29th and 30th Annual North Carolina Turfgrass Conference and Trade Show

January 9-11, 1991 and January 8-10, 1992

North Carolina Turfgrass Conference

PROCEEDINGS

Vols. XII and XIII

Sponsored by:

Turfgrass Council of North Carolina
North Carolina Cooperative Extension Service
North Carolina Agricultural Research Service

PREFACE

Proceedings of the 29th and 30th Annual North Carolina Turfgrass Conference are being provided as a permanent reference to those who attended the two conferences. The 1991 and 1992 conferences were held at the Charlotte Convention Center on January 9-11, 1991 and January 8-10, 1992. Sessions on general turf topics and concurrent sessions for golf course, lawn care, roadside and low maintenance turf, landscape maintenance, sod, and athletic field topics were held. Workshops on Calibration of Fertilizer and Pesticide Equipment, Advanced Bentgrass Putting Green Management, Insect and Disease Identification and Management, Environmental Stress, Weed Control for Commercial Lawn Care, and Soil Test Recommendations for Turf Managers were held on January 9, 1991. Workshops conducted on January 8, 1992 were Turf Management for Cemeteries, Turfgrass Insect and Disease Identification and Management, Personnel and Time Management for Turf Professionals, and Tree Management in a Turfgrass Setting, Pesticide Regulations and Compliance and Ornamental Insect and Disease Identification and Management. The trade show used over 40,000 square feet of space each year and approximately 1,800 and 2,100 people attended the conferences, respectively.

Special thanks are extended to everyone who helped make these Conferences successful. Each speaker is to be commended for their excellent presentations.

The following committee members contributed to the success of the **29th Annual Turfgrass Conference and Trade Show**:

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We would also like to take this opportunity to thank the NCSU Technical Support Staff and Graduate Students for their invaluable assistance in conducting the annual North Carolina Turfgrass Conference and Trade Show. Very special thanks to Marcia Gray for taking the lead in designing and developing these Proceedings.

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These Proceedings are printed on Recycled Paper

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PUBLIC CONCERNS FOR PESTICIDES

R. L. Brandenburg[1]

The past year has seen a dramatic increase in the public awareness of pesticide use in the environment. Unfortunately, the public's source of information has not always been the most reliable and as a result has aroused the public's emotions. On occasion, the media has played on these emotions to further spread a fear of pesticides. This fear has been called chemophobia, and many lawn care customers have been caught up in this scare. The purpose of this article is not to refute all of the past articles written about the dangers of pesticide use, but rather to present a logical and scientifically based report on how to educate the public concerning pesticides. If we use facts appropriately, and not emotions, I believe we can gain the public's confidence.

The first concern, of course, is the risk of pesticide use to human health. Of these, the greatest is cancer. This disease stirs people's emotions probably as much as any health problem. Although much of this concern has focused on pesticides in food, it carries over into all pesticide uses. The public must be educated as to the stringent test requirements of the EPA to prove product safety. In most cases, at least a 100 fold safety factor is used. While laboratory animals are used in these studies and this information can be difficult to translate to human effects, it should be noted there are no pesticides on the market today known to cause cancer in humans.

Another misconception the public has is that they are being bombarded with toxic residues. This, in fact, is far from the truth. In food, for example, state inspections have found that over 80% of all food has absolutely no detectable levels of pesticide residues, much less even remotely harmful levels. And that is with the latest scientific equipment capable of detecting levels below one part per billion. What the public is being bombarded with are natural products that are potentially carcinogenic or hazardous. However, the public has been misinformed and believes what is natural is safe and synthetic is dangerous. Rotenone, for example, is a natural pesticide, yet it is more toxic to humans than most turf pesticides. Aflatoxins, arsenic, cyanide, hydrazines (similar to the product Alar®) are all found in nature. It has been estimated that we may be exposed to some of these natural toxins at rates 10,000 times greater than we are to synthetic ones. In addition, it has been estimated that as much as 90% of our cancers may be related to the environment. The public is willing to accept "natural" risks while rejecting "synthetic" risks that pose only a minute threat. Perhaps it was best stated by former Surgeon General C. Everett Koop when he said, "People just have an inappropriate sense of what is dangerous. They get overly upset about minor problems". Additionally, the National Cancer Institute has not seen any increase in cancer rates with the exception of lung cancer, which they relate to smoking, and skin cancer, related to sunbathing. This alone stands as a fairly good argument as to the safety of pesticide use.

However, if used improperly, pesticides can cause problems. While public awareness is high, it is imperative that lawn care maintenance specialists show special attention to this subject. Be straightforward with your clientele about which pesticides you use. If they desire, pick one that has a lower human toxicity. Utilize IPM by scouting and treating when necessary. Many homeowners want this service, and it won't cost your business. Time normally devoted to preventive treatments can be spent scouting for pests.

Have all your workers properly trained and certified. Not only will this reduce the risk of pesticide misuse, but will educate them concerning many of the questions people may have. Support appropriate posting and prenotification laws. If we fight them completely, it looks like we are trying to hide something. Dress professionally; make sure

[1]Associate Professor, Department of Entomology, North Carolina State University

you give the appearance of a safe, conscientious organization.

Finally, look into the use of other control strategies if your clientele desires them. Milky spore, nematodes, cultural practices, endophyte carrying varieties of turf are all areas of potential pest control. However, for the most part, there is still work that needs to be done in these areas as results with these practices have often been erratic.

A **final** note concerning pesticides focuses on the wise use of each product to avoid environmental problems such as groundwater contamination and wildlife kills. While these are critical issues, additional problems follow. Environmental problems frequently lead to the loss of a product. With few new products in the pipeline, we must preserve, through intelligent use, those which are currently registered.

In closing, do your homework and educate yourself on pesticide hazards. There have been a lot of articles in trade journals lately on this subject. Use these facts to intelligently educate the public and preserve the integrity of the turfgrass management industry.

RUNOFF AND LEACHATE FROM TURF TREATED WITH FERTILIZERS AND PESTICIDES

T. L. Watschke[1]

Certain landscape management activities (particularly applications of fertilizers and pesticides) are viewed as "nonessential" and they also presume these activities contribute in a significant way to a decline in water quality. Very little research has been conducted on the quality of runoff emanating from landscapes. Most of the information on nutrient/pesticide content of runoff is the result of research conducted on the quality of water leaving cropped land. Significant amounts of nutrients and pesticides have been found in such agricultural runoff, primarily in the eroded suspended sediment. Where grass buffer strips have been used between agricultural fields and receiving waters, concentrations of nutrients and pesticides were found to decrease after the water traverses the buffer strip. Such information provides indirect evidence of the potential that turf may have to improve the quality of water associated with it.

It has been documented that when land development increases, the pervious portion of the watershed decreases and is subsequently replaced by impervious surfaces (streets, rooftops, parking lots). These impervious surfaces contribute significantly to runoff from the watershed and to a decrease in the quality of such water.

The water quality facilities at the Landscape Management Research Center were developed at the Pennsylvania State University on a site formerly used for soil erosion research. The objective of this interdepartmental project (Agronomy, Agricultural Engineering, Entomology, Plant Pathology, and Horticulture) is to investigate the effects of turf and landscape management activities on the quality of turf runoff and leachate. Development and construction of the physical facilities involved the renovation of the soil erosion research area, fabrication of collection and subsampling equipment, instrumentation and data logger linkage with computer access, and establishment of turfed slopes on which the applications of nutrients and pesticides could be made. Slopes were established with either PA Certified Kentucky bluegrass sod or one of two seeding mixtures: A high quality mixture of perennial turfgrass species (Penn State recommendation) or a commercial "contractors' mix" containing a high percentage of annual ryegrass (65%). By late 1985, the facility was completed and since that time much of the research has focused on the hydrological characterization of the sloped sites involved.

In 1985, the individual plot irrigation systems were equipped to deliver 3"/hour, but this intensity was not capable of producing consistent runoff from the sodded plots. Hence, the irrigation system was equipped in 1986 with heads capable of delivering 6"/hour. When interpreting runoff results it should be remembered a 6" storm could be characterized as being highly unlikely to ever occur once every 125 years. However, 6" heads were required to study the hydrological characteristics of the site. Even under these highly exaggerated storm conditions, no more than 5% of the water ever ran off of the sodded plots.

During the experimental period (August 1986 to September 1988), no detectable levels of runoff were documented from any natural precipitation event. On several occasions, however, nondetectable flow produced amounts of runoff sufficient for quality analyses. For the individual runoff events significantly higher peak runoff flow rates and total runoff volumes were found for seeded plots.

For sodded slopes it is likely that the presence of vegetative cover from the day of establishment prevented the degradation of surface soil aggregates that would otherwise contribute to crusting and reduced infiltration rates. In addition, the 17 to 25 mm thatch layer associated with the

[1]Professor, Department of Agronomy, Pennsylvania State University.

bluegrass sod provided an interception-like storage capacity for a nearly equivalent amount of water, as well as a tortuous flow path that significantly reduced flow velocity along the surface. The resulting increase in surface residence time allowed greater infiltration instead of overland flow. Neither of these vegetation related phenomenon were factors on the relatively thatch-free seeded plots. Averaged over time and establishment method, it can be said that less than 10% of the water applied (even at 6"/hr) was found to runoff.

Analyses of water samples for nitrogen, phosphorus, and potassium showed that average concentrations of these nutrients in runoff and leachate did not exceed 10 ppm even when sampled as early as two days after their application. Most samples contained less than 5 ppm. Overall, nutrient concentrations in samples rarely exceeded those observed in the water used for irrigation.

Analyses for pendimethalin and chlorpyrifos did not once detect these materials in any sample even at a detectability level of 1 ppb. Over 70% of the samples analyzed for pesticides did not detect anything. Runoff and leachate samples taken within 48 hours of application found detectable levels of 2,4-D, 2,4-DP and dicamba. Although detectable, concentrations were almost always below the Public Drinking Water Standard and represented no more than 1 1/2% of that applied to the site.

REDUCING WATER NEEDS IN TURFGRASS MANAGEMENT

Richard H. White[1]

Irrigation is required when rainfall limits turfgrass growth and quality. Although extended drought periods are more common in the Western United States, urbanization in the Southeastern United States and climate change are altering the way turfgrass managers deal with turfgrass irrigation in the humid East. It is not uncommon in the humid eastern United States, for water use restrictions to be imposed on turfgrass managers. During long periods of low rainfall, irrigation of lawns, golf courses, and other turf areas is often a criminal offense.

The turf industry needs to take an active role in educating water resources planning commissions, legislators, and local governments to the requirements of the turfgrass industry for adequate water supplies to support a multi-billion dollar industry. Other water dependent industries simply slow down during periods when water restrictions are imposed. However, limiting the application of water to turf may cause serious damage to established turf areas and loss of golfing revenues, and tourist dollars in the hotel and restaurant industries. Unlike other industries that can readily restart once water restrictions are lifted, the turf industry is affected by environmental constraints on planting, establishment, and grow in periods. The regeneration of suitable turf cover to meet specific functions may require as much as 12 to 18 months.

Society's concern for the environment and for resource conservation will continue to increase the need for turfgrass managers to use irrigation water wisely and efficiently. Bentgrass is the predominant grass species grown on golf course putting greens, and unlike lawn grasses, often require daily watering to prevent permanent turf loss. Often, up to 0.5 inches of water are required each day just to meet the needs of the turf during periods of drought. There is no question that irrigation is required for putting green maintenance, however, turfgrass managers will have to become water managers rather than simply apply irrigation to turf. There are a number of things that turfgrass managers can do now to manage irrigation more effectively.

An effective water manager should be knowledgeable of soil characteristics that affect water availability, irrigation equipment, primary cultural factors that affect transpiration rates, weather or environmental factors that affect transpiration, and the irrigation requirements of different turfgrass species and varieties. Some estimate that as much as 25 to 30% of turfgrass irrigation water can be conserved if a few basic guidelines are followed. Water is one of our most vital, non-renewable natural resources. We must be good stewards of this resource to maintain our professions and environment.

Water's Role in Plants. A real key to becoming a good manager of irrigation water is to have an understanding of the function of water in turfgrass plants. Water serves five primary functions in plants. Water is a constituent of plants and makes up from 70 to 90% of turfgrass contents.

Water also provides support for plant cells. As a plant dries, leaves often wilt because the internal water content is not sufficient to provide the turgor pressure required to maintain expanded cells. Thus, individual cells collapse much like a deflated balloon or tire and the plant wilts.

Water serves as a conducting stream for transport of nutrients from the root system to the above ground tissues. Likewise, carbohydrates produced in leaves are transported to the roots and storage sites in a conducting system composed mainly of water.

[1]Assistant Professor, Department of Crop Science, North Carolina State University.

Water is required during the photosynthetic process when carbon dioxide is converted to carbohydrates. Green plant cells capture sunlight and use this solar energy in a controlled process to release electrical energy from water molecules. The electrical energy supplied by water molecules helps power the conversion of carbon dioxide to carbohydrates. Carbohydrates are necessary building blocks for new plant cells. During the release of electrical energy from water molecules, oxygen is released. Thus, turfgrasses serve a function vital to the existence of humans and all other animals when oxygen is released during the photosynthetic process. Although less than 1% of the water consumed by plants is used during photosynthesis, the release of oxygen from water molecules (H_2O) is one of the more important functions of water in plants.

Another important function of water in plants is heat dissipation or cooling. In order for plants to take in carbon dioxide, small pores in leaves, called stomata, open. When stomata open, water inside leaves evaporates and is lost to the atmosphere in the form of water vapor. This process is called transpiration. The conversion of liquid water to water vapor requires an extremely high level of thermal energy and results in considerable heat dissipation. The canopy temperature of a well-watered turf will usually be several degrees cooler than the air temperature on a bright sunny day. However, a water-stressed turf may have a canopy temperature 10 to 40 degrees higher than the air temperature because little water is available to be transpired. An acre of turf may lose several hundred thousand gallons of water to the atmosphere during a growing season. Transpiration accounts for about 98% of all the water taken in by turfgrass roots.

Root Zone Properties. Soil texture and structure affect soil water availability and turfgrass water use. Soils consist of solid particles and pore spaces which are filled with either air or water. Pore space may account for 40 to 50% of the soil, depending on texture, structure, and degree of compaction. Individual pore spaces are classified as small pores (capillary pores) or large pores (non-capillary pores). Small pores are usually filled with water and large pores are filled by air. Total pore space and pore size distribution determine most of the physical properties of soils that are important to irrigation practices. Well structured clay soils hold more plant available water than do sandy soils. However, as clay soils become compacted a greater portion of the total water held is not available for plant use. Compacted clays may have a high water content but much of the water is not available for plant use because it is so tightly held within very small pores.

Water moves downward in a soil through the large pore spaces until the flow is interrupted by a significant change in pore size. A barrier such as a thatch, compacted soil, a gravel layer, or clay pan will impede the downward movement of water. Irrigation rates and schedules must be adjusted when these barriers are near the surface of the soil to prevent excessive surface run-off. Where thatch accumulation is excessive, significant amounts of irrigation water may be required just to wet the thatch layer. Evaporation losses are considerably higher from thatch than from soil. A heavily thatched turf is usually shallow-rooted which also prevents effective utilization of irrigation water. Light, frequent applications of water are more efficient than more thorough irrigations when roots are restricted to a thatch layer.

The movement of water into a soil is called infiltration. A dry soil may have a very high initial infiltration rate, but as the soil pores become saturated with water, the infiltration rate decreases sharply. When a soil is saturated with water, the infiltration rate is equal to the percolation rate. Percolation is the movement of water through the soil profile. Infiltration and percolation rates determine the rate at which water can be effectively applied to a soil. An irrigation application rate that exceeds infiltration and percolation causes water to run off of the targeted area and reduces irrigation efficiency.

The amount of water stored or retained by a soil is determined by soil texture and structure. Clay soils may store 2 to 2.5 inches of plant available water per foot of soil depth. A sand, however, may hold less than 1 inch of plant available water per foot of soil depth. Typically water in the root zone should be replenished when 50 to 60 percent of the available water has been depleted.

Irrigation Equipment. Uniform, accurate water applications begin with a well designed and maintained irrigation system. Regardless of whether the system is a hose and sprinkler or a multi-zone computer based inground system the operator needs to make sure that water applications are made when and where needed. Faulty, missing sprinklers or irrigation heads that are poorly adjusted or poorly placed will not deliver the correct amount of water where needed. Additionally, water is often wasted through runoff when application volume exceeds infiltration rates into soils. Adjust irrigation time to match infiltration rates. If needed, decrease irrigation time to 5 to 10 minutes and repeat cycles to apply the quantity of water required. Check systems frequently for malfunctioning sprinklers or irrigation heads. The system should also be calibrated routinely to determine distribution patterns and application volumes. Flow meters also provide an indication of water applied but do not provide an indication of irrigation distribution. A flow meter in the system can be a useful indicator of irrigation applied per area if the total irrigated area is known.

Management and Turfgrass Water Use. Nitrogen fertility, mowing height and frequency, and irrigation practices can influence transpiration rates and efficiency of water use by turfgrasses. Excessive nitrogen application rates can increase the shoot to root ratio and increase transpiration rates because of an increased leaf surface area and leaf extension rates. In a research study, increasing nitrogen applications from 0.25 to 1.0 pound per 1000 square feet increased the daily water use by tall fescue from 0.16 to 0.22 inches per day under 80% relative humidity and 32 degrees F. Although daily water use rates were relatively similar, water use for a six-month growing season would be 10 inches greater when 1.0 pound of nitrogen was applied each month. Similar responses can be expected for other turfgrasses. Nitrogen fertilizer recommendations vary from region to region and from turfgrass to turfgrass. Your cooperative extension service should be contacted for nitrogen applications for use on turf grown in your location. The actual nitrogen requirement of turfgrasses will depend on length of growing season, environment, soil type, and intended use. Use moderate nitrogen applications whenever possible.

Cultural practices influence the depth, extent, and viability of turfgrass rooting. Rooting depth decreases with reduced mowing heights. Low mowing and excessive nitrogen fertilization decrease depth and extent of rooting more than either practiced alone. 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 generally require less frequent irrigation. Consult your local cooperative extension service for more specific information regarding mowing heights of turf in your location. The exact mowing height will vary from season to season and with the intended use of the turf.

Irrigation frequency and volume also affect rooting patterns. Turfs receiving light frequent irrigation develop shallower root systems than those receiving infrequent irrigation. On turf with shallow root systems, there may be little benefit of applying irrigation volumes sufficient to totally recharge the soil. Soils may not be depleted of soil moisture below the rooting depth. Applying water in excess of that required to rewet just below the root zone is wasteful and may have no benefit except when trying to leach soluble salts from the root zone.

Weather and Evaporative Demand. Weather greatly impacts turfgrass water use rates. ET is an abbreviation for evapotranspiration. ET is the water lost from both the soil and turf canopy. ET rates are affected by weather as well as grass and soil characteristics. Wind, relative humidity, available sunlight, and temperature all affect ET because each impacts on the atmospheric demand for water from plants. Atmospheric demand is greater on a sunny, dry, windy day than on a humid, overcast day.

Turf characteristics, such as growth habit, rooting patterns, canopy density, and turfgrass physiology impact on water use rates. Tall fescue and St. Augustinegrass with coarse leaves and more open canopies have higher ET rates than centipedegrass and bermudagrass.

Soil texture, structure, and fertility also affect

ET. Well structured clay soils hold more plant available water than do sandy soils. However, as clay soils become compacted a greater portion of the total water held is not available for plant use. Compacted clays may have a high water content but much of the water is not available for plant use because it is so tightly held within very small pores. Experienced turf managers can readily determine when to irrigate based on observations of soil moisture and turf appearance. A more precise method of determining irrigation need is based on a water balance method. The method is similar to balancing a checkbook. The method requires a general knowledge of the rooting depth, the plant available water holding capacity of the soil, the daily ET (what is going out or debits), and rainfall or irrigation amounts (what is going in or credits). The most critical for efficient water management is to know what is going in and what is going out.

The amount of water going into the turf can be determined with a simple rain gauge and a calibrated irrigation system. Maintain accurate records in terms of volume or inches of rainfall plus irrigation. Several methods can be used to determine the amount of water leaving the system through ET. In the Southeast, as a general guide, turf will loose about 0.25 inches of water per day. An evaporation pan can be made by filling a dish pan to within one inch of the top and measuring the depth of water lost each day. A running account of water lost daily from such a pan will be a relatively good guide to replacement irrigation needed. Replacement needs for cool-season grasses is usually about 80% of that lost from an evaporation pan. The United States weather surface also collects pan evaporation data and provides this information in many areas.

Sandy loam soils will hold about one inch of plant available water per foot of rooting depth. Well structured clay soils will hold more and sands less plant available water than sandy loam soils. If a turf growing on a sandy loam soil looses 0.25 inch per day in ET and has a rooting depth of 12 inches, then the plant available water in the soil would be depleted in about 4 days. The water balance method indicates that one inch of irrigation would be needed within four days to replace water lost through ET.

Grass Needs. The discussion above provides a means for maintaining a daily balance sheet for irrigation needs of turf. When managing turf areas in drought situations there are several things to keep in mind concerning the ability of plants to adapt to stressful environments. Turfgrass drought resistance involves drought escape, avoidance, and tolerance. Drought escape is an undesirable mechanism of drought resistance. This mechanism is typical of annual plants such as annual ryegrass. As warmer and dryer conditions develop, annual ryegrass produces seed and then dies leaving little functional turf cover. Death of such plants leaves voids that disrupt turfgrass quality and use. Drought avoidant turfgrasses continue to grow and develop even though drought stress conditions exist. Mechanisms such as reduced ET, deep root systems, high root to shoot ratios, and reduced radiation absorption enable the plant to avoid wilt and continue growth. Cultural practices such as mowing, fertilizing, watering, and cultivation, influence drought avoidance through direct and indirect effects on turfgrass water use and rooting. Drought tolerant plants are capable of withstanding low tissue water content for extended periods of time. There are several physiological mechanisms of drought tolerance which enable the plant to maintain turgor and more normal plant function during stress and to survive severe desiccation. The most effective turfgrasses are those which can both avoid and tolerate drought. Turfgrass managers should use plants and cultural practices that enhance drought avoidance and tolerance. The warm-season grasses have higher drought resistance than the cool-season grasses. Of the warm-season turfgrasses, buffalograss, bermudagrass, and zoysiagrass have high drought resistance. Among the cool-season turfgrasses, fine fescues and tall fescue have relatively high drought resistance. Tall fescue has a high water consumption rate but this negative characteristic is offset by a deep, extensive root system and good physiological tolerance of dessication.

Overall, those grasses with good drought resistance will reduce the need to irrigate. During critical periods of drought, irrigation can be applied less frequently and only as needed to ensure stand survival. Although turf quality of

even the most drought resistant turfgrasses may decline during critical water shortages, using drought resistant grasses will ensure plant survival, soil stability, and recovery of turf quality once rainfall or irrigation is resumed.

Research is improving our knowledge of drought avoidance, tolerance, ET, and irrigation needs. Many of the guidelines outlined here can be readily implemented into a water management program to reduce turfgrass irrigation requirements. The future holds great promise at further reductions in turf irrigation needs.

NCSU PLANT PATHOLOGY UPDATE

Dr. L. T. Lucas[1]

Several projects on turfgrass diseases that have been in progress over the last two years will be discussed. Activities include the evaluation of fungicides for control of dollar spot and brown patch on tall fescue and bentgrass, identification of *Pythium* species that are associated with summer decline on bentgrass and the use of infrared photography to help detect stressed conditions in turfgrasses.

Fungicides were evaluated on tall fescue at two locations in North Carolina. One was on a sod farm and the other was on a test area that was established at the Sandhills Research Station. A number of new fungicides were evaluated. The results indicated that there are a good number of new products that are coming on the market and some will be available in the next year or two. Others should be available in the next four or five years. Some of these same chemicals were evaluated for control of dollar spot and brown patch on bentgrass. The purpose of this presentation is not to cover the specific chemicals but to show that there are new fungicides coming on the market.

Pythium species have been associated with the decline of bentgrass and other cool season grasses. Over the last several years, we have isolated many fungi from the roots and crowns of declining plants. We now have a graduate student that is working with Dr. Shew on the identification and pathogenicity of these isolates. She has identified at least 25 different species of *Pythium* from the roots and crowns of bentgrass from golf greens in North Carolina. She has developed techniques to identify these fungi and is developing a technique to evaluate pathogenicity. In pathogenicity tests, some isolates of different species have caused disease. Others appear not to cause any disease at all and some even appear to be useful to the plant by stimulating root growth. This research will continue under the direction of Dr. Shew who now has research responsibilities on root diseases on turfgrasses. Dr. Shew and I will work together in trying to better understand the role of *Pythium* species in the decline of bentgrass throughout the year.

The *Pythium* species in root and crown rot diseases appear to be active throughout the year. Under very stressful conditions in the summer, the root and crown system deteriorates severely and once this occurs, the tops begin to decline. We think these Pythium root and crown rot diseases are quite important in this decline that we have been seeing. These diseases appear to be associated with the slow recovery of bentgrass during the fall. We think that these diseases are damaging the root systems severely in the summer and are active into the winter and causes bentgrass to recover slowly.

Another problem associated with these Pythium root and crown rot diseases is control. These fungi are in the soil and the roots and crowns and are difficult to reach with current fungicides. We have shown that some of these fungi are not sensitive to some fungicides such as Subdue. In laboratory tests, we have shown that the fungi are sensitive to fungicides such as Koban. Also, the fungi have been sensitive to the combination of Fore + Subdue which appears to be useful in their control. Future work will relate to identifying these fungi, determining the role of pathogenicity, and evaluating fungicides for the control of Pythium root and crown rot.

Research using infrared photography has been initiated to try to detect stress in plants before visible symptoms are evident. The infrared will detect a reduction in photosynthetic activity before the plants start showing symptoms. We have taken pictures from airplanes and have been able to detect stress on golf greens that superintendents did not know was there. Some of this work has been in cooperation with the Innova Company which has an infrared photography service. The

[1]Professor, Department of Plant Pathology, North Carolina State University.

with the infrared photographs is that interpretation is difficult if you are not very familiar with this technique. Dr. Keith Jones has been working with Dr. Shew and me for the last year. He has put together the necessary equipment to take the photographs and to help analyze these with a computer. This computer system can be used to put infrared photographs into a computer. Once in the computer, the system can be used to make very light red areas, which would be stressed, show up as red; very healthy turf show up as green; and areas that might be too wet will show up as blue. We think this computer analysis system will help in interpreting infrared photographs and be more useful to the superintendents than current infrared techniques.

I am evaluating video cameras with infrared filters to help analyze areas for problems, also. I hope to develop this system so that golf course superintendents can evaluate their own golf greens to help detect stress before it can be seen. I think this technique will be useful particularly for detecting problems such as localized dry spots. I hope that it can also be used to detect diseases such as brown patch several days before the symptoms actually appear. If this system can be developed, this would give the superintendent several days lead to determine when a fungicide is actually needed. This system could be part of an IPM program which would help the superintendent make better decisions on when to spray for diseases. In the long run, it may help reduce the need for fungicides. I think it can be used to help to detect when turf is becoming stressed from drought and help to manage irrigation. This technique may also be used to help evaluate the effects of new management methods on golf greens such as fans. We have been able to detect much healthier grass where fans were blowing across the greens versus where it was not on a portion of those greens.

Dr. Jones and I will be evaluating and developing the infrared photography techniques and the computer analysis system in the future. Hopefully this technology might be available soon to help golf course superintendent to detect problems earlier rather than waiting until symptoms become visible. Once the symptoms become visible, the problem is often very difficult to treat. I think this technology will help detect some problems and it will give you some information to start treating the problems earlier or help avoid unnecessary pesticide applications.

