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OF THE
18TH ANNUAL NORTH CAROLINA TURFGRASS CONFERENCE

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Sponsored by

Turfgrass Council of North Carolina

North Carolina State University

North Carolina Agricultural Extension Service

PREFACE

Proceedings of the 18th Annual North Carolina Turfgrass Conference are being provided to those who attended the conference to serve as a permanent reference of the many presentations. The 1980 Conference was held at the Inn on the Plaza in Asheville, NC on January 9, 10 and 11. Concurrent sessions for golf courses and general turfgrass topics were part of the conference. The attendance of 250 persons resulted in a very successful conference.

Special thanks are extended to all persons whose efforts made this conference a great success. Each speaker is to be commended for his excellent presentation and for providing a written summary for these proceedings. The Annual Turfgrass Conference is sponsored by the Turfgrass Council of North Carolina, Inc., North Carolina State University, and the North Carolina Agricultural Extension Service in cooperation with the Turfgrass Associations. The efforts of the following committees contributed to the success of the Conference.

Conference Chairman - W. B. Gilbert

Program Committee

Carl Blake	John Hilton	Jim Welch
Dale Blazer	Charlie Jordan	Leon Lucas
Mac Crouch	Monty Moncrief	Les Kuykendall
Joe DiPaola	Bob Robertson	

Local Arrangements

Les Kuykendall
Charles Fierke

Advertisements

Doug Miller

The 1981 Turfgrass Conference will be held in Raleigh, NC, in January.

PROCEEDINGS EDITORS: L. T. Lucas and J. M. DiPaola

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Additional copies of these proceedings are available from Dr. L. T. Lucas, Department of Plant Pathology, N.C. State University, Raleigh, NC 27650.

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MAINTAINING THE GROUNDS AT BILTMORE ESTATE

Tim Tielke
Biltmore Estate
Asheville, NC

The grounds at Biltmore Estate provide visitors an opportunity to see a wide variety of grounds maintenance under way at just about any time of the year. The grounds include a 4 to 10 acre shrub garden, 12 acres of rare azaleas, a large conservatory and greenhouse complex, a 4 acre formal walled garden, with a large rose garden included, and a budding viticulture project.

Biltmore estate employes 100 to 150 full time workers, with 30 to 50 of these directly related to the grounds maintenance program. Crews are given specific areas to work in, but are shared with each other as particular needs arise.

The large front lawn area, which covers about 4 acres directly in front of the house, was completely reworked about 5 years ago, which involved removing the sod completely from the area to eliminate several weed problems, installing a solid set irrigation system, and resowing the lawn to Flyking Kentucky bluegrass, and mixing it with creeping red fescue to handle sunny areas and heavy foot traffic. The formal lawns are clipped twice a week in a pleasing pattern, the importance of using sharp blades being a top consideration.

The importance of turf on Biltmore Estate is obvious after a visit, as all horticultural plantings are accented by about 300 acres of healthy green grass. The beauty of flowers, shrubs, trees, and building would be greatly diminished if it were not for the carefully tended sod in these areas.

The Shrub and Azalea Gardens are maintained by a crew of 4 to 6. Both have the widest variety and best maintained plants of any privately owned complex of their kind. Many who come to the Estate in the spring come especially to see the remarkable beauty and variety of the wild azalea collection.

The conservatory and greenhouse complex provides year-round horticulture for those interested in the beauty of plants. Over 200 genera are represented in the indoor gardens, and are maintained by a crew of 3 to 7. All indoor cut flowers, spring bedding plants, Christmas poinsettias, fall mums, and other seasonal and specialty crops are also grown including cactus, fern, and orchids.

The formal Wall Garden and Rose Garden is a center of interest 7 to 8 months out of the year, requiring 5 to 7 employees. There is always something blooming at any one time of the growing season,

offering visitors a dazzling display of floral color regularly. Tulips, annuals, and chrysanthemums are grown in an endless yearly cycle, and over 70 varieties of roses are grown, with a total of over 3000 bushes tended. A wide variety of perennials and ground covers are also grown.

The newest development at Biltmore Estate is viticultural research. Besides being one of the largest wineries in the East, Biltmore Estate, if successful, will be the first to cultivate Vinifera grapevines with commercial success in the area. It is believed that "Chateau Biltmore" will compare with the finest wines available in the United States.

These are only some of the many facets of grounds maintenance at Biltmore Estate. Diversity is the name of the game, and accounts for the impressive effect of the total attraction.

PARKS AND RECREATION IN ASHEVILLE

Ray L. Kisiah
Director, Parks and Recreation Department
Asheville, NC

Parks and Recreation Departments have evolved down through the years from being a playground with a whistle-tooting, tennis shoed, sweatshirted recreation leader to departments of local governments which comprise several facets of services to the residents of their locality. Here in Asheville we have what we like to consider a comprehensive Parks and Recreation Department including among other things twelve recreation centers, 23 playgrounds, 14 neighborhood parks, 76 street medians, traffic circles, etc., the maintenance of all street trees, an approximately 85-acre cemetery, a golf course, an amusement park and a 5,000-acre natural area known as Bee Tree Lake. Our annual operating budget is now approximately $2,300,000 and we have spent more than $7 million in the past eight years rebuilding our park system here in Asheville. Bee Tree Lake Park has an annual operating budget of about $145,000 and includes a 55-acre trout lake, a 53-site camping area, a swimming pool, picnic facilities and, to the best of our knowledge, the only municipally operated trout hatchery in the United States. We buy trout eggs from the Oregon area and raise fish from the eggs to the adult size trout which are then released into the lake for, we hope, catching by the fishermen. In addition, we have the maintenance and operation of the Memorial Football Stadium, a professional baseball field and other special facilities such as the downtown Pritchard Park, the rose garden in the northern section of the city, and as was previously mentioned, an 18-hole golf course.

Our golf course revenues as well as expenditures are approximately $125,000 per year. We have just recently made some rather extensive improvements to our golf course, including the construction of a 50' x 100' maintenance building, the installation of a 12-foot high chain link fence along an adjoining highway and the installation of 4" x 6" x 5' posts in the ground to prohibit cars from coming onto the golf course. Some of you in the audience may remember that we used to have a great problem of cars coming off Highway 81 and various side streets onto our fairways and indeed it seemed at times that our fairways were a favorite picnic spot for visitors to Asheville. To give you an indication of the kind of condition our golf course was in, about six years ago we fertilized our fairways for the first time in 41 years. Now, under the very capable leadership of Mr. Jack Pennell, our Golf Course Pro-Manager, we are very proud of the excellent condition of our golf course. We still have a great deal to do to the golf course and have long-range plans for such items as increasing the size of the tees, installing water lines in the fairways, and others, but we believe that under Jack Pennell's excellent guidance we now have one of the better municipally owned golf courses in this area.

Our department is also somewhat unique in that we do our own park design, park construction and landscaping. Mr. Dick Meehan, our Superintendent of Parks, is a very capable and efficient individual. His degree, in fact, is in Civil Engineering and his capabilities have enabled us to develop our own construction crews. Mr. Ken Kendall, our Landscaping Foreman, is a graduate of Haywood Tech and we are very proud of the excellent work which he and his crew have done throughout our park areas. In all, the Asheville Parks and Recreation Department maintains approximately 1,000 acres of developed parkland. In order to accomplish the efficient and productive maintenance of these areas, we have had to rely heavily upon the use of mechanized equipment. An example of this was the purchase of a Lely turf shaper from Les Kuykendall of Porter Brothers. With this and other types of equipment, we have effectively reduced the number of man-hours required to maintain the various park areas, even though we have added considerably to the amount of acreage maintained.

We are delighted that you are holding your annual Turfgrass meeting in Asheville and sincerely hope that you will be able to come back and visit with us again and enjoy some of the many recreation opportunities afforded by this area.

SOIL TEST RESULTS

Carl T. Blake
Crop Science Extension Specialist (Turf)
N. C. State University
Raleigh, NC

The human eye, or other senses, cannot detect the chemical content of most soils (except sterile sand). However, in order to grow turfgrasses we must know the content and availability of some chemicals in soils. The Agronomic Division, North Carolina Department of Agriculture, Blue Ridge Road Center, Raleigh, North Carolina, tests soil without charge. Turf managers must use such services if they intend to compete with the better managers and if they expect their non-native turfgrasses to compete with native species (crabgrass, crowfoot, etc.).

The North Carolina soil test will give pH which is the most common measure of soil acidity or alkalinity. However, it has recently become known that pH alone is not sufficient for adjustment of acidity in all soils. As a result, the acidity factors (Ac) are measured and reported in the Ac block. The total Ac value being roughly equal to the dolomitic limestone required per acre to bring the pH to the proper range. The remainder of the blocks under "Test Results" are test values giving the level of plant nutrients found or other fertility measures. The values will be indexed so as to be uniform and to relate to plant production in a quantitative way. In general, values of 25 or less are considered low, 26 to 50 medium, 51 to 100+ are high.

The Phosphorus Index (P-I) gives the level of P found in the soil. Values less than 100 are of concern in predicting the need for fertilizer phosphorus. The Potassium Index (K-I) measures soil K and may exceed 100. But, as with P, values less than 100 are used for fertilizer potassium recommendations. Calcium (Ca-%) and Magnesium (Mg-%) are measured and shown as percentages of the total cations (positively charged elements) in the soil. Manganese (Mn-I), zinc (Zn-I), copper (Cu-I), and Sulfate sulfur (S-I) are shown as index values which are, or may be, used to predict the need for adding these elements as fertilizers.

For most situations suggested treatment will deal with fertilizer suggestions for phosphorus (P) and potassium (K) since these elements are required in vastly greater amounts than other elements. Single or split applications are not given -- the manager and the condition and quality desired dictate this. For turfgrasses nitrogen (N) applications are given in special notes so as to try to take into account the different grasses and their different nitrogen requirements; the different types of turfgrass installations; the different rate of growth, condition, and quality demanded; etc. Of course, no person can answer all the above differences in sterile note. The "eye of the master", the manager, must make these nitrogen decisions. Lime suggestions are also given.

The importance of liming cannot be overstressed. Lime modifies the pH to the proper level for the particular turfgrass being used and lime supplies both calcium and magnesium (dolomitic) for grass growth and survival.

Other treatment suggestions normally will be used in problem-solving and may not be given on all sample reports.

In conclusion, the soil test report gives the results of chemical testing of the soil. No eye or finger can do these tests. We have the best tool available. Use it! Or, the natives will win!

SMALL GREENHOUSES AND PLANT PROPAGATION

Tommy Anderson CGCS
Carolina Country Club
Raleigh, NC

It was the desire of the Board of Directors of the Carolina Country Club to beautify to a greater and more meaningful degree the entire property of the club.

In June 1976 we built a 14 x 40 foot propagation greenhouse with an automatic misting system. The greenhouse was constructed with 1/2 conduit pipe and covered with 4 mil. clear plastic.

To get our initial stock we asked our members to prune their azaleas between June 15 and August 1, and bring the trimmings to us as soon as possible. This worked very well, maybe too well. We got more cuttings than we knew what to do with. Therefore, I would suggest that any of you who would be interested in trying this approach be very selective in the variety of plants you choose. Plan ahead and know what varieties do well in your area. There are varieties that bloom in April, mid-season varieties bloom in May, and late varieties in early June. Some varieties grow 18", other 5' in height.

Propagation. To begin plant propagation fill wood or plastic trays with a 50-50 mix of peat moss and pearlite. A small cement mixer works fine for mixing. Fill trays level with mix and dampen down with light sprinkling of water to settle the mix. Take 3" cuttings of new growth, strip 1/3 of leaves, pinch buds from top, and dip the bottom ends in a rooting hormone, such as Rootone, which can be purchased from local garden centers. Place cuttings in rooting media and sprinkle again with water and place under mist in the greenhouse. Plants are usually well rooted at the end of three months at which time they are ready to be transplanted into 3" pots and kept in the greenhouse until spring. They can then be transplanted to larger pots in outdoor growing area or planted directly in prepared beds. After plants are potted into 3" pots they should be fertilized once a week with a 21-7-7 liquid fertilizer and kept checked for insects and disease.

PESTICIDE STORAGE AND SAFETY

Harry DuBose
Catawba Valley Technical Institute
Hickory, NC

The potential seriousness of health and environmental hazards due to improper use, storage and disposal of pesticides became clear in the late 1960's. In 1968 it was estimated that 665 million pounds of pesticides were being used in creating 240 million spent containers to be disposed of in a manner safe to the environment and general public.

As a result of these concerns and hazardous potentials to our general populations, many laws were passed to insure safeguards. Among the laws were North Carolina Pesticide Law of 1971 and the Federal Insecticide, Fungicide, and Rodenticide Act of 1972 better known as FIFRA. The main parts of these laws which concerned applicators the most were:

That all pesticides must be classified as either general or restricted use.

That you were required to be certified as competent to use any of the pesticides classified as restricted use.

That penalties were established for people who do not obey the law.

Most of you have now been certified, through the diligent work of Mr. Bob Robertson and others at N. C. State. During the original certification process, we at Catawba Valley Technical College hosted several training and licensing sessions with many of you and our students attending. After these sessions, students attending made numerous comments about inadequate and unsafe storage facilities on our campus. We had realized this situation for some time and decided to put together what we felt would be a sound proposal for our administration and board of trustees.

In April of 1974 we contacted the North Carolina Department of Agriculture and the Environmental Protection Agency for further guidance. The following major guidance was given and is also contained in the May 1, 1974 federal register (Volume 35, Number 85). Our facility, which I will use as an example, was completed and occupied in 1977.

Pesticides should be stored in a dry, well ventilated, temperature controlled, separated room, building, or covered area where fire protection is provided.

Unauthorized entry should be provided by a climb-proof fence and doors and gates should be kept locked to prevent unauthorized entry.

Provision should be made for decontamination of personnel and equipment. Where feasible, a wash basin and shower with a delayed closing pull chain should be provided.

All contaminated water and runoff should be treated as excess pesticide. Decontamination area should be paved or lined with impervious materials.

Realizing that even the best of facilities improperly used and maintained are hazardous, we have strived to adopt and adhere to the following operating procedures for all persons storing, selecting, mixing, applying, and disposing of pesticides:

All persons shall thoroughly read and understand the label prior to performing any of the above.

In selecting a pesticide, use the least toxic material that will control the pest.

All containers should be stored off the floor in rows with the labels plainly visible and isles between the rows for easy access and inspection.

All pesticide containers shall be inspected upon receiving and periodically thereafter to insure against leakage and corrosion. No pesticide container found to be faulty will be accepted. If leakage or corrosion occurs while in storage, the material will be transferred to a larger, safe, sound, and suitable container and be labeled appropriately.

Absorbent materials such as absorptive clay, hydrated lime, household bleach, sawdust, or vermiculite will be kept on hand and used to treat spills and leakage.

Inventories and records of pesticides stored and used will be maintained as required by law especially in regard to restricted use pesticides.

No smoking, eating, drinking, or using tobacco is permitted when pesticides are present.

While mixing and applying pesticides bearing the signal words DANGER, POISON, and WARNING protective clothing and respirators will be worn. Clothing will be cleaned regularly with a strong detergent and chlorine bleach. Filters in respirators will be replaced as specified by the manufacturer.

Application equipment including nozzles will be checked thoroughly for proper operation, using water, prior to incorporation of any pesticide into the tank.

Non-degradable pesticide containers will be rinsed three times dumping the rinsings into the tank.

Used containers will be kept in the storage area until properly disposed of or moved for reconditioning.

All areas and equipment will be thoroughly cleaned after each use.

In case of an accident and an emergency exists retain used pesticide label, call emergency room at Catawba Memorial Hospital (322-0850, 0851, 0852) or Chemtrec (800-424-9300).

In case of fire call the Fairbrook Fire Station (464-3112) and inform them of the types and amounts of materials currently stored.

These are some of the simple rules we follow in order to do our part in pesticide storage safety. I feel that if we all will truly realize that pesticides are dangerous and treat them as such we will continue to have these necessary and useful products available when needed.

LANDSCAPE MAINTENANCE: "GETTING THE RIGHT JOB DONE AT THE RIGHT TIME"

M. A. Powell, Jr.
Extension Horticulture Specialist (Landscaping)
North Carolina State University
Raleigh, North Carolina

The most important rule of landscape maintenance is getting the right job done at the right time. As will be pointed out several times in the following paper, timing is the critical factor in carrying out nearly all maintenance practices for trees, shrubs and turf in the landscape.

The landscape maintenance schedule is the guide for executing maintenance practices at the correct time. A well-developed schedule permits the superintendent to use his work crews with the greatest efficiency. It allows him to plan for equipment use and repair and helps in ordering supplies well in advance of the time they will be used. Another added benefit of a well planned and followed schedule is that a maintenance budget can be developed for a site. Often this will be the deciding factor in future operations.

Several topics will be discussed for the maintenance of landscape plants. Probably one of the most important but neglected or misunderstood maintenance practices is pruning. The first key to proper pruning is knowing the character of the particular plant in question -- i.e. is this plant supposed to grow with a weeping effect, or is the texture supposed to be coarse, etc.?

Knowing the whys, whens, and hows won't hurt either!

PRUNING:

I. WHY?

1. Improve health of plant by removing dead and diseased wood
2. Reduce size
3. Shape the plant
4. Increase flower display
5. When transplanting to reduce shock
6. Special effects: topiary
   espalier
   "tree form"

II. WHEN?

General recommendations

1. Broadleaf and narrowleaf evergreens should be pruned during their dormant season. This should be an annual maintenance

function on most evergreens. This is especially true for the narrowleaf ones as these cannot tolerate a severe pruning. In North Carolina the dormant period is mid-late November - late February - early March (e.g. respectively Chinese holly and pfitzer juniper).

2. Spring flowering trees and shrubs should be pruned immediately after flowering. Pruning late in the year will reduce the number of flower buds for next season as the buds were formed on the previous season's growth (e.g. azaleas).

3. Summer flowering shrubs should be pruned in their dormant period. The flower buds on these plants develop on the current season's growth (e.g. hydrangea).

4. Fruit or berry producing shrubs should be pruned lightly each season after fruit production. The flower reproduction will only be reduced slightly for the following year (e.g. nandina).

III. HOW?

Knowing what pruning does will help you decide what and where to cut. Pruning causes a local stimulation of dormant buds. New shoots will develop from buds immediately below the cut. Cutting back to a side bud will stimulate development of several lateral branches and will result in a more compact plant.

Modern trends in landscaping call for the "natural" look. Landscape plants should be chosen because of a particular characteristic -- such as shape, form, color, texture, and size. A plant should be pruned to enhance this natural beauty and accentuate its particular landscape features. Proper pruning can only be accomplished by having the appropriate pruning tool, the knowledge and how to use it, and an awareness of the natural growth habits and characteristics of landscape plants.

PRUNING TOOLS

I. HAND PRUNERS

a) hood and anvil
b) blade and anvil

II. LOPPERS

III. SAWS

a) light weight folding saw
b) bow saw
c) curved saw
d) telescoping extension saw
e) chain saw

MULCH

Another important aspect of landscape design and maintenance is the use of mulch. Don't be stingy with the mulch and make an area too small, by cutting the boundaries too close to the trees or shrubs. Incorporate and area that is at least 18"-24" beyond the drip line of the shrubs. This will give the bed more depth and minimize damage to plants by fast moving lawnmowers!

Before spreading the mulch try to get rid of all bermudagrass, broadleaf weeds, fescue and nutsedge. It's true a 3" to 4" layer of mulch will control weeds -- but not by just piling it on top. Identify the weeds and eradicate physically or chemically. Several herbicides are labeled for home use on most weeds. Dowpon, Roundup, or Varsol (depending on the size area you are working with) are readily available without a pesticide license. Be sure to observe label directions and avoid drifts by applying at low pressure.

Now to decide on the type mulch to use. Again, the trees are an influencing factor. Under pine trees mulch with a 2" to 3" layer of pine straw. Under hardwoods and small ornamentals you might consider a 2" to 4" layer of decayed bark. This is readily available at many landscape nurseries or large sawmill operations. Other recommended organic matter would be decayed sawdust, compost, leaves, grass clippings, etc. Again, the good part about these natural areas is that when the needles and leaves fall it adds to the mulch and compliments the area with little maintenance time.

Black plastic is used as a mulch -- usually in conjunction with some type organic matter. There are several advantages and disadvantages when using plastic. Most weeds will not come through the plastic. The plastic might be pushed up a bit, but the weeds will eventually die. Black plastic helps prevent crusting of soil and leaching of nutrients by rainfall. Plastic lasts from 3 to 5 years before needing to be replaced and also helps retain moisture in the soil.

The plastic is made in strips that can be rolled out and walked on with flat-heeled shoes. It should be weighed down with soil at about 5 ft. intervals to keep from blowing. Don't try to plant trees and shrubs and pull the plastic up to the plants. The idea is to spread plastic then plant through it. The plants can be set through slits cut in the plastic.

There are a few disadvantages when mulching with plastic. If a slope is to be mulched the plastic is not recommended as the organic matter on top can be easily blown or washed off. If you are mulching over bermudagrass or nutsedge -- get it out first. Otherwise the bermudagrass will find its way to the planting slits and grow out and the nutsedge can puncture the plastic as it grows. Sometimes in hot weather the heat buildup near newly planted shrubs can be excessive.

FERTILIZATION

North Carolinians are offered the free service of soil testing. This applies to the farmer, home gardener, and commercial landscape contractor. A soil test will determine the exact nutrient requirements for a particular plant to be grown in a particular soil. Additional information includes existing pH, desirable pH, organic content, and trace elements. Soil kits are free from your local county extension office. Results are available within a week to 10 days. So take the guess work out of fertilizing -- it could save you time, effort, and money and could just save your plants.

Most North Carolina shrubs and ground covers require an annual fertilization. A properly fed plant displays healthy foliage, abundant flowers or fruit, optimum stem and shoot growth and is more resistant to disease and insect attacks. Whereas many landscape plants are not being grown in fertile, well-drained soil, where they could survive without added nutrients, a proper fertilization schedule is recommended.

Commercial fertilizers containing nitrogen (N), phosphorus (P) and potassium (K) along with essential trace elements are used to supply nutrients. The percentage of nutrient elements contained in the fertilizer is represented by 3 numbers in the formula. A 5-10-10 formula contains 5% N, 10% P_2O_5, and 10% K_2O. Thus 100 lbs. of 5-10-10 contains 5 lbs. N, 10 lbs. P_2O_5, and 10 lbs. K_2O.

Several indications that plants are hungry are when: the branch growth is shorter than usual; a large amount of dieback and foliage loss; and off-color foliage; the foliage is smaller than normal; the plant is infested with disease and/or insects.

