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P R E F A C E

The Proceedings of the 34th Annual Texas Turfgrass Conference are provided to those who registered at the Conference December 3-5, 1979 at Texas A&M University as a reference to the information presented during the program. Since it was not possible for you to attend all of the educational sessions, the Proceedings will give you an opportunity to review additional information.

We are grateful to the program participants who contributed their time and talent to make the program a success. And, we owe a special debt of gratitude to those speakers who took the extra time and effort to write these Proceedings.

Special appreciation is also extended to Mrs. Barbara Johnigan, my secretary, for her assistance with the preparation and distribution of these Proceedings.

We invite each of you to return to Texas A&M University December 8, 9 and 10, 1980 for the 35th Texas Turfgrass Conference.

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In The 1980's

TURFGRASS: ITS CONTRIBUTIONS AND CHALLENGES[1]

by

Richard L. Duble*

Turfgrass affects the lives of most people living in the U. S. today. A recent survey by a major publication reported that the number one desire of most Americans was to be surrounded by green grass and trees. Whether the effect is real or imagined, the fact is that a vista of manicured turfgrass stimulates enthusiasm, accents awareness and renews ones vitality. A director of the National Apartment Association stated that, "Turfgrass was a contributing factor in a renters choice of apartment complexes or condominiums." Likewise, turfgrass trees are major considerations when selecting a homesite, a fact which explains why so many residential developments begin with a golf course.

Contributions of Turfgrass

Turfgrass may be defined as a grass cover maintained for environmental, aesthetic or recreational purposes. Environmental contributions of turfgrass include erosion control, noise, dust and glare reduction and moderation of surface temperatures. The contribution of the turfgrass to erosion control alone is measured in thousands of acres of land saved each year. Without a grass cover roadsides, ditch banks, mine spoils, dump grounds and other sites would be eroded each year. And, without some degree of maintenance (mowing, fertilization, weed and brush control, etc.) those areas would become overgrown with undesirable vegatation. As an example, the U. S. Corps of Engineers spends millions of dollars each year removing brush and silt from clogged ditches and waterways and restoring eroded ditch banks. Without question, turfgrass on these sites saves taxpayers many times the cost of its establishment and maintenance.

Environmental contributions of turfgrass also include reduced dust, glare, surface temperatures, noise and air pollution. During World War II considerable research was conducted to reduce dust around airports because it interfered with traffic and safety. Turfgrass was found to be most effective for reducing dust around these facilities. Even in the arid west where water is precious, turfgrass is the most popular and effective ground cover to reduce blowing dust around homes and buildings.

One only needs to walk through a city where concrete is the dominant ground cover to appreciate the reduction in glare, noise and temperature produced by turfgrass. Temperatures are always 3 to 5 degrees higher in

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cities than in rural surroundings where trees and turfgrass cover most of the surface. Even more contrasting, temperatures on an artificial turf approach 140^o on summer days compared to 85^o on a grass turf.

In urban areas, earthen berms planted to turfgrass and trees are effectively used to reduce noise levels around schools, businesses and homes. Turfgrass and trees also filter harmful pollutants from the air in urban and industrialized areas. As a result of these environmental benefits, greenbelts consisting of turfgrass and trees are popular in high density population centers.

Aesthetic contributions of turfgrass are best exemplified by the millions or manicured lawns in residential areas. A beautiful turfgrass is the singular most important feature in a residential landscape. If that were not the case, Americans would not spend over 6 billion dollars and 1 billion man-hours maintaining lawns. In support of these expenditures, real estate agents have shown that beautiful landscapes increase the value of homes beyond their cost of establishment and maintenance.

Turfgrass not only beautifies the home landscape, but parks, schools, churches, commercial buildings, roadsides and many other sites are enhanced by turfgrass. A dense, green turfgrass accents other landscape features and structures like no other ground cover can. A green, manicured lawn also provides a warm welcome to residents, guests and passers-by. In spite of the work it requires, a beautiful lawn is the most enjoyable part of the home landscape. To quote the noted author, J. Frank Dobie, "The sight of a turf restores my soul. A valley of green grass is beautiful in the way that mountains, seas and stars are beautiful."

