PROCEEDINGS OF THE 28TH ANNUAL NORTH CAROLINA TURFGRASS CONFERENCE

Volume XI

January 10-12, 1990

Raleigh, North Carolina

Sponsored by

Turgrass Council of North Carolina

North Carolina State University

North Carolina Agricultural Extension Service

PREFACE

Proceedings of the 28th Annual North Carolina Turfgrass Conference are being provided as a permanent reference to those who attended the Conference. The 1990 Conference was held at the Raleigh Civic and Convention Center, on January 10, 11 and 12. Sessions on general turf topics and concurrent sessions for golf course, lawn care, roadside and low maintenance turf, landscape maintenance and athletic field topics were scheduled. Workshops on Developing a Chemical Budget for Lawn Care, Identification and Control of Weeds in Cool Season Grasses, Nitrogen Sources for Turfgrasses, Insect and Disease Identification and Management, Aquatic Weed Identification and Management, and Calibration of Fertilizer and Pesticide Equipment were held the afternoon of January 10. The trade show used 40,000 square feet of space. Approximately 1800 people attended the Conference.

Special thanks are extended to everyone who helped make this Conference successful. Each speaker is to be commended for their excellent presentation. The following committee members contributed to the success of the Conference.

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The Turfgrass Conference was sponsored by The Turfgrass Council of N.C., INC, N.C. State University, The N.C. Agricultural Extension Service and The Triangle Turfgrass Association.

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Printed June, 1990

The 1990 North Carolina Turfgrass Conference will be held in Charlotte, NC, on January 2, 3 and 4.

Additional copies of the Proceedings are available at $5.00 each from Dr. L. T. Lucas, Department of Plant Pathology, Box 7616, North Carolina State University, Raleigh, NC 27695-7616. Make checks payable to the Turfgrass Council of North Carolina.

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Water - An Endangered Heritage

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Importance of Water

Water is something everyone seems to take for granted, and one becomes concerned about it only during times of scarcity. Yet, it is the most abundant chemical compound in the world. It is a major constituent of all living organisms without which life would cease to be. It is used in most agricultural and industrial processes, but most importantly, there is no technological substitution for water, even in this day and age of high technology!

Based on cultural system and management involved, turfgrasses contain 75 to 85% water. It differs with turfgrass cultivar, weather conditions, time of day, season of the year, age and kind of grass tissue, and management level. Water is important in several areas of plant growth: photosynthesis, the process in which water and carbon dioxide are converted into plant foods; nutrition as a solvent in which nutrients dissolve; transport medium for nutrients and plant foods within the plant; catalyst in metabolic processes within cells; cell turgidity for better wear tolerance; air conditioner by cooling the plant through transpiration; and microbiological processes in the soil medium.

Evapotranspiration is the total water lost from the soil (evaporation) and turfgrass canopy (transpiration). Unfortunately, maximum plant growth is correlated with maximum transpiration. Hence conversion of water into plant dry matter is very inefficient. Classical botany books report that it takes 1000 pounds of water (approximately 120 gallons) for a plant to produce one pound of dry matter. Industrial needs also have great demands for water, requiring 200 gallons to produce a pound of rubber, 30 gallons to produce a pound of paper, and 18 gallons to produce a pound of steel (4). Furthermore, agricultural and industrial demands on water are heavily impacted by human needs, which in many cases are very wasteful. On the average, we use 25 gallons of water for a shower, 16 gallons to run the dishwater, 3 gallons to flush the toilet, but only 5 to 6 pints for body functions (3). A person may survive one week without food, but only three days without water!

Water Crisis

Most people are unaware that we have a water crisis today involving both water quality and quantity (3, 4, 6, 7, 8, 9). This is because of increasing demands on a fixed or constant supply. Worse yet, we have contaminated and we continue to pollute our present resources. By overpumping underground waters, we cause land settlement due to lower ground water tables; salt water intrudes into fresh water supplies; atmospheric losses of irrigation water increase, which redistributes water throughout the world through the hydrological cycle; and salt content of our agricultural soils increases. F. E. Moss (6) states that "for the next generation of Americans, water - its competing uses and conflicts that arise out of those uses -may be <u>the</u> most critical national problem." Because the amount of available water in the world is fixed and water needs multiply with increased population and industrial growth, how may we use it wisely, share it fairly, and still maintain water quality? The U.S. Water Resource Council (7) predicts that our 1980 water needs for municipal, industrial, and agricultural needs of 443 billion gallons of water per day (bgd) will double to 805 bgd by the year 2000, and triple to 1,386 bgd by the year 2020! Wollman and Bonem (8) also project a gloomy outlook for water:

1. Projected population growth into the future <u>demands</u> new technologies for using limited water resources.

2. Our short range goals should be to expanded capital to cover increased operating costs for recycling waste water.

3. Southwestern United States will continue to have a quantitative water shortage, but other states in the US will share their fate.

4. On a national scale, QUALITY is more important than QUANTITY.

Average annual precipitation in the United States generally varies from 30 to 60 inches per year in the humid East to 10 to 30 inches in the dry West. Attempts have been made in the past to increase natural precipitation from the atmosphere by "cloud seeding." Limited success was achieved only in mountainous areas and was quite costly. Kellogg and Schware (5) estimate that if we continue to increase use of fossil fuels at the present rate of 4% per year, the estimated mean global temperature will increase 2°C by the year 2000 and 7°C by the year 2050. This may not seem like a significant change, but it would have a profound influence on the North American continent, which would become significantly drier than it is today. This, of course, would magnify our needs for water in the future.

Water quality has changed significantly over the past years. Fossil fuels have influenced the distribution of acid rain throughout the United States and Canada. Overpumping has decreased underground water supplies in the U.S., leading to increased salinity of irrigation water. Surface waters have been polluted by heavy municipal, industrial, and agricultural uses. This ultimately has increased pollution of our underground water resources.

Water Resources

Oceans cover 70% of the earth's surface and contain 97% of its water, which of course is quite saline (9). This is a result of the hydrological cycle mentioned earlier. Throughout the world, water evaporates from soil and water surfaces into the atmosphere as a vapor, where it condenses as rain or snow which falls back to earth as precipitation. Free water then percolates through the soil, picks up dissolved minerals, and carries them back to the ocean by means of streams and rivers. This cycle continues ad infinitum, and this is why the oceans of the world are saline today. Only 3% of the earth's water supply is fresh or nonsaline. Of this 3% fresh water, 75% is trapped as ice and snow in polar ice caps and glaciers. Only 25% is found in rivers, lakes, and groundwater. The 25% is further broken down to only 1.2% surface water with the remaining 98.8% as groundwater. The ocean is currently being used as a limited water source whereby processes such as reverse osmosis and desalination are removing salinity but at a costly capital investment (3). Present day water resources involve wells, rivers and streams, and effluent. Well water was once considered to be a relatively constant source of stable, good quality water free of toxic materials and pest problems. Overpumping and ground water contamination have caused serious environmental concerns with this water source. Rivers and streams are also polluted because of surface runoff. Effluent, which I feel is truly "liquid gold" for the turfgrass industry, may be our salvation.

Recycled Effluent Water

Increased population goes hand in hand with increased waste. It is a biological fact that no higher organism can live in its own waste. We have polluted the air we breathe and the water we drink. On the average, each person produces 70 to 100 gallons of waste water and 0.25 pounds of sewage sludge daily (1, 2). Thus 400 gallons of polluted water are used to transport one pound of organic matter to the nearest sewage treatment plant. In the past, waste water was dumped into the nearest stream, river, or ocean. Government regulations no longer permit this. Water recycling will have to become the rule rather than the exception, and turf would be a NATURAL for recycling effluent water. Nutrients it contains could be used for turfgrass growth. Turf is a perennial ground cover which grows most of the year, in contrast to annual agronomic or horticultural crops. Turf has a high water requirement. Perhaps, most importantly, turf is an urban commodity which is utilized close to the source of effluent supply. Wastewater is used on a turf ground cover for plant uptake, evapotranspiration into the atmosphere, and percolation into the ground where it is filtered and then purified by soil microbes. Thus, benefits of wastewater irrigation are several:

1. Inexpensive source of water,
2. Save potable water for other purposes,
3. Urban greenbelt areas for recreation,
4. Economic returns on crop sales,
5. Positive alternative to advanced wastewater treatment and surface water discharge.

Depending on the degree of wastewater treatment and availability, many states are in fact requiring the use of recycled water for turf irrigation instead of potable water.

Grey Water

Grey water is a relatively new idea being incorporated into new housing developments. Average household water use is composed of 40% for the toilet, 30% for bath and shower, 15% for laundry, 10% for kitchen, and 5% for other purposes (3). The grey water concept isolates the toilet from other used water in that only this source of waste water with its organic matter is connected to sewage lines for transportation to a sewage treatment plant where it undergoes normal processing. Thus, processing at the treatment plant is reduced 60% because the remaining sources of water are collected, treated, and recycled at the home. Grey water is used for washing automobiles, watering landscapes, etc. Also, this water may be recycled back to the bathroom where it can be used in the toilet to further reduce our demands on potable water.

The Future

The 1972 Federal Water Pollution Control Act amendments set a national goal that discharge of pollutants into navigable waters be eliminated by 1985. We made a lot of progress to date, but we still have a long way to go. Obviously a master plan involving federal, state, and local water planning groups is needed to analyze our existing and future needs. All water related industries must be protected. During times of water shortages, turf facilities are the first to be restricted. Water priorities must be set based on essential, critical needs which are fair to all concerned. Water is one of our most precious heritages. Be careful how you use it.

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DO TURFGRASS PESTICIDES THREATEN THE ENVIRONMENT ?

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In order to understand the movement of pesticides after application to turfgrass areas, one must first understand the nature and composition of a turfgrass community. Any analysis of the potential for a pesticide to leach to groundwater must take into account the amount of applied material reaching the soil surface and the amount which in fact moves down through the soil past the root system. Thus, plant density, rooting, and thatch development have a significant effect on leaching potential.

Following seeding, turfgrass plants have a great capacity to produce additional plants from the one primary plant which develops from the seed. This process of tillering, as well as rhizome or stolon production, enables a turfgrass area to maintain and actually increase its density over a period of years despite the fact that existing plants are maturing, senescing, and dying due to environmental stresses and pests. Although we think of turfgrass as being perennial in nature, individual plants are not truly perennial and seldom live more than about one year. The turf stand as a whole is perennial only because of its ability to continuously produce additional plants which grow and mature to take the place of those which are dying. Thus, turfgrass areas can attain plant densities approaching 2000 - 4000 plants per square foot, depending upon species and conditions. This dense soil cover of plants is capable of intercepting and significantly reducing the amount of applied pesticide available to reach the soil surface and potentially leach.

Each of the several thousand plants growing per square foot of turf develops a root system to provide for water and nutrient uptake. As with shoot development and tillering, the roots of turfgrasses are not long lived perennials and must be replaced on a regular basis in order to maintain their function. Thus, in a period of one to two years there exists an extensive and well developed network of roots underlying healthy turfgrass areas. Root systems underlying bentgrass and Kentucky bluegrass turf have been observed to reach maximum depths of 12 and 48 inches, respectively, with a majority of the root system occurring within the top four to six inches of soil. While root development will vary with soil texture, mowing height, fertility, etc., these estimates provide an appreciation for the extensive nature of a typical turfgrass root system. Turfgrass root systems are quite extensive and fibrous, and are capable of adsorbing and absorbing applied pesticides which might penetrate the canopy and thatch and reach roots. Indeed, numerous pesticides are formulated as systemic materials designed to be absorbed by plant roots. The prolific rooting of healthy turf helps to reduce the vertical movement of applied pesticides.

In a vigorously growing turf environment such as a golf course, the rate of plant tissue accumulation often exceeds the rate of decay resulting in the development of thatch. Thatch is defined as a layer of living and dead plant material which accumulates between the zone of green vegetation and the soil. A moderate thatch layer is useful in tying up pesticide residues and preventing their leaching in soil. Also, the eventual decay of leaves, stems, roots, and thatch increases the organic matter content of underlying soil. This increase in soil organic matter may aid in binding pesticides and retarding their movement to groundwater.

In addition to the tendency of the turf system itself to adsorb pesticides and limit their vertical movement, other processes act to degrade or adsorb pesticides applied to turf and thus reduce their potential to leach. Depending upon the compound applied, avenues of dissipation include: gaseous losses (volatilization), photodegradation by ultraviolet light, microbial decay, hydrolysis (breakdown in water), conversion to other compounds, and adsorption to soil in unavailable forms.

Concerns about possible adverse effects of turfgrass pesticides on the environment generally focus on potential pesticide movement in runoff, or groundwater contamination. Several research studies have demonstrated that a well maintained, dense turf area can reduce runoff to near zero. This is due in large part to the fact that a turfgrass area has tremendous potential to absorb precipitation. It has been estimated that a 150 acre golf course has the capacity to absorb 12 million gallons of water during a heavy (3 inch) rainstorm. The velocity of overland flow of water across a dense turfgrass stand is sufficiently slow that, under most conditions, the vast majority of water will infiltrate into the turf/thatch/soil profile before it can move horizontally from a site as runoff.

Studies conducted in Rhode Island have revealed that during a two year period overland runoff from lawn type turf (3% slope) occurred on only two occasions. Both runoff events resulted from unusual climatic conditions. In one case rainfall fell on snow covered frozen ground, and in the other case extremely wet conditions preceded a five inch rainstorm which generated runoff. In the latter case, although a total of 10 inches of rain fell within one week, depth of runoff was less than 1/13 inch. Work in Pennsylvania determined that irrigation applied at a rate of six inches per hour was necessary to cause measurable runoff from sodded slopes of 9 - 14% overlying a clay soil. Runoff due to natural rainfall did not occur during the study (1985 - 1988). In many areas of the northeastern United States, storms generating rainfall of even four inches can be expected to occur only once every five years. Because turfed areas have a great capacity to absorb precipitation and prevent runoff, runoff from turf would not be expected to routinely travel onto adjacent non-target areas.

Research concerning the effect of pesticide application on groundwater underlying turf areas has increased substantially within the past five years. Most of this work has focused on the fate of herbicides and insecticides. The fact that these materials are in many cases intended to reach soil and are more persistent than most fungicides makes them a greater concern for leaching than materials which are targeted for aboveground pests.

Work in Ohio by Niemczyk and associates has consistently shown that turfgrass insecticides normally penetrate no deeper than 1 - 1.5 inches into the soil profile. When commonly used turfgrass insecticides including bendiocarb, chlorpyrifos, ethoprop, isazofos, and isofenphos were applied to a golf course fairway, 98 - 99% of the residue remained in the thatch layer rather than leaching into the soil below (as determined one to two weeks after treatment). Residues in the upper inch of soil never exceeded 0.8 ppm during the 34 week sampling period. Indeed, one of the factors hampering soil inhabiting insect control is the inability of turf insecticides to penetrate below the first few centimeters of the soil profile.

Research evaluating the vertical mobility of preemergent herbicides applied to turfgrass has recently been reported in Ohio by Krause and Niemczyk. When applied to thatched turf, 78 to 100% of recovered residues of pendimethalin, bensulide, and oxadiazon were found in the thatch layer. When applied to thatch free turf, 82 to 99% of recovered residues of those herbicides were located in the upper inch of soil. Other work evaluating the preemergence herbicide pendimethalin has shown it to be relatively immobile and not susceptible to leaching.

The mobility of the broadleaf herbicides 2,4-D and dicamba has been evaluated by Gold et al. following application to Kentucky bluegrass growing on a sandy loam soil. Both herbicides were applied at standard rates (2,4-D: 1.0 lb./acre; dicamba:0.09 lb./acre) either during June alone or three times yearly during April, July, and September. In addition, duplicate treatments were overwatered by applying 1/2 inch of irrigation three times weekly regardless of rainfall. During the two year study, 2,4-D and dicamba concentrations were less than 1 ppb in 80% and 91%, respectively, of a total of more than 350 samples. No increase in soil concentrations were detected during the second year, indicating that degradation of both herbicides was sufficient to prevent accumulation. Average concentrations of 2,4-D ranged from 0.55 - 0.87 ppb while dicamba averaged 0.26 - 0.55 ppb. Federal drinking water standards for 2,4-D and dicamba are 100 ppb and 12.5 ppb, respectively. These researchers stated that the thatch/soil zone underlying Kentucky bluegrass creates an aerobic zone high in organic matter which enhances microbial degradation and adsorption of the herbicides. They concluded that, "Given the current water quality standards, routine applications of 2,4-D and dicamba to home lawns do not appear to threaten groundwater quality".