A major part of my program involves regular extension activities, such as giving programs at meetings, identifying diseases, and helping in fungicide and nematicide recommendations. Pesticide education is a major activity. In addition to giving programs for recertification credits, I help teach pesticide training schools for people who are taking their license examinations. A total of about 800 people attended these 12 training sessions last year.

I teach a course for Agricultural Institute students on diseases of ornamentals of turf each fall semester. Sixty students were in this course last fall.

I plan to continue many of these activities in the next year. If I can assist you with your turfgrass disease problems, contact your local coperative extension agent or me, and we will try to provide assistance.

TURF WEED CONTROL UPDATE

W. M. Lewis[1]

Turf weed control research this year has emphasized evaluation of two new herbicides which have pre- and postemergence activity for control of crabgrass. Also, we continued to study the effects of aerification on preemergence herbicide activity.

Dimension (code no. MON 15100 and common name of dithiopyr) from Monsanto was evaluated for preemergence and early postemergence control of smooth crabgrass and preemergence control of goosegrass in turf. Single and split applications were compared, and the potential window of application was examined for preemergence smooth crabgrass control. Tall fescue seeded the previous fall, ryegrass overseeded in a common bermudagrass fairway, and 'Penncross' bentgrass were evaluated for tolerance to Dimension. Control studies were conducted during 1987, 1988, and 1989 on common bermudagrass fairways at Oxford and Wake Forest, NC, and in tall fescue at the North Carolina Turf Field Center. Tolerance studies were located at Pinehurst and Pine Needles Country Clubs in Pinehurst, NC, and the North Carolina Turf Field Center.

Preemergence smooth crabgrass control with 0.5 lb active/A of Dimension 1EC was > 85% at 19 to 22 weeks after application. Control was greater than with Balan 2G at 3 lb active/A, Dacthal 6F at 12.5 lb active/A, Betasan 12.5G at 12.5 lb active/A, Surflan 4AS at 3 lb active/A, Ronstar 2G at 3 lb active/A, and Barricade 65WDG at 1 lb active/A, but not significantly in each case. Split applications (8 weeks apart) of Dimension at 0.25 + 0.25 lb ai/A and 0.375 + 0.375 lb ai/A provided equivalent control to single applications at 0.5 and 0.75 lb ai/A, respectively. Split applications improved control slightly for comparison herbicides. At 0.75 and 1 lb ai/A, Dimension effectively controlled emerged smooth crabgrass with 1 to 3 leaves. Favorable preemergence smooth crabgrass control was obtained from Dimension at 0.75 lb ai/A applied on February 10, March 1, March 10, or March 28 which indicated a wide window of application.

At 1 lb ai/A, Dimension provided 100% preemergence control of goosegrass which was 16 to 35% greater than Surflan, Ronstar, Pre-M, and Barricade.

No adverse effects on turf quality or root weight were noted from Dimension applied in the spring to tall fescue seeded the previous fall. Dimension at 0.5 to 2 lb ai/A did not adversely affect overseeded ryegrass in bermudagrass fairways. Bentgrass was tolerant to a June application at 0.75 lb ai/A, which was the only rate evaluated.

BAS 514 (common name of quinclorac) is an experimental herbicide from BASF AG. Preemergence evaluations of BAS 514 were conducted in common bermudagrass and Ky-31 tall fescue. BAS 514 50 WP at 1 lb active/A provided 87 to 93% smooth crabgrass control for 8 to 10 weeks following application. Control rapidly declined after this period.

Postemergence application of BAS 514 to 2 to 5-leaf smooth crabgrass provided excellent season-long control of smooth crabgrass, decidedly superior to Daconate (MSMA) which does not have preemergence activity. A single application at 1.0 lb active/A was equally as effective as two applications at 0.75 or 1.0 lb active/A. Goosegrass was not controlled by BAS 514. The postemergence applications of BAS 514 discolored the common bermudagrass at or below a minimally acceptable level for five weeks after application. The bermudagrass was rated as having 90+% greenup at time of application.

BAS 514 is taken up by roots and foliage. Tolerant grasses include tall fescue, Ky. bluegrass, and ryegrass. Not tolerant grasses are bentgrass, centipedegrass, and St. Augustinegrass. Bermudagrass tolerance is questionable. The

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product may be available in 1991.

Aerifying is routinely performed on high quality turf to reduce the effects to compaction. Many turfgrass managers are reluctant to aerify following herbicide applications since this operation could disrupt the herbicide barrier where each core is removed. This disruption could possibly reduce crabgrass control. The objective of the study was to determine the effects of aerification on the performance of preemergence herbicides under golf green and fairway conditions. These tests were conducted in creeping bentgrass, Tifgreen bermudagrass and common bermudagrass. Herbicides were Ronstar 2G (3 and 2 + 1 lb active/A), Betasan 7G (12.5 and 7.5 + 7.5 lb active/A), Pre-M 60DG (3 and 1.5 + 1.5 lb active/A), Surflan 4AS (3 and 1.5 + 1.5 lb active/A), and bensulide + oxadiazon (7.5 and 3.75 + 3.75 lb active/A). All the herbicides were applied at two rates, (1) full in late March or (2) split rate (1/2 late March and 1/2 after aerifying). Plots were aerified in early May. For bentgrass and Tifgreen, each herbicide plot was either aerified with the cores returned, aerified with the cores removed, or not aerified. For the common bermudagrass, the herbicide plots were aerified with cores returned or not aerified. Crabgrass counts of each plot were made monthly from May through September. Three years of research (1987-1989) indicate there was no decrease in herbicide performance due to aerification after preemergence treatments in Tifgreen and common bermudagrass. The bentgrass test plots that were aerified with the cores returned had significantly greater amounts of crabgrass than plots not aerified or aerified with cores removed.

NCSU UPDATE ON INSECT MANAGEMENT

R. L. Brandenburg[1]

Recent emphasis has been placed on strategies to reduce the environmental impact of our pest control methods. Increasing regulations and public scrutiny as well as a better understanding of pest management on the part of the turf manager has produced new incentives to work in this area.

Initial studies investigating the effectiveness of several entomopathogenic nematodes has produced results below our expectations. Although they do appear to be somewhat effective, improvement in application techniques is necessary to meet the needs of today's turf management programs. Products directed toward various caterpillars and mole crickets have been evaluated and will be studied again in 1992.

The use of pheromone traps and soil degree day information was initiated in 1990 to develop a means to predict insect outbreaks. Preliminary data indicate that such tools can be very useful in providing guidelines for scouting and treatments. They can predict upcoming peaks in insect abundance and activity. This can save turfgrass managers time and money by allowing them to better schedule their scouting.

Much work was done in 1991 on alternative technology for applying insecticides to turf. These include the use of high-pressure liquid injectors and a granular formulation injection. The advantages include no drift, no surface residue, improved performance, reduced rates, and reduced environmental effects. While the cost of such equipment may be prohibitive for some and little equipment is available for home lawn maintenance, this does appear to be a trend for the future. The results have been promising and, as a result, more manufacturers and agrichemical companies are interested in this technology. Undoubtedly, more equipment will be on the market in the coming years.

Efforts have continued to develop materials useful for educating the public on pesticides use in the environment. This issue is still an important topic to the public and directly affects the turf industry. A sympathetic, yet fact-filled approach is continually being updated to help the public separate fact from fiction.

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NEW(?) TECHNIQUES FOR MONITORING AND DETECTING TURF DISEASES

James C. Adams[1]

INTRODUCTION

Diseases present one of the largest threats to maintenance of quality turf in the U. S. Unfortunately, the most prevalent disease control measure, application of fungicides, increasingly has come under fire. Modern turf managers may find themselves squeezed between the need to utilize the best tools available for disease protection and the need to satisfy environmental concerns.

Most fungicides on golf courses are applied "preventatively" prior to obvious turf loss. However, the definition of "preventative" often depends on who is doing the spraying. In its various "use forms" preventative may mean: applications on a fixed calendar schedule; application at first sign of disease; applications when environmental conditions are conducive to disease development; or a combination of the above. In practice, this amounts to a balancing act, attempting to use chemicals only when they are needed, but at the same time, applying those chemicals prior to any evidence of a disease problem.

Given this 'balancing act" scenario, what tools are available to superintendents to ease the pressure and make disease control less of an art and more of a science?

WHAT'S NEW VERSUS WHAT'S PRACTICAL

First of all, let's be practical. Over the last thirty years turf maintenance has evolved dramatically. Grass, has become "fine turf," and with that distinction, there has been increasing pressure to "fine tune" the system. At this point in time, fungicides are the most appropriate control measure for disease outbreaks. Practically speaking, the worth of any technique for disease detection will be measured by how it augments preventative fungicide programs.

Unfortunately, very few "new" techniques satisfy the "fungicide criterion." A variety of techniques have been developed to identify the presence of disease-causing organisms, but very little of this technology has been developed to the point of having practical value to turf managers. The good news is, there are plenty of simple techniques/products available to superintendents that will improve efficiency of fungicide use.

DISEASE CONTROL ON TURF IS A THINKING MAN'S GAME

We live in a world that is accustomed to "instant everything." Technology has surpassed our ability to assimilate all the information that passes our way. And, after all, you don't have to understand the workings of an internal combustion engine to drive a car! But disease control on turf has become a "thinking man's game." Knowing a fungicide's mode of action can help you avoid the specter of resistance. Knowing the effects of pH on certain products can avoid disastrous results in acidic or alkaline solutions. Knowing when to respray an area without waiting for symptoms to reappear allows you maximum flexibility without the risk!

SOME LOW-TECH OPTIONS

It's not so much what you have to use, it's how you use it! Even if you intend to use the latest in technology to supplement your disease control strategies, do not underestimate the utility of some "old" techniques.

Visual Diagnosis

Even a preventative spray program doesn't cover all the angles. On the down side, early

[1]Agri-Diagnostics Associates, Moorestown, New Jersey.

symptoms of disease or signs of a pathogen can be misleading if not supported by other information. However, symptoms and signs are still a good place to start gathering information. In concert with environmental conditions, previous disease history and a little "local knowledge," visual diagnosis is a valuable support tool. Do not, however, fall into the trap of assuming a visual diagnosis is correct based purely on the results of a fungicide application. With the possible exception of *Pythium* products, many modern fungicides are so broad spectrum, they can mask the effect of a poor diagnosis.

Microscopic Features

In some areas of the country, superintendent's offices have taken on the look of plant pathology labs! In fact, more often than not the modern superintendent has the background and training to identify the prevalent fungal pathogens in his or her area. As with visual diagnosis, microscopic features of certain fungal pathogens can be a valuable tool in identification. Likewise, caution should be exercised in drawing conclusions from microscopic observations alone.

How can such a precise technique provide the "wrong" answer? Mainly it has to do with distinguishing between "signs" of the pathogen and actual infection of the grass plant. When a disease occurs on turf, even Pythium Blight, there is no spontaneous generation at work. Instead, the pathogen already exists, often in the soil or thatch, surviving in a somewhat quiescent state until environmental conditions trigger plant infection. Although production of obvious mycelium may be a good "sign" of certain diseases, presence of fungal structures does not guarantee them as the cause of the observed symptoms.

SOME HIGH-TECH OPTIONS (THAT ARE USEABLE)

Predictive Systems

There are many plant diseases, including some on turf, for which the factors affecting infection and disease development are fairly well understood. Using statistical methods, plant pathologists have developed models that predict onset and development of diseases based predominantly on environmental factors. Until recently "commercial"application of these models was restricted to use of simple degree-day/humidity/free moisture relationships that could be used as gross indicators for timing applications of fungicides.

Today, there are products available,, such as the Envirocaster, that automatically collect environmental data, feed the information into a computer program and tell you when to expect a particular disease. By automating data collection and using computer models, these systems provide greater accuracy than simple temperature/humidity models.

Biological Probes

This rather forbidding-sounding category consists of a whole range of biotech products, most of which have not made it to the turf market. Generally speaking, these are products that utilize the specificity of basic biological recognition factors to identify (and sometimes quantify) pathogens that cause diseases. Examples include DNA hybridization and immunoassay. Although various biological probes have been used by laboratories for several years, only immune-assays have been commercialized for disease detection on turf.

Immunoassay are sold under the trade name REVEAL@ for detection of Brown Patch, Pythium and Dollar Spot. Since the REVEAL assays are specific for particular pathogens, positive results indicate not only that the organism is present, but also that infection of the turf has taken place and the disease is active. Results can be quantified, which means the assays can be used with a preventative fungicide program to determine the efficacy of the chemical treatment and determine when to reapply the product without waiting for development of symptoms.

EFFECTIVE MOLE CRICKET CONTROL IN NORTH CAROLINA

R. L. Brandenburg[1]

North Carolina has recently been added to the list of southeastern coastal states doing battle with mole crickets. While the southern mole cricket has been present in the coastal plain area of North Carolina for over 15 years, the recent discovery of the tawny mole cricket has caused a renewed interest in this pest. The tawny mole cricket has become a serious threat to the golf industry in the southern coastal areas of North Carolina and has become a pest of the highest priority for many superintendents. Unlike the southern mole cricket, which is primarily a predator, the tawny mole cricket feeds directly on the roots of the grass. This root feeding as well as severe tunneling can ruin a tee or green and create unsightly fairways. The tawny mole cricket requires an aggressive plan for its management and one cannot simply wait for the insect to "show up" and then expect effective control.

Turf managers are somewhat fortunate in North Carolina because we have the advantage of being the recipients of years of research conducted in coastal states further to the south. At the same time, however, every situation is different, and what applies to mole cricket control in Florida or Georgia may have little application in North Carolina. In addition, some of our coastal courses are utilizing bentgrass greens. The hot weather places this grass under a lot of stress and only a high level of management will produce the quality of greens desired. Add the tawny mole cricket to the problem of growing bentgrass greens in the Southeast and one can become quite frustrated. However, this doesn't mean that bermudagrass greens are in any way immune to severe damage from this pest.

I believe mole crickets can be effectively managed in coastal areas, but they must be placed at the top of the pest priority list on the golf course. They must be viewed similar to pythium, something that must be watched carefully and acted upon immediately. We feel that most eggs from the tawny mole cricket have hatched by July 1. During the spring months we may see quite a bit of damage from the adults. Then in late April, May, and even early June the adults lay eggs. Most of these eggs are laid right back in the same areas where the damage was present last fall and that spring. So the subsequent infestation from the offspring will be concentrated in those areas already seriously attacked. The adults soon die after mating and egg-laying. Then during June and July the bermudagrass on the tees and fairways recovers and even the greens may begin to look better.

This improved appearance may give the impression that all is well. However, by July 1 most of the eggs have hatched and the tiny mole cricket nymphs are feeding away under the soil surface. But since they are so small and since turf growing conditions are good, the turfgrass looks fine and no one suspects the imminent problem that lurks just below the surface. Then as the nymphs get larger in August and September their damage starts to become obvious and then many superintendents begin their management programs. Unfortunately, once the mole cricket has gotten this large, they are hard to control and have already done serious damage.

Our best control philosophy at this time is to map out the areas of heaviest infestation in the fall and spring. Then in late June and the first of July go back into these areas and use a soapy water flush to determine the presence of the small nymphs. Be sure and look closely as these nymphs can be a 1/4 inch in length and may be easily overlooked. Once it has been determined that the mole crickets are present back in the same areas as last year immediately begin your management program. Treating when the mole crickets are small will result in much better control since they are easier to kill while still small. Plus they are controlled prior to any significant damage occurring. If a treatment is well timed and covers

[1]Associate Professor, Department of Entomology, North Carolina State University.

all the areas where eggs were laid, then a vast majority of the mole crickets can be eliminated early in the season., After that time, spot treatments can be used to eliminate hot spots later in the summer and fall.

Treating the adults in the spring will provide some benefit and will reduce some egg laying. However, these spring adults are hard to kill and its probably not a very cost effective approach. In some cases, unfortunately, spring infestations may be so severe that treatments may be necessary. This will not eliminate the need for the July I application to knock down the new generation. As previously mentioned, mole crickets require an aggressive approach to their control and sitting back and waiting until the problem gets serious in the fall will result in poor control and extra expense.

MONITORS AND SPRAYER CONTROL SYSTEMS IN TODAY'S MODERN TURF MANAGEMENT

John H. Gallup[1]

When I learned that I was officially going to be a speaker at this year's North Carolina Turfgrass Conference on monitors and sprayer control systems I wondered how I could approach this situation without making it sound like a sales meeting. I summized that it would be very difficult in that I'd be talking about some of the products my company manufactures. I decided that, in order to be fair, I would mention other companies that manufacture similar equipment -- namely: Raven Industries and Dickey-john Corporation.

One of the great things about monitors and sprayer control systems is that you can purchase them at any level your budget will allow.

Simple monitoring devices that give you very accurate MPH along with area covered and distance traveled start at approximately $200.00. These monitors are extremely popular in that the operator can know exactly what speed he's at to help him accurately stay at his target spray rate. These monitors are very accurate at low speeds.

A step up from this type of monitor is one that also comes with a flowmeter. So, in addition to speed, area covered, and distance, you also get a continuous upgraded readout in total gallons applied along with a spray rate. Monitors of this type normally cost in the $500.00 to $800.00 range.

The next step up is a sprayer control system. This type of system, in addition to what monitors give you, allows you to automatically stay at your target spray rate regardless of your changing ground speed. Some systems available also give you a pressure reading and an alarm light if you ever deviate plus or minus 10% from your target spray rate. Another feature some control systems have is the ability to increase or decrease your target rate (while you're moving) to satisfy your changing turf conditions. This is accomplished by simply hitting a plus/minus toggle switch to increase or decrease gallons per acre at a pre-set increment provided by the operator.

For example, if the operator, while spraying, sees ahead an area where he's had a bad weed problem, he can increase his spray rate to precisely where he wants it by hitting a toggle switch x number of times. As soon as he gets through that area, he can toggle right back down to his original target rate or even go lower if very few weeds are prevalent. Sprayer control systems range in price from $1,000.00 to $3,000.00.

The next step up from a sprayer control system would be an injection system. A system of this type may incorporate the use of a sprayer control system and enables the operator to change chemicals while spraying to satisfy changing turf conditions.

This is accomplished by pushing a button enabling the desired chemical (injected into the carrier) to be sprayed at a predesignated rate. Injection systems range in price from $6,000.00 to $10,000.00.

An advanced type of system presently being developed by Micro-Trak is one that includes all the features of both the sprayer control system and injection system -- and, in addition to having the ability to automatically inject the right chemical at the proper spray rate, this system will also automatically spray the chemical in the proper place. This is accomplished by premapping a certain stretch of turf according to soil and weed conditions. This information is programmed into the system and then completely removes all the guesswork an operator may have as far as what chemical, how much, and where sprayed.

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[1]Commercial Sales Manager, Micro-Trak Systems, Inc., Box 3699, Mankato, MN 56002.

These systems I've just covered are all mainly designed to save the average golf course spraying operation thousands of dollars in chemical expense -- not to mention helping to maintain EPA compliance.

Another good reason why these units are becoming so popular is because of the information they give you for accurate record keeping. I'm not sure what the EPA requires in North Carolina, but in some states (California) they require that the applicator not only be licensed, but monthly reports have to be sent in with all the information on the chemicals used, where applied and so on.

If you presently have a chemical program incorporating some sort of monitoring system, it would be a very good idea to volunteer this information to the public in every way possible; i.e., a press release to your local newspaper and a bulletin to your club membership.

In conclusion, if you haven't explored the possibility of some sort of monitoring or control system as yet, it might be very much worth your effort to do so. The old adage, "an ounce of prevention is worth a pound of cure," really fits here.

TOUGH TO CONTROL WEEDS

W. M. Lewis[1]

Weed management approaches will be discussed for selected difficult to control weeds. Control may entail selection of the proper herbicide, application timing, and/or repeat applications. Easy to control weeds such as crabgrass and annual bluegrass will not be included.

Dallisgrass and sandbur are difficult to control weed grasses. Dallisgrass is a perennial and sandbur is an annual. However, following mild winters, sandbur has been observed to regrow from roots. Both Dallisgrass and sandbur can be effectively controlled with repeat postemergence applications of arsenate herbicides, CMA, DSMA, and MSMA. These herbicides will also control crabgrass, goosegrass, annual sedges, and nutsedges. Bermudagrass is tolerant while bluegrass, tall fescue and zoysia are slightly sensitive to these herbicides. Do not use these herbicides on bahiagrass, centipedegrass, nor St. Augustinegrass. For effective control, spray when atmospheric temperatures are at least 80 degrees Fahrenheit and there is good soil moisture. Spray uniformly in 30 to 40 gallons of water per acre. Most of these herbicide formulations contain a surfactant. Do not irrigate or mow for at least 24 hours after application to allow the herbicide to be absorbed through the leaves and move throughout the plant. Two applications spaced 7 to 10 days apart will be necessary for control, and in many cases it will take a third application. In bermudagrass, centipedegrass, St. Augustinegrass, and zoysiagrass, Image herbicide may be used for sandbur control.

Yellow and purple nutsedge are perennial plants with leaves arranged in three vertical rows with a triangular shaped stem. These plants reproduce vegetatively by rhizomes and tubers which contribute to the difficulty of control. Herbicides for control of the nutsedges and their turf tolerance are indicated in tables 1 and 2.

Table 1. Nutsedge Control in Cool-Season Turfgrasses

Application Time and Herbicide	Turfgrass Tolerance: Tall fescue	Fine fescue	Ky. blue
Yellow and Purple Nutsedge Postemergence			
Basagran	T	T	T
MSMA	I	I	I

T = tolerant when used properly according to the label. I = intermediately tolerant, use with caution, use at reduced label rates, or minimum label rates.

Table 2. Nutsedge Control in Warm-Season Turfgrasses

Application Time and Herbicide	Turfgrass Tolerance: Bermuda	Centipede	St. Augustine	Zoysia
Yellow Nutsedge				
Preemergence				
Pennant	T	T	T	-
Postemergence				
Basagran	T	T	T	T
Image	T	T	T	T
MSMA	T	-	-	I
MSMA + Image	T	-	-	-
Purple Nutsedge				
Postemergence				
Image	T	T	T	T
MSMA	T	-		I

Nutsedges are difficult to control requiring one or two postemergence applications per year for two or more years. Late June to early July seems to be a better application time than late May or early June. The only herbicide for preemergence yellow nutsedge control in warm-season grasses is Pennant.

Examples of winter **annual broadleaf weeds** difficult to control are corn speedwell, lawn burweed (spurweed), parsley piert, and wild pansy. Descriptions of these weeds including several others

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are found in *Turfgrass Pest Management Manual*, AG-348, North Carolina Agricultural Extension Service. Examples of herbicides controlling these weeds are presented in Table 3.

Table 3. Winter Annual Broadleaf Weed Response to Herbicides

	Dicamba	2,4-D + dichlor-prop	2,4-D + mecoprop + dicamba	2,4-D + triclopyr
Corn speedwell	I-R	I-R	I-R	I-S
Lawn burweed	S	I	S	S
Parsley piert	S-I	R	S-I	I
Wild Pansy	S-I	I	I-R	I

S - susceptible, I - intermediately susceptible, good control can sometimes be achieved with high rates, but a repeat treatment 3 to 4 weeks later each at the standard or reduced rate is usually more effective. R = resistant in most cases.

Examples of these herbicides, which are available for the professional/commercial applicator, including turfgrass tolerance follow.

Dicamba (Banvel): Tolerant: fescue, bluegrass, ryegrass, bermudagrass Sensitive: bentgrass, carpetgrass, centipedegrass, St. Augustinegrass Rate: 0.1 to 0.25 lb active/A, can mix with 2,4-D, MCPA, MCPP

2,4-D + dichlorprop (Weedone DPC Ester & Amine, Turf D + DP Amine, Turf 2D + 2DP Ester)
Tolerant: fescue, bluegrass, ryegrass, bermudagrass Use at reduced rates (half) : carpetgrass, centipedegrass, St. Augustinegrass

2,4-D + mecoprop + dicamba (Lesco's Three-Way, Trimec Classic)
Tolerant: fescue, bluegrass, bermudagrass Not Tolerant: centipede & St. Augustinegrass However, all turfgrasses are tolerant to Trimec Southern

2,4-D + triclopyr (Turflon D)
Tolerant: tall fescue, bluegrass, perennial ryegrass

Atrazine (AAtrex) and simazine (Princep) provide preemergence and early postemergence control of several winter annual weeds including annual bluegrass, lawn burweed, chickweed, corn speedwell, henbit, hop clover and parsley piert. Tolerant grasses are bermudagrass, centipedegrass, St. Augustinegrass, and zoysiagrass. The rate is 1 to 2 lb active per acre. The preferred time of application is November 15 to December 30. Applied at this time 1.25 lb active per acre is sufficient.

Roundup applied postemergence will control many winter annual weeds in dormant bermudagrass. The rate range is 8 to 64 fl oz per acre. The rate will depend upon the weeds present, therefore, follow the label suggestions.

Two difficult to control summer annual broadleaf weeds are annual lespedeza and prostrate spurge. Suggested control is listed in table 4.

Table 4. Summer Annual Weed Response to Herbicides

	Dicamba	2,4-D + dichlor-prop	2,4-D + mecoprop + dicamba	2,4-D + triclopyr
Annual lespedeza	S	I	S	S
Prostrate srurge	S	S-I	S-I	S-I

Perennial broadleaf weeds often difficult to control are listed in table 5 with herbicides for control.

Florida betony, a perennial with ring-constricted tubers, may be controlled with atrazine in bermudagrass, centipedegrass, St. Augustinegrass, and zoysiagrass. Also, reports indicate 2,4-D, MCPP, or dicamba or combinations of two or three of these herbicides will control Florida betony in both cool- and warm-season grasses. However, base herbicide selection upon the tolerance of the turf to be sprayed. More than one application may be necessary. Space applications six weeks apart, if the full rate is used.

Table 5. Perennial Broadleaf Weed Response to Herbicides

	Dicamba	2,4-D + dichlor-prop	2,4-D + mecoprop + dicamba	2,4-D + triclopyr
Ground ivy	S-I	I	S-I	S-I
India mock strawberry	S-I	R	S-I	-
Oxalis	I-R	S	I-R	I
Virginia buttonweed	I	I	I	I-R
Wild garlic	I	I	I	I
Wild violets	S-I	I	I-R	I

An excellent herbicide for wild garlic control is imazaquin (Image 1. 5 LC) which may be applied in dormant bermudagrass, centipedegrass, St. Augustinegrass, and zoysiagrass. Avoid spraying during spring green up. The rate is 0.5 fl oz per 1000 square feet. Delay mowing for 8 to 10 days after application.

The preferred time to treat winter annual broadleaf weeds is from October thru February and summer annual broadleaf weeds is May and June. The preferred time for spraying perennial broadleaf weeds is as follows:

Table 6. Preferred Time to Treat Perennial Broadleaf Weeds

Weeds	Time
Ground ivy	Apr - May
India mock strawberry	Oct - Nov & Mar
Oxalis	Apr - May
Virginia buttonweed	May and repeat
Wild garlic	Oct - Nov & Feb - Mar
Wild violets	Apr

Control measures discussed thus far have emphasized spraying appropriate postemergence herbicides. However, preemergence control of certain broadleaf weeds may be obtained with isoxaben (Gallery 75 DF). Examples of selected weeds on the Gallery label are:

lawn burweed	speedwell, purslane
chickweed, common	speedwell, thymeleaf
chickweed, mouseear	geranium, Carolina
cudweed, purple	parsley piert
henbit	spurge, prostrate
knotweed, prostrate	spurge, spotted
pennywort, lawn	woodsorrell, yellow

All turfgrass are tolerant to Gallery. The application rate depends upon the weeds to be controlled and ranges from 0.25 to 0.5 oz per 1000 square feet. Specific rates are listed on the label.