Turfgrass is the most important feature of playgrounds and recreational facilities such as golf courses, athletic fields and other sports fields. In all cases the quality of the golf course or sports field is judged primarily by the density, texture and color of the turfgrass. In addition, player safety is greatly improved by a resilient cushion of turfgrass. Players, almost to a man, in the National Football League prefer playing and practicing on natural grass fields rather than on fields with synthetic turf.

Thus, turfgrass contributes to improved environmental conditions, safer athletic fields and playgrounds, improved mental attitudes and beautification of homes, park, roadsides and other greenbelt areas. In densely populated urban centers where 4/5 of the world's population live, turfgrass makes significant contributions to the physical well being and mental attitudes of people.

Scope of the Turfgrass Industry

In terms of dollars, jobs and acres of land turfgrass is big business. Americans spent over 10 billion dollars in 1979 maintaining lawns, golf courses, parks, roadsides and other turfgrass areas. Turf maintenance costs are projected to approach 24 billion dollars by 1990. Today, 500,000 people are employed in the turfgrass industry. By comparison, that number equals employment by the entire petrochemical industry in the U. S. Job opportunities in turfgrass encompass all levels of skills including labor, supervisory, management, technical, sales and professional. Projections suggest that the industry will show a slight increase in jobs during the next 10 years. Increased efficiency and inflation, however, will prevent significant increases in the number of new jobs in turfgrass.

Some components of the turfgrass industry will show significant increases over the next 10 years. Professional lawn and grounds maintenance will continue to grow in jobs and dollar value. By 1990 professional lawn service will reach 5 billion dollars in maintenance contracts, a fivefold increase since 1978.

The profile of the labor force in the turfgrass industry will also show significant changes over the next 10 years. Women will replace men in many turf maintenance jobs such as equipment operators, grounds keepers and supervisors. The educational level of the labor force will also increase as technicians replace laborers in an effort to improve efficiency. The professional level of the industry will increase sharply through organization, training and greater educational opportunities.

Today, turfgrass is maintained on 25 million acres in the U. S., or 1.5% of the total land area. Roadsides account for over 1/3 of the acreage in turfgrass, but only 3% of the dollars spent on turfgrass. Total acreage of turfgrass will show little or no change over the next 10 years. As the acreage of lawns, parks, golf courses and other facilities increases, the acreage of maintained turfgrass on highway rights-of-way will decrease. For example, the Alabama Highway Department maintained 124,000 acres of right-of-way in 1979, and the projected figure for 1981 is 100,000 acres. Other states project similar decreases due to the rising cost of mowing.

Acreage in individual home lawns, which accounts for the largest acreage of intensively maintained turfgrass, will continue to increase due to construction and the luxury and benefits of a beautiful lawn. Golf courses, commercial grounds, parks and other intensively maintained turfgrass areas will show similar increases due to a greater demand for recreation and greenbelt areas in population centers.

Challenges of the 1980's

The turfgrass industry has grown from a 4 billion dollar to a 12 billion dollar industry in the past 15 years. Projections are that it will double again within the next 10 years. All such growth industries face challenges with regard to labor, government regulation, technology, leadership and inflation. In addition, the turfgrass industry will be challenged by problems relating to energy, water and the environment. The order in which these challenges are presented do not reflect their importance or their impact on the turfgrass industry.

Inflation. Every citizen and industry or business must face the consequences of inflation. Equipment, supplies, labor and services will all increase in cost at a rate at least equal to the rate of inflation. Thus, the cost of turf maintenance will double in the next 5 to 7 years. Obviously, those who pay the cost of maintenance for large turfgrass facilities such as golf courses, parks, highways and others cannot support that kind of increase. As a result, more defined limits will be placed on areas of turf maintained, less demanding requirements will be placed on turfgrass managers and technology will reduce requirements for labor. The net effect of these adjustments will be that increases in turf maintenance costs per acre will lag behind the rate of inflation. And, the acreage of turfgrass maintained will remain near today's total in spite of the growth in new facilities over the next 10 years.