Evidence concerning the immobility of turfgrass fungicides and herbicides has also come from recent groundwater sampling studies on Cape Cod Massachusetts golf courses. Four Cape Cod courses were chosen for study because they represented a 'worst case scenario' for leaching of pesticides into groundwater. All four courses were located on highly permeable, sandy soils, were more than 30 years old, and had a history of high pesticide use. In addition, sampling wells were located where the depth to groundwater averaged 28.5 feet and was as shallow as 5.3 feet below the surface in one case. Cohen et al. reported that no currently registered turfgrass pesticides were detected in toxicologically significant concentrations. In addition, they concluded that "Use of turfgrass pesticides by the four golf courses with vulnerable hydrogeology was found to have minimal impact on groundwater quality".

Conclusions

The potential environmental hazard associated with most turfgrass pesticides appears to be minimal since the pesticides most frequently used on turf are not generally highly mobile, highly toxic, or very persistent. Those herbicides and insecticides which are intended to reach soil are not usually applied more than once or twice per year. In addition, turfgrass pesticides are normally applied in extremely dilute solutions rather than in concentrated forms. Processes such as volatilization, photodegradation, hydrolysis, and microbial decay often act to break down existing residues. And finally, the dense canopy of a well maintained turf and highly adsorptive thatch minimize runoff and potential leaching.

The pesticide binding capacity of a turf is strongly related to plant density, thatch development, and rooting which are improved through proper fertilization and pest management. Rather than threatening environmental quality, improved turf quality achieved through judicious use of pesticides can protect the quality of water emanating from a turf area compared to a poorly maintained area or other land uses.

While the evidence is strong that use of turfgrass pesticides does not appear to threaten groundwater, one should not take this as a license to apply pesticides excessively or without due caution. Cultural and biological approaches to pest control need to be more fully integrated into management plans with an eye toward reducing pesticide application. There is little doubt that, in numerous cases, pesticide use could be reduced substantially by employing primarily curative spray programs for non-lethal pest problems and by increased adherence to integrated pest management practices.

MAINTAINING QUALITY TURFGRASS AREAS WITH LESS PESTICIDES

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Many years ago, "state of the art" turfgrass management included liberal use of pesticides for pest control. In fact, when pesticides were somewhat new on the scene, reliance upon pesticides was viewed as desirable and evidence that the turf manager was willing to embrace new technology. My how things have changed. Today's "state of the art" turf management program is turning away from routine pesticide use toward a minimal use approach. In the northeast, many new golf courses are being required to develop and adhere to an Integrated Pest Management (IPM) philosophy as a precondition to approval.

IPM employs a multiple system approach to keep pest damage below an aesthetic threshold. Rather than relying heavily upon pesticide use for weed, disease, and insect control, IPM dictates that preventative measures such as proper cultural methods and biological controls be used whenever possible. Chemical control is reserved as a tactic to use when other methods have proven unsatisfactory. IPM does not imply that no chemicals will be used. IPM is an interlocking network of good maintenance practices which provides a healthy turf stand, thus minimizing the need for pesticide use. IPM methods combine cultural practices, biological controls, and chemicals usage as needed.

Cultural Practices

Use sound cultural management practices . A healthy turf stand will be less prone to pest invasion than an area suffering from improper management. When establishing a new turf area, always choose species with resistance to local problems if possible. Sound cultural practices include proper mowing, fertilization, irrigation, and cultivation. Mow as high as possible while retaining the usefulness of the area. The higher the height of cut, the more extensive and deep the root system will be, providing the turf with the ability to withstand stress periods. Never remove more than one third of the blade in any one mowing. Avoid fertilizer applications during stress periods and fertilize at rates which avoid succulent turf or excess growth surges. Irrigate deeply, only as needed, to promote deep rooting. Avoid lengthening the number of hours of leaf wetness by irrigating after the dew has fallen and before it has evaporated. Cultivation (aerification, vertical mowing, etc) while beneficial at times should be avoided during stress periods, to avoid placing an additional stress on the turf and increasing the likelyhood of pest damage.

Weeds are often a common pest problem in turf, especially with moderate to low management levels. A weed may be defined as a plant out of place. Thus, a plant may be a weed in one situation and not a weed in another. Kentucky bluegrass in a home lawn would most likely not be considered a weed, but Kentucky bluegrass growing in a bentgrass fairway would be considered a weed. Many weeds in turfgrass are widely distributed with no real pattern to where they might occur. Crabgrass, for example, is a ubiquitous problem weed. Certain weeds, however, often occur in large amounts only when there is a specific condition troubling the turf area. Goosegrass, knotweed, and annual bluegrass are often indicators of excessive compaction. Ground ivy often indicates excessive shade. Red sorrel indicates acid soils. Clover often thrives in soils low in nitrogen and high in potassium while yarrow grows in dry soils with low fertility. While these weeds might be controlled with herbicide applications, the improvement in turf quality will only be temporary unless the underlying management problem favoring the weed is remedied. IPM dictates that the turf manager treat the underlying cause of the problem rather than simply spray a herbicide. Remember, the best defense against weeds is a thick, aggressive turf stand.

In addition to weed problems, turf areas are sometimes plagued by an excessive accumulation of thatch. Thatch is a layer of living and dead plant material (rhizomes, stolons, roots, etc.) which accumulates between the green vegetation and the soil. A moderate thatch layer improves wear tolerance, insulates the crowns against temperature extremes and improves resiliency. Excessive thatch, however, restricts air, water and root movement and provides an ideal environment for pest survival. Many disease causing pathogens and insects exist in the thatch until environmental conditions favoring attack of the grass become prevalent, at which point they may cause damage. Thatch also binds pesticides and has been reported to reduce their activity. Thus, not only does thatch sometimes favor pest attack, but in the case of soil insect control it may also inhibit effective control when a pesticide application is made.

<u>Biological Controls</u>

When considering IPM, many people first think of utilizing living organisms which can attack and kill pest organisms, thus eliminating the need for a pesticide. These organisms are often referred to as a group as biological controls. Biological control for insects has progressed to a greater extent than for weed or disease organisms. In practical terms, however, biological control of turf insects is at this point primarily limited to control of Japanese beetles. Products currently on the market include milky spore disease, (*Bacillus popillae*) for control of the grubs, and traps with attractants for control of the adults. Milky spore is applied in a grid pattern over a small area, relying on wildlife, the grubs themselves, and other mechanical means to spread throughout the population. Milky spore can be very effective for spot control in areas where a heavy population of grubs exists. Milky spore may prove too slow, however, to be effective over a large area, or in areas where the grub population is small.

Parasitic nematodes are an additional type of biological control which have shown promise for control of soil inhabiting insects. These nematodes are sprayable and, unlike plant pathogenic nematodes which harm turf, may be used to control insects without harming the desirable grasses. Research studies evaluating white grub control from nematodes has been variable with excellent results in some years and very poor control in others. More work is needed to determine which nematode species are most effective, which overwinter the best, how soil moisture effects control, and other similar factors.

A third biological control gaining increasing notoriety in turfgrass pest control are the endophytic fungi, or endophytes. Endophytic fungi are non-parasitic fungi (*Acremonium ssp.*) which reside in stem and sheath tissue of some turf species. These fungi exist intercellularly (between the cells) within the plant and deter surface feeding insects such as sod webworms, cutworms, armyworms, bluegrass billbug larvae and chinchbugs. The have no effect on root feeding insects such as grubs since the endophyte does not reside in root tissue. Endophytic cultivars of tall fescue, perennial ryegrass and fine fescue have been found and are available for purchase, however, no cultivars of Kentucky bluegrass or Creeping bentgrass have been found to contain the endophyte. If endophyte-containing seed is purchased the seed tag should certify a minimum of 80% viable endophyte. The seed should be planted within one year of purchase, since storage decreases the viability of the endophyte.

Chemical Usage

While biological controls exist for insect pests, they are not currently available to combat turf diseases. Nonetheless, an IPM philosophy may still be followed for disease control. IPM as it relates to disease management often means approaching disease control from a curative rather than preventative viewpoint. The vast majority of disease pathogens on turf are not extremely aggressive and do not cause lethal damage in a short time period. With the exception of pink snow mold (*Fusarium nivale*) and pythium (*Pythium ultimim, P. aphanidermatum*), most diseases can be effectively managed by waiting until one sees the disease symptoms before spraying. In today's anti-pesticide climate, applying a fungicide "just to be sure" will not sit well with most regulatory bodies.

An alternative to a preventative disease control approach is to determine by sampling if pathogen populations have reached a level which warrants fungicide application to prevent potentially severe disease damage. Diagnostic kits are currently available for pythium blight, brown patch and dollar spot which allow pathogen inoculum levels to be assessed before deciding to spray. For example, if conditions favor the development of pythium but pathogen levels are low one might be able to avoid a spray thus saving several thousand dollars. Also, one can monitor pathogen levels to determine if a previously applied fungicide is still working rather than simply applying every ten to 14 days.

In closing, it is important to note that IPM is a management philosophy which is here to stay and will likely increase in importance with time. While the concepts basic to IPM are not generally difficult, one must invest some time and thought to analyze a particular management program with an eye toward reducing pesticide use. This article is meant primarily to introduce some elementary concepts of IPM. For more detailed information, the following references should prove useful.

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ECOLOGICAL SIDE EFFECTS OF PESTICIDE AND FERTILIZER USE ON TURFGRASS

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Recent growth of the turfgrass industry has resulted in an increasing number of lawns, golf courses, and other turf areas being maintained with regular applications of pesticides and fertilizers. Pesticides are indispensable tools of the modern turf manager and there are many situations for which use of a pesticide will be required in order to maintain quality turf. Nevertheless, the unnecessary or excessive use of pesticides can sometimes have undesirable side effects on beneficial organisms and on important processes, such as thatch decomposition and natural regulation of pest populations. Research is underway to clarify how chemical applications affect these processes.

Numerous kinds of predators and parasites are abundant in turfgrass. In Kentucky, more than 30 species of spiders, 42 species of ground beetles (Carabidae), and 40 species of rove beetles (Staphylinidae) were represented in pitfall trap samples from urban turf sites (Cockfield and Potter 1985). These creatures may be important in maintaining pests at non-damaging levels. For example, in one field experiment (Cockfield and Potter 1984) we placed sod webworm eggs in untreated lawns and recorded their fate over time. Interestingly, turf-inhabiting predators consumed up to 75% of the eggs within 48 hours. Natural enemies that may help to reduce turf pest populations include parasitic wasps, nematodes, spiders, ants, and beetles.

Insecticides applied for the control of pests may also affect beneficial species. For example, one surface application of insecticide was found to reduce predator populations by 60% for as long as six weeks (Cockfield and Potter 1983). In another experiment, natural predation on sod webworm eggs was greatly reduced by an insecticide application (Cockfield and Potter 1984). Although there has been little research on this subject, a few studies do suggest that pest outbreaks on treated lawns are sometimes related to interference with natural control agents (Streu and Gingrich 1972, Reinert 1978, Potter 1982). Research is underway to identify insecticides that provide good control of pests with minimum impact on beneficial organisms.

Another important role that non-target invertebrates play in turfgrass involves decomposition of thatch. Thatch is a tightly intermingled layer of living and dead roots, stolons, and organic debris that accumulates between the soil surface and green vegetation in turfgrass. Problems associated with excessive thatch build-up include restricted penetration of fertilizers and insecticides, reduced water infiltration, and shallow root growth accompanied by increased vulnerability to heat and drought stress.

Excessive thatch results from an imbalance between production and decomposition of organic matter. Soil animals (other than microorganisms) that may contribute to decomposition include earthworms, mites, springtails, millipedes, and others. The main effect of these creatures is in breaking up organic matter and helping to incorporate it into the topsoil, where it can be further broken down by bacteria and fungi. Earthworms also aerify the soil and enrich it with their excreta.

Experiments with thatch pieces buried in mesh bags showed that thatch decomposition is much more rapid with earthworms present than without them. The earthworms pull down the organic matter into the soil, and mix soil into the thatch. Destruction of earthworms by pesticides results in slower thatch breakdown. After only 3 months underground, thatch pieces that were exposed to earthworms contained ca. 33% less organic matter and 33% more soil by weight than pieces from which earthworms were excluded (Potter et al. 1990). Turfgrass pesticides found to be particularly toxic to earthworms in our field tests include Sevin, Turcam, Mocap, and Benlate. Heavy use of ammonium nitrate fertilizer may also affect earthworms. Application of 5 lbs of nitrogen per 1000 sq. ft. per year for seven years resulted in a decline in soil pH (6.2 to 4.8), increased thatch accumulation, and 50% reduction in earthworm populations (Potter et al. 1985). Earthworms are intolerant of acidic soils (Satchell 1967, Edwards and Lofty 1977).

A four year experiment was conducted to study the side effects of a total high-maintenance lawn care program on the turfgrass system. Although changes in predators, herbivores, and decomposers were observed, the overall impact of the program was generally less severe than might be expected given the frequency of pesticide and fertilizer use (Arnold and Potter 1987).

In summary, the intent of this presentation is not to condemn chemical use on turf, but rather to provide "food for thought" for turf managers. There are clearly many situations for which the use of pesticides is essential for the maintenance of quality turf. However, pesticide applications, like human medicines, may have some side-effects, and these must be weighed against the overall benefits that the treatment provides. The accumulated evidence suggests that turfgrass is a complex system with many buffers. Understanding these interactions will make it easier to develop new products and turf management programs that get the job done with minimum disruption of the natural processes that are important to healthy turf. In general, it takes a better turf manager to use less pesticide.

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EVERYTHING YOU NEED TO KNOW ABOUT WHITE GRUBS

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White grubs are highly destructive pests of turfgrass in home lawns and golf courses. Following the philosophy that understanding one's enemy is the first step in defeating him, my graduate students and I have been investigating several aspects of white grub biology, including mating behavior, factors affecting distribution and severity of grub problems, damage thresholds, and use of milky disease to control species other than the Japanese beetle. Most of our research is with masked chafer and Japanese beetle grubs, but our findings are generally applicable to other grub species.

When masked chafer adults emerge in the early summer, they engage in interesting mating rituals. Females produce a powerful chemical sex attractant that is highly attractive to males. When solvent rinses of female beetles, or the females themselves, are put into traps, they can be used to lure males to traps. Research is underway to identify the attractant. Possible applications of this work include development of baits for mass trapping or for timing insecticide applications, or for assessing beetle and grub populations in a particular lawn or fairway for the purpose of control decisions.

Eggs of masked chafers and Japanese beetles absorb water from the soil during their development. Our research has shown that the eggs are unable to survive in soils containing less than 11% moisture. Newly hatched grubs are also very vulnerable to heat and drought. Female beetles can assess soil moisture levels, and are attracted to moist or irrigated areas for egg-laying. Grub populations in non-irrigated turf may suffer high mortality in drought years.

Soil moisture also affects the severity of grub damage once their feeding begins. Our work has shown that the impact of feeding on quality and yield of Kentucky bluegrass is much greater on non-irrigated than on well-watered turf. This points to an important interaction between grub injury and drought stress. Watering tends to help turf to withstand grub injury. The severity of grub problems in a particular year appears to be related to rainfall patterns and the degree of drought stress in the late summer.

Milky disease of white grubs is caused by certain spore-forming bacteria. When the spores are ingested by the feeding grub, the bacteria invade the body cavity, turning the blood milky-white and eventually killing the grub. Milky disease is an environmentally safe and may be a long-lasting alternative to chemical pesticides in some situations. However, commercial milky spore formulations are specific for the Japanese beetle, and will not kill grubs of other species. Moreover, our research suggests that infectivity of commercial formulations is relatively low in field situations, so that the time required to attain economic control may be prohibitive.

Field populations of masked chafer grubs that were naturally infected with milky disease were found in Kentucky. The strain of bacteria infecting these grubs is distinct from that which infests Japanese beetle grubs. Research was undertaken to determine if the masked chafer milky disease agent could be exploited as a biological insecticide. Laboratory experiments indicated that the bacteria could be formulated, stored, handled, and applied in the same manner as commercial milky spore powder, and that the preparations were highly infective to masked chafer grubs. Initial field tests have been promising. There is no biological reason why a commercial milky spore product that is effective against masked chafer grubs cannot be developed, but additional research on how to best exploit this biological control is needed.