PUTTING GREEN DRAINAGE

James T. Snow[1]

Several years ago the Sports Turf Research Institute in England Burveyed all of the golf courses in Britain and found that a full 80% considered that they have at least one poorly drained green. I **suspect** that if a survey were done of American golf courses, the results would be quite similar.

There is no telling the disproportionate amount of time and money spent dealing with these problem greens on golf courses wherever golf is played, but it must be substantial. There is little that is more aggravating or worrisome than **a** poorly drained green during periods of wet weather, especially when temperatures are high or traffic is heavy. Turf on poorly drained greens is generally more susceptible to disease incidence and stress injury, and the soil on such greens is more prone to compaction than greens that drain well.

For golf course superintendents who have managed poorly drained greens, the symptoms are easy enough to identify. They often include thin turf, shallow roots, compacted surfaces, greater disease, increased traffic injury, mower scalping, algae encroachment, footprinting, and **a** predominance of Poa annua.

Good drainage and poor drainage are relative terms. If all greens could be incorporated into a graph, it would probably show a bellshaped curve with a majority of greens in a broad mediocre, range as far as drainage is concerned. what this means is that many greens could be drainage problems under a certain set of circumstances, even though they drain satisfactorily much of the time. Golf course architects and builders who say they never lose greens to poor drainage even though they don't test their materials through a laboratory are kidding themselves and their clients. what they fail to say, or don't understand, is that many of these "low cost" greens can be a real headache during wet weather even though they may not fail completely. many of their greens fall into the mediocre, category.

When a golf course superintendent classified one of his greens as poorly drained, it doesn't necessarily mean that the soil in that green is of poor quality. what he should say is that under these climatic conditions, in this location on this golf course, and under this particular cultural management program, this green drains poorly. under a different management program, at a different site on the same course, or in an area that receives less rainfall, for example, this same green might be considered well drained.

The message is this: there are many factors that can contribute to a green being considered poorly drained, and there are many things that can be done to shift a green from the poor, to the satisfactory, category. Among the practices that need to be considered are irrigation management, tree effects, dealing with traffic, and drainage installation.

Irrigation Management

The fact is that many greens diagnosed as being poorly drained are actually overwatered. It is telling, for example, when a new superintendent takes over a course that he is able to eliminate the poor drainage symptoms from certain greens by instituting a different irrigation program or by redesigning or remodeling the irrigation system. After all, overwatering can be due to improper irrigation practices, poor irrigation system design, or both.

The following symptoms of overwatering may actually be the basis for a green being considered poorly drained. To be an actual symptom of overwatering, these observations must be seen on a regular basis; many could be casual observations made after a heavy rain and would not be considered the result of overwatering. If you can identify quite a few of these observations as being commonplace on your course, then perhaps your

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irrigation program needs attention.

- puddling after irrigation
- deep pitted ball marks
- spike marks and wear injury around cup
- complaints of wet shoes after walking on greens
- triplex ring symptoms
- Poa annua encroachment
- poor stress tolerance
- weak root growth
- heavy spring irrigation
- disease activity (pythium, brown patch)
- black layer
- manual irrigation system
- single row irrigation system
- lack of cultivation
- lack of use of soil probe
- lack of hand watering program
- insufficient daily visual monitoring
- insufficient monitoring of maintenance needs of the irrigation system
- isolated dry spots
- black algae

It is not uncommon, then, for poor irrigation practices or poorly designed irrigation system to be the actual cause of what many people might consider to be a poorly drained green.

The Effects of Trees

It is more than coincidence that the greens that superintendents identify as being poorly drained on their golf courses are often the ones located in a pocket of trees. on most of these courses, all of the greens were built at the same time and constructed of the same materials and in the same manner. Why, then, should these certain greens exhibit symptoms of poor drainage?

The answer to this question has to do with the environment in which the green is growing. The trees that surround these greens block air circulation through the area and may cast shadows on the turf, preventing the soil in the greens from drying as quickly as other greens on the course. They quite literally stay wet for a longer period of time than the others, and exhibit symptoms of poor drainage such as disease activity, algae and moss encroachment, poor tolerance to traffic, poor root development, etc. This prolonged period of wetness also makes them more subject to soil compaction, a factor that compounds the drainage problem.

This problem is made worse yet by careless irrigation practices on these greens. since they stay wet for a longer period of time, greens located in pockets of trees should not be irrigated as often or as heavily as other greens. superintendents who do not recognize this and who don't make the necessary adjustments often blame the subsequent turf problems on poor soil drainage.

The solution to this drainage problem is sometimes as simple as removing or thinning out a few of the nearby trees to improve sunlight penetration and air circulation. Adjustments to the irrigation program may also have to be made. If trees cannot be removed for some reason, or if these practices do not work, then the traditional methods of drainage or reconstruction may have to be used.

The Effects of Traffic

Many greens that exhibit adequate drainage characteristics under light to moderate use can develop poor drainage symptoms when subject to heavy traffic. when a municipality takes control of a private club, for example, this scenario is quite common. It also can occur when a switch is made from walk-behind greens mowers to triplex greens mowers.

The cause of the problem in this situation is compaction in the upper part of the root zone. water infiltration is reduced in compacted soils, causing runoff and puddling symptoms in many instances. Also, compacted soils do not dry as quickly, compounding the problem even more.

When poor drainage symptoms occur due to the effects of heavy traffic, cultivation practices should be increased. core cultivation, followed by core removal and topdressing with a sandy, compaction resistant material, should be practiced as often as necessary to improve and maintain good water infiltration. Deep tine cultivation may be needed on soils that are being affected at a greater depth.

Green design sometimes impacts the effects of traffic. For example, heavily trafficked greens that

lack adequate cupping area can show severe symptoms of surface compaction and poor drainage in the most common hole locations. By redesigning the green to expand hole location areas, these symptoms can sometimes be greatly reduced or eliminated.

When traffic problems occur on walk-on and walk-off areas, redesigning the green or the nearby sand bunkers can sometimes relieve the symptoms. Also, switching to walk-behind mowers for part or all of the time can significantly reduce traffic effects.

Dealinq with Poor Drainage

If drainage symptoms persist, even though the problems mentioned previously have been addressed, then a more direct approach to solving the drainage problem will be needed. First of all, however, the cause of the drainage problem in the green needs to be determined. It could be one of three possibilities:

- Poor surface drainage
- Poorly drained soil
- Layering problems

Poor surface drainage is often recognizable by the surface puddling that occurs after light to moderate rainfall or irrigation. It stems from poor green design or to settling after the green was built.

Poor surface drainage can be overcome in several ways, depending on the extent and severity of the problem. In some cases, low spots can be eliminated by selectively topdressing the area on a light, frequent basis. where a broader area is involved, sod may have to be removed, the subsurface regraded, and the sod replaced. In some instances, the entire surface may have to be stripped, regraded, and resodded, or be rebuilt completely. sometimes, nothing at all needs to be done if good surface infiltration can be maintained with a program of regular core cultivation.

When poorly drained soil is the cause of the problem, developing a solution is usually a matter of degree. where the problem is not too severe, a good program of core cultivation, core removal, and topdressing with a sand or high sand content material affords relief over a period of years. Deep tine aerification also can be incorporated into the program for faster results.

Where the symptoms are severe, the addition of drainage tile to the green may be necessary. The installation of 21, to 41, plastic perforated pipe sometimes works quite well, though the disruption to the putting surface can sometimes take years to eliminate. various types of sand injection systems and geotextile-covered drainage systems have been tried, but in many instances the results have been insufficient or temporary. If a green has a long history of drainage problems, the best solution is to rebuild to good specifications.

Layering problems caused by poor construction, topdressing inconsistencies, or some other factor, can sometimes be overcome by breaking through the layer and allowing water to reach the well-drained soil below. This is accomplished by regular core cultivation or deep-tine cultivation, depending on the location of the layer. If the coring holes are filled with sand, real progress can be made in overcoming the effects of the layer. In a more severe case, drainage tile may need to be added. Greens that do not respond well to these techniques should be rebuilt to good specifications.

Summary

Greens drainage problems arena necessarily what they appear to be. Poor irrigation practices, tree effects, and traffic effects sometimes mislead golf course superintendents into thinking they have a drainage problem. on greens where poor drainage is identified, the cause of the problem could be 1) poor surface drainage, 2) poorly drained soil, or 3) layering problems. The cause must be determined before a good solution can be developed and implemented.

REDUCING *Poa annua* WITH HERBICIDES

W. M. Lewis[1]

Annual bluegrass (*Poa annua* L.) is a troublesome weed in golf course turf. it is unsightly in fairways as well as greens. The lighter green shoots of annual bluegrass and its bunch type growth habit disrupt the uniform color and reduce the putting quality of greens. Management practices such as improperly timed fertilization, shallow and frequent irrigation, inadequate soil drainage, excessively close mowing, and use of heavy equipment causing compaction have encouraged its persistence. It can survive and produce seedheads when mowed at putting green height. In North Carolina annual bluegrass behaves as a tufted bunch type winter annual with an upright growth habit. Also short-lived perennial subspecies have been observed in golf greens within the state.

Control in Fairways

Preemergence herbicides may be applied in the fall for *Poa annua* control, provided overseeding or reseeding is not planned. These herbicides also affect the germination of turfgrass seeds. Most preemergence herbicides normally used for crabgrass control, also provide good control of annual bluegrass. Possible herbicides for preemergence control in bermudagrass fairways are: benefin (Balan), benefin + oryzalin (XL), benefin + trifluralin (Team), bensulide (Betasan, Bensumac & Lescosan), DCPA (Dacthal), oryzalin (Surflan), oxadiazon (Ronstar), and pendimethalin (Pre-M, Weedgrass Control). Fewer herbicide are available for cool-season grasses. When Kentucky bluegrass, fine fescue, and/or perennial ryegrass are present in a fairway, only bensulide and pendimethalin may be applied.

Because annual bluegrass germination is influenced by fall moisture and cool temperature, it is perhaps more difficult to indicate a definite time for application. In our tests, we have received good preemergence *Poa annua* control from late September applications using the maximum label rate for the selected herbicide. When this has been followed by another application in early February at half the label rate, improved Poa annua control has been observed plus summertime crabgrass control. It is preferable to use this two application approach only in dense turf with low traffic potential.

Atrazine (AAtrex) or simazine (Princep) effectively controls annual bluegrass in bermudagrass fairways. A 1.25 lb/active per acre rate of either product gives excellent *Poa annua* control when applied from mid-November to the end of December. If application is delayed until January, atrazine is the better choice. These herbicides also control winter annual broadleaf weeds such as chickweed, corn speedwell, henbit, hop clover, parsley piert, and lawn burweed (spurweed).

Another possibility for *Poa annua* control in dormant bermudagrass is Sencor 75 Turf Herbicide applied at 0.67 lbs product per acre. Apply this product is usually applied in January and February and definitely before spring greenup. It will also control common chickweed, corn speedwell, henbit, hop clover, parsley piert, prostrate knotweed, and lawn burweed.

Kerb 50 W applied at 2 to 3 lbs product per acre will provide preemergence and early post-emergence control of annual bluegrass, mouseear chickweed, and ryegrass. Apply from September 15 to February 1. However, avoid spraying areas that may drain onto bentgrass or to areas overseeded with cool-season grasses.

In completely dormant bermudagrass, Roundup at 16 ozs of product per acre will provide postemergence control of annual bluegrass, chickweed, henbit, and corn speedwell. Apply in 10 to 20 gallons of water with 2 quarts of nonionic surfactant per 100 gallons of spray solution.

When applying any of these postemergence

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herbicides, be careful to prevent the movement of the herbicide by spray drift or water movement onto any desired cool season grasses.

Control in Overseeded Bermudagrass Greens

Ethofumesate (Prograss) provides pre-emergence and postemergence control of annual bluegrass in dormant bermudagrass which has been overseeded with perennial ryegrass. The herbicide Prograss is primarily root absorbed and translocated into the foliage following uptake by the roots. The first application should be 30 to 45 days after overseeding. The rate is 5.33 pints per acre of the emulsified concentrate (1 lb active per acre) or 2 fluid ozs per 1000 square feet. Follow with one supplemental application 30 days later at the same rate. Control is reduced, if applications are spaced 60 days apart. Prograss gives excellent control of annual bluegrass applied at 1 lb active per acre. Higher rates do not increase the degree of control. In addition, the turf quality of the overseeded ryegrass is generally better at the 1 lb active per acre rate than at the 1.5 active per acre rate.

According to the label, early applications of Prograss can cause "premature onset of dormancy," if applied to bermudagrass which is not yet fully dormant. Relaying the initial Prograss application until 30 to 45 days after overseeding, reduces the chances of bermudagrass going off color. This also enables the overseeded ryegrass to become better established. In areas where bermudagrass does not naturally go into winter dormancy, do not apply Prograss. Also, it is advisable to delay Prograss application in unseasonably warm falls until periods of cool weather which encourage bermudagrass to go into dormancy. We have started Prograss applications as late as the first week in December with favorable results. The label states, "Do not apply Prograss after February 1. Late applications may temporarily delay resumption of active growth habit of bermudagrass in the spring". Based on our results, I prefer January 10 as the last date for applying Prograss.

Control in Bentgrass Greens

In bentgrass golf greens, bensulide may be used for preemergence control of annual bluegrass as well as bensulide + oxadiazon (ProTurf Goosegrass/Crabgrass Control).

Ethofumesate (Prograss) provided effective control of annual bluegrass in 'Penncross' bentgrass golf greens with tolerable levels of injury to the bentgrass in tests conducted over a five year period in North Carolina. These results are presented for information only, for they are not a recommended label use. The most favorable control was obtained with 3 applications of Prograss spaced at 20 or 30 day intervals applied at 0. 75 lb active per acre per application (0.75 lb active per acre = 1.5 fluid ozs of Prograss emulsified concentrate per 1000 square feet) or 5 applications spaced at 20 day intervals at 0.5 lbs per active per application (0.5 lb active per acre = 1 fluid oz of Prograss emulsified concentrate per 1000 square feet). Also, favorable control in bentgrass greens, was influenced by initiating applications after the average daily temperatures drop below 65 degrees Fahrenheit. This is the last of September or early October in the northern piedmont and October 10 to 14 in the southern piedmont and in late August in portions of the mountains.

Slight discoloration of bentgrass turf may follow each application, however, permanent injury has not been noted under favorable management conditions. Observations indicated that bentgrass having a shallow root system or growing under stress conditions or in a compacted soil is more susceptible to injury from Prograss and therefore should not be treated. The chances for bentgrass injury increased when Prograss was applied in late January or in February. Prograss should not be applied, if soil temperatures are expected to be below 40 degrees Fahrenheit. Controlling heavy infestations of annual bluegrass may result in bare areas. If this condition cannot be tolerated, the bentgrass should not be treated. As indicated previously, this information on Poa annua control in bentgrass with Prograss is not a recommendation.

Rubigan for *Poa annua* Management

Fenarimol (Rubigan) is a systemic fungicide which may **also** be used to reduce *Poa annua* populations in bentgrass and overseeded bermudagrass greens. Rubigan affects the annual types and has no significant effect on the perennial forms of *Poa annua*.

For best control of *Poa annua*, apply Rubigan

before the germination of any *P. annua* seeds. We have observed favorable control with three applications. The rate per application is 4 fl oz per 1000 square feet. The spray interval is 14 days. The last application of Rubigan should be made at least 14 days prior to overseeding ryegrasses and at least 30 days prior to overseeding bentgrass.

As with any weed management program, the selection of herbicide to control annual bluegrass depends upon the tolerance of the desired turfgrass to that herbicide. Also, consider if a preemergence or postemergence herbicide is the most desirable for the situation. Lastly, when spraying, prevent off target movement of the herbicide to sensitive grasses.

CONDITIONING TURF FOR ADVERSE ENVIRONMENTS

R. E. Schmidt[1]

In preparing for adverse conditions for turfgrasses, type of grass must be considered. Cold weather is an adverse condition for warm season grasses while hot conditions are adverse for cool season grasses. Heavy traffic could be an adverse condition for both warm and cool season grasses. However, traffic could be more detrimental for one than another depending on the season. Warm season grasses are more efficient in photosynthesizing than cool season grasses, the cool season grasses such as bentgrass respire carbon during the photosynthesis process, but warm season grasses, such as bermudagrass, do not.

If the loss of carbon from dark respiration (the respiration that occurs in plants with or without light) and the carbon utilized in growth is acerbated with chemicals or fertility, carbon reserves (carbohydrates) may be utilized to the point the plant loses vigor. The plant could then negatively respond to any condition less than optimal.

First, let us determine what the common adverse conditions are for cool season grasses. Hot, dry weather that occurs during the summer is the environment that generally is considered most adverse to producing cool season grasses. What characteristics of the cool season grasses differ at the time of year when compared to other seasons?

The biggest difference is that during this period the carbohydrate reserves are at their lowest and root growth is the poorest. Carbohydrate content and root growth seem to go hand in hand. In late winter the carbohydrates naturally build up because of low temperatures. Respiration is low and growth is slow. Since grass roots grow at lower temperatures than the shoots, root development will occur in the spring before the shoots. Root development correlates with the carbohydrate content. Therefore, it seems prudent to manage to enhance carbohydrate content of the plant. Of all 16 nutrients, essential elements needed for turfgrass growth, nitrogen has the greatest impact on carbohydrate content. Nitrogen application can stimulate growth and enhance chlorophyll development and photosynthesis rate. However, nitrogen fertilization normally will stimulate respiration and increase shoot growth. Both aspects utilize and reduce the carbohydrate reserves. Lack of carbohydrate reserves limits the production of roots which eventually reduces the plant vigor.

If nitrogen is made available to a cool season grass immediately prior to and during periods of low temperatures, carbohydrate content will actually increase. This relates to the fact that nitrogen enhances chlorophyll activity. That is, carbon dioxide fixation is increased which causes an increase in carbohydrate development. Since foliar growth and respiration is limited under low temperatures, the carbohydrates are stored. These stored carbohydrates subsequently support vigorous root growth that will influence the tolerance of the grass to the high temperatures during the summer.

Stimulation of the spring flush of growth with heavy nitrogen fertilization or nitrogen application in the heat of the summer could affect the plant's metabolism and reduce the plant's tolerance to adverse conditions. Results from studies involving heavy spring fertilized creeping bentgrass at Virginia Tech have shown that dollarspot disease and crabgrass infestation were increased when compared to a heavy fall fertilization.

A balanced fertilization program has long been recognized as an important aspect in conditioning turfgrasses for adverse conditions. A maintenance ratio of 3N, 1P, to 2K has been established as an excellent nutrient balance. Recently there has been a move to increase the potassium portion of the ratio. We have found applying more K than N will cause an increase in dollarspot disease and crabgrass infestation increases.

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Our work since the mid sixties has demonstrated that of all the essential micro-elements, iron appears to be the most important. Research at Virginia Tech has shown that iron fertilization not only improves the plant's color, but reduces the influence of desiccation, enhances root growth, decreases thatch buildup, and has lessened disease infection. Our best results were always obtained with the heavy fall N fertilization in conjunction with iron fertilization during cool temperatures in the fall and prior to and during the hot summer months.

In addition to fertility management, the cool season turfgrasses may be conditioned to tolerate adverse conditions by raising the mowing height. This is especially true of bentgrass. An increase of 1/16 of an inch mowing height often makes the difference of whether or not bentgrass will tolerate the hot summer temperatures experienced in Virginia and the Carolinas.

The warm season turfgrasses differ from the cool season grasses mainly in three ways. First, the warm season grasses do not exhibit photo-respiration; therefore, are more efficient in photosynthesizing than cool season grasses. Second, the warm season grasses store energy as starch rather than simple sugars stored by the cool season grasses. Simple sugars are more readily utilized by plants than the long polymer starches, one reason why the warm season grasses do well during hot weather. The third difference is that the warm season grasses go dormant during the winter and cool season grasses do not. It is this dormancy period that is the most adverse period for warm season grasses.

Our research shows that the shorter the dormancy period of bermudagrass, the less the adversity of the winter on bermudagrass survival. It has been well established that heavy potassium fertilization improves the winter hardiness of bermudagrass. Also, our studies show that phosphorus fertilization reduces bermudagrass winter injury. Applications of iron has reduced the influence of traffic on dormant bermudagrass and prolonged green color in the fall.

As with cool season grasses, we feel that nitrogen fertilization of warm season grasses is best if correlated with the natural buildup of carbohydrates. The highest percent of carbohydrate content in warm season turfgrasses occurs just prior to dormancy in the fall. We have found that heavy applications of nitrogen applied in late summer or early fall, along with adequate potassium, extends bermudagrass chlorophyll activity in the fall and encourages postdormancy growth in the spring. Our research indicates that high amounts of fall-applied nitrogen does not reduce winter survival. The addition of early fall iron further reduces the bermudagrass dormancy period.

Recent research conducted at Virginia Tech has shown that applications of some of the triazole fungicides or fortified seaweed extracts has enhanced both cool and warm season turfgrass vigor during periods of adverse conditions. These materials, referred to as biostimulants, have enhanced color, reduced the effect of traffic, drought, and saline irrigation on turfgrasses. We feel the biostimulants have a positive role in conditioning turfgrasses for adverse conditions.

POTENTIAL FOR GROUNDWATER CONTAMINATION BY TURF HERBICIDES: A HERBICIDE/SOIL RANKING SYSTEM

J. B. Weber[1]

ABSTRACT

A system for selecting environmentally safe herbicides for use in turf is discussed. Three pieces of information are needed: 1) major soil series of the field to be treated, 2) herbicide selected, and 3) application method. The leaching potential of 35 herbicides is computed based on their retention by the soil, half - life, rate applied, and fraction hitting the soil. Leaching potential of 66 coastal plains soils, is computed based on texture, pH, and organic matter content of the 0 to 3 foot deep soil profile. Herbicides and soils are ranked according to their leaching potentials and a matrix is provided for allowing applicators to avoid using "hot" chemicals on "hot" soils and to select environmentally safe chemicals or to select application methods that safen a given product.

INTRODUCTION

Pesticides have been found in ground water in more than 30 states (Williams et al. 1988). Most of the chemicals detected were herbicides. Chemicals found most often generally had many of the following characteristics: 1) highly mobile in soil leaching studies (high R, values) , 2) low retention by soil in adsorption studies (low Koc values) , 3) applied at moderate to high rates (2 to 15 Kg ai/ha) over large acreages, and 4) moderate to long lived in the environment (half -lives of 30 days or longer) . Some of the compounds found included atrazine, alachlor, bromacil, and aldicarb. Information available on the mobility and potential for contaminating ground water of pesticides used on turf is limited. Studies by several investigators [Sears and Chapman (1984), Braham and Webner (1985), Goh et al. (1986) , Sears (1987) , Niemczyk et al. (1988)] showed that the chlorinated hydrocarbon insecticide chlordane and several organophosphorus pesticides, including chlorpyrifos, diazinon, dichlorvos, ethoprop, isazofos, and isofenphos, were retained in large amounts (> 90%) by bluegrass thatch and that only small amounts (< 10%) leached below the thatch zone. Gold et al. (1988), in studies with dicamba and 2,4-D, however, found 1.0 and 0.4 percent, respectively, of the total amounts applied in percolate that passed through turf. Cohen et al. (1990) sampled and analyzed water from 16 monitoring wells on golf courses and found chlorpyrifos, 2,4-D, dicamba, isofenophos, and trichloropyridinol in one of each of the wells, chlorothalonil in 2 wells, DCPA in 3 wells, heptachlor epoxide in 4 wells, chlordane in 7 wells and DCBA in 9 wells. Eighty percent of the compounds were found in concentrations less than 0.5 ppb. In a comprehensive review of turf pesticides, Walker et al. (1990) correctly concluded that "Quantitative data on national or regional pesticide use for pest and disease management on golf courses is currently not available."

Herbicide Leaching Potential (HLP)

The potential for pesticides to leach to ground water depends on the: 1) properties of the chemical, 2) properties of the soil, 3) application conditions, and 4) climatic conditions. The relative potential for selected pesticides to leach has been estimated using the following equation (Weber 1990):

$$HLP = Koc/(T\text{-}1/2)\ (R)\ (F)$$

where:

- HLP = Herbicide leaching potential index
- Koc = Herbicide retention by soil index
- T-1/2 = Half-life of herbicide in the field for the region
- R = Rate of herbicide applied (kg ai/ha) for the region
- F = Fraction of herbicide hitting the soil (assumed to be 0.5 for turf and 1.0 for bare soil)

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Table 1 contains calculated HLP indices and ratings based on worst case conditions (smallest Koc, and largest T-1/2 reported, and highest rate registered for use).

A sample calculation for asulam is as follows:

Koc = 20 to 60 T-1/2 = 6 to 14 days
R = 2.2 kg ai/ha
F = 0.5 (estimated for established turf)

HLP (Asulam) = 20/(14)(2.2)(0.5) = 1.3

The HLP indices (previously called GWCP indices) ranged from <0.01, for chemicals with a very high potential to contaminate ground water, to 10" for chemicals with extremely low potential to contaminate ground water for approximately 100 pesticides (Weber 1990). For the 37 herbicides shown in Table 1, the following HPL ratings were selected: High (H) = values less than 1.0, Moderate (M) = values of 1.0 to 10.0, and Low (L) = values of 10.1 or greater.

Soil Leaching Potential (SLP)

The leaching potential of a soil depends on many factors but the ones that are of greatest importance to herbicide movement are texture, organic matter content, and pH (Weber 1972, Weber 1987, Weber and Miller 1989, Weber and Whitacre 1982). The relative importance of each of these three factors differs with each pesticide, but for this paper I have assigned them weighing factors of 3, 10, and 4, respectively (Tables 2, 3, and 4, respectively). Dissolved chemicals move most readily through sand and silt and less readily through clay and muck, thus the rating scheme for various soil textures ranges from 1 for clay or muck to 10 for sand, loamy sand, sandy loam, loam, silt loam, or silt (Table 2). The textural component of the SLP is the product of the rating and the weight factor.

Organic matter (or humic matter) adsorbs herbicides to varying degrees depending on the chemical properties of the compound (Weed and Weber 1974). Adsorption increases and mobility decreases as soil organic matter content increases, thus the rating scheme for various organic matter levels (of the surface 15 cm of soil) ranges from 1, for soils with high organic matter content (> 6% OM or > 4% HM), to 10 for soils with low organic matter content (< 2% OM or < 1% HM) (Table 3). The organic matter component of the SLP is the product of the rating and the weight factor.

Soil pH affects the mobility and/or the degradation of herbicides to varying degrees depending on the chemical and biological properties of the compound (Weber 1972). The mobility of herbicides with acidic or basic properties normally increases as soil pH increases. Chemical degradation of many herbicides is also normally greater under acidic conditions than under neutral (or alkaline, or calcareous) conditions. Thus, a rating scheme for various soil pH levels ranges from 1, for soils with pH levels less than 5, to 10, for soils with pH levels greater than 7.0. (Table 4). The pH component of the SLP is the product of the rating and the weight factor.