Fortunately, the largest component of the turfgrass industry, lawns, will not be significantly affected by inflation, because costs will be divided among some 40 million individual homeowners. Also, the value of home lawn turf to the homeowner will rise even more sharply than the cost of maintenance. Thus, even a twofold increase in the cost of lawn maintenance over the next 5 years will have little effect on the level of maintenance.

Golf courses will be hardest hit by inflation since membership dues and green fees are already limiting growth of the golf business. Club membership is a luxury many people will forego due to sharply increased fees. Clubs will need to keep golf course maintenance costs in check to hold down rising membership dues. Also more defined maintenance patterns for greens, fairways and rough areas, more tolerant requirements for turf quality and greater dependence on technology may provide a temporary solution to the inflation problem for golf course operations.

Energy. Increasing costs and decreasing availability of energy sources affect most phases of turf maintenance including mowing, watering, fertilization, pest management and clipping disposal. The effect of fuel shortages and price increases on turf maintenance was dramatized this year on golf courses throughout the U. S. Other serious shortages can be expected during the next few years.

The turfgrass industry can survive these temporary shortages without serious consequences. But, the attitude and policy changes, resulting from fuel shortages and price increases could have serious implications for the turfgrass industry. For example, the "no mow" policy many highway departments initiated during the 1973 energy crisis has not changed appreciably. The low priority, with respect to fuel allocations, given turf maintenance operations will hurt the turfgrass industry if fuel rationing plans are adopted. And, the "minimum maintenance" concept popular for lawns, golf courses and landscape areas in general is a result of the energy problem. This concept gains impetus each time there is a fuel shortage or a significant price increase. These policy and attitude changes produced by the energy problem could significantly affect the industry in the 1980's.

Labor. The major resource of the turfgrass industry is labor. Approximately ½ million people are employed in the turfgrass industry in the U. S. Perhaps more so than any other, labor is a limited resource. The turfgrass industry requires all levels of labor from the worker in the field to the research scientist or the business manager. Like other industries, skilled labor is the backbone of the turfgrass industry.

During the last decade the labor pool formerly available to the turfgrass industry has been dried up by higher paying industries and government programs. The quality of labor available to the turfgrass industry has reached a critical level. Positions formerly occupied by experienced or trained personnel are being filled today by unskilled and inexperienced workers.

For example, a golf course might pay a skilled equipment operator $6 per hour; whereas, the same operator could make $10 or more per hour in construction or other heavy industry. As an alternative, two less skilled employees might be hired at $4 per hour to do the same work. Minimum wage laws have affected employment or unskilled labor in the turfgrass industry. Many turf maintenance operations cannot afford to employ unskilled labor at minimum wage requirements. Thus, where skilled labor is not available to the industry and unskilled labor at minimum wages cannot be justified, the turfgrass industry suffers.

Labor unions also present a potential problem to the turfgrass industry through inflated wages. Union wages and working conditions are a threat to the turfgrass industry which depends heavily on cheap labor. In many situations, turfgrass is a luxury that people will do without if installation and maintenance costs become unreasonable. Historically, as other industries became unionized, the costs of goods and services rose sharply.

Employment of women as equipment operators, grounds keepers and supervisors may help to fill the vacancies created by men leaving for higher paying jobs in other industries. Also, greater educational opportunities in turfgrass and better training programs for new employees will increase the skills of the labor force presently in the turfgrass industry.

Water. Water, like energy and labor, is a limited resource of vital concern to the turfgrass industry. Water shortages have plagued the turfgrass industry in some areas of the country for years. Severe water shortages affected turfgrass maintenance on the West Coast only last year. Projections suggest that water supplies for turfgrass will become even more critical within the next decade.

Water conservation has been on the minds of turfgrass managers, researchers and manufacturers for years. Improved irrigation equipment, better management practices and drought tolerant turfgrasses have increased water use efficiency and promoted water conservation. But, conservation is only part of the solution to the water problem.

Alternative water sources must be exploited if the turfgrass industry is to survive. Greater use of effluent water is essential. Industrial waste water, cooling plant water with its accumulated salts, sewage effluent and other secondary water sources must be utilized. Perhaps, economic desalinization of sea water will be required before the water problems of the turfgrass industry are solved.

