compared to late-fall sodding (Table 2). The root strength of sod transplanted during the early-fall was equivalent to that found for late-winter and early spring treatments which were harvested after winter's coldest temperatures. So, even though no turf injury was visible, these data suggest that some low temperature damage to late-fall sod treatments had occurred.

With the exception of ABA (antitranspirant) and annual ryegrass overseeding (7 lbs/1000 ft^2), cultural and chemical treatments, regardless of timing, did not influence the spring root strength of off-season transplanted bermudagrass. The antitranspirant, ABA, tended to have a negative impact on bermudagrass spring root strength. Annual ryegrass overseeding (over the top) at the time of sod transplanting reduced the spring root strength of both bermudagrass cultivars studied. Overseeding with annual ryegrass resulted in a 36% decrease in the spring root strength of Tifway bermudagrass (control (299 lbs/ft^2) vs overseeded (190 lbs/ft^2) pull force). Overseeding Tifgreen resulted in a 19% decrease in the spring root strength (control (338 lbs/ft^2) vs overseeded (274 lbs/ft^2) pull force). Depth of sod harvest did not influence bermudagrass root strength the following spring.

Rooting depth responses to treatments were similar to those observed for spring root strength. Rooting depth was not influenced by cultural or chemical treatments regardless of the time of application.

Bermudagrass regrowth in sod fields that were harvested prior to soil low temperature extremes (January) during the dormant season was poor (Table 3). Tifway fields harvested from September through December had 67% of the plots infested with weeds, compared to only 6% infestation for plots harvested in February or March. The former plots had 54% bermudagrass regrowth cover by May, compared to only 5% bermudagrass cover for the latter series of plots. This poor bermudagrass regrowth is most likely due to the exposure of residual rhizomes to low temperatures and competition from the various weedy species infesting the area. A similar response was observed for Tifgreen bermudagrass.

The survival of dormant transplanted Tifgreen and Tifway bermudagrass sod clearly removes much consumer concern in the adoption of this practice. However, the unacceptable regrowth of harvested sod fields demonstrates a risk to the sod producer. This practice might increase the cost of sod to cover field re-establishment expenses following bermudagrass sod harvest during the off-season.

Table 1. Spring Greenup of bermudagrass sod following dormant sod installation 1984-1985.

Installation Date'	Tifway		Tifgreen	
	2 Apr	24 Apr	2 Apr	24 Apr
	- - - - - - - % green shoots - - - - - - -			
Sep, Oct vs Nov, Dec	10 > 4	71 > 52	27 > 6	71 > 26
Sep, Oct vs Feb Mar	10 > 3	71 > 52	27 > 8	71 > 45
Nov, Dec vs others	4 < 6	52 = 59	6 < 16	26 < 55
Feb vs Mar	5 > 2	59 = 48	9 = 7	43 = 45

' Comparison means denoted with = are statistically equivalent, while those with < or > are significantly less or greater, respectively.

Table 2. Root strength of bermudagrass sod in June following dormant sod installation 1984-1985.

Installation Date	Tifway	Tifgreen
	- - - - Sod pull force' - - - -	
Sep vs Oct	301 = 309	347 = 309
Sep, Oct vs Nov, Dec	311 > 276	328 > 223
Sep, Oct vs Feb Mar	311 = 299	328 = 303
Nov, Dec vs others	276 < 305	223 < 313
Feb vs Mar	330 > 282	317 = 297

' Comparison means denoted with = are statistically equivalent, while those with < or > are significantly less or greater, respectively. Units are expressed in lbs/ft^2.

Table 3. Weed encroachment and regrowth of bermudagrass harvest sites during May following dormant sod harvest in 1984-1985.

Installation Date	Tifway Site		Tifgreen Site	
	Weeds	Bermuda	Weeds	Bermuda
	- - - - - -	% Cover'	- - - - - -	
Sep vs Oct	80 = 78	5 = 2	53 = 56	11 = 6
Sep, Oct vs Nov, Dec	79 > 54	3 = 5	55 > 34	9 = 15
Sep, Oct vs Feb Mar	79 > 6	3 < 54	55 > 6	9 < 65
Nov, Dec vs Feb, Mar	54 > 6	5 < 54	34 > 6	15 < 65
Sep, Oct, Nov, Dec vs Feb, Mar	67 > 6	4 < 54	44 > 6	12 < 65

' Comparison means denoted with = are statistically equivalent, while those with < or > are significantly less or greater, respectively.

ROOTING OF TURFGRASS SOD FOLLOWING PREEMERGENCE HERBICIDE APPLICATION

W. M. Lewis, J. M. DiPaola and A. H. Bruneau
Crop Science Department, North Carolina State University
Raleigh, NC 27695-7620

Landscapers may face the question whether or not the application of a preemergence herbicide will influence the establishment of a turfgrass sod following transplanting. To answer this we applied four preemergence herbicides below and on four turfgrass sods at transplanting to determine their effects on turf rooting. Application below the sod, we felt, would also give an idea on the effects of the herbicides on sprigging three of the turfgrasses. The herbicides, formulations, and rates were: bensulide (Betasan 7G) 12 lb ai/A, oryzalin (Surflan 4AS) 2 lb ai/A, oxadiazon (Ronstar 2G) 3 lb ai/A, and pendimethalin (Pre-M 60DG) 1.5 lb ai/A. The turfgrasses included centipedegrass, tall fescue/Kentucky bluegrass (a 50/50 mixture), Tifway bermudagrass, and Meyer zoysiagrass. The first test was conducted on a sandy clay loam soil and was initiated May 1, 1986. Sod root strength measurements were taken on June 17 (47 days after treatment). The second test was on a modified soil, somewhat similar to USGA golf green specifications, and was initiated July 2, 1986. Evaluations were made on August 15 (44 days after application). Both tests were irrigated frequently to encourage sod establishment.

Sod was laid over expanded metal frames, 1 x 1 ft, that were placed even with the soil and the sod was laid on top of the frames. The effects of the herbicides on root development were determined as the force required to lift the sod from the soil and termed root strength. Rooting depth was measured as the distance from the soil surface to the point of root breakage following each sod pull. Turf quality was rated visually on a scale of 1 to 9 with 9 being best and 5 considered minimally acceptable.

The turfgrasses had the greatest root strength, similar to the untreated sod, when oxadiazon was applied on top of the transplanted sod. Root strength values declined 22% for bensulide and pendimethalin and 60% for oryzalin. Root depth and turf quality were greatest for oxadiazon followed by pendimethalin and bensulide and least for oryzalin. With the exception of oxadiazon, placement of the herbicide below the sod was very detrimental to turf quality and root growth as measured by root strength and root depth. In the first test, root strength and depth was greatest for: centipedegrass and Tifway bermudagrass, intermediate for tall fescue/bluegrass and least for Meyer zoysiagrass. However, the tall fescue/bluegrass sod had the poorest development in the second test.

Additional treatments conducted at the same time and location as the second test included: benefin (Balan 2.5G) at 3 lb ai/A, pendimethalin (Pre-M 60DG) at 3 lb ai/A and prodiamine (an experimental herbicide) at 0.5 lb ai/A and 1 lb ai/A. The first three treatments performed similar to pendimethalin at 1.5 lb ai/A in the other tests.

On the basis of both tests oxadiazon, pendimethalin, or bensulide applied preemergence on top of newly laid sod of the four turfgrasses did not adversely affect root development and turf quality. Only oxadiazon could be applied with safety underneath a sod. This observation also supported the possibility of using oxadiazon when sprigging warm-season turfgrasses.

Centipedegrass, Tifway bermudagrass, and Meyer zoysia were successfully established with use of these three herbicides both in early and mid-summer. Tall fescue/bluegrass sod establishment was only successful in early summer when these herbicides were applied.

CENTIPEDEGRASS AND ITS PROBLEMS

Landon C. Miller
Horticulture Department
Clemson University

Centipedegrass (Eremochloa ophiuroides) came to the United States from Southeastern Asia. It is best adapted to the same area as St. Augustinegrass -- the lower Atlantic and Gulf coasts. Although distinctly less winter hardy than bermudagrass, it has survived 12 degrees F in Mississippi. Called "poor man's grass" because of its low management requirement, it needs little fertilization and mowing but is not as drought tolerant as other grasses.

Centipedegrass is not as fine-textured as bermudagrass and is not the species to grow in finely manicured lawns, but often it is more attractive than badly cared for fine-textured grasses. It would be foolish to use an intensive maintenance program on centipedegrass as it would probably result in complete loss of the lawn during the winter. Demonstrations have shown that heavy nitrogen fertilization causes severe winter injury problems.

THATCH

What is it? Thatch is an excessive accumulation of undecomposed surface organic matter. It is formed chiefly from the periodically sloughed roots, crowns, and horizontal stems (stolons) at the soil surface. Rate of thatch accumulation is a direct result of management practices which produce abundant vegetative growth without the proper or favorable conditions for decay.

How does it develop? A major factor is that each season centipedegrass grows new surface runners (stolons) abundantly. These runners replace live growth of the previous year, and as they grow over the top of the latter they develop new roots and crowns. Centipedegrass is strictly a stoloniferous grass. Below-ground runners (rhizomes) are not produced as in bermudagrass. If thatch decay does not keep pace with new growth, live runners are soon 2 inches or more above the soil line and exposed to the open environment where temperature fluctuations are much more severe than at the soil level, such as cold at night and warm during sunny days.

Another factor is nitrogen fertilization. Heavy nitrogen fertilization during the growing season increases vegetative growth and thereby thatch accumulation.

A third factor is mowing height. With high mowing through the growing season, the turf develops a heavy, loose cover. During the winter, this cover dies and forms a mat. This mat becomes part of the thatch layer as the next growing season progresses. As the tender portions (leaves) of the mat decay, older stolons and roots, which are more resistant to decay, add to the thatch layer. Lower mowing heights help prevent this heavy loose cover from forming. The best mowing height for centipedegrass is 1 to 1½ inches.