Consider the soils when fertilizing. Most landscape plants require good drainage, and sufficient organic content in the soil. If the soil is heavy clay, add sand and organic matter (bark) to aid in aeration and drainage, along with mounding the plant. Also, if the soil is sandy, add equal parts of organic matter and topsoil to aid in fertilizer and water holding capacity.

The pH of the soil should be considered. A soil test will determine this. Most garden soils are naturally acid and over the years the soil will become more acid with the accumulation of organic matter in the soil. Many plants require an acid soil (4.5 to 6.0). The acidity can be increased by adding aluminum sulfate or sulfur. Again soil tests will determine the amounts.

An important aspect to remember in applying fertilizer is this -- fertilizer will not solve problems caused by improper planting, watering, or poor drainage.

Organic vs. Inorganic Fertilizers

Organic fertilizers are derived from plant or animal substances. Inorganic fertilizers are mined from mineral deposits or obtained through complex manufacturing processes.

The major advantages of organic fertilizer is its slow release capability. The material must be decomposed in the soil to become available to the plant, thus reducing the possibility of fertilizer injury. The major disadvantage is the cost and availability.

Organic Fertilizer	Analysis	Lbs. # 100 sq. ft.
Dried blood	13-1.5-0	3
Bone Meal	4-22-0	5
Stable manure	.5-.5-.5	20-30

Inorganic fertilizers are available which have slow-release capabilities. The source of nitrogen breaks down slowly over a period of months. This is desirable for even distribution of N and also reduces the possibility of burning the plant.

General Fertilizer Schedule

Broadleaf and Narrowleaf Evergreens: Fertilize broadleaf and narrowleaf evergreens with a complete fertilizer such as 8-8-8, or 10-10-10. Use 2 to 4 lbs. over 100 sq. ft. of bed area. The fertilizer may be split into two applications: 1/2 in early spring and 1/2 in early summer.

Deciduous Shrubs: Fertilize this group of shrubs in early spring with a complete fertilizer. Use 2 to 4 lbs. of 8-8-8 or 10-10-10 per 100 sq. ft. of bed area.

For Specimen Shrubs: Use 1 to 1-1/2 lbs. of complete fertilizer 8-8-8 or 10-10-10 per plant. The fertilizer may be split into 2 or 3 applications from early spring to midsummer.

Ground Covers: Apply 1 lb. of 8-8-8 or 10-10-10 per 100 sq. ft. in early spring and again (1 lb.) in early summer. Remove all fertilizer from foliage of ground over plants by watering or brushing.

One can readily see that a well maintained landscape does not come easy and take care of itself. Knowledge of plants, chemicals, and equipment are all contributing factors, but the most important is personnel. Every attempt should be made to keep employees up to date with the latest trends and developments by encouraging the person to attend workshops, short courses, read pertinent publications and possibly develop their individual skills as a landscape maintenance professional.

UPDATE OF TURF ACTIVITIES AT NORTH CAROLINA STATE UNIVERSITY

B. E. Caldwell, Head
Crop Science Department
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Raleigh, NC

This presentation is an attempt to review the changes that have occurred in our turf program during the past four years. I can say we, because what has been accomplished could not have been done without the support of the Turfgrass Council and the Turfgrass Industry. When I say that we have come a long way, we must remember where we began. In 1975, the turfgrass research and extension program at N.C. State University was a very poorly supported program. This is not a reflection on the project leaders or the administration. It is an indication of the priority given to turf research and extension at that time. I want to also say that the status and accomplishments of turf research today is due in most part to the ability of the faculty involved in turfgrass to take the little and do a tremendous job in support of an industry. This group has served as an excellent nucleus for the establishment of an expanded program. Let's look at the three areas of research, extension and teaching and see what we have accomplished.

First, let us look at how we have grown. We have grown not only in dimension and numbers, but also in expansion of program activity. We are no longer serving any one particular clientele but are trying as best we can to serve the entire turf industry in North Carolina. Our biggest boost in support came in 1977 when the legislature gave us a sizeable increase in our research effort. We obtained two positions, one in turfgrass physiology assigned to Crop Science and one extension-research position assigned to Plant Pathology. With these positions came additional funds for support of graduate students and technical help. Joe DiPaola is our turfgrass physiologist, and you know L. T. Lucas and what he is to our program and the potential that his program has for solving problems. Over the past four years we also obtained monies from turfgrass associations. In addition, we have obtained the loan of equipment from Porter Brothers (Cushman) and E. J. Smith & Sons (Toro). John Dutton and John Lawrence assisted in the design of the irrigation system for the Faculty Club turf area. We are on the move.

Very briefly, these are some of the areas we are about in research. Dr. Gilbert will continue his work in management, nitrogen, fertilizers, and those management factors that are needed for turfgrass, and will

continue his work in the variety and species evaluation--looking for better turf species. Dr. DiPaola will begin his program in turfgrass physiology by looking at things such as cold hardiness, root growth, environmental effects on management, and water stress. I want you to understand that we have only one turf program in Crop Science and Dr. Gilbert and Dr. DiPaola work together in this program.

Dr. W. M. Lewis (25% turf research and extension) continues his efforts in the evaluation of the effectiveness of herbicides, in determining the effects of herbicides on growth of turf, and in looking at both growth regulator effects of herbicides and their interactions. His efforts, as you know, have led to the clearance of Sencor as a herbicide to be used in controlling some problem weeds.

Dr. Lucas' (50% research-50% extension) program has intensified on spring deadspot and nematodes. I feel we are one of the leaders in the country to work in these areas.

Because we know so little about nematodes, we need research on nematode damage as well as effective control. We also need to know more about the fungi, such as the fungi causing fairy rings and the fungi relating to the brown patch diseases. We need to know more about the spectrum of turf diseases in North Carolina -- where they are, what are their importance, what are their hosts, and what grasses and species are involved.

We do not have an entomological research project. Dr. Robertson does applied research as part of his extension program. He has replicated trials on pesticides, mole crickets, eastern seed corn beetle, masked chafer grubs as well as cutworms. I hope that one or more entomologists of the Department of Entomology will investigate some of the problems that face the turf industry.

I am going to give you a list of some of the things that we have done to improve our facilities. We are in the process of expanding the research area at the Faculty Club from about 1.4 acres to 8.4 acres. We have constructed and established a 9,000 sq. ft. bentgrass research green, established about 1,000 sq. ft. of fescue cultivars, and established a shade adaptation research area. We have constructed a pump house, completed the design of the turfgrass irrigation system, and we are in the process of ordering the equipment. We are very pleased with industry response to provide the equipment and material needed at reduced prices. We received a $15,000 increase in our regular budget from the Director of Research to buy laboratory furniture for the Turf Physiology Lab. Seed has been provided by the industry for our overseeding studies.

We have begun a new project with a grant from the N. C. Department of Transportation. This is a cooperative program to study the ecology of North Carolina in terms of grasses and companion crops. Our goal is the development of grass, legume combinations that will persist, and require minimal management, and still contribute to the beauty and stability of the soil. Although this program is aimed primarily at highway roadsides, there are many areas around golf courses, cemeteries, and industrial sites that could benefit from similar management. We feel that this is a needed dimension of our program and this grant allows us to pursue this area of research.

We do want to move forward and in the future complete many of the projects we have begun such as the irrigation system, plot area, and shop and laboratory facilities. We can then devote full time to our research programs.

In summary, you can see how the research program has grown and that we have moved forward rather boldly for the past couple of years.

Our extension program has progressed in a similar way. We have one of the best turf extension programs in the United States. We have quality people who know the turf industry and its problems. Dr. Blake received additional funding from the legislature, and he has expanded all the activities. His objectives have been primarily to demonstrate climatic and soil adaptation of turfgrasses. He has worked to increase the confidence and competence of county staff to deal with turfgrass problems and to provide information on the management of turfgrasses. On-site demonstration plots have been increased throughout North Carolina. There are demonstrations on species and varieties at 18 locations -- 17 counties and one research station. Ground cover demonstrations have been established in cooperation with the Department of Horticulture. A program that is of value to the coastal area of North Carolina is a program on dune stabilization. This program emphasizes the use of the proper grass to protect against wind erosion, beachgrass, sea oats, purple panicum and others. Eight locations were established in six counties until the hurricanes of last summer destroyed three.

Dr. Blake has been involved in formation of many of your regional associations and continues to work with you to strengthen these. Under Dr. Blake's leadership, two newsletters are published. One is designed specifically for golf course superintendents, and the other for those individuals in turf management. In addition, workshops, TV programs and publications have been used.

Dr. Robertson continues his work in the area of managing insects that damage turf. He has demonstration trials in support of the educational effort of county agents and turf managers. The demonstra-

tions also serve as a source of information to be used in evaluating chemicals and developing effective management programs.

As indicated in the research section, Dr. Bill Lewis, continues his activity in herbicides evaluation and their effectiveness in controlling turf weeds. The goal is to provide information on the best system for controlling weeds. On site tests, meetings and publications are used to keep turf managers informed.

Dr. Lucas has a combination research and extension program. He continues his survey work on disease that causes damage and control methods. He is focusing on fungi and nematodes. The goal is to increase the ability of the turf industry to use the management program to reduce disease incidence.

We continue to try to improve our educational output in the teaching program. During the past several years, we have made a major revision of our Agronomy curriculum. We now have the Agronomy degree, but an individual also has five sub-options from which he can choose. One of these sub-options is turf. So an individual in the four-year program can now enter Crop Science or the Agronomy program and specialize or tailor his program to focus on turf and turf management. Our two-year Institute program continues with about 40 enrolled. We have quality instructors who continue to work to strengthen this program.

I want to thank you for your support of scholarships and for your summer employment of students. This allows our students to have something more than academic training when they begin looking for a job. Many of them would not have the opportunity for golf course work or turf work experience otherwise.

In the graduate program, we now have on Ph.D. who is nearing completion. We have one teaching assistant, Smitty Bugg, who has just begun his program and is assisting Dr. Gilbert in teaching the turf program. Dr. DiPaola has a vacant assistantship for which he is now recruiting. Dr. Lucas has two graduate students in his program.

All our faculty continue to work with the various regional organizations, as well as other turf related organizations in North Carolina. Our job in these roles is as an enabler. If we enable you to become a stronger organization, then you are better able to support us at times when we seek support from the University or from Legislative bodies in Raleigh.

What about the future? Why aren't we satisfied? We are not satisfied because we have not yet reached our full potential. Unfortunately, new research and extension programs can't be started overnight. I am

amazed at the time it takes to get simple things done, but we must be patient. We must continue to push. We have excellent leadership. Many of the things that have been accomplished in the past two years were done by the leaders' sweat of brow. Believe it or not, Dr. Gilbert can make a straight line of blocks. All of them are good with a shovel.

I am optimistic about the future. We look forward to having a Rhizotron and some growth chamber facilities, and to moving into an even more expanded program; but right now we are focusing on putting into place those resources we now have on hand. I am confident we have the manpower and ideas to do the job. We just need to get underway.

I am very proud of where we are, and I look forward to continued work with you. I hope you will continue to be a responsive group, not only in assisting us in obtaining resources, but in supporting us with ideas and communicating with us on what you like and what you need. Only as we work together in associations, councils, research, extension and teaching for the common goal of improving our ability to produce better turf in North Carolina can we reach our ultimate goal.

Thank you for this opportunity to speak to you.

WATER MANAGEMENT FOR GOLF COURSES

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Water is required for plant growth and activity and is involved either directly or indirectly in all phases of the care and management of turfgrass. Water is necessary for germination, cellular development, tissue growth, food manufacture (photosynthesis), temperature control and resistance to pressure. It acts both as a solvent and as a carrier of plant food materials. Nutrients dissolved in the soil are taken in through the roots and then carried to all parts of the grass plant in water. The food manufactured in the leaves is also distributed through the plant body in water.

Water transpired by the leaves and evaporated from the surface serves as a temperature regulator for the plant. Syringing of golf greens during periods of excessive evapotranspiration is based on these phenomena. The amount of water within the cells of the grass leaves plays a role in counteracting the effects of traffic. When the plant cells are filled with water, they are said to be turgid, a condition that helps leaves resist pressure from traffic (foot and vehicular) and avoid the damage, sometimes death, that may occur. Wilt is a condition that exists when cells do not contain enough water and are said to be flaccid. A ten percent loss of water from the plant body frequently will cause permanent wilting and death.

To understand the complexity of factors involved in water management of golf course turfgrasses, one must recognize the fundamental role water plays in plant growth, understand the effects climate and weather have on growth rates and how they influence water-use rates and choice of grass. Further, effective and efficient satisfaction of water requirements of turfgrasses demands a knowledge of the basic physical and chemical soil properties and how these affect water absorption, storage and drainage as well as the frequency, rate and manner in which supplemental water must be applied. All such basic information must be correlated with the requirements for color, play or use, adjusted to fit the existing or planned irrigation facilities, and modified to suit, or adjusted to, the level or standard of maintenance at which the turfgrass facility is being kept or maintained. Finally, due consideration must be given to conservation of water. We must recognize and accept the reality of the impending water crisis, learn to distinguish between potable and non-potable waters and begin to use the latter in the management of our golf courses.

For the most part we are limited in our choice of turfgrass for a particular facility in a particular area. For either irrigated or non-irrigated turfs in North Carolina and adjacent areas, our choice probably is limited to no more than five species for each condition. There are major differences in potential rooting depth within and between species. These differences along with tolerance to adversity (cold-heat-salt) and physiological differences (some yet to be identified), provide a basis for fruitful research that could modify the water needed for golf course water management. For the present, given existing conditions or the state of the art today, modification of soil, selection of superior cultivars and studied attention to cultural practices provides the best opportunity to reduce water needs.

SOIL

The soil from any turfgrass area must provide support for the grass, serve as a storehouse for nutrients, supply oxygen and act as a reservoir for moisture. The texture (size of soil particle), structure (arrangement of soil particles), and porosity (percentages of soil volume not occupied by solid particles) of a soil are the basic physical factors which control the movement of water into the soil (infiltration), through the soil (percolation) and out of the soil (drainage). Texture, structure and porosity, along with organic matter content, determine the water-holding capacity and control and air-water relationships of the soil.

These characteristics directly affect water requirements. The intake of water is through the roots -- the root hairs are the organs through which water is taken in. Hence, the depth of rooting and the extent to which a given root system occupies the soil determines the depth to which the soil should be wet. The volume of soil occupied by roots represents the soil reservoir capacity for that plant. When the need for water by the plant is great (high temperature, high winds, low humidity) this reservoir may have to be continually replenished, especially if the root system is shallow.

Generally, water requirements can be satisfied if enough supplemental water is applied to replenish that portion of the available water in the root zone which has been used since the last irrigation. Some authorities say water should be added when approximately 50% of the available soil water has been exhausted -- theoretically true -- but from a practical standpoint we need to use judgment.

Enough water should be applied to ensure that the entire root zone will be wetted. Too, on natural soils, as opposed to those modified for intensive use (golf greens, for example), sufficient water should be applied to bring about contact with sub-soil moisture. Continuous contact between the upper and lower levels of moisture will avoid a dry layer through which roots cannot penetrate -- except in periods of extended drought; not too much of a problem in North Carolina.

Under certain conditions water must be added in quantities larger than is actually required to satisfy the water requirements of the grass or to replenish the soil reservoir. This is necessary to ensure periodic "flushing" of the soil to remove salt accumulation. Again, not usually a problem in North Carolina because of your normal rainfall -- but keep this in mind in event of drought, for it is a basic consideration in good water management of golf courses.

In other words, good water management means that water must be moved through the root zone (percolation) and out of the root zone (drainage) to ensure an environment suitable for plant growth.

Application of too much water at one time (misuse) is serious when the soil is poorly drained and the excess cannot be removed within a reasonable period of time. Such a situation is more critical in either natural or man made saline or salty conditions. And when such conditions are obtained, water practices to meet theoretical water requirements must be modified. You must bring to bear all your knowledge and manage, modify or manipulate the environment that exists -- and still not lose grass.

EVAPOTRANSPIRATION

Evapotranspiration is a word which refers to the water lost by evaporation from the soil and from transpiration by the plant. On turfgrass areas transpiration accounts for most (80 to 85%) of the water loss or reservoir depletion. Transpiration rates vary almost hourly within any given season. They are greater in summer and lower in fall and spring. A similar phenomena, desiccation, occurs during the winter months and is responsible for the loss of turfgrass on high, exposed sites. Light intensity and duration, temperature, wind, rainfall, and physiological factors all influence the rate of transpiration. Of these, sunlight is the most critical. Thus a measure of solar energy can be used to develop evaporation data which serves as the key to meeting water requirements of turfgrass.

If the need for moisture is 0.2 to 0.3 inch daily -- as the case may be during June, July and August -- the soil must supply to the plant 0.3 inches of water between irrigations. Soils that are otherwise very good for putting greens may only hold 0.5 to 0.75 inches per cubic foot. This would be an adequate amount of water for one to two days if all of it were available to the plant. For this to be the case, the roots must extend through (permeate) the entire volume of soil and the soil must have the capability to supply the needed amount of water, or have the characteristics necessary to move the needed amount of water at a rate rapid enough to permit uptake by the root. The root systems on most putting greens frequently do not extend to a one-foot depth (especially in the summer). When they grow only to a depth of three or four inches, the volume of potentially available water is reduced by one-third to one-fourth. The reservoir (soil) insufficiency must be replenished by irrigation. Thus, the advice to water deeply and infrequently is not valid for many putting greens; or for that matter, for many turgrass areas.

Poor aeration, whether from poor drainage, compaction or an inherent soil condition, further complicates watering practices needed to meet water requirements of turfgrass on shallow soils of low water-holding capacity.

AMOUNT OF WATER

The actual amount of supplemental water required to keep the turfgrass green and healthy throughout the growing season is dependent, principally, on temperature, sunlight, wind movement and rainfall. In North Carolina, to sustain growth and to keep turfgrass green during the growing season, it has been calculated that supplemental water will have to be applied in varying amounts for five to six months -- May through September -- October -- a substantial percentage of the growing season. This calculation is based on average weather data over a thirty-year period for climatic regions in North Carolina.

The most critical areas are the Southern and Central coastal plains -- Wilmington and Kinston.

Finally, if reliable, well-trained manpower were available, the job of meeting the supplemental water requirements for turfgrass could be accomplished with any type of sprinkler device or other conventional means (flooding, hose and devices). However, since such operators are not readily available and, in many cases, not reliable, there seems little doubt that the most effective, most efficient, most convenient, and most economical way to water golf courses and other landscaped turf and recreational facilities is by automatic underground sprinklers. Clock-controlled systems are flexible and constant -- always on duty and available on demand. They are a practical means of preventing waste and conserving water and of assuring good water management for our golf courses.

NITROGEN FERTILIZATION OF BENTGRASS

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Nitrogen has been the most important fertilizer element to golf course superintendents for many years. This is especially true for superintendents growing bentgrass in the Piedmont and Coastal Plain regions of North Carolina. Bentgrass is environmentally out of place in the warm, humid south. Nitrogen has to be used very carefully in this region for bentgrass to survive. Research has been conducted the past two years at the turfgrass research plots in Raleigh on fertilizing bentgrass. Raleigh is on the edge of the Piedmont and Coastal Plain. The results of this research, then, apply primarily to the warmer regions of North Carolina.

Nitrogen (N) was tested from four sources, and at three rates and timings. The nitrogen sources used involve both slow release and soluble N forms. The ammonium nitrate is soluble and immediately available. The 50/50 combination of ammonium nitrate and ureaformldehyde is a soluble-slow release combination commonly found in mixed fertilizers. Ureaformaldehyde releases its nitrogen more rapidly in hot weather. Milorganite, like UF, releases its N in the warmer months. IBDU (31-0-0 fine) is a slow release N source which is not directly temperature dependent. IBDU releases its N slowly through the action of water.

The N rates used reflect a range from somewhat low (4# N/1000 ft^2 per year) to very high (12# N/1000 ft^2 per year). The timings tested differ in the emphasis placed on winter and spring. The fall-winter timing involved fertilizing the turf essentially from mid-september through the entire month of February, but very little in between. The fall-spring timing avoided fertilizing the turf during the winter while relying on March, April and early May applications.

The turf was evaluated for several responses. The responses can roughly be divided into two general areas: a) those which are obvious to the eye (such as color, weed invasions, and disease development), and b) those which can't be seen (such as root weight, carbohydrate levels, and thatch development).

The color of the turf was affected primarily by the rate of N used. Color variations were highly seasonal. Very little difference was seen in the summer and fall, regardless of N rate. By late fall

differences appeared, and by winter wide variations were seen. The 12# rate was deep green, while the 4# rate for all sources was yellow-green. These differences carried on through the spring.

Those plots fertilized during the winter months were considerably greener than those whose fertilization ended in the fall (November). Although winter fertilization greened up the grass, very little growth occurred. The plots receiving winter N remained greener than the others even through early spring. By summer all plots were esentially the same color, but it was interesting that spring fertilization had no advantage over winter fertilization in the springtime color of the grass.

The source of N used did not make much difference as far as the color of the grass was concerned. The one exception to this is that when UF was used, the late fall and winter color of the turf was somewhat poorer than when ammonium nitrate or IBDU was used. Milorganite was only applied in warm months, with ammonium nitrate filling in during the cool season, but Milorganite alone would not be expected to green up the grass in the winter.

No herbicides were used on the plots during the time the data was being collected. As a result, variations in the degree of weed invasion occurred, primarily as a result of the nitrogen rate used. Crabgrass, both smooth and hairy, was a problem in the summer. Dandelions and spotted spurge were the main winter weed problems. Weeds were a significant problem at the 4# N rate. The 8# and 12# plots had about the same numbers of dandelions and spotted spurge. Crabgrass, however, was a greater problem in the plots receiving 8# than in those receiving 12#. The use of herbicides could have alleviated many of the problems, of course, but fertilizer management should be used when possible to combat weed problems.

The timing of fertilization had a less striking effect on weed problems. Spring N applications seemed to increase crabgrass populations in the summer. This effect was not statistically significant, but it was consistent enough to be notable. Subsequent years' results may verify these indications.

Dollar spot was the only disease to attack the plots. Disease development was affected by N rate, but not by source or timing. Dollar spot was considerably more severe at the 4# rate, and decreased in severity in linear fashion up to the 12# rate.

In other miscellaneous visual aspects, the 12# N rate resulted in grass with wide blades compared with the lower rates.

Not all turf responses can be seen. Some of the most significant responses include root weight, carbohydrate levels, and thatch development. For bentgrass to survive hot North Carolina summers, it needs a good root system and a good reserve of carbohydrates to take it through periods of stress.

Both N rate and timing affected root weight. Of these factors, N rate had the more striking and consistent effects. In general, the 4# rate plots had almost double the root mass of the 12# plots. This is in keeping with research from other states in which higher N rates have decreased root weights of several species of turfgrasses (unless 0 N is a treatment, in which case a little N on the turf usually increases root weight over turf receiving none). Nitrogen seems to force the grass to use food reserves for top growth, decreasing the amount left for root growth.