Government. More and more, governmental laws and regulations dictate what we can, and cannot, do in all phases of our industry including employment, wages, fuel allocations, safety, health and environment. The solution to this problem, governmental interference, is perhaps the most difficult task facing the turfgrass industry. So long as turfgrass is a stepchild of agriculture, so long as the industry remains unorganized and so long as the value of turfgrass remains unknown the industry will be subject to the whims of politicians.

Problems created by governmental interference cannot be dealt with by the present fragmented structure of the turfgrass industry. Organization of the industry to support common goals of national significance is essential to influence governmental decisions. Greater visibility of turfgrass, as a valuable and useful commodity, is required to influence legislation on matters vital to the industry such as fuel allocations, safety regulations, employment practices and environmental concerns. Acceptance of turfgrass as a first-class member of the agricultural community is also important to entitle the industry to the exemptions, allocations and services given other agricultural programs.

Environment. The contributions turfgrass make toward environmental improvement have already been discussed. But, there are environmental concerns with regard to turfgrass that must be faced. During the last decade some 30 million pounds of pesticides and 500 million pounds of fertilizer nutrients were applied each year to turfgrass in the U. S. Even when properly applied some of these pesticides and nutrients are lost from the target area by runoff and leaching; thus, contributing to pollution of ground water, creeks and streams. Misuse of these materials, particularly by homeowners, produces even greater damage to the environment.

In the 1980's the Environmental Protection Agency will place more restrictions on the use of pesticides that are important to turfgrass maintenance. They will also look more closely at the effect of fertilizer nutrients, particularly nitrogen, on water resources in urban areas. Intensively maintained turfgrass facilities such as lawns and golf courses will be most affected by restrictions on the use of fertilizers and pesticides.

Greater use of cultural and biological controls for turfgrass pests and greater use of slow release fertilizers will help the industry overcome these environmental problems. Continued support for turfgrass research will also help the industry through the 1980's.

Leadership. Leadership in the turfgrass industry has been provided by major manufacturers and distributors of turfgrass equipment and supplies, by turfgrass associations and organizations such as the GCSAA and the USGA Green Section and by universities through research and education programs in turfgrass. Leadership on a national level is lacking although the organization of the American Council for Turfgrass is a step in that direction.

The framework for building a national organization already exists through state and regional turfgrass associations, special interest groups (GCSAA, Lawn Care Association, American Sod Producers Association, etc.) and turfgrass foundations (O. J. Noer Foundation, Musser Foundation, Ohio Turfgrass Foundation, etc.). On a local, regional or national level these are strong, viable organizations, but none encompass the entire turfgrass industry. If the industry is to protect itself against unfair restrictions and excessive government regulation, strong and effective leadership on a national level will be required.

Technology. As the technology available to the turfgrass industry becomes more complex, the skill of the operator and supervisor must also increase. One challenge the turfgrass industry faces in this regard is competing with higher paying industries for skilled labor. Computor controlled irrigation systems, hydraulic mowing equipment, timed release fertilizers, pesticides and other technological advancements require skilled operators and supervisors for turfgrass maintenance operations. As skilled labor becomes increasingly difficult to employ and retain, the turfgrass industry will become more dependent on technology to take up the slack.

More efficient mowing and irrigation equipment has done much to reduce our dependence on labor during the last decade. Perhaps even greater improvements will be made in the 1980's. Research will produce turfgrasses with lower maintenance requirements for use on home lawns and other low traffic areas. Growth retardants which offer great potential to reduce turf maintenance requirements will be improved over those presently available. And, more effective pest management programs, including resistant varieties of turfgrass, will be developed to reduce our dependence on pesticides.

These are some of the challenges facing the turfgrass industry during the 1980's. How we, as individuals and as a whole, respond to these challenges will determine the course of the industry through the 1980's. These challenges will not be resolved over the next 10 years; these same problems will continue to challenge the turfgrass industry. But, we must confront these challenges with intelligence, farsightedness and great determination. Leadership in the turfgrass industry must not overlook any of these challenges, nor can it underestimate their significance.