What problems does thatch accumulation cause? A major problem is winter injury.

Centipedegrass, at home in the tropics, has no natural winter rest period; thus, if temperatures remain mild, it will grow the year round. If temperatures in the fall drop fairly slowly and steadily, the grass will adjust and tolerate temperatures well below freezing for some time. In the South, however, intermittent warm spells occur with temperatures well in the growing range. But these brief warm periods are often quickly terminated by sudden cold spells. It is believed that these drastic temperature fluctuations can cause considerable winter injury. Even though no visible growth occurs during these mild periods, internally the plant cells activate enzymes responsible for growth. Invariably this increases cellular water uptake (hydration). When temperatures drop sharply to below freezing, ice crystals then form in these cells and rupture their membranes. Many nonhardy plants are killed this way, and centipedegrass is no exception.

In the Greenville area, in 1972 for instance, temperatures dropped from 64 degrees F on January 14 to 15 degrees F on January 15 to 7 degrees F on January 16. By January 20, the high was again 70 degrees F. Similar temperature fluctuations can easily be responsible for severe injuries. However, the closer to the soil the stolons can be maintained, the less susceptible they are to severe freezes. That's because temperatures above the thatch vary more than in the soil; low temperatures will be up to 10 degrees F lower and high temperatures will be 10 degrees F or higher, especially on clear days and nights. Although thatch buffers the soil below, it is responsible for increased temperature fluctuations above. Since centipedegrass only grows above the thatch layer, the potential for winter injury can readily be recognized.

Another problem develops on droughty soils. The bottom layers of grass do not decompose rapidly enough to allow the live top layers to settle down in direct contact with the soil. Since the top layer of live stolons is not in direct contact with the soil, it does not develop an adequate root system from the nodes along the stolons.

Combined with an accumulation of thatch is a loss of tolerance to drought conditions. When the root system of new stolons is primarily located in this thatch layer, it cannot use efficiently the soil water reservoir. Closely associated with the lack of adequate soil water is the problem of nutrient availability. Thatch, unlike soil humus, has a very low exchange capacity and therefore cannot hold a sufficient supply of nutrients. Also, if roots do not extend into the soil, available nutrients are not used.

Thatch Removal

You can control thatch with dethatching equipment and by mowing at the proper height. You may have to remove thatch once or twice a year while the grass is actively growing (early June and early August). Avoid hot, dry weather and keep turf moist after this operation to aid recovery. Dethatching machines should vertically groove the thatch layer at 1- to 1½-inch intervals and tear up part of the organic debris.

Dethatching should be done to the soil level in one or two directions, depending on the depth of the thatch layer. Afterwards remove all loose debris by rake, sweeper, blower, or vacuum.

A type of dethatching blade that is attached to the rotary mower in place of the regular blade seems to work satisfactorily if used with proper caution. Mounted on these blades are vertical spring teeth which loosen the thatch so that it can be removed with a sweeper, rake, or vacuum mower.

Thatch Control

Limit amount of nitrogen fertilizer to the level that promotes a moderate, continuous rate of growth. Continuous low mowing (1 to 1½ inches) will encourage live stolons to remain close to the soil surface. For proper vigor of the grass, it is important not to remove more than 50 percent of the grass height at any one mowing.

If you do not use the vertical mower or rotary thatching blade, lower periodically the mowing height (once during the early part of the growing season) to less than 1 inch to cut out dead grass along with live stolons which are not in direct contact with the soil. Rake up the debris and discard. Then raise the cutting height back to 1 to 1½ inches for the next mowing.

FERTILITY

Nitrogen promotes turf density, vigor, and increases green color. Centipedegrass is naturally rather light green. Do not overfertilize to equal bermudagrass color! This will result in severe winter injury.

Low to moderate amounts of nitrogen (½ to 1½ pound/1,000 square feet/year) are usually enough to maintain centipedegrass in good condition. The higher rate may be needed on very sandy soils with low nutrient-holding capacity. Making a late application of nitrogen delays proper hardening of the grass in the fall as protection against low temperatures.

If you use 50 percent water-insoluble nitrogen fertilizer (16-4-8), the application rate each time can be ½ pound N/1,000 square feet or about 3 to 4 pounds fertilizer per 1,000 square feet. With water-soluble nitrogen only, the ½-pound nitrogen rate/1,000 square feet will be adequate.

It is wasteful to fertilize centipedegrass too early in the year. Make the first application when the grass has made good recovery in the spring (May); otherwise much of the fertilizer may leach out before the grass can use it.

Make the last application no later than July or else the grass will grow too vigorously in the fall and may be killed by early frosts or low temperatures.

Phosphorus. Because phosphorus leaches slowly and centipedegrass needs only small amounts of this element, do not make repeated applications as with nitrogen and potassium.

On sandy soils low in buffer capacity, high phosphorus levels can cause nutritional problems. Medium to high amounts of phosphorus in the soil can tie up available iron necessary for proper grass color. Centipedegrass thrives best when phosphorus levels are kept medium to low.

Where high soil phosphorus is a problem, deep plow to mix the top layer of soil high in phosphorus with the lower levels of soil containing less phosphorus. This should be done only when the lawn is to be renovated or when a new lawn is to be planted. This, in effect, will dilute the phosphorus concentration in the root zone.

Where high phosphorus levels exist and the lawn is to be continued, omit all phosphorus from the fertilization program for several years or until soil tests indicate that it is needed again. Fertilizer, such as 14-0-14 or 13-0-44 (potassium nitrate), should be used during the interim.

Potassium leaches rather quickly, especially on sandy soils. So repeated applications are necessary to maintain a proper level in the soil for healthy plant growth.

Generally a 4:1:2, 4:1:3, 3:1:2, or 1:0:1 fertilizer ratio applied once a year is satisfactory to fill the K requirement. Other agricultural fertilizer grades such as 4-12-12, 5-10-10, or 3-9-18, are not suitable to use on centipedegrass unless soil tests indicate both phosphorus and potassium are low.

The P/K ratio (phosphorus to potassium) has been reported to be important in winter hardiness of grass. Low P combined with high K enhanced cold temperature tolerance; so the last annual application of a complete fertilizer should contain a fairly high level of potassium.

SOIL ACIDITY AND IRON DEFICIENCY

Centipedegrass is an acid-loving plant. It prefers pH values of 5.5 - 6.0. As the pH goes above 6.0, availability of iron (Fe) in the soil goes down. Thus, at high pH levels, the grass can at times show chlorosis because of iron deficiency similar to the symptoms created by high phosphorus. When the pH is too low, magnesium and calcium become limiting. With low soil test readings of magnesium and/or calcium at a low pH, a light dolomitic limestone application of 25 pounds/1,000 square feet is advised. Dolomitic limestone contains both calcium and magnesium. If the pH is high and magnesium (Mg) is low (L), use magnesium sulfate or sulfate of potash magnesium. Normal application rate of magnesium sulfate is 1 pound/1,000 square feet. Severe deficiencies of magnesium can be corrected with 2 pounds/1,000 square feet of Epsom salts. In cases where the potash is high, use only magnesium sulfate (Epsom salts).

The soil pH can be lowered by adding elemental sulfur or aluminum sulfate. Double check soil pH to be sure it is necessary to lower the acidity before using these materials. If the pH needs to be lowered, consult your county Extension agent, who has a soil and plant information sheet on lowering pH. Elemental sulfur will burn grass leaves.
Wash the sulfur off the grass leaves immediately with water after applying. Spread the sulfur as evenly as possible, using a drop-type spreader. Do not try to spread sulfur by hand over a large area.

Decreasing the pH is too slow a process to correct severe iron deficiencies. Thus, in addition to the sulfur treatments, spray iron sulfate or iron chelate on the turf to alleviate the iron chlorosis temporarily until soil acidity reaches proper level. Use iron sulfate at a rate of 3 ounces in 5 gallons of water per 1,000 square feet. In many cases iron can be used to "green up" the grass instead of applying more nitrogen.

Do not use basic slag, a liming material, to correct iron deficiency unless additional lime is needed. Basic slag may also contain iron, magnesium, and phosphorus.

EARLY SPRING YELLOWING

In early spring you may note yellow leaves in patches through the lawn. This occurs when daytime temperatures are warm but nighttime temperatures are low. The higher daytime air temperatures help promote growth of leaves and stolons. Cold soil at the same time limits root activity. The roots in cold soil cannot assimilate enough nutrients to supply demand by the growing leaves. As a result, the leaves turn yellow. This temporary nutrient deficiency disappears as the soil becomes warmer.

WATERING CENTIPEDEGRASS

Do not irrigate frequently with small amounts of water unless the grass is in a young sprig or seedling stage. Frequent, light irrigation will encourage a shallow root system, which is more subject to drought. Wait until the grass just starts to show signs of wilting; then irrigate at least 8 to 10 inches deep so the applied water makes contact with the soil water. This will maintain a deep root system. If possible, irrigate during the early part of the day so that grass leaves can dry quickly. Grass leaves that remain wet for several hours will be more susceptible to disease invasion.

Excessive irrigation during the latter part of the growing season, especially in the presence of high soil nitrogen fertility, not only is wasteful but also encourages the grass to become tender and susceptible to winter damage.

When nitrogen fertilizers are broadcast on the grass during hot, dry summer days, it is important to rinse them off the leaves. Even though the leaves may be dry during application, soluble fertilizers attract enough moisture from dew and air to melt and cause severe burning (plasmolysis) of the foliage.

HERBICIDES

Using herbicides, such as 2,4-D, mecoprop, and dicamba for broadleaf weed control, during hot, dry weather can injure centipedegrass. Avoid using these herbicides during hot, dry stress periods of summer. With temperatures in the 70's and 80's in the spring, fall, and warm periods of winter, good postemergence control of broadleaf weeds can be achieved. Repeat application as needed for control.