Calculation of the SLP for a given soil series is done by rating the texture and pH components of the 0 to 91 cm depth of the soil profile and the organic matter component of the 0 to 15 cm depth surface soil, multiplying by the appropriate weight factors and summing the mean product of each component. A sample calculation is given in Table 5 for a Goldsboro soil. The maximum SLP index possible for a highly leachable ("hot") soil is 170 and the minimum SLP index possible for a soil with low leaching potential is 17. SLP ranges for the 66 soils listed in Table 6 are as follows: High (H) = 131 or greater, Moderate (M) = 90 to 130, and Low (L) = 89 or less.

HLP/SLP Matrix

To avoid contaminating ground water, herbicides should be selected that have the lowest potential for leaching on the soil type to be treated. The matrix given in Table 7 allows one to determine the ground water contamination potential (GWCP) if one knows the HLP for the herbicides that he wants to use and the SLP for the soil type that he wants to treat. The GWCP ratings range from "hazardous" for the case where a herbicide has a high HLP and it is to be used on a soil with a High SLP, to "risky" for cases where a herbicide with High HLP is considered being used on a soil with Moderate SLP or a herbicide with Moderate HLP is being considered for use on soils with High or Moderate SLP, to "safe" for cases where herbicides with Low SLPs are considered for use on soils with High, Moderate,

or Low SLPS.

For example, if the herbicide 2,4-D, which has a High HLP, is being considered for use on a Lakeland sand, which has a High SLP, the HLP/SLP matrix would suggest that under worst case conditions it might be "hazardous" to the ground water. If the herbicide bentazon, which has a Moderate HLP rating were being considered for use on the same Lakeland soil (High SLP), the HLP/SLP matrix would suggest that the situation is "risky" to the ground water. If benefin (Low HLP) was being considered to be used on the same soil, the HLP/SLP matrix would suggest that it is "safe" to use and will not pose a problem to the ground water.

It would be desirable if no herbicide (or contaminant of any kind) finds its way to the ground water to contaminate wells, so herbicide applicators should select chemicals with the lowest potential to contaminate ground water for the soil types of the fields that they want to treat. This scheme is offered as a guide to accomplish this.

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Table 1. Herbicide leaching potential (HLP) indices and ratings for 37 herbicides used in turf.

Common name	Trade name	Application method	HLP index[1]	HLP Rating[2]
Asulam	ASULOX	Est. turf	1.3	M
Atrazine	AATREX	Est. turf	1.5	M
Benefin	BALAN	Est. turf	49	L
Bensulide	BETASAN	Est. turf	1.0	M
Bentazon	BASAGRAN	Est. turf	0.85	H
Bromoxynil	BUCTRIL	Est. turf	66	L
CMA	CALAR	Est. turf	48	L
2,4-D	WEEDAR 64	Est. turf	0.40	H
Dalapon	DALAPON	Est. turf	0.009	H
Dicamba	BANVEL	Est. turf	0.48	H
Dichlorprop	WEEDONE CB	Est. turf	2.2	M
Dithiopyr	DIMENSION	Est. turf	143	L
Diruon	KARMEX	Est. turf	3.0	M
DSMA	METHAR-30	Est. turf	24	L
Ethofumesate	PROGRASS	Est. turf	0.75	H
Fenarimol	RUBIGAN	Est. turf	21	L
Fenoxaprop	ACCLAIM	Est. turf	59	L
Glyphosate	ROUNDUP	Est. turf	112	L
Imazaquin	IMAGE	Est. turf	3.6	M
MAMA	MAMA	Est. turf	44	L
MCPA	CHIPTOX	Est. turf	0.79	H
Mecoprop	LESCOPEX	Est. turf	0.28	H
Metolachlor	PENNANT	Est. turf	1.7	M
Metsulfuron	ALLY	Est. turf	3.0	M
Metribuzin	SENCOR	Est. turf	2.4	M
MSMA	DACONATE 6	Est. turf	39	L
Napropamide	DEVRINOL	Est. turf	2.6	M
Oryzalin	SURFLAN	Est. turf	39	L
Oxadiazon	RONSTAR	Est. turf	9.2	M
Paraquat	GRAMOXONE	Est. turf	893	L
Pendimethalin	PROWL	Est. turf	65	L
Pronamide	KERB	Est. turf	20	L
Sethoxydim	POAST	Est. turf	14	L
Siduron	TUPERSAN	New seeding	0.73	H
		Est. turf	1.4	M
Simazine	PRINCER	Est. turf	1.9	M
Triclopyr	CARLON	Est. turf	0.055	H
Trifluralin	TREFIAN	Est. turf	131	L

[1]HPL = Koc/(T-1/2) (R) (F), where Koc = soil binding index for herbicide, T-1/2 = half - life in days, R= rate applied in kg ai/ha, and F = fraction hitting soil. The soil (assumed to be equal to 0.5 for established turf and 1.0 for bare soil).
[2]HPL Ratings: High (H) = <1.0, Moderate (M) = 1.0 to 10.0, and Low (L) = >10.0.

Table 2. Textural component of the soil leaching potential (SLP) index.

Soil texture[1]	Weight Rating	Factor	Product
S, LS, SL, L, SiL, Si	10	3	30
SCL, CL, SICL	6	3	18
SC, sic	3	3	9
C or muck	1	3	3

[1]S = sand, L = loam, Si = silt, C - clay

Table 3. Organic matter (or humic matter) component of the soil leaching potential (SLP) index.

% OM[1]	% HM[1]	Rating	Weight factor	Product
< 2	< 1	10	10	100
2 - 4	1 - 2	6	10	60
4 - 6	2 - 4	3	10	30
> 6	> 4	1	10	10

[1]OM = % organic matter, HM = % humic matter

Table 4. Soil pH component of the soil leaching potential (SLP) index.

Soil texture[1]	Weight Rating	Factor	Product
< 5 (very acid)	1	4	4
5 - 6 (moderately acid)	3	4	12
6 - 7 (slightly acid)	6	4	24
> 7 (neutral)	10	4	40

Table 5. Calculation of the soil leaching potential (SLP) for a Goldsboro soil.

Soil Texture Component:

Depth (in)	Texture	Rating	Weight factor	Product	Mean product
0-6	SL	10	3	30	
6-18	SCL	6	3	18	22
18-36	SCL	6	3	18	

Organic Matter Component:

Depth (in)	% OM	Rating	Weight factor	Product	Mean product
0-6	0.2-2	10	10	100	100

PH Component:

Depth (in)	pH	Rating	Weight factor	Product	Mean product
0-6	4.9	1	4	4	4
6-18	4.8	1	4	4	4
18-36	4.7	1	4	4	4

Total 126 (SLP)

[1]Maximum possible = 30 + 100 + 40 = 170 and minimum possible = 3 + 10 + 4 = 17. SLP ranges are as follows: High (H) = 131 or more, Moderate (M) = 90 to 130, and Low (L) = 89 or less.

Table 6. Soil leaching potential (SLP) indices and ratings for 66 Coastal Plains soils.

Soil series	SLP Index	SLP Rating[1]	Soil Series	SLP Index	SLP Rating
Altavista	106	M	Kenansville	134	H
Arapahoe	73	L	Kureb	138	H
Argent	111	M	Lakeland	134	H
Augusta	134	H	Leon	104	M
Autreyville	134	H	Lynchburg	86	L
Aycock	104	M	Lynn Haven	104	M
Belhaven	17	L	Meggett	98	M
Blanton	134	H	Nahunta	86	L
Butters	138	H	Norfolk	126	M
Byars	52	L	Ocilla	130	M
Cape Fear	47	L	Pamlico	17	L
Centenary	130	H	Pantego	80	L
Chastain	66	L	Paxville	80	L
Chewacla	100	M	Perquimans	100	M
Chowan	83	L	Ponzer	17	L
Conetoe	134	H	Portsmouth	47	L
Congaree	111	M	Pungo	17	L
Coxville	90	M	Rains	80	L
Croatan	17	L	Roanoke	106	M
Dogue	130	M	Roper	34	L
Dorovan	17	L	Stallings	104	M
Dunbar	87	L	State	138	H
Duplin	120	M	Toisnot	134	H
Exum	126	M	Tomotley	87	L
Forestan	134	H	Torhunta	75	L
Goldsboro	126	M	Wagram	139	H
Grantham	86	L	Wahee	80	L
Grifton	114	M	Wakulla	134	H
Gritney	123	M	Wasda	22	L
Hyde	52	L	Weeksville	72	L
Johns	126	M	Wickham	134	H
Johnston	17	L	Wilbanks	86	L
Kalmia	126	M	Woodington	114	M

[1]Ranges: High (H) 131 Moderate (M) - 90 to 130, Low (L) = 89 or less.

Table 7. HLP/SLP matrix for determining the ground water contamination potential (GWCP) rating for selected herbicides on selected soils.

Herbicide leaching Potential Rating	Soil Leaching Potential Rating		
	High	Moderate	Low
	(GWCP Rating)		
High	Hazardous	Risky	Safe
Moderate	Risky	Risky	Safe
Low	Safe	Safe	Safe

WATER SOURCES, AVAILABILITY, AND QUALITY

Rodney L. Huffman[1]

Water is the crucial substance on which life depends. The relative abundance or lack of water in our environment is probably the single most important factor that shapes our climate.

Within any particular geologic/climatic setting, water can be found. It is the availability and quality of that water that helps to determine what forms of life can be supported.

Sources

The *hydrologic cycle* is the pattern of movement of water through the atmosphere, along the surface of the earth, and under the surface. Almost all water is in motion -endlessly cycling in this grand loop. At the beginning of the cycle, water is distilled from the oceans and made fresh. Of all the water on earth, only about 3% is fresh. About 2.25% is locked in the polar ice caps (fresh). So, only a little over 1/2% is even usable. For our purposes, we can split this into three sources: 1) atmospheric, 2) surface water, and 3) ground water.

Atmospheric Water

Water enters the atmosphere as evaporation from the oceans, surface waters, land surface, or as transpiration from plants. In this process, it is purified, leaving behind any minerals, contaminants, or sediments. Most precipitation is very nearly pure, but air pollution can cause such problems as acid rain. Atmospheric water accounts for about 1/1000% of the water on earth.

North Carolina is in the humid eastern portion of the United States. Annual rainfall averages about 50 inches over most of the state. The lowest average rainfalls are in the lower 40's. These occur in the areas of Mecklenberg county, Guilford-Rockingham-Caswell counties, Warren county, and Madison-Yancey counties. The highest rainfall in the state, 80 inches, occurs in a small area near the Georgia line, in Jackson and Transylvania counties.

Unlike many other areas of the country, in North Carolina, the distribution of rainfall throughout the year is nearly uniform. Every month averages at least 2.5 inches. For many plants, the rainfall (and snow) is sufficient. For more drought-sensitive plants, other sources of water are needed.

Surface Water

Surface water refers to all of the water that you can see - rivers, lakes, streams, ponds, - and oceans. About 97% of all water is surface water, but only a tiny fraction is fresh. The fresh water on the earth's surface accounts for about 1/50% of the total.

The natural availability of surface water at a location along a river or stream depends on rainfall distribution and the topography and geology of the contributing watershed. Rainfall distribution determines the input into the system. Size of the watershed determines the overall amount. But topography and geology determine the rate of conveyance and storage capacity of the system. A flat watershed will drain more slowly than a mountainous one. Open, porous formations will allow rainfall to infiltrate and move slowly through the ground, rather than running quickly off the surface.

The dependability of surface water sources can be enhanced by means of impoundments - building ponds or reservoirs. The quality of the water captured will depend on the land use in the watershed above the impoundment. The concentration of dissolved solids may also vary considerably with flow rates. This is explained by the relative proportions of rain and ground water in the stream.

Ground Water

Once water enters the soil, it moves through the pore spaces between soil particles. In the unsaturated zone, the pore space is only partly filled with water. Deeper, where the pore space is completely filled with water, is the saturated zone. Water in the saturated zone is called ground water.

Ground water accounts for 1/2% of the total water on earth. As a whole, it is the most abundant source of fresh water. Ground water can be found virtually anywhere, but its quantity, quality and ease of access vary greatly.

Not all ground water is fresh. Near the sea,

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deeper aquifers tend to be salty and high withdrawals can cause salt-water intrusion, the flow of sea water into the aquifer. In general, deeper water has been in the system longer than shallow water and tends to contain more dissolved minerals. Some types of rock are more soluble than others, leading to highly mineralized or hard water. The hardness of water from the Castle Hayne aquifer (limestone) in eastern NC is about ten times that of water from the crystalline aquifers of the Piedmont and Blue Ridge parts of the state.

In many sedimentary and volcanic formations, there are sufficient pores for water to move easily. In other rocks, the only channels for water are through cracks or joints. These features determine both the storage and transmission characteristics of the formation.

A well is essentially just a deep hole for water collection. We pump water from the well bore, then wait for more to run in from the surrounding formation. The frequency and type of pores or cracks determine how fast water can move to the well. In general, deeper wells and wells having larger diameters will have higher yields.

Connections

Atmospheric water replenishes surface and ground water. Surface and ground water are intimately connected. The *base flow* in streams is supplied by ground water discharge, a slow release of water from the vast underground reservoir. This is the reason why streams continue to flow weeks after any significant rainfall. Surface waters can also recharge ground water, if the ground water level is lower than the stream level. There are dramatic examples where streams disappear entirely, flowing through the ground, and perhaps reappearing at some lower point.

PERENNIAL RYEGRASSES FOR OVERSEEDING

Dr. William A. Meyer[1]

Since the release of improved perennial ryegrasses in the early 1970's, they have become increasingly more popular for the overseeding of dormant bermudagrass in the southern United States.

The quick germination rate (5-6 days) and rapid tillering ability of these new perennial ryegrasses gives them a big advantage over other cool-season turfgrass species for overseeding. These new, improved ryegrasses also have shown excellent traffic tolerance.

Manhattan, Pennfine, Derby, and Citation are some examples of the first generation of improved perennial ryegrasses. They were found to have much better frost tolerance, a lower rate of vertical growth, improved density and color, and better leaf spot and brown patch resistance than annual ryegrass, which had been widely used.

In the 1980's, another new generation of perennial ryegrasses were released wth improved turf characteristics compared to the first generation. These new varieties showed improvments for mowing qualities, better brown patch resistance, and a finer, denser turf. Some of these new varieties also showed improvements for stem rust resistance, which is a serious disease in seed production fields. Some examples of the new stem rust resistant varieties were Citation II, Birdie II, Manhattan II, Saturn, Omega II, SR4000, and SR4100.

Examples of other varieties without stem rust improvements were Palmer, Prelude, Pennant, and All Star. Some of these varieties, such as Pennant, SR4000, SR4100, and citation II, also contained high levels of endophyte which provides good resistance to above ground feeding insects.

In the late 1980's and early 1990's there are some new developments of perennial ryegrass that are showing a dwarfer growth habit, a dark, richer green color, and additional improvements in mowing qualities and disease resistance. Some examples are Charger, Quickstart, Dimension, GH-89, 246, Palmer II, and Prelude II. There are improvement programs which focus specifically on disease resistance and special needs of perennial ryegrass.

In order for a new variety to be successful in the overseeding market, it must be a good seed producer because of competition in the market place.

There is no doubt that the new turf-type perennial ryegrasses have been proven as superior grasses for overseeding dormant bermudagrass. Compared to all other cool-season species that can persist under high traffic, they are flexible in that they can tolerate very close cutting heights on putting surfaces and yet be used to create a challenging rough mowed at 3 inches or more.

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LATE SEASON FERTILIZATION OF COOL SEASON GRASSES

Charles H. Peacock[1]

When the term "late season" is used, a number of responses are usually found among turf managers. Most determine that "late season" refers to the period in the late fall, mid-October to mid-November when the weather is unpredictable and mild, moderate temperatures may prevail, or heavy frosts may occur. Within the last decade a number of research projects have addressed the best time for fertilization of cool season turfgrasses during this time period. This has prompted a change in strategy from the early 1960's when a single spring and fall fertilization application was considered adequate.

The rationale for improving fertilization timing has been determined by a better understanding of the physiological responses of the plant. From an environmental concern the following is noted:

1) photosynthesis is *effected* little by temperature within the optimum range.

2) respiration is *greatly* affected by temperature, with a direct increase as temperatures increase.

3) food is *accumulated* in cool temperatures, and depleted in high temperatures.

4) food is also accumulated when growth is slow, yet photosynthesis continues.

These factors combine to warrant fertilization providing adequate levels of nitrogen, phosphorus and potassium to promote good growth during this late fall period and thus maintaining good stress hardiness. There is a minimum nutritional level necessary to ensure recovery from injury, providing carbohydrate reserves are adequate. Correspondingly, a number of factors influence nutrient uptake, primarily, the depth and extent of the root system and the energy available for root respiration.

A number of positive responses have been documented from research on late season fertilization. These include the following:

- more efficient photosynthate use and partitioning
- reduced mowing, especially during spring flush of growth
- stimulated root growth
- improved stand density
- longer fall color retention
- earlier spring greenup
- fewer weed problems
- fewer disease problems
- improved summer performance less thatch

Research in North Carolina, South Carolina, Virginia, Rhode Island, Minnesota and Illinois has concluded that 1/3 to 2/3 of the total yearly nitrogen requirement should be applied in the fall with the last application occurring before the air temperature reaches 40 F. With this approach, a healthier, better performing, more stress tolerant turf is possible.

IMPROVED METHODS OF SOD INSTALLATION

Richard H. White and Art Bruneau[1]

Successful establishment of turfgrass areas can be accomplished by different methods. Sodding is the most rapid method available to establish turfgrass areas. Sodding is a desirable means of turf establishment when there is a need to provide immediate visual appeal, rapid area use, and quick erosion control. Also, sod may be used to establish turfgrass areas at times when seedings often fail. Although sodding may initially cost more, the disadvantages of seeding such as the frequent need to reseed, limited desirable seeding periods, a need for seedling weed control, and a long waiting period before the area can be used, make the use of sod more appealing to customers and turf managers.

The use of sod may not be necessary or desirable in all cases. At times, the decision to use sod may restrict the selection of turfgrass species and varieties to be installed. If sodding is determined to be the best method then there are certain guidelines one should follow to insure establishment success. The keys to successful sod establishment include starting right, proper soil preparation, scheduling operations, and supplying adequate moisture.

Start Right. The turf area established by sodding can be no better than the quality of the starting product. Obviously, purchasing low quality sod of poorly adapted turfgrass varieties greatly limits the chances for successful establishment. Judge the success of your sod installation procedures on both a short term (rapid rooting and provision of high aesthetic appeal) and a long term (persistence of high quality, functional turf) basis. Poorly adapted varieties may provide short term success but probably will not maintain high quality for more than one or two seasons.

Purchase sod from reputable growers containing varieties or blends of varieties that are well adapted to the area of use. Certified sod, in states that have sod certification programs, provides assurance that you get the variety or varieties requested. Turfgrass extension specialists at state universities can provide information about sod producers and varieties of grasses to look for when buying sod for your location.

Don't wait for delivery to find out the quality of sod supplied by the grower. A scheduled visit to prospective suppliers' fields will acquaint you with growers and the quality of the sod that they produce. Consider the following when looking for a supplier of high quality sod. Sod should be mowed uniformly to a height of cut appropriate for the individual turfgrass species prior to harvest and have n(3 more than 0.5 inch of uncompressed thatch. Excessive clippings must be removed prior to harvest to reduce the potential for heat build-up in stacked sod. Moderate fertilization with 0.25 to 0.75 pounds of actual nitrogen per 1000 square feet may be used to improve color prior to harvest. Avoid excessively fertilized sod, as indicated by very dark green and lush leaves. Sod fertilized with excessive nitrogen stimulates stress susceptible turfgrass plants with poor rooting potential. Sod in this condition has a greater tendency to heat on the pallet and is more susceptible to transplant failure.

Although sod pieces come in various sizes, the width should not vary by more than 0.5 inch to insure installation ease and a uniform initial appearance. Sod thickness, excluding thatch and leaf length, should be 0.5 to 0.75 inch. Thick cut sod, 1.5 to 2.0 inches, is sometimes used on specialty use turfgrass areas such as athletic fields to shorten the waiting time before the area can be used. However, for most turfgrass areas, thin cut sod is easier to handle and roots more readily into underlying soil. The sod must be strong enough so pieces support their own weight and retain their size and shape when suspended vertically from one end. Sod that falls apart easily may have been harvested too young or managed poorly, is difficult to install, and is high risk.

Proper Soil Preparation. Sod often fails to establish or perform well because deficiencies in the physical and chemical condition of the soil were not corrected before sod installation. Prepare soil in a similar manner whether the area is to be sodded or seeded. Collect a soil sample and have a soil test analysis conducted by a state or other reputable testing laboratory to determine the amounts of nutrients needed to correct deficiencies. Also, follow the laboratory's

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recommendations for correcting an acid or alkaline soil to a pH of 6.0 to 6.5.

When renovating existing turfgrass areas, it is best to remove the old grass below the thatch layer rather than tilling it in. Treat difficult to control weeds, such as quackgrass, johnsongrass, or nutsedge with appropriate chemicals before soil preparation begins. Apply repeat treatments if needed to insure adequate control. Add approximately 30 cubic feet of peat moss per 1000 square feet to very sandy or heavy clay soils to improve water retention properties and soil structure. Include a nitrogen containing fertilizer to supply 1.0 to 2.0 pounds actual nitrogen per 1000 square feet. Apply fertilizer, lime, or other amendments recommended by soil test and thoroughly incorporate all added materials to a depth of at least six inches. Rake the soil to a smooth, level finished grade, and roll to provide a firm planting bed.

Site preparation for construction of buildings often removes topsoil and brings heavy clay soils or soils with poor chemical characteristics to the surface. Where extremely unfavorable soil conditions occur in existing turf areas and on areas to be planted for the first time, a high quality topsoil (loamy sand, sandy loam, or loam texture) may be brought in to provide an acceptable planting bed. The topsoil must be free of viable parts of any undesirable and difficult to selectively control plant material such as bermudagrass, quackgrass, or johnsongrass rhizomes. Establish a subgrade with the existing soil material and adjust the upper 3 to 6 inches of the subgrade to pH 6.0 to 6.5. Grade and firm the subsoil to approximate the final contour and slope. Be certain that adequate surface drainage will result from the final grade and if necessary install subsurface drain lines within the subgrade to insure proper internal soil drainage. Spread enough high quality topsoil to cover the subgrade to a depth of at least 4 inches and till the topsoil into the upper 2 to 3 inches of the subsoil to prevent a distinct layering between the topsoil and subsoil. Correct mineral nutrient deficiencies and pH of the topsoil following the recommendations of a soil testing laboratory. Establish the final grade, smooth, and firm the planting bed prior to installing the sod.

Where a high quality topsoil is difficult to obtain or economically prohibitive, incorporate sand and organic matter to improve existing soil conditions. Follow Cooperative Extension Service or university recommendations for the correct modification of soils in your area.

Schedule Operations. Schedule operations carefully and complete all soil preparation prior to delivery of sod. Allowing sod to remain on pallets while completing final soil grading decreases the potential for sod establishment success. Install sod immediately after delivery; within 12 hours of harvest in warm weather and 36 hours during cool weather. Sod with yellow leaves and signs of mold and mildew indicates that sod remained on pallets or stacks too long, has reduced vigor, and will establish poorly. Sod that arrives on site in this condition should not be accepted for delivery.

Supply Adequate Moisture. Maintain adequate moisture within the sod to insure installation success. Remember that sod is a living turf with a limited root system. The sod must remain moist until a new root system develops into the underlying soil if it is to maintain high quality. Water the soil lightly prior to installation or schedule soil preparation to insure moist Underlying soil conditions at the time sod is installed. Moist soil conditions contribute to cooler surface soil conditions in summer and aid in thoroughly wetting underlying soil by irrigation water after sod installation. Apply irrigation water within 20 to 30 minutes of installing the first piece of sod.

Make sure all sod pieces are butted together tightly and do not overlap. Stagger the joints in each row like rows of bricks and use wooden stakes to hold sod in place on steep slopes. Roll sod to smooth the surface and to bring the bottom of the sod layer into intimate contact with the soil surface.

Irrigate often enough to keep the sod pad moist until a new root system begins to develop. Thorough wetting of the soil to a depth of 6 inches immediately after installation may help maintain an adequately moist sod condition. One quarter of an inch of irrigation water per day may be required to maintain an adequately moist sod for the first week after installation. After a sufficient root system develops, reduce irrigation frequency to a 5 to 10 day schedule of deep watering to a depth of 4 to 6 inches. Bermudagrass sod may root down sufficiently within 3 to 5 days and quickly allow a reduction in irrigation frequency. However, Kentucky bluegrass sod and other cool-season turfgrasses require careful irrigation for 2 to 3 weeks during summer stress periods to become successfully established.

Mow the newly sodded area when a 30 to 50 percent increase in vertical shoot growth is reached. For example, if the sod was maintained at a 2 inch cutting height prior to harvest, mow for the first time when the grass reaches a height of 2.75 to 3.0 inches. Fertilize with 0.5 to 1.0 pound of nitrogen per 1000 square feet after to 6 weeks if the grass begins to show signs of nitrogen deficiency. Use lower rates during summer on cool-season grasses and higher rates during more favorable seasons. Use the upper nitrogen rate on warm season turfgrasses. After the sod is well established, begin a maintenance program recommended by your local turfgrass extension specialist or cooperative extension service for the turfgrass species, intended use, and the climatic conditions of your area.

MANAGING TURFGRASSES IN SOUTHEASTERN NORTH CAROLINA

Dr. C. Bruce Williams[1]

Turfgrass maintenance in coastal southeastern North Carolina poses special challenges to the professional grounds manager. Unique insect and disease problems, ecologically sensitive areas, and a demanding public coupled with harsh coastal environmental conditions can create situations which are difficult to manage. A thorough understanding of the problems common to turfgrass management in eastern North Carolina is essential to providing economic and environmentally acceptable solutions. Awareness and early detection of potential turf problems is the best management solution.

Most turfgrass problems found in eastern North Carolina are common to turf management throughout the state. Improper grass species selection, localized dry spots, incorrect installation of seed or sod, improper fertilization, pests, poor water quality, lack of irrigation, and diseases are management problems which are found where ever turfgrass is grown. However, in coastal areas climatic conditions often pose a unique environmental regime upon grass growth that compounds or exaggerates problems to a greater extent than seen in more inland areas.

Turfgrass growth is limited by light, temperature, moisture, mineral nutrients, oxygen, disease, insects, and traffic. All turfgrass problems can be related to the involvement of one or more of these factors. Lack of adequate water for optimum grass growth is perhaps one of the most common problems. The soil type, irrigation scheduling and distribution, and the appropriate grass species should be evaluated to determine if growth is being limited. Many eastern North Carolina soils are very sandy and have a low water holding capacity. This necessitates constant monitoring of water applied through irrigation or natural rainfall.

Localized dry spots in residential lawns and highly managed established turf stands are often the result of inadequate irrigation distribution complexed with excess thatch build-up, hydrophobic soils, traffic, and environmental conditions. The use of wetting agents, improved water distribution, and soil aeration will normally correct localized dry spots.

Poor irrigation water quality is a problem common to coastal turfgrass management. Saline or brackish water contaminated wells can cause major damage to established turfgrass stands. Use of grass species tolerant to saline conditions(such as bermudagrass, St Augustinegrass, or zoysia-grass) and routine well water monitoring are recommended in areas with a history of brackish wells. In addition, poor water quality and high pH will influence the efficacy of tank mixed pesticides. NCDA water testing is a low cost method of evaluating irrigation water quality. Commercial salinity meters and pH indicator strips are also convenient methods for rapidly accessing irrigation water quality.