THE CHALLENGE OF THE EIGHTIES

by

Roger J. Thomas*

In today's economy people appear to have doubts about our nation's abilities to cope with the problems that face it. It seems that in these days, it is macho to be a spreader of gloom. Many surveys point our how depressed people are, and how fearful they are of the future.

But remember, we, as Americans, underestimate ourselves tremendously. Critical attitudes have a definite tendency to drag all of us down.

Let's analyze it. We have had bigger and tougher problems in the past than are facing us today. We had a crushing depression in the 30's. We have had two world wars. We have had assassinations and civil riots and the war in Viet Nam tore us apart. Going back even earlier in our history, our nation was split in half with two governments fighting each other. Yet, we survived those times and went on to grow to be the greatest nation in the world!

There are not many people in this room that lack confidence in themselves. Perhaps, just perhaps, we lack the confidence in our government. Well, why shouldn't we? For years we have been told that the government could do more for us than we could do ourselves, and a whole host of generations have said, "Let the officials make the decisions."

We have seen billions wasted in taxes which were to end poverty, give everyone jobs, and fantastic pensions, as well as unlimited prosperity. We have seen inflation run rampant, eroding savings, crippling early pensioners with a lack of money to live out their retirements, and all of this has contributed to the lack of confidence in the dollar throughout the world.

We have seen inflation rates silently rob us of our earnings, but I think on the horizon is a whole new group of people awakening to our previous blunders. We have people who are now starting to band together on the subject of taxes (proposition 13) and certainly at least a few men in government are becoming vocal about the deficit spending we are doing, and we certainly can be proud of our young people displaying patriotism in the Iranian Crisis. Well, are we headed for doom? Of course not! People are aroused, and when that happens the spirit returns. Everybody determines to grow stronger, and we are ready to move ahead again and put our government in its proper perspective.

We have been lax so productivity must improve. Our present work force will be a little older, better skilled, and will feel more responsible. Our plants and factories will become better equipped and automated with better legislation for tax write-offs. We can put our country in top condition to compete with anyone in the world.

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What about the 80's? Energy conservation will play a big part in our economy. We have been plagued with myths such as, the world will run out of oil in the 80's. In actuality, when oil was placed into a free market, suddenly it became available and there were no more long lines at the pumps. Strange, isn't it? Not really. We are told now it was a distribution problem. Was it that the government interferred in a very complicated distribution system?

It is totally unknown how much more oil still remains to be discovered and is producible at today's prices. Geologists estimate a range of a twenty-year supply to a high of fifty years! Discoveries of oil in shale deposits are in Colorado, Utah, and Wyoming, and indicate 1.87 billion barrels of oil is contained in this shale. Six hundred billion barrels are recoverable at higher prices, and this is enough to supply us for another one hundred years. There are other reserves in the tar fields of Canada, Missouri, Kansas, and Oklahoma which would be economically workable at the higher prices. An interesting recent discovery was a method to obtain oil from shale, coal, and lignite, which would produce high grade coke and the distilling of a heavy duty crude oil by Microwave Methods.

We have also been told that the cause of our dollar depreciating has been the adverse payments balance. Well, if oil causes an adverse balance of payments, or if the greater increase in crude oil prices in 1974 were a cause of adverse balance payments, then certainly Germany and Japan would be in much deeper trouble than we. They import all their crude oil, while we import less than half. They import all the natural gas, while we import only a small fraction. And, how would you like to be sitting as a resident of Switzerland, getting your natural gas from Russian dominated countries? Their fear is really justified! Yet, their balance of payments is positive. How come? Only 250 companies in America do 80% - 85% of our export volume and we only ship 8% of our gross national product. On the other hand, those countries mentioned are exporting 35% - 40% of their gross national product. Believe this! The average person in those countries realizes how important it is to work hard and long to maintain export shipments out of their country. I wonder if the average American realizes how important it is to do greater exporting. As I travel the world, I hear from many critics of our country and our government, but we have no wall around our country.

America is spending millions and millions of dollars to help people, to keep them from starving and bringing many to our continent. Sounds like "Mom, Apple Pie, and America", but recently when landing in New York from Switzerland, I could see the 'Great Lady' in the harbor with her outstretched arms, and what a feeling to know that we are still committed to our founding principal of "Give me your tired, your hungry, your poor....".