Methane arsonate herbicides, such as AMA, MSMA, and DSMA, will kill centipedegrass in addition to postemergence control of crabgrass and dallisgrass. Therefore, use preemergence herbicides, such as DCPA, benefin, bensulide, atrazine, and simazine for crabgrass control.

The postemergence herbicide POAST now has a supplemental label for crabgrass, goosegrass, and bahiagrass control in centipedegrass.

It is important to follow directions on pesticide labels. Using application rates higher than those required for adequate weed control can result in decreased vigor or harm to the grass as well as decreased weed control.

Triazine herbicides are suggested for annual grass weed control in centipedegrass lawns. However, more than two applications a year can cause serious injury. Some turf fertilizers contain triazine herbicides. An example is Bonus Type S containing atrazine formulated by Scotts. Applying these fertilizers each time it is necessary to improve color and vigor of the grass could cause too much herbicide to accumulate in the soil and thus injure the turf. Limit triazine herbicide (atrazine, simazine) applications to spring for summer annual weed control and late summer or early fall for winter annual weed control.

AN AWARD WINNING LANDSCAPE

M. A. POWELL, Landscape Extension Specialist

NCLCA's Environmental Improvement Awards Program reflects the commitment to the creation and preservation of the beauty of our landscape. The program is designed to recognize and make awards to those landscape professionals who execute quality landscaping projects, and to recognize citizens who underwrite such work. In sponsoring the Awards Program, NCLCA is striving to increase public awareness of environmental improvement through quality landscaping, and to encourage the landscape contractors' consistent use of quality materials and workmanship.

We invite all eligible landscape professionals to submit their work for consideration in the Awards Program.

Eligibility

All NCLCA member landscape firm and/or North Carolina registered landscape contractors involved in landscaping are eligible to participate in the Awards Program. Work performed on entered projects must have been done by private industry. Membership in NCLCA is not required.

Each entry must be accompanied by a fee of $75 for NCLCA members and $100 for non-members. There is a limit of four entries per firm.

Presentation of Awards

The awards are generally presented in a special ceremony during the Seashore Seminar in September. Grand awards and awards of merit and distinction will be presented. As there is no set number of awards to be presented, judges may recommend as many entries as they determine deserving of this special recognition.

The ceremony will honor the winner, the landscape architect and the project owner. If the award winner desires to have the landscape architect and/or owner receive the Award Plaque with him or her, such arrangements can be made.

Slides of winning entries and their descriptive texts will become a part of a permanent NCLCA collection and will be sent to industry publications for national exposure and to local media for local exposure. They will also be shown to attendants at the Seashore Seminar, and to various trade, professional, civic and educational groups throughout the year.

Entry Categories

Landscape projects on which the entrant has executed the major portion of the work may be entered for judging in one of the following categories:

1. Erosion Control/Revegetation
2. Commercial Landscape Maintenance
3. Residential Landscape Maintenance
4. Interior Landscape Installation
5. Residential Landscape Contracting
6. Commercial Landscape Contracting
7. Commercial Design/Build
8. Residential Design/Build

Residential Landscape Contracting will include only landscaping done at single family residences, typically owner occupied. Apartment projects and similar multi-family buildings must be entered in the commercial category.

Commercial Landscape Contracting will include landscaping done at commercial sites and governmental or institutional projects, as well as multi-family residential projects.

Design/Build projects will include those on which the firm entering has done the landscape design as well as the installation or construction. Site design must be an original design. Plans must be submitted with the entries, specific areas of design must be indicated.

Judging Criteria

Each of the entry categories will be evaluated independently. A jury of experts in these respective fields will judge the entries and recommend award recipients to the Awards Committee. Work will be judged on the basis of difficulty, craftsmanship, and relative contribution to the quality of the environment. The type, size and cost of the project are currently not criteria for judging and should not be a part of the text.

Erosion Control/Revegetation, Interior Installation, Residential Landscape Contracting and Commercial Landscape Contracting will be judged primarily on the quality of work performed, including coordination of work, quality of materials and workmanship, and overall appearance.

Design/Build will be judged on the basis of the design, in addition to the above criteria used for installation.

Exterior Commercial and Residential Maintenance will be judged on the extent and quality of work performed. Entering firm must have maintained the project for at least twelve months prior to entry date. Slides, taken at least twelve months after assumption of project, must show sufficient detail to allow judges to adequately determine quality of work performed. Entry should included the date the project was taken over.

Participants will be informed of the judges' final decision not later than August.

Entry Procedures

1. Complete the entry form and which can be obtained from the NCLCA Executive Director (919-266-3322). Be sure to include all relevant information, as only this information will be given to the judges.

2. Design/Build entrants must submit a complete set of site design plans.

3. Submit a set of not less than 10, or more than 15, 35 mm color slides. Identify each with the name of the entering firm, and number each to correspond to the slide description section of the entry form. Description should be typed and must fit within the assigned space. Entries must conform to the guidelines or they will not be considered. Slides should clearly display the quality of material and workmanship involved. Whenever possible, in-progress slides of the project should be included.

4. Submit each entry in a single envelope or package.

5. Entries must be received in the NCLCA offices no later than June 30, 1985. Entries received late or incomplete will not be judged. All entries accepted become the property of NCLCA and may be used for publication or for any other purpose the Association deems appropriate.

6. All material submitted for award must be cleared for release upon submission. NCLCA will accept no responsibility for copyrights or photographic fees.

Entry Deadline

Generally, all entries must be received at the NCLCA offices by June 30.

Home Lawn Insect Control Update

R. L. Brandenburg, Extension Entomologist

When considering home lawn insect control, one of the most important considerations is safety, safety not only to the applicator but also to the users of the turf area. Quite often, these treated turf areas are in close proximity to dwellings, and residents and their pets will spend much time there. Proper application is essential to keep risks to a minimum. An applicator must also consider that some lawns are subject to considerable runoff that could cause significant environmental harm.

Recent action by the Environmental Protection Agency to cancel the use of diazinon on golf courses and sod farms reminds us of the impact of certain pesticides on the environment. Close scrutiny of pesticide use on turf will most likely increase in coming years. It is important that pesticices continue to be used in accordance with the label, as this particularly applies to the use of agricultural formulations not labeled for turf use (i.e., Lorsban vs. Dursban).

New insecticides in the turf area are limited at this time. While Orthene received a federal label for mole cricket control, no other new insecticides have come into use. Several new compounds are at various stages of development, but it will most likely be at least two years until product registration. Triumph, a turf insecticide developed by Ciba-Geigy, has performed very well in tests through the Southeast. At this time, it is not known if and when Triumph will be available.

Oftanol has been a standard for white grub control. In several parts of the country, failures of this insecticide have been reported. These failures are apparently due to a buildup of a microorganism capable of breaking down the insecticide. No such problems have been reported in North Carolina. Any suspected cases of product failure should be reported to the manufacturer.

Diazinon is still available for use on home lawns. However, the maximum use rates have been reduced from 8 lbs. active ingredient/acre to 4 lbs. active ingredient/acre. This is reflected in the new label application rates for several insects. The use of diazinon on golf courses and sod farms was canceled by the EPA but is still being contested by Ciba-Geigy.

All of the currently recommended compounds still appear to perform effectively in North Carolina. In general, when poor control results, it is usually the result of improper application. Proper rate and gallonage are essential. The insecticide must be directed toward the specific pest. If the insect is a surface feeder, it is essential that the insecticide be applied late in the afternoon using at least 12-15 gallons of water per acre and no irrigation or mowing for 2 or 3 days. Underground insects, such as white grubs, are best cotnrolled when the insecticide is watered in after application. It is important that the insecticide be watered in immediately, before it dries and adheres to the foliage and thatch.

Poor performance can also be due to the pH of the spray water. Water pH near 8.0 or higher presents a real risk for pesticide breakdown in the tank. In areas where water pH is high, applicators may find it necessary to experiment with various buffers or acidifying agents to obtain satisfactory results.

NON-TARGET EFFECTS OF HERBICIDES USED IN THE LANDSCAPE

Walter A. Skroch
Extension Specialist
Weed Science
Department of Horticulture
North Carolina State University
Raleigh, North Carolina

Herbicide problems in landscape maintenance can be discussed based on herbicide characteristics. Ideally, we want a herbicide that will kill all the weeds with little or no effect on our landscape plants. This could be possible; however, herbicide mode-of-action is very variable, and we must understand how the individual chemical performs:

If we understand a few basic principles of herbicide activity, many of our off-target problems could be avoided.

Volatility

Volatility is the phenomenon by which a chemical passes from a solid or liquid state to a gaseous state. This is particularly important with some herbicides. As an example, loss of weed control occurs when dichlobenil (Casoron or Norosac) is applied at temperatures above sixty. On warm, sunny days losses of up to 10 percent per day can occur; yet, when it's incorporated with snow melt, cool rains or mechanically, it will provide 6 months of control for some of our toughest weeds, i.e., mugwort, alligator weed, Florida artichoke. Another example of the importance of volatility is with vapor drift--the most common example of this is with the ester formulation of 2,4-D. This very widely used chemical can be purchased as an amine or acid formulation which has negligible volatility. The length of the carbon chain is directly related to the volatility of the esters. Low volatile esters have long chain structures. Also, keep in mind that volatility increases as temperature goes up. You might spray a golf course fairway in March without damage to adjoining shrubbery, but 6 weeks later, when temperatures are 20°F warmer, much damage can occur.

Leaching

Leaching is the movement of herbicides in soils as influenced by water movement.

Leaching may be desirable for soil activation of the herbicide (ex. Ronstar, Devrinol, Surflan, or Prowl). On the other side are the undesirable characteristics associated with leaching. Heavy volumes of water leach the herbicide out of the surface soil, and as a result, weeds germinate above the herbicide zone. Herbicides may be moved down a bank or into the soil next to desirable plants causing damage. Another effect of leaching is accumulation of herbicide in the rooting zone in amounts toxic to otherwise tolerant plants.