A high level of soil variability is often present in many eastern areas of the state. Soil reaction in native eastern North Carolina soils ranges from as acid as a pH of 3 to as alkaline as a pH of 8. Inappropriate selection of turfgrass species and/or improper soil modification contributes to poor turf quality in many coastal sites. Careful attention to soil testing procedures and follow-up amendment applications coudled with the appropriate turfgrass selection can overcome the majority of problems associated with high soil variability.

Ground pearls are a small scale-like insect that cause considerable damage to residential lawns. Severe damage is commonly observed on centipedegrass lawns. Although ground pearls are reported to infest other species of turf, the only ground pearl infestations I have observed have been on centipedegrass. No chemical, physical, or cultural practice has shown to be effective in the long term control of this insect. Sites with severe infestations should minimize water stress and optimize turf cultural practices to maintain vigor in the uninfested areas. Complete soil sterilization and conversion to a ground pearl tolerant turfgrass species is recommended if economics is not a major consideration.

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Several other insects damage turfgrass in eastern North Carolina. Chinch bugs are routinely found to be a problem in St. Augustinegrass during the summer. Early detection and the application of the appropriate insecticide usually remedies the infestation. Mole crickets are a relative new comer to the insect pest scene and have caused considerable damage to golf course turfgrass and residential lawns. Damage is usually first observed in the late summer or early autumn. Current research at NC State indicates that a June or July application of insecticides to areas heavily infested in the previous growing season is most effective in killing the new generation of the insects. Grub infestation and fire ants cause significant damage to commercial and residential turfgrass. Insecticides appear to be adequately controlling grub and fire ant problems.

Turfgrass culture in eastern North Carolina presents managers with a challenge. Unique climatic and environmental conditions often pose a unique set of problems not encountered in other parts of the state. Careful attention must be paid to proper soil preparation, turfgrass species selection, and integrated pest management strategies to cultivate a superior quality turf in eastern North Carolina.

DEVELOPING RATIONAL LAWN PEST MANAGEMENT PROGRAMS

Gil Landry, Jr.[1]

The success of all turfgrass managers depends on their ability to integrate all the factors affecting turfgrass performance into the desired results. This integration of turfgrass growth factors and pest management practices is frequently referred to as Integrated Pest Management (IPM). An IPM program puts more empahsis on turf or host management, environmental manipulation, and pest monitoring than on pesticide use.

Most approaches to pest management should begin with focusing on proper turfgrass management to encourage any competitive advantage active turfgrass growth may provide. This first requires recognizing that most turfgrass growth is affected by fluctuations in temperatures. For example, most warm season turfgrasses have little or no growth during the winter months and therefore winter weeds have a competitive advantage. However, obtaining a dense turf cover prior to dormancy can significantly reduce weed invasion. Likewise, most cool season turfgrasses don't compete well with pests during the summer because high temperature stress reduces turf vigor.

Although pesticide use is an important part of a cultural program, pest management also includes:

1. selecting pest-resistant turfgrasses that are adapted to the environmental conditions,
2. following recommended establishment procedures, including site preparation; and
3. following recommended turf maintenance practices.

Although there is very little documentation of turfgrass pest resistance, there is substantial information on turfgrass adaption to environmental conditions such as shade, heat, cold, drought, soil acidity and alkalinity, and traffic tolerance. One of the most common errors repeated in the Southeast is the belief that zoysiagrass is more drought tolerant than other warm season turfgrasses. Recent research in Georgia and Texas shows present zoysiagrass cultivars are some of the least drought tolerant of the warm season turfgrasses and even less tolerant than some tall fescues. In fact, when a zoysiagrass is placed in a dry location and not properly irrigated, it will frequently become severely infested with dollar spot. National, regional and local cultivar trials are excellent ways to evaluate cultivar suitability to environmental conditions.

Generally proper turfgrass maintenance includes fertilization, irrigation, mowing, and cultivation. Each of these practices can affect turfgrass performance and directly or indirectly affect pest problems. Some examples include high nitrogen levels encouraging brown patch infestations, low nitrogen and/or potassium levels encouraging leaf spot diseases, drought stress reducing turf resistance to disease and insect pressure, and soil compaction reducing turf resistance to most pest pressures including weed invasion.

Something as simple as improper mowing may predispose a turf to disease or weed problems. For example, high mowing heights can encourage disease problems. Improper thatch management is another common culturally induced problem which affects turf vigor and pest resistance.

An integral part of an IPM program is the monitoring of environmental conditions and pest populations, and the determination of pest thresholds. Monitoring or scouting can include using insect traps, soapy water drenches, simply digging for the pest, and maintaining property profiles since many pest problems tend to reoccur.

The wise use of pesticides is dependent proper pest identification and pesticide application. The latter involves recognizing appropriate pesticide selection, rates, timing, and application method. The overriding objective of pesticide use should be to use the minimum amount of chemical to provide acceptable pest control. Biological controls offer relatively new avenues of reducing pest problems and therefore chemical use.

A final component of an effective pest management program should include client education. The more informed the client is about

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proper turf management, pest infestation signs, and practical and environmentally sound control procedures, the more effective a program should be.

To summarize, let's examine the disease brown patch and determine how to use proper IPM practices against this pest. Begin by recognizing the characteristics of this disease which include:

1. the disease will attack all turfgrasses,
2. the environmental conditions conducive to brown patch development include night temperature above 65°F, leaf wetness for over 12 hours, and soil pH less than 6.5; and
3. cultural management practices that encourage disease include high N levels, low K levels, and high mowing heights.

Therefore controlling this disease would include:

1. using cultivars that have documented brown patch resistance such as Rebel II tall fescue,
2. maintaining low N and high K levels, and proper soil pH;
3. modifying the environment by reducing shade, and improving air movement by pruning shrubs and branches; and finally
4. using the proper fungicide for brown patch control.

LONG-TERM MANAGEMENT FOR TURF DISEASE CONTROL

Dr. L. T. Lucas[1]

Long-term management for disease control in lawns emphasizes good basic turfgrass management practices. These practices include the selection of the best adapted grass for the site, proper site preparation, proper management and the use of pesticides if needed.

Environmental conditions vary greatly throughout North Carolina. The northwest mountain region has a climate similar to the northeastern United States and the cool-season grasses such as bluegrass is best adapted to this region of the state. The southeastern region is the opposite extreme with a climate similar to northern Florida where the warm-season grasses such as centipedegrass or bermudagrass are best adapted. The region in the central part of the state is the transition zone between the best adapted zones for the cool- and warm-season grasses. All the cool- and warm-season turfgrasses are grow in this region with tall fescue being the most used grass. This region is often too cold in the winter for the warm-season grasses to survive the winter and is often too hot in the summer for the cool-season grasses to grow well. Microclimates of sites in the transition zone determines which turfgrasses are best adapted to particular lawns in this area. The warm-season grasses are best adapted to open lawns with southwest exposures while the cool-season grasses are best adapted to lawns with northern exposures in the same community. Evaluation of the climate or the exposure of the lawn will help determine the best type of turfgrass to plant to avoid severe disease problems in the future.

Inadequate soil preparation before planting contributes to many disease problems in the future even if the proper grass was selected for the site. Most of the soils in the state have a low pH and low phosphorus levels if the area was wooded just before the lawn was planted. Soil tests should be taken from the site earlier enough to know how much lime and phosphorus should be incorporated into the soil before planting. The pH of many of the soils may be 4.0 or lower where trees have been growing for years. All of the turfgrasses used in the state are not native to this area and grow best in soils with a pH near 7.0 except centipedegrass which prefers as pH near 5.5. The pH scale is logarithmic which means that a pH of 4 is 1000 times more acid that a pH of 7. Some things that you might associate with pH is vinegar which has a pH near 4 and milk which has a pH near 7. We would not expect turfgrasses to germinate and to grow well in vinegar which in effect is what is happening in many lawns where the soil pH was not properly adjusted. The soil pH determines the availability of nutrients in the soil to the plants. The soil test is often omitted and not enough, if any, lime and phosphorus is applied. These nutrients move very slowly in the soil and should be incorporated 6 to 8 inches deep before planting. Tall fescue lawns in the Raleigh area have been observed to grow well and not need any reseeding for as long as 10 years where the proper amounts of lime and phosphorus was incorporated into the soil before planting. Whereas, adjacent lawns that did not receive proper amounts of lime and phosphorus had to be reseeded yearly.

The depth of incorporation the lime and phosphorus determines the depth of rooting of the turfgrasses. A good deep and healthy root system results in a healthy plant that can better tolerate environmental stresses, compete with weeds and recover from insect and disease damage.

Time of planting, the amount of seeds and varieties and types of grasses used are important long-term disease management practices. The cool-season grasses grow better and conditions are less favorable for diseases if planted in the fall. The temperatures are cooler at this time and the fungi that cause many of the diseases are less active during cooler weather. High seeding rates of tall fescue, 10 pounds per 1000 square feet or more, usually result in rapid greening of lawns but often contribute to poor survival the following summer. Many small seeding do not develop deep root systems and are very susceptible to diseases such as brown patch and drought stress. Lower rates of seeds, as low as 4 pounds per 1000 square feet, would result in slower greening of the lawn after planting but will result in stronger plants that can survive disease and drought stresses the following summer. Using mixtures of several

[1]Professor, Department of Plant Pathology, North Carolina State University.

varieties of tall fescue and mixing bluegrasses with the tall fescues will help to reduce damage from diseases. The susceptibility to diseases may be different between the varieties and the bluegrasses. If one is killed the others will remain to provide a better lawn. The warm-season grasses should the planted in late spring or early summer to provide enough growing time for the grasses to become well established to reduce the chances of winter damage.

Management of the established lawn can affect the damage from diseases. Some disease is likely to occur in all lawns sometime during the year, but a good management program can reduce the amount of damage. Fertilization based on recommendations for the specific type of grass and soil test results is the best method to use. High rates of nitrogen in the summer on tall fescue will increase the severity of brown patch. Tall fescue should be fertilized in the fall, winter and spring and not during the summer. Small amounts of nitrogen fertilizer with iron can be used in the summer to improve color and may not increase susceptibility to brown patch. A lighter green color in the summer may not be acceptable to the homeowner or customer, however, it would help reduce the severity of brown patch. Irrigation practices can affect the damage from diseases. Turfgrasses in lawns should be irrigated about once a week enough to wet the soil 6 inches deep. Frequent light irrigations keep the foliage wet and provides favorable conditions for diseases to develop. Turfgrasses should be mowed when the foliage is dry. Mowing when wet can spread the disease causing organisms from infected to healthy leaves and plants more rapidly.

Environmental changes in lawns over a number of years often contribute to conditions that are more favorable for diseases and less favorable for the growth of turfgrasses. Shade and root competition from trees increases as the trees enlarge. Also, hedges become larger and thicker which reduce air movement in the lawn. The shade and reduced air movement cause relative humidity and moisture levels to remain higher and for longer periods on the turfgrass leaves which creates more favorable conditions for diseases. Some of the trees and shrubs should be removed to make conditions more favorable for the growth of turfgrasses and less favorable for diseases. If trees cannot be removed, the best solution to the problem would be to redesign the landscape and use mulch or ground cover plants in the area in place of grass. Homeowners often describe the problem as "I used to have a good lawn in the area", and my response is that "the trees used to be small and the turfgrasses used to have more sun exposure." The long-term solution to this problem is to decide which is more important to the owner and grow trees or grass because it is very difficult to grow both in the same area

Fungicides should be considered as a last resort for a long-term disease management practice. Fungicides are available that can be used to control diseases on turfgrasses in lawns. These chemicals will be needed frequently under favorable disease conditions, such as hot-wet weather for brown patch on tall fescue. The cost for fungicides may exceed the normal cost of a professional lawn maintenance program and most homeowners are not willing to pay this extra expense.

In summary, long-term disease management for turfgrasses in lawns involves best management practices that encourages the growth of healthy turf. A healthy turf may have some diseases, but will have less severe disease and can recover from the damage more quickly than poorly managed turf.

TALL FESCUES FOR THE HUMID SOUTH

Dr. William A. Meyer[1]

Since the 1980's, many new turf-type tall fescues have been released that have given superior performance to the old common varieties Fawn and Ky31. The first turf-types that were released were Rebel, Falcon, and Olympic. These new varieties were finer leaved, denser, lower growing, and more persistent than Ky31 in turf. They have shown good heat, drought, and shade tolerance with a darker green color.

Many breeding programs have been underway to develop improvements compared to the original three turf type varieties. The varieties Apache, Bonanza, Arid, Finelawn 5GL, and Jaguar are some examples of the next generation turf-type varieties that did well in the 1983 National Turfgrass Evaluation Program. These varieties showed improvements for persistence and summer performance.

One of the greatest challenges to a turf tall fescue breeder is that as the turf density increases in a new variety, there must also be a concurrent increase in the level of resistance to brown patch and other foliar pathogens for a successful variety. In the last five to seven years there have been another generation of tall fescues released that would be considered as improvements that I describe as intermediate dwarf varieties. These are varieties showing improved density, a reduced vertical growth, and an attractive color with improvements in disease resistance. Some examples are Monarch, Rebel II, Tribute, Shenandoah, Safari, Tomahawk, Amigo, Virtue, and Rebel Jr.

In the last five to seven years, there has been another type of tall fescue released that some breeders describe as dwarf varieties. There are differences amongst this new group that we have defined as those with a mature plant height of 3' or less. In areas such as Southern California, where there is low humidity, most of the new dwarf-type varieties have performed very well. They have a very fine leaf texture, a reduced vertical growth rate, high density, and a dark green color. Examples of dwarf type varieties are Silverado, Shortstop, Eldorado, Bonsai, Trailblazer, and Crewcut.

In Eastern trials under higher humidity conditions the varieties Silverado and Eldorado have performed better than some of the other dwarf varieties.

All of the turf type tall fescues have shown good performance as a shade grass. Tall fescues generally have good insect tolerance. Some varieties that contain an endophyte fungus have shown good resistance to above ground feeding insects. Examples of high endophyte varieties are Tribute, Titan and Ky31.

In the past year, our company initiated a breeding program in Rolesville, North Carolina to make further improvements in brown patch resistance in tall fescue. This is a unique program since earlier breeding programs were in other areas with less humidity, heat, and brown patch pressure. This is an exciting new venture under the direction of Dr. Melodee Fraser, which we have great hopes for in the future.

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IMPORTED FIRE ANT CONTROL AND REGULATIONS

Lloyd Garcia[1]

There are two species of imported fire ant (IFA) which have been introduced into the United States from South America: the red and the black. The black IFA is currently located only in portions of Mississippi and Alabama and is only of local concern. The red IFA, however, now occurs in eleven states in the southeastern U.S. plus in Puerto Rico.

In North Carolina, the current federal IFA quarantine covers six counties and portions of twelve others. A proposed quarantine which will go into effect in 1991 will increase these numbers to thirteen (Beaufort, Bladen, Brunswick, Carteret, Columbus, Craven, Hyde, Jones, New Hanover, Onslow, Pamlico, Pender and Robeson) county-wide and portions of thirteen others (Anson, Cumberland, Duplin, Hoke, Lenoir, Martin, Pitt, Richmond, Sampson, Scotland, Tyrrell, Union and Washington). These areas are within the federal IFA quarantine and individuals or companies who wish to ship soil, nursery stock, hay, straw, soil-moving equipment, or sod out of the quarantined area must either obtain a certificate or a compliance agreement before shipping. A recent cooperative agreement between the USDA-APHIS and the North Carolina Department of Agriculture (NCDA) allows NCDA personnel to issue certificates and compliance agreements. This cooperative agreement further provides that IFA infestations outside the regulated or quarantined area are the primary responsibility of NCDA.

Nurseries and turf farms located within the IFA quarantine area who wish to ship across state lines need to establish a federal compliance agreement. The requirements of this compliance agreement are: 1) apply chlorpyrifos 10% granular at 40 lbs. per acre every four weeks OR apply chlorpyrifos 10% granular at 60 lbs. per acre every ten weeks and 2) after application soak the treated area with water to below the cut line. Operations that can restrict sales to within North Carolina should contact their area NCDA Plant Protection Specialist to determine what their requirements will be. Shipments that have not received prior insecticide treatment will be permitted within North Carolina provided that no IFA are found at the nursery.

Within the quarantined area, NCDA Plant Protection Section offers a community assistance program which operates on a limited budget appropriated by the legislature. This program is available to homeowners, residents, farmers with pasture, and public properties through local county governments. NCDA will provide technical assistance and IFA insecticidal baits for individual mound treatments and limited broadcast treatments.

Outside the quarantined area NCDA's objective is to eradicate IFA infestations. Each infestation is handled on a case by case basis. Active mounds are typically treated with an insecticidal bait or chlorpyrifos or both depending upon the infestation's characteristics. After treatments have been made, follow-up surveys are conducted at yearly intervals to ensure the ants have been eradicated.

[1]Staff Entomologist, North Carolina Department of Agriculture, P. 0. Box 27647, Raleigh, NC 27611.

PARK AND ATHLETIC FIELD MANAGEMENT IN CHARLOTTE

Quin Hall[1]

The City of Charlotte's Park Operations Division is responsible for the management of many different turf and landscaped areas. These areas range from small ornamental parks to huge district parks which combine walking trails, playgrounds, and picnic areas with athletic fields and sports complexes. This discussion is divided into 2 categories: A) Parks and related turf areas and B) Athletic fields.

Parks, Playgrounds, Medians, etc.

The city Park Operations Division currently maintains approximately 320 projects in and around the city, covering some 3,000+ acres of area and 172 sq. miles of right-of-way. These are divided into 1) Playgrounds, 2) Neighborhood Parks, 3) Ornamental Parks, 4) District Parks, 5) Recreation Centers, 6) Natural areas, 7) School Parks, 8) Other projects. Other projects may be anything from medians and right-of-way, to government building or cemeteries.

The turf most often in parks and related areas is composed of cool season grasses. Most turf areas in the Central Business District, high visibility medians, and highly used areas receive as close to "by the book" type care as possible. This includes fertilization 2 to 3 times a year, mowing at 3-3 1/2" every 7 to 10 days, and edging 2 to 4 times a month. Preemergent herbicides are usually not used. Chemicals such as 2, 4-D combinations or glyphosate are the main postemergent herbicides used. Weed-n-feed materials have been tried with moderate success. Most often cultural practices have to be relied on.

Large district parks, school parks, neighborhood parks, rights-of-way and cemeteries have a different level of care. Limiting factors are acerage, type of use, vandalism, etc. The district parks have staff at each location. These parks, at times, act as satellite units for other projects. This helps on equipment transport, scheduling, storage, etc. The turf is mowed at 3 1/2" on 10-14 day rotations for smaller areas and up to 6 week rotations on rights-of-way. Fertilization is one to two times a year with a complete 50% slow release fertilizer. Park Operations staff apply fertilizers using Lely spreaders and push spreaders. One option being looked into is bulk spreading, which should help cut costs and labor. It has draw backs such as being limited to open flat areas and causing compaction. Weed control is limited to post emergent applications on fence lines, obstacles, and rip rap ditches.

More areas are being annexed each year. Because of this we are turning more to contract mowing. One noticeable effect from this is that medians closer to the city are now maintained as rights-of-way instead of more manicured area.

Some turf areas are often very large and, as with cemeteries, full of obstacles to mow around. Most of these turf areas require medium to low maintenance. One exception is City Hall and the City-County government center. Turf is bag mowed twice a week, fertilized 3 to 4 times a year, and given extra care routinely.

Hurricane Hugo drastically changed many areas of the city. Areas of parks which were once heavily shaded are now in full sun. Once cleanup finally was completed a fairly intensive renovation and reseeding effort was initiated especially in erosion prone areas. These efforts along with a good fertilization program have shown very positive improvements.

Two other items we have to consider on our turf areas are vandalism and special events. Events such as SpringFest, Jazz Charlotte, and Festival in the Park that draw over 100,000 people a day cause large areas of turf to become compacted. Periodic aerification, filling ruts, and stricter nutrient requirements help but do not eleviate the problem. Since most of these events are during the growing season repairs can be timed with the fall renovation program.

Athletic Fields

Of all parks within the city system approximately 30% of them contain athletic fields. These vary from low maintenance multiple use fields to highly maintained fields for tournament, collegiate, or professional play. Most athletic fields contain warm season grasses or a mixture of warm and cool season grasses. The higher quality

[1]District Supervisor, Charlotte Parks and Recreation Department, Charlotte, NC.

fields usually contain Tifway 419 bermuda grass.

The majority of our fields are softball fields, others consist of soccer, football, or a combination of any of the three. All of our athletic fields are classified by use. Below is a classification chart for athletic fields.

	SOFTBALL. BASEBALL FIELDS		
	Class "A" (Reservable) Tournament Suitable for tournaments and scheduled league play	Class "B" (Reservable) Recreation Suitable for scheduled league play	Class "C" (Not-reservable) For unorganized informal play and practice
Turf Care	Soil test, overseeding and weed control annually. Fertilization up to 3x year, mowing weekly - lime - per soil test	Weed control and aerification annually, fertilization - 2x year, mowing at least 2x/month seeding as needed, soil test every 3 years	Fertilize annually, mow 2x month, seeding as needed, aerify every 2 years, soil test every 3 years
Infield Care	Grade and add potato dirt/clay as needed. Weed control annually Dragging and lining daily Mon-Fri when scheduled for play; Sat & Sun for Tournament Play, base anchors home plate and pitching rubber provided	Grade and add potato dirt/clay every other year. Dragging and lining 2x every 5 working days, home plate and pitching rubber provided	Grade and add potato dirt every 3 years. Weed control as needed. Dragging and lining once e very 5 working days. Ho.e plate a.d picching robber provided
Players Benches	At least 2 benches per diamond	2 benches per diamond	None required
Spectator Seating	Litter pick up daily. Permanent or temporary seating for a minimum of 50 people	Seating for minimum of 50 people. Litter pick up 3x week.	None
Lights	As required to permit after dark play. Inspected weekly, bulbs replaced as needed	None	None
Irrigation	Automatic system. Water as needed	None	None
	FOOTBALL, SOCCER, RUGBY FIELDS		
	Class "A"	Class "B"	Class "C"
Marking Lines	Lining lx week when scheduled for play or as needed to provide clean lining.	Lining once per two weeks	Lining once per three weeks

Memorial Stadium

The stadium is the most intensely managed turf area in the city park system. The field has many faces throughout the year, some of which are not conducive to growing turf. The crew that maintains it also takes care of 6 to 7 other landscape and turf projects within the Central Business District.

The turf at the stadium is a blend of Tifway 419 between the hashmarks and Tifgreen 328 and common bermuda everywhere else. Although it would be desireable to have all one type of grass such as 419, costs prevented this from occurring when it was put in. The bermuda is overseeded in October with a treated perennial ryegrass blend. Palmer, Prelude, Yorktown and Repell in some combination have given us the best results.

A yearly turf program is set up and amended each January based partly on the previous year's use. All materials are ordered and dates of application are set up at this time. Soil or pH tests are made I to 3 times a year.

The stadium turf has many different events held on it throughout the year from athletic events to major concerts. All of these are stressful on the turf and cause moderate to severe compaction.

The field is aerified and fertilized about every 3 weeks during the summer and twice in the fall. A 50% slow release fertilizer in conjunction with urea

is used during the bermuda season. A high phosphorus ammonium nitrate mixture is used on the rye. These applications are supplemented by high potasium applications in the spring and fall.

The bermudagrass is mowed during the growing season every other day at 3/4" with a Toro Turfpro 84 reel mower. The ryegrass is mowed once or twice a week at 1 1/8". No clippings are caught except when necessary on the bermuda. Clippings are caught everytime the rye is mowed.

Our ultimate goal is the Shrine Bowl game the 1st week of December. The turf and field need to be in top condition for this game. Preparations start about 2 weeks before, however the Shrine Bowl is in our interests all year long. The field is overseeded several times in October and fertilized periodically to give a balanced feeding but also to have the greenest field possible the 1st Saturday in December. To achieve this, applications of a complete ammonium nitrate fertilizer at 1/2 lb of N per 1000 sq. ft. every 3 to 4 weeks along with a liquid application of 33-0-16 or Ferromec 15-0-0 6 to 7 days before the game are necessary.

The Park Operations division has quite a large task in caring for its parks and maintaining its turf areas. By using good horticultural and agronomic practices along with a plan of attack, timing, and a little luck we can provide turf and park areas that are safe, enjoyable, and pleasing to the citizens of our area.

VEGETATION MANAGEMENT ALONG NORTH CAROLINA'S HIGHWAYS

William D. Johnson[1]

The Roadside Environmental Unit in the Division of Highways Department of Transportation is involved in the management of approximately 300,000 acres of roadside vegetation along the nation's largest state maintained highway system of 76,000 miles. The normal mowed area along the system totals approximately 285,000 acres of turf.

The vegetation species utilized along our highway system is diverse and includes both warm season and cool season grass species along with legumes. In the eastern part of North Carolina and southern part of the piedmont, warm season species including Bermudagrass, Bahiagrass and Centipede are utilized. In the remaining cool season areas of the state, Kentucky 31 Tall Fescue, Hard Fescue such as Reliant, Scaldis or Aurora and Kenblue bluegrass are utilized in a mixture as recommended by NCSU. Much emphasis is being placed on the utilization of this mixture to improve cool season turf and also in the use of centipede for warm season turf. In addition to these grasses Sericea lespedza and Crownvetch are utilized along steep backslopes where adapted. Crownvetch is mainly adapted to the piedmont west.

To manage this vegetation an extensive herbicide program is in place. Following is a brief synopsis of this program:

1. **Plant Growth Regulators**: An Embark/Telar mixture is used to slow the growth of fescue and reduce mowing requirements along portions of our primary and interstate system.

2. **Warm Season Release**: Winter weed control, or warm season grass species release, is accomplished with the use of Simazine or Oust. This is very effective in early weed control and reducing the first mowing.

3. **Broadleaf Weed Control**: Broadleaf weeds along our highways are controlled with the use of Garlon 3A and 2,4-D traditionally, however, this season we will be using a three way mix in conjunction with the Garlon 3A being 2,4-D, 2,4-DP and MCPP. We know of no broadleaf weeds that this new combination will not control along roadsides.

4. **Brush Control**: We have a very active brush control program utilizing Krenite. We also use some Garlon 3A for ditchline brush control and in remote areas on backslopes on our secondary roads. We are experimenting with dormant brush control utilizing Garlon 4 and other products.

5. **Guardrail and Stationary Object Weed Control**: We basically utilize a Roundup and Surflan/Simazine mix under guardrail for post-emergence and preemergence control of weeds. This has worked well over the years and is a safe combination to utilize that does not leach down slopes.

6. **Paved Shoulder Treatments**: Over the years we have used a considerable amount of Roundup to control Bermudagrass in paved shoulders. This continues to be a serious problem and is worthy of a major emphasis to save these asphalt pavements.

7. **Noxious Weed Control**: We put Johnsongrass and Kudzu in this category and maintain considerable programs to control these two weed pests along our roadsides. For Johnsongrass we have used a considerable amount of Asulox for selective control over the years. Acclaim is also a product we will be looking at for selective Johnsongrass control in fescue.

[1]Roadside Environmental Unit, N. C. Dept. of Transportation, Raleigh, NC.

For Kudzu, the material of choice remains Garlon 3A which does an excellent job.