Recently we were informed that the government will now have to plow billions of dollars into our energy research to avoid running out in the 80's. Should we be prepared to spend that kind of money when the industry itself, because of the higher prices, can perform their own research and development? Our energy problems will be solved by American techniques, brains, and skills of our scientists, and the competition of free enterprise companies behind them. Many companies already are hard at work finding new sources of energy. Expensive? Of course, but we will be spending our money here, and not in a foreign country. We'll be opening up new jobs, opportunities, and industries. Don't be misled; there will be some shortages of energy, and time will be needed to find solutions.

What can we do in the meantime? Seek ways to conserve energy for the interim period.

1. Consider the use of more diesel equipment.

2. Consider <u>less</u> transport of equipment.

3. Find ways to reduce our fuel usage by less horsepower.

4. Provide better service to our equipment for optimum performance.

5. Consider use of growth retardants in non-recreational areas.

The list will grow long if each of us applies our own ingenuity to solve the problems.

Another phase of the challenges ahead deals with managers and manpower. Traditional incentives are not well matched to today's work force. It is believed by many experts that we must find new motivational tools that are effective. At a recent turf conference that I attended in New Mexico reports were made regarding motivating employees in some different ways. One report involved techniques of sending letters to the employees. Foremen were required to keep daily records on the performance of their people. Records had to do with their work accomplishments as well as their absenteeism. Personal letters were prepared for those employees that had done an excellent job. Cash incentives were sent out at Christmas time for those people having a perfect work record. Immediate results -- 28% less absenteeism. Well, is that what it's going to take, or what other techniques can be used to encourage people to work harder? Each organization will have to tailor incentives to the individuals and the form may take place in the concept of money, recognition, job stability, or any other of the ideas <u>that turn people on</u>.

Some of the future incentives which you, as managers, may have to consider could be those involving <u>time</u>. Flexi-time schedules which permit better vacation scheduling, less formal schedules, and some freedom providing incentives of better leisure activities or even health opportunities. Certainly some form of feedback from the individuals involved in these incentives will be necessary to monitor the effectiveness.

To get this economy moving, as manufacturers, we are going to have to accelerate our new product introductions into the market. Another item of importance is to plan long-term strategies for increased export of our products and services. Yes, even in the face of the foretellers of gloom, <u>now</u> is the time for us to plan.

This recession will pass; the weak will cower, and will not have planned for the uptake of the 80's. In other words, the chickens will run into hiding. The hawks will take advantage of what appears to be an opportunity, and will be prepared for the growth that is to come. So - - - it is up to each and every one of us in this room to determine if we are going to be chickens or hawks! ! ! Whatever is our world today, we know we need some new methods, new techniques and new ideas. Grasp the strategies of a simple recession as an opportunity for the future.

You know, no matter what age you are you have a responsibility to yourselves and your fellow men to take positive action for the betterment of our society. Samuel Ullman once said, "Youth is not a time of life, it is a state of mind. Nobody grows old by merely living a number of years. People, whatever age, grow old by deserting their ideas and their ideals." Your presence here today indicates you have taken the role of the hawks by better preparing yourselves in your chosen field for a great future.

Your help is needed to wake up Americans to meet the challenges of the 80's by becoming active on all the issues facing us. Good luck, and have a great conference!

MOWING - AS IT AFFECTS TURFGRASS QUALITY

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Mowing is one of the primary cultural practices used to maintain turf. In fact, mowing is probably the most fundamental practice constituting turfgrass cultural systems, since even the most poorly maintained turf will require periodic mowing for grooming and mechanical weed control.

Mowing is a defoliation process. It is a compromise between agronomic requirements of the plant and the ornamental, functional, and recreational demands placed on the site where the grass is growing. Grasses with their crown or growing points located near the soil surface have the ability to tolerate frequent defoliation, while tall growing grasses with growing points elevated above the soil surface cannot tolerate close or frequent mowing. Turfgrasses have evolved with the ability to tolerate defoliation to varying degrees depending upon the species, cultivar, intensity of use, pest problems, and interaction with other cultural practices.