Longevity

Longevity refers to the length of time that a herbicide remains in the soil at phytotoxic levels. This is particularly important as it dictates how often reapplication must take place for many herbicides. In addition, soil sterilants, which last for more than a year, may damage plants as roots grow into the treated zone. This is a common problem near power stations, railroads, and parking lots which are treated with sterilants. Often, trees begin to die a year or two later near these sites.

Mode of Action

The way the herbicide actually affects plants is called its mode-of-action.

If the material is a root inhibitor (Surflan, Prowl, Devrinol), it probably will have little effect on established weeds. It must be in the soil, below the seed, before the seeds germinate. This is very different from materials such as Roundup, Paraquat and 2,4-D which must be taken into the plant through the leaves or stem.

Selectivity

The mode-of-action of a herbicide that allows it to control one kind of plant without damaging another plant is referred to as selectivity.

Physiological selectivity is the underlying principle which makes herbicides useful in landscape maintenance. We long recognized the usefulness of taking broadleaf weeds out of grass with 2,4-D. Within limits we can accomplish this, but remember if the rate is excessive, even grasses can be killed with 2,4-D. Similarly, Poast and Fusilade 2000 can be used to take grasses out of non-grass plantings. Exceptions occur, however, in clover, and chickweed which are tolerant to 2,4-D or in grasses such as the red fescues which are tolerant of Poast and Fusilade 2000.

Another type of selectivity is physical, that is, applying a material which is active in root pruning after the landscape plant is established such as Ronstar, Surflan, Treflan, etc. These materials will damage plants if they get to the rooting zone but have little or no effect if they are kept in the surface soil around deep rooted plants. Since they are relatively water insoluble, they will stay near the surface controlling newly germinating weeds without damaging the established plant.

Ray Comer
Turf Service, Inc.
129 Manley Avenue
Greensboro, NC 27407

ATHLETIC FIELD ESTABLISHMENT AND RENOVATION

Normally when we are called in to do an athletic field renovation we deal with the athletic director, coach, or principal. Normally we are on a limited budget. We can't build an Orange Bowl or an RFK Stadium but we try to do the best we can to give an acceptable playing surface for game fields. Every year we learn a little more about renovating football fields. If we were to do this renovation next year it might be different. This talk or paper would describe to you today what worked for us in 1986.

First of all, when we are called out to look at a field, sometimes it is warm season turf-- maybe bermuda that's been worn out from heavy play. Once in a while we look at a field that they have tried to have fescue on, a cool season turf that's worn out, or a mixture of the two--both bermuda and fescue. Poor drainage, poor soil--usually a subsoil, poor management practices (including mowing, fertilization, weed control) and normally there's no irrigation.

The first thing we do is recommend that we sprig with vamont bermuda. We have found it to be winter-hardy and excellent in repairing itself once damage has occurred. We check the crown of the field. We need as much surface drainage as we can get becuase we know that we will not get much internal drainage. We check the drainage around the perimeters to be sure that once the water gets off the field it has a place to go. We recommend and install an irrigation system. We feel this is a must. If funds are so limited where we can't irrigate and renovate in the same year, we recommend that they put the irrigation in one year and come back and renovate the next year. Soil tests are done to determine the nutrient requirements.

Now we are ready to sprig. To begin with if there is an existing turf we may spray it out with roundup and kill the existing vegetation before we begin our tilling. We apply our lime and our starter feterilizer. We want to work the lime and fertilizer down into the top six inches of the soil. Here we want to recommend a good starter fertilizer such as an 18-24-12, not a 10-10-10 or 8-8-8. We disk the field six inches deep. If you are doing a small area that is within a large field you can use a rotivator rather than a disk. But for large areas a disc is faster. We smooth the field and usually when we get to the smoothing process we use a drag harrow. Now it is time to start thinking about the sprigs.

Usually we can obtain game conditions within 75 to 90 days in order to be ready for fall play. I like to sprig as early in June as we can -- usually between the 12th and 15th. We have done it later and had good results but ideally we want to start in June and get it done as soon as we can. If the weather is extremely hot and we have a lot of sprigging to do we bring the sprigs down the afternoon before and everybody gets a good night's sleep and is ready to sprig first thing in the morning. We do not like to sprig in the hot part of the day. If you have three or four fields to do it would pay to have a refrigerator truck to keep them cool.

When sprigging we recommend a rate of 500 bushels of vamont per acre. This is a high rate, but to get to game field conditions in less than 90 days I think it is necessary. We put a few extra sprigs in the middle, around the soccer goal where the goalie would stand, and around the sidelines. The wear areas we put a little more on.

Then we begin the sprigging. After the area is sprigged we roll the sprigs in. To do this we normally use a cultipacker. Once an areas has been sprigged and rolled we apply the Ronstar at three-fourths the normal rate and begin to water. We don't want to wait until we have the whole field sprigged before we begin to water. We want to have water on the small areas as soon as we can. We normally grid the field off so we can sprig the way the sprinklers are sequenced. Once the field is watered in once, the sprinklers will need to run four to five times a day for 5 to 10 minutes according to the type of sprinkler. This will need to go on for probably a week. After the sprigs take hold we can start to water a little less. It is going to be very important for someone to look at the field twice every day during the first critical week after sprigging. After that it needs to be looked at every day.

We will fertilize the field every 10 days with a quick-release nitrogen product. We normally put on a half pound of nitrogen per 1000 square feet per application. Mowing will be important once the field is established. We need to mow two to three times per week at a height of about one inch. At the first of September we will raise our mowing height to about an inch and a half. Now that the field is established we need to talk about managing the field both with chemicals and fertilizer once it is established. In September we will apply high potassium, low nitrogen fertilizer such as 5-10-30. This will improve its winter-hardiness.

During the football or soccer season we need to closely monitor the new field to be sure we are not playing on it when it is too wet or getting excessive traffic. We need to have the ability to control the play. If we permit play when the field is wet, damage will for sure result. We have found, and it has been shown, that the later in the fall and earlier in the spring that we damage the field the worst the results. Another suggestion is to let the bands practice somewhere else besides the field--maybe the parking lot.

After we have had our season, in December and January we come in with a clean up spray. We are right now using Kurb and this controls broadleaf weeds and Poa Anna and gives us a little bit of pre-emergence weed control. About the first of April we will apply our first pre-emergence crabgrass control. In May we apply a fertilization of about a pound of nitrogen for 1000 sq. ft. We like to use a turfgrade fertilizer of a 3-1-2 ratio 50-60% sulfur coated. We repeat the fertilization in June and also at this time we apply a second pre-emergence crabgrass application. June is a very important month in athletic field establishment and renovation. If there are any week areas or areas that are not covered, now is the time to add some extra fertilizer, to bring some more sprigs in, sod or whatever to get the field covered. The first of August we apply another fertilization.

Aerification is important. I have not touched on that but 2-3 times during the growing season we need to aerate the field and go over it at least twice per aerification.

In closing, I would like to talk about probably the two most important areas of athletic field management. First is water management. Very close attention needs to be made to the water requirements of your field. Automatic irrigation systems are a great tool but they do not think. You cannot set it up at the first of June and not look at it again until the time to play football. This is not management when you do it this way. The field should not be kept too wet or too dry. I like to water two days in a row and let it dry for two or three days. During dry periods with no rainfall I like to apply 3/4 to 1" of water per week.

The next thing is mowing management. The field should be mowed at least twice per week during the mowing season. Sometimes three mowings are necessary. Mow at a height of 1" being careful not to let the turf grow to a height more than and inch and a half.

That pretty much closes out the management. One thing I need to say is that I didn't talk about renovating with seed or sod. Sod is a good way to renovate a field, obviously, but most of the time the people we are dealing with don't have the funds to go with sod. Therefore, sprigging is the best alternative. I do not recommend trying to renovate athletic fields with seed and play on the field in the same season. I don't think you can establish the turf soon enough.

CONDITIONS ON ATHLETIC FIELDS

Donald V. Waddington
Department of Agronomy
The Pennsylvania State University
University Park, PA 16802

A wide range of turfgrass and soil conditions exists on college, high school, and community athletic fields. Conditions on athletic fields are largely determined by construction methods, past and current maintenance practices, and intensity of use. A primary goal in construction and maintenance of fields should be to obtain a safe field. Prevention of injuries in sports should be of concern to all: players, coaches, parents, and fans. The amount and severity of injuries may be affected by the equipment used, the rules of the sport, and field conditions. The artificial vs. natural turf debate often centers on injuries; however, the range of conditions on grassed (or natural) fields has received relatively little attention.

In Pennsylvania we conducted a study on high school fields that provided information on both field conditions and injuries. In the study Dr. Jack Harper, Turfgrass Extension Specialist, and I represented the Agronomy Department and collected data on field conditions and management practices, and Dr. C. A. Morehouse, Director of Penn State's Sports Research Institute, and Mr. William Buckley, Instructor in Health Education, worked with athletic trainers to collect and analyze injury data. Objectives of our study were 1) to evaluate conditions on high school game and practice fields used for football and determine the relationship between field conditions and maintenance practices; 2) to determine whether a relationship existed between field conditions and the incidence of field related injuries; and 3) to provide recommendations to participating schools that would result in better quality fields.

Twelve schools (24 fields) were included in the study. Information was obtained on field maintenance and use. Fields were evaluated in August and again in November, when the season was ending, for conditions such as cover, density, weeds, undulations, depressions, and stones; and soil nutrient levels, bulk density, and texture were determined. Trainers at these schools provided injury data to NAIRS (National Athletic Injury/Illness Reporting Service), located at Penn State, using standard forms plus two additional items: whether an injury occurred on the practice or game field, and whether the injury was definitely, possibly, or not related to the field. Injuries were rated as 1) Minor (back to participation within 7 days); 2) Significant (out for more than 7 days and all head and dental injuries); 3) Major (a significant injury and out for 21 days or more) and 4) Severe (permanent disabling injuries). Statistical correlations were used to indicate relationships among soil properties, field surface conditions, vegetative characteristics, maintenance factors, and injuries.