Timing also affected root weight. The effect was notable primarily in the spring. When the fall-spring timing scheme was followed the weight of the roots in the spring was considerably less than when the fall-winter scheme was followed. Differences were not particularly noticeable at other times of the year.

Carbohydrate levels in the stems, crowns, and leaves were measured throughout the year. Nitrogen rate had a slight effect on the levels. No other factor was important. The higher the N rate, the lower was the carbohydrate level in the grass.

Thatch weight was taken as a measure of thatch development rather than depth. The thatch was compressed when the samples were taken, making depth measurements difficult to assess. Thatch weight was nearly identical for the 8# and 12# treatments, but dropped sharply at the 4# rate. Source and timing had no effect.

The results have to be summarized and looked at as a whole for any general conclusions to be drawn concerning nitrogen management on bentgrass.

Basically, the souce of N used did not create a lot of differences in our plots. When slow release sources are used, their effects may not show up for several years, but we can still draw some general conclusions from the work done so far.

The ammonium nitrate - UF source had some problems keeping the grass any color but yellow-green in the late fall and winter, except at very high N rates. IBDU did result in acceptable color in the cold months. Other than that, all the sources tested kept the turf about the same shade of green throughout the year, fluctuating with the seasons. Color was more a function of rate and timing.

Using organic N in the warm months caused no variation in thatch depth, weeds, or any other aspect researchers have occassionally reported.

Overall, it appears that IBDU is a very attractive N source since it doesn't have to be applied very often (up to 1-1/2 to 2 pounds per thousand can be applied at a time) to maintain year round color, and it is easy to handle.

There is a note of caution regarding the use of IBDU. Since it is generally advisable, when growing bentgrass, to try to keep nitrogen in short supply during the summer months, you should hold back on using IBDU heavily in the spring.

At the 12# rate of IBDU we found the turf turning a little bluish and wilting in the summer. This was especially so when the heavy spring timing scheme was followed. Apparently too much N was still in the soil and being released to the bentgrass in the summer. If this problem is avoided, however, IBDU is a desirable N source.

Nitrogen rate had numerous effects on the bentgrass. The 4# rated seemed to be a little too low for most purposes, and the 12# rate was much too high. The 4# rate did increase root weight, carbohydrate levels, and decreased thatch. But a rate that low caused a lot of weed and dollar spot problems. The color of the grass at that rate was often poor. Bentgrass should be kept a little "hungry" for N, but 4# is probably too little. About 6# seems an ideal compromise for the Piedmont and Coastal Plain regions of North Carolina.

At 12# the turf was definitely green, but the blades were very wide, and the grass could have been mowed almost twice a day. Poa annua, when it did come in, was nearly always more prevalent on the 12# N plots. Root depth and carbohydrate levels decreased at that rate, and thatch was more of a problem.

One of the more interesting results of the timing study was that putting almost all the N on in the fall and winter kept the grass greener through both the winter and spring than did waiting until March or April to fertilize. This was especially true for the slow-release sources.

Spring N had a tendency to increase summer crabgrass problems. Spring N also caused some problems for bentgrass in the summer if high rates of slow release N sources were used.

The winter fertilization scheme seems to be preferable for the warm areas of North Carolina. Workers in Virginia and Rhode Island have reported that photosynthesis occurs during the winter when N is applied then, but that no growth occurs. Consequently they found a buildup of carbohydrates in the grass, and an increase in rooting. Future data may verify this in North Carolina.

The winter timing scheme is difficult to apply to the mountain regions. It seems advisable, however, to begin fertilizing bentgrass as early as possible in the spring so that photosynthesis can get off to a good early start.

Nitrogen affects bentgrass in many ways. Although luck is often involved in the success of bentgrass greens in the warm, humid south, good nitrogen management will surely help your odds.

IRON FERTILIZATION OF BENTGRASS

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Iron fertilization of bentgrass in the Mid-Atlantic regions has become increasingly popular. There still remains a great many unanswered research questions with regard to the use of nitrogen and iron on fine turf. Practical observation and limited research results do indicate that iron can have a very favorable affect on bentgrass quality, particularly during periods of stress.

Research on the use of iron fertilization was conducted by Dr. Vincent Snyder while completing the requirements of his Master of Science and Doctor of Philosophy degree at Virginia Polytechnic Institute and State University (2,3).

Iron was shown to be essential to plants as early as 1843. However, it is such a commonly available element in the eastern United States, that it has seldom been considered nutritionally important in turfgrass-management. Most soils contain massive amounts of iron with a range varying from .5 to 5.0 percent in most soils. This means that an acre plow depth of soil would contain from 10,000 to 100,000 lbs. of iron. Even though these massive amounts of iron exist in soil, iron chlorosis is common, due to the relatively large amount of soil iron that is unavailable to the plant. Iron chlorosis is generally observed in the youngest leaves first, as iron is considered to be an immobile element in the turfgrass plant.

Iron chlorosis in the western states is much more common than it is east of the Mississippi River. The alkaline soils of the west have a pH which makes iron unavailable to the plant. Scientists, Lindsey and Norvel of Colorado State University, have developed the diethylene triamine pentaacetate (DTPA) iron soil test which has been helpful in the diagnosis of iron deficiency. Iron chlorosis can be caused by excessive irrigation, poor soil aeration, high soil phosphorus, excessive heavy metals, low or high temperatures, high light intensity, high nitrate concentrations and alkaline soil pH. Obviously, these conditions prevail in the majority of areas where quality turfgrass is being maintained. Excessive watering, poor drainage, and high phosphorus availability are common in turf throughout the mid-Atlantic region. In 1971, the Virginia Soil Test Survey indicated that 49.6% of the greens tested contained very high levels of phosphorous.

Iron is considered a micronutrient element and is used by the plant in relatively small amounts. It is essential in chlorophyl production,

the electron reduction system and severl enzyme systems of the grass plant. Work on Merion Kentucky bluegrass has shown that iron removal in clippings will average approximately 1.96 grams per 1000 sq. ft. per growing month (1).

Iron exists in essentially four forms in the soil: mineral, inorganic precipitate, organic complex and in ionic form. The ionic forms of iron in the soil are ferric (Fe^{+++}) and ferrous (Fe^{++}). The ferrous form is most readily available to the plant; however, the majority of applied iron is immediately converted to the ferric form and forms insoluble iron oxides which are unavailable to the grass plant. This rapid conversion of iron to a plant unavailable form can be slowed down by chelating the iron molecule. This is a process wherein the reactive iron is protected or surrounded by an organic molecule.

Work by Snyder and Schmidt (4) has shown that a combination of fall applied iron and nitrogen can enhance green color and speed up bentgrass green-up by as much as three weeks in the spring when compared with nitrogen or iron alone. The combination treatment provided 3 lbs. of total nitrogen per 1000 sq. ft. applied 1 lb. in October, 1 lb. in November and 1 lb. in December plus 2 ounces of iron per 1000 sq. ft. with each nitrogen application. Timing is important and when a fourth nitrogen and iron treatment, 1 lb. nitrogen per 1000 sq. ft. plus 2 ounces of iron, was applied in February, bentgrass root growth was decreased by 21% when compared with the application of nitrogen and iron only in October, November and December. The nitrogen plus iron combination applied in October, November, and December produced a 22% increase in chlorophyl content of the creeping bentgrass plants when compared with nitrogen alone.

The most striking positive effect of iron application was observed in winter desiccation recovery. Fall applied nitrogen plus iron treatments exhibited 70% healing on April 24 compared to equivalent straight nitrogen treatments which only had 9% living ground cover on that same date.

Further work by Snyder examined the effect of iron on photosynthesis and dark respiration. This work showed that net carbon dioxide (CO_2) fixation was increased by as much as 32% by the application of iron to Kentucky bluegrass.

Further work indicated that some sources of nitrogen were more efficient in eliciting the iron response than others. IBDU and urea formaldehyde sources appeared to enhance the iron effect upon photosysthesis. Iron tended to reduce dark respiration when compared with no iron treatments. The net iron effect then was to increase photosynthetic efficiency while decreasing the rate of dark respiration.

The net effect was, therefore, an increase in net CO_2 fixation with the use of iron. Greatest root production on Penncross creeping bentgrass was found in situations where iron was applied in association with Isobutylidene diurea (IBDU) and ammonium nitrate. The use of urea formaldehyde plus iron did not have a favorable effect on root growth.

In summary, the use of iron in a bentgrass management program has been shown to improve winter desiccation resistance, color and root growth as well as decreasing the incidence of dollar spot and Helminthosporium leaf spot, proving earlier spring green up and complimenting late fall fertilization.

In trying to make the decision whether to use a chelated form of iron or inorganic source such as iron sulfate, it is important to remember that chelated sources of iron are more mobile in the plant and generally provide better results during stress periods. It has been noted, however, that chelated forms of iron do create growth inhibition when used in early spring. Iron sulfate sources of iron will be cheaper and provide faster plant absorption. In situations where use of iron is deemed necessary in the spring, it is better to use iron sulfate than chelated iron.

Current iron recommendation for use on bentgrass greens suggest 3 to 4 applications of 2 ounces per 1000 sq. ft. of iron sulfate or iron chelate during fall and winter. Three to four applications at the same rate are recommended during summer. It is important to avoid the use of iron from March to June in Virginia.

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SOIL AMENDMENTS FOR TURFGRASS AREAS

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Soil is the complex medium containing inorganic and organic materials in which we grow turfgrass plants. This medium is the major source of water and nutrients for growth as well as providing physical support and anchorage for turfgrass roots.

A knowledge of the physical characteristics and functions of the soil is necessary before considerations can be made on how to improve soil characteristics with soil modification. All soils consist of three distinct phases: solid, liquid and gas.

The solid phase of the soil is known as the soil matrix. The size and relative proportions of the various mineral and organic particles in soils will dictate the physical properties of the soil. Describing the soil based on particle size is called soil texture. Various textural groupings are assigned based on the proportions of the various sized mineral particles. These textural groupings reflect the general physical properties of these soils. More significant, however, is the formation of complexes between the mineral particles and organic materials in the soil which is called aggregation. The organic matter provides the "glue" or sticky material that holds the mineral particles together in the larger complex particles called soil aggregates. The aggregate complex provides the good aeration and drainage of coarser textured materials, while at the same time individual granules can absorb water and nutrients similar to fine-textured clays. This provides a medium with the best properties of both fine- and coarse-textured materials. The extent to which aggregates are formed is referred to as soil structure and is the most important property in determining the agricultural value of the soil. The influence of organic matter on soil far exceeds the small amounts that are generally present or added. Organic materials have the ability to absorb large amounts of water. Some synthetic mineral particles such as calcined clays are also able to absorb water but generally to a lesser extent on a weight basis. This explains the importance of distinguishing between particles on organic and mineral basis rather than using solely particle size.

The gas phase of the soil is known as soil air. The soil air content of the soil is controlled by the soil matrix and the soil solution. Air fills that portion of the volume that is not occupied

by solid particles or water. Air in soil is contained primarily in the large non-capillary pores and is in a constant state of fluctuation. Air is displaced from the non-capillary pores when the soil is wet and diffuses back when the pores drain due to gravitational forces.

Soil air has the same composition as the atmosphere, however, with lower O_2 levels and higher concentrations of CO_2 and water vapor. The exchange of CO_2 for O_2 in the atmosphere is called soil aeration. This exchange of good aeration is necessary for active root growth and development which directly influences water up-take. Non-capillary porosity of 10-20% by volume will result in favorable exchange of CO_2 for O_2. Good aggregation of soil particles in soils with adequate organic matter levels is responsible for good aeration, infiltration and percolation, however, where traffic is heavy, soil modification or hole punching is often necessary to provide these properties.

The liquid phase is referred to as the soil solution. The moisture status of the soil is instrumental in determining the suitability of the medium for plant growth. Soil water falls into three categories: gravitational, capillary, and hygroscopic. Gravitational water is that moisture that drains out of the large pores or spaces between particles and aggregates due to the forces of gravity. Capillary and hygroscopic water remain in the soil. Capillary water moves freely through the capillary pores between soil particles while hygroscopic water is bound in the minute pores between particles with such great force that it is unavailable for use by the turfgrass plants.

Field capacity is an inexact but useful term to denote the water remaining in soil after the drainage of gravitational water from non-capillary pores. In most soils at field capacity 20-25% of the soil volume is water (capillary) and only about half of this water is available for plant utilization. The movement of water through soils and into plants is determined by the tightness with which it is held to soil particles. The size of the spaces or pores between soil particles determines this tightness or tension (Matrix Potential).

Drainage is the key to fine turf management. Common sense and good drainage will produce the kind of turf you want. If you are short on common sense, add a little more drainage.

It has taken fifty years or more to develop an understanding of the influence of the coarse sand and gravel layers that have historically been used under turfgrass areas to "improve drainage". Dr. Gardner has done a good job of depicting this in his movie on soil-water movement. Placing gravel under a soil mix breaks the continum in the liquid phase in the soil profile and creates a "false water table". Water fails to drain into the gravel until the moisture level in the mix is at field capacity. This principle can be used effectively in green construction where the layer is 8-10 inches below a desirable soil mixture and sub-surface drainage is provided. Layers can be a hindrance by restricting moisture flow

and rooting especially when close to the surface. An undesirable layering effect can be caused by thatch, poor topdressing or introduction of a layer due to sodding. Very few roots of either bentgrass or bermudagrass have been observed to move across these layers. Where thatch is present it may take 25 minutes of irrigation just to wet the thatch. Cycling of irrigation would be required first to wet the thatch and subsequently to wet the soil to the desired depth due to the low infiltration rates.

Compaction or the destruction and distortion of soil aggregates causing the closer orientation of mineral particles is considered the foremost problem in turfgrass management. Traffic and water are the main factors for compaction and result in the reduction of non-capillary porosity. This in turn impairs drainage (infiltration and percolation) and aeration of the medium. Compaction is at a maximum when soils are at field capacity which, unfortunately, is the moisture level that turf managers try to maintain for maximum growth.

Economics and the extent of traffic levels will dictate whether soil modification and/or hole punching will be necessary to provide the desired soil conditions.

There are a number of inorganic and organic materials that have been used to amend turfgrass soils.

Inorganic	Organic
Sand	Peat
Calcined Clay	Bark
Processed Mica	Sawdust
Expanded Shale	Sewage Sludge
Ash	Manure

The selection and effective use of amendments for soil modification has been influenced most by: 1) cost, 2) stability of the material, 3) lack of phytotoxicity, and 4) availability.

Particle size distribution is the most important factor in incompatibility of the soil matrix. Trying to dilute heavy soils with sand can create more problems than are often solved. When sand is added to a clay soil there is a continual loss in porosity until sand comprises over 80% of the mixture. It is not until sand makes up 90-95% of the medium that non-capillary porosity is sufficient to provide the desired physical properties. This is why it is more practical to start with a coarse-textured material (sand) and add fines (organic matter and soil). The selection of a sand for soil mixtures has long been known to be the critical ingredient. The tremendous differences in sands, due to particle distribution, has a great influence on the solid phase characteristics. Particle size range .25mm to 1mm is the most acceptable. Naturally, washed or well-rounded sands, with

greater than 80% for the particles in this range, are preferred because of the reduced tendency to compact.

As compaction is predominately a surface phenomenon (primarily confined to the top 1" and seldom below 3") considerable relief can be obtained in a maintenance program with equipment designed to disrupt this zone of soil. Both grooving and hole punching equipment have been used effectively to eliminate the effects of compaction. Several newer pieces of equipment have the ability to penetrate up to an 8" depth which allows them to penetrate any existing layers to that depth. One program of partial modification is to cultivate with core or grooving equipment to the 6-8" depth, remove existing soil and fill the void with sand of improved mixture.

The soil modification process is only effective to the extent that surface and/or sub-surface drainage is able to remove superfluous amounts of moisture from the turf areas. Allowing 1-2% grade with tile or vertical drainage are the most commonly used method of drainage. Vertical (French or Slit) drains have become very popular on turf areas because of effectiveness and ease of installation. This type of drain is merely a modification of an open ditch which drains run off and lowers the water table. The width of the trench varies from 1/2" on putting surfaces up to 3" for those used on fairways. The depth of the trench is generally around three feet and is backfilled to the surface with gravel and faced with sand or calcined clay. The narrowness of the trench allows grass to grow over the trench which will continue to function for many years. The use of tile in these trenches and connection to an outlet increases their efficiency but trenches have often been used effectively without either.

In conclusion, I would like to say if you understand soils and soil modification, you can be a much more effective turfgrass manager.

REPAIRING VANDALISM ON GOLF GREENS

Jim A. Humphries
Golf Course Superintendent
Deep Springs Country Club
Stoneville, NC

As a student at North Carolina State, I can remember those days when I could hardly wait until I could conquer the world. During my school years I served as General Flunky and later Assistant Superintendent, and then upon graduation, 4 years ago I was employed by Deep Springs Country Club. During these years of employement we have found many challenges. First, in 1975 we were known as the spring dead spot of the world, but soon the winter of 1976 to 1977 was to take our fame away. We had so much success that year we decided to construct nine new holes of golf. In 1978 we began major construction of our new nine. This venture enabled me to use some of the techniques I had acquired while at State, and the practical experience I had acquired.

My professors never told me about the six weeks of wet weather we would experience in the middle of the planting season. They never talked about the problems one might encounter trying to coordinate maintenance on an existing nine and a new construction program at the same time. They also never told me about the malicious case of vandalism which would virtually destroy eight out of the ten greens that we had. In August 1978, one week before our Member-Guest Tournament was scheduled, all of this took place. It is also very hard to initiate a membership drive to support our new nine, when your greens are dead. On Friday, August 12, 1978, a vandal applied a herbicide on our greens, which was later identified as Spike, on eight of the ten greens we had. Spike is an 80% wettable powder labeled for total vegetation control in non-cropland areas. As a result, we had to replace over 30,000 square feet of bentgrass sod and completely rebuild one 10,000 square foot green. I would like to explain how one individual handles the most devestating act of vandalism he has ever seen.

In the early stages of vandalism caused by this herbicide application, one must remember one important point. Do not confuse the problem with that of dry wilt. It looks the same. In general, know where each green has a tendency to wilt. You can check each green and if your indicator areas are not suffering from dry wilt your can be more suspicious of those particular areas. If your greens have localized dry spots as many greens do, you can easily identify these areas. Secondly, you can rule out the possibility of dry wilt.

If your greens are constructed with high amounts of silt and clay, do not hand water those areas. More than likely you will initiate lateral movement of the herbicide and water causing more damage. If your greens have high contents of sand, high rates of water may be helpful and leach the herbicide through the soil profile more rapidly. Thirdly, be sure you have some soil samples of the damaged areas. Later, you will want to identify the herbicide used, and present your results to your Board of Directors. A better method would be to have a representative from an independent laboratory present the results of the tests.

Next, do not compound your problem by transferring the herbicide by mechanical means (i.e. greens mower, spiker, foot traffic). As soon as possible, locate some area away from the damaged area for your pin placements or close the green for play if at all possible. Time is a very important factor in trying to contain damaged areas. Apply activated charcoal as soon as possible. If there is a question of the rate of charcoal, cover the area until you cannot see any ground beneath.

Next, do not waste your time carrying soil samples to the Pesticide and Plant Division in Raleigh. They are unable to analyze the samples because their laboratory can only be utilized when an enforcement action against an individual or company is anticipated under the N.C. Pesticide Law. The North Carolina Department of Agriculture requested funds to provide for a service laboratory to perform pesticide analysis on samples such as we might have. The North Carolina General Assembly failed to provide for such a laboratory. You must never forget that your membership is waiting for some concrete answers and results. One must seek help from an independent laboratory. In the Piedmont section of North Carolina, I would personally recommend CIBA-Geigy Corp. of Greensboro. The Agricultural Division was most helpful in identifying the herbicide and recommending rates of activated charcoal needed to neutralize the effects of the herbicide.

After the recommended rates of charcoal are known, N.C.S.U. Turf Specialist will help you determine the next step. They can germinate seedlings in the recommended rates of charcoal and soil. For best results, N.C.S.U. found that you must incorporate the charcoal into the top 4 to 6" of soil before planting. Before we got the results from State, we had applied charcoal to the damaged areas and only scarified 1" deep trying not to disturb the putting surface. We then seeded Penncross Bentgrass at a rate of 1-1/2 pounds per 1000 square feet. We then topdressed with a suitable material and smoothed the area with a drag mat. Two weeks later the bentgrass was germinating, and soon damped off.

After all has failed, you must completely rebuild the green or begin sodding. When sodding, one must have access to bentgrass sod

either from a commercial grower, a large nursery on site, or have large greens so that you can utilize the perimeter grass and not significantly change the design of the green. Once the sod is obtained, completely strip affected areas. Next, apply activated charcoal at the recommended rates and completely mix soil to the depth of 6 inches. Next, compact the soil with a Tamp or Roller, and lay the sod as even as possible allowing approximately 1/2 inch at the top for further setting of the soil from beneath. Roll sodded areas dry, then apply water and roll again wet. This helps in smoothing the area. I found that the thicker (approximately 1-1/2 to 2") the sod, the better job one could attain.

After the job is completed, you must topdress thoroughly. We topdressed our greens about every two weeks until we were able to smooth the surface significantly. Try to time your sodding about a month before aerification and vertification. Give the sod ample time to establish some root system. During aerification, use the largest tines possible (5/8") and verticut as much as possible, then topdress again. This one mechanical process will help as much as anything else.

Depending on the amount of damage incurred, and the type of growing season, one could expect a suitable putting surface in five to six months.

In conclusion, there are many types of vandalism that have occurred on golf greens. This has been only one example of a case of malicious vandalism.

MANAGEMENT OF FAIRWAYS AT ETOWAH VALLEY

Gene Blanton
Etowah Valley Country Club

First of all, I notice there are a good number of out-of-town people here, plus local people. As a member of the Western North Carolina Turf Association, I would like to give you a very special welcome to Asheville and to the conference. I am here to talk on management of fairways at Etowah.

First, a little bit about Etowah. It was built in 1966-67 and 68. The course opened in July of 1968 and I became the superintendent in January of 1975.

Etowah Valley Golf Club is in the cool season belt of North Carolina. Our fairways consist of a mixture of bentgrass and bluegrasses. We have tried bermudagrass on some of our tees but this proved unsuccessful. The reason for trying this was heavy play during the regular season -- not just on weekends.

When the winter breaks in the spring, everyone is anxious to get on the course and we must utilize our time to the fullest extent. My normal work crew during the season is six, which includes an assistant.

I'll try to cover our work plan for the fairways for the season by categories:

A. MOWING

1. SPRING - As soon as we start mowing in April, we mow constantly for several weeks (5 days per week) depending upon weather conditions. Our mowing height in the spring is 3/4" to 7/8".