With regards to equipment utilized by the Roadside Environmental Unit forces, we have developed by our own design and implementation a high-tech broadcast spraying system utilizing a 1,200 gallon stainless steel truck mounted applicator with approximate 20 foot hydraulically operated booms. This applicator is capable of putting out liquid fertilizers. We utilize a waste product which is a 7% nitrogen source for turf topdressing. This sprayer unit is also equipped with control dropper applicators which allows us to broadcast spray at 4 to 5 gallons per acre of volume, saving a considerable amount of time and money and application costs. Of other interest in the equipment area is our use of Tye no-till grain drills for interseeding into sod and Befco Greenrite II units for interseeding in wildflower beds. We also have our own methyl bromide fumigation rigs to fumigate wildflower beds and are looking into the use of metam sodium for fumigation with a specialized rotovator and power roller that seals the soil surface without plastic.

Of notable mention is our wildflower program. We have, since 1985, developed a system which successfully establish wildflowers along our roadsides in North Carolina. We have approximately 1,200 acres of wildflowers established currently and continue to add about 300 acres per season. This program is funded through the sale of personalized license plates and not tax revenues. This is by far the most popular roadside program that our unit has ever been involved in with comments and letters received from all over the United States and also Canada. Species that have performed well for us include annuals such as orange California Poppy, red Corn Poppy, multi-colored Toadflax and yellow and mahogany Plains Coreopsis. Perennial species that have done well include white with a yellow center Ox-eye Daisy, yellow with a brown center Blackeyed Susan, lavender Catchfly and yellow Lance-,leafed Coreopsis. We also have recently collected a native species that grows across our state, Bidens Aristosa or Bur Marigold, and have planted a 6 acre plot at Goldsboro to increase our seed supply as this material is not commercially available. Our mountain roadside folks have also collected a considerable amount of Narrow-leaf Sunflower and replanted this along our roadsides in western North Carolina which has performed very well.

We feel we have a very comprehensive vegetation management program for the roadsides in North Carolina and were fortunate to be awarded the 1988 National Roadside Vegetation Management Association's award as having the best roadside program in the United States.

GROWTH REGULATORS AND COLD TOLERANCE OF WARM SEASON TURFGRASSES

Dennis P. Shepard[1]

A research project was initiated at the North Carolina State University turfgrass research center in 1989 to determine if plant growth regulators cause partitioning of carbohydrates to different storage sinks of three warm season turfgrasses and if this partitioning has an effect on warm season turfgrass cold tolerance. The turfgrasses being investigated include common bermudagrass, bahiagrass and St. Augustinegrass. Bermudagrass and bahiagrass are maintained at a 2 inch height (an unmowed check plot is included). Bahiagrass plots are unmowed. The plant growth regulators studied include: maleic hydrazide at 4.0# AI/A, mefluidide at 0.5# AI/A, flurprimidol at 1.0# AI/A and paclobutrazol at 1.0# AI/A.

Plant growth regulators (PGRs) are being increasingly used in the maintenance of utility and recently intensively managed turf. Mowing costs of interstate highway medians in North Carolina have been reduced $30.00 per acre per year when treated with PGRs. PGRs are also used to suppress seedheads for aesthetics and safety, and to decrease clipping accumulation. Garbologists claim grass clippings and tree limbs occupy up to 20% of landfill space. The EPA projects over 3,000 landfills will be closed within 5 years. Eleven states have enacted legislation to keep lawn waste out of landfills by 1993. This information shows the potential for increased PGR use in the future.

The transition zone, which includes North Carolina, experiences large periodic losses of warm season turf. A number of factors are probably involved in the various micro environments, but the two leading hypotheses are: 1) Turf loss due to a rapid drop in temperature. Temperatures between 23 and 28 F may result in 50% loss of turf. 2) The alternate warming and cooling periods in the winter and early spring may deplete the carbohydrate reserves prior to breaking dormancy in the spring. The reduction in reserves may make the turf more susceptible to other environmental stresses.

It has long been known that warm season grasses rely on stored carbohydrates to help survive winter conditions. As the grasses enter fall dormancy, carbohydrate production exceeds that used and the excess is stored in the crown, lateral stems and other storage areas in the plant. Previous researchers have studied carbohydrate changes during fall hardening. Dunn and Nelson found bermudagrass carbohydrates, mostly as starch, increased by 23% during the fall. Rogers found that zoysiagrass may have up to a 3 fold greater fall accumulation of carbohydrates than bermudagrass and Gilbert and Davis found there is a strong association between carbohydrate reserves and freezing stress tolerance. Hanson and Branham studied the effect of PGRs on carbohydrate partitioning in Kentucky bluegrass in a greenhouse utilizing 14 C2O labeling. Amidochlor and mefluidide increased carbohydrate accumulation in the crown at 4 weeks after treatment by 3.7 and 2.3 times. Crown carbohydrate levels in plants treated with flurprimidol and paclobutrazol were equivalent to controls. DiPaola et al. tested the effects of May applications of seven growth regulators on the cold tolerance of Pensacola bahiagrass under no mow conditions. Most of the growth regulators evaluated did not adversely influence bahiagrass cold tolerance. Turfgrasses have seasonal variability in their cold hardiness. Upon dormancy, maximum warm season turfgrass hardiness occurs in early winter. (Dec.-Jan.) This also corresponds to the highest TNC levels. Hardiness declines slightly during February. Hardiness drastically decreases in late winter/early spring as carbohydrate reserves run out and tissue water content of the crown increases substantially. (Alternate warming and cooling periods contribute to a reduction in carbohydrate reserves).

First year results of this work has provided the following information: 1) Carbohydrate partitioning does occur in different plant parts and levels vary during the year. 2) There is a difference in carbohydrate levels between different

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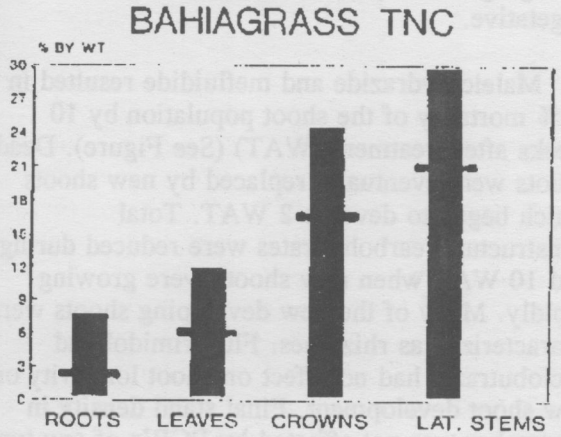
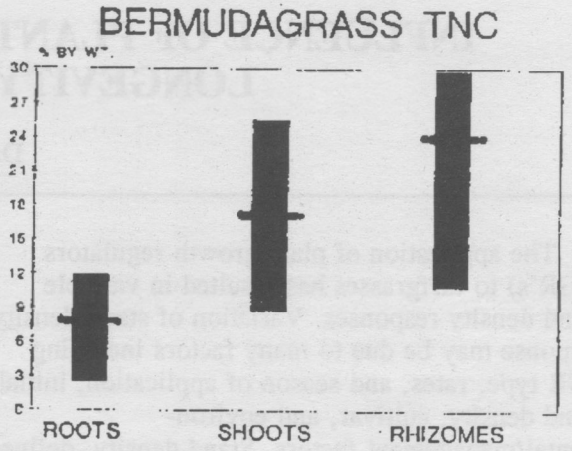
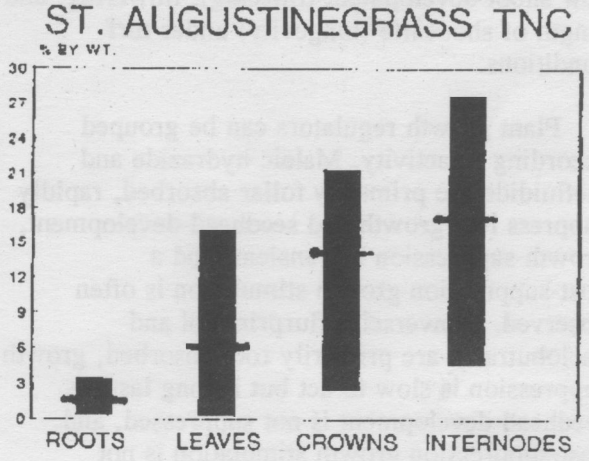
warm season species. 3) Preliminary results indicate the PGRs tested have no adverse effect on cold tolerance. 4) Further testing is needed before deciding conclusively that PGRs can contribute to turfgrass cold tolerance by increasing carbohydrate levels. 5) Further testing is needed to determine the relationship between low carbohydrate levels and the environment. Total nonstructural carbohydrate levels and ranges are presented on the next page. (Average levels are indicated by a hatch mark.)







INFLUENCE OF PLANT GROWTH REGULATORS ON LONGEVITY OF TALL FESCUE

David R. Spak[1]

The application of plant growth regulators (PGR's) to turfgrasses has resulted in variable stand density responses. Variation of stand density response may be due to many factors including PGR type, rates, and season of application, initial stand density, cultivar, and environmental/management factors. Stand density, defined as the number of shoots per unit land area, is an important component of turf quality and performance. Very little is known about the influence of PGR's on sward events, including new shoot development (tillering), flowering, and length of shoot life (longevity) under turf conditions.

Plant growth regulators can be grouped according to activity. Maleic hydrazide and mefluidide are primarily foliar absorbed, rapidly suppress leaf growth and seedhead development, growth suppression is transient, and a post-suppression growth stimulation is often observed. Conversely, flurprimidol and paclobutrazol are primarily root absorbed, growth suppression is slow to act but is long lasting, seedhead development is not suppressed, and post-suppression growth stimulation is not commonly observed.

A study was initiated in 1989 at the North Carolina State University Turfgrass Field Center to determine the influence of several plant growth regulators on the sward dynamics of Ky-31 tall fescue. Plant growth regulators were applied in late March of 1989 and 1990. Treatments were maleic hydrazide (4 lb ai/A), mefluidide (0.5 lb ai/A), flurprimidol (1 lb ai/A), paclobutrazol (1 lb ai/A), unmowed control, and a mowed control (3.75 inches). Tall fescue receiving PGR applications was not mowed until October of the same year. Twenty shoots were labeled in each plot with a plastic "pull-tight" tie and coded tag. Shoots were periodically located and observed for the following characters: living or dead, number of mature and total leaves, number of new leaves emerging, and reproductive (seedhead) or vegetative.

Maleic hydrazide and mefluidide resulted in 75% mortality of the shoot population by 10 weeks after treatment (WAT) (See Figure). Dead shoots were eventually replaced by new shoots which began to develop 2 WAT. Total nonstructural carbohydrates were reduced during 6 and 10 WAT when new shoots were growing rapidly. Many of the new developing shoots were characterized as rhizomes. Flurprimidol and paclobutrazol had no effect on shoot longevity or new shoot development. Final stand density in September was not affected by PGR's of any type. Maintaining tall fescue at a 3.75 inch mowing height resulted in the highest stand density and greatest shoot longevity. Approximately 50% of the initially labelled shoots survived 1.5 years and are still being followed.

Stand density of tall fescue was highest in early spring and reached a seasonal low in late summer (September). Low stand density in the summer can be attributed to the death of vegetative shoots, absence of new shoot development, and of lesser importance was the death of reproductive shoots. With the onset of cooler temperatures and shorter days in the fall (October), new shoot development began and continued throughout the winter and early spring. It is thought that new shoot development will continue until the canopy "closes" and light levels are reduced deep within the canopy.

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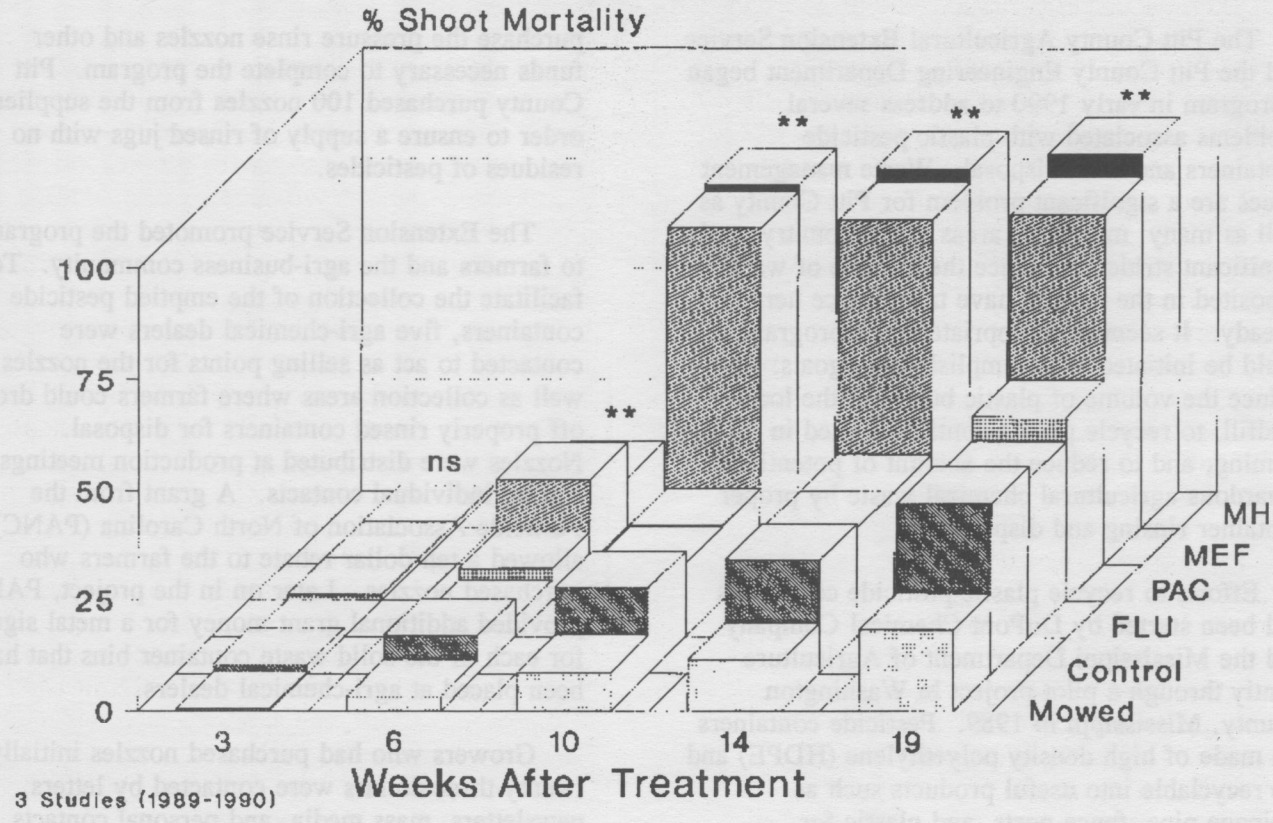
Effect of PGR's on Tall Fescue Shoot Mortality.



RECYCLING PLASTIC PESTICIDE CONTAINERS IN PITT COUNTY

Samuel N. Uzzell[1]

The Pitt County Agricultural Extension Service and the Pitt County Engineering Department began a program in early 1990 to address several problems associated with plastic pesticide containers and their disposal. Waste management issues are a significant problem for Pitt County as well as many municipal areas in the country, and significant strides to reduce the volume of waste deposited in the landfill have taken place here already. It seemed appropriate that a program could be initiated to accomplish three goals: to reduce the volume of plastic buried at the local landfill, to recycle plastic containers used in farming, and to reduce the amount of potentially hazardous agricultural chemical waste by proper container rinsing and disposal.

Efforts to recycle plastic pesticide containers had been started by DuPont Chemical Company and the Mississippi Department of Agriculture jointly through a pilot project in Washington County, Mississippi in 1989. Pesticide containers are made of high density polyethylene (HDPE) and are recyclable into useful products such as drainage pipe, fence posts, and plastic for formulating into other pesticide containers. Because obtaining clean plastic was critical in handling plastics for recycling, efforts were made in Pitt County as well as in the Mississippi project to use pressure-rinse nozzles to clean the interior of the emptied plastic containers. It was determined that pressure rinsing cleaned containers 600 times cleaner than triple rinsing.

Pitt County provided several important components to this project. A large-capacity baler to crush and bale the plastic jugs was already in use to bale cardboard and other materials. The solid waste management company already working with Pitt County donated five 40 cubic-yard container bins to collect the empty jugs as well as the trucks necessary to haul the container bins to the baling facility. Finally, the County provided financial support through a special fund to purchase the pressure rinse nozzles and other funds necessary to complete the program. Pitt County purchased 100 nozzles from the supplier in order to ensure a supply of rinsed jugs with no residues of pesticides.

The Extension Service promoted the program to farmers and the agri-business community. To facilitate the collection of the emptied pesticide containers, five agri-chemical dealers were contacted to act as selling points for the nozzles as well as collection areas where farmers could drop off properly rinsed containers for disposal. Nozzles were distributed at production meetings and by individual contacts. A grant from the Pesticide Association of North Carolina (PANC) allowed a ten dollar rebate to the farmers who purchased nozzles. Later on in the project, PANC provided additional grant money for a metal sign for each of the solid waste container bins that had been placed at agri-chemical dealers.

Growers who had purchased nozzles initially at twenty-three dollars were contacted by letters, newsletters, mass media, and personal contacts. Rebates were mailed to them and for the remainder of the program, nozzles were sold at a net cost of thirteen dollars to growers who entered the program later. It was felt that growers needed to pay some amount of money for the nozzle so that they would have a financial interest in the program. Growers in Pitt County are not familiar with the pressure-rinse nozzle as a normal farm tool. There will be a continuing need to encourage and promote the use of this tool in proper pesticide use and disposal.

The pesticide containers were collected at the five agri-chemical dealerships during a six week period, mid-June through the last of July. All five of the solid-waste container bins were nearly full of containers at the end of July. They were then transported to the East Carolina Vocational Center for baling. The East Carolina Vocational Center

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is a Pitt County operated facility where collection and recycling of cardboard has taken place for several years. The plastic containers were placed on a conveyor prior to baling and the trash, cardboard, and unwanted materials were removed.

The results were encouraging. Seven thousand pounds of rinsed plastic pesticide containers were collected and baled for shipment to the processor as a result of the six-week collection period. The support of County government, the assistance of the agri-business community, the participation of farmers, and the generosity of those who donated materials, financial support, and labor are responsible for the excellent beginning. In 1991 and subsequent years, Pitt County solid waste container sites will have a compartment dedicated to the collection of agricultural plastic. Any farmer who wishes to dispose of agricultural plastics for recycling can bring pressure-rinsed plastic containers to any of these solid waste containers throughout Pitt County. The containers will be inspected, and if pressure-rinsed properly, can go into the stream of recyclable materials that Pitt County is sorting out.

Hopefully, this program will pave the way for Pitt County farmers to use and dispose of pesticide containers in a way that will minimize environmental contamination from pesticides and the improper disposal of containers. It is also a beginning for reaching the other desirable goals of convenient disposal, needless loss of landfill space, and lowered dependence on foreign oil used in formulating the plastic used in agriculture.

SOIL ACIDITY, LIMING AND FERTILIZERS

Jack V. Baird[1]

Soil Acidity and Lime Use

North Carolina soils are highly weathered (leached) because of excessive rainfall and therefore are naturally acidic. This process has depleted the nutrient elements calcium (Ca) and magnesium (Mg) from naturally occurring minerals as well as those of previously applied agricultural limestone. Plants also remove calcium and magnesium. Decay of crop residue or any kind of surface organic matter or the addition of animal waste increases soil acidity. Furthermore widespread use of most nitrogen containing fertilizer also increases soil acidity.

Therefore nearly all soils in North Carolina that produce grain and oil crops, tobacco, cotton, vegetables, fruit, some forest species, turf, many ornamentals, and forages need lime for optimum growth unless lime has been added recently. I say this because of reviewing soil test summaries compiled by the Agronomic Division, North Carolina Department of Agriculture.

For example, 1990-1991 416 turf samples from the Mountains (3 counties) show that 33% of these samples need lime. In the Piedmont, 2,037 turf samples (8 counties) show that 37% of the samples would need lime. Additionally, in the Coastal Plain 4,301 turf samples (13 counties) showed that 47% of the samples would need lime. You will note that in the Coastal Plain where the surface soils are more sandy, that leaching has been more intensive and given rise to a greater percent of samples needing for lime. In all probability many of the samples for utility , sod, parks, and athletic turf have similar lime needs. In fact, they may even be greater.

Furthermore,, agronomists at the Agronomic Division, North Carolina Department of Agriculture emphasize that a high percent of the "problem samples" that they receive each spring and summer, where serious growth problems have been recognized, have very low soil pH and therefore need significant amounts of lime. Although the soil's response to lime is frequently rather subtle, in contrast to an application to nitrogen, ignoring its regular use will limit the longevity and vigor of turf.

The soil acidity problem is somewhat complex and is influenced by, not only, soil properties but climatic conditions as well as the sensitivity of the turf. There are several benefits from proper lime use. By this, I mean lime use based on soil test suggestions. To begin with, many of the plant nutrients to maintain strong growth are influenced by soil pH. For most of the nutrients that you need to be concerned with, the optimum pH ranges from 6 to 7.

Let's review the numerous benefits of proper liming. First, proper liming will reduce the levels of aluminum (and manganese in most Mountain and Piedmont soils) which may be toxic and restrict root and associated top growth. Restricted root growth also reduces drought tolerance.

Secondly, as hinted above, more efficient use of fertilizer supplied phosphorus will occur if a proper pH is maintained. Aluminum, as suggested, particularly at low soil pH, is chemically active and combines with fertilizer phosphorus causing it to become insoluble. This tying up of fertilizer phosphorus means that less is available to this crop or the next one. In some instances, fertilizer phosphorus has inadvertently served as a liming material, in that it has immobilized aluminum.

Thirdly, economical provision of essential magnesium is obtained when one uses suggested dolomitic limestone. Furthermore, the magnesium supplied in dolomitic limestone is released slowly over a period of 3-4 years and therefore is better protected from leaching than that supplied by fertilizer.

Fourthly, if legumes such as clover are involved in your sod, where ever it be, proper liming will improve the nodule development on legume roots which synthesize or generates nitrogen from the soil atmosphere for use by that crop. When the soil pH is low, these nodules,

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which contain rhizobia, have difficulty supplying any supplemental nitrogen.

Fifthly, on sandy soils, proper liming reduces the leaching of potassium, one of the important nutrients for vigorous turf. On sandy soils particularly the soils exchange complex has a limited number of sites that can hold nutrients such as potassium, magnesium, calcium and, in fact, ammonium nitrogen. If these sites are occupied by strongly attached aluminum (low pH) any potassium added in fertilizer is more susceptible to leaching. Let me emphasize, though, that proper liming will not completely prevent leaching of potassium but will tend to minimize it, particularly on those soils in the Coastal Plain with deep sandy surfaces.

Finally, you may experience improved performance of some of the herbicides. Triazines - atrazine and simazine - do not perform as effectively below the optimum pH. Furthermore there is increasing evidence that optimum pH also may improve the performance of some nematicides should you be involved in needing to use these soil amendments.

In general, you will find that two sources of limestone serve turf needs very effectively. The most widely available lime is that called "dolomitic." Dolomitic lime contains magnesium, in addition to calcium, and is important where the soil tests show that magnesium is needed. Most of what is supplied to North Carolina is finely ground and meets the minimum size requirements dictated by the North Carolina Department of Agriculture. A second source that might be satisfactory, particularly if it could be obtained as inexpensively is that called "calcitic" lime. Although it does not contain magnesium it will also correct soil acidity. The soil tests will indicate whether you can use calcitic lime satisfactorily. This would be the case where we are interested in raising soil pH and the need for magnesium is not as critical as in other situations. Many organic soils and some Piedmont soils are naturally high in magnesium, whereas most sandy soils in the Coastal Plain are low. It is possible to use a magnesium fertilizer instead of dolomitic lime but the cost of these materials is usually considerably higher. You may want to consider this if calcitic lime is cheap and magnesium is needed.

As I indicated above, most of the dolomitic and/or calcitic lime is sold as a finely ground material that is frequently "dusty" when spread on turf. on the other hand, and in more recent years, lime is available in pelleted form. The pellets are formed from lime that has been finely ground; it is not large grains of solid limestone. The pelleted lime is loss dusty and easier to spread but it is a little more expensive. Pelleted lime is somewhat slower to act than powered lime. I would also emphasize that pelleted lime must slake down (disburse with rainfall or sprinkler water) when it comes in contact with moisture. In the case of pelleted lime its change in soil pH will be improved if the soil can be retilled thoroughly several days after the pellets have been mixed since they become soft where water is applied. Pelleted lime has become popular because it can be spread with the same kind of spinner spreaders that are used to broadcast granulated fertilizer.

If at all possible, lime should be thoroughly mixed with the surface 6-8 inches to insure that you have rapid dissolving of the lime and enhanced correction of the acidity problem. I can't emphasize too much the importance of proper lime incorporation prior to the establishment of turf because after the turf is in, the only option a person has is topdressing.

Topdressed lime is not as reactive as when it is physically mixed throughout the soil surface. Therefore, the improvement in soil pH is much slower. On the other hand, lime does dissolve slowly at the interface of the soil and organic matter and through this process gradually releases the nutrients as well as correct soil pH. If there is any opportunity to do a little bit of tillage, or mixing by coring or perhaps plugging, this will encourage incorporation of that topdressed lime.

Fertilizer Use

Now I would like to turn my attention to a few topics about nutrient use, particularly as it relates to sod establishment, athletic turf management and other miscellaneous uses of turf for long-term use. We can, again, look at soil test summaries regarding phosphorus and potash needs of turf across the state. In the Mountain region one half of the samples will definitely need phosphorus. In the Piedmont and Coastal Plain about one third of the samples from each region need phosphorus. Phosphorus is important for strong root

development. On the other hand, phosphorus is not very mobile in the soil and therefore to adequately meet the needs for optimum root development the fertilizer supplied phosphorus should be incorporated prior to the establishment of sod. After sod is established, topdressed phosphorus of mixed fertilizers tends to remain at or near the surface and unless it has been previously incorporated in the soil to considerable depth the absence of it to any depth in a soil greatly restricts deep root development. If phosphorus is not thoroughly distributed in the distributed in the profile, topgrowth is also less than optimum.

With respect to phosphorus application it goes without further emphasis that the soil test suggested amount should be applied. It is important to realize, as I emphasized above, that proper liming greatly increases the efficiency of response or availability of this nutrient. If the soil is not properly limed then some of the phosphorus neutralizes the aluminum at low soil pHs and a smaller percent of that fertilizer supplied phosphorus is available for the established crop.

Let's turn to turf potash needs across the state. This nutrient enhances root development, winter hardiness and general growth. About 4 out of 6 samples in the Mountains need additional potash. In the Piedmont about 1 out of 3 need additional potash, whereas, 1 out of every 2 sample need potash in the Coastal Plain. I again would stress the importance of incorporating potash prior to sod establishment. On the other hand potash is a mobile nutrient (subject to water movement) and if not adequately supplied at time of sod establishment will infiltrate into the soil profile and move downward through the root system. This is one of the advantages of annual applications of nutrients, particularly the mobile nutrients like nitrogen and potash.

Most of the micronutrients except perhaps iron are in adequate supply in North Carolina for establishment and maintenance. Soil test reports will indicate a need, which, if documented, can be applied when the sod is established. Several special situations occur. For example, iron may be necessary for centipede grass, particularly if the soil pH is a bit high and the iron supply is inherently low in the field. Small amounts of the micronutrients can be applied foliarly. The soil test report will give you some suggestions for micronutrient applications.

In summary, I would suggest that much attention be given to dealing with the soil acidity problem. The proper soil pH (proper pH range) greatly enhances the effectiveness of other nutrients and pesticides that are so important in maintaining high quality turf.