Feeding preferences of white grubs are under investigation. This research indicates that tall fescue is just as suitable as Kentucky bluegrass as a resource for masked chafer grubs. This suggests that the relatively lower amount of grub damage suffered by fescue is probably due to tolerance, i.e., outgrowing or not showing the grub damage, rather than unsuitability of fescue as food. Perennial ryegrass and hard fescue seem to be especially palatable to chafer grubs. Preliminary tests suggest that fescue endophyte may have some adverse effects on grubs.

Additional information regarding recent performance of conventional insecticides and nematodes against white grubs was reported.

SELECTING NITROGEN SOURCES

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Nitrogen is the tool that turfgrass managers use to control growth. It is the prime macroelement in turf nutrition. As an essential element it is mobile within the plant and soil, therefore it is leachable and subject to very rapid concentration shifts. It is absorbed by the plant as NH_4^+, NO_3^-, urea, and even as short chain organic molecules.

Nitrogen deficiency symptoms are primarily twofold; a reduction in growth and when most severe a change in leaf color to a lighter yellowish-green or chlorosis. Chlorosis will appear on the oldest leaves first since the mobility allows it to be moved from the oldest leaves to the most actively growing areas in the plant. The best determination of plant nutrition status is tissue testing. Nitrogen content on a dry weight basis may be from 2 to 6 percent over all grasses. However, within species the range is narrower for healthy turf, commonly this is called the sufficiency range. Laboratories which perform tissue testing should be familiar with the ranges for the most common turfgrasses.

Nitrogen requires a proper balance with the other nutrients, especially phosphorus and potassium for a healthy plant condition. Cool season grasses do best for routine maintenance when fertilized with a 3-1-2 (N-P-K) ratio while warm season grasses prefer a 4-1-3 ratio.

Nitrogen sources can be divided into two broad categories, quickly available and slowly available sources. A comparison of the characteristics of each is in Table 1.

Table 1. Characteristics of Nitrogen Sources.

Quickly available	Slowly available
High solubility	Low solubility
Rapid turf response	Slow initial turf response
Short-lived response	Long term response
No temperature dependency	Low to high temperature dependency
High burn potential	Low burn potential
Low cost/lb. N	Medium to high cost/lb. N
High leaching potential	Less N leaching

The quickly available carriers can be further divided into inorganic salts - ammonium nitrate, ammonium sulfate, mono- and diammonium phosphates and potassium nitrate; and urea - which is a water soluble organic material.

The <u>slowly available</u> carriers include those which are 1) slowly soluble - ureaformaldehyde (UF), isobutylidenediurea (IBDU), and crotonylidenediurea (CDU); 2) slow release- coated ureas such as sulfur coated urea (SCU) and the polymer coated ureas (RLCU and PCU); and 3) natural organics - materials which come from primarily waste by-products such as sewage sludge, manures, feather meal, and composted tankage.

With the <u>slowly soluble</u> nitrogen carriers nitrogen release is different depending on the chemistry of the materials. Ureaformaldehyde may be a combination of short chain methylene ureas, which are totally <u>w</u>ater <u>s</u>oluble <u>n</u>itrogen (WSN) and longer chain ureaforms which are <u>w</u>ater <u>i</u>nsoluble <u>n</u>itrogen (WIN). Release of the WIN from this material and from CDU is highly dependent on microbial activity which is regulated by soil temperatures. Nitrogen release from IBDU is regulated by granule size and moisture availability. The percent of WIN for these materials may range from 70% for ureaform to over 90% for IBDU.

With the coated urea carriers, nitrogen release is dependent on coating thickness, uniformity, and particle size. To evaluate carrier characteristics and determine uniformity of nitrogen release among products a TVA 7-day dissolution rate test is performed and the percent N released is listed on the label. While this does not correlate to actual field performance, it does allow comparisons of products.

Natural organics usually are a low N analysis, typically ranging from 4 to 11% N. Nitrogen release is almost entirely by microbial degradation and this is highly dependent on soil temperatures and moisture availability. In many cases the proliferation of microbes has been shown to be beneficial as an antagonism to pest problems.

Proper nitrogen selection is determined by the three following criteria:

1) Time of year

2) Cost

3) Compatibility

Every turf manager must understand how nitrogen release occurs from these different carriers before deciding which will best fit into their program.

NEW INNOVATIONS FOR INSECT MANAGEMENT

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While new innovations in insect management occur in all areas, they are occurring very rapidly in the turfgrass management area. There are several reasons behind this. One is that the turfgrass industry is in a rapid growth phase, and many new companies are entering the market. In addition, many established agrichemical companies are setting up specialty divisions to work with turf products.

But perhaps of greatest importance is the recent public concern with the use of pesticides, especially near the home. Unfortunately, the public has often been misled concerning the facts on pesticide use, and the media has often made it an emotional issue. When emotions are involved, it is difficult to effectively educate the public. As a result, there has been a lot of emphasis on making pesticide use safer and finding alternatives to pesticides.

Some of the advances will be the introduction of safer pesticides, as related to human toxicity. Synthetic pyrethroids will become more popular for turf, and Tempo is one of the first to be registered. As these new synthetic pyrethroids are registered, sprayer calibration will become even more critical since the rates will be very low. Reducing exposure will call for stricter attention to irrigating properly after treatment. However, new equipment such as high pressure injectors may get used a lot in the future. They can incorporate relatively low water soluble pesticides into the soil. This eliminates above the ground exposure to humans, and the low water solubility of the pesticide reduces the chance of groundwater contamination and runoff.

Biological control will definitely become more important. Milky spore has been around for years, but recent advances in the technology of producing it in the laboratory should eventually lead to an improved product. Various nematodes parasitic to turf insects are available, and new ones are being evaluated. However, with many of these, the results to date have been inconsistent.

The bacteria Bacillus thuringiensis is being developed for turf use for caterpillar control. This is a disease that attacks insects and is harmless to man. Some work is taking place on selecting predators and parasites for turf pests, but this is restricted to specific pests such as mole crickets.

Several studies are underway evaluating the use of pheromone traps to detect levels of insects prior to their damaging stage. For example, pheromone traps can attract the male moths of cutworms and armyworms and indicate that adults are present, laying eggs, and their relative abundance. This could be use to time scouting or sprays, rather than using preventive treatments. Work on insect development by monitoring degree days is also underway in various parts of the country. Again, such information can tell us when to expect certain insects.

Finally, there is considerable work underway on feeding attractants. The concept behind these studies would be to put the attractant on the insecticide so the insect actually ingests it. This might allow us to use much lower rates of pesticides and reduce environmental risks.

These are the main innovations I see on the horizon. Some are currently available, and others are years away. As they become available, be sure to investigate each one and look at its compatibility with your pest management program.

EXPOSURE AND REENTRY STUDIES ON TURF PESTICIDES

EVALUATION OF POTENTIAL EXPOSURE OF GOLFERS AND GOLF COURSE MAINTENANCE PERSONNEL TO DACONIL 2787[R] FLOWABLE FUNGICIDE

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In 1986, field studies were conducted at two golf courses to evaluate potential exposure of golf course personnel to chlorothalonil during the mixing, loading, and application of Daconil 2787 Flowable Fungicide to greens, tees, and fairways. Following application, the potential exposure of workers or golfers to chlorothalonil was evaluated as they entered the treated courses to mow greens, tees, and fairways or to play golf. The re-entry evaluations were made on the same day of spraying after the sprays had dried.

The studies were conducted on both a high-maintenance and a low-maintenance course. At the high-maintenance course (Quail Hollow), the rate of application of Daconil 2787 Flowable to greens and tees was 7.5 oz./1000 sq. ft., while greens and tees at the low-maintenance course (Deer Lake) were treated at 3.85 oz /1000 sq. ft. Fairways at both golf courses were treated with Daconil 2787 Flowable Fungicide at six pints per acre. Exposure evaluations were made following three spray dates at each golf course.

Potential dermal exposure was evaluated by attaching gauze patches to the inside and outside of clothing and by light cotton socks and gloves worn underneath the normally worn socks and work gloves used by workers. This allowed measurement of the effectiveness of clothing, gloves, and socks in preventing chlorothalonil from reaching the skin. Potential inhalation exposure was evaluated by samplers in the breathing zone of each worker or player during the entire activity period. Following completion of the work activity or the round of golf, the patches, gloves, socks, and air sampling device were carefully removed and frozen for subsequent analysis for chlorothalonil. In the laboratory, the gauze patches, gloves, socks, air filters, and air-absorbent tubes were extracted and the levels of chlorothalonil present were determined. Potential exposure values were calculated by multiplying residues on patches (area basis) by the average surface area of the face, neck, shoulder, arms, forearms, hands, chest, back, hips, thighs, calves, and feet. Residues on the outside of clothing and that penetrating clothing were measured and used to estimate potential exposure.

The results showed that for mixers and loaders, most of the dermal exposure (on the skin) potential was on the hands. The experienced applicators at Quail Hollow had less dermal exposure than the less experienced applicators at Deer Lake. Clothing was a very effective barrier to chlorothalonil and only 3.3 to 7.7 percent of the residue penetrated clothing to reach the skin.

Similar results were seen with workers applying the spray to fairways and greens with only 2.4 to 6.9 percent of residue penetrating clothing. Applications with boom sprayers resulted in low potential exposure. Fairway applications at Quail Hollow were made with a Meyers air assist sprayer and resulted in greater deposits on the outside of clothing than seen with boom sprayers. These deposits resulted from spray blowing onto the applicator as he travelled down-wind with the Meyers sprayer. Little residue penetrated clothing, however.

Personnel who entered the treated golf courses to mow greens, tees, and fairways after the sprays had dried were potentially exposed to low levels of chlorothalonil. Nearly all of this potential exposure was on the hands (92 to 95 percent of residues reaching the skin). Thus, these workers can virtually eliminate exposure to chlorothalonil by wearing gloves and washing their hands after mowing is completed.

Golfers who played on the course the same day of spraying had little to no exposure on most body parts. The only detectable residues were found on the hands, hips, and legs.

Virtually all of the exposure potential was represented by dermal exposure. There was virtually no potential for inhalation exposure. Inhalation exposure to mixers was only 0.002 percent of the total. For applicators, inhalation exposure was only 0.004 to 0.03 percent of total potential exposure for fairways and 0.03 percent for spraying greens. Thus, greater than 99.97 percent of potential exposure during application of Daconil 2787 Flowable Fungicide is on the skin, with virtually no risk of inhalation exposure.

A similar profile was seen with workers who mowed greens and fairways on the same day of spraying. The levels of potential exposure were even lower than for workers applying the spray. The percentage of total exposure potential due to inhalation was only 0.02 to 0.1 percent for greens and fairways, respectively.

This study demonstrated that for all golf course workers and golfers:

a) A very high percentage of exposure is on the hands;

b) Most potential exposure can be eliminated by wearing gloves;

c) Work clothing is an effective barrier to chlorothalonil, and by wearing long sleeves and trousers, workers can effectively reduce potential exposure;

d) There is virtually no potential for inhalation exposure, so no respirators are needed.

Other studies have shown that any potential for long-term exposure can be virtually eliminated by workers washing their hands after the work activity, showering at the end of the day, and laundering work clothing before re-wearing. Thus, it is recommended that golf course workers wear gloves, long-sleeved shirts, and long-legged trousers while working with Daconil 2787, and that they wash/shower and launder clothing after completing the work activity.

DISEASES OF HIGH SAND CONTENT GOLF GREENS

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Bentgrass has been difficult to manage on some of the new golf greens that have been constructed in recent years. Most of the greens have been constructed with a large percentage of sand, ranging from 80 to 90% sand, that has been mixed with some type of peat. The advantages of these mixtues are high percolation rates that allow play to resume soon after heavy rains and the reduction of compaction problems. The disadvantages are the decline of bentgrass on these greens during the summer, problems with nutrient deficiences and imbalances and the development of thatch layers.

Deep root systems usually develop in the sand mixtures during the fall and spring but decline severely during the summer. The first above ground symptom associated with the root decline is yellowing of the grass. The turf continues to decline and becomes weak and thin and may die in late summer. The names black layer and Pythium root rot have been given for the problem in some areas of the country. I prefer to use the name summer delcine since a number of factors discussed in the text have been associated with the problem.

A black layer may develop near the surface, or deeper in the soil, on some greens and has been indicated as the cause of the decline in some states. I think a black layer is a symptom of the problem because anaerobic (lack of oxygen) conditions in the soil are needed for it to develop. The black layer is seen in the high sand content greens due to the light color of the sand. It is formed from the reduction of sulfur compounds in low oxygen conditions to sulfides that combine with iron and manganese which are black. Sulfur is oxidized to sulfates which are not black in soils with good aeration. The first indication that the black layer condition is developing is a bad smell, like rotten eggs, from sulfides in the soil. The lack of oxygen (drowning) can kill the bentgrass roots and the sulfides are toxic to roots, also. Therefore, I think the roots have died sometime before the black layer becomes visible in the soil. Algae have been indicated as the cause of the black layer, and are associated with the problem, in many cases. The growth of algae are favored by wet soils and produce substances that interfer with the movement of water in the sandy mixtures. The algae contribute to the anaerobic conditions mentioned previously. The best management practices to avoid the black layer and to help algae problems are to irrigate carefully and to aerify the greens as often as needed. The mancozeb fungicides such as Fore and Tersan LSR can be used to help control algae in combination with the management practices.

The development of a layer of thatch on the surface of the high sand content geens contributes to the decline. The thatch layer acts like a perched water table and water does not move into the sandy mixture until the layer is saturated. Water can be squeezed out of the top 1/2 inch of thatch in a plug from these greens for several days after irrigation although the sand mixture below is relatively dry. This saturated condition in the thatch layer causes an anaerobic condition that contributes to black layer as discussed above and provides an environment that is favorable for fungi that cause brown patch and Pythium root rot. A layer of thatch is necessary on these greens to obtain acceptable ball holding qualities and firm surfaces. Frequent aerifications and topdressings with proper soil mixtures are need to reduce the adverse effects of the thatch. Aerification as frequent as once a month during the summer with small hollow tines or solid tines has helped to reduce the problem of the saturated thatch layer.

Localized dry spots are often a severe problem on the high sand content golf greens. The dry spots are thought to be caused by the sand particles becoming coated with microbical products. Once the soil in these spots becomes dry it is almost impossible to wet it again without aerification or using wetting agents and then saturating the soil. The stress from dry wilt in the areas and the extra water make the plants in the areas more susceptible to diseases such as Pythium root rot. Most superintendents have found that it is best to keep the sand mixtures moist to avoid the severe problems associated with the localized dry spots. A dry ring often is a problem at the edge of the high sand content greens where the greens mixture meets the native soil. The native soil draws the water away from the sand resulting in a dry area. The sand mixture should be extended out far enough to have the fairway type grass growing on the sand mixture or use a barrier between the sand and the native soil.

Nutrient deficiences and the other extreme of excessive nutrient levels that results in high soluble salts have been more of a problem on high sand content greens than on greens with more soil. The sand mixture often has a very low cation exchange capacity, often less than 2, that causes rapid leaching of nutrients. The low cation exchange capacity and rapid leaching requires the application of more fertilize on these greens. Some superintendents have used as much as 20 pounds of nitrogen per 1000 square feet on these greens during the first year. Small amounts of a complete fertilzer with micronutrients should be applied at frequent intervals to keep nutrients in the root zone and to avoid damage from high soluble salts. High soluble salts have caused damage on many of these greens due to the low cation exchange capacities and the accumulation of salts in the thatch layer. As water evaporates from the soil the salts may be concentrated around the crowns of the plants. The damage has been associated with the use of some of the slow release water soluble nitrogen and potassium fertilizers. Apparently these materials slowly release the nutrients into the thatch and they are retained in the thatch layer rather than leaching rapidly. The use of these materials should be encouraged because of the leaching in these greens, but smaller quantites should be used at one time than on greens with more soil. The symptoms of high soluble salt damage are areas or streaks on a green turn yellow, begin to decline and even die from a few days to several weeks after fertilization. The problem is usually more severe during dry weather when small amounts of irrigation water are being applied. The streaks are usually from where the fertlizer application overlapped. Once high soluble salts are detected which involves a simple extraction procudure and the measurement of electical conducticity, leaching with large amounts of water from irrigation or rain is the only way to remove them.