Of 35,155 exposures (participation in games or practices), 90% were in practices. Of 210 reported injuries, 152 were minor and 58 were significant (23 major), and 110 of the injuries occurred during scheduled practices. Also, 5.7% of the injuries were rated as definitely field-related, 15.2% as possibly field-related, and 76.7% as definitely not field-related. Most injuries judged to be related to field conditions involved the lower extremities: hip/leg, knee, and ankle/foot. Also for these lower extremities, most injuries were definitely not field-related.

Soils on the fields were either medium or fine textured. Bulk density was greater on practice fields: 1.46 vs 1.40 g/cc. Soil pH, P and K were in acceptable ranges on all fields. In general, practice fields had more undulations, depressions, and vegetative clumps; were rougher and stonier; and had less cover, lower density, and more weeds.

Cover, weeds, and turf density decreased from August to November. Major contributing factors to these changes were poor wearing quality of clover and knotweed, and loss of summer annuals: crabgrass, goosegrass, and knotweed.

Game fields received more N fertilization, core cultivation, and weed control. None of the schools had used weed control on practice fields within the past year. Mowing heights were similar on game and practice fields. Twenty of the 24 fields were overseeded in the spring, but only 12 were aerated and none used a disk or groove seeder. Thus some fields were overseeded without adequate seedbed preparation. Success of such seedings is highly unlikely.

Correlations among all the factors studied indicated the following relationships. Schools with the better constructed fields also had the better maintenance practices. Field conditions reflected the input of maintenance practices. For example, good cover prior to the season was associated with N fertilization and aeration. Field related injuries were not significantly correlated with any of the maintenance practices or field characteristics; however, the results indicating that one of five injuries may have been field-related should be an incentive to construct and maintain high quality playing surfaces.

Suggestions for maintenance and renovation programs were sent to each school. Follow-up visits indicated improvements on fields when those recommendations were followed. One school used the recommendations as leverage when requesting new maintenance equipment. The equipment was purchased.

The study documented the variety of conditions present on fields. It also showed that those responsible for the management of the fields need some guidance. Many of these individuals were not aware of information on athletic field maintenance and construction that has been published in various forms. Our research interest on athletic fields continues. We have completed a laboratory study and have begun field experiments to obtain quantitative measurements of impact absorption characteristics of turf and soil surfaces. Factors such as texture, moisture content, compaction, aeration, cutting height, and presence of vegetation are being studied. Also, impact absorption characteristics of a number of high school fields is being monitored. Our goals include defining the range of values found on natural fields, and determining the effectiveness of maintenance practices that can be used to prevent or alleviate conditions causing poor impact absorption characteristics.

PESTICIDE TOXICITY AND SYMPTOMS

Shirley K. Osterhout, M.D.
Duke University Medical Center
Durham, NC 27710

In reviewing the material sent about the products that are most commonly used on turfgrasses, I was impressed with the use of the organic phosphates and the similar carbamates. Both of these insecticides, the most commonly used pesticides, are neurological toxins with a definite physiologic effect. Each cell in the body responds to stimulation in essentially the same way.

Impulse via nerve to end-cell = reaction. the enzyme acetylcholinesterase is at all nerve endings and is critical in transmitting nerve impulses. The impulse-transmission substance action is stopped by this important enzyme. If acetylcholinesterase is blocked so it cannot function, the transmission substance accumulates and the nerves are bombarded -- constantly functioning resulting in tearing, muscle twitching, diarrhea, vomitting, etc. This also affects transmission to the brain and the nerves affecting the respiratory drive so that respiratory depression is the usual cause of death. Recovery depends ultimately on regeneration of enzyme.

The major effect of the organophosphates and carbamates is essentially the same with two major exceptions:

1. The enzyme-insecticide combination of carbamate is fairly easily reversible, thus making exposure to this group not as potentially dangerous.
2. The treatment is not quite exactly similar.

Yet, they do have many similarities. They are absorbed readily by ingestion, by inhalation, and by skin absorption regardless of whether the material is a powder, emulsion, liquid, or solid! The symptoms are the same.

Mistakes in diagnosis used to be more common than they are today and probably would not involve turf workers as much as tobacco farmers.

1. Mistaken for Green Tobacco Sickness.
2. Confused in use and by users with sucker control products which frequently caused serious problems. For example, trucks spraying insecticide precedes the other spraying equipment using herbicides and similar products. The drivers of sprayers are inhaling the insecticide and consequently become ill. Most of these individuals have no knowledge of the insecticides and usually only give the history of the work with non-insecticides causing much confusion.

Treatments mentioned earlier for the organic phosphates consist of atropine which is also effective with carbamates as it protects the cell from continuing stimulation. A specific antidote for an organic phosphate is pralosoxame or protopan cloride that will break the enzyme-insecticide bond releasing more active enzyme. This is not effective in cases of carbamates.

It is absolutely crucial that the following preventative measures be carried out:

1. Know what you are using.
2. Know how to use it.
3. Wear protective clothing while mixing, using, and cleaning.
4. Never mix nontoxic chemicals without realizing toxins may still be present.
5. Avoid inhalation/skin contact.
6. Watch what you wear, what your eat or drink.
7. Avoid having other people around as well as animals.

If you feel there has been an exposure, go to fresh air and wash immediatley. Take <u>all</u> containers to medical care facility.

One of our major concerns is <u>chronic</u> poisoning. The victim starts showing symptoms when the enzymecholinesterase is lowered by 50%. An acute exposure, inhalation, may lower it, but not enough to cause illness. The next day the same clothes that were exposed are worn, the same equipment is used, and consequently, with repeated exposure becomes ill, yet the only positive exposure the victim remembers is several days earlier. He may not remember that exposure at the time he is ill. This happens quite frequently causing problems in diagnosis. BE AWARE and always consider that the following factors could be a problem.

1. Bottles poorly stored
2. Spillage
3. Dirty clothes
4. Dirty equipment

I cannot discuss all the products which are frequently used, but I will generalize about other chemicals.

Most fungicides are from three different groups:

I. The dithiocarbamates and thicarbamates -- Although these are similar chemicals, they are metabolized differently and the effects on human health is different. In general, by oral dosing studies toxicity is low, but occupational exposures can cause acute reactions and even some chronic problems. Alcoholics should beware of thiram which is related to antabuse, an antialcoholic agent resulting in metabolic disturbances. Contact other than ingestion can cause dermatitis, nasal stuffiness, and cough.

Ingestion (acute) of these chemicals can cause vomiting, diarrhea, fever, ataxia, and muscle weakness. Symptoms with alcohol can be flushing, headache, sweating, seizures, and coma. They are rapidly metabolized and excreted and no blood testing is readily possible.

II. Acti-dion is a cycloheximide which is an antibiotic fungicide of high toxicity. Ingestion of it results in excitation, tremor, salivation, and diarrhea with blood. It is not absorbed through the skin.

Treatments for cycloheximide is to empty the GI tract and use activated charcoal and IV fluids. Hydrocortisone and atropine may be useful.

III. The "other" or miscellaneous fungicides are of low toxicity, but are considered skin and mucous membrane irritants. These include Daconil, Dyrene, and Benomyl, for example.

When you review the herbicides, both pre- and post-emergents, these also fit into the low order toxins, but with irritant capabilities including Siduron, Balen, Asulan, Surflan, Ronstar, and Roundup. The last group of herbicides is DSMA, MSMA, and CMA which contain arsenic. Ingestion is the route of virtually all cases of arsenic poisoning. Arsenic affects all areas of the body and is one of the most toxic of all chemicals. There may be some degree of skin and lung absorption, but toxicity is rare.

For more information on pesticide poisoning and in case of emergencies, contact the Duke Poison Control Center (1-800-672-1697).

Mole Cricket Control in North Carolina

R. L. Brandenburg, Extension Entomologist
N. C. State University

Recently, mole crickets have become a serious pest of turfgrasses in North Carolina. Although the greatest problem is found in the sandy soils of the Coastal Plain, mole crickets have damaged turf throughout the state. Unfortunately, it appears this insect will present a real challenge for turfgrass managers as it becomes better established in the state.

The reason for the recent appearance of mole crickets is that it is relatively new to North Carolina. Accidentally introduced into Georgia and South Carolina in the early 1900's by ships arriving from South America, mole crickets moved northward into North Carolina over 20 years ago. Some of the southeastern coastal areas have suffered from mole cricket infestations for about 10 years. Mole crickets can be found throughout the Coastal Plain and even as far west as Henderson County.

The mole cricket is very destructive as it feeds. As individuals tunnel just under the soil surface, they feed on grass roots. At the same time, they loosen the soil and create their tunnels or "runs" that resemble a small mole tunnel. This may smother some grass and may also create scalping problems on closely-mown turfgrasses. Aesthetically, the area becomes unsightly and in the case of golf greens may become unplayable. Damaged grass is more susceptible to drought from the damaged roots and loosened soil. In addition, secondary damage may result from skunks, rodents and birds digging up turf areas to feed on the mole crickets.

Mole crickets have only one generation per year. Adults mate and fly to new areas to lay eggs in June and July. The small nymphs that hatch do considerable damage in August through November. As soil temperatures cool, these nymphs and a few individuals that have developed into adults overwinter deep in the soil. Then in the spring they become active again. As the mole crickets develop into adults, the feeding damage is usually less severe than is observed in the fall. When summer approaches, the adult females lay eggs to begin the next generation.

The mole cricket has created special problems in developing an effective yet economically-sound management program. However, recent studies have provided new guidelines for mole cricket control that have proven effective in North Carolina. Baits have shown consistent performance when properly applied. Several insecticides have been formulated into baits for mole cricket control including Dursban, Baygon and Sevin. It is essential to follow several guidelines for maximum control. Baits used in August through October are more effective against nymphs. Irrigate before application and don't irrigate over the baits for 24-48 hours, if possible. Apply baits in the late afternoon and use only if nighttime temperatures are expected to stay above 60°F. If cold weather is expected, do not apply until temperatures are expected to be warm for at least two or three days.