GRASS SELECTION FOR SOD PRODUCTION

Arthur H. Bruneau and Richard White[1]

Introduction

Turfgrass selection should be based on evaluation trials conducted over several years and under conditions similar to those where the turf will be grown. In order to meet this need, the turfgrass work group at North Carolina State University has established and maintained a number of cultivar evaluation trials across North Carolina. The following information reflects the results of these trials and in some instances testing at other universities.

Fall seeded trials, with the exception of the bentgrass trial, were maintained at a height of 2 inches and fertilized with a complete fertilizer at a rate of 2 pounds of N per 1,000 square feet per year as a split application of 1 pound each in September and February. The bentgrass trial was mowed every other day and at 1\4 inch mowing height and fertilized at the rate of 6 pounds of nitrogen per year. The zoysiagrass trial was established at Raleigh and in Brunswick county using 2 inch plugs set 12 inches apart. All trials were watered to prevent drought. The ranking of grasses where appropriate was based on turf quality, a reflection of overall performance and how they related to a well known cultivar for comparison purposes. Average quality ratings were subjected to a statistical procedure referred to as a Waller-Duncan K-Ratio Test. It is used to determine if the differences observed are in fact due to cultivar performance or simply a reflection of random chance.

Although cultivar trials provide important information regarding the performance of monoculture stands, it is necessary to keep in mind that cultivars can perform differently when used in mixtures. For this reason, one should not to dismiss a particular cultivar because it has not performed well in a certain cultivar trial. The use of blends and mixtures is encouraged whenever possible to ensure top performance over a wide range of conditions. This is especially true for the cool season grasses.

Bentgrasses

A number of seeded bentgrass cultivars have been or will soon be released commercially. Very little research information is available at this time, however, a national bentgrass trial has been established at a number of locations around the country. A list of entries and sponsors can be found in Table 1. We have evaluated some of these newer cultivars at the Turf Field Center and a summary of cultivar performance data for 1987 and 1988 can be found in Tables 2 and 3. This data is considered preliminary. There appears to be a lot of interest among superintendents concerning these new cultivars and some are establishing putting greens using some of these new cultivars. SR 1020, Putter and SR 1019, now known as Providence, appear to be receiving a lot of attention.

Tall Fescue

Table 4 provides a relative ranking of the tall fescue cultivars. The improved performance of the newer cultivars compared to Kentucky 31 was primarily due to finer texture, greater density, darker color and the ability to perform better at a lower mowing height. Enhanced performance in the shade has also been noted. Preliminary studies suggest that some of the newer low growing cultivars, referred to as "dwarf type tall fescues," may not perform as well as some of the older "turf type or semi-dwarf type tall fescues." Increased brown patch activity, a possible result of increased shoot density has been reported for some of these third generation tall fescues. In addition, their slow growth rate can delay the recovery process once thinning from disease or environmental stress occurs. A number of seed companies have increased their breeding effort in the region looking for cultivars that are more brown patch tolerant.

Kentucky Bluegrass

Table 5 provides a relative ranking of the Kentucky bluegrass cultivars.

[1]Associate Professor/Extension Specialist and Assistant Professor, Department of Crop Science, North Carolina State University.

Kentucky bluegrass is a fine textured, sod forming grass that has excellent resiliency and performs best in open sun although shade tolerant cultivars are available. It prefers well drained, fertile soils and forms a dense, medium textured turf. It will perform well alone in the higher elevations of western North Carolina, but should be combined with tall fescue in the lower elevations or in the eastern edge of the mountains. Many of the newer cultivars continue to perform better than Kenblue due to their increased tolerance of diseases such as leafspot and mildew. Blending of two or more of the improved cultivars is highly recommended because of the lack of genetic diversity within a Kentucky bluegrass cultivar. Bristol, Glade, Nugget, America, Columbia, Enmundi, Georgetown, Midnight, Sydsport, Ram 1 and Mystic have been reported to be more shade tolerant than some of the other Kentucky bluegrass cultivars.

Fine Fescue

Table 6 provides a relative ranking of the fine fescue cultivars. Find fescue (fine leaf fescue) is a generic term that encompasses three species of fescue - creeping red, chewings and hard fescues. Fine fescues are fine in texture and best adapted to the Western region and the shady sites of the Piedmont. They are extremely shade and drought tolerant, better able to withstand infertile soil conditions compared to many other grasses, but are adversely affected by heat and diseases. They are an excellent companion with bluegrass; however, they should not be planted alone in most stances. They may not persist in sunny locations exposed to high temperature extremes or heavy traffic. Our trials suggest that, overall, the hard fescues have outperformed the chewings and creeping red rescues. The chewings fescues have performed better than the creeping red fescues. These differences are primarily due to their varying tolerances to diseases such as leafspot and dollarspot.

Perennial Ryegrass

Table 7 provides a relative ranking of the perennial ryegrass cultivars.

Perennial ryegrass is best adapted to the Western region rather than the Piedmont and Coastal Plain because of its low tolerance for shade, drought and temperature extremes. Its susceptibility to diseases such as rust, pythium and red thread have limited its use in some areas. It is often seeded with Kentucky bluegrass because of its ability to establish quickly and its similarity in appearance and management requirements. Most of the newer cultivars of perennial ryegrass are superior to the earlier improved cultivars such as Linn. They are finer in texture, lower growing, easier to mow, more pest resistant and more attractive than earlier cultivars. The quality of perennial ryegrass cultivars can quickly change within a growing season providing exceptional performance in the fall and very poor performance in later summer. This is another reason why it is suggested that they be planted in blends and mixtures and not as monocultures.

Zoysiagrass

Tests have been established at the Turf Field Center and on a sod farm located in Brunswick County. Although less than a year old, the studies suggest that some of the newer cultivars will establish much quicker than the standard cultivars-Emerald and Meyer. The establishment rate of recently released El Toro and several experimentals has been good at both locations (Table 8). Additional observations as to disease resistance, winter hardiness and thatch buildup are needed prior to adoption and use of some of the new materials in North Carolina. El Toro was developed in California and may not have the winter hardiness required for good year-long performance in North Carolina. It appears that some of the newer zoysiagrasses have the ability to establish within one growing season if planted early enough. Many of the new zoysiagrass cultivars are similar in texture to the tall fescues and have a medium to dark green color.

In summary, there are a lot of new cultivars either being released or soon-to-be released with what appears to be improved characteristics over existing cultivars. Keeping abreast of the latest findings allows the sod producer to plant and sell a marketable product that both homeowners and turf managers will find pleasing. Attending the Turfgrass Conference and Field Day and obtaining the latest extension publications are excellent waysto keep informed of the latest findings regarding the performance of turfgrass cultivars.

Table 1. Entries and sponsors of the 1989 National Bentgrass Test.

Entry No.	Name	Species	Sponsor
1	BR 1518	A. castellana (dryland bent)	USGA Green Section
2	Carmen	creeping	Van der Have Oregon
3	Tracenta	colonial	Van der Have Oregon
4	Putter	creeping	Jacklin Seed Co.
5	SR 1020	creeping	Seed Research of Oregon
6	Providence	creeping	Seed Research of Oregon
7	Bardot	colonial1	Barenbrug USA
8	Penncross	creeping	Tee-2-Green Corp.
9	Pennlinks	creeping	Tee-2-Green Corp.
10	UM 84-01 (Biska)	creeping	Johnson Seeds, Ltd.
11	Egmont	A capillaris (browntop bent)	Olsen-Fennell Seed Co.
12	Normarc 101 (Regent)	creeping	Normarc, Inc.
13	Forbes 89-12 (PRO/CUP)	creeping	Forbes Seed & Grain
14	WVPB 89-D-15	creeping	Willamette Valley Plant Breeders
15	National	creeping	Pickseed West
16	88.CBE	creeping	International Seeds
17	88.CBL	creeping	International Seeds
18	Cobra	creeping	International Seeds
19	Emerald	creeping	International Seeds
20	TAMU 88-1	creeping	Texas A&M University
21	Allure	colonial	Willamette Seed Co.
22	MSCB-6	creeping	Mississippi St. Univ.
23	MSCB-8	creeping	Mississippi St. Univ.

Table 2. Bentgrass cultivar performance at Raleigh, NC during 1987.

No.	Entry[1]	Turf Quality 1986				Jun 87	Aug 87	Aug 87
	May	Jun	Aug	Mean	TEX[4]	D Spot[5]	Root Wt	
		9=best				9=fine	No/730cm^2	g/81 cm^2
1	Pennlinks	6.5	6.8	8.5	7.3	8.0	1.6	1.88
5	Cobra	8.0	6.5	8.0	7.5	7.8	1.3	1.93
3	Penneagle	6.3	6.3	8.5	7.0	8.0	1.4	3.40
2	Penncross	7.8	6.0	6.8	6.9	6.5	5.6	1.88
6	Emerald	6.0	5.3	7.3	6.2	6.3	4.6	1.76
7	SR1019	6.8	6.5	8.8	7.4	8.0	0.8	1.26
4	Seaside	6.3	5.0	5.5	5.6	5.0	1.1	1.25
8	SR1020	7.3	6.3	7.0	6.9	8.0	6.1	1.01
10	Proiflinent	4.8	5.0	5.5	5.1	5.5	0.8	0.88
11	Penncross	4.8	4.5	5.8	5.0	5.8	0.6	0.85
12	Streaker	3.8	4.0	li.3	3.7	3.3	0.5	0.90
9	NJMix	6.5	5.8	7.8	6.7	7.3	0.6	0.92
	LSD 1.2	0.7	0.6	--	0.7	4.3	1.56	
	Pr>F	**	**	**	--	**	*	*
	HIGH Entry	5	1	7	7	1	8	3
	LOW Entry	12	12	12	12	12	12	11

[1]Entries 1-6 were seeded on 23 Sep 1985, while entries 7-12 were seeded on 3 Dec 1985 and held under a plastic cover until 4 Mar 1986.
[2]Turf quality scores were taken on a 1 to 9 scale, with 9 as best and 5 as minimally acceptable.
[3]TEX = Texture score on a 1 to 9 scale, with 9 as very fine and 1 as very coarse.
[4]D Spot = Number of dollarspot patches per 730 cm^2.

Table 3. Bentgrass cultivar performance in Raleigh, NC during 1988.

Entry	Turf Quality[1]						Sept 88
	Apr	May	Jun	Aug	Oct	Mean	Root Wt
Pennlinks	6.7b	7.9a	8.3b	6.4a	6.6b	7.2	4.7a
Penncross	6.7b	7.9c	8.1b	6.8a	7.2a	7.3	5.1a
Penneagle	6.4b	7.6b	8.4a	5.9b	6.3b	6.9	----
Cobra	7.8a	8.1a	8.1a	6.1b	6.9a	7.4	5.3a
Providence	6.4b	7.9a	8.3a	5.8b	5.5b	6.8	4.0b
SR 1020	7.0a	8.1a	7.9a	6.0b	6.0b	7.0	4.4b

[1]Turf quality scores taken in 1 to 9 scale, with 9 as best and 5 minimally acceptable.

Table 4. Tall Fescue Cultivar Performance in North Carolina

Tall Fescue Cultivars			
Very Good	Good		Fair
Bonanza*	Adventure	Maverick	Amigo
Phoenix*	Apache*	Maverick II	Aztec
Taurus*	Aquara	Mesa	Bonsai*
Thoroughbred	Arid*	Murietta	Chesapeake
Trident	Astro*	Mustang	Chieftan
	Avanti	Olympic*	Guardian
	Barnone	Olympic II	Ky 31*
	Brookston	Rebel *	Monarch*
	Carefree	Rebel Jr.	Pacer*
	Cochise	Rebel II*	Silverado
	Crossfire	Richmond	Tip
	Emperor	Shenandoah*	Trailblazer
	Falcon*	Shortstop	Tribute
	Finelawn I*	Sundance	Willamette*
	Finelawn 5GL*	Titan*	Winchester*
	Houndog*	Twilight*	
	Jaguar*	Wrangler	
	Jaguar II		

*Cultivars readily available in North Carolina at time of printing.

Table 5. Kentucky Bluegrass Cultivar Performance in North Carolina

Kentucky Bluegrass Cultivars			
Very Good	Good		Fair
A34	Abbey	Gnome	Merion
Aspen	Able-I	Haga	
Kelly	Amazon	Huntsville*	
Blacksburg	America	Ikone	
Bristol	Aquila	Joy	
Classic	Asset	Julia	
Coventry	Baron	Kenblue*	
Monopoly	Challenger	Merit*	
Nassua	Chateau*	Midnight	
Parade	Cheri	Mystic	
Ram I	Cynthia	Princeton	
Rugby	Eclipse	Sydsport	
Somerset	Estate	Tendos	
Suffolk	Georgetown	Victa	
Trenton	Glade*		
Wabash			

*Cultivars readily available in North Carolina at time of printing.

Table 6. Fine Fescue Cultivar Performance in North Carolina

Fine Fescue Cultivars				
Very Good	Good	Fair		Poor
Aurora*	Flyer*	Atlanta	Ensylva	Logro
Scaldis	Longfellow	Banner	Highlight	
Spartan	Reliant*	Biljart	Jamestown	
	Shadow	Boreal	Koket	
	SR3000	Center	Mary	
	Valda*	Ceres	Pennlawn*	
	Victory	Checker	Ruby	
	Waldina	Enjoy	Waldorf	

*Cultivars readily available in North Carolina.

Table 7. Perennial Ryegrass Cultivar Performance in North Carolina

Perennial Ryegrass Cultivars					
Very Good		Good		Fair	
Allaire*	Omega II	Barry	Manhattan II	Barcredo	Gator*
Barrage	Patriot II	Caliente	Nova	Belle	Manhattan II*
Birdie II	Pennant*	Charger	Ovation	Blazer	Pennfine*
Competitor	Prelude	Citation II	Palmer	Brenda	Regal*
Dillon	Saturn	Dasher II	Ranger	Commander	Rodeo
Fiesta II	SR 4100	Dimension	Regency	Cowboy	Sheriff
Lindsay	Vintage 2DF	Diplomat	Repell	Delray	Tara
Manhattan II		Goalie	SR 4000	Derby*	Yorktown II

*Cultivars readily available in North Carolina.

Table 8. Percent ground coverage of commercial and experimental zoysiagrass established June 18 at Raleigh and June 26 at Brunswick County, North Carolina. Data from Raleigh are for August 19 and from Brunswick County for September 11.

Entry	Percent Ground Cover	
	Raleigh	Brunswick Co
El Toro	80.0	53.3
DALZ8514	70.8	70.0
DALZ8512	69.2	50.0
TGS-B10 (Seeded)	49.2	15.0
Sunburst	48.3	13.3
Korean common (Seeded)	47.5	13.3
JZ-1 (Seeded)	40.0	15.0
TGS-W/O (Seeded)	38.3	11.7
Belair	30.8	15.0
Emerald	24.2	8.3
Meyer	22.5	20.0
MSD	8.7	11.7

SPECIAL CONSIDERATIONS IN ATHLETIC FIELD MAINTENANCE

Gil Landry, Jr.[1]

The rigors of athletic field maintenance require the blending of turfgrass management skills with the demands of facility use. The goal is generally to produce a safe, quality surface that is always ready for use. Recently, more emphasis has been placed on field and facility appearance because facilities are recognized as a source of school and/or community pride.

The challenge of successful turfgrass management begins with an understanding of turfgrass species and cultivars, soil properties, environmental conditions, weather, and turf maintenance practices. A good field manager begins just like a coach by developing a game plan or program. Sources to develop a program may include reputable suppliers, consultants, and the local county Extension agent. Of course a good program cannot be developed without a budget. And wisely using a budget can be just as important as years of turfgrass management experience.

A very common problem with sports fields is not maintaining proper surface slope to provide adequate surface runoff. Of course, good surface drainage can greatly reduce excessive moisture problems and limit soil compaction because dry soils are more resistant to traffic. It is very common for fields to lose this slope with time unless the field is regularly cored. Once the slope is lost renovation or topdressing will be necessary.

Like drafting professional athletes, proper turfgrass selection is becoming more important as new cultivars are being introduced. The most widely used cultivar for all warm season fields is Tifway bermuda which is also commonly called Tifton 419. Common alternatives include Tifway II which is very similar to Tifway and common bermudagrass. Common bermuda is generally used on non-irrigated sites and it certainly does not provide the traffic tolerance, recovery rate, or turf quality of the hybrids. Other cultivars suited to areas where hybrid bermuda winter kill is a problem include Vamont, Midiron, and for low traffic fields zoysiagrass. Although there may be some special cases in the south, most sports fields established in cool season turfgrasses end up being invaded by common bermuda and weeds.

The core of a good field, like the line of a good football team is the fertilization program. Such a program relies on a soil test analysis. In most cases using a 4-1-2 or 3-1-2 ratio fertilizer or following a program which provides N-P-K in this ratio is safe. Most fields need from three to seven pounds of N per 1000 sq. ft. per season. Nitrogen is generally applied at one pound of N per month of active growth. On healthy fields not being used much, three pounds of N applied seasonally in spring, summer, and fall may be enough.

Just as conditioning is a key to successful teams, proper mowing is important for a well maintained field. The general mowing height for hybrid bermuda is between 0.5 and 1.5 inches. A very common problem occurs when the hybrid bermudas are mowed above 1.5 inches because the grass then has too much stem which reduces quality and playability. Especially since excellent field quality is produced when the grass is mowed one inch or lower. However, the shorter mowing height requires more frequent mowing. Common bermuda generally does better when mowed between 1.5 and 2.0 inches and at this height needs mowing every five to seven days. Of course staying on the proper frequency to remove no more than 30% to 40% of leaf area is very important to turf vigor and quality.

Just as a football team needs water to keep going, turfgrasses need about one inch of water per week. Irrigation should occur only when the grass shows signs of moisture stress like turning dull or a bluish color. If possible, avoid irrigating on game days and extend the time between irrigation and field use to 24 to 48 hours. The wetter the soil is when used the more soil

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compaction will occur.

Like the opposing pitcher, soil compaction can be and frequently is a big problem. Compaction due to field use generally occurs in the top two to three inches of soil. This results in a gradual thinning of the turf due to poor root growth. Soil compaction problems are initially very subtle and hard to diagnose. Reduced vigor and poor color may be followed by more frequent drought stress symptoms and more rapid surface runoff. Obviously, compaction is more severe where field use is concentrated like between the hash marks on football fields.

Core cultivation is essential where such traffic occurs and can be used before these symptoms appear. Most fields should be cored at least around spring greenup, in early summer, and again after the season is over. Heavily used fields can be cored monthly or even more frequently if necessary. Coring tines only have to penetrate through the compacted layer. If soil compaction is deeper than standard aerators go (2 - 4 inches), the new deep-tine units are capable of going about 10 inches deep. Relieving soil compaction increases turf rooting and thus increases water efficiency.

Traffic management is the final consideration to address. Generally, the first step in traffic management is to avoid continual use in the same area. Develop a field rotation plan to distribute the traffic evenly over the entire area and allow for turf recovery. Minimize field use when the soil is wet and during spring greenup.

Athletic field maintenance is a special challenge that requires the blending of agronomic principles, environmental awareness, and facility and people management to provide quality playing surfaces that are safe and attractive.

WEED MANAGEMENT IN ATHLETIC FIELDS

W. M. Lewis[1]

Weed management practices in athletic fields may be influenced by: 1) grass species, 2) intensity of use and 3) season of use. The most common warm-season grass species grown on athletic fields are common bermudagrass, Tifway bermudagrass and Vamont bermudagrass. The cool-season grass species include bluegrass, tall fescue/bluegrass mixture, and perennial ryegrass/bluegrass mixture. Whether an athletic field is a spectator field or a multiple purpose field affects weed management as well as turf management practices. The more intense the use and the longer the use makes turf management and weed management more difficult. Therefore, if you expect to have a safe and serviceable athletic field, particularly a spectator field, play only scheduled games and do not conduct any sports practices, P. E. classes or band practice on the field.

Weed management approaches in athletic fields are similar to other turf areas and involves: 1) selecting an adapted grass for the locality, 2) mowing this selected grass at proper height and frequency, 3) fertilizing at the proper time and rate according to the turfgrass growth, 4) irrigating as needed to encourage establishment and to reduce stress periods, 5) aerifying to relieve compaction or dethatching according to the turf and the amount of play and 6) using the appropriate preemergence and/or postemergence herbicides for the weed problem and turf present. The goal is to first produce a vigorous turf competitive to the weeds. Also, remember if you bring in topsoil to smooth the field or raise the crown you can expect various grass and broadleaf weed problems; crabgrass, goosegrass, fall panicum, cocklebur, pigweed, ragweed, smartweed, etc.; as found in cultivated fields. To avoid management problems, any added soil or soil mix should be the same as the original field.

Suggestions for the control of specific weeds in athletic fields will be discussed on the basis of the seasonal growth habit of the weeds and whether the turfgrass is bermudagrass or a tall fescue/bluegrass mixture.

Winter Weeds

Winter annual broadleaf weeds which grow in athletic fields include common and mouseear chickweeds, henbit, hop clover, parsley piert, and lawn burweed (spurweed). Winter annual weeds germinate in the fall and early winter, remain somewhat dormant during the coldest part of the winter, and produce seed as temperatures warm in the spring and die with yet warmer temperatures. It is important to control winter annual weeds because they delay spring greenup of bermudagrass and the resumption of growth of tall fescue and bluegrass. Furthermore, early control increases the ability of the turfgrass to grow into thin areas and become more competitive.

In bermudagrass, winter annual weeds can be controlled with atrazine (AAtrex) or simazine (Princep) applied at 1.25 lb active per acre. These sprayable products are available as a 4 pound gallon, 80% wettable powder and a 90% water dispersable granule. Both atrazine and simazine are absorbed primarily by the roots of the germinating weeds and then translocated throughout the plant. Atrazine is also slightly absorbed through the foliage. These herbicides will control emerged annual bluegrass (*Poa annua*) and chickweed. According to our test results the best control is obtained from applications applied from November 15 to December 30. Late applications, for example in February have delayed spring greenup of bermudagrass. If applications are made in January, atrazine will give more favorable control and the rate should be increased to 1.5 lb active per acre.

In completely dormant bermudagrass, Roundup at 16 ounces of product per acre will provide postemergence control of annual bluegrass, chickweed, henbit, and corn speedwell. Apply in 10 to 20 gallons of water per acre with 2 quarts of

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nonionic surfactant per 100 gallons of spray solution.

Sencor 75 Turf Herbicide may be applied on dormant established bermudagrass turf prior to spring greenup to control many emerged common winter annual broadleaf weeds plus annual bluegrass. Sencor controls Carolina geranium, common chickweed, corn speedwell, henbit, hop clover, white clover, london rocket, parsley piert, prostrate knotweed, shepherdspurse, small flowered buttercup, spotted spurge, and lawn burweed. The rate is 0.67 lb of product per acre.

If the bermudagrass athletic field has been overseeded to ryegrass, do not apply AAtrex, Princep, or Sencor because the ryegrass will be severely injured. For this situation, use a herbicide combination product as described for tall fescue/bluegrass mixtures following the same application precautions. However, do not use Turflon D on bermudagrass. Avoid spraying bermudagrass during spring green-up.

In tall fescue/bluegrass mixtures control of winter annual broadleaf weeds is achieved with a broadleaf herbicide applied to growing weeds (postemergence). To control a number of different winter annual broadleaf weeds, a combination product containing two or three broadleaf herbicides should be selected for effective control. Susceptibility of various weeds to specific broadleaf herbicides is given in an annual publication on "Pest Control Recommendations for Turfgrass Managers" published by the North Carolina Agricultural Extension Service. Herbicides included in combination products are 2,4-D, mecoprop (MCPP), dicamba (Banvel), dichlorprop (2,4-DP), or triclopyr. They cause abnormal growth responses within the weeds (for example, leaf curling or puckering, stem twisting) and affect respiration, food reserves, and cell division.

The combination products also control or suppress perennial broadleaf weeds such as dandelions, ground ivy, plantains, and white clover. To improve control of the more difficult-to-control weeds (corn speedwell, lawn burweed (spurweed), parsley piert, and violets) use 2,4-D + mecoprop + dicamba at one-half the recommended rate and repeat in 10 to 20 days. Weedone DPC and Turflon D offer improved control of oxalis and violets. Some combination herbicide products are listed on the following page. These herbicide products do not control grassy weeds. **Do not use herbicides on newly seeded or renovated fields until new seedlings have been mowed at least three times.** Always follow label instructions.

Table 1. Products and Application Rates for Broadleaf Control

Product Trade Name (Common Name)	Product Per Acre
Triamine (2,4-D + mecoprop + dichlorprop)	3 to 4 pints
Trimec (2,4-D + mecoprop + dicamba)	3 1/4 to 4 pints
Trexsan (2,4-D + mecoprop + dicamba)	2 to 3 pints
Three-Way Selective Herbicide (2,4-D + mecoprop + dicamba)	3 1/4 to 4 pints
Weedone DPC (2,4-D + dichlorprop)	3 to 4 pints
Turflon D (2,4-D + triclopyr)	3 to 4 pints
2 Plus 2 (2,4-D + mecoprop)	5 pints

Apply the herbicide as a postemergence spray at the product label rate to the emerged weeds from December to March or before the turfgrass resumes active spring growth. By doing this, the weeds will be removed from competition and the desired grasses will have a greater chance to fill in vacant spaces.

Summer Annual Broadleaf Weeds

Summer annual broadleaf weeds commonly found in athletic fields include: annual lespedeza, carpetweed, prostrate knotweed and prostrate spurge. Summer annual weeds germinate in the spring or summer, produce seed, and die with the coming of colder weather or frost.

Annual lespedeza usually germinates in May or June and is controlled by products containing mecoprop or dicamba. Knotweed germinates in late March to early April and is considered to be a summer annual weed. It frequently indicates a compacted soil, especially where play is concentrated. It is susceptible to dicamba (Banvel) at 0.2 lb active per acre. In addition, the soil should be aerified or cored to reduce soil compaction. Prostrate spurge may germinate and produce seed within a four-week period. Combination products control prostrate spurge.

Summer annuals may be controlled by the same broadleaf herbicides mentioned previously for winter annual broadleaf weeds. In some cases, weeds which are susceptible to 2,4-D can be controlled by adding 1 pint of 2,4-D to one of the MSMA applications when controlling crabgrass

with a postemergence spray. Delay broadleaf herbicide application in bermudagrass until it has turned green in the spring. Hybrid bermudagrass, for example Tifway, is more susceptible to broadleaf herbicides than common bermudagrass. Therefore, use lower rates. If perennial broadleaf weeds are also present, a combination product increases control.

Perennial Broadleaf Weeds

Examples of perennial broadleaf weeds are dandelion, white clover, and plantains. Perennials can live more than two years producing seed each year. Effective control may require both a fall and spring application or repeat applications six weeks apart. Dandelions and plantains are susceptible to 2,4-D, while white clover is susceptible to mecoprop and dicamba.

Application Techniques for Postemergence Broadleaf Herbicides

Certain application techniques are helpful when spraying postemergence broadleaf herbicides in turf. Herbicides should be applied to actively growing weeds. Herbicides will be more active when sprayed when daily temperatures are 60 to 80 degrees Fahrenheit. There should be adequate soil moisture. Apply the herbicides before mowing to have ample leaf surface for herbicide absorption. Generally spray applications are more effective than granular applications. Avoid spray drift to susceptible desirable plants. Always check the label for sensitivity of turfgrasses and any other precautions. When applying to newly seeded turf, wait until after the third mowing. It has also been observed for more difficult to control weeds that using the minimum label rate or 1/2 rate and repeating in 10 to 20 days will provide more effective control.