2. SUMMER - Mowing frequency is reduced some as temperatures rise and rainfall is less. We usually mow two times per week. During the summer, we raise our mowing height slightly to 1" to 1-1/8".

3. FALL - Our early fall mowing is similar to spring. It is constant mowing for a few weeks. As temperatures drop, so does our mowing frequency. Our fall mowing height is 3/4" to 7/8".

B. CLIPPING REMOVAL

1. SPRING - In case of excessive wet weather and we miss a day or two of mowing, the clippings get heavy and must be removed. This is done by using both a turf sweeper and a 3 point hitch PTO driven blower.

2. FALL - Some removal, but not as much as in spring. We use the same blower and sweeper to clear the leaves from the fairways, which keeps the leaves from smothering the grass and enables the golfers to find their golf balls easier.

C. WATERING

Fairway irrigation is used primarily in summer months -- June, July and August. We use sprinklers which put out 1/3" water per hour. The grass needs at least 1" of water per week. That means three hours of irrigation per week. If it is extremely dry, we will water at night, if not, we will put one sprinkler per fairway. This will give you better coverage of the area and does not bother the golfers as much.

D. AERIFICATION

I try to aerate two times a year and we use a close core type of tine. In spring and fall I work this into my fertilization program.

E. FERTILIZATION

I like to use a split application during the spring.

1. SPRING - middle of March - 150 lbs. per acre
first of May - 150 lbs. per acre

2. FALL - We put special emphasis on our fall fertilization. This is a very important application to carry us through the winter months and enables us to have healthy turf in early spring. I also use a split application in the fall -- 150 lbs. first of September and 200 lbs. middle of October.

We have good results using a complete fertilizer. I use a slow acting organic fertilizer at a ratio of 4-2-1. Also, in the fall, we take soil samples in order to make our plans for the next year. After receiving test results, lime is applied as needed.

F. PESTICIDES

1. FUNGICIDES - Rather than following a preventative program, we check fairways daily for disease and spray as required. I use Daconil 2787 and TGF.

2. INSECTICIDES - I Keep a close check as a lot of the long lasting chemicals have been taken off the market. I use Seven and Proxol.

3. HERBICIDES

a. Pre-Emergence

First, I split my application of Dacthol, and the reason for this is the crabgrass will come out before goosegrass. When the temperature reaches 55 degrees, your crabgrass seed will begin to germinate. The second application will help control goosegrass from germinating later. This gives me complete control through late spring and summer.

b. Post-Emergence

We use very little post-emergence chemical control. We do have some problems with clover and dandelions and treat for this with 2,4-D MCPP and Dicamba mixture.

G. RESEEDING

I like to seed the first of September. I do this with my fall aerification, plus my first fall fertilization.

Everyone has their ideas and ways to manage their fairways. This has been basically the way we do it at Etowah.

MANAGEMENT OF BLUEGRASS FAIRWAYS

John R. Hall, III
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Virginia Polytechnic Institute and State University

The management of Kentucky bluegrass fairways in the Mid-Atlantic region is not an easy task. The disease, insect and weed pressure which exists on Kentucky bluegrass fairways in this region is extreme. The margin of error between living and dead turf is small.

In this region of the United States, it is important to develop a philosophy of management which accounts for the fact that all management factors, mowing, irrigation, fertilization, cultivation, and pesticide-use are interrelated. Not one of these management factors can be altered without affecting the total stress on the plant community.

These management factors can obviously be affected by environmental factors, knowledge, and material resource availability. The very best management system can be destroyed by unfavorable environmental factors or a lack of knowledge or material resources.

It is essential that managers of Kentucky bluegrass fairways in the Mid-Atlantic region realize that it is important to budget stresses which are present on their bluegrass fairways. There should be a constant effort to produce the highest quality turf with the least amount of total stress on the plant community. This philosophy will maximize the chances of producing quality Kentucky bluegrass fairways in the Mid-Atlantic region during the months of June, July and August.

The primary mowing stress factors are height of mowing, frequency of mowing, and the type of mower utilized. The lower the mowing height and the greater the mowing frequency, the more stress is created on the turfgrass plant. Reel mowers are generally less injurious to the grass plant than rotary mowers. However, either mower can injure the turf if not properly maintained. Unnecessary bruising of leaf blade tissue simply forces the plant to utilize carbohydrate reserves for the production of wound hormones and callus tissue. These same molecules of carbohydrate that could be producing leaf, root, rhizome, and stolon tissue is wasted healing bruised leaf tissue. Kentucky bluegrass fairways in the transition zone are put under rapidly increasing stress as the mowing height is lowered below 1 inch. Time of the year is a factor and certainly a 1 inch mowing height is going to be less injurious to a turfgrass plant in the fall and spring than it is going to be during the months of June, July and August. Lower mowing heights promote the invasion of crabgrass, often necessitating the increased expense of preemergence herbicide.

Irrigation management influences the total stress on the plant community through the frequency of irrigation, the amount of irrigation, and the time of irrigation. Coupled with irrigation stress factors, is the extreme need for good drainage in situations where quality turf is desired. Improper use of automatic irrigation systems has frequently led to a decline in turfgrass quality on Kentucky bluegrass fairways where drainage was inadequate. In poorly drained areas annual bluegrass and other annual grassy plants are extremely competitive with the perennial grasses and tend to dominate stands. On bluegrass fairways where adequate water retention is available, the old axiom of watering as infrequently, but heavily when you do, still appears to be sound agronomic advice.

Selecting Kentucky bluegrasses for drought tolerance and disease resistance in the transition zone is extremely important. Varieties such as Vantage, Georgetown, and Merion have shown excellent drought recovery and ability to persist during extended drought periods. Adelphi, Plush, Birka and Sydsport have exhibited good turf quality and disease resistance in our Newport News test demonstrations.

The use of irrigation systems for cooling the turfgrass plant during extremely hot periods in June, July and August is important. This method of irrigation, called syringing, does not saturate the thatch but simply provides a mist layer on the glass blades which can evaporate and dissipate the energy of the sun. When used appropriately, it can reduce turf temperatures 10 to 15 degrees at critical periods during the day. Approximately 540 calories of sunlight energy is dissipated in converting each gram of water on the turf from a liquid to a vapor. If the mist layer were not present, the heat energy would be dissipated by increasing the temperature of the Kentucky bluegrass plant. Considerable stress reduction can be brought about by the proper use of syringing.

Fertilization timing, amount and type of fertilizer can have a significant effect upon stress factors on bluegrass fairways in the Mid-Atlantic region. Late fall fertilization, providing 3 to 4.5 lbs. of N per 1000 sq. ft. per year, with approximately 80% of the nitrogen being applied between September 1 and January 15 provides nitrogen to the Kentucky bluegrass plant during periods when photosynthesic efficiency is high and respiratory loss is minimal. This creates a situation wherein maximum carbohydrate storage and root growth is promoted during the winter months of the year.

Some of the advantages of late fall fertilization which have been noted in Virginia from practical experience and research are increased turfgrass density and root growth, decreased requirement for spring mowing, improved fall to spring color, decreased weed problems, increased drought tolerance and decreased summer disease activity. A typical fertilization program for Kentucky bluegrass fairways in Virginia is shown in Table 1. If the total program cannot be followed, the priorities noted in that table should be followed. The most important time for fertilization, if only one fertilization is going to be made, is in October 1 to November 15 time frame.

Table 1. A sample fertilization program for Kentucky bluegrass fairways in Virginia utilizing water soluble nitrogen sources.

Date of Application	Nitrogen	Priority
	--lbs/Acre--	
September	50	4
October 1 - November 15	50 - 65	1
November 15 - January 15	50 - 65	2
May 15 - June 15	0 - 30	3

Cultivation practices such as aeration, topdressing and dethatching can increase or decrease the amount of stress on the total system. Aeration frequency and timing as well as the amount, frequency and timing of topdressing, can influence the total stress on the system. The timing and intensity of dethatching can also affect the total stress on the system. It is important to aerify bluegrass fairways with tines that bring soil to the surface and reinoculate the thatch layer with soil to aid thatch decomposition.

Many of the pesticides that we use also have subtle side effects upon the desirable species. Evidence now suggests that some preemergence herbicides may reduce root growth of the desirable species (1). Fungicides have also been shown to increase rates of thatch buildup, thereby possibly having a negative effect upon the health of the Kentucky bluegrass plant (2). It is important to realize that all management factors are interrelated in determining the total amount of stress on any Kentucky bluegrass fairway (Fig. 1). For example, if mowing height is lowered this will increase the need for irrigation because of the decreased root system which the lower mowing height will create. The increased irrigation requirement will possibly increase the need for aerification and verticutting because the fairway will be wet during a greater period of time, therefore, the amount of compaction occurring will be increased. The lower mowing height and increased irrigation need, coupled with increased compaction will predispose the turf to greater disease activity. The decreased root system and increased irrigation will increase the requirement for nitrogen fertilization because greater leaching of the applied nitrogen will be occurring.

Figure 1. Diagram of the interrelationship of management factors that influence the total stress on the plant system.

Mowing Stress	X	Irrigation Stress	X	Cultivation Stress	X	Pesticide Stress	X	Fertilizer Stress	=	TOTAL PLANT STRESS

This is just one example of how changing single management factors can affect all of the other management factors involved. Once any management factor is altered, the professional turfgrass manager needs to look to the other management factors and determine how they are being affected by that one change. If the total stress on the system is going to be maintained at the same level as before the management practice change, then some of the other management factors need to be altered in such a way that they accomodate the increased stress created by, for instance, a lower mowing height.

So, in the final analysis, management factors, environmental factors, knowledge factors and material resource factors are all interrelated to create a situation where altering any one of these factors affects the total system and just as a cobweb is bounced up and down when it is touched on any portion of the cobweb, the total stress on a turf community is affected by the alteration of any one management factor. The superintendent is what really holds this cobweb of management together in that he is the knowledge and source of the decisions which are being made that affect the severity and frequency of disruption to the cobweb or management system. The superintendent needs to manage Kentucky bluegrass fairways in the transition zone in such a way that he is minimizing the disruption to the total management system and, therefore, minimizing the total stress on the system.

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AERIFYING AND FERTILIZING BERMUDAGRASS FAIRWAYS

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Buies Creek, North Carolina

Before getting into the mechanics of my program, let's begin with the reasons we began our program. In 1975, I attended the national and several state turf conferences for the purpose of researching ways to help or prevent the problem of spring deadspot. My conclusions at the end of these sessions was that excessive thatch, too much nitrogen fertilizer, low potash levels, cutting the height too low going into winter, and excessive cart traffic over frozen or wet fairways during winter months all had a part in causing winter kill or some degree of spring deadspot.

With 1975 being our second growing season and given the soil condition of our fairways, we decided to cut back nitrogen levels to 2-1/2 lbs. of nitrogen per thousand square feet per year. We break this down to 2 lbs. of slow release material and 1/2 lb. of ready available nitrogen. After checking our soil samples we decided to increase our potash amounts to 4 lbs. per thousand square feet per year. Our basic schedule was to aerify fairways the first of May and put the first application of potash on (using sulfate of potash at 3-1/2 lbs. per thousand square feet) behind the aerification. This was followed two weeks later with 1 lb. of slow release nitrogen. By late June, the color would start going off and we put 1/2 lb. of ready available nitrogen on to improve color and for moderage growth. The last application of slow release material would be put on in late July or early August depending on the weather. With some research showing a benefit of fall fertilization, we decided to go with 275 lbs. per acre of 5-15-30 to give the roots a chance to develop in the winter and to improve spring green-up. We normally spray for weeds in the winter so the disadvantage of increasing weeds did not matter. We lime our fairways following soil samples recommendations. Our present pH average is 6.5 or better.

With the soil conditions at Keith Hills being hardpan clay and tight river bottom soil, starting in 1980 we are going to cut the amount of slow release fertilizer to 1-1/2 lbs. per thousand square feet per year. We believe that a build-up of the material is beginning and have noticed excessive growth on the fairways during the summer of 1979. Since 1975, we have stayed on this program but would modify it to weather and other conditions.

We try to aerify fairways once a month starting in May and continuing until mid-September. The monthly aerification is set up so we can fertilize within the same week. This helps the penetration of the fertilizer and water into the soil. We aerify with a Ryan fairway aerifier with 3/4 inch tines and use a 10 x 10' piece of chain link fence as a drag behind the machine to breakup the plugs. We then water the fairway to wash off the soil and if any excessive material is still left we blow off the fairway. We have a problem with rocks at Keith Hills but have not had an excessive problem with bringing up large amounts with the aerifier. The aerifying is done without closing the course and each aerifying normally takes 2 days. The aerifying not only removes thatch material but helps a great deal in allowing for maximum penetration and absorption of rain and irrigation water.

Midway through our first season, 1975, we discovered that our golf course could not withstand the constant golf course traffic. Compounding this problem, our fairways are very narrow allowing for very little spreading of traffic. We, therefore, built cartpaths around the golf course and roped off the fairways that traffic would not be permitted on under any conditions. This has allowed us to have a good surface to hit off of even during the winter months.

In summary, the program above has given us good fairways and during the springs of 1977 and 1978, we had little problem with winter kill or spring dead spot. Our fairways normally green up in mid-April and keep their color until November, giving us seven months of good fairways.

ROOT GROWTH OF WARM SEASON TURFGRASSES

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The findings reported in this paper are results from investigations conducted during the senior author's study at Texas A&M University.

A well-developed and vigorous root system is desirable for both low and high intensity turfgrass culture. The turfgrass root system is responsible for the uptake and transfer of water and plant nutrients to the shoot, anchorage of the plant to the soil, and, to a limited extent, carbohydrate storage. Turfgrass management directed towards the development of a deep and active root system is contingent on an understanding of the seasonal behavior of the turfgrass root.

Previous investigations concerning the seasonal rooting characteristics of perennial grass have dealt with the cool season species and utilized periodic root system evaluation methods, principally soil core sampling and washing. These investigations centered on warm season turfgrass species and utilized a continuous root evaluation technique. The objective of these investigations was to study the seasonal rooting behavior of two warm season, perennial turfgrasses.

Procedures:

Root observations were made using the Texas A&M turfgrass rhizotron. The rhizotron is an underground facility in which a ceiling separates two rows of 24 root observation boxes. Each root observation box is 30 inches deep and has one glass side which faces the interior of the rhizotron, thus allowing non-destructive viewing of the turfgrass root system by an observer standing beneath the ceiling. Root growth and number were recorded by daily tracing each root's position on acetate sheets fixed over the glass plate of each root observation box.

Turfs of 'Floratam' St. Augustinegrass and 'Tifgreen' bermudagrass were established in the rhizotron in August, 1976. Nitrogen and potassium applications were made at a rate of one pound per 1000 square feet per growing month. Phosphorus applications were made annually at a rate of three pounds per 1000 square feet. Bermudagrass and St. Augustinegrass turfs were clipped weekly at a one and two inch cutting height, respectively. Soil temperatures were continuously recorded at four and twelve inch depths. Four replicate turfs of each cultivar were examined.

Results:

The daily root growth rate of both species averaged one inch/day during the warm summer months. Individual root daily extension rates ranged from 0 to 4 inches per day, however. Bermudagrass and St. Augustinegrass rooted to depths in excess of 30 inches in the sandy soil of the root observation boxes. The majority of each turf's root system was located in the upper foot of the soil. Root density (number per unit area of sod) of Tifgreen bermudagrass was some five times greater than that of Floratam St. Augustinegrass. However, St. Augustinegrass roots were larger (2 to 3 times) in diameter than those of bermudagrass.

Root growth rates of these two warm season turfgrasses gradually decreased as soil temperatures declined during the fall. As temperatures declined to 50° F and below, shoot growth cessation was followed by complete shoot color loss (conditional winter dormancy). Root growth of these two grasses continued after shoot growth ceased and while the turfs appeared to be in a dormant state. Root growth continued for 28 days after shoot growth cessation in 1977. During the winter months visible root growth was not observed, yet bermudagrass and St. Augustinegrass roots remained a white to light-tan in color and alive in appearance.

The root system status of bermudagrass and St. Augustinegrass underwent a series of distinct and previously unknown changes (Table 1) during early spring. Approximately one week after the first new leaves were initiated in the spring, the root systems of these grasses turned from a white-light-tan to brown signalling a rapid death of the turf's root system. This root browning was followed by a period of significant new green leaf production without the development of new root initiation. Root browning was observed in all three years of this study thus far completed. During 1978 new root initiation occurred some 1 day and 14 days after root browning for bermudagrass and St. Augustinegrass required an additional 20 days and 15 days, respectively, before they reached a one foot depth. Thus, from a practical point of view, the spring root loss period of these two warm season grasses was approximately three weeks in length.

This root system loss and restriction during late winter/early spring subjects these turfs to a greater likelihood of being susceptible to injury from low temperature stress, desiccating winds, traffic, diseases, and insect pests. The management and culture of these warm season turfgrasses during the spring root loss period can be critical in determining the survival and performance of these grasses during the spring. Some cultural practices such as delayed spring nitrogen fertilization, mowing, and verticutting may all prove to be beneficial, but additional information of these real benefits and the effects of timing and the environment must be obtained through additional research. Inadequate root system development of

of these two warm season turfgrasses is likely to be a major contributing cause of the winter kill, pesticide and establishment problems during the early spring.

Figure 1. Shoot and root development of Tifgreen bermudgrass and Floratam St. Augustinegrass during the spring of 1978.

MST-10** Value (F)	Tifgreen	Date	Floratam
64	First new leaves appear	3/21	
		3/22	First new leaves appear
53	Root browning occurs	3/26	Root browning occurs
	First new root initiation: turf shoots 46-50% green	3/27	
65	Turf shoots 61% green. RGR* = 1.02	4/2	Turf shoots with 2 green shoots per dm^2 or 3% green.
67	Turf shoots 86% green; RGR = 0.56	4/9	First new root initiation; turf shoots with 4 green shoots per dm^2 or 6% green.
67	Rooting depth reached 30 cm. RGR = 0.74	4/15	RGR = 1.02
		4/22	Rooting depth reached 30 cm. RGR = 0.78

* RGR = Mean daily root growth rate in inches/day.

**MST-10 = Mean soil temperature (F) at a 4-inch depth.

INTEGRATED PEST MANAGEMENT

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There are many different definitions of integrated pest management (IPM), but simply it is the use of all economically sound methods of preventing, suppressing or controlling damaging pest populations on a continuing basis. Each pest control method used in an integrated pest management system should be environmentally sound and be compatible with the overall production and management practices of the particular commodity plus the user's objectives. In many cases, IPM programs may include the use of resistant varieties, trap crops, rotations, sex attractants, or other hormonal compounds, parasites, and predators, cultural practices, the release of sterile insects, and the use of pesticides as needed based on pest populations.

Integrated pest management can be simple or complex, ranging from the management of one or two insects on a single crop to the management of insects, diseases, nematodes and weeds on multiple crops. Presently in North Carolina, programs in commercial agriculture range from insect management on cotton to the management of all pests on complete cropping systems. Pilot programs are also being conducted on some vegetables and poultry.

In 1979, the Cooperative Extension Service was operating Integrated Pest Management programs in all 50 states, Puerto Rico and the Virgin Islands. These were directed primarily at commercial agricultural crops and livestock where research technology was available and the economic benefits of IPM could be demonstrated. Presently, four states are developing urban IPM programs.

Farmers, grower organizations, industry and state and federal agencies cooperate with Extension in carrying out IPM programs. In the IPM programs, pest control decisions are based on field monitoring of pest and beneficial insects and levels of weeds, nematodes, diseases and other pests. The most appropriate pest control technology is then used. Where technology permits, other control methods such as resistant varieties, rotations, cultural practices, natural enemies, attractants, and autocidal techniques are used. Since the producers are the primary beneficiaries of IPM programs, they pay all direct costs involving field scouting and monitoring of pest population densities.

Unfortunately, some advocates of IPM portray it as a "cure-all" for all environmental and agricultural problems associated with pest control. This is a mistake that can adversely affect IPM, because very few pests can be adequately controlled with the use of pesticides. We should recognize that biological controls, resistant varieties, cultural practices, rotations and other pest control methods are partial aids; but, when pest populations exceed economic thresholds, pesticides are necessary. With this integration of control methods, we have an economically and ecologically sound program and IPM will be accepted.

IPM programs identify environmental concerns and incorporate control methods that are environmentally sound. Frequently, the need for pesticides is reduced when based on an "as needed only" concept. In some cases, though, IPM programs result in increased pesticide usage; but in all cases, pesticides are used in a more judicious manner and greater benefits are realized from proper use and timing.

Another benefit of the program has been the growing cooperation among entomologists, plant pathologists, weed scientists, nematologists, economists, and production specialists. This has resulted in better overall programs.

Unfortunately, there have not been any IPM programs developed for turf, although there are many good management practices for turf that aid in suppressing or reducing pests. With the development of economic thresholds for certain pests, these can be incorporated into an overall management program and, hopefully, an IPM program can be developed for turf. In fact, Dr. Lucas will discuss some of the implications of IPM for turf.

INTEGRATED PEST MANAGEMENT FOR TURFGRASSES

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Integrated pest management (IPM) programs have been developed in recent years for agricultural crops. Extensive IPM programs have not been developed for turfgrasses, however, many IPM principles are used in growing turfgrasses and controlling pests. IPM for turfgrasses means to manage all pests that are present, use all methods that are available, use methods that are economical and consider the effect of pest management practices on other pests.

An IPM program for turfgrasses uses normal management practices for growing turfgrasses, biological control methods and pesticides to manage pests. Several turf management practices affect pests and normal biological control systems that exist in turf areas. The decision to use pesticides in an IPM program should be based on the presence of a pest in the turf and an accurate identification of the pest causing the problem.

Some management practices normally used in turf that affect pests include construction, soil mixtures, time of seeding, fertilization, irrigation, mowing, aerification, verticutting and top dressing. These practices are used to encourage better growth of turfgrasses which in many cases involves the control of pests. Examples of the effects of management practices that turf managers can use to control pests are discussed below.

Construction of areas can affect the growth of turfgrasses and the management of pest problems. Construction of contours so that good surface drainage results will help reduce disease and weed problems. Incorporation of lime and fertilizer into the soil during this stage will help grow a healthy turf that can better overcome pests during establishment and years later. Removal of nearby trees at the time of construction will help prevent weed and disease problems that might be encouraged by shade and competition from the trees. By constructing a turf area correctly, problems with pests may be eliminated or reduced by providing conditions favorable for a good healthy turf.

Soil mixtures that are specified for golf greens provide good soil drainage and help to avoid rapid compaction of the soil. Good soil drainage encourages root growth and helps to prevent disease problems by removing excess water from around the plants. Less soil compaction helps grow a healthy turf that can prevent or overcome weed problems that often develop in compacted soil.