Soil test and tissue analysis results should be used reqularly to determine the fertilizer needs of the bentgrass. Soil tests for the high sand content greens usually indicate a deficiency of phosphorus, potassium and some micronutrients. The accuracy of the recommendations for large quantities of nutrients for the low cation exchange capacity mixtures is in question because tissue analysis from clippings from these greens often show adequate levels of nutrients in the tissue. The soil test results should be used as a guide to correct any pH problems or nutrient deficiences or imbalances by applying small amounts of the nutrients at frequent intervals. The application of large amounts of potassium often indicated at one time could result in damage from high soluble salts. The use of water soluble fertilizers that are disolved in the spray tank and sprayed at low rates, often 1/8 pound of nitrogen per 1000 square feet, have worked well on the high sand content greens. This fertilizer application method is very important during the summer months and has been used all year in some cases.

The environmental conditions surrounding bentgrass greens is important for all types of construction, but are very important for the high sand content greens. Summer decline usually appears first on greens in low areas that are surrounded by trees on the east, south and west sides. Wind movement is usually restricted in these areas and results in hotter and more humid environments than on nearby open greens. Trees and undergrowth should be removed on the southwest side to improve air movement from the predominate southwest winds that we have during the summer.

Diseases caused by fungi are often a problem on the high sand content greens. Brown patch and Pythium blight are often a problem in the summer on all types of bentgrass greens. The bentgrass on the sand mixtures often appears more succulent and more susceptible to these diseases. A fertilization program with the lowest levels of nitrogen possible in the summer will help reduce the susceptibility to these diseases. Pythium root and crown rot is very prevelent on the high sand content greens. Pythium species that cause the root and crown rot have been isolated from as many as 90% of the plants sampled from these greens. These fungi apparently do not cause much damage unless the plants are weakened by some condition such as anaerobic soil conditions, localized dry spots, high soluble salts or environmental stresses. Correcting or avoiding these conditions will help to prevent damage from this disease in the summer decline complex.

The Pythium species that cause root and crown rot are different than the species that cause Pythium blight. These species, many of which are Pythuim graminicola, are not sensitive to Subdue and Banol but are sensitive to Koban. The use of Koban at 5 to 6 ounces per 1000 square feet in 5 gallons of water per 1000 square feet as a preventative has help controlled Pythium root and crown rot in some cases. This treatment does not work very well once the bentgrass has started to decline. A combination of aerification for the other problems mentioned above and the use of Koban has given the best results.

Some nematodes have been found in the sand mixtures. The most damaging nematode often found is the stubby root nematode which prefers a course wet sand like used in these greens. It has been difficult to manage this nematode because the currently available nematicide for golf greens, Nemacur, does not control the stubby root nematode very well.

Bentgrass can be grown very well on some high sand content golf greens if proper construction and management techniques are used. Great care should be taken during the construction process to be sure that proper sand and peat types are used and mixed uniformly. Mixing can best be done off site and then move the mixture to the green with very carefully prepared subsurface contours. The mixture must have a uniform depth, 12 to 14 inches, all over the green for proper results.

The use of sands that have the correct particle sizes and mix properly with the organic matter to give desired percolation rates of 10 to 15 inches per hour is the the first step in preventing many of the problems associated with these greens. This can be done only by using physical soil analysis which is available form several different laboratories. Samples should be taken from the sand when it is delivered and analized to be sure that all of the sand meets the specifications.

The type of peat or organic matter used in the mixture will make a big difference in the properties of the mixture. For example, a sand mixed with a sphagnum peat resulted in a percolation rate of 17 inches per hour. The same sand mixed with a reed-sedge peat resulted in a percolation rate of 5 inches per hour. The addition of some loamy soil, especially with sphagnum peat, to increase the cation exchange capacity has worked well in some cases. The addition of some soil resulted in greens that were easier to manage, however, be sure to follow physical analysis recommendations in all cases.

The USGA recommendations for golf green construction are the best guidelines to follow for drainage, subsurface contouring and the addition of the top 12 to 14 inches of sand mixture. Also, you should recognized that your high sand content greens may need a totally different management program than what has been and can be used on old greens or on greens with different mixtures.

USING GRASS CARP TO MANAGE WEEDS IN IRRIGATION PONDS

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Plants are important components of all aquatic environments. They form the basis of the food chain by directly (for herbivorous animals) or indirectly (for the primary and secondary carnivores as well as the decomposers) providing food for all of the animals in the system. Plants also provide breeding and nesting sites and cover for fishes, birds, and mammals, resting areas for many species of migratory waterfowl, and oxygenate the water. Any aquatic habitat totally devoid of plants is unproductive and incapable of sustaining an animal population. Consequently, some vegetation is necessary in all streams, lakes, and ponds in order to have a healthy, functional ecosystem.

The amount of vegetation in aquatic habitats is regulated by the presence of nutrients in the water and the amount of available light for photosynthesis. High nutrient input, particularly phosphorus and nitrogen, and large areas of clear, relatively shallow water inevitably lead to weedy growths of algae and other aquatic vegetation. Once these weeds become established they may invade areas of deeper water and often overrun an entire pond or shallow lake. Dense growths of aquatic weeds clog irrigation water intakes, pumps, and distribution systems and must be managed to avoid shutdown of the entire irrigation system. The use of herbicides in irrigation systems is quite limited. Of those available for use in North Carolina, only copper compounds and glyphosate formulations may be used without restrictions on irrigation. The most effective algicide, simazine, can <u>not</u> be used at all in irrigation systems. Diquat and various formulations of endothall, 2,4-D, and fluridone may be used under certain circumstances, but have varying restrictions on use of the water for irrigation. Often it is not possible to withhold irrigation for the period of time specified on the label. Consequently, potentially effective herbicides can not be applied, and other management tactics (including mechanical removal and biological control) must be used.

Probably the most common alternative to herbicides has been some form of mechanical removal (raking, seining, chaining, or the use of backhoes or draglines). Mechanical removal is expensive, inefficient, only temporary, requires the availability of a disposal area, and often leads to the spread of the problem to other areas. Water level fluctuation (i.e., drawdown) usually is not an option in the relatively small irrigation ponds used throughout most of the state, as most of these ponds do not have an adequate water level control structure. Biological control, may be the only remaining option available short of draining and rebuilding the entire pond. A number of organisms (insects, ducks, geese, and various species of fish) have been used with varying degrees of success for biological control of aquatic weeds. In North Carolina, the primary agent used for aquatic weeds is the Chinese grass carp, or white amur. Other fishes, including the blue tilapia (an algae feeder) and the redbelly tilapia (a macrophyte feeder) have been used. Both of the tilapia species are tropical and are unable to tolerate the cold water temperatures which occur during the winters. When the water temperature drops below approximately 50-55 degrees, the fish die. Consequently, the use of these species is limited to waters where a thermal effluent exists (e.g., power plant cooling effluent or a thermal spring). Common carp and several variants of the carp (Israeli carp, silver carp, etc.) occasionally have been tried for weed control but generally have not been effective, as these fish are omnivorous rather than herbivorous. In cases where they have been effective, most of the control has resulted from their habit of muddying the water while rooting in the pond bottom for food, rather than from the actual consumption of vegetation. The remainder of this paper will focus on using grass carp for weed control in irrigation ponds.

The grass carp is the primary fish used for the biological control of aquatic vegetation in the United States. This fish originated in the Amur River region of China and was imported into the United States as a potential biocontrol agent for hydrilla and other aquatic vegetation, as no native species in North America are herbivorous. This fish is not capable of reproducing in ponds, lakes, or reservoirs, because it requires conditions found only in large river systems. Juvenile grass carp are plankton feeders but become obligate herbivores when they reach a length of about six inches. Because of obligate herbivory, they do not compete for food with desirable game and commercial species. The grass carp grow rapidly, attain relatively large size (20-25 lb fish are normal, 40 lbs. and larger are not uncommon), and may live for 10 years or longer.

Concern for the possible negative impacts of the grass carp within our large river systems and associated estuaries has resulted in the limitation of their use in many areas. In response to this problem, researchers developed a technique to create sterile offspring by altering the genetic material during fertilization. This technique induces the newly fertilized egg to form one extra set of chromosomes (triploid condition). The triploid fish is normal in all respects except that it cannot successfully reproduce. To insure quality control, the new embryos are passed through a sophisticated apparatus (Coulter counter) which can discriminate triploid from normal (diploid) embryos. To be certain that each fish that is to be shipped to distributors is triploid, each individual fish is again subjected to testing. The red blood cells of fish (unlike those of mammals which totally lack nuclei) contain nuclei with the same number of chromosomes as in other cells of the fish's body. These cells, hence, are triploid and are larger in size than the cells of normal fish, which contain only two sets of chromosomes. Blood samples from each individual fish are passed through the instrument to determine whether it is a sterile, triploid fish. In some cases, this process is repeated prior to shipment. Those which are triploid can be sent to the distributor for sale. Fertile fish (diploids) are retained for breeding stock or are destroyed. Because of this process, triploid grass carp are relatively expensive (about $ 7 to 8 per fish).

Stocking of grass carp in North Carolina and in most other states which allow grass carp is done by permit only. This is done to insure that only triploid fish are released. To obtain information and an application for a permit to stock grass carp in North Carolina, contact the Wildlife Resources Commission (WRC) at 919 733-3633. A biologist from the WRC will visit impoundments larger than 10 acres to determine whether or not there is sufficient containment to confine the fish to the targeted body of water. This site visit is not required for smaller impoundments. In some cases, a containment structure may have to be installed to prevent escape of the fish before a permit will be issued. The WRC determines whether or not a permit will be issued and the stocking rate allowed. Stocking of grass carp presently in not allowed in open systems (rivers) or in large lake systems in which escapes are likely. Stocking rates vary somewhat with the type and density of the vegetation to be controlled but generally fall into the range of 8 to 15 fish per vegetated acre. Larger fish (8 to 10 inch size) are stocked to avoid predation by largemouth bass and other large predators, including wading birds. Fish may be released only in those bodies of water for which the permit originally was issued and may not be moved to another area without permission.

There are a number distinct advantages in using grass carp for aquatic weed control. A major advantages is that long-term control (up to 10 years) usually is attained with a single stocking, whereas treatment with herbicides often is needed annually or more frequently. Since no herbicides have been applied, the water contains no chemical residues which potentially may be harmful to desirable plants, fish, livestock, or humans. Oxygen depletion associated with decaying vegetation after herbicide treatment and resulting fish kills also do not occur when grass carp are used. There also are several disadvantages associated with the use of grass carp. The fish initially are expensive and control is attained over several seasons. Grass carp are preferential feeders on submersed vegetation, and hence may not be effective on many of the weeds of concern, especially floating, floating-leaved, and emergent species (see Table 1 for information on vegetation preferences). About half of the plant material eaten is not digested and is returned to the water where decomposition and nutrient release may cause algal blooms. The fish also tend either to consume all of the vegetation present and then starve to death or to not control the weeds at all. In case of starvation, fish may be fed trout or catfish feed or grass clippings. If weed control was not attained, the cause may be the loss of fish (escapes or predation), improper stocking rates, or stocking for a weed which it does not eat.

Table 1. Effectiveness of grass carp for control of aquatic weeds in ponds.

Species Usually Controlled*	Species Sometimes Controlled**	Species Not Usually Controlled**
Naiad	Duckweeds	Lotus
Fanwort	Watermeal	Rushes
Hydrilla	Aquatic grasses	Cattails
Coontail	Water pennywort	Bulrushes
Pondweed	Eurasian watermilfoil***	Smartweed
Bladderwort	Waterfern (<u>Salvinia</u>)	Maidencane
Watermilfoil***	Mosquito fern (<u>Azolla</u>)	Waterlilies
Widgeongrass		Spikerushes
Parrotfeather		Torpedograss
Creeping rush		Alligatorweed
American elodea		Waterhyacinths
Brazilian elodea		Filamentous algae
Muskgrass (<u>Chara</u>)		Reeds (<u>Phragmites</u>)
Proliferating spikerush		Stonewort (<u>Nitella</u>)
		Eelgrass (<u>Vallisneria</u>)
		Watershield (<u>Brasenia</u>)

* All of these species are submersed plants.

** All of these species are floating, floating-leaved, or emergent plants, except Eurasian watermilfoil, stonewort, and filamentous algae.

*** The watermilfoils, particularly Eurasian watermilfoil, are less preferred than many of the other submersed plants and often are not readily eaten until more preferred species have been consumed first.

DAMAGES TO GOLF COURSES FROM HURRICANE HUGO

BY

PATRICK M. O'BRIEN, SOUTHEASTERN DIRECTOR

USGA GREEN SECTION

GRIFFIN, GEORGIA

Hurricane Hugo hit Charleston Harbor at midnight on September 22, 1989. The storm left a path of destruction in both North and South Carolina. It is estimated that 40% of the golf courses in these states sustained some form of damage. Damage was caused by not only the gusting winds of up to 175 mph, but by tidal surges and plough mud deposits:

Hurricane Hugo traveled a distance of over 2,300 miles during it's journey of destruction. The hurricane first caused damage at St. Croix and Puerto Rico. It is estimated that over 50% of St. Croix's population is still homeless because of the storm. The famous Hyatt Dorado Beach Resort reported tree lost from the heavy winds, but luckily major damage was avoided. The next stop was historic Charleston and an inland Carolina path which crossed through Santee, Charlotte, Hickory, and Roaring Gap before heading into western Virginia. Hugo left a trail not seen in the Carolinas since the last major hurricane in 1752.

Meteorologists were confounded by the unpredictable path of the storm. After hitting Charleston, the storm was predicted to travel through the eastern Carolinas. Instead, the storm took a northwesterly path and regained strength over Lake Marion before striking Charlotte early the next morning. Most golf courses lost over 1,000 trees in this city with the 100 mph gusting winds. Fortunately, the beautiful coastal courses south of Charleston were spared from serious devastation.

Tree damage was the most widespread form of damage to golf courses. Typically, most golf courses in the path of the storm lost between 500 and 2,000 trees. The mountain course of the Old Beau Golf Club at Roaring Gap, North Carolina lost almost 5,000 trees. The coastal courses at the Country Club of Charleston and The Debordieu Club each lost approximately 2,000 trees. To remove the downed trees, most clubs rented accessory equipment to help remove the debris. Chainsaws, chippers, bucket trucks, dump trucks, and stump grinders made the tree cleanup easier.

The tall southern pine trees became uprooted most easily with the high winds. Many clubs estimated that 50% or more of their tree losses were pines. The pine trees root systems couldn't withstand this stress. Partially uprooted and leaning pine trees are existing evidence of the storm's passage along many Carolina highways. Some deeper rooted live oaks had the top canopies blown away. A small positive note caused by the winds is the bermudagrass turf will benefit without the shade and root competition caused by some of the lost trees on these courses.

It will take many years for the landscapes to recover. In the meantime, fairway contour mowing programs will help provide some additional strategy for the golfers. Landscape architects have advised the golf course staff on where to plant new trees.

Another major destructive force of the storm was the tidal surge along the coastline. Many coastal courses from Charleston to Myrtle Beach felt the effects of the tidal surge. The highest storm surge was 17 feet reported about 20 to 30 miles NE of the hurricane eye from Charleston. A 13 foot surge occurred at the famous Wild Dunes Course on the Isle of Palms. At least 50% of the Country Club of Charleston was underwater.

The tidal surge caused some significant concerns for the golf superintendents. Most coastal courses are at elevations less than 25 feet above sea level. This wall of water associated with Hurricane Hugo covered large areas of the coastal courses. Greens, tees, fairways, roughs, and bunkers became submerged with the sea water. Also, many irrigation ponds received a dose of the seawater. Expensive pump stations and field satellite irrigation controllers became submerged. Plough mud and silt deposits from nearby marshes covered the turf on some sites. The Country Club of Charleston had between 3 inches to 3 feet of mud and silt deposits throughout the golf course. The mud removal was one of the most difficult tasks of the recovery process. The heavy mud deposits were removed with shovels, and hoses helped to wash lighter deposits and remaining mud from the turf.

A third major concern after the storm was the potential saltwater damage to the turf, soil, and irrigation ponds. The following day, intense sunshine caused sunscald on many bermudagrass fairways. The complicated anaerobic soil conditions created by the tidal surge initiated a browning leaf color in other turf areas. Initial irrigation water samples indicated total soluble salts between 22,000 and 15,000 ppm. It was an unbelievable site with the brown turf, mud, and fallen trees on these formerly impeccable landscapes.