There are several factors which effect foliar applied herbicides. These may be briefly summarized as follows: Uniform spray coverage is important. The use of fan nozzles and 25 to 35 gallons of water per acre is suggested. As temperature increases within a range of 40 to 85 degrees Fahrenheit the foliar penetration of the herbicide usually increases. Above 85 degrees Fahrenheit volatility increases for Banvel and ester forms of 2,4-D. There should be a rain free period of 4 to 6 hours following the application of a herbicide. These herbicides are less effective, if applied when the weeds are under stress. Generally high relative humidity increases herbicide action by increasing absorption. The structure and plant processes contribute to differences in retention, absorption and metabolism of the applied herbicide. Annual weeds are easier to control in the seedling stage, biennials in the rosette stage and perennials after root reserves are depleted in the spring or applications in the late summer.

Preemergence Control of Broadleaf Weeds

Isoxaben (Gallery 75 DF) is a preemergence herbicide for control of certain broadleaf weeds in established turf. A few of the weeds controlled are bittercress, chickweeds, white clover, Carolina geranium, henbit, prostrate knotweed, yellow woodsorrel, and buckhorn plantain. Spray Gallery in late summer or early fall for controlling winter annual broadleaf weeds and early spring for summer annual broadleaf weeds. Germinating seeds of certain perennial weeds are also controlled. Gallery does not control established weeds.

Summer Annual Grass Weeds - Preemergence Control

Smooth and large crabgrass and goosegrass are the predominate summer annual grass weeds in athletic fields. They may be controlled with preemergence herbicides applied by the time dogwoods are in bloom. Products available for preemergence crabgrass, foxtail, and goosegrass control include: benefin (Balan 60DF), bensulide (Betasan 4E, 7G, Bensumec 4LF, Lescosan 4E, 7G), dithiopyr (Dimension 1EC), DCPA (Dacthal 6F), oxadiazon (Ronstar 2G), pendimethalin (Pre-M 60DG, Weedgrass Control 60WP), and benefin + trifluralin (Team 2G). With the exception of Ronstar, these herbicides inhibit root development of germinating weeds by affecting cell division. Ronstar has a contact action by affecting the young weed shoot as it grows through the treated zone.

Those preemergence herbicides inhibiting weed roots also affect the root development of desired turfgrasses, for example bermudagrass rooting at the nodes of the stolon. These herbicides are not suggested for use in bermudagrass athletic fields in the spring, if bermudagrass is thin, badly worn or reseeding or sprigging is planned. Ronstar shows the least adverse rooting effects on newly sprigged bermudagrass or newly laid bermudagrass sod. Dacthal is another possibility.

If tall fescue, bluegrass, or perennial ryegrass was reseeded in the fall, use only Balan 60DF, Betasan (bensulide), Dacthal 6F, Ronstar 2G, or Tupersan 50W in the spring for preemergence crabgrass control. If spring seeding of tall fescue or bluegrass is planned, siduron (Tupersan 50W) may be used for preemergence crabgrass control. Spray at seeding or before expected crabgrass emergence. This product will also provide fair control of goosegrass. Newly laid sod of tall fescue and bluegrass has tolerance to over-top applications of Ronstar 2G and Dacthal.

Summer Annual Grass Weeds - Postemergence Control

Crabgrasses and goosegrass may be controlled with postemergence spray applications of CMA, DSMA, or MSMA. There are various trade names for these compounds. MSMA is the most frequently used compound. These herbicides also control dallisgrass, bahiagrass, barnyardgrass, foxtail, annual sedges, nutsedges and sandbur. Bermudagrass is tolerant to these herbicides. Though slight off color may occur for one to two weeks. While bluegrass and tall fescue are slightly sensitive, that is, discoloration may be evident for one or two mowings. MSMA may be used on newly sprigged bermudagrass for postemergence control of seedling crabgrass and goosegrass. The rate to use is 1 to 1.5 lb active per acre which should control three-leaf grassy weeds. However, if the grass weeds are larger a repeat application will be necessary in 7 to 10 days. Other weedy grasses require at least two applications. If the MSMA product does not contain a surfactant, add a nonionic surfactant at 1 quart per 100 gallons of spray solution.

Acclaim 1EC Herbicide controls seedling crabgrass and goosegrass in tall fescue/bluegrass mixtures. When applying Acclaim, tall fescue should be at least 4 weeks old and Kentucky bluegrass at least 4 months old. Postemergence application rates are according to grass weed growth stage. For untillered plants, apply 15 fl oz of product per acre (0.34 fl oz/1000 sq ft) and for 1 to 2 tiller plants 23 fl oz/A (0.53 fl oz/1000 sq ft). Acclaim may be tank mixed with certain preemergence residual herbicides and postemergence broadleaf herbicides.

Application Techniques for Postemergence Grass Weed Control

When applying postemergence herbicides for grass weed control, several application techniques should be considered. If the crabgrass plants are small (3- to 4-leaf stage) one application usually provides control. However, larger plants require two applications 7 to 10 days apart. The usual rates for MSMA are 1.5 to 2 lb active per acre, while DSMA is used at 3 lb active per acre per application. Repeat applications at the indicated rate are more satisfactory than a single application at a higher rate. Two or more applications are definitely required to control dallisgrass, nutsedges, and sandbur. The herbicide should be applied when atmospheric temperatures are at least 80 degrees Fahrenheit and with good soil moisture. Spray uniformly in 30 to 40 gallons of water per acre. Do not mow or water for at least 24 hours after application. Do not treat new seedings of grasses until they have been mowed at least three times. Do not apply the herbicides to any turf growing under stress conditions. It is best to apply herbicides to cool-season grasses (tall fescue and bluegrass) early in the summer. Try to avoid applications to these grasses in mid-summer.

Nutsedge Control

Two or three applications of DSMA (at 3 lb active per acre) or MSMA (at 2 lb active per acre) as described for postemergence control of crabgrass will control or suppress yellow and purple nutsedge. Imazaquin (Image 1.5 LC) at 2 to 2.7 pints/A or 0.7 to 1 fl oz/1000 sq ft will control purple and yellow nutsedge in bermudagrass turf. For improved purple and yellow nutsedge control, Image may be applied with MSMA at 1.5 lb active per acre. Add a nonionic surfactant at 0.25% v/v (2 pints per 100 gallons of spray mixture). Bentazon (Basagran T/O) may be used for only yellow nutsedge control in bermudagrass, bluegrass, fescue and ryegrass. The rate is 2 to 4 pints per acre or 0.75 to 1.5 fl oz/1000 sq ft. Add a crop oil concentrate at 2 pints per acre or 0.75 fl oz/1000 sq ft. For optimum control, do not mow 3 to 5 days before or after application. Make repeat applications at 10 to 14 day intervals until controlled.

Wild Garlic Control

In dormant bermudagrass, imazaquin (Image) at 0.75 to 1 fl oz/1000 sq ft (1 to 1.33 quarts per acre) is very effective on wild garlic. Add a nonionic surfactant at 2 pints per 100 gallons of spray. For spot spraying, mix 2 fl oz of Image in

3 gallons of water and spray to wet the plants. In tall fescue/bermudagrass mixtures, a combination broadleaf herbicide product will suppress wild garlic. A second application the following year will be necessary for control.

Weed Control in Baselines

In the baseline of baseball fields annual grass weeds may be controlled by incorporating very shallowly herbicides such as Balan, Pendimethalin, or Team. For edging, Roundup may be applied in a shielded sprayer using a 1 or 2% solution. Add a nonionic surfactant at 0.25% by volume of spray solution (0.33 fl oz per gallon).

Moss and Algae Control

Sometimes in athletic fields algae or moss appear, which may indicate low fertility, low pH, compacted soil, poor drainage, excessive water or watering, or any combination of these factors. There are certain cultural practices which may help in the prevention of control of algae or moss which include conducting a soil test and applying any suggested lime and or fertilizer, avoiding excessive water and watering, aerifying (coring) compacted soils and improving the drainage. Algae and moss may also be controlled chemically. Algae is controlled by using 2 to 3 oz/1000 sq ft of copper sulfate. Moss may be controlled by using 5 oz/1000 sq ft of copper sulfate or ferrous sulfate. Before reseeding after chemical treatment apply 5 to 10 lb/1000 sq ft of limestone. Aerify and removed algae crust or dead moss.

Weed Management in Athletic Fields Summary

Weed management in athletic fields may be summarized by emphasizing the following spraying techniques: 1) select the proper herbicide for the weed and turfgrass, 2) follow label rates and precautions 3) calibrate the sprayer, 4) apply uniformly as a broadcast spray, 5) avoid skips or excessive overlaps in spraying, 6) use precision equipment which include: boom sprayer, fan nozzles, dripless nozzles, pressure regulators, strainers, tank agitation, etc., 7) employ a reliable spray person who has the proper applicator's license, and 8) wear protective clothing while spraying.

WEED MANAGEMENT FOR WILDFLOWERS

W.A. Skroch and L.B. Gallitano[1]

The ultimate objective in planting a naturalized wildflower area is to develop a permanent planting that will flower year after year with self-seeding annual and perennial flowers. However, wildflower plantings that are not managed will eventually revert to the composition of plant species in the original plant community through a process called succession. Succession is a gradual change in species of the plant community over time. The species that appear during this time change can generally be predicted based on historical knowledge of the planting site. For example, it is well documented that in Piedmont North Carolina, the following sequence of successional species will be seen in a cultivated area that is abandoned and not managed or maintained after the initial growing season:

Years 0-2	Crabgrass *(Digitaria spp.)*
	Horseweed *(Conyza caensis)*
	Ragweed *(Ambrosia artemisiifolia)*
	Aster spp.
Years 3-5	Broomsedge *(Andropogon spp.)*
	Loblolly pine *(Pinus taeda)*
Years 10-15	Loblolly pine
Years 15-75	Loblolly pine with hardwood understory

Wildflowers plantings essentially follow this successional process because they are given very little maintenance after the initial establishment period. In addition to these successional changes, other weed encroachment problems can be anticipated based on the site selected. One of the primary sources of weed contamination is from seed that have been deposited in the soil seed bank over a long period of time. These seed often remain dormant for many years but will germinate when lifted to the soil surface by tilling where moisture, air and light conditions are favorable. Early successional fields have been found to contain as many as 1,000-1,200 seeds per square yard. This quantity of seed, if allowed to germinate, would present a formidable weed population in a new planting. Therefore, in selecting a site for a wildflower planting, knowledge of previous weeds and how the land was used in the past will allow insight into ftiture potential weed problems.

One approach to weed management in wildflowers is site preparation and establishment of the planting. In North Carolina, fall (October - November) is the recommended planting time for wildflowers. Generally, the soil is cool and moist at this time of year which benefits seed germination. Winter annuals and some perennials will germinate and overwinter as small seedlings. The soil is cool enough to hold annual seed in a dormant state to germinate in early spring. The most effective weed management for establishing wildflowers is to kill as many weeds and viable weed seed as possible to prepare the site for planting. There are essentially two methods that are effective, the use of a broad spectrum, non-residual herbicide or ftimigation.

A systemic non-residual herbicide, such as glyphosate (Roundup), is the weed control approach most often used in establishing wildflowers. Glyphosate is often thought to be a cure-all to kill all plant material, however, it does have selectivity for some plants depending on the time of year it is applied and the growth state of the plant. Proper timing of the application is therefore important to get maximum results. (See AG-427, Weed Control Suggestions for Christmas Trees, Woody Ornamentals, and Flowers, North Carolina Cooperative Extension Service, for application rates and timing for specific weeds.)

In order to plant a site with wildflowers in October - November, site preparation must begin in late summer (August - September). Total site preparation time is approximately four-six weeks using this method. First, be sure the area has not been mowed so grass and weeds will be the size specified on the product label at the time of spraying. Spray only when the plants are dry.

[1]Professor and Graduate Student, respectively, Department of Horticultural Science, North Carolina State University.

When the site meets these conditions, uniformly spray for coverage but do not wet the plants to the point of runoff. Allow at least six hours of drying time for maximum plant kill with glyphosate. The timing of this first application is important because optimum susceptibility to glyphosate injury to perennial weeds is when they are actively growing. They are also most susceptible when they are not under stress.

A second technique for site preparation and establishment of wildflowers is the use of fumigation. Fumigants will kill most weeds and dormant weed seed except those with hard seed coats such as Carolina geranium, white clover and nutsedge. Fumigation is a temporary weed control method and new weed seed will germinate as they are introduced into the planting area. The advantage to fumigation is that wildflowers may become better established in the absence of weed competition. Research has also shown that fumigants can also result in increased plant size which can benefit the growth of wildflowers.

There are several fumigants available for use in wildflowers including methyl bromide, metham and dazomet. Methyl bromide is a gas and for large areas requires the use of specialized equipment and a licensed applicator. Metham (Vapam) is a water soluble liquid and is less active than methyl bromide but is easier to use. Dazomet (Basamid Granular) is a granular product that is most effective in cool soil temperatures. It generally remains in the soil for a longer period of time than other fumigants. To ensure the soil is safe for planting after any fumigation, a soil bioassay should be conducted. A bioassay is essential when dazomet is used due to the potential for prolonged soil activity. See AG-427 for additional fumigation information and a complete procedure for conducting a soil bioassay.

After a wildflower planting is established, there is no single approach or magic formula to manage encroaching weeds. The problem is further compounded by the fact that most wildflower plantings are a mix of species thereby reducing the range of herbicides that can be safely used for weed control. Many of the popular wildflowers are in the Compositae family as are some of the most troublesome weeds in North Carolina. Similar plants, such as those in the same family, generally have similar tolerance to selective herbicides. As a result, if the herbicide is safe for the wildflower, it will porbably have no effect in controlling closely related weeds. With a mix of wildflowers from various families, it is unlikely that one herbicide will be completely effective for weed control without damaging some wildflowers. Therefore, weed management programs must be a combination of several weed control techniques.

Competition. One method of weed control that is often overlooked is competition. Seedlings that emerge first are often able to capture more space and resources than later germinating species giving them a competitive edge over later germinating seed. Therefore, if wildflowers are planted in a properly prepared weed free site, they will be quicker to germinate than weed seed and may be able to suppress future weed growth. Early development of the wildflower canopy in the spring will also help suppress weed growth. In North Carolina, horseweed can be expected to encroach in the first two years based on successional changes. Horseweed is difficult to control in wildflowers because it is a fall germinating composite. Horseweed, however, can be suppressed with a good cover of fall wildflowers because it requires bare ground to germinate. Understanding weed and wildflower biology is essential in order to make maximum use of those characteristics for weed suppression.

Mowing. Most wildflowers in North Carolina are maintained with an annual mowing. Mowing prevents development of pines and hardwood trees and arrests the successional development at the herbaceous plant stage. Mowing should be timed to meet three objectives: 1) to remove weeds before they develop viable seed; 2) to disperse wildflower seed for reseeding within the site, and 3) to remove dead plant material and improve the appearance of the planting. Mowing is an important weed management tool and timing is essential to maximize weed control and wildflower reseeding.

TURF BIOSTIMULANTS AND SOD PRODUCTION

R. E. Schmidt[1]

Biostimulants refer to non-mineral substances that stimulate metabolic activity when applied to plants. They may be referred to as plant growth regulators that stimulate growth and include hormones (auxin, gibberellins, ethylene and cytokinins), vitamins, organic acids, chelating, agents, enzymes, coenzymes, and triazole compounds. To date, our main research has dealt with the cytokinin and triazole fungicide compounds.

Cytokinins

Initially we evaluate the effects of a synthetic cytokin, benzylaminopurine (BA) on turfgrass performance. More recently we have been investigating the influence of seaweed concentrate on plant growth. Seaweed naturally contains high levels of cytokinins, but it also contains other growth regulating materials, such as auxins and abscisic acid, therefore performing better in stimulating turfgrass growth than the synthetic cytokinin.

Seaweed has been known to stimulate plant growth for centuries. However, it was not until the early 1970's that the growth enhancement of plants correlated with seaweed was attributed to cytokinins. Since then cytokinins have been associated with delaying leaf senescence, enhancement of bud initiation and promoting, plant growth. The first reported turfgrass experiment (in the mid 1980's) involving cytokinins showed that BA-treated leaves of Big bluestem contain high chlorophyll content.

Although applications of cytokinins have been shown to inhibit root formation, it appears a small amount of cytokinin is necessary for the formation of rooting. Evidently for root initiation, a low cytokinin level and a favorable auxin:cytokinin ratio is essential.

Positive results, including enhanced rooting, associated with exogenous synthetic cytokinin applications, may have resulted with sufficient endogenous auxin or auxin-like compounds to create a favorable auxin:cytokin ratio. This balance appears to be easier to obtain when seaweed extract is the source of cytokinin. Seaweed not only contains cytokinins, but also exhibits gibberellin, abscisic acid, and auxin-like activity.

Triazole Fungicide

In 1972 it was demonstrated that triazole fungicides controlled fungi by inhibiting sterol synthesis. In 1983 it was shown that triazole compounds caused a blockage of C-14 dimethylation when applied to plants. The C-14 dimethylation leads to precursors associated with the biosynthesis of cytokinins, abscisic acid and gibberellic acid. Application of triazole compounds that inhibit sterol biosynthesis also cause an increase to abscisic acid synthesis. Abscisic acid causes an increase in water content of plants. This aspect could have an important impact on the water management of the plant.

It was shown in 1983 that Kentucky bluegrass shoot and root growth was reduced when triazole compounds were applied at high rates. There is strong evidence that triazole compounds move only toward the leaf tips. Therefore, at low rates, these compounds cause growth reduction of the foliage but not roots. This is because the growing points of the foliage is at the base of the sheath, whereas the growing points of the roots are at the root tip. The reduction of top growth and increased plant water retention of triazole-treated plants appears to contribute to an enhanced root development.

Virginia Tech Unpublished Biostimulant Research on Turfgrass

Unpublished results have shown that applications of seaweed extracts, as well as triazole compounds to turfgrass, has enhanced plant water retention, salt tolerance, drought tolerance and shifted fatty acids within the plant to more unsaturation. Also, preemergence herbicide injury was reduced when the turfgrass was previously treated with biostimulants.

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Recent Sod Studies-Kentucky Bluegrass

Biostimulants applied at light or moderate rates to Kentucky bluegrass seedlings in November 1990 and again in April 1992 increased the sod strength from 29% for fortified seaweed extract to 43 % for triazole-treated turf when measured in June 1992. Root development of the sod transplanted in June did not differ significantly between treatments. However, rootings of sod transplanted in August showed an increase of 30% for seaweed-treated sod and up to 75 % for triazole-treated sod. Sod strength measured at that time was enhanced only with the triazole treatments (up to 30%).

In a separate but similar test in which heavy biostimulant applications were only applied in November 1990, rooting of sod transplanted in September 1991 (ten months later) was enhanced up to 107% with a triazole treatment and up to 82% with a fortified seaweed extract. Sod strength was not significantly effected with these biostimulant treatments a few months after treatment.

An additional light application of biostimulants in April actually reduced the Kentucky bluegrass rooting of the September-transplanted sod when compared to the sod treated only in the fall. However, addition of the spring application did tend to increase the sod strength.

Tall Fescue Sod

Rebel II tall fescue treated with low to moderate rates of triazole in November and April enhanced sod strength by 35 to 71 % when measured the following July. In August, ten months after the biostimulant treatments, the sod strength was increased by 47 to 98% with triazole application.

In an experiment where heavy rates of biostimulants were applied in November to seedling tall fescue, sod strength was enhanced in the summer of the following, year. A triazole treatment increased sod strength by 55 and 92 % when measured in July and August. Sod treated with a seaweed extract increased sod strength by 63 and 92% in July and August, respectively.

When an additional light application of biostimulant was made in April, only the triazole-treated sod showed an increase in sod strength when compared to the control the following summer. Sod strength measurements were generally higher in August (ten months after treatment) than in June. In June the highest tall fescue sod strength of treated turf was 33% stronger than the control. The same treatment had 49% stronger sod in August. Treated sod with the best sod strength when measured in August was 71 % stronger than the control. However, this treatment produced only 15% larger sod strength than the control when measured previously in June.

The 1991 sod study results indicate that the enhancement of Kentucky bluegrass sod strength is best obtained when the biostimulants are applied in the fall. Enhanced post transplant root development was best obtained with spring biostimulant applications.

When heavy biostimulant rates are applied in the fall, additional moderate rates in the spring cause a reduction in post-transplant rooting and sod strength. It appears best to apply the biostimulants at moderate rates in the fall and the spring to obtain optimum sod strength and post-transplant rooting.

VEGETATION OF PROBLEM SITES

Dr. C. Bruce Williams[1]

What is a problem site?

A problem site to the Corp of Engineers, Department of Environmental Management, or Soil Conservation Service is often described as one that threatens the stability of environment on or around that site. However, the definition of a problem site to the landscape contractor, golf course superintendent, or landscaper is often quite different. A problem site to these individuals is more subjective and will depend upon the clients goals and their standards of quality and environmental consciousness. In my work I most commonly see the later types of problem sites and those are the ones I will primarily address.

I routinely see "problem sites" due to poor water or air drainage, excessive shade, soil compaction, poor soil fertility, or salt spray. However in most every case, sufficient ground vegetation is present and only rarely does the site pose an environmental liability as defined by regulatory agencies. For the sake of simplicity, I usually try to classify a problem site as one that is temporary or chronic.

A temporary problem site is one that has been disturbed or is aesthetically unpleasing to the turf manager and will recuperate fully with simple corrective agronomic or horticultural practice. Partially shaded sites, less than optimum soil pH, poor air drainage, soil compaction, and pest damage will often cause a temporary problem site. Untreated temporary problem sites can escalate into more severe problems or even develop into chronic problem sites. In general, temporary problem sites can most often be treated with minimum resources and technology.

Chronic problem sites are due to physical, chemical, or environmental conditions that because of natural, economic or social barriers are beyond the control of the turf manager. Poor soil drainage, low water or nutrient holding capacity of the soil, severe water or wind erosion, uncontrollable pest problems, excessive shade, and many others are just a few examples of the kinds of chronic problems that affect our landscapes. Chronic problem sites in most cases can be corrected provided sufficient resources and technology are available.

Finding a solution to your problem site is simply a process that involves information collection, planning, action, reaction(evaluation), and if necessary, repetition. Solutions to vegetating problem sites often requires a great deal of knowledge, a lot of work, and a little luck. Use teamwork and an interdisciplinary approach in researching the alternatives available to you.

First, identify the primary factors that are most limiting to plant growth or turf quality. Take time to visually evaluate the site for slope, soil characteristics, existing vegetation, and any other factors that may contribute to the problem. The next step is to take soil samples. Results from soil samples combined with the physical and environmental characteristics of the site should prove to be an excellent insight into the problem.

Construct a plan of action to take based upon the information collected. Implement your plan of action. React to the results of your action by recording the progress of your corrective procedures. For example, corrective applications of soil amendments will not always correct the problem. If the solutions you attempt fail, repeat the entire process over.

Problem sites come in all sizes.

One of the larger problem sites I have worked with in the past year was a reclaimed city solid waste dump. The 100 acre+ Fleminton Waste site in New Hanover county had been covered over with soil since 1985 or before. Native vegetation was sparse, soil was infertile, acidic, and extremely sandy. Privately owned and undeveloped native sand dunes adjoin the site. Numerous soil samples were taken and sent to the NCDA Soils Laboratory for analysis. Dolomitic limestone and 500 pounds of 10-10-10 were incorporated per acre as recommended by NCDA soil tests. A

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mixture of 50 pounds of ryegrass (*Lolium multiflorum*), 25 pounds of bahiagrass (*Paspalum notatum*), and 5 pounds of centipedegrass (*Eremochloa ophiuroides*) were broadcast seeded and lightly incorporated in mid-April. Wheat straw mulch was distributed at the rate of 3 bales per 1,000 square feet on slopes.

Weather conditions after planting were poor. A very dry spring was proceeded by a very wet summer. Coverage of the area was nearly 100 percent by September 1 of that year. Approximately 50% of the coverage was due to unplanted native plant or weed species that responded to the added fertility of the soil. The bahiagrass component was well established though greater plant density would have been desirable. Centipedegrass was remarkably well established in some areas.

Shade from trees often creates problem sites for landscape designers and maintenance contractors. For cool season grasses, red fescue is one of the most shade tolerant species. Warm season grasses with shade tolerance include St. Augustinegrass (*Stenotaphrum secundatum*), centipedegrass, and zoysiagrass (*Zoysia spp*).

However, the best solution to shade problems is to remove the source of the shade. However, removing trees from the landscape is sometimes nearly impossible due to social, political, or aesthetic reasons. Pruning low hanging limbs is an alternative to tree removal but usually this solution is only temporary. Several solutions I have seen work for vegetating a heavily shaded site have included installation of an irrigation system(since shade and tree roots usually come in the same package), utilizing ground covers other than turfgrass, and the use of organic mulches. Numerous shade tolerant deciduous and evergreen ground covers are available. A visit to the NCSU Arboretum or a local botanical garden should help in the selection of a ground cover suitable for your shady site.

Wet sites are often difficult to keep vegetated during certain times of the year. An underground drainage field is the most logical solution to poorly drained wet sites. other alternatives should include species that prefer or tolerate wet sites. carpetgrass (*Axonopus affines*) is a warm season grass that tends to be very tolerant of wet sites but has poor cold tolerance. Rough bluegrass (*Poa trivialis*) is a cool season grass with the ability to tolerate wet soils. Ornamental aquatic plants are being used success-fully in home landscapes and golf courses and should not be ignored as a solution to wet sites.

Seashore sites pose quite a challenge. American Beachgrass (*Ammophila brevigulata*) or other salt tolerant bunch-grasses are routinely used to prevent severe erosion on ocean sites due to wind or water erosion. A number of other native and introduced woody plants are available for use behind dune areas.

Ornamental grasses are gaining increasing popularity in the landscape. Many ornamental grasses can be used with great success in difficult to irrigate areas or extremely wet areas. Weeping Lovegrass (*Eragrostis curvula*) is widely used with great success on arid, sandy infertile sites. However numerous other ornamental grasses are available in the nursery trade that will fit just about any site.

The major point to remember in finding the right solution to your problem site is to considered all the options available to you. Use the education and technical resources available to you and keep an open mind about all the alternatives you discover. I have included a list of publications I find helpful in solving the problems I encounter. Most of these publications, with a few exceptions, can be obtained from your county cooperative extension service.

Selected Publications for Problem Site Solutions

1. **Building and Stabilizing Coastal Dunes with Vegetation**. 1982; S.W. Broome, E.D. Seneca, and W.W. Woodhouse, UNC Sea Grant College Publication UNC-SG-82-05.

2. **Carolina Lawns**. 1992; Arthur Bruneau et al., North Carolina Cooperative Extension Service.

3. **Ground Covers for North Carolina**. 1988; Kim Powell, North Carolina Agricultural Extension Service Publication AG-75.

4. **North Carolina Landscape Contractors Manual**. Current Edition. M.A. Powell and T.E. Bilderback, NC Landscape Contractors'

Registration Board, Post Office Box 25838, Raleigh, NC 27611.

5. **Ornamental Grasses and Grasslike Plants**. 1990; A. J. Oakes, VanNostrand Reinhold, New York.

6. **Planting Marsh Grasses for Erosion Control**. 1981, UNC Sea Grant Publication 81-09.

7. **Technical Guide** (Section IV). USDA-Soil Conservation Service; *Critical Area Planting* (Section 342-I to VI), 1986; available through county Soil Conservation Service representatives.

8. **Wildflowers on North Carolina Roadsides**. 1898. NC Department of Transportation, Roadside Environmental Unit, Raleigh, NC 27611.

The Turfgrass Council of North Carolina

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- Encourage student interests in turf.
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