Time of seeding is an important disease control practice, particularly for cool season grasses. By seeding cool season grasses in early fall when temperatures are cooler, diseases are less of a problem on young seedlings than in hot weather. Diseases such as brown patch and Pythium blight may kill many of the seedlings during warmer weather. Warm season grasses should be seeded during early summer so that plants can become well established before cold weather in the fall.

Fertilization practices can affect pest problems that might develop or are present in turf. Cool season grasses particularly in central and eastern North Carolina should be fertilized with nitrogen in the fall, winter and spring and not during the summer. The cool season grasses grow best during the cool time of the year and should be encouraged to grow at that time. Fertilization during the summer encourages top growth and not root growth which produces plants that are more susceptible to drought stress and diseases. Diseases such as brown patch and Pythium blight are more severe following heavy summer nitrogen fertilization. The diseases can cause the turf to become thin which allows weeds to grow in affected areas and become a problem. Adequate amounts of phosphorous and lime are needed to develop healthy seedlings that can compete with weeds and overcome diseases. Proper fertilization will help turfgrasses recover from insect damage. Fertilization of warm season grasses during early summer encourages growth of the turf that can compete with or overcome weeds in the area. These grasses should not be fertilized with high rates of nitrogen during late summer which would make them more susceptible to damage from cold weather in the fall and winter. Extra potassium in late summer is needed on both warm season and cool season grasses to help improve winter hardiness. Weeds often become a problem where grasses are damaged by cold weather.

Irrigation is an important practice in an IPM program. Extra water is often necessary during the dry, hot months of summer but should be applied only when needed. Enough water should be applied infrequently to wet the soil 6 inches deep, and frequent shallow irrigations should be avoided. Frequent irrigations will cause plants to develop shallow root systems that will be more susceptible to drought stress and weed problems. Frequent irrigation may keep the leaves of plants wet for long periods of time and encourage the development of certain diseases. Irrigation of cool season grasses on golf greens in early morning can help reduce diseases by allowing the leaves to dry quickly and removing exudates from the surface of leaves. The use of irrigations systems to syringe bentgrass golf greens during hot weather may help these grasses overcome pest problems. Also, proper use of irrigation during the establishment of young seedlings will help seedlings to compete with weeds. Irrigation may be needed in managing insect pests by using it to wash certain insecticides into the soil.

Mowing practices can affect pest problems. Mowing grass when it is wet may spread pathogens from diseased plants to healthy plants. Also, mowing plants too high or too low may encourage the development of diseases or favor competition from weeds.

Aerification is used to help overcome soil compaction and provide better soil drainage and aeration. Better drainage removes water from around the crown and leaves of the plants and results in an environment less favorable for diseases. Removal of soil compaction allows for better turf growth and less weed problems. Aerification might be a disadvantage with some insects such as the black cutworm which will hide in the aerification holes during the day. However, this is not a severe problem and the benefits of aerification are much greater than the problem with cutworms.

Verticutting is used to help control thatch in turf. By controlling thatch, some pest problems can be reduced and better control can be obtained when pesticides are needed. Where thatch is a problem, pesticides may become attached to thatch and not be available to control the pests. Verticutting could be detrimental and cause more pest problems in some cases. For example, verticutting cool season grasses heavily during the summer months would reduce the stand of the grass so that weeds could invade and become a problem. Verticutting should be used to prevent the accumulation of thatch and encourage the growth of turfgrasses. Localized dry spots may develop in heavy thatch areas, that become dry and it is difficult to wet these areas again. Diseases and weeds may be more of a problem in or around the dry areas.

Top dressing with soil is a management practice that is commonly used to level turf surfaces and to help prevent thatch accumulation. Top dressing covers the thatch with a layer of soil which encourages biological activity in the thatch and increases the rate of decomposition. Pathogenic fungi that survive in the thatch may also be affected and numbers reduced by competition from saprophytic microorganisms and the production of antibiotic substances. Topdressing can also be used to modify the existing soil by aerifying and filling the aerification holes with an appropriate type of soil. Heavy soils can be modified for better soil drainage and less compaction by top dressing with sand. This type of management practice will help reduce disease problems because of a healthier plant, and less moisture on the surface around the leaves and crown of the plant. Also, it will help overcome weed problems by developing a stronger turf that can compete better with the weeds.

Selection of the best adapted turfgrasses is a practice that can be used in a turf IPM program. For general turf areas in eastern North Carolina, bermudagrasses, St. Augustinegrass, or centipedegrass should be used. Bluegrass, perennial ryegrass or fescue varieties should be selected and used in Western North Carolina. Certain bentgrass varieties can be used throughout North Carolina and others are adapted in the mountains. Selection of the best varieties will result in a better turf that can compete with weeds and overcome disease and insect attacks. The use of bermudagrass varieties with the best cold hardiness in the transition zone will help avoid damage from cold weather, but also will help prevent weed problems that develop where the turf is open and thin from cold damage.

Removal of shade can be used to manage pest problems. Diseases are often a problem in a partially shaded area because of more humidity and more susceptible plants. Weeds are often a problem in shade because of a poor turf that does not compete well with weeds. Another example of problems associated with shade was seen following the severe winters during which the bermudagrass was damaged. Bermudagrass is often killed on the south side of fairways and greens that were shaded by evergreen trees and on slopes that were exposed to the north. Weeds such as crabgrass and goosegrass invaded the poor turf areas during the summer. Several years of good weed control programs may be needed to reestablish desirable turfgrasses in areas that are killed.

Biological control methods have not been developed for most pest problems on turf, however, biological factors are involved in many pest management practices on turf. Biological control methods on turf for diseases include the use of resistant varieties and competition and antagonism among microorganisms in the soil or on the plant. Biological control methods for insects include the uses of diseases of insects, predators, sterilization of insects, and the use of resistant plant varieties. Milky spore disease of Japanese beetles is a disease of the insect that is being used at the present time. The disease is a bacterial disease of larvae of these insects in the soil. Larvae become infected with the bacterium, and the number of larvae in the area are slowly reduced over a 2 to 3 year period. Biological control methods for weeds includes the use of competition and diseases of weeds. Competition involves growing a good healthy turf that does not allow weeds to become established or that can overcome weeds that develop in the area. Biological control methods for nematodes includes the use of resistant varieties or types of grasses and antagonism. Many soil microorganisms are antagonistic to nematodes and certain types of cultural practices will help increase this antagonism.

Research is underway to develop more resistant varieties to diseases, insects and nematodes. Relatively little is being done in the area of biological control with competition and antagonism for microorganisms. Research has shown that the use of large amounts of pesticides often reduce the level of microbial activity in the soil and thatch in turf. As a result, thatch often increases more quickly in an area that has been treated with large amounts of certain fungicides. Competition is a very useful biological control method for weeds, and a good healthy turf is one of the best weed control programs. More research is needed in this area on biological control of turf pests.

Many different pesticides are available to use in managing pests of turfgrasses. Preventative or curative control programs are used for diseases. The preventative program is based on the past history of the disease, the environment, and the susceptibility of the plants. Curative programs involve an accurate identification of the disease, selection of the proper fungicide and treatment of a disease after symptoms have been observed. A preventative program should be used to prevent diseases such as Pythium blight during the hot, humid summer months on bentgrass. This disease is likely to develop when these weather conditions have been present for several days, and a fungicide should be applied before Pythium blight becomes a problem. A curative control program can be used with other diseases such as dollar spot. The use of a curative or preventative program for a disease depends on the disease, the time of year, type of plant, and also the type of management program that is being used. A good turf management program has reduced the number of fungicide applications and disease problems in many cases.

Insecticides are used for insects when they are present and causing damage. Proper insecticides should be selected and applied in the proper way and at the proper time for good control. Weeds are controlled with herbicides in two types of programs. A preemergence herbicide is applied

to the soil before seeds germinate and seedlings emerge. Preemergence control programs should be used where weeds are usually a problem and are likely to be a problem again. A post-emergence program is used when weeds are already present. Some herbicides are selective and can be used to selectively control weeds. Others are non-selective and cannot be used on some grasses or must be used when turfgrasses are dormant. Chemical control for nematodes should be used when high number of certain nematodes are present.

Chemical control for any pest is based on the presence of the pest or the history of pest problems and on an accurate identification of the pest. A good chemical control program involves the selection of the proper chemical that will control the pest. The least toxic chemical should be selected and applied at the lowest effective rate, and applied properly when needed.

An example of IPM on turf can be illustrated by control of nematodes. A weed and nematode problem occurred on bermudagrass golf greens on a golf course in eastern North Carolina. Herbicides had been applied to control the weed problem without success. The sting nematode was found at high populations, and a nematicide was applied to control the nematode. Within three weeks good quality bermudagrass was obtained and few weeds were present in treated areas. In addition to controlling the nematodes and weeds, over-seeded grasses developed more rapidly in areas where the nematicides were applied. Poor quality turf remained the following year in areas that were not treated.

The economics of pest management practices must be considered in an IPM program on turfgrasses as in agricultural crops. It is not economical to use certain management practices and pesticides on all types of turf-grasses. More expensive methods can be, and are used, on golf greens than on lower maintained turf areas such as fairways and lawns. The decision to use certain types of pest management practices varies from one type of turf-grass area to another. Golf courses that have large maintenance budgets can afford to use more expensive management practices. Other golf courses and home owners with lawns that have lower maintenance budgets cannot afford some pest management practices and must select other types of grasses and have lower quality turf. One example of the economics of a pest management program on a golf course was where a golf course superintendent decided not to control weedy grasses on a bermudagrass fairway because of the expense and the effect it might have on the amount of business at the course. Since most of the people using the facility did not recognize that a weed problem existed on the fairways, he decided not to control the weeds. The poor turf on the fairways for a few weeks following a herbicide application would have reduced the number of people playing golf. More attention was given to maintaining the greens, and golfers continued to play and returned to play the course often even with some weeds on the fairway. Other golf courses with a more demanding clientele and a larger maintenance budget could not have decided to leave the weeds in the fairway.

An effective IPM program requires information about pest problems and turfgrasses. Information about pests that occur on turfgrasses, conditions under which the pests develop, accurate identification of the pest problem and proper control methods are needed. Thus, current educational programs on turfgrasses and pests are an important part of

an IPM program. Many different conferences, workshops and types of literature are available through universities and commercial companies to provide the latest information on turfgrasses and pests.

Some IPM practices have been used on turfgrasses for many years, but the usefulness of these practices and the benefits to turfgrasses and the environment are not generally known. An attempt has been made to point out some of these factors in this paper. In summary, IPM involves the use of knowledge about weeds, insects, nematodes, diseases and turfgrasses and the interactions among them in the turf environment. Turf managers should be aware of the effect of management practices on turfgrasses and pests and select the most economical and effective control methods when needed. The turf managers who do not use available information intelligently may be "gone with the WIND" -- wind in this case means weeds, insects, nematodes and diseases.

TURFGRASSES USED IN NORTH CAROLINA

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Surveys in many states show planting and care of lawns and other turfgrass acreage rank close to the top of all agricultural activities. For perhaps 90% of the population, this is the crop closest to their lives. The total "outdoor living" market for turfgrass or intimately associated commodities amounts to some 12 billion dollars annually.

As with agriculture in general, the search goes on for ever higher quality. Hundreds of special turfgrass selections have been uncovered or bred, adapted to particular tastes, climates, and growing conditions. Whole new facets of commerce have sprung up dedicated to convenient care of the reigning lawn favorites.

In North Carolina we have a wide variety of grasses from which to choose. Some are coarse and for rough purposes only, while the fine-textured grasses produce turf of exceptional quality. Potentiality for quality comes from choice of grass, and depends on the care this grass receives. This care can be more lax in climatic zones where the grass of choice is perfectly adapted. Move the variety to a marginal climate, or subject it to unfavorable factors, and care assumes greater importance, for management must then be tailored precisely to local conditions.

When pure stands of grass are well grown at favorable seasons, all look excellent and there is often little to choose among them. Grown in mixtures, differences in survival and performance appear, and the more extreme the environment the more selective. If such selection were positive, one would need only to sow a mixture of seeds and survival would be of the best adapted seed. In practice, when a mixture is sown, individuals of each species manage to survive and compete so that a turf of motley shades and textures results. Grasses best adapted to the environment will predominate, and management will be easier and more effective if only those are grown.

The question of the best turfgrass for a given purpose can be answered if we know the limitations of the grass under consideration, where the turf is to be grown, and the desired appearance. The perfect turfgrass has not been produced and all have good and bad features. We must understand the characteristics of each grass, decide what is required in the turf to be planted, and then choose the variety that most nearly meets these requirements.

Is the variety selected adapted to the conditions of temperature, wind, humidity and moisture? Can it tolerate shaded conditions? Where conditions are favorable for disease activity, it will be profitable to plant grasses with higher resistance to diseases.

Each of the turfgrass varieties has a given tolerance to adverse soil conditions of compaction, salinity, poor drainage, drought, etc. If conditions exist that can't be corrected, take advantage of the turf best able to withstand less than optimum environments.

How much time, effort, and money can be allocated to the installation and maintenance of the grass? There is no sense in planting a high value turf with a low value budget.

Northern Grasses

Green large part of winter. Tend to become somewhat dormant during July-August toward southern limit.

Kentucky Bluegrasses - Poa pratensis

Prefers fertile, limed, well-drained soils in sun or moderate shade. Color is attractive and texture graceful. Excellent sod results from rhizome spread, with most varieties being recuperative and tolerant of pest control chemicals. Mow reasonably tall, fertilize in autumn and only lightly in hot weather. Many new varieties are being produced that have a broad spectrum of shades of green, leaf textures, heights, growth patterns, and disease resistance.

Varieties: "Wild" types of mixed populations with broad genetic base	Natural (Kenblue, South Dakota) "Common," Park, Arboretum, Cougar, etc.
Selections similar to natural, often with improved color, vigor, etc.	Arista, Campus, Delft, Geary, Newport, Prato, Primo, Windsor, etc.
Selection for specific purposes, low-growth and disease resistance	Adelphi, Bonnie Blue, Baron, Flyking, Merion, Nugget, Pennstar, Sodco, etc.

The Fine Fescues - Festuca rubra

Noted for tolerance of shade, drought, and poor soil, yet fine-leafed with rich dark green color. Excellent seedling vigor establishes new seedings quickly but fine fescues are best mixed with bluegrass for an even sod since most varieties spread slowly. Especially useful for lawns getting limited maintenance, shaded spots, and sandy soils. Hardy but somewhat more sensitive to certain pest control chemicals.

Requires limited fertilization and relatively tall height of mowing. Well-liked in the South for winter seeding into fine bermudagrass turf, with the Chewings type preferred since a better transition to bermuda grass in early summer is obtained.

Fine Fescues

A Chewings Type F. rubra commutata	B Spreading Type F. rubra rubra	C Hard Type F. longifolia
Banner	Boreal	Agram
Cascade	Dawson	Balmoral
Checker	Fortress	Biljart
Highlight	Golfrood	Centurion
Jamestown	Illahee	Scaldis
Koket	Pennlawn	
Oregon		

Bentgrasses - Agrostis spp.

Creeping bentgrass is a long-lived perennial with vigorous creeping stolons that develop at the surface of the ground and initiate new roots and shoots from the nodes. Bentgrass usually persists during midsummer heat stress, but shoot growth is seriously impaired and death of the root system may occur. Proper drainage, irrigation, and disease control are particularly important at high soil temperatures.

A number of vegetatively propagated cultivars are available from sod farms in the United States. The most commonly used ones are Cohansey (C-7), Old Orchard (C-52), Toronto (C-15), and Nimisilia.

The seeded cultivars possess more disease resistance due to their broader genetic heterogeneity. Over a period of time (3-6 years) they tend to segregate into distinct patches. This occurs more quickly with Seaside than in Penncross.

Other varieties are being evaluated for heat tolerance and other desirable characteristics.

Bentgrass Variety Trial
1977-78 NCSU

Cultivar	Quality Means	Dollar Spot	Brown Patch
ARC - 1	7.5	8.6	8.4
Emerald	6.8	6.7	7.9
HCC - 7	6.3	7.5	7.9
MCC - 3	6.8	7.5	8.0
Penncross	8.1	8.4	8.7
Phoenix	6.2	7.6	7.5
PSU - X	7.0	7.8	7.8

Rating Scale 1-9: 9 = best or least disease

Ryegrasses - Lolium spp.

Annual or common ryegrass is tolerated as a minor component in mixtures for quick cover or for overseeding bermudagrass for winter play or color. It is not expected to persist and turns coarse the second year. The perennial ryegrasses are more acceptable and generally are finer textured and do not become as coarse as common. Ryegrasses sow and establish easily, require little care, are non-spreading and do best in full sun.

Perennial Ryegrasses

Some Fine-turf Types

Acclaim	Delray	Loretta
Barry	Derby	Manhattan
Belle	Diplomat	NK-200
Birdie	Elka	Omega
Blazer	Eton	Pelo
Caravelle	Fiesta	Pennfine
Citation	Goalie	Regal
Dasher	Hunter	Yorktown

Tall Fescue - Festuca arundinacea

Reliable, easily started, with good seedling vigor, but coarser than bluegrass, and has a tendency to clump with the stand thins. Plant heavily, for crowding dwarfs the plants and makes it more presentable. Used for roadsides, rough areas, athletic fields, and lawns where bluegrass and fine fescues do not persist. Tall fescue is disease resistant, drought tolerant, supports heavy traffic and persists with minimum care. It may winterkill in northern locations.

Varieties: Due to tall fescue being cross-pollinated, producing new varieties is more difficult than Kentucky bluegrass. Several grass breeders have programs underway, and testing of these cultivars are being carried out, particularly in the Southern region. The second regional test is:

1978 Southern Turf Work Group

Tall Fescue Test No. 2

1. Kenhy	10. Fawn
2. Monaco	11. KY 31
3. PHB-1-5	12. Kenmont
4. L-FA-Syn I	13. Alta
5. AG-125	14. Goar
6. NS-78	15. Belt Syn 16-1
7. Kenwell	16. Belt KPH 1
8. K5-27	17. Belt T F 11
9. T-5	18. Belt T F 25

19. Blend of 7-645, 63-14, 36-1, SOFM

Southern Grasses

Ordinarily are dormant and brown during cold weather.

Bermudagrasses - *Cynodon* spp.

Fast growing, spreading by rhizomes and stolons, but not true to type from seed. Seeded bermudagrass is widely used, with the vegetative finer textured varieties for golf greens and other speciality turfs throughout the South. When well tended, the finer hybrids are very attractive. Requires a high level of maintenance, with generous fertilization and frequent, low mowing. Does not do well in shade, but is tolerant of most pest control chemicals.

New bermudagrass varieties are being developed, particularly for cold tolerance, at Tifton, Kansas, and Oklahoma. The USDA centers at Tifton and Beltsville, Maryland, are developing mutations with radiation, while selections from common varieties are being made in numerous locations.

Bahiagrass - *Paspalum notatum*

For the deep South, especially useful for utility lawns and roadsides that receive only average care. It thrives in most soils, in shade or sun, is fairly coarse, spreads, and stabilizes sandy soils quite well. Does not need a great deal of fertilizer and has no particular disease or insect problem. When mowed high, it is very tolerant of adverse conditions, but seedheads are objectionable.

Bahiagrass Cultivars

Argentine (A)	Pensacola (Pe)
Paraguay (Pa)	Wilmington (W)

Characteristics	
Cold Tolerance	W, Pe, A, Pa
Disease Resistance	Pe, A, Pa, W
Color	W, A, Pa, Pe
Texture	W, Pa, Pe, A
Least Seed Heads	W, Pa, A, Pe

Centipedegrass - *Eremochloa ophiuroides*

The "golfer or fisherman's" grass, survives and even thrives under low maintenance. Generous fertilization makes it look better temporarily but often causes chlorosis and winterkill. Prefers acid soil, tolerant of moderate shade and medium mowing height. Does not stand traffic well or most weed control chemicals. From seed little centipedegrass is seen the first year, but by the second year will fill in and make good but not luxurious lawn.

Centipedegrass is an excellent grass for golf course roughs, giving a fair lie and requiring almost no maintenance.

Varieties: Few to choose from, but breeding from selections made in China by Glen Burton is being conducted at Tifton. Selections from old stands are being made in several locations.

Carpetgrass - Axonopus affinis

A perennial grass adapted to wet, acidic, sandy loam soils of low fertility. Has poor wear and drought tolerance. Easily established from seed, and since it requires minimal care, would be a good choice for wet areas in the roughs of golf courses.

St. Augustinegrass - Stenotaphrum secundatum

Much used in the deep South, tolerant of shade and salt spray, adapted to mucky soils and warm, moist climate. Coarse, but of attractive color, low-growing, and spreads reaily by runners. In recent years it has been badly afflicted by chinchbugs and diseases difficult to control.

Varieties: Floratam, Floratine, Bitter Blue, NCSU-21, and other local selections.

The selection made at N. C. State (NCSU-21) has been released to growers in Texas and one each in North Carolina and Virginia. The superior cold tolerance and resistance to SAD virus makes it an attractive selection.

St. Augustinegrass. Variety Trial
1976-77, MSU

Cultivar	Average Survival
Floratam	4.00
Floratine	2.66
Bitter Blue	3.00
Common	4.00
Dwarf	1.66
NCSU-21	1.00

Rating Scale 1-4: 1=100% survival; 4 = complete kill.

Zoysiagrasses - Zoysia spp.

A widely tolerant grass; some varieties are winter hardy in the North, but used mainly in the South for better quality turfs that can receive moderate attention. Spreads by rhizomes and stolons, but is slow-growing and needs early weed control. Does well in moderate shade or sun, and is very wear-resistant. Somewhat difficult to mow, needs occasional thinning, tolerates most pest control chemicals, and is moderate in fertility and watering needs.

Varieties: Does not come true from seed. Meyer, Matrella, and Emerald.

ESTABLISHMENT AND MAINTENANCE OF TURFGRASSES

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The turfgrasses we use in North Carolina are not native to the continental United States. Thus, we must consider that the soils in which we grow these imported plants may not be as suitable for their growth as for native species of grasses. All of us know this is very true because under native soil conditions -- acid pH, low phosphorus, low potash, low calcium, low magnesium -- crabgrass and other weedy species easily outcompete and overthrow the turfgrasses.

The only way to change conditions so the desirable plants, turfgrasses, can have the competitive edge is to modify the entire potential rootzone. This means that lime, phosphorus and potash must be thoroughly and evenly mixed with the soil material as deeply as the roots are expected to penetrate. Otherwise, the roots of these non-native plants will not enter and remain in this unmodified soil. This principle must be understood and put into practice if we are to enjoy a full stand and the desired condition and quality of our turfgrasses.