The turfgrasses grown on most coastal courses have excellent saltwater tolerance. Bermudagrass and zoysiagrass are the most widely planted turfs on these courses. The Debordieu Club had many bentgrass greens submerged by the tide and covered with mud. Fortunately, bentgrass also has an excellent salt tolerance rating. A concern was the centipede rough turf grown at a few courses. Centipede has very poor salt tolerance.

A fortunate occurrence happened for the turf and soil with the 8 to 10 inches of rain following the storm. Any sodium loading of the soil profile was significantly reduced with the rains. The predominantly sandy soils are very suitable for this flushing and leaching. Recent soil tests are indicating acceptable total soluble salt levels. Many clubs didn't have to apply gypsum after the soil tests. Most coastal clubs are already on a regular soil amendment program because of lower quality irrigation water or effluent water.

It now looks like the warm season turfgrasses are recuperating quite well. The bermudagrass fairways had good color again prior to the cold weather. Some courses applied extra nitrogen, potassium, and iron to the bermudagrass fairways after the debris removal. Many superintendents reported mowing of the bermudagrass turf was necessary by December. A few bermudagrass low areas with additional salt accumulation may require resodding or sprigging next season. Extra spring aerification and slicing will help the roots to penetrate through any silt layers caused by the mud. It appears even most centipede rough survived the tidal surge.

A few high nematode areas may require resodding. A full growing season should return the centipede to last year's quality.

The bentgrass greens at The Debordieu Club provided several interesting agronomic stories from the hurricane. Some greens were submerged and covered with mud and died, while others survived. The practice green, #1, and #9 greens are all located around the clubhouse and at the same elevation. All became submerged with the tidal surge. However, only the #9 green died. It was a real mystery to observe this occurrence. During the renovation, a total of eleven greens were reseeded and will be ready for play again soon.

An economic impact has been felt by all clubs in the storm path. Most coastal clubs had cleanup costs between $50,000 and $250,000 depending on their circumstances. A few courses had much higher costs associated with the damages.

The golf superintendent has some very different duties after the storm, but the same job of taking care of the golf course. Cleanup work, finding labor, and dealing with insurance and government agencies became part of the job. The golf superintendent again demonstrated creativity and poise during this disaster.

PESTICIDE CONCERNS OF GOLF COURSE SUPERINTENDENTS

Robert K. Hudson
Field Supervisor
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Raleigh, N. C. 27611

Several regulatory issues relating to the use of pesticides frequently come to mind when golf course applications are discussed. First of all, golf course operators applying pesticides to golf courses are considered commercial ground applicators and must be licensed by the North Carolina Department of Agriculture. This involves passing an initial licensing exam and paying an annual fee for the license. Employees apply pesticides on the golf course under the direct supervision of the licensed operator.

Another area of major concern is pesticide rinsate, pesticide residues and rinse material from rinsing pesticide containers and spray tanks. The best manner in which to dispose of a pesticide is to use it as it was intended. The rinsate of a pesticide should be applied back onto the target site in accordance with the product label.

Pesticide mixing and loading sites must be kept free of pesticide contamination that may threaten groundwater supplies. If pesticide contamination is confirmed, appropriate regulatory action will be taken.

Pesticide labeling is also an important issue to the golf course operator. It is vital that you read the entire pesticide label before you begin an application. The label is your directions and it is the law. Using more product than the label calls for in hopes that you will get a better "kill" does not work and is illegal.

Do not use agricultural chemicals on the golf course unless a product is specifically labeled for ornamental and turf use. Remember if an agricultural product is labelled for collards, turnips and other greens, this does not mean the golf course greens "variety".

Pesticide storage is also an issue of concern to the golf course superintendent. Pesticide storage regulations were promulgated in order to reduce the number of pesticide fires and spills and to minimize the impact on the environment when pesticides are suddenly released during fires and spills.

Storage requirements for all pesticides include storing pesticides in labelled containers, in a manner that foods, feeds, seeds or fertilizer cannot become contaminated and in a dry and well ventilated area. No burning activity such as welding can be done in a pesticide storage facility. The pesticide storage area must also be kept free of combustible materials.

If you store restricted use pesticides, there are additional requirements. All pesticide storage areas must be kept secure to prevent unauthorized access. Pesticide warning signs must be posted at all entrances to pesticide storage areas. Absorptive material must be kept on hand to absorb pesticide spills. Pesticides shall not be stored within 50 feet of a private water supply or within 100 feet of a public water supply. A pre-fire plan and annual fire inspection must be completed by the local fire department. A current inventory list of restricted use pesticides by brand and formulation (updated every 30 days) must be kept at the storage facility with a copy at an off-site location.

This brief discussion of pesticide storage is not meant to be all inclusive. For a copy of the pesticide storage regulations or if you have questions concerning pesticide laws and regulations, you should contact:

Pesticide Section
Food and Drug Protection Division
N. C. Department of Agriculture
P. O. Box 27647
Raleigh, N. C 27611
Telephone: (919) 733-3556

RECLAIMING THE LAND: CHARLES T. MYERS PUBLIC GOLF COURSE

Mark D. Kincaid
Turf and Landscape Operations Coordinator

Mecklenburg County Park and Recreation Department

Charles T. Myers Public Golf Course is built on top of a portion of the Mecklenburg County Landfill. There are nine holes currently operational, and the back nine will be constructed when the remainder of the landfill closes down. This paper attempts to summarize some of the landfill - specific decisions and problems that were encountered during the planning, construction and maintenance of this golf facility.

First, let's briefly define/describe three items. In the operation of a landfill, each day's solid waste is compressed into cells that range from 6'-10' deep. At the end of each day a 6" layer of fill dirt is placed on top of the cell. This process repeats itself until a stockpile, ranging up to 70' deep, is created. When a stockpile reaches its designated height, it is closed-down and a soil cap, 2 or 3 feet thick, is placed on top. Landfills create certain bi-products, two of which need to be mentioned at this point. Methane is an odorless gas that is created as the garbage decomposes. It will find the path of least resistance out of the landfill. This is typically a vertical path up through the soil cap and out into the atmosphere. The presence of methane in the root zone tends to crowd out oxygen, and in that sense methane is toxic to vegetation. The second bi-product is leachate, which is a liquid seepage that comes out of the ground at the base of the slope of a stockpile. It is unsightly and has an unpleasant odor.

With these items in mind, let's cover some architectural considerations. The County wisely decided to build nine holes at a time. This has allowed us to learn from our mistakes. The course design takes advantage of the open terrain by placing the clubhouse on high ground, and then locating the holes so that all tees and all but one green can be seen from the clubhouse deck. Trees are being installed with these "site lines" in mind, so the view from the clubhouse will not be blocked.

One of the toughest problems has been an inconsistency in the thickness of the soil cap, so before the construction of the back nine we will test drill the completed stockpiles to ensure a 3 foot cap is in place. A three foot cap is preferred over a 2 foot thickness in order to: (a) provide an acceptable trench for the irrigation lines, (b) provide a comfortable root zone for turf, shrubbery and trees, and (c) allow for the regrading of some erosion problems without exposing garbage at the surface, or creating a weak point in the cap.

To our knowledge, the only successful way to actively vent methane is to place vent pipes every 100 feet over the entire landfill, which makes for an ugly golf course. So, the decision was made to simply allow the methane to vent through the cap, with the theory that the common bermudagrass fairways and the Penncross Bentgrass greens would stay healthy with a good turf management program in place.

When we encountered problems establishing the common bermudagrass in several areas, our first thought was that there was a methane problem. Staff has since discovered that the topsoil was not only very acidic, but also totally deficient in Phosphorus and Potassium. As it turns out, this "topsoil" was actually subsoil taken from 20 to 30 feet below the surface during landfill operations. With correct Ph and nutrient levels in the soil, the bermudagrass is filling-in nicely.

Some innovative design features were incorporated at the greens. On top of the 2 foot cap, an additional 4 foot cap was installed at each green. The greens were not built to USGA specifications. Instead, at the bottom of the 24" cavity is a 12" base of stone (1/4" to 1/2"). On top of the stone is a 6" layer of mason sand, and on top of that is 6" of an 80/20 pre-mix of mason sand and spagnum peat. When the drain lines were installed in the bottom of the cavity, not only were they designed to run the water downslope, but they also extend upslope to atmosphere in an effort to give any methane under the bentgrass an easy escape route.
It should be noted that prior to actual golf course construction, additional fill dirt was placed on top of each green in order to accelerate the settling process. When the greens were built, this excess was then removed, leaving the 6 foot cap from which the greens were constructed.

Certain engineers recommended using a liner under the greens. Staff had concerns that this 40 mil rubber liner may:

(a) Act as a "hot air balloon" as the methane gathered underneath it. This may cause the unstable cap to shift or rise.
(b) Get torn somehow, creating a concentrated "nozzle" of methane into the green cavity.

Therefore, the underliner was not used. Methane does vent into the greens in smaller amounts, but does not create problems with the bentgrass. Staff is considering increasing the cap under the back nine greens to as much as 10 feet (up from 6 feet on the front nine).

Staff monitors methane levels on the golf course. Three fixed points on each side of each fairway are established and monitored monthly to chart methane activity through time.

Tree survivability is a concern. Therefore, staff records tree species, locations, year planted, and time-of-year planted. So far the best survivors include: Red Cedar, Virginia Pine, Loblolly Pine, Leyland Cypress, Crape Myrtle, and Bradford Pear. Over 300 trees have been planted so far, and several thousand more are needed.

Today, the landfill is being filled-up according to the topography established in the architect's proposal for the back nine. This is an attempt to get away from the boring "plateau" shape of the front nine. More mounds for tree planting will be incorporated into the back nine. Also, a larger stockpile of fill dirt will be set aside for back nine construction, hopefully in excess of 100,000 cubic yards. Construction could begin as soon as 1993.

Mecklenburg County Park and Recreation Department feels that its cautious, patient approach towards construction, maturing, and opening of this public golf facility has been appropriate. The course handled traffic very well after opening in May of 1989, and we look forward to a busy 1990.

ONE SUPERINTENDENT'S PHILOSOPHY ON OVERSEEDING

GEORGE B. THOMPSON, CGCS

Bermuda is the choice fairway turf in this section of North Carolina. It is important for us to provide the Bermuda with sound management programs so it can flourish. At times our climate can be harsh and certain weather extremes can slow our quest for the perfect fairway.

Those of you who manage bermuda from Raleigh and Greensboro and further north & west have some winter kill problems, and those of you on the coast have more summer type problems with mole crickets and nematodes. Those of us in the sandhills have some of both type problems and we also have more resort play in the spring and fall.

Some of our challenges are to prime the courses in April and October when our play is most heavy. Generally, this means overseeding the fairways, tees and fringes with a combination of cool season grasses so that the fairways will look good and resist some of the wear from heavy play.

I came to The Country Club of North Carolina in 1982. Our original (Dogwood) course had been overseeded for twenty consecutive years and I continued to overseed because it was a normal procedure. Our fairways were not good Ryegrass fairways and not good Bermuda fairways, because the rye was full of Poa Annua and the Bermuda didn't have enough recovery time after the Rye died out. The next two years we made some slight improvement with chemicals for Poa and for transition, but they were still not good.

My Green Committe and I believed we could improve our fairways by not overseeding them. We had to demonstrate this to our membership. We received permission to not seed nine holes on the newest nine on our Cardinal course. The members were quite happy with these non-overseeded fairways, so we decided to not do the entire Cardinal course the next two years, but continued to overseed Dogwood. The members observations were that Cardinal was getting better and Dogwood worse. Everyone wanted to play Cardinal. We suspected that our membership would play the overseeded course in the winter and early spring and the non-overseeded course the remainder of the year. The trend started this way, but eventually, the majority wanted to play Cardinal year round, green or brown. We had been working on cleaning up the old rye grass clumps and the Poa for two years and the fairways were becoming much more clean each year.

We were having some spring dead spot on the young Bermuda which was hurting our effort a little, but in spite of that, most of our golfers accepted the dormant condition and finally were beginning to learn the difference between dormant and dead.

My past and present Green Chairmen, Jack Busby and George Pottle and I decided we needed to stop overseeding Dogwood and get those 419 fairways back in shape. Our Green Committee sent a series of three questioneers to our membership to see if they were for or against overseeding. The questioneers were mailed in the spring, summer and fall to a total of 766 members. On a total return basis, one-third had no opinion, of those who expressed views either for or against. seventy-nine per cent were against. The response patterns for the men and ladies were similar, but a higher percentage of ladies were against...

Men - 75% Against - 25% for overseeding.
Ladies - 85% Against - 15% for overseeding.

We knew non-overseeding was best for our golf courses, but we were not positive that it was best for our golfers. The survey confirmed that our members didn't want it either.

We haven't overseeded any fairways since the fall of 1986, and our fairway turf has shown tremendous improvement since that time. Our greens have also improved because our Poa Annua herbicide programs are more effective. Golfers are no longer tracking in a fresh crop of Poa Annua seed and re-innoculating our greens.

Golf Course labor can be channeled into course improvement projects. Other benefits from not overseeding are cost savings from seed, extra fertilizer, extra energy to grow in the rye and then turn around in April and use more energy to kill it. Golfers can play by the rules of golf year round, if we do our job and keep it free from weeds.

Aeration and vertical mowing can be done in July and August when our play is light and the hybrid heals more rapidly.

There is no transition problem, when bermuda is ready to grow, it has no competition. We have been prolonging the green color with the use of iron in September, October and November. With some luck, we can have green fairways at Thanksgiving and again in early April.

The winter overseeding has a brilliant shade of green during the winter months, but I am learning to really appreciate the tawny gold bermuda.

THE RESTORATION OF PINEHURST #2 GOLF COURSE

Bob Farren CGCS
Assistant Director of
Golf Courses & Grounds

The project involving the reconstruction of the greens of #2 Golf Course was actually in the 3rd year of a five year plan involving a facelift of the entire resort. These plans involved a variety of projects ranging from master drainage systems to cart path additions and even included the construction of #7 golf course. It was relatively easy to convince most people of the need to convert the greens from 328 to bentgrass, the largest obstacle came in deciding on a means by which to do them and retain the original Donald Ross design characteristics.

I want to take this opportunity to stress the importance of developing short and long range goals and objectives. These will enable you to communicate with your membership on the direction of the club as well as give you a means by which to measure your success. If you currently don't have a written game plan for your department or your club I suggest you initiate the idea, you should be commended for your effort.

The decision having been made to convert the greens, we began to search for a method to record the exact controus of the greens. The only time this had previously been tried was at Augusta National. They had used the conventional grade stake method, we felt this method would be too time consuming when doing a complete 18 greens. We contacted Ed Conner, with Golforms, Inc. in Florida. He applied a previously developed system known as Computer or Digital Terrain Modeling. This process involved the use of standard laser type survey instruments, incorporating a computer software program to store the co-ordinates. The same equipment is used to provide printouts for visual displays of the putting surfaces, these instruments provide accuracy to 1/1000'. The pre-construction site plans and survey were done in March, preceding a June 15th construction date.

The next phase of our planning was to write out the detailed process of the entire project. (see attached) We immediately began establishing a time frame and a sequence of events that must happen in order for our project to be successful. Considering fall is a very busy time of the year for our resort, we concluded it would be cost effective for us to sod the greens, allowing them to open in early October versus seeding that would require them to be closed throughout the winter. Equally important is the fact that sod allowed us to protect the delicate contours from erosion.

The next phase of our planning involved becoming acquainted with construction methods and specifications prescribed by the USGA Green Section. These, along with a video tape can be obtained from:

USGA Green Section
Far Hills, N.J. 07931

Once these were determined we began searching for sources for the components of the subsurface drainage materials as well as the top mix or growing medium. This process should definitely involve a reuputable soils lab. The U.S.G.A. can recommend a number of them as well as their addresses. We used a soil blender to ensure proper mixing. The following represents volumes of materials needed per 1000 square feet:

3/8" stone (pea gravel)	4" depth	12 cu. yd.
Coarse sand (choker)	2" - 4" depth	6 - 12 cu. yd.
Top mix	12" depth	37 cu. yd.
4 in. perf. tile	100 ft/1000	

Also shown here are some estimated material costs (U.S.G.A. estimates) *Cost obviously will have regional variations as well as freight differences. Cost are based on 6,000 sq. ft. greens:

3/8" pea gravel
120 tons x 13.75 = $1,650.00
$1,650.00 x 19 greens = $31,350.00 total costs

Coarse Sand (2 inches)
60 tons x $35.00 = $2,100.00
$2,100.00 x 19 greens = $39,900.00 total cost

Rootzone mixture (12 inches)
320 tons x $23.50 = $7,520.00
$7,520.00 x 19 greens = $142,880.00 total cost

I have included the above calculations as examples to help estimate project costs and also as a means to relate your costs per green or per 1000 sq. ft. as opposed to terms of tons or cubic yards. Expressing these in this manner should be more clear to your green chairman, general manager, etc.