Mowing Practices incompass a number of dimensions that influence the turfgrass plant (i.e. cutting height, frequency, equipment and operation, and clipping disposition). These practices and their interaction with other cultural aspects have a bearing on the quality of turf maintained. This article will cover these dimensions of mowing and will discuss their influence on turfgrass quality.

Turf Quality

Turf Quality is not a fixed entity. It is a relative term that differs to a certain degree with individuals, turfgrass species, and intended use of the turf. In other words, turf quality acceptable to one person may not be to another, and the quality required for a golf or bowling green turf would surely differ from that required for a roadside turf. There are six basic components of turfgrass quality, including color, density, uniformity, texture, smoothness and growth habit. The relative importance of these aspects varies with the function of the turf. Mowing, along with other cultural practices, influences turfgrass quality both directly and indirectly. It is used by turf managers to keep plants within defined limits of height and maintain a dense, uniform, smooth surface.

Cutting Height

Cutting or mowing height is defined as the distance above the soil surface at which the turf is cut. The height of cut should be adjusted by determining the distance of the mower's cutting edge (bedknife for reel mowers) from a flat, level surface upon which the mowing unit is resting. This is termed the <u>bench height of cut</u>. The actual cutting height after

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adjustment is called the <u>effective height of cut.</u> The effective height of cut is usually slightly greater than that of the bench height adjustment, since the grass plants tend to elevate the mowing equipment above the soil surface. The preferred height for several turfgrasses is shown in Table 1. As the cutting height is lowered from the optimum, the turfgrass plant undergoes changes that generally result in a weakened turf.

Table 1. Relative cutting heights for warm and cool season turfgrasses.

Species	Cutting height(inches)	Relative Mowing Tolerance
Creeping bentgrass Bermudagrass(improved) Annual bluegrass	0.2-0.5	Very Close
Zoysiagrass Bermudagrass(common) Colonial bentgrass	0.5-1.3	Close
Buffalograss Centepedegrass Carpetgrass Kentucky bluegrass	1.3-2.0	Medium
Bahiagrass Tall fescue St. Augustine Bromegrass	2.0-3.5	High

Mowing below the species optimum height results in a number of changes in the growth and development of the turfgrass plant. Shoot density, growth and succulence, disease and environmental stress, and short-term water loss from wounded tissue increase as mowing heights are reduced. Leaf width, leaf area index (LAI(, root growth and production, rhizome and stolon production, wear tolerance, and carbohydrate synthesis and storage decrease as mowing heights are reduced. The turf manager has to have a thorough understanding of the species that they manage to understand their mowing limitations. Along with this knowledge of the plant, turf managers must adjust their cultural practices appropriately. For example, mowing putting greens close may enhance putting speed, but it will require frequent watering, fertilizing and pesticide applications to maintain desired turf quality.

Suboptimal mowing heights reduce leaf width and shoot size, making a finer textured turf, but also results in reduced leaf area (Leaf Area Index). As the LAI drops the ability of the turfgrass plant to intercept incident sunlight drops proportionately, and carbohydrate synthesis and storage is reduced. This, coupled with increased shoot growth rate at suboptimal mowing heights, results in a net loss of reserve carbohydrates that affect the initiation and production of roots, rhizomes and other vegetative structures. The resulting effect of suboptimal mowing heights is a turf with high shoot density, finer texture and improved uniformity, but the turf is weaker since shoots are smaller and the root system is reduced. Wear tolerance and recuperative potential decrease with decreased mowing heights.

Water use rate declines with lower mowing due to reduced leaf area exposed for evapotranspiration, but drought tolerance also declines, since at suboptimal mowing heights the extent and depth of rooting is reduced and rhizome and stolon production decline.

Turfgrass seasonal growth rhythms related to temperature and day length can influence mowing practices, particularly in cool-season grasses like Kentucky bluegrass. During warm summer periods with long photoperiods, turfgrass shoot growth tends to be erect and stolons and rhizomes tend to grow only short distances. While in the fall and spring, shoot growth is more decumbent and stolon and rhizome growth is longer. Lower mowing heights should coincide with the decumbent growth and higher with the summer growth periods. Higher mowing heights aid cool-season turfgrass species during periods of high temperature stress. The increased vegetation at higher mowing heights insulates the soil surface and reduces soil temperatures associated with the crown of the grass plant.