Several insecticides in sprayable and granular formulations are labeled for mole cricket control in North Carolina. These have been used with various levels of success. Recently, a federal label was obtained for Orthene 75S for mole cricket control on turfgrasses. This insecticide performs quite well and its cost per acre offers a reasonably priced approach. Unlike other sprays or granular insecticides applied for mole crickets, irrigation is required before treatment rather than after application.

None of the current control recommendations appear to provide long-term residual control. Retreatment of infested areas is often necessary. When high-value areas such as golf greens are treated, it is advisable to treat an area surrounding the green to slow migration back into the green itself. No specific guidelines are available, but an area 20 feet wide is suggested.

Weed Control in Sprigs

Wayne Bingham
Professor and Extension Specialist, Weed Science
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061

Bermudagrass is popular for lawns and recreational facilities in the Southern United States. This turfgrass is normally established from sprigs during an active growth period in spring and early summer. Sprigs are stolons, rhizomes, and tillers used in vegetative establishment of turfgrasses. Sprigging is the vegetative planting of any of these plant parts in prepared soil. Generally, sprigging is accomplished in the spring and the turf is utilized for recreational activities about 4 months later. Annual grasses are a serious problem during the establishment period, for they compete with the sprigs reducing the rate of establishment. Competition prevents stolons from rooting and tillering at the nodes and thus delays the time to obtain complete ground cover.

Preemergence herbicides are widely used for annual grass control in well-established turfgrasses. However, these herbicides sometimes delay root development from bermudagrass nodes. Despite slowed growth, the bermudagrass provides improved ground cover following herbicide treatment for the annual-grass control. Oxadiazon, however, has been successfully utilized during the bermudagrass sod establishment with little effect on root growth and development. In addition to crabgrass control, oxadiazon controls goosegrass during the establishment period as well.

During recent years, goosegrass has become a serious bermudagrass competitor; this annual grass germinates well during the optimum bermudagrass sprigging time. Goosegrass is commonly found on bermudagrass sod and sprig farms and soil planted with sprigs or sod contains ample seed to cause weed problems during establishment.

Control of crabgrass and goosegrass is essential for growth of bermudagrass sprigs into excellent ground cover within 6 to 10 weeks. The high level of irrigation and open space during bermudagrass sprigging provides ideal germination conditions for these annual grasses. Rapid annual-grass growth prevents normal establishment of springs for a good turfgrass cover. Rapid achievement of adequate cover with bermudagrass is of particular importance.

A final factor involves being able to utilize the area within a few days after sprigging or allowing minimal walking traffic soon after sprigging. This is accomplished through minimal soil disturbance. We removed the thatch and dead turfgrass that was killed with glyphosate utilizing a vertical mower set to penetrate the soil surface about 1/4-inch. This vertical mowing was done in 2 or 3 directions catching the debris and removing from the area. After this operation, the surface was smooth, had small amount of loose soil and was ready to receive the surface transplanted sprigs.

In our sod-rooting and root-effect research, we obtained from slight to serious root inhibition from preemergence herbicides. Oxadiazon was selected for the bermudagrass sprig studies for 2 reasons. It showed slight effects during our sod evaluations and oxadiazon provided the best goosegrass control. We first observed that bermudagrass sprigs partially incorporated in the prepared soil had good tolerance to oxadiazon applied on the surface soil. Further research showed that bermudagrass with sprigs applied to the surface soil and kept wet rooted well through an oxadiazon surface treatment. In these experiments, oxadiazon at rates up to 4 lb/A did not retard ground cover development with 'Midiron' and 'Vamont' bermudagrasses. On the contrary, at 3 to 12 weeks, ground cover with bermudagrass was equal to or superior in oxadiazon treated soil as opposed to no treatment. Root development from Vamont and tifway sprigs was similar in oxadiazon treatments up to 4 lb/A as in the untreated plots. The Midiron cultivar rooted well but showed a reduction in root development during the six week root evaluation.

NEW PESTICIDE AND RELATED LAWS

John Wilson
North Carolina State University
Raleigh, NC 27695

DISPOSAL

N. C. and Federal Pesticide Laws require that pesticide containers be disposed of as follows:

a. Let containers with liquids drain into the spray tank at least 30 seconds "after they are empty".

b. Fill container 1/2 full of water, shake thoroughly and pour the rinsate into the spray tank. Repeat 3 or more times.

c. Punch holes into and crush the container

d. Take containers to an approved sanitary landfill for disposal.

Shake granular, dust and powder formulation containers thoroughly into the application equipment until all the contents are removed. Rinse where possible and take containers to a landfill.

If you cannot legally use all of a pesticide on a labeled crop, animal or site, or cannot give it to someone who can legally use it, you should:

a. Notify the Pesticide Section, NCDA, (919) 733-3556 for advice on disposal or

b. Have a licensed hazardous waste company collect and dispose of the pesticide. These companies addresses can be obtained from local Agricultural Extension Office or the N. C. Department of Agriculture.

HAZARDOUS WASTE

Pesticides and other materials may be classified as hazardous waste. A manual entitled "Hazardous Waste Management for Small Generators" that identifies hazardous wastes and hazardous waste disposal companies is avialable. This manual will help you comply with RCRA (Resource Conservation and Recovery Act) and other N. C. hazardous waste regulations. This manual and information on a short course for persons handling hazardous waste can be obtained by calling The Industrial Extension Service (919) 737-2303 at N. C. State University. These short courses are being offered by The Industrial Extension Service and by UNC Charlotte, UNC Asheville and UNC Greensboro.

You are a small quanity hazardous waste generator if you generate 220 to 2200 pounds of hazardous waste or 2.2 lbs. of acutely hazardous materials per month. Materials that are accepted by publically owned sewage treatment works, batteries picked up by legitimate recyclers and used oils that are not contaminated with hazardous materials are exempt from these regulations.

WORKER PROTECTION STANDARDS

N. C. Worker Protection Standards make pesticide applicators responsible for the safety of workers engaged in agricultural hand labor in or near fields treated with pesticides.

These Standards require you to:

1. Be sure label directions are understood and followed.

2. Inform workers verbally or through posted warnings signs visible at 25 feet and placed at entrances to treated fields of the:

a. type and name of pesticide(s) applied;

b. time and date of the most recent application;

c. period of time the field should not be entered without the appropriate protective clothing;

d. type or description of clothing that should be worn; and

e. actions to take in case of accidental exposure to a pesticide.

The Hazardous Chemicals Right-To-Know Act (N.C.G.S. 95-173 et seq.) was adopted by the N. C. General Assembly in 1985. The purposes of this Act are (1) to see that firefighters have all the information they need to respond to chemical emergencies and (2) to ensure that citizens have access to sufficient information to make informed judgments about the hazards in their communities.

All employers, both public and private, who normally use or store at least 55 gallons or 500 pounds of any hazardous chemical must comply with the law. Although the full requirements of this Act do not apply to farms with 10 or fewer full-time employees, the employer must tell fire departments whom to contact in case of an emergency.

Chemical manufacturers must now inform you of hazardous materials through a statement on the label. If you receive a Material Safety Data Sheet (MSDS) with a product you purchase, you can learn if the material has been classified as hazardous. The MSDS will inform you of health-related information, emergency and first-aid procedures, and other information needed to use, store, and dispose of the chemical properly.

GROWTH REGULATOR USE ALONG HIGHWAYS

W. M. Lewis and J. M. DiPaola-Crop Science Department
North Carolina State University, Raleigh, NC 27695-7620

Growth regulators have recently been developed for use in suppressing shoot growth and hence reduce the mowing requirements of turfgrasses. Used along highway roadsides, they have the potential of lowering mowing, labor, and equipment maintenance costs. Seedhead growth contributes significantly to the total turf height along roadways, particularly in tall fescue. Seedheads can become a fire hazard, increase the need for mowing, smother the existing turf once mowed and limit the line-of-sight along roadsides. The characteristics and use of several commercial and experimental growth retardants for turf are presented in Table 1.

Growth regulator induced growth suppression of turf is typically accompanied by some leaf discoloration. Discolored turf is usually the result of a browning of leaf tips and/or enhanced aging of older leaves. The suppressed growth of new leaves and the accelerated senescence of older leaves also results in a temporary openness to the turf. Leaf discoloration can occur at anytime following application, but typically is most visible at about three to four weeks after treatment.

Tall fescue seedhead suppression under roadside conditions has been successfully attained following spring applications of maleic hydrazide (MH-K) at 3 to 4 lb ai/A, amidochlor (Limit) at 2.5 lb ai/A, mefluidide plus chlorsulfuron (Embark + Telar) at 0.125 lb ai/A + 0.125 oz ai/A, mefluidide alone at 0.5 lb ai/A, and ACP1900 (experimental compound) at 50 grams ai/A (Tables 2 and 4). While combinations of mefluidide and chlorsulfuron provided excellent seedhead suppression, combinations of mefluidide and metsulfuron methyl (Embark + Escort) reduced the stand of tall fescue (Table 3). April applications of MH-K plus chlorsulfuron (Telar) at 3 lb ai/A + 0.125 oz ai/A resulted in tall fescue stand reductions to 28% compared to 92% cover for control plots. This data clearly indicates that the response of tall fescue to mixtures of growth regulators is quite variable and cannot be predicted from the effects of each individual component or by comparisons to "similar" mixtures.

A summary for 1981 through 1985 of seedhead control in tall fescue with plant growth regulators is presented in Table 5. For the years evaluated, Embark, Limit and MH-K had less than 10% seedheads present in May. Turf quality visual ratings are also summarized in Table 6 for the same period. All the plant growth retardants received acceptable turf quality ratings. Ratings for MH-K were similar to the check for each of the five years. Stand density for the four growth retardants did not differ from the check in 1983 through 1985 (Table 7).