Having completed the preliminaries of material selection and mixing in early spring we were set to begin actual excavation of the putting surfaces on June 15th, with our target date to sod greens August 15th and the course set to open October 15th.

The greens were excavated to a depth of 20 inches and took 3 weeks to complete. Once the first green was excavated we immediately began re-creating the subgrade to same contour as original surface installing drainage and constructing the new green. It was at this point many tasks began to overlap, placing a real demand on planning and communication skills.

At the end of the first month we had several greens completed to the point of final grading. Prior to beginning the sod operations we amended the soil with N-P-K at a 2-5-2 ratio and adjusted the Ph to desirable levels. The sodding operation began on August 15th using Penncross Bentgrass, purchased from Rohoza Turf in Sewickly, Pa. The turf had been maintained at 1/4 inch, with preventitive fungicide applications and was shipped in refrigerated trucks.

During the sod installation tasks really started to accumulate, each green demands so much attention (i.e. irrigation, disease control, rolling and eventually mowing) while simultaneously other greens are still being installed. The sodding operation required two weeks to complete and approximately 1800 - 2000 man hours.

Many other projects coincided with the refurbishment of the greens. Included in these were several drainage projects, resanding of the bunkers, leveling of many tees and most notably the hybridization of the fairway and tee turfgrasses.

The fairway projects began in early June with an application of Round-Up at 5 quarts/acre, followed by extensive verticutting (4x) and aerification (4x), theses were followed by raking and blowing the remaining debris. These areas were planted with Tifway 419, on 6 inch centers at a rate of 550 bushels per acre. The most critical aspect of this operation is the need for immediate irrigation and constant dampness until established. The use of Ronstar WP is highly recommended for weed control during establishment, MSMA can be used in post emerge situations by following label directions for newly sprigged areas. Proper preparation and planting techniques, sufficient irrigation followed by weekly applications of fertilizers high in nitrogen will enable you to have surprisingly good (95 - 100%) coverage in as little as 8 - 10 weeks.

In closing, I will leave you with a few suggestions:

1 - Set goals and objectives.(allow adequate time)
2 - Consult with other professionals. (U.S.G.A., soil labs, other qualified superintendents, etc.)
3 - Communicate with membership; gain their confidence.
4 - Don't cut corners.
5 - Take pictures and keep records, share experience with others.
6 - Allow and plan time for other recreational activity away from project. Stay fresh!

PLAN YOUR WORK AND WORK YOUR PLAN

*Acknowledgements

1. Brad Kocher CGCS-Director of Golf Course & Grounds Maintenance, Pinehurst Hotel and C.C.
2. Scott Lavis-Superintendent Pinehurst #2 & #6 Golf Courses
3. Jeff Granger-Currently Superintendent MacGregor Downs C.C., Cary, N.C.

*Companies providing services; not intended as advertisement.

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USING PREEMERGENCE HERBICIDES ON IMMATURE TURF

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In this discussion, a broader interpretation to immature turf will be given by including herbicides that may be used in turf at the time of seeding, sprigging, and laying of sod or in the spring following fall seeding.

In newly seeded or established bluegrass, fescue, perennial ryegrass, Penncross bentgrass, and zoysiagrass, Tupersan 50WP (siduron) may be used for preemergence control of large and smooth crabgrass. The rate to apply is 4 to 12 pounds of Tupersan 50WP per acre or 1.5 to 4.5 ounces per 1,000 square feet. When no more than 6 pounds are used, retreat 1 month later with an additional 4 to 6 pounds per acre. We have obtained favorable control with 8 pounds of product per acre or 3 ounces per 1,000 square feet. Applications should be followed by rainfall or irrigation of 0.5 inch within 3 days in order to carry the chemical into the root zone of the germinating weeds. Tupersan is an effective herbicide to spray when seeding tolerant grasses. It may be applied at the time of seeding or before expected crabgrass germination.

Another question frequently asked is, at what time can grasses be reseeded after preemergence herbicide application. The waiting periods for selected herbicides are as follows: Balan (benefin); 6 weeks, Dacthal (DCPA); 8 weeks, Team (trifluralin + benefin) and XL (benefin + oryzalin); 12 to 16 weeks, and Pre-M (pendimethalin) and Ronstar (oxadiazon); 16 weeks. In other words, it is safe to reseed turfgrasses in the fall, if preemergence herbicides were applied in the spring.

Herbicides which are labeled for use at the time of sprigging bermudagrass, St. Augustinegrass, centipedegrass, and zoysiagrass are quite limited. However, AAtrex (atrazine), or Princep (simazine) at 1 lb/active per acre may be used for preemergence large crabgrass control and the control of certain broadleaf weeds. If needed, a second application may be applied 30 days later. Tupersan may be used at the time of sprigging zoysiagrass for control of both large and smooth crabgrass. Newly sprigged bermudagrass, centipedegrass, and zoysiagrass has shown tolerance to Ronstar (oxadiazon) applied for preemergence crabgrass control. Unfortunately, Ronstar does not have a label for this practice.

Preemergence herbicides may also be applied at the time of laying sod. It may be necessary to control emerging crabgrass within the sod or that which may germinate in the seams after the sod has been laid. We studied the effects of Surflan, Betasan, Pre-M, and Ronstar on the rooting of four turfgrass sods; Tifway bermudagrass, centipedegrass, zoysiagrass, and a mixture of tall fescue and bluegrass. We compared the effects of herbicides placed over the top of sod to the same herbicides placed below the sod. Measurements were taken on turf quality, rooting depth, and root strength which was determined by the force required to pull a square foot of sod from the soil. We observed that: the root strength and root depth of the four turfgrass sods were reduced the greatest by Surflan, intermediately by Betasan and Pre-M, and least by Ronstar which was similar to the untreated. The reduction in root strength and depth was significantly greater when the herbicide was placed underneath the sod than over top of the sod. In general, the root strength and root depth were greatest for Tifway bermudagrass and centipedegrass. Turf quality ratings ranked similar to root strength values for the four herbicides and turfgrass sods. Ronstar applied over the sods produced the least adverse effects on the establishment of the four turfgrass sods. This was also true when placed below the sod which indicated the possibility of using Ronstar when sprigging bermudagrass, centipedegrass, or zoysiagrass.

Another concern in turf management is the effects of preemergence herbicides applied in the spring to tall fescue which has been seeded the previous fall. To study this effect, we conducted one test each in 1987, 1988, and 1989. Tall fescue cultivars included Ky. 31, Rebel II, Cimarron, and Trailblazer. The herbicides evaluated were Team 2G, at 3 pounds active/A, Surflan 4AS at 2 pounds active/A, Ronstar 2G at 3 pounds active/A, Pre-M 60DG at 3 pounds active/A, and Barricade 60WDG (prodiamine) at 1 pound active/A.

Results revealed that root strength of tall fescue seeded in the fall was reduced by the spring applied preemergence herbicides in the study. Reductions were greatest for Pre-M and Surflan, intermediate for Barricade and Team, and least for Ronstar which was similar to the untreated tall fescue. Turf quality, which was rated visually, was significantly reduced by Pre-M and Surflan. This was evident by reduced stand density and vigor. Also, we noted that fumigation of the seedbed prior to seeding the tall fescue cultivars did not alter the herbicide effects on the root strength.

SOUND MANAGEMENT FOR LAWN CARE COMPANIES IN THE 90'S

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As the lawn care industry matures and markets become more competitive, survival strategies must be developed.

Presently there are approximately 6500 lawn care companies operating in the United States, of these only a handful operate regionally and nationally. The large national companies represents a small percentage of the total companies leaving the balance comprised of entrepreneurs.

In the last three to four years, many of the large companies have either been bought or they themselves have gone on acquisitions sprees. As a result of this, many entrepreneurs are having to compete against the large national companies, and are finding that they are losing their market share and margins.

If the small operator is to survive this onslaught he or she must develop a sound plan and set goals for their company to achieve. In many instances this is the key difference between the small company and the large corporation. Entrepreneurs traditionally shoot from the hip and do not develop a sound business plan. None of the large nationals leave anything to chance. They plan and develop contingency plans for their business. They force things to happen.

The small business operator has a distinct advantage over the large nationals in that they are not confined to the strict rules and policies and can react quicker to changes in the market place. If the entrepreneur can develop a sound business plan that encompasses all aspects of their business and leaves nothing to chance , then they can successfully compete and continue to grow.

A plan has to be realistic, attainable and goal oriented. If a plan will not work on paper, you can be assured of failure in the field.

EXECUTIVE GROUNDS RENOVATION

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Current assessments and renovation suggestions for the lawn area of the Executive Mansion grounds were received from Dr. Joe DiPaola, NCSU Crop Science Department, on April 3, 1987. These recommendations were immediately placed into a plan of action and combined with other projects. An extensive renovation process began under the supervision of NCDOT and NCDOA personnel and management.

Current Assessment: Turf was a mixture of bermudagrass, tall fescue, ryegrass, broadleaf weeds and bare soil with the overall turf quality being poor to fair. The shade was heavy.

Management Considerations: The lawn should be renovated and planted with a tall fescue and Kentucky bluegrass mix. Trees should be selectively pruned to improve light penetration. The landscape areas should be improved using ground covers, annuals, perennials, shrubs, etc. A weed control program should be initiated for grass and broadleaf weeds.

Renovation Procedure: Renovation included pre-emergence and broadleaf herbicide applications: glyphosate treatment in July; verticut and allow regrowth; retreat with glyphosate; seed using both broadcast and slit seeding; and fertilize and irrigate.

Maintenance Problems: Problems included foot and vehicle traffic, pigeons, bermudagrass, shade and tree root competition.

Routine Maintenance: Maintenance included irrigation as needed, proper moving height, soil tests, fertilizer applications, seeding, aerating and dethatching.

All major renovation projects were completed by January 1990 including: installation of a highly specialized irrigation system; reseeding or sodding turf areas; completed Victorian South, North Perennial, East Shade and Herb Gardens; and various planting beds throughout the area.

WEED CONTROL IN WARM-SEASON TURFGRASSES

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The goal of the professional landscape manager is to establish and maintain a vigorous high quality, weed-free warm-season turfgrass. Achievement of this goal will require the development of a two-phase weed control strategy. The first phase involves the use of cultural practices and insect and disease control programs that promote a dense, vigorous turfgrass cover. When grown in their area of adaptation and with proper maintenance, warm-season turfgrasses are highly competitive with weeds. Adherence to proven cultural practices for fertilizing, watering and mowing for a particular turfgrass species will promote vigorous turfgrass growth and aid in the prevention of weed infestations. The second phase of the weed control strategy involves the use of herbicides. When used in combination with approved practices and insect and disease control programs, herbicides can assist the landscape manager in achieving the goal of a weed-free, high quality turfgrass. However, a strict reliance on herbicides without regard to the overall weed control program will not result in a high quality, aesthetically appealing warm-season turfgrass.

Preemergence herbicide form the base of a chemical weed control program and are primarily used in the spring months for the control of crabgrass spp. and goosegrass and in the fall months for winter annual weed control. In past years, there were only four to five preemergence herbicides available for use on warm-season turfgrasses. However, there are now 16 herbicides or herbicide combinations registered for preemergence use on warm-season turfgrasses. Isoxaben (Gallery) is the newest registration and was labeled in 1989 for weed control in both cool- and warm-season turfgrasses. Isoxaben effectively controls a wide variety of summer and winter annual broadleaf weeds, but is not effective for the control of annual grass weeds. Additionally, dithiopyr (Dimension) and prodiamine (Barricade) are in the final stages of the registration process and may be available for use in 1990.

Preemergence herbicides should only be used on established warm-season turfgrasses. Newly-seeded and sprigged turfgrasses have a low level of tolerance and can be severely injured by most preemergence herbicides. An alternative to using preemergence herbicides during the "grow-in" of a warm-season turfgrass is to use postemergence herbicides. For example, MSMA, DSMA and 2,4-D are safe to use on newly sprigged bermudagrass. Sethoxydim (Poast) may be used on newly sprigged centipedegrass after 3 inches of new stolon growth has occurred. Fenoxaprop (Acclaim) is labeled for use on newly plugged zoysiagrass.

While there are many similarities, the tolerance of warm season turfgrasses to preemergence herbicides does vary among the different preemergence herbicides. Without a doubt, the herbicide label is the best reference to determine if a preemergence herbicide may be used on a particular warm season turfgrass. With the exception of atrazine (Aatrex), simazine (Princep), and pronamide (Kerb), properly timed spring applications of preemergence herbicides will control crabgrass spp. Goosegrass is more difficult to control than crabgrass. Single applications of oxadiazon (Ronstar), dithiopyr and bensulide + oxadiazon (Goosegrass/Crabgrass Control) have provided high levels of goosegrass control in experiments conducted in Georgia. Split applications, each at an interval of 6 to 8 weeks, of benefin + oryzalin (XL), oryzalin (Surflan), pendimethalin (various trade names) and napropamide (Devrinol) will also give acceptable control of goosegrass.

In contrast to preemergence herbicides, warm-season turfgrasses markedly differ in their tolerance to postemergence herbicides. For example, centipedegrass has excellent tolerance to sethoxydim (Poast); however, other warm-season turfgrasses can be severely injured by this herbicide. Additionally, cultivars within a turfgrass species may respond differently to the same herbicide. Research conducted in Georgia showed that 'Meyer' zoysiagrass had better tolerance to MSMA than 'Emerald' and 'Matrella'. The risk of injury from postemergence herbicides is greater during the spring green-up process (transition from winter dormancy to active growth) than when the turfgrass is fully dormant or actively-growing (completely green).

Postemergence herbicides can be used on warm-season turfgrass to supplement the level of control obtained with a preemergence herbicide and for the control of problem weeds such as nutsedge spp., wild garlic, Virginia buttonweed, dallisgrass and bahiagrass. Bentazon (Basagran) will control yellow but not purple nutsedge. Monthly applications of MSMA and DSMA in bermudagrass will suppress the growth of both nutsedge species. Imazaquin (Image) is useful for the control of purple nutsedge and wild garlic. In tolerant turfgrasses ('Meyer' zoysiagrass, bermudagrass), the addition of MSMA to imazaquin will usually increase the control of both yellow and purple nutsedge.

Virginia buttonweed is an extremely difficult weed to control in warm-season turfgrasses. Research conducted in Mississippi showed that 2,4-D + dichlorprop (Weedone DPC) is generally more effective for Virginia buttonweed control than other two-way and three-way broadleaf herbicide mixtures. Dallisgrass and bahiagrass can be controlled in bermudagrass with repeat applications of MSMA or DSMA. In centipedegrass, two applications of sethoxydim (Poast), each at an interval of 10 to 14 days, will suppress bahiagrass but not dallisgrass. Asulam (Asulox) will provide fair control of bahiagrass in St. Augustinegrass.

Postemergence herbicides may be used at various times during the year. Applications to weeds that are actively growing and not under drought and/or temperature stress will result in better control. Target the application to coincide with air temperatures of 60 to 90^{0} F. Applications made below 60^{0} F. can result in poor herbicide activity. Temperatures greater than 90^{0} F. increases the chance of injury to the turfgrass.

Turfgrass managers should base their decision on which herbicide to use on 1) the tolerance of the warm-season turfgrasses to the herbicide, and 2) the weed species composition of the site. Herbicide decisions based solely on cost may result in disappointing results. Careful study of turfgrass herbicide weed response and tolerance tables combined with accurate weed identification will enable the manager to limit the deleterious effects and appearance of weeds in a warm-season turfgrass.