In order to accomplish the above, we must first get the soil tested. A chemical soil test is a must because man cannot look at a soil and tell what it contains, what it does not contain or what should be added. Next, broadcast evenly over the soil surface the lime and seedbed fertilizer (especially phosphorus) suggested through the soil test. Even surface application is essential and most important because lime and/or phosphorus fertilizers are only slowly water soluble and move very slowly downward in most soils. Very little or no lateral movement occurs. Then, rotovate or rototill (or third best, disk) the lime and fertilizer into the entire potential rootzone -- 6 to 8 inches deep. This is the key to establishment. Unless the entire potential rootzone is uniformly limed and fertilized, the roots of these plants will never occupy this soil zone and will die (thin out) during stress periods.

Following thorough incorporation of the lime and fertilizer, rake or harrow the area to leave the surface as smooth and level as possible. Roll or cultipack lightly before seeding. Plant the seed or other planting stock as per "time and rate" schedules in Tables 1 and 2. Cover the seed lightly (1/4 to 1/2 inch for large seeds or 1/4 inch for small seeds) by hand raking or other suitable method. Roll with a light roller or cultipacker to firm the soil around the seed and level the soil surface. Vegetative material (stolons, etc.) should be broadcast evenly, pressed into the top 1 to 2 inches of soil, and firmed with a roller or cultipacker.

Mulch areas seeded in cool-season grasses with 1 to 2 bales of weed-free grain straw/1000 sq. ft. Straw will shade warm-season grasses too much. Use netted mulch on warm-season plantings if erosion is probable.

New plantings must be kept moist until well established. Do not allow the soil surface to crust. However, care must be exercised not to overwater because diseases will kill young plants very quickly.

Begin mowing and continue mowing so as not to remove more than one-fourth to one-half of the total leaf surface at one mowing. The suggested height and frequency of cut for the different turfgrasses are given in Table 5.

Again, in considering, and in the actual operation of maintaining these turfgrasses, we must realize that they are not native species. As related to maintenance fertilization and liming, the soil test should never be forgotten. It is the essential tool. The more intensively managed turfgrass areas should be sampled and tested every year. Less intensively managed areas should be tested every 2 to 3 years -- never allow longer than 3 years without testing! Then, apply lime as suggested by test, and apply fertilizer (phosphorus and potash) according to the growing season of the grass and the growth needs by the facility. Maintenance fertilization (amounts, times, frequencies, etc.) is given in Tables 3 and 4. Nitrogen levels and frequencies should be governed by the desired condition and quality of grass and by the need for new growth to replace leaf material damaged by wear and/or injury. However, remember it can be expensive to grow excess grass, maintain it, then mow it and throw it away.

Good management is a function of MAN. And if left in the native state, the natives will win.

Table 1. Vegetative Grasses - Time and Rate of Planting

Grass	Amount per 1,000 sq.ft.	Time of Planting
Sprigging		
Bermudagrass (hybrid)	1/5-1/3 sq.yd.	April - June
Zoysiagrass	1/6-1/4 sq.yd.	May - July
Centipedegrass	1/2-3/4 sq.yd.	May - July
St. Augustinegrass	3/4-1 sq.yd.	April - June
Stolonizing		
Bermudagrass (hybrid)	3-5 bu.	April - June
Zoysiagrass	3-5 bu.	May - July
Centipedegrass		Usually not done
St. Augustinegrass		Usually not done

Table 2. Seeded Grasses - Time and Rate of Seeding

Grass	*Pounds seed per 1,000 sq. ft.	Optimum Times of Seeding
Warm-Season:		
Bermudagrass (common)	1-2	April - June
Centipedegrass	1/4-1/2	March - May
Carpetgrass	3-5	March - May
Cool-Season:		
Tall fescue	5-7	**Mtns: Aug 15 - Sep 1 Pied: Sep 1 - Sep 15 C.P.: Sep 15 - Oct 15
Kentucky bluegrass	1-2	Mtns: Aug 15 - Sep 1 Pied: Sep 1 - Sep 15
Tall fescue (for shady areas) + Kentucky bluegrass	4-5 1	Same as for tall fescue Same as for tall fescue
Red fescue	2	Same as Ky. bluegrass
Italian ryegrass	4-5	Sep or Oct

* To convert lb./1,000 sq. ft. to lb./acre, multiply lb./1,000 sq. ft. by 43.5.

** Cool-season grasses seeded 1 month later (than optimum) have an average of 80% chance of establishment. If seeded 2 months later, a 50% chance.

Table 3. Suggested Maintenance Fertilization for Cool-Season Lawn Grasses.

*Feb. 15	April 1	**May 1	Sep 15	Oct 15	Dec 1
25 lbs.***					
0-10-20 + 1-1/2 lbs. N	1/2 lb. N	1/2 lb. N	1 lb. N	1 lb. N	1 lb. N
			or		
12 lbs. 14-4-8	1/2 lb. N	1/2 lb. N	10 lbs. 12-4-8	1 lb. N	1 lb. N
			or		
12-25 lbs, 10-10-10			12-25 lbs. 10-10-10		

*Dates suggested are for central Piedmont. Dates may be 1-2 weeks later in spring and earlier in fall in west and north, 1-2 weeks earlier in spring and later in fall in south and southeast.

**If cool-season grasses are used east of central Piedmont do not apply the May 1 nitrogen.

***All rates are lbs./1,000 sq.ft. Multiply by 43.5 to convert to acre basis.

Note: The above rates and dates are optimum values for high-quality turf areas which will be mowed often and closely and otherwise managed intensively. For homeowners who do not wish to mow more than once a week (or extensive areas), the May 1 and December 1 nitrogen should be omitted (or the lower rate used as in 3rd option).

Table 4. Suggested Maintenance Fertilization for Warm-Season Lawn Grasses

*April 15	**Each 4-8 Wks. Between	August 15
***15 lbs. 3-9-18	1 to 2 lbs. N	15 lbs. 3-9-18
	or	
4 lbs. 12-4-8	10 to 15 lbs. 12-4-8	4 lbs. 12-4-8
	or	
12 lbs. 0-10-20		12 lbs. 0-10-20
+		+
1/2 lb. N	1 to 2 lbs. N	1/2 lb. N
	or	
12 lbs. 10-10-10	1 to 2 lbs. N	10 lbs. 10-10-10

*Dates suggested are based on upper Coastal Plain and eastern Piedmont. Dates may be 1-2 weeks earlier in spring and later in fall in south and/or southeast, 1-2 weeks later in spring and ealier in fall in west and north.

**Bermudagrasses will respond to N applications every 4-6 weeks; zoysia and St. Augustine every 6-8 weeks; carpet and centipede once in mid-summer (none on centipede on fertile soils).

***All rates are lbs./1,000 sq.ft. Multiply by 43.5 to convert to acre basis.

Note: The above rates and times are optimum values for high-quality turf areas which will be mowed often and closely and otherwise managed intensively. The homeowner who does not wish to mow more than once a week (or extensive area) should use the lower rate of nitrogen and the longer interval between applications.

Table 5. Height and Frequency of Cut for Warm- and Cool-Season Turfgrasses

Grass	Height of cut (inches)		Frequency of cut (days)	
	*Intensive Management	Extensive Management	Intensive Management	Extensive Management
Warm-season:				
Bermudagrass (common)		1		5-10
Bermudagrass (hybrid)	1/2	3/4-1	3-5	5-10
Zoysiagrass	1/2	3/4-1	4-6	5-10
St. Augustinegrass		1		5-10
Centipedegrass		1 - 1-1/2		7-14
Carpetgrass		1		7-14
Cool-Season				
Tall fescue		2-3		5-10
Kentucky bluegrass**	1 - 1-1/2	2-3	4-6	5-10
Red fescue		2-3		5-14
Italian ryegrass	1	2-3	3-5	5-7

* Intensively managed areas are usually small sites where people will be looking at the grass very closely and must be well groomed. Extensive areas are viewed from a longer distance.

** Some of the newer varieties will take closer cut than common. Check with agricultural agent or N.C. State University for current varietal information.

FERTILIZATION OF GENERAL TURF

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The native soils of North Carolina do not contain, or in most cases retain, adequate amounts of the fertilizer elements required to maintain a stand of the turfgrasses we use. Further, this lack of fertility will not allow the condition and quality desired and needed, especially under the more intensive levels of management. The infertility and acid conditions of our native soils are the result of a combination of conditions - parent material from which the soils arose, high quantities of precipitation resulting in leaching, long periods of time in which weathering (such as alternative freezing and thawing) has occurred, the uses and abuses which have been imposed.

Considering the above factors and influences, it becomes apparent that we must lime and fertilize our soils regularly in turfgrass production. Since the turfgrasses we use are not native species, we must recognize that they will not compete with native plants under indigenous soil conditions.

The first step in any fertilization and liming program is to get a chemical soil test (every 2 to 3 years). To do otherwise is foolhardy and wasteful. Such tests will give information on which to base an establishment and/or maintenance lime and fertilizer program.

Adequate research information is now available about turfgrass requirements for establishment and growth and about lime and fertilizer materials in the market. These can be put together to grow turfgrasses of superior condition and quality. In general, the turfgrasses we use will require nitrogen, phosphorus, and potash in roughly a 4-1-2, 4-1-3, or 4-1-3+ ratio over the year. The variations in potash, and potentially in other elements, is dependent on the soils on which the plants are grown; the growth, condition and quality desired; the level of intensity of management imposed (irrigation, clippings removed, etc.); and other factors. However, it has been established that proper rates and timing of potash fertilizers improves winter hardiness in bermudagrasses, and the vigor of most turfgrasses.

In most situations, except perhaps the most intensively managed installations, the phosphorus and potash should be applied on the basis of the soil test. Split applications are generally beneficial, especially for potash and for intensive management. Once a year treatments are suitable under lower levels of management. Table 3 and Table

4 of the preceding paper give some general fertilization schedules for cool-season and warm-season turfgrasses.

Lime by soil test. Most of our turfgrasses grow best at a pH of 6.5 to 7.0. Finely ground dolomitic limestone is usually the safest, most economical and convenient form to use. Dolmitic limestone adjusts the pH and supplies calcium and magnesium. Table 1 gives a guide for counteracting the acidity built up by using some nitrogen sources.

Table 1. Amount of Dolomitic Limestone Required to Neutralize Acid Formed by Some Nitrogen Sources**

Nitrogen Source	Pounds of Dolomitic Lime to neutralize when 1 pound of N is used
Ammonium nitrate	1.9**
Ammonium sulfate	5.6
Anhydrous ammonia	1.9
Ammonium nitrate & Lime	0
Ammonium nitrate solution	1.9
Urea & ammonium nitrate solution	1.9
Ammonium nitrate & ammonia solution	1.9
Urea	1.9
Calcium cyanamid	3.1 B***
Nitrate of soda	1.9 B***

*Complete fertilizers may be either acid or basic depending on manner of manufacture.

**As an example, if 10 lbs. N/1,000 sq. ft. were applied in one year via ammonium nitrate (30 lbs. of 33.5% material), nearly 20 lbs. of dolomitic limestone would be needed each year to offset the acidifying effect.

***Those sources with B after the value are basic; for example, they raise the pH as if that amount of lime had been applied.

Nitrogen fertilization, frequency of applications or total amount per year, depends on the type of fertilizer (quick-release or slow release) being used, the needs of the grass being fertilized, and the turf conditions and quality desired by the owner or manager.

In conclusion, proper fertilization and liming is as essential for general turf under North Carolina conditions as it is for the most intensively managed turf. The differencs is just a matter of degree as related to the demands and needs for quality. The higher the quality demanded, the higher the total amount of fertilizer and lime and the more frequent the applications. If large areas of general turf don't require that quality, don't go to the expense to have it. Again, the turfgrasses we use are not native plants. Thus they do require soil modification by liming and fertilizing. Otherwise, BACK TO NATURE!

WEED CONTROL IN LAWNS AND OTHER TURF AREAS

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Weeds are unattractive in a lawn or other turf areas. In addition, they compete strongly with desired grass for space, water, nutrients and light. To begin with the most effective weed control is a thriving turf - one that has been correctly fertilized, watered and mowed. Crabgrass is the predominant grassy weed of turf areas in North Carolina. We have both large (hairy) and smooth crabgrass. They are annuals and seed may germinate from April through the summer as long as the soil is warm and moist. All plants are killed by heavy frost in the fall.

PREEMERGENCE CRABGRASS CONTROL

Several satisfactory materials for preemergence control of crabgrass and certain other annual grasses are listed below. In addition, these chemicals may also control certain broadleaf weeds.

Benefin (Balan) is safe to apply on established lawns and golf courses of Kentucky bluegrass, perennial ryegrass, fescue, bahiagrass, bermudagrass, centipedegrass, St. Augustinegrass, and zoysia. Established stands of fine-leaved fescues may be thinned. Do not apply in the spring to turfgrasses planted the previous fall. A spring application of Balan may thin over-seeded winter grasses in bermudagrass areas. Do not use on putting greens, dichondria, or newly sprigged areas of bermudagrass, St. Augustinegrass or centipedegrass.

Bensulide (Betasan, Pre-San) can be applied to the following well established turfgrasses; bahia, bentgrass, bermudagrass, perennial bluegrass, centipedegrass, fescue, perennial ryegrass, St. Augustinegrass and zoysia. Can be applied in the spring to turfgrasses seeded the previous fall. It is not advisable to use bensulide on a bermudagrass golf green especially where the stand is thin for it affects rooting at the nodes of the stolons. The stolons (or runners) will not knit down tight to the soil. Balan, Dacthal and Tupersan will show similar effects. Do not apply to newly sprigged turfgrasses. Bensulide has been the most consistent performer for preemergence crabgrass control in the state.

DCPA (Dacthal) is applied on well established lawn grasses grown in North Carolina. However, certain bentgrasses are less tolerant. Consult the label. Stands of fine-leaved fescues may be thinned. Can be applied in the spring to turfgrasses seeded the previous fall.

Oxadiazon (Ronstar) is for use in established perennial bluegrass, bermudagrass, perennial ryegrass and St. Augustinegrass turf; such as lawns, parks, fairways and golf courses. Red fescue and bentgrasses are not tolerant. Do not apply to zoysia or centipedgegrass, to putting greens or tees or to newly seeded areas.

Siduron (Tupersan) may be used in newly seeded or established plantings of the following turfgrasses only; perennial bluegrass, fescue, perennial ryegrass, zoysia and certain bentgrasses (check label). Do not use on bermudagrass, carpetgrass, or centipedegrass. It is not recommended on golf greens. Tupersan is an unique product for it can be applied immediately following seeding of perennial bluegrass, fescue, perennial ryegrass, and certain bentgrasses and sprigging of zoysia for selective control of crabgrass. Application at seeding is the primary utility of this product.

Time of Application

Apply these herbicides 10 to 14 days before crabgrass is expected to germinate in the spring. For North Carolina conditions, apply during the following dates:

Southern Coastal Plains:	March 10 - March 25
Northern Coastal Plains & Piedmont:	March 10 - April 1
Mountains:	March 25 - April 10

Or another way to remember the application time is when the dogwoods are in full bloom.

Methods of Application

Materials may be applied as a spray or granule. Wettable powders or liquid formulations are mixed with water and then applied with a pump-up sprayer or hose sprayer. Follow spray applications with at least 1/5 inch of water - irrigation or rainfall - to wash the preemergence herbicide off the grass and down into the soil where the weed seeds are located.

Granules are applied with a lawn spreader. Research in North Carolina indicates generally more favorable results are obtained when a herbicide is applied as a granular product than when the same herbicide is applied as a spray. Herbicides are also available on fertilizer carriers. Granular and fertilizer products are frequently marketed in a given size bag to cover 2500 or 5000 sq. ft. with settings listed for different spreaders.

POSTEMERGENCE CONTROL OF CRABGRASS, DALLISGRASS, GOOSEGRASS, FOXTAILS, BAHIAGRASS, SANDBUR, BARNYARDGRASS, AND NUTSEDGE

Postemergence control is the use of chemicals to kill growing crabgrass, dallisgrass, goosegrass or other weedy grasses present in the turf. These weedy grasses have a greater susceptibility to the chemicals than turfgrasses. More favorable control of goosegrass is obtained from postemergence treatment than preemergence.

Herbicides to Use

Chemicals known as arsonates; CMA, DSMA, MAMA, and MSMA are used for postemergence control. Do not use these materials on carpetgrass, centipedegrass, or St. Augustinegrass. Temporary discoloration of turf may be expected, especially in hot weather with low soil moisture. Rain or irrigation will revive the turf. Bentgrasses and fescues are generally more sensitive and may be temporarily discolored. Bermudagrass, bluegrass, and zoysia are more tolerant. CMA is the safest of the arsonates to use on bentgrass. Treated areas may be seeded two weeks after the last application.

Time and Method of Application

Begin treatment when the grassy weeds are young (3 to 4 leaf stage) because control becomes more difficult as plants mature. One application may be sufficient if applied when seedlings are less than 2 inches tall. At least 2 applications are necessary, 7 to 10 days apart for medium to mature crabgrass. More mature plants may require additional applications. Since CMA, DSMA, MAMA, and MSMA have no residual toxicity, treatment must be repeated as new seedlings appear. In the case of nutsedge and sandbur, 3 to 4 applications may be necessary.

Uniformly spray infested area when soil moisture is adequate for rapid growth of turf and weeds. For effective results, treat when air temperature is 80° to 90°F. For temperatures below 80°F increase application rates according to recommendations in the product label.

Do not water or mow turf for at least 24 hours after application. Apply in any type of sprayer, including hose-end sprayers. Do not treat new lawns until after the third mowing.

ANNUAL BLUEGRASS (*Poa annua*) CONTROL

Preemergence application of benefin (Balan), bensulide (Betasan or Pre-San), and DCPA (Dacthal) control annual bluegrass. Certain winter annual broadleaf weeds are also controlled, for example,

chickweed. Application time varies in the state with location and moisture and temperature conditions in late summer and fall. With good soil moisture and cool temperatures, annual bluegrass may germinate in late August in the Mountains and early September in the Piedmont or it can be as late as October or November. With fall herbicide applications it is not possible to fall seed turfgrasses. To extend annual bluegrass control and provide preemergence control of crabgrass in the spring, follow with another application at two-thirds the rate on March 1.

Pronamide (Kerb) provides preemergence and postemergence control of annual bluegrass (0.75 to 1 oz. per 1000 sq. ft. or 2 to 3 lbs per acre of Kerb 50W). Use only on bermudagrasses. Apply September 15 to February 1. Will also control annual ryegrass, common and mouseear chickweed, corn speedwell and henbit (preemergence only). Injury symptoms from postemergence applications are slow to develop. Weeds gradually turn yellow and die over 3 to 5 week period. Do not use on areas to be overseeded with susceptible cool-season grasses within 90 days after application.

Metribuzin (Sencor 50W) may be applied to dormant common bermudagrass golf course fairways for postemergence control of annual bluegrass, common chickweed, henbit, parsley-piert, and spurweed. Use 1 lb. per acre of Sencor 50W.

BROADLEAF WEED CONTROL

The herbicides used for selective control of broadleaf weeds in turf are 2,4-D, dicamba and mecoprop (or MCPP). These are used primarily on growing weeds.

Time and Method of Application

In general the younger the weed the easier it is to control. Well established turfgrasses can be safely treated noting any precautions listed on the label and in the following section for each specific herbicide. Do not treat newly seeded turf until after the third mowing. Better results are obtained when the weeds are actively growing and daily temperature is expected to be 60°F or higher. Do not spray during times of drought or when turfgrasses are under other stresses. Repeat treatments may be necessary especially on perennial weeds. Wait 4 weeks between treatments.

Winter annuals are preferably sprayed from February to April depending on location within the state and temperature and growing conditions. Many summer annuals should be sprayed in April or May, while lespedeza and spurge should be sprayed in June or early July. Perennials are usually sprayed in April or May. They also may be treated in the fall, October or November.

Herbicides to Use

The susceptibility of important broadleaf weeds to herbicides is listed in the table. Many herbicide formulations are available at many different concentrations. Consult the product label for specific rate suggestions.

SUSCEPTIBILITY OF BROADLEAF WEEDS TO HERBICIDES

	Classification of weed	Response of Weed to Herbicides		
		2,4-D	Mecoprop (or MCPP)	Dicamba
Bittercress	WA	S	S-I	S
Black Medic	A	S	I	S
Buttercups	WA, B, & P	S-I	I	S
Buttonweed, Virginia	SA	S-I	I	-
Carpetweed	SA	S	I	S
Chickweed, Common	WA	R	S-I	S
Chickweed, Mouseear	WA	I-R	S-I	S
Clover, Hop	WA	I	S	S
Clover, White	P	I	S	S
Cranesbill	WA	S	S-I	S
Dandelion	P	S	S	S
Dichondria	P	S	I	S-I
Dock	P	I	I-R	S
Garlic,Wild	P	S-I	R	S-I
Ground Ivy	P	I-R	I	S-I
Hawkweed	P	S-I	R	S-I
Healall	P	S	R	S-I
Henbit	WA	I	I	S
Knawel	WA	R	I	S
Knotweed	A	R	I	S
Lespedeza	SA	I-R	S	S
Mugwort	P	I	I-R	S-I
Parsley-piert	WA	S-I	-	S-I
Plantains	P	S	I-R	I-R
Prostrate Spurge	SA	I	I	S
Red Sorrel	P	R	R	S
Speedwell, Corn	WA	I-R	I-R	I-R
Spotted Spurge	SA	I-R	S-I	S-I
Spurweed	WA	I	-	S
Violet, Wild	P	I-R	I-R	S-I
Wild Strawberry	P	R	R	S-I
Woodsorrel, Yellow	SA	R	R	I
Yarrow	P	I	I-R	S
Yellow Rocket	WA	S-I	I	S-I

A = annual WA = winter annual SA = summer annual B = biennial P = perennial
S = weed susceptible
I = Intermediate, good control sometimes with high rates, sometimes poor, usually require more than one treatment
R = resistant weed in most cases

Combination Products. There are many products on the market containing two or three herbicides to provide control of a broader spectrum of broadleaf turf weeds. Some examples are: 2,4-D + MCPP (Weed-B-Gon) Lawn Weed Killer M), 2,4-D + dicamba (Banvel + 2,4-D and Super-D Weedone) and 2,4-D + MCPP + dicamba (Trimec, Trex-san, Trex-San Bent, 33 Plus). Read the product label carefully for weeds controlled, recommended rates, application methods, safety to various turfgrasses, safety to nearby ornamentals, shrubs, trees, flowers, vegetables and other desirable plants and other precautionary statements.