Pensacola bahiagrass seedhead suppression under roadside conditions has been successfully achieved following May applications of MH at 4 lb ai/A, glyphosate (Roundup) at 0.19 to 0.25 lb ai/A, sulfometuron methyl (Oust) at 0.02 lb ai/A, and ACP1900 (experimental compound) at 0.07 lb ai/A (Table 8). Applications of amidochlor (Limit) and mefluidide (Embark) at rates that are effective on tall fescue did not result in acceptable suppression of bahiagrass seedheads. An additional application of glyphosate (0.13 lb ai/A) in July to bahiagrass previously treated in May with glyphosate at 0.25 lb ai/A improved the duration of seedhead suppression. However, consecutive annual applications of glyphosate at 0.25 lb ai/A in May plus 0.13 lb ai/A in July has thinned the bahiagrass stand.

As more knowledge is gained on the proper use of plant growth regulators, they can be incorporated into a turf management program for roadsides. Supplemented with mechanical mowing, they can contribute to a safe and efficient operation.

Table 1. Turf Growth Retardants Classified According To Site Of Uptake.

Growth Retardant	Trade Name	Rate ai/A	Suppression Activity Seedhead	Suppression Activity Vegetative	Turfgrasses Tolerant
Foliar					
Maleic hydrazide	Slo-gro Retard	2 -4 lb	yes	yes	AB,BH,BM,FF, KB,RY,TF
Mefluidide	Embark	0.125 - 0.5 lb	yes	yes	AB,BM,FF,KB, RY,TF
Glyphosate	Roundup	0.25 - 0.5 lb	yes	yes	BH,TF
Root					
Amidochlor	Limit	2.5 lb	yes	yes	FF,KB,RY,TF
Paclobutrazol	Parlay Scotts TGR	0.25 - 0.5 lb	No	yes	MOST
Root and Foliar					
Chlorsulfuron	Telar	0.125 oz	yes	yes	TF
EPTC	Shortstop	4 - 8 lb	yes	yes	TF
Sulfometuron Methyl	Oust	0.25 - 0.75 oz	yes	yes	BH
Flurprimidol	Cutless	0.5 - 3 lb	No	yes	MOST

AB=annual bluegrass, BH=bahiagrass, BM=bermudagrass, FF=fine fescue
KB=Kentucky bluegrass, RY=ryegrass, TF=tall fescue

Table 2. Tall Fescue Seedhead Control With Plant Growth Retardants On May 23, 1985.

Treatment	Rate	Application Date 3/27/85	4/12/85
	ai/A	% Seedheads	
Check	0	42	50
Embark	0.5 lb	4	2
Escort	0.125 oz	23	18
MH-K	3 lb	7	2
Telar	0.125 oz	35	33
Embark + Escort	0.125 lb + 0.125 oz	2	0
Embark + Telar	0.125 lb + 0.125 oz	0	4
MH-K + Telar	3 lb + 0.125 oz	5	0
LSD		5	10

Table 3. Stand Density Of Tall Fescue On June 26, 1985 After Plant Growth Retardant Treatment.

Treatment	Rate	Application Date 3/27/85	4/12/85
	ai/A	% Cover	
Check	0	80	92
Embark	0.5 lb	90	93
Escort	0.125 oz	82	83
MH-K	3 lb	83	88
Telar	0.125 oz	100	98
Embark + Escort	0.125 lb + 0.125 oz	8	17
Embark + Telar	0.125 lb + 0.125 oz	65	87
MH-K + Telar	3 lb + 0.125 oz	67	28
LSD		21	11

Table 4. Tall Fescue Seedhead Control And Turf Quality With Plant Growth Retardants - 1986.

Treatment	Rate ai/A	% Seedheads 5/22/86	Turf Quality[1] 5/22/86
Check	0	60	7.2
Limit	2.5 lb	35	7.3
MH-K	4 lb	1	6.5
Embark + Telar	0.125 lb + 0.125 oz	4	5.7
ACP-1900	50 g	2	5.5
ACP-1900 + Arsenal	50 + 1.5 g	0	6.0
LSD		7	1.1

Applied March 28, 1986, NCSU Turf Center

[1] 1 to 9, 9=best; 5=minimally acceptable

Table 5. Tall Fescue Seedhead Control In May With Plant Growth Retardants At Raleigh, NC.

Treatment	Rate	1985	1984	1983	1982	1981
	lb ai/A	% Seedheads				
Check	0	42	73	43	63	92
Embark	0.5	4	*	*		
EPTC	8	27		*	*	
Limit	2.5	10	*	*	na	na
MH-K	4	0	*	*	*	*

*Treatments with <10% Seedheads
na = Not Evaluated
Applied late March to mid April

Table 6. Turf Quality Of Tall Fescue 2 To 4 Weeks After Plant Growth Retardant Treatment.

Treatment	Rate	1985	1984	1983	1982	1981
	lb ai/A	Turf Quality[1]				
Check	0	7.5	7.3	6.3	6.9	6.0
Embark	0.5	6.5	-a	-a	-a	-a
EPTC	8	6.8	ns	-a	-a	-a
Limit	2.5	7.3	ns	na	na	na
MH-K	4	7.2	ns	ns	ns	ns
LSD		0.7	0.3	0.3	0.5	1.0

[1] 1 to 9, 9=best, 5=minimally acceptable
+,-,ns=improved, reduced, or nonsignificant
a=acceptable; u=unacceptable, na=not evaluated
Applied late March to mid April

Table 7. Stand Density Of Tall Fescue 12 Weeks Ater Plant Growth Retardant Treatment.

Treatment	Rate	1985	1984	1983	1982
	lb ai/A		% Cover		
Check	0	80	88	50	53
Embark	0.5	95	ns	ns	ns
EPTC	8	95	ns	ns	-
Limit	2.5	80	ns	na	na
MH-K	4	68	ns	ns	ns
LSD		21	10	9	8

-,ns=reduced or nonsignificant respective to check
na=not evaluated
Applied late March to mid April

Table 8. Seedhead Control Of Bahiagrass After Plant Growth Retardant Treatment.

		1985*		1984	
Treatment	Rate	8 WAT	12 WAT	6 WAT	10 WAT
	lb ai/A		% Seedheads		
Check	0	45	48	47	67
MH-K	4	0	12	2	13
Roundup	0.19	8	22	15	25
Roundup	0.25	5	13	5	13
Roundup + Seq[2]	0.25	0	0	7	0
ACP 1900	0.07	5	17	12	30
Oust	0.02	0	7	2	8
LSD		6	10	6	6

* 1984 plots were retreated for 1985 study
1 WAT=weeks after treatment
2 Sequential application of 0.13 lb/A 6 weeks after initial treatment (May 22), Fayetteville, NC

TURF WEED CONTROL RESEARCH-1986

W. M. Lewis, Crop Science Department
North Carolina State University, Raleigh, NC 27695-7620

Four research studies conducted in 1986 will be summarized in this report. They include Poa annua control in Penncross bentgrass greens, tolerance of turfgrasses to herbicides, control of broomsedge along highway roadsides, and the performance of turf herbicides when applied in combination with colorants. Other research concerning effects of preemergence herbicides on root strength of turfgrass sods and effects of plant growth retardants on turf are reported elsewhere in the proceedings.

We continued our studies on Poa annua control with Prograss in bentgrass greens at Alamance Country Club and High Meadows Country Club. Results continued to support are previous findings that for most favorable control Prograss applications should begin when the long-term daily average temperature drops below 65 F in the fall. The Prograss rate is 0.5 lb ai/A (1 fl oz/1000 of Prograss 1.5E) per application. Five applications spaced 20 days apart are necessary for best control. Also 0.75 lb ai/A per application for 3 applications is effective. Initiating applications late or extending applications into December reduced turf quality.

Warm-season turfgrasses were evaluated for their tolerance to several sprayable formulations of herbicides, including ones currently available and experimental. Tolerance was based upon visual color ratings. Results are summarized in the following table. Pre-M, prodiamine, and Ronstar are used for preemergence weed control while Pursuit and Image are applied for postemergence weed control.

Tolerance of Turfgrasses to Herbicides - Based on Color Ratings July 11, 1986, (21 days after treatment).

Herbicide	Rate lbai/A	Turfgrass Centi-pede	C.bur-muda	Tif-green	St.Aug-ustine	Emer-ald zoysia	Meyer zoysia
Pre-M 60DG	3	a		a	a	a	a
Prodiamine 65WDG	1	a			a	a	a
"	2	a			a	a	a
"	4	a			a	a	a
Ronstar 50W	2	u*			a	a*	a*
"	4	u*			a*	u*	u*
Pursuit 2E	0.11	a	a*	a	a	a	a
"	0.17	a*	a*	a*	a	a	a
"	0.22	a*	a*	a*	a	a*	a
Image 1.5E	0.38	a	a	a	a	a	a
"	0.5	a	a	a	a	a	a
"	0.63	a	a*	a	a	a*	a
Check	0	8.0	8.0	7.0	8.0	8.0	8.0
LSD		0.5	1.1	1.2	1.0	0.7	0.8

a=acceptable rating of 6.0 or above on scale of 1 to 9, 9=best
u=unacceptable rating <6
*=significantly lower than check

Of the several herbicides evaluated for postemergence control of broomsedge along highway roadsides, MSMA was the only effective one. Over 90% control was obtained with 2 lb ai/A of MSMA applied one summer followed by a second application the next summer or 2 applications at 2 lb ai/A/application the same season spaced 10 days apart. Applications initiated in July or August were effective.

The performance of sprayable turf herbicides was not affected when applied in combination with the colorants, Blazon Blue or Blazon Red. Herbicides included those for postemergence control of winter and summer annual broadleaf and grass weeds and preemergence control of annual grass weeds.

Turf Extension Update

Arthur H. Bruneau
North Carolina State University
Raleigh, NC 27695

The Aquatic Weed Control Specialist position, vacated by Dr. K. A. Langeland is yet to be filled. It is uncertain at this point in time if funding is available to fill this position even though there is a definite need to do so.