TREE PROBLEMS ASSOCIATED WITH TURF MAINTENANCE

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The word trees is a generalized term which in North Carolina could be referring to potentially a hundred or more species and cultivars of perennial, woody plants, each of which has a particular set of biological and ecological requirements for establishment, growth, survival and reproduction. Similarly, grass or turf are generalized terms which in North Carolina could refer to about a dozen species or cultivars of generally perennial, non-woody plants, each of which also have a particular set of biological and ecological requirements for establishment, growth, survival and reproduction.

In the natural landscapes of the world, trees and grass are groups of plants that seldom occur in close, long term association in the same area or ecosystem. So, in man's "superior" wisdom, why should trees and turf be expected to coexist in a man-made landscape in a compatible relationship. As food for thought, "Why do you want trees growing in your turf?" Realizing that trees and grass do not always make for a compatible relationship, you've got your work cut out for you if you have turf maintenance contracts on properties where trees and grass are in close associations. You won't run out of work! Because in North Carolina, trees and turf in the same landscape are the rule rather than the exception, and as a result, there are tree problems associated with turf maintenance.

In order to understand why turf maintenance can cause tree problems, one needs to have a basic understanding of the root system of a tree. The majority of a tree's roots (feeder, transport and support) occur in the top 6-12 inches of the soil. Horizontally, a tree's roots can extend beyond the dripline of the crown one or two times the radius of the crown spread. Soils that are compacted, droughty, water-logged, oxygen-depleated, excessively hot and nutrient-imbalanced or-lacking prevent tree roots from developing properly.

Trees are the largest and longest lived plants on the landscape. All to often, only the largest, oldest trees are selected to remain when a natural forested area is converted to some type of man-made landscape, to including a turfed landscape. Trees with extensive roots systems in desirable undisturbed soils do not adapt well to harsh unnatural conditions of man-made landscapes. In order for trees to survive such environmental changes, special considerations must be undertaken before, not after, site conversion begins. Trees which are successful in man-made landscapes will grow and expand. If they don't; they die. This tree expansion or growth for survival, both above the ground and within the soil, can and does affect turf and turf maintenance.

During turf establishment around trees; grading, soil compaction, filling, tilling and ditching kill tree roots. Hand labor and small, lightweight equipment is less damaging to roots and soil than larger grading equipment, particularly under the crown spread of the tree. When installing irrigation, ditch or tunnel toward the tree's trunk in a manner similar to the spokes of a wheel. Never ditch tangentially across the radiating root system of a tree.

In large turfed areas with electrically controlled irrigation systems, the wiring and their current can create an artificial magnetic field that attracts lightning which can strike and kill trees. Lightning protection to protect buildings, people and valuable trees and also a properly grounded and turned-off irrigation system are necessary.

"Lawn mower blight," irrigation flooded soil, soil compaction, edging to cut intruding roots and improper pruning of shade producing limbs are some of turf maintenance activities that "traditionally" cause tree problems. High quality turf maintenance professionals should never allow these types of insults to occur to a tree or its root system.

Misuse of herbicides and soil nutrient imbalances stress and kill many trees. Reading, understanding and following a herbicide label is a must (and the law). Exercise extreme care when applying non-selective and broadleaf herbicides. Many trees are broadleaf plants too! It only makes good sense, professionally, economically, biologically and environmentally to soil test before fertilizing. Soil chemical imbalances, particularly abnormal pH's and ratios of phosphorous/calcium/ magnesium, created by improper fertilization stress and kill trees. Utilize soil testing and foliar analysis to develop tree and turf fertilization programs.

In summary, maintaining beautiful trees and turf simultaneously in a landscape requires a continuous effort that demands not only skill but also attention to the biological needs of both groups of plants.

'XERISCAPING'

Eight Ways to a Water-efficient Landscape

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Water is one of our most precious natural resources. It's also the basis for one of the most prominent environment issues facing North Carolina today. Population growth is placing an ever-increasing strain on our limited water supplies. It's estimated that by the year 2000 another 2 million people will move to N.C., and 70% of these will migrate to urban areas of the state.

Water conservation is everyone's responsibility. Records show that as much as 60% of all household water used during the summer months is used outdoors on the landscape. Unfortunately, much of this water is wasted by those who don't know how to water, when to water, how much water to apply, the most efficient methods for applying water,and the water requirements of our southern ornamental plants and turfgrasses.

Xeriscaping (pronounced Zera-scaping) has become a new buzzword in N.C. It means water-efficient landscaping. The term was coined in Colorado in 1981 and later adopted by the National Xeriscape Council in Austin, TExas. Xeriscaping requires the implementation of a series of concepts that save water in every phase of the landscape scheme - from design to installation and maintenance. Several states, including Florida and California, have modified and adopted the concepts.

To some the term Xeriscape implies cactus gardens or barren landscapes. This is simply not true. A Xeriscape is nothing more than a traditional landscape made water efficient. It does not require the sue of new or exotic plants; most of our native and introduced southern plants have high degree of drought tolerance and fit well into a xeriscape. You don't have to totally re-design your present landscape to make it more water-efficient. You do, however, need to re-design your thinking toward ways to reduce the irrigation needs of your landscape. Every landscape, whether newly designed or well-established can be made more water-efficient without any sacrifice in quality.

Since the Xeriscape concepts were originally developed for more arid regions of the U.S., some of them are not directly applicable to our N.C. soils and climate without some modification. THis publication presents the N.C. version of these concepts in outline form. Bear in mind that the concepts are all inter-related and should be viewed as a total package if you are to achieve the most water-efficient landscape possible.

N.C. XERISCAPE CONCEPTS

1. ***Proper Planning and Design:*** A xeriscape design includes the zoning the landscape into three eater-use zones: low, moderate and high. Low water-use zones require little or no supplemental water after establishment. Moderate water-use zones contain those plants that require some supplemental water during hot, dry periods. High water-use zones are limited areas in the landscape where plants are provided with their optimum water requirements at all times. These are usually the so-called "high-impact" or most visible areas of the landscape, such as the entry to a home.

2. ***Keep Irrigated Areas Small:*** As irrigated areas are decreased in size, water-use efficiency increases. Avoid irrigating areas of the landscape that may not need water, and make not of areas that can be gradually weaned to require less water.

3. ***Efficient Irrigation:*** Irrigation should be tailored to meet the needs of the plants being watered and should be operating efficiently and effectively at all times. Drip systems or micro-sprinklers are more efficient in their water use that sprinklers and should be used for ornamental plants. When using sprinklers, you can avoid excessive evaporative water loss by watering between 9 pm and 8 am.

4. ***Shade to Reduce Water Loss:*** Shade, whether it's from plants or structures, helps cool the landscape and reduces water loss. A shaded landscape can be as much as 20°F cooler than a landscape in full sun. Patios, decks, drive and walks in the landscape, should be shaded to prevent them from radiating heat and increasing water loss from the landscape.

5. ***Soil Improvements:*** When planting ornamental plants or turfgrasses, cultivate the soil in a large area. Digging a large hole when planting ornamentals improves soil structure, reduces compaction, breaks up hard-pan layers and improves the infiltration of water and essential elements into the soil. The goal of soil improvement should be to provide optimum soil conditions for best root growth.

6. ***Mulch to Conserve Moisture:*** Mulching is vital to a water-efficient landscape. It not only conserves soil moisture but also helps prevent weeds that compete for water. Mulch also reduces certain sol-borne diseases that stress plants and cause them to have a higher demand for water. The best mulches are those that area organic, fine-textured, and non-matting.

7. ***Use Drought-tolerant Plants:*** Many of our native plants and most of our introduced species, once established, are inherently drought-tolerant and can survive long periods without supplemental water. When designing a new landscape, try to save the native species when possible. They are usually well adapted to the site and have a high degree of resistance to environmental stress and pests.

8. ***Maintenance to Reduce Water Needs:*** Many cultural practices can help you save water in the landscape. For instance, during dry weather, mowing turfgrasses so that no more than 1/3 of the leaf tissue is removed at each mowing will reduce plant stress and water demand. Also, avoid shearing plants or giving plants high-nitrogen fertilizers during dry periods, because these practices encourage water-demanding new growth.

INSECT CONTROL - DOING A SAFE JOB EVEN SAFER

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Some recent articles on pesticides have put fear in the public and have distorted their perspective of the real risks associated with pesticide use. Too often these articles have played on the public's emotions and, as a result, it has been difficult to adequately educate them. However, it is imperative for those involved in turfgrass management to understand the facts concerning pesticide use and make a visible effort to demonstrate that their operation is using pesticides safely.

The recent public concern can be a selling point for IPM-type pest management programs. These programs utilize pesticides only when necessary and incorporate alternative pest controls. Reasonable posting and prenotification laws can be beneficial, because they bring the issue out in the open and demonstrate to the public that we have nothing to hide.

In order to preserve the integrity of the turfgrass maintenance industry, we must make sure we are properly applying pesticides. Be sure the product you are using is labeled for the use. Don't use agricultural chemicals in place of specialty turf products. If turf isn't on the label, then it's a violation of the law. Be sure to calibrate your equipment properly. This is a very common mistake. Applying too little often requires retreatment, and of course applying too much can cause environmental and human hazards. In addition, one must carefully follow instructions regarding the proper watering in of many pesticides.

As already mentioned, using an IPM approach to scout for insects and treating only when necessary can reduce pesticide use. When treatment is necessary, you may want to select a pesticide that is effective yet has the low human toxicity of those recommended. Various biological controls such as milky spore, parasitic nematodes, and endophyte carrying varieties are available, but recently control results with these have been inconsistent, and one really needs to thoroughly understand these before use. New equipment, such as high pressure injectors, can also make control safer by placing a fairly water insoluble product directly in the soil.

Last, one must know the pest he is trying to control. Almost all pests have one or more stages at which they are most susceptible. By making sure controls are applied during this stage, lower rates can be used and product failures will be fewer.

In the future, I'm sure we'll see new biological organisms to control insect pests as well as attractants to increase insecticide effectiveness. Until then, let's safely use what we've got so they aren't removed by the EPA due to our own mistakes.

QUICK ESTABLISHMENT METHODS FOR TURF

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Sports turfs are damaged continuously during periods of intense use. Repair and improvement in turfgrass cover is very difficult, especially on football fields, unless the facility is closed temporarily from play. Sowing pregerminated seed is a method of minimizing germination and establishment time when overseeding or reseeding cool-season turfgrasses. Although pregermination is practiced somewhat throughout the turf industry and various methods are described in popular literature, no research reports have been found in scientific literature. Pregermination treatments to minimize germination time and, thus, establishment time under optimum and suboptimum temperature regimes were evaluated for cool-season turfgrasses, which may be seeded on turfgrass athletic fields. The objective of our studies was to identify the best method of pregerminating seed before sowing for fast germination to minimize establishment time.

Italian ryegrass, which has a relatively fast germination rate, was compared to Kentucky 31 tall fescue, which has a relatively slow germinatin rate. Seed was either treated by soaking for 24 or 48 hours in aerated water, unaerated water, in gibberellic acid at 50 or 100 ppm, or by not soaking. Germination rates were compared 14 days after seed sown on blotters in petir dishes were incubated in controlled environments at daily optimum temperatures of 77 to 60 F or at suboptimum temperatures of 68 to 50 F and 60 to 41 F with an eight-hour photoperiod during the daily high temperature cycle. A germinated seedling was identified as one having a shoot when viewed with 2X magnification.

Our studies showed that pregermination before planting can significantly reduce emergence time of ryegrass and tall fescue. Annual ryegrass should be treated with 100 ppm of gibberellic acid and kept moist for 48 hours at 77 F prior to planting. Rate of seeding should be increased 30% and great care should be taken when seed is sown. Fifty percent of viable seed should germinate in 7 to 17 hours depending on temperatures after sowing. In comparison, 50% of untreated, dry seed should germinate in 4.2 to 7.1 days under the same conditions. If soaking is the preferred method of pregerminating annual ryegrass, seed should be kept in well-aerated water for 24 hours at 77 F. Fifty percent of viable seed should germinate in 3 to 6 days with this method. In comparison, dry, untreated seed should germinate in 3.6 to 7.6 days under the same conditions. If kentucky 31 tall fescue is used, seed should be treated with 50 ppm of gibberellic acid and kept moist for 48 hours at 77 F. Fifty percent of viable seed should germinate in 1.8 to 4.2 days depending on temperatures after sowing. In comparison, 50% of untreated, dry seed should germinate in 5.9 to 10.8 days under the same conditions. Kentucky 31 tall fescue seed also may be soaked in 50 ppm of gibberellic acid for 24 hours at 77 F. Aeration also should be provided if possible. Fifty percent of viable seed should germinate in 4.2 to 8.4 days depending on temperatures after sowing. In comparison, 50% of untreated, dry seed should germinate in 5.1 to 10.2 days under the same conditions.

LOW MAINTENANCE WEED CONTROL STRATEGIES

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Turfgrasses that are utilized on large areas of airports, right-of-ways, military bases, industrial sites, parks and difficult to mow sites generally have a low level of managerial input. Depending on the site, low maintenance turfgrasses may or may not receive fertilization or irrigation, and may be mowed only often enough to remove turfgrass seedheads and tall growing weeds.

The development of a weed control strategy dramatically differs for low and high maintenance turfgrasses. On high maintenance sites, such as golf courses and commercial properties, complete weed control is often necessary to satisfy the demands of the clientele that regularly use or view the turfgrass. However, on low maintenance sites, complete weed control is not demanded by clientele that view or use the turfgrass.

A low maintenance weed control strategy should include:

1. the control of tall growing weeds that may block the vision of motorists, harbor unwanted animals and that dramatically alter the appearance of the site.
2. the control of highly competitive weeds, such as bahiagrass, which if not controlled would become the dominant species on the site.
3. cultural and chemical practices that favor the release or growth of a desirable turfgrass over that of weeds or a less desirable turfgrass species.

The development of the weed control strategy begins with the identification of the predominant turfgrass that is located on the site. Turfgrasses differ in their tolerance to herbicides. Herbicides should be selected that cause minimal or no injury to the predominant turfgrass. In the event that the predominant turfgrass is not the desired species, herbicides should be selected that would release or favor the growth of the desired species over that of the predominant species. An example would be a herbicide program that favored the growth of either tall fescue or bermudagrass over that of bahiagrass.

The major problem weeds that are located on the site must be identified. Herbicides should be selected that will control the problem weeds with only minimal injury to the turfgrass. Weed response and turfgrass tolerance tables that show the response of various weed and turfgrass species to herbicides should be reviewed.

After a herbicide has been selected, the application should be timed to gain the maximum effect on the target weed species. The performance of postemergence herbicides is dramatically affected by the environmental conditions present at the time of spraying. Normal or good soil moisture, moderate air temperatures (55 to 90^{0}F.), medium to high relative humidity and low wind speed are environmental conditions that favor optimum postemergence herbicide activity. Also, avoid days where rainfall is expected on the day of postemergence herbicide application. Generally, a 6 to 24 hour rain free period will result in better herbicide activity than if rainfall occurs immediately after a herbicide application. Also, mowing should be delayed 3 to 4 days before and after herbicide application. The delay prior to treatment will increase the leaf surface area of the weed and result in better spray coverage and control. The delay after treatment is necessary to allow adequate time for herbicide absorption and translocation in the target weed species.

Postemergence herbicides are primarily used on low maintenance turfgrasses. Preemergence herbicides could be used, but cost and the lack of control for problem weeds usually found on low maintenance sites generally prevent their use. Useful postemergence herbicides for low maintenance turfgrasses include 2,4-D (numerous trade names), dicamba (Banvel), MSMA and DSMA (numerous trade names), atrazine (Aatrex), simazine (Princep) and sulfometuron (Oust).

2,4-D remains one of the most economical herbicides on the market today. While this herbicide is not effective for the control of woody type species, it is highly effective for the control of dandelion, plantains and ragweed. A tank mix of 2,4-D with MSMA is useful to control a wide range of broadleaf and grass weeds.

Dicamba is generally more effective than 2,4-D for difficult to control species such as curly dock, dogfennel and woody brush and trees. However, unlike 2,4-D, plantain(s) are difficult to control with dicamba. A tank mix of 2,4-D (1.0 lb. a.i./acre) with dicamba (0.125 to 0.25 lb. a.i/acre) is effective for the control of a wide range of broadleaf weeds.

Similar to 2,4-D, MSMA and DSMA are very economical herbicides. These herbicides control a wide range of annual and perennial grass weeds and may be used on low maintenance bermudagrass and tall fescue. On sites with a high population of bahiagrass, repeat applications of MSMA or DSMA are useful for tall fescue or bermudagrass release.