SENCOR FOR WEED CONTROL

For the past three years we have evaluated the use of metribuzin (Sencor 50W) for weed control in bermudagrass. Sencor currently has a state label for use on well established common bermudagrass fairways. It should be applied when the weeds are actively growing and there is a good soil moisture. Our studies may be summarized as follows:

Preemergence application of Sencor 50W at 1.5 lb. active/A will control large (hairy) and smooth crabgrass. For postemergence control it will take two applications at 0.5 lb active/A per application. In many cases, one application of Sencor + MSMA at 0.062 + 2 lb active/A has also given postemergence control. More mature crabgrass may require two applications.

Goosegrass has been effectively controlled with two postemergence applications of Sencor at 0.5 lb active/A per application or with two applications of Sencor + MSMA at 0.062 + 2 lb active/A per application.

Sencor will also control four winter annual weeds, common chickweed, henbit, parsley piert and annual bluegrass. Applications in January controlled these weeds at 0.25 lb active/A while in February and March it took 0.375 to 0.5 lb active/A.

Common bermudagrass has the most tolerance to Sencor while Tifton 328 is intermediate and Tifton 419 the least tolerant of the three cultivars.

INSECT PESTS OF TURF

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Several insects are common in turf in North Carolina, but only a few cause enough damage to require control measures. Grubs, mole crickets and billbugs live in the soil and feed on the roots of grasses. Sod webworms, armyworms, and cutworms feed on leaves and stems, while chinch bugs, leafhoppers, spittle bugs and scale insects suck juices from the plants.

Naturally occurring parasites, predators, and diseases, as well as climatic factors, often keep injurious insects in check. Therefore, you need to know what kind and how many insects are present before applying insecticides. If your lawn has stunted, distorted growth, browning or yellowing leaves, or dead areas and you suspect insect problems, make frequent and thorough inspections of your turf, especially during periods of peak insect activity from late spring until fall. Diseases, nematodes, drought and nutritional deficiences also cause similar disorders, so be sure of your diagnosis and use the proper treatment.

Grubs - The larvae of several different kinds of beetles such as the Japanese beetle, green June beetle, southern masked chafer, May beetle, Asiatic garden beetle and others live in the soil and damage grass by feeding on the roots or uprooting plants by their burrowing. Moles, skunks, birds or other animals may severely damage large areas of turf while searching for grubs for food. Heavy infestations of Japanese beetle grubs or masked chafers may completely destroy the roots and the turf can be rolled back like a carpet. To detect these pests, closely examine a sample of roots and soil to a depth of 4 to 6 inches. Apply Sevin for green June beetle or diazinon or trichlorfon (Proxol/Dylox) according to label directions for control of other grubs when one or more grubs are present per square foot.

Sod Webworms, Armyworms, and Cutworms - These insects feed on the leaves and stems of grass plants, causing scattered, irregular brown patches in lawns. To detect these pests, closely examine dying and healthy sod for worms late in the afternoon. Apply diazinon, Sevin, Dursban, or Proxol if damage is noted and five or more sod webworms or one armyworm or cutworm are present per square foot of general turf area or when one sod webworm is present per square foot or one armyworm or cutworm per square yard on golf greens.

Chinch Bugs - These insects are primarily a pest of fescues and bluegrasses in the mountains and of St. Augustinegrass in the East. Damage appears as yellowish spots or areas which rapidly turn brown and die. Injury is caused by the immature chinch bug, which is bright red, or adults, which are 1/6-inch long with black and white markings. Chinch bugs can usually be found by pushing the grass to one side and examining the base of the plants at the soil surface or by cutting both ends out of a metal can and pushing one end into the soil. Fill the can with water. If chinch bugs are present, they will float to the surface within 5 minutes. Examine three or four places in the suspected area. If six or more bugs are found within a 6-inch diameter area, treat with an insecticide such as diazinon, Sevin or Dursban.

Mole Crickets - Mole crickets are light brown crickets about 1-1/2 inches long when full grown. They have short, stout forelegs and shovel-like feet. They feed on the roots of grass, and their burrowing uproots seedlings and causes soil to dry out quickly. One mole cricket can damage several yards of newly seeded area or a golf green in a single night. Baits containing Dursban or Baygon should be used for control.

Bees and Wasps - There are several species of bees and wasps that occasionally damage turf by digging up the soil, making holes or forming mounds. Some of the more common are cicada killers and scoliids. Diazinon or Sevin used according to label directions will control these pests.

Ants - Ants do not feed on grass, but they may damage grass by uprooting plants and smothering out areas with their mounds. Thresholds will vary greatly depending upon location of the infestation and the use of the area. Mound or broadcast applications of diazinon, Sevin or Dursban should be made when the infestation is annoying in recreational areas.

Protect yourself, your family, neighbors, pets, bees and birds by reading the pesticide label and following all directions and precautions. In general, never apply pesticides when people or animals are on a lawn or turf area and do not permit people or pets on a treated area until the spray has dried completely.

DISEASES OF TURFGRASSES IN NORTH CAROLINA

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Diseases are often a problem in home lawns, golf courses, industrial lawns and other turf areas throughout North Carolina. Many diseases occur on turfgrasses that can reduce turf quality or increase maintenance costs. Diseases are caused by mircoscopic organisms that cannot be seen with the unaided eye except when large masses of the microorganisms are present. A disease becomes evident when symptoms such as leafspots or dead leaves are observed. Certain symptoms are characteristic of different diseases and are used to identify turf diseases. The identification of a disease is confirmed by the identification of the pathogen under the microscope in the laboratory. The important diseases of turfgrasses in North Carolina are caused by fungi and nematodes.

Brown patch that is caused by the fungus Rhizoctonia solani occurs on turfgrasses throughout the state. Brown patch is a serious problem on cool season grasses during hot and humid weather in the summer. Tall fescue and bluegrass in lawns and bentgrass and overseeded grasses on golf greens are very susceptible to this disease. Brown patch is usually not a problem on warm season grasses such as bermudagrass, centipede grass and St. Augustine grass in North Carolina.

Symptoms of brown patch on higher cut grasses, such as tall fescue, are first brownish circles 1/2 to 2 feet in diameter in early summer. The brown areas may continue to develop until the entire turf has a brown to tan color late in the summer. In the early stage of disease development, small tan lesions with light brown margins develop on the leaves. The fungus spreads to the adjacent healthy leaves and the patches enlarge during favorable weather conditions. Sometimes thread-like structures of the fungus that are composed of many microscopic hyphae of the fungus can be seen on the leaves in early morning. Brown patch on shorter cut grass such as bentgrass and overseeded grasses on golf greens develops in a more defined circular pattern than on the higher cut grasses. A grayish ring of fungus mycelium, called a smoke ring, is often associated with the edge of the circles when the disease is developing rapidly.

The fungus that causes brown patch is a normal inhabitant of most turf areas. The fungus survives the winter in soil or infected

plant material and resumes growing in the spring of the year. The fungus grows most rapidly when temperatures are 80 to 90 degrees F and abundant moisture is present.

Cool season grasses that have been fertilized with higher than recommended rates of nitrogen fertilizer during the late spring or summer are more susceptible to brown patch. Proper management of cool season grasses in home lawns is the only practical control for brown patch. Tall fescue, for example, should be fertilized as recommended in the fall, winter and spring, and not during the summer to help control this disease. Proper soil pH, correcting shade problems, mowing the grass frequently, and mowing when the grass is dry are other management practices that will help prevent brown patch. Broad spectrum fungicides can be used in home lawns, but are not usually economical to use. Brown patch on golf greens can be controlled by using a combination of good management practices and proper fungicides.

Dollar spot, caused by the fungus Sclerotinia homoeocarpa, is an important disease of turfgrasses in North Carolina. The disease occurs on both warm and cool season grasses but is usually a serious problem only on cool season grasses on golf greens in North Carolina. Symptoms of dollar spot on short cut grasses are many small spots about the size of a silver dollar. Spots are larger and more irregular on taller cut grasses.

Extra nitrogen fertilization can be used to help overcome the symptoms of dollar spot. Most of the problems with dollar spot in lawns and higher cut grasses can be controlled by management. Proper management including extra nitrogen will help control dollar spot on golf greens, but fungicides are usually needed. Care must be taken to avoid using too much nitrogen on cool season grasses during warm weather since other diseases such as brown patch and Pythium blight may be more of a problem.

Helminthosporium leaf spots and crown rots occur on many turfgrasses. Symptoms are small spots on the leaves with infected leaves turning yellow and dying prematurely. Leaf spot symptoms develop in cool weather in the spring and fall and root and crown rot symptoms develop during the summer with many Helminthosporium diseases. Stands of cool season grasses infected with Helminthosporium diseases often become thin during hot summer months.

Management practices that produce a good healthy turf will help overcome Helminthosporium diseases. Broad spectrum fungicides in the spring and fall are often needed on golf greens but usually are not needed on lower maintained turf.

Rust occurs on many grasses and is a problem in North Carolina. on bluegrasses, ryegrasses, and zoysia grasses. The early symptoms of rust are small yellow flecks on leaves that develop into rust colored areas. Infected leaves turn yellow and die prematurely. Turf that is infected with rust often has a bright orange color and becomes thin and weak in affected areas. Rust is often a problem in areas with too much shade. The use of more resistant varieties of grasses is the best control of rust. Broad spectrum fungicides can be used where needed.

Strip smut is a serious disease on some bluegrass varities. Infected grass has black streaks on the leaves in the spring. Infected plants die during the summer months leaving a thin turf. There is no practical chemical control for this disease on bluegrass, and other grasses may be needed in areas that have a problem with stripe smut.

Powdery mildew is often seen on cool season grasses that are growing in shady areas. It is usually not a serious problem in North Carolina. It can be controlled with fungicides where it is a problem.

Red Thread is a disease that frequently occurs on cool season grasses in western North Carolina. Symptoms of red thread are circular brown patches 1/2 to 1 foot in diameter. Small "red threads" of the fungus can be seen at the tip of many of the dead leaves. Extra nitrogen fertilizer will help overcome the symptoms of this disease. Broad spectrum fungicides can be used for control when needed.

Pink and gray snowmolds are sometimes a problem on cool season turfgrasses in western North Carolina. Proper maintenance practices and fungicides are needed to control these diseases during the winter where these diseases occur.

Pythium blight is a serious disease of cool season grasses on golf greens and young seedlings in new lawns or on golf greens. This disease can develop very rapidly during warm-wet weather. Seeds are often treated with fungicides to help prevent seedling blight caused by Pythium species. Waiting to seed cool season turfgrasses until the weather turns cool in the fall will help control this disease on seedlings. Specific fungicides are needed on bentgrass and overseeded golf greens when the weather has been hot and wet for extended periods of time to control Pythium blight. Lower nitrogen levels and good soil drainage will also help control this disease.

Fairy rings occur in all types of turf areas. Some fairy rings cause green circles, some dead circles, some produce rings of mushrooms,

and some produce various combinations of these symptoms. Fungi that cause fairy rings grow on organic matter in the soil and affect the surrounding grass by releasing nitrogen or toxic substances in the soil. Fairy rings often occur for many years and continue to enlarge each year.

Fairy rings often develop from debris buried in the soil; therefore, removing old stumps or debris from a turf area before planting is the best control method. Sterilization of soil or removal of affected soil and replanting the turfgrass can be used on a limited basis with serious fairy ring problems. Fungicides have not been effective in controlling this problem. Sometimes management practices such as the use of extra fertilizer, water, seeds, and topdressing on affected areas will help mask the damage from fairy rings.

Gray leaf spot of St. Augustinegrass can be a problem in the southeastern part of the state. The leaf lesions can develop to the extent that the affected turf has a brown appearance. Certain fungicides can be used to control gray leaf spot, but a good management program will usually help the St. Augustinegrass overcome the disease in North Carolina.

Centipedegrass decline is a problem throughout eastern North Carolina where centipedegrass is grown. Symptoms of this disease are poor turf areas throughout a lawn after it has been established for several years. Several different factors such as too much nitrogen fertilizer, the use of herbicides, pH above 5.5, damage from cold weather, ground pearls, fairy rings, and nematodes have been identified as the problem in many centipedegrass lawns.

Slime molds are fungi that develop on the surface of plants during warm-wet weather and appear as grayish or bluish growth on the leaves of many different turfgrasses. Any damage that results from slime molds is from the shading of leaves by the fungi on the surface of the leaves. These fungi can be removed by mowing, brushing, or washing with water. Fungicides can be used if slime molds continue to develop and cover large areas of turf.

Spring deadspot (SDS) is the most serious disease of bermudagrass in North Carolina. The disease is evident as circular dead areas of turf in the spring as bermudagrass resumes growth from winter dormancy. Hybrid bermudagrasses such as Tifway (Tifton 419) and Tifgreen (328) are more susceptible than common bluegrass. The disease usually develops on turf that is 3 to 4 years old that has been managed at a high level and thatch has accumulated. Bermudagrass grows over the spots slowly during the summer, and weeds often invade the area further suppressing the growth of bermudgrass over the spots.

The cause of SDS in North Carolina is not known. Management practices that avoid heavy rates of nitrogen and thatch accumulation help to prevent the development of SDS. Fungicide applications in the fall have given good control of SDS the following spring in experiments in North Carolina.

Nematodes occur on turfgrasses throughout North Corolina, however, serious damage from nematodes has been demonstrated on turf only in the sandy soils of eastern and southeastern North Carolina. Symptoms of nematode damage are poor turf that does not respond properly to good management and fertilization practices. The roots are usually stunted and the turf wilts rapidly during dry weather. The only way to determine if nematodes are a problem is to have a soil sample assayed for nematodes. Soil samples can be assayed for $1 per sample by sending samples to the Nematode Assay Laboratory on Blue Ridge Road in Raleigh. Contact your local County Agent for details on collecting and sending soil samples to the Nematode Assay Laboratory. Nematode populations in turf are usually highest in the fall of the year, and this is the best time to have the soil assayed.

The sting and stubby-root nematodes have been shown to be the most important nematodes on turfgrasses in North Carolina. Nematicides can be used to control these nematodes when large numbers are present. Nematicides that are available can be used on golf courses and sod, but not in home lawns. Be sure to follow label directions when applying nematicides because some of the chemicals are highly toxic and some may damage cool season grasses.

Other problems such as low pH, too much fertilizer, animal damage, pesticide toxicity, etc. occur on turfgrasses and may resemble diseases. Therefore, it is very important to accurately identify the disease before selecting a control method. In many cases, simply using a good management program will help control or prevent many of the diseases, particularly in home lawns and low maintenance turf areas. When pesticides are used, follow the label directions and apply them correctly.

ESTABLISHING A HOME LAWN MAINTENANCE BUSINESS

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I was told there are only two ways to work. You can work for yourself or you can work for someone else. Working for myself has proven much more rewarding and a lot more fun.

The first criterion of starting a business is having a master plan. Success or failure depends on this plan. Most advisors recommend planning for at least 18 months before taking the plunge into starting a business. Statistics show that 90% of all small businesses fail in the first two years. Poor management is usually blamed for these failures.

Starting a business Under capitalized, a poor sales force, lack of business experience, and lack of a market for the product are the major examples of poor management.

A careful inventory of your management skills must be taken to ascertain that you have the combination of grit, education, and applied management skills to begin a new venture.

Finding the capital to finance a company can be accomplished in many ways. The Small Business Administration, commercial banks, refinancing property, selling stock, and borrowing from individuals (doctors and criminal lawyers are a good source) are possible ways of generating the necessary capital. Of these choices, selling stock might relieve some initial pressures since you don't have big loan payments breathing down your neck. However, the price of not owning 100% of the company might override this advantage.

One of the first questions I had to deal with was which comes first, the money or getting customers lined up? I decided that having customers' signatures on the dotted line would increase the possibilities of obtaining funds.

Obtaining capital is a perfect example of the results of your Master Plan. Before you approach a lending source, have a detailed plan to present. Anticipated income and expenses for at least a year should be on paper in detail. Be prepared and ready with facts and figures.

Choosing a company name and logo is another important part of your plan. I chose my company's name three years before the company was formed.

A professional artist will design a logo for $25.00 to $500.00. Once you design your logo and present it to the public, be very hesitant to change it. If it is changed, it is confusing to the public who may think it's a new company.

Having a business telephone is a must even if you operate from your home in the beginning. People relate to the logo and name before they relate to you and communication is far easier.

The next big step was purchasing equipment. I purchased all new equipment deciding that I couldn't make money or service customers with equipment breakdowns no matter how minor.

Our equipment is painted and lettered in accordance with national advertising methods and it is a constant source of advertising.

The best advertising by far, is by word of mouth. Brochures, newspapers, and the yellow pages have proven to be the most effective methods of advertising for a lawn care company.

Be selective in the customers you sign up. Help is available through the Merchants Association in giving credit to customers you don't know.

A good accountant, not only in terms of education, but someone you feel relaxed with and trust is a necessary "must" for guiding you and helping you choose directions.

To summarize:

Why did I quit a profession that I had been in for over 20 years and start my own business?

1. It's the Great American Dream.
2. Job secuirty
3. Independence and Freedom
4. Seeing the results of my decisions
5. From an economic point of view, owning your own business allows you to build an estate in addition to earning a salary.

All of these were important reasons why I "took the plunge", but the most important reason of all is that every morning when the alarm goes off, I'm ready for the day and the satisfaction it will bring.

COMMERCIAL LAWN SERVICES

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Lawn service companies as they now exist are relatively new and are just beginning to find their place in the turfgrass industry. Although lawn care companies in some form may have existed for many years, it is safe to say that they did not become prominent until pesticides became a major factor in agriculture. Early lawn services were largely an extension of other horticultural activities and it has only been in the last ten years that lawn care companies have operated on a regional or national scale.

LAWN SERVICES TODAY

There are several types of lawn care companies now in operation. Perhaps the most numerous type is mowing and grooming which may be operated either by students and others on a part-time basis, or by full-time commercial companies that may offer other services in addition to mowing. Mowing services are mostly local and small, however, the total expenditure for this type of service is undoubtedly large.

In some areas of the country, lawn service companies specialize in pest control. Many times these operations are a part of structural pest control services or other related businesses. These services are prominent in Florida and other locations where chinch bugs or other insects are especially troublesome.

Several regional and national companies sell franchises to someone to operate a lawn service business in one location. The parent company usually helps in establishing accounting and operating procedures and may sell chemicals to the franchise. However, a recent court decision ruled that a franchise had the right to purchase materials on the open market and is not obligated to purchase from the parent company.

Franchise operators offer a wide range of services. Most of them apply fertilizers and various pesticides. Some of them overseed, spike, aerify and do other operations. Many times, special equipment that does several operations at one time is included in the franchise cost. In most instances, an individual franchise remains small because of boundary restrictions that are a part of the franchise agreement.

Another type of lawn care service is operated by the owner on a local level. This type of company may be small to medium in size, and may service from a few hundred to ten thousand or more customers. These companies offer a wide range of services depending on the individual operation. Mowing, landscape maintenance and other services may be included in a base price or may be offered as optional services at additional costs. Local lawn service companies operated in many different ways and it is impossible to place them into a common category.

In the last ten years, some lawn care companies operate in several cities on a regional or national level. Each branch is company-owned and is operated by company employees. Some of these companies utilize part-time employees, others do not.

The type of service offered by the regional or national companies varies almost as much as service options of local firms. Most of them, however, apply fertilizer, herbicides and insecticides according to the needs of local conditions. A few companies apply fungicides on a programmed basis but most do not unless there are unusual disease problems.

Some companies offer the complete package at an annual cost. Others charge separately for each component of the program.

The amount and kind of fertilizer and other chemicals used differ among companies. Some use soluble and water insoluble nitrogen sources, while others use only soluble materials. Phosphorus and potassium may or may not be included in all applications. Lime, where needed, is applied by some companies, others either ignore it or use one of the so-called "liquid lime substitutes". Some companies include "soil conditioners" in their programs. These may be anything from potassium carbonate to any one of the several liquid materials on the market.

CONTRACTS AND PRICING

Lawn service companies may either require an annual contract with or without prepayment, or they may operate without contracts and charge only after applications are made. Cost of services vary several hundred percent among companies. Cost for chemical applications to an 8,000 sq. ft. lawn vary from as little as $85 to as much as $300 for 4 to 6 scheduled annual treatments. Some lawn care companies make service calls and apply supplementary applications at no additional cost to their customers; other offer limited service without additional charges and some charge for all service calls.

LAWN CARE AS A SERVICE

The most important item that any lawn care company has to sell is service. Homeowners are not particularly interested in what products

are applied to their lawns. They are interested in a nice-appearing lawn, free from weeds and other problems. They expect the company to quickly respond to service calls and they expect prompt corrective action if they have problems. Many of their questions are related to trees, shrubs and other landscape plantings. Customers want qualified people with professional equipment to make applications and they expect the treatment to be made with care -- care for both the lawn and for surrounding plants and properties. Service is the name of the business.

OBSERVATIONS ABOUT LAWN SERVICES

Two points are obvious from the previous discussion. First, the lawn service industry is unorganized and there is little chance that it will be organized in the near future. Secondly, there is no standard of quality for the industry and it is unlikely that standards could be agreed on and even less possibility that they could be put into effect. State and Federal requirements for pesticide operators' license and label restrictions for the use of pesticides have made it more difficult for marginal operations, and some states require that the invoice must state the amount of fertilizer applied to a lawn. Other than these, the only standards are those set by leaders in the industry. An individual selecting a lawn care company should have a clear understanding of the services offered by the company, the materials that will be applied to the lawn, and the reputation of the company in question.

GROWTH AND ESTABLISHMENT OF SOD
(THE USE OF SOD SUCCESSFULLY)

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The decision to use the method of sodding to establish a turf is made for a number of reasons. Intensive use areas may not have sufficient time in the off season to establish mature turf (examples are football fields, tees, greens). New dwellings or apartments placed on the market are much more saleable with an established lawn. For the repair of worn or disturbed areas in parks, monuments, and other aesthetic areas, sodding is the logical method. The use of sod as an erosion control is well documented. In fact, when used in place of concrete ditches considerable savings can be realized. There are many uses of sod which are expedient and worthwhile and one may just want to avoid time consuming and costly work of growing turf from seed.

Once the decision is made to use the sodding method of establishment, more decisions are in order. Most important is deciding which species or variety of grass to select. Consider use intensity of the area, shade, time of year, the work that is to be done, level of expected management on the area, availability of water on drought tolerance of the grass selected. Another important decision at this point is choosing a supplier who will deliver quality material and to select a range of services you require. Some suppliers deliver, some deliver and install, some furnish management program instructions or may offer one-year management programs. It is a good idea to touch base with or visit your supplier early to determine availabilities of the desired species and to discuss prices, delivery schedules and the like. Good suppliers are interested in your success and are glad to offer advice.