Turf workgroup personnel met with members of the NCDA Agronomic Division to discuss the need to revise soil test recommendations for homelawns based on current research findings. Changes in fertilizer recommendations have been approved by both groups and will be put into effect spring, 1987. A summary of the recommendations are provided in Table 1 and Table 2 for and all other lawn grasses respectively.

The TCNC and N. C. Agricultural Service jointly sponsored a turfgrass demonstration area during the N. C. State Fair. This is the second consecutive year that fairgoers were allowed to see first-hand some of the major grasses grown in N. C. A podium displaying several lawn maintenance calendars invited interested fairgoers to contact their local agricultural extension office.

The permanent self touring turfgrass management demonstration area located adjacent to the existing NCSU Turfgrass Field Center has been completed. It is being used by extension personnel for inservice training, teaching faculty for instructing students and the general public.

PUBLICATIONS

"Pest Control Recommendations for Turfgrass Managers" guide - this 12 page guide, published by the TCNC, contains pesticide recommendations for disease, weed, insect and nematode control. Recommendations concerning the use of plant growth regulators as well as the control of aquatic weeds is an addition to this 1987 guide.

"Tall Fescue Lawn Maintenance Calendar" and "Centipedegrass Lawn Maintenance Calendar" are now available for use by lawn care, garden center and nursery personnel for distribution to their clientele. The turf memo No. 20 "Algae and Moss Control" is also available for distribution.

TURF DISEASE UPDATE

Leon T. Lucas
North Carolina State University
Raleigh, NC 27695

Fungicides listed in the table were evaluated for the control of dollar spot on bentgrass in 1986 at the NCSU Turf Research Center in Raleigh. The turf was maintained similar to a golf green. Chemicals were first applied on June 15 when symptoms of dollar spot were present. Results were taken 12 and 27 days after the first treatment and 12 days after the second treatment on July 22.

The new fungicides, RH 3486, Systhane, Spotless, and Prochloraz, gave excellent control of dollar spot. The control with these chemicals was as good or better than Bayleton or Chipco 26019. Less disease was present in plots treated with Alliette in the first two evaluations but not in the third. Subdue and Fore at the lower rate did not control dollar spot. Several of these new fungicides should be available in the future and will be very useful for controlling dollar spot and other diseases.

Pythium root rot was a serious problem on bentgrass golf greens in 1986. The article in the Proceedings on this disease gives more details. Brown patch was severe on bentgrass and tall fescue during hot and humid weather in the summer. Fungicides were needed every 4 or 5 days to control this disease on bentgrass in some cases. Proper fertilization and water management were useful to help control this disease.

Talks were given at 10 Landscape Management Workshops in different areas of the state. Over 500 people attended pesticide training schools on Ornamentals and Turfgrasses at 10 schools throughout the state. Many visits were made to problem sites in 1986 with county agents and turf managers.

A grant was obtained from the United States Golf Association to work on spring dead spot of bermudagrass. Dr. Bert McCarty has been working on this problem and is making good progress in identifying the cause and evaluating chemicals for the control of this disease. More details are given in the article by Dr. McCarty in this Proceedings.

Disease identification on samples submitted to the Plant Disease and Insect Clinic and at problem sites will be continued. More emphasis will be placed on early identification of disease so that control measures will be more effective. Also, the prevention of disease by using the best management practices will be emphasized.

Treatment with rates (a.i.)/1000 ft^2	% area with disease 25 Jun	10 Jul	22 Jul
Control	3.5 a	12.5 a	17.5 ab
RH 3486 50W 2 oz	0.3 c	0 e	0 c
RH 3486 50W 4 oz	0 c	0 e	0 c
Systhane 40W 0.1 oz	0 c	0.8 de	0 c
Systhane 40W 0.2 oz	0 c	0.8 de	0 c
Systhane 40W 0.4 oz	0 c	0.3 de	0.3 c
Spotless 25WP 0.1 oz	0.3 c	1.8 de	0 c
Spotless 25WP 0.2 oz	0 c	0.3 de	0 c
Spotless 25WP 0.4 oz	0 c	0 e	0.5 c
Prochloraz 40EC 1.88 oz	0.3 c	4.8 de	0.3 c
SN 596 25DF 0.125 oz	0 c	0.5 de	0 c
Prochloraz 40EC 0.125 + SN 596 25DF 0.125 oz	0 c	1.3 de	0.3 c
Bayleton 25W 0.25 oz	0.3 c	1.3 de	0 c
Fore 80W 3.7 oz	3.0 ab	13.8 a	10.0 a
Fore 80W 6.4 oz	0.8 c	11.3 ab	16.3 ab
Subdue 2E 0.5 oz	3.8 a	12.5 a	11.3 b
Chipco 26019 50WP 1 oz	0 c	0.8 de	0.5 c
Alliette 80WP 3.2 oz	1.5 bc	7.5 bc	15.5 ab

*Means within column followed by the same letter are not significantly different according to Waller-Duncan, P=0.05.

TURFGRASS PHYSIOLOGY AND MANAGEMENT RESEARCH UPDATE

Joseph M. DiPaola
North Carolina State University
Raleigh, NC 27695

Turfgrass growth regulation studies remain in progress on most of our commonly used species including bahiagrass, bermudagrasses (common and hybrids), centipedegrass, creeping bentgrass, St. Augustinegrass and tall fescue. Growth regulator compounds are evaluated under low and moderate maintenance conditions to determine there impact on turf quality, stand density, seedhead production and cold hardiness.

Warm season turfgrass cold tolerance through the winter months continues to be studied with the use of a low temperature stress simulator. Tifgreen and Tifway bermudagrass have been being evaluated for ways to enhance the survival of sod transplanted during the off-season while the bermudagrass is dormant. Treatments have included potassium fertility, cutting height, plant hormone applications, antitranspirant coatings, overseeding and thickness of sod.

Current syringing studies are concentrating on the effects of this practice on wilt. Over 500 cultivars, including many bluegrasses, bentgrasses, bermudagrasses and fescues, are being studied for their adaptability to North Carolina climatic conditions. These trials are located throughout the state.

It is a pleasure to acknowledge the financial and material program support from the following:

BASF	**E.J. Smith**	**Lofts**	**Pickseed West**
CGA	**Elanco**	**Monsanto**	**Seed Research**
Carolina Sod	**FHWA**	**NCDOT**	**Smith Turf & Irr.**
Chevron	**ICI Americas**	**Northrup King**	**Tin Whistles**
Cyanamid	**ISI**	**O.M. Scotts & Son**	**Turf Seed**
DuPont	**Lesco**	**Porter Brothers**	**United Turf**

The excellent technical efforts of David Beard, Doug Dahms, Joanna Miller, Bobby Moore, Mike Newnam, Les Privette, Eileen Sutker and Leon Warren are sincerely appreciated. Finally, many research projects are conducted away from the NCSU turf plots with the cooperation of many individuals including: Mr. Harrison Cambell, Mr. Al Wooten, Mr. Harley Blackwell, Mr. Henry Fox, Mr. Lewis Clark and the personnel of the NCDOT Landscpe Unit, particularly Mr. Bill Johnson and Mr. Frank Vernon.

THE TURFGRASS COUNCIL OF NORTH CAROLINA, INC.

The Turfgrass Council of N. C. is a Non-Stock Association incorporated under the laws of North Carolina and is tax-exempt.

PURPOSES AND OBJECTIVES

The purposes of the Turgrass Council are: (1) to promote the turfgrass industry; (2) to encourage study and research in turfgrasses; (3) to disseminate information relating to turfgrasses; (4) to represent the turfgrass industry in matters of policy. The objective of the Council is to help obtain the best turf possible for lawns, recreational areas, roadsides and cemeteries throughout the state.

ACTIVITIES

The Annual North Carolina Turfgrass Conference and the NCSU Turf Field Day are co-sponsored by the Turfgrass Council and N. C. State University. A newsletter is published to inform the membership of Council activities and turf programs in the state. Turfgrass research, extension and scholarship programs receive financial support from the Turfgrass Council. A Turfgrass Research and Extension Fund has been established at N. C. State University to provide additional funds for turf research and extension programs.

MEMBERSHIP

Individuals interested in turfgrasses, representatives of turf related organizations and sales representatives of turf products are encouraged to become members. Dues for individuals are $30 per year. Sustaining memberships at $75 are also available.

BOARD OF DIRECTORS FOR 1987

Charles Tomlinson, President	George Thompson, Vice -Pres.
P. J. Lenihan, Treasurer	Bob Tumey, Secretary
Les Kuykendall, Past President	R. L. Robertson, Executive Dir.

Luke Veasey	Fred Biggers	Charlie Jordan
Sam Linker	Gene Maples	Bill Riggan
Ray Avery	George Thompson	Bob Bell
Les Kuykendall	Charles Fierke	

ONE YEAR TERMS FROM ASSSOCIATIONS

Ray Avery (North-South), Joe Kennedy (West), Rick Briley (Piedmont), Galen Decker (Triangle), David Bentley (Eastern)

MEMBERSHIP APPLICATION

Name .... Address ....

City .... State ...... Zip ....

Circle type of work - Golf Course, Lawn Care, Commerical Sales, Parks and Recreation, Educational, Other ....

Make check for $30 payable to Turfgrass Council of N. C. and mail to Turfgrass Council, Box 5395, Cary, N. C. 27511

north carolina
AGRICULTURAL
EXTENSION
SERVICE

Published by
THE NORTH CAROLINA AGRICULTURAL EXTENSION SERVICE

North Carolina State University at Raleigh, North Carolina Agricultural and Technical State University at Greensboro, and the U. S. Department of Agriculture, Cooperating. State University Station, Raleigh, N. C., Chester D. Black, Director. Distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. The North Carolina Agricultural Extension Service offers its programs to all eligible persons regardless of race, color, or national origin, and is an equal opportunity employer.

10-87-1000-170906