On warm-season turfgrasses, atrazine and simazine are particularly useful for the control of a wide range of winter annual weeds. The preemergence and postemergence activity of these herbicides on winter annual weeds enables them to be applied from October to February.

Sulfometuron is an extremely versatile herbicide for use on low maintenance bermudagrass. This herbicide will effectively control bahiagrass, tall fescue, ryegrass and many broadleaf weeds. Low rates of sulfometuron (0.19 oz. a.i./acre) tank mixed with glyphosate (Roundup) (0.19 lb. a.i./acre) may be used to suppress bahiagrass growth and seedhead suppression on low maintenance sites.

Regardless of the herbicide used, attention should be given to using approved cultural practices on low maintenance turfgrasses. Frequent mowing combined with meeting the fertility needs of turfgrass will improve the effectiveness of any herbicide program.

Weed Control in Bedding Plants and Wildflowers

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Weed control programs for annual bedding plants and bulbs are best planned so that applications are done immediately after transplanting. This allows use of preemergence herbicides that are listed in Table 1. Much of the safety of these materials is based on positional tolerance, thus application to transplants is safe, while seedling weeds are controlled. In addition, Poast and Fusilade can be used after the escaping grassy weeds are growing to give control. Using short residual materials is very important consideration when using short cycle bedding plants

In perennial flowers the approach is quite different since the planting will be in place for more than one season. Plant succession, that is species shifts, became a major management concern. I most cases preemergence herbicides must be applied to coincide with the peak germination periods in the fall for winter annual weeds and many perennials, or early spring to control the summer annuals. Several herbicides are useful for this purpose. Table 2 lists the herbicides and many of their registered uses for the landscapes. As with annual bedding plants, Poast and Fusilade are available for emerged grass control.

Table 1.

HERBICIDE REGISTRATIONS - ANNUAL FLOWERS AND BULBS

	Betasan	Dacthal	Devrinol	Eptam	Fusilade	Poast	Surflan	Treflan
Ageratum		F		F	E			F
Aster	F	F	E	F				
Begonia	F	F	E	F	E	F		
Candytuft	F	F			E			
Centaurea (Cornflower, Bachelor's Button)	F				E			F
Coleus		F			E	F		
Cosmos		F						F
Dahlia	F	F	E	F				F
Gazania rigens	F				E		F	
Geranium		F	E		E	F	F	
Gladiolus	F	F	F		E	F	F	F
Iris		F			E	F	F	F
Marigold	F	F		F	E	F	F	F
Narcissus (Daffodil)	F		E					
Nicotania								F
Pansy	F			F			F	
Periwinkle	F					F		
Petunia		F	E	F	E	F	F	F
Rose Moss (Portulaca)		F			E			F
Scarlet Sage		F			E			
Snapdragon					E	F		F
Sweet Alyssum	F	F			E			F
Tulip	F							
Verbena								F
Zinnia	F	F	E	F	E	F	F	F

Site Description: F = Field or landscape; C = Container; E = Either

Table 2.

HERBICIDE REGISTRATIONS - PERENNIAL FLOWERS

	Betasan	Dacthal	Devrinol	Eptam	Fusilade	Poast	Surflan	SWGC	Treflan
Achillea (Yarrow)		F			E			E	F
Ajuga	F		E	F				E	
Alyssum	F	F		F	E				
Aster	F	F	E	F					F
Astilbe					E				
Begonia				F	E	F			
Candytuft (Iberis)	F	F			E				
Carnation (Dianthus)					E	F			F
Chrysanthemum		F	E	F	E	F	F		F
Columbine		F							
Cereopsis		F			E				F
Dicentra (Bleeding Heart)		F							
Dusty Miller		F			E				F
Foxglove		F							
Gaillardia		F							F
Gerbera daisy	F		E						
Hemerocallis (Daylily)		F		F	E			F	
Liatris					E				
Peony		F							
Phlox									F
Purple coneflower		F							
Rudbeckia (Blackeyed Susan)			E						F
Salvia					E				F
Sedum	F		E	F	E		F		F
Shasta daisy	F		E		E				F
Sunflower (Helianthus)		F							
Tritoma (Poker Plant)		F							
Viola		F		F			F		

Site Description: F = Field or landscape; C = Container; E = Either

TURF WEED CONTROL UPDATE

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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 hoted from Dimension applied in the spring to tall fescue seeded the preivous 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 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.

1990 AQUATIC WEED CONTROL UPDATE

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This update briefly summarizes the results of studies conducted by the aquatic weed research unit at NCSU during 1989 including: 1) a continuation of tests begun in 1988 to determine the timing of fluridone (Sonar™) applications for control of watermeal in irrigation ponds; 2) initial testing on the effects of triclopyr amine on aquatic alligatorweed; 3) the effects of a June release of flea beetles for biocontrol of alligatorweed; and 4) a bioassay to determine the safety of fluridone-treated pond water prior to use in irrigation.

Pond studies in 1988 suggested that either of two fluridone formulations could successfully control watermeal in ponds when applied prior to the growing season. These studies were continued in 1989 to further examine the timing of application for improved efficacy.

Table 1. Effects of fluridone on watermeal - 1989 tests.

Treatment	Trt. Date	Percent Coverage May 2	Jul 3	Oct 9
Control	N/A	18	80	100
4 AS	3/30	6	9	9*
5P	3/30	13	9	0.3
SRP	3/30	4	48	2
4AS	6/14	N/A	43	0.1
4AS	8/07	N/A	N/A	33

* 1 pond flushed out; avg. w/o = 0.5

Table 1 shows that either the liquid formulation (4AS) or the 5 % pellets (5P) was effective if applied either in late winter or early spring. Similar control was achieved with 4AS applied in late spring or early summer. Control will not be attained until early July or August, regardless of the application date. Slow release pellets were not entirely effective, as the fluridone concentration in the water apparently was not high enough initially to give complete kill before the end of the growing season. This confirmed the results of the 1988 tests in which either the 4AS or 5P formulations were effective, but not the SRP formulation. Late season (fall) applications were not effective. The 1989 tests were complicated by the heavy rainfall continuing through July. This resulted in substantial outflow from a number of ponds within the first week after treatment. We concluded that fluridone would be quite effective for control of watermeal if applied in early to mid-season, provided that no substantial outflow occurred during the first three weeks after treatment. This problem could be avoided by reducing the water level about one-foot below the overflow level (i.e., top of the stand pipe, spillway, etc.) in the pond prior to treatment either by pumping or siphoning.

Triclopyr amine currently is labelled as Garlon™ 3A for use on non-irrigation ditchbanks and in other non-crop areas for broadleaf and woody vegetation control. Triclopyr amine has limited activity on grasses and most other monocots (effective on waterhyacinths, however) and is non-toxic to fish and wildlife. A 14-day water use restriction is required for irrigation. Field studies for aquatic application were conducted in 1989 under an experimental use permit. A full aquatic label is expected by early 1992. Tests conducted in three locations in 1989 indicated that this new herbicide should be as effective as glyphosate (Rodeo™ or Pondmaster™) which currently is the only effective herbicide available for use on aquatic mats of alligatorweed. Table 2 shows that rates varying from 0.75 to 4.5 lb ai/acre applied in 20 gallons of water or a 1.25%

Table 2. Efficacy of triclopyr amine on alligatorweed - 1989 field tests.

Location	Trt. Date	Percent Control 2 wks	Sep/Oct
Sweetwater Cr.	5/02	93-98*	60-77
Hertford	5/13	40-97**	regrowth
Newton Grove	8/08	90-95	90-95

* Effects similar from 0.75-4.5 lb. ai/acre, 1.25% spray-to-wet (STW) or 1.25% Rodeo™ STW.

** Rain occurred 2 hr after spraying

solution sprayed to wet (STW) gave essentially the same percent top kill within two weeks after treatment as did a 1.25% Rodeo™ solution applied STW. The initial kill was approximately the same, regardless of the treatment date, with the exception of the Hertford location, where heavy rainfall occurred within 2 hours after the last plots were sprayed. This rainfall significantly reduced the effect of all treatment rates, but the effect was most apparent on the last plots treated. The percent top kill was directly proportional to the length of contact following spraying and suggested that three to four hours contact time would be the minimum required for adequate control. Regrowth occurred in all plots, indicating that a second treatment would be needed later in the season for maximum efficacy.

A successful release of alligatorweed flea beetles occurred in Perquimans County on June 26, 1989. Approximately 750 insects were released on a 1/4 acre pond adjacent to a swamp near Hertford. The beetles successfully reproduced and destroyed the integrity of the aquatic alligatorweed mat by the end of the growing season. Successful releases of flea beetles are unusual in North Carolina, as the insects normally are not available from Florida until too late in the season to avoid the heat and dryness of midsummer. Normally, flea beetle activity from these releases ceases during the hottest periods of the summer. The success in 1989 was the result of high humidities and moderate temperatures accompanying the unusual rainfall well into July. Although the insects did effectively disrupt the alligatorweed mats, the overall effectiveness of the insects will depend on the date and severity of the first killing frost at the site. Some regrowth can be expected to occur during the 1990 growing season. The extent of this regrowth will depend upon the severity of the 1989-90 mid-winter weather.

Studies conducted in 1988 to assess the efficacy of early-season fluridone applications on watermeal indicated that fluridone may persist well beyond the 30-day waiting period required for using treated water for irrigation. Corn irrigated three months after pond treatment showed fluridone symptoms, but greened up and produced a normal yield. A more sensitive crop such as tobacco would have been unmarketable. Because of this potential problem and the need for using fluridone to control watermeal in irrigation ponds, studies were begun to determine the tolerance of sensitive crops to fluridone and to develop a bioassay to determine the safety of fluridone-treated water prior to its use for irrigation. Figure 1 shows that tobacco seedlings

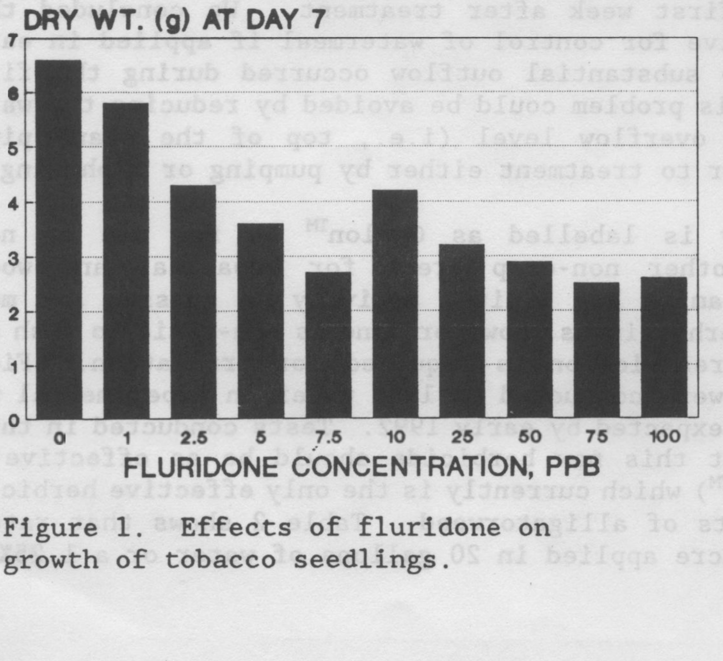

Figure 1. Effects of fluridone on growth of tobacco seedlings.

treated three weeks after planting were very sensitive to fluridone. Concentrations as low as 10 parts per billion (ppb) in the water produced bleaching of new leaf tissue and significantly reduced growth of tobacco seedlings. The bleaching occurred within four to five days after treatment and was very pronounced after seven days. Growth was substantially reduced at fluridone levels greater than 50 ppb and was slightly reduced at 10 ppb. Duckweed was more sensitive to fluridone than tobacco. Bleaching (chlorophyll loss) occurred after only three days at 10 ppb and five days at 5 ppb. Table 3 shows that new growth was significantly reduced by 10 ppb fluridone after 12 days. Chlorophyll content was depressed significantly by 10 ppb fluridone after only four days and by 5 ppb after 12 days. Duckweed should be an effective species to provide a rapid test for the safety of fluridone-treated water prior to its use for irrigation. Studies are continuing, and this concept will be field tested during the 1990 growing season.

Table 3. Effects of fluridone on duckweed - 1989 tests.

Treatment rate, ppb	New Growth mg Dry Weight Day 4	New Growth mg Dry Weight Day 12	Chlorophyll mg/g Dry Weight Day 4	Chlorophyll mg/g Dry Weight Day 12
0	5.1	20.6	3.0	6.6
1	4.2	18.1	3.3	11.2
5	4.1	19.0	2.8	4.8
10	3.4	15.1	1.9	3.2
50	3.3	12.2	3.0	2.6
100	3.2	11.0	2.5	2.2

TURFGRASS DISEASE CONTROL UPDATE

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Fungicides were evaluated for the control of brown patch on tall fescue and bentgrass, dollar spot on bentgrass and spring dead spot of bermudagrass in 1989. Pythium species were isolated from bentgrass with Pythium root and crown rot, were identified to species and were tested for sensitivity to fungicides in the laboratory.

Fungicides for the control of brown patch on tall fescue were evaluated on a one-year-old stand of tall fescue on a sod farm near Raleigh. Brown patch was severe in 1989 with the check plots having 90% of the area with brown patch in August because of the very wet and warm weather. All of the treatments were significantly better than the control in August. Fungicides tested included Banner, Bayleton, Chipco 26019, Daconil 2787, DPX-965, Lynx, Manzate 200, RH 3866, Prostar, Rubigan, SAN 832, SAN 619 and Tersan 1991.

Dollar spot and brown patch control on bentgrass was evaluated at the Turf Field Center in Raleigh in 1989. Good control of dollar spot was obtained with all fungicides except Prostar. This result was expected because this new fungicide is very specific for basidiomycete type fungi such as the fungus that causes brown patch. It gave very good control of brown patch. Several new unlabelled fungicides gave excellent control of both dollar spot and brown patch on bentgrass and did not cause any phytotoxicity. The future development and label approval of these new fungicides will make more chemicals available for the control of dollar spot and will provide chemicals that will give better brown patch control.

Spring dead spot control was evaluated on a Tifton 419 bermudagrass fairway near Pinehurst. Spring dead spot was severe in the area in 1988 and was servere again in 1989 in the check plots. Rubigan, Tersan 1991 and Banner treatments resulted in significantly less spring dead spot than in the check plots. However, Rubigan applied in September gave the best control which was in part due to faster regrowth of bermudagrass over the affected spots in the spring of 1989.

<u>Pythium</u> species were isolated from bentgrass with root and crown rot from many golf greens in 1989. Ten different species were isolated and 50 isolates were identified to species. The isolates were tested for sensitivity to five fungicides that have been reported to be effective against different <u>Pythium</u> species. The most significant result was that the species varied in their sensitivity to the fungicides. Most of the isolates from bentgrass with Pythium root and crown rot were not sensitive to Subdue. The sensitivity of isolates to Banol and Teremec SP was variable. All

of the isolates of all the species were sensitive to Koban and most were sensitive to Fore. An isolate of Pythium aphanidermatum that causes Pythium blight was sensitive to Subdue, was less sensitive to Banol and Fore and was not sensitive to Teremec SP.

The use of the word sensitivity indicates that these fungi have never been sensitive to some of these fungicides because many of the isolates came from areas where these fungicides have never been used. The use of the word resistance would indicate that these fungi had developed resistance after long periods of exposure to these chemicals. The sensitivity of these fungi to Koban is the basis for recommending this fungicide in a preventative program to help control Pythium root and crown root on bentgrass. Additional research is in progress to evaluate the importance of these fungi on bentgrass and the effect of these fungicides on the diseases caused by these fungi.

THE TURFGRASS COUNCIL OF NORTH CAROLINA, INC.

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

PURPOSES AND OBJECTIVES

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

ACTIVITIES

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

MEMBERSHIP

Individuals interested in turfgrasses, representatives of turf related organizations, and sales representatives of turf products are encouraged to become members. Dues for individuals are $30 per year. Sustaining memberships at $75 are also available. Membership application forms are printed in the North Carolina Turfgrass News. Additional information can be obtained from Mr. R. L. Robertson, Executive Director of the TCNC (P.O. Box 5395, Cary, NC 27511, phone 919/467-1162).