The third step in utilizing the turf is in preparation of the areas to be sodded and the facilities required to accomplish the sodding. This is a critical area in the future success of any endeavor and particularly so in the case of successful sod utilization. Initially testing the chemical and physical properties of the soil is important. Arrange for proper fertilization and liming of the area. Determine the degree of tillage necessary or feasible on the area. If physical amendments are indicated, be certain to consult with knowledgeable individuals concerning the type, amount, and methods of adding these. Many hours and dollars are wasted on unnecessary and improper physical amendments to soils. It is important that schedules are set which will allow for completion of all phases of preparation prior to delivery of sod. This includes completion of existing proposed facilities including irrigation, walks, etc. and completed, proper, finished grade. It is heartbreaking

to see a beautiful sod job ruined by settled irrigation ditches, poor or inadequate drainage, inadequate or no irrigation facilities, or wheel tracks and debris from continuing construction on the site. As sod has a definite and short storage life, all should be in readiness when it is delivered.

Installation of sod is not difficult to accomplish with in-house labor; however, many times the real cost is not apparent. A seasoned installation crew can be much more productive, with better quality work at a lower cost. This is your management decision. Consult your supplier for advice on proper techniques. Avoid gaps and work as much as possible with straight edges, patch where necessary. Each job is different but good workers can catch on quickly if properly motivated to do good work expediently. Use of pins or other special techniques can aid in problem areas, especially slopes or ditches and waterways.

Once sod is placed and lightly rolled to insure good sod to soil contact (Note: this is not a particularly good grading tool), water is needed promptly. It is often helpful to syringe the soil prior to installation of sod on very hot, dry conditions and lightly water sod prior to rolling and subsequent deep watering. The immediate demand for water cannot be overstated! Be sure that watering capabilities are functioning and adequate.

Once the initial stage of watering (one to two weeks generally) is over, management should continue according to the use prescribed for the area. Mow as soon as equipment can get on the area and adjust the watering schedule as the roots lengthen and grow into the soil. Daily watering will lengthen gradually into weekly or as-needed irrigation. On low maintenance areas this may end up as no watering. Remember that a large portion of the plant (the roots) was left behind and must be regenerated. This requires added moisture, the amount of which varies with species and time of year.

The "instant lawn' syndrome is a bit of a misnomer. The result of sodding is the appearnace of instant grass and this is a very useful aspect; however, there is a requirement for follow-up management. The immediate needs are outlined above. Any species of turf grown from seed, sprigs or sod will require attention to result in a long term useful, beautiful turf. Quality sodding eliminates washouts, weed control problems, undesirable species found in many turf seed supplies and generally is insect and disease resistant. However, it requires continued feeding and protection to remain in its purchased condition. Most sod suppliers maintain a high degree of fertility and management to ensure a quality product and this is to your benefit. Beware of cheap low quality turf which will probably end up costing more in the long run.

Successful establishment of turf by sodding is not difficult nor particularly costly, all factors considered. Attention to details, good planning and execution, and proper follow-up management will result in a generally better end product that is useful and beautiful in a much shorter period of time and time is money in everybody's game.

ECOLOGY OF TURFGRASSES

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Ecology is the study of the relationship between organisms and their influence on each other.

Plant communities have developed naturally in response to the complex interaction of environmental influences that include climatic, biotic and soil factors. Plants growing adjacent to each other have certain requirements for light, water, and nutrients which specify a set of conditions called the niche in which it can survive. The competition for light, water and nutrients results in the development of mixed plant stands in nature. The intense competition among plants of the same species and/or variety makes monostands like turf virtually non-existent in nature. Natural plant communities exist in the form of forests and prairies. The turfgrass swards as we know them are not natural plant communities. Only through cultivation and maintenance can the desired ecological relationships be maintained for turfgrass establishment and persistence.

Turfgrass management is the science of understanding the response of turfgrasses to natural and man-imposed influences. Some of the most common man-imposed influences include: mowing; fertilization; liming; irrigation; control of weeds, insects and disease; soil modification; coring; grooving; and topdressing.

Each of these operations has an influence on the turfgrasses and the effect is modified when more than one practice is used concurrently. Fertilizers and lime result in more rapid growth but may also encourage certain plant diseases. The use of pesticides to control disease may also eliminate organisms associated with organic matter decomposition which can result in the excess accumulation of organic debris or thatch.

There are approximately 5,000 species of grasses in the world today but only a relatively small number are effectively used for turf purposes. The 12 most widely used turfgrass species are:

Warm Season	Cool Season
Bermudagrass	Bluegrass
Zoysiagrass	Bentgrass
Centipedegrass	Red Fescue
St. Augustinegrass	Tall Fescue
Bahiagrass	Perennial Ryegrass
Carpetgrass	Annual Ryegrass

Despite the fact that all of these grasses are grown in the Carolinas none are native to the continental United States.

Grasses are classified into the two broad groups based on the season of their most active growth. The warm season turfgrasses make their maximum growth during the summer months when the temperatures are in the range 80-95° F. The cool season grasses grow during the spring and fall when temperatures are in the 60-75° F range. Isotherms are geographic delineations of regions into areas with the same mean temperatures. Seldom are warm season grasses found growing extensively above the 40° F January isotherm or cool season grasses below the 80° F July isotherm. This explains the tremendous difficulty of maintaining turfgrasses in the transition zones where it is generally too warm during the summer months for the survival of cool season perennial species and too cold during the winter for the survival of warm season perennial species. The fact that annual species like crabgrass and goosegrass are found in preponderance in these areas is indicative of the problem and hence the name "Crabgrass Belt" is often used. The proliferation of the annual weed species is due to the production of large numbers of viable seeds that lay dormant during unfavorable periods when most perennial species are severely injured by environmental extremes. The seedlings of these annual species germinate faster, are more vigorous and can cover open areas more rapidly than the perennial turfgrass species.

The selection of a suitable grass for a particular turf situation is the most important consideration in turfgrass management. A turf manager must consider species adaptation, intended use, level of maintenance required, and degree of quality desired prior to the selection of a turfgrass for a given situation. Temperature and moisture are the major climatic factors in determining species adaptation. Temperature is the most critical factor as irrigation can be used to supplement natural rainfall.

The fluctuation in day-night (diurnal) temperatures is a function of relative humidity. Where the relative humidity is low, temperatures drop quite rapidly after sunset. Lower night temperatures during periods of active growth mean healthier plants due to reduced respirational activity. Disease activity is minimal on healthy turf particularly under conditions of cooler temperatures and lower relative humidity. This is why bentgrass can be maintained in the arid southwest with less difficult than in the humid southeast. The selection of turfgrass ecotypes specifically suited to regions is extremely important. Cool season turfgrasses used in the Southeast must have increased insect and disease resistance in addition to improved heat tolerance. Many naturally occurring types and some improved cultivars have these qualities.

Micro-climate is the climate that exists in close proximity to the turfgrass plant. Within any climatic zone there can be a tremendous variation in conditions in the area immediately around plants. Micro-

climate is influenced by various geographic as well as man-made features. Geographic features such as mountains and valleys often create different climatic conditions than found in adjacent areas that are more level. Trees, shrubs, and slopes provide major influences on climatic conditions. The south-facing slopes and areas sheltered by trees and shrubs can be much warmer than north facing slopes, shaded areas or low areas where frost pockets exist. This may require the selection and use of several different species or cultivars of turf within the relatively small areas encompassed by a golf course.

Soil is the medium in which turfgrass plants grow and they respond quite differently to the various soil conditions of moisture, structure, fertility and pH. Shallow, poorly structured, infertile soils that are common to many areas of the country complicate the culture of turfgrasses. In cool season areas bentgrass will persist under wet and low pH conditions; while red fescue tolerates dry infertile soils. Centipedegrass tolerates infertile and low pH conditions; while carpetgrass will persist in wet soils in warm season areas.

Soil that receive considerable traffic such as golf greens must be amended. Amending minimizes the damaging influence of traffic and reduces the loss of turf due to the additive effects of poor drainage and temperature during both the summer and winter months. Putting green construction has evolved with the use of highly permeable sand mixtures with sub-surface tile drainage. The use of highly porous mixtures requires increased irrigation and fertility levels to maintain turf quality. These areas however are less susceptible to injury from traffic, temperature and diseases after irrigation or periods of heavy or prolonged rainfall.

Management and cultural programs are the key to the successful growth of turfgrasses. Management becomes of greater and greater significance as grasses are used farther and farther from the zone of their best adaptation. The careful use of the various management practices on turf can improve the tolerance of species to various stresses. Timing irrigation and fertilizer applications will not only improve density and quality of turf swards but will reduce injury from temperature extremes and disease. A light application of water (syringing) to the leaf surface takes advantage of the cooling effects of evaporating water. Syringing is therefore an effective tool in modifying the microenvironment and is used to cool grasses during heat stress periods. The inter-relationship between fertility and mowing influences turf vigor. These programs should be timed to encourage turfgrass plants to store ample food reserves for regenerative growth and develop deep fibrous root systems to take up moisture and nutrients.

The current energy shortage and resulting increase in the cost of fertilizers, pesticides and equipment have drawn our attention to conservation of resources in the growth of turfgrasses. This can be accomplished only with a better understanding of the ecology of turfgrass swards. As

each management practice influences all of the others this can be a very complicated task. At this point in time with existing turfgrass varieties, applications of water, fertilizer and pesticides should be made only as needed. A sign of the future is the increased emphasis in the selection of grasses that provided quality turf with lower requirements for nutrients, moisture, and pesticides.

Ecology or an understanding of the relationships between organisms will play a role of ever increasing importance in the future of turfgrass culture.

FERTILIZATION FOR WINTER HARDINESS

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A major portion of the plant dry matter of turfgrasses is composed of carbon, hydrogen, and oxygen which is obtained from water and atmospheric carbon dioxide. Six elements, nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur are required in relatively large amounts and are the macronutrients. The remaining seven essential elements, iron, manganese, zinc, copper, molybdenum, boron, and chlorine are micronutrients.

Essential nutrients have a number of vital functions in plant growth and development such as (a) constituents of living tissue; (b) catalysts in certain biochemical reactions; (c) influencing the cell osmotic pressure; (d) influencing the acidity of plant tissue; and (e) affecting membrane permeability to nutrient uptake and transport.

It has been recognized for several years that nitrogen, phosphorus and potassium influence the hardening process in plants, thus affecting plant responses to cold temperatures. A close look at the functions of these elements on turfgrasses will be helpful.

Nitrogen

Turfgrasses require more nitrogen than any of the essential elements except carbon, hydrogen, and oxygen. Nitrogen is a vital constituent of (a) the chlorophyll molecule; (b) nucleic acids; (c) amino acids and proteins; (d) enzymes; and (e) vitamins. All are very important in turfgrass growth and development.

The effects of nitrogen on turf are usually very marked and rapid, and can affect the grass in a number of ways including (a) shoot and root growth; (b) shoot density; (c) color; (d) disease proneness; (e) recovery from injury; and (f) hardiness to heat, cold, and drought stress.

Phosphorus

Phosphorus is an essential macronutrient contained in every living cell. It is involved in a number of physiological functions within the plant including (a) energy transformations, (b) the cell nucleus, and (c) conversion of carbohydrates.

Phosphorus affects the (a) establishment, (b) rooting, (c) maturation, and (d) reproduction of turfgrasses. It is particularly vital during the seedling stage of turfgrass growth and development. Mature turfgrasses respond to phosphorus applications when the soil level is below 5 ppm.

Potassium

Potassium is not a constituent of living cells, but is essential in plant growth and development processes. It functions in (a) carbohydrate synthesis and translocation, (b) amino acid and protein synthesis, (c) catalyzing enzyme reactions, (d) regulating transpiration, (e) controlling the uptake rate of certain nutrients, and (f) regulating the respiration rate.

Potassium influences turfgrass (a) rooting, (b) drought, heat and cold hardiness, (c) drought proneness, and (d) wear tolerance. High potassium levels increases root, stolon, and rhizome growth.

Potassium regulates the absorption and retention of water by plants, which influences the heat, cold, and drought hardiness of turfgrasses. High potassium levels reduce the incidence of many diseases in turf, being due to favorable N levels, strong cell walls, composition of cell sap, and improved plant vigor.

Turfgrass wear tolerance is reported to increase proportionally with the potassium level. Thicker cells walls, increased vigor, higher cellulose content, and increased tugor pressure associated with higher potassium levels may contribute to improved wear tolerance.

Nutrient Balance

Much research information has been released pertaining to nutrient balance. When there is an imbalance between nitrogen, phosphorus, and potassium, the nitrogen can be taken into the plant, but not utilized, and therefore, ineffective. The same imbalance can also result in greater disease potential. It also can affect enzyme activity and root development, as well as cold hardiness. This imbalance affects both cool and warm season turfgrasses.

The harmful effects of imbalanced nitrogen fertilization in the fall on the winter survival of Kentucky bluegrass has been reported. It was determined that bluegrass with high tissue nitrogen was less resistant to winter injury than turf from low-nitrogen or balanced fertility plots. Evidently, grass tissue high in N without an adequate supply of P and K may completely fail to harden. A comprehensive review of the literature indicates potassium is beneficial to winter hardiness development in all plants.

For many years, the accepted ratio for N-P-K in turfgrass fertilizer was 3-1-2 or 4-1-2, typified by the 12-4-8 or 16-4-8 mixes. Recent investigations indicate potassium may play a more important role in turfgrass fertilization than previously realized.

Christians, Martin, and Wilkinson, (Ohio State) reported Merion bluegrass and Penncross bentgrass grown in sand culture responded to very high levels of potassium. Their results showed a quadratic relationship between levels of N and K in solution and tissue dry weight, giving an initial response to N, peaking, and then decreasing with increasing N (Figure 1). When N was held constant, bentgrass continued to increase tissue production, with maximum response not reached at the highest level of K (Figure 2).

Quality responses of Merion bluegrass and Penncross bentgrass are given in the following table:

Table 1. Solution culture nutrient levels (ppm) resulting in the highest quality turf.

Nutrient	Merion	Penncross
N	96	54
P	2	2
K	+196	+196

The lack of response to P level in solution may have been due in part to precipitation of P at high concentrations. In soil studies, response to P is found at 5 ppm, but P is not as available in soil as in solutions.

The effects of N and K on root growth of Penncross bentgrass are in the following table:

Table 2. N and K effects on root growth of Penncross bentgrass

	Solution Culture (ppm)	
Nutrient	Maximum	Minimum
N	6	150
K	196	64

Christians et al. stated, "The primary goal of turf production is to achieve high quality from a visual standpoint. In a dense, uniform turf, high yield of vegetation is not necessarily a desirable attribute. Under conditions of this experiment, less N and more K

were required to maximize quality of Kentucky bluegrass and Penncross bentgrass than to maximize tissue production".

These responses to higher levels of K for both quality and yield of bluegrass and bentgrass are comparable to the results of high K for winter hardiness in bermudagrasses as the following experimental results indicate.

Adams and Twersky (Alabama) determined that at high levels of nitrogen, winter injury to Coastal bermudagrass decreased with increasing levels of potassium (Figure 3).

As nitrogen was increased from one to eight pounds N/M at 0 level of K, winter survival decreased from 87% at one pound to only 33% at eight pounds/M. With increasing K at all levels of N, better survival was obtained with 75% surviving at eight pounds N and four pounds K/M. The curves for all K treatments had not reached their peak at four pounds K, suggesting that a higher survival rate would have been obtained with K applications above four pounds/M.

Davis and Gilbert (N.C. State) determined the influence of different ratios of N, P, and K in cold tolerance of Tifgreen and Tifdwarf bermudagrasses.

Plugs of each grass were taken from the field and grown, for four months in a greenhouse without nutrients. The fertility ratios were applied to the grasses which were allowed to respond for three weeks, then the grasses were placed in a controlled environmental chamber for four weeks at 40° F and with eight hours light at 3000 foot candles. These treatments produced grass resistant to low temperature injury. The grass samples were subjected to a standard freezing test and after removal from the freezer, were thawed and placed in a greenhouse for four weeks. The data were as follows:

Table 3. Mean values in grams for top regrowth Tifgreen bermudagrass following exposure to low temperatures.

Nutrient Ratio (N-P-K)	28°F	23°F	18°F
4-0-0	1.7	1.3	0.0
4-1-0	1.8	1.7	0.1
4-0-2	2.2	2.0	0.1
4-1-2	2.5	1.9	0.9
4-1-5	2.3	2.2	1.3

The greatest differential among fertilizer ratios occurred in the 18°F treatment. The high potash (4-1-5) treatment resulted in the greatest production of top growth following the freezing test. There was no regrowth in pots receiving nitrogen only (4-0-0).

The low temperature points which caused 50% reduction in regrowth Tifdwarf and Tifgreen following the freezing test are given in Table 4.

Table 4. Low temperature killing point (LTK-50) calculated on 50% regrowth after exposure to low temperature.

Nutrient Ratio (N-P-K)	LTK-50 (°F)	
	Tifdwarf	Tifgreen
4-0-0	24	23
4-1-0	22	23
4-0-2	23	21
4-1-2	18	19
4-1-5	17	17

The ratio 4-1-5 was the optimum of those studied for improving cold resistance in bermudagrass. The results indicate that a balanced fertility program with emphasis on adequate potassium in late summer would improve cold tolerance.

When the top regrowth of Tifgreen was plotted in Figure 4, an interesting point appears. The curve has evidently not reached its peak! This also occurred with the curves in Figure 3, and also follows the data of high K effects obtained by Christians et al. in Tables 1 and 2.

What would have been the survival temperature of the bermudagrass if the ratio had been 4-1-20? The data from these experiments suggest strongly that more potassium could be utilized for higher quality and more cold resistant turf.

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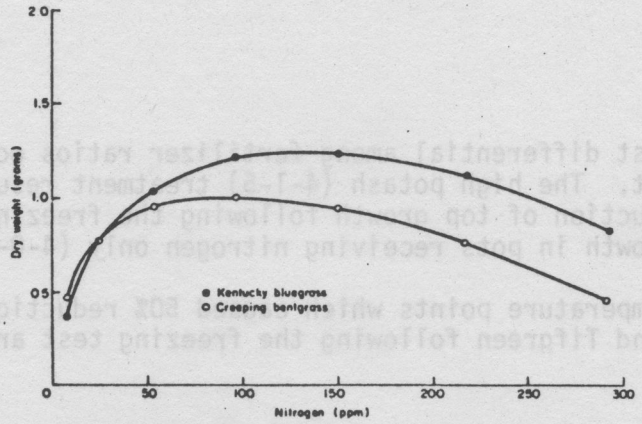


Fig. 1. The predicted response of Kentucky bluegrass and creeping bentgrass tissue production to increasing levels of nitrogen when potassium was at the 64 ppm level.

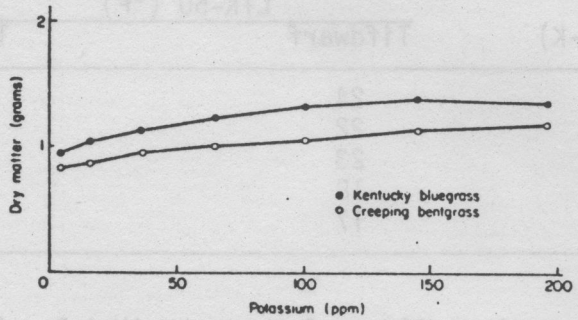


Fig. 2. The predicted response of Kentucky bluegrass and creeping bentgrass tissue production to increasing levels of potassium when nitrogen was at the 96 ppm level.

Figure 3

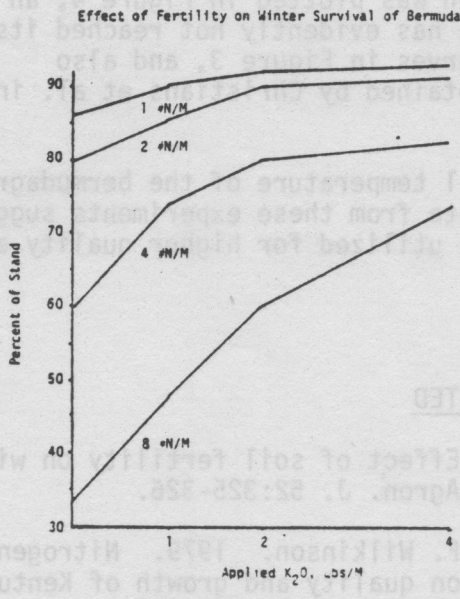
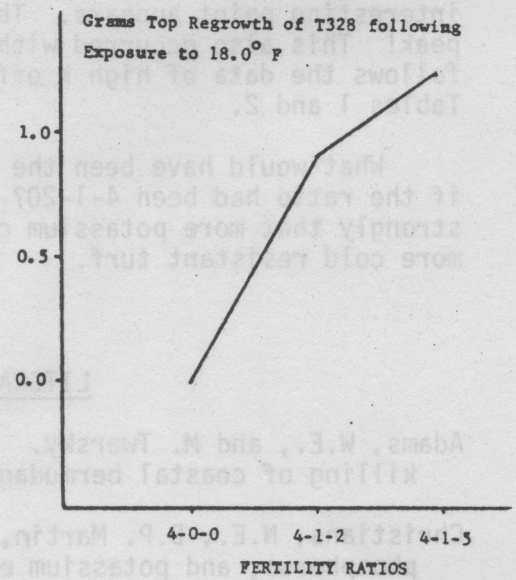


Figure 4



THE TURFGRASS COUNCIL OF NORTH CAROLINA, INC.

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PURPOSES AND OBJECTIVES

The purposes of the Turfgrass Council are: (1) to promote the turfgrass industry in North Carolina; (2) to encourage further study and research in turfgrasses; (3) to analyze and disseminate information relating to turfgrasses in the State; (4) to represent the turfgrass industry in matters of policy; (5) to do everything necessary to carry out the above activities. The objective of the Turfgrass Council is to help obtain the best turf possible for lawns, golf courses, athletic fields, parks, cemeteries, and roadsides throughout North Carolina.

ACTIVITIES

The annual North Carolina Turfgrass Conference is one of the major activities of the Turfgrass Council. This conference is sponsored by the Turfgrass Associations and the North Corolina State University Turfgrass Program. This conference seeks to provide all persons interested in turfgrasses the opportunity to keep up-to-date with the new trends and practices. A newsletter is published regularly by the Turfgrass Council to inform its membership of its activities and turf related programs in the State. Turfgrass research and scholarship programs in North Carolina receive financial and commodity group support from the Turfgrass Council. The Turfgrass Council has worked with the N. C. State University Agricultural Extension Service to establish workshops on turfgrasses in different areas of North Carolina.

MEMBERSHIP

Memberships are available to individuals interested in turfgrasses, representatives from turf related organizations, and sales representatives from commerical companies. The Turfgrass Council invites and encourages all persons engaged in any phase of the Turfgrass Industry in North Carolina to become members. Write to: Turfgrass Council of Council of N.C., Inc., P.O. Box 5155, Raleigh, NC 27650, for more information.

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