Mowing Frequency

Turfgrass mowing frequency should be dictated by the growth rate of the grass plant. It is usually best to remove no more than 30-40% of the top growth with anyone mowing. Removing excessive amounts of topgrowth with a single mowing results in scalping injury to the turf. Scalping injury results in root growth stoppage and can result in root death.

Frequent mowing results in a dense, uniform turf that is generally more susceptible to disease and environmental stress than less frequently mowed turfs. When the turfgrass function or use dictates frequent mowing to maintain a dense uniform surface, management practices must be changed to compensate for the detrimental aspects of frequent mowing on the turfgrass plant.

Mowing frequency is equally as important as height of cut in its overall influence on the growth and development of the turfgrass plant. As mowing frequency increases, the following aspects increase: shoot density, shoot succulence, and susceptibility to disease and environmental stress. Conversely, carbohydrate reserves, root growth, rhizome and stolon development, chlorophyll content, shoot maturity, wear tolerance and recuperative potential decrease with increasing mowing at suboptimal heights is particularly detrimental to the turfgrass plant and results in a weakened turf.

Mowing Equipment

Turf mowing units are classified into four types: (1) reel, (2) rotary, (3) flail, and (4) side bar. Reel mowers produce the best mowing quality. They are more difficult to adjust, but last longer and use less fuel per acre of turf mowed than rotary mowers. Rotary mowers are the most commonly used mowers, especially for homeowners. Rotary mowers have a high power requirement, high blade velocities, and require extreme caution to operate safely. Flail mowers are often used on low maintenance turf sites. They are also commonly used on school grounds where the potential of injury from projectiles (rocks, sticks, wire, etc.) is great. Flail mowers are particularly suited for mowing areas where the turf is tall or excessive top growth is present. The housing on a flail mower allows the clipping residues to be cut and recut until the debris is reduced to a fine mulch. Side bar mowers are least commonly used of the four types discussed. Side bar mowers are used primarily on low maintenance sites such as airfields and roadside turfs.

No matter which type of mowing equipment is used, it is extremely important to keep it in good repair and use a sharp cutting surface. Mowing studies comparing the effects of repeatedly mowing with a dull mower versus a sharp mower, have been conducted at the University of Nebraska. These studies indicate that mowing with a dull mower increases disease susceptibility and decreases turf quality and water use rates when compared to mowing the same turf with a sharp mower.

Clipping Disposition

Clipping disposition or removal is dictated by the turfgrass growth rate and the intended use of turf. Clippings should be removed when they interfere with the intended use of the turf (i.e. disrupt the playing surface), when excessive growth results in heavy accumulation of clipping debris, or when disease and weed problems are enhanced by their return. When an adequate mowing frequency is maintained, clippings contribute very little to thatch accumulation. In fact mowing studies at Nebraska have indicated that thatch accumulation is more a function of mowing height than clipping return. Clippings returned to the turf, inconjunction with proper mowing frequency, breakdown rapidly and recycles nutrients to the plant system.

Summary

Mowing is a fundamental and integral part of a turfgrass cultural system. It interacts with watering, fertilizing, soil cultivation, and pest control, in direct and indirect ways. Frequent mowing at suboptimal heights of cut results in a weakened turf that requires more frequent watering, fertilizing, and pest control. An awareness of the interaction between mowing height and frequency, and other cultural practices is essential to the turf manager. Adjusting these practices to the mowing height and frequency necessary for the use and function of the turf will result in the best possible turfgrass quality.

FATE OF NITROGEN IN TURF

by

A. J. Turgeon*

Turf differs from annual-crop systems in at least three important respects: the turfgrass community is perennial; turfgrasses form dense communities that provide a nearly contiguous ground cover; and a semi-stable layer of residual biomass, conventionally referred to as thatch, frequently exists atop the soil surface. Because of these differences, the fate of nitrogen and other materials applied to turf may differ substantially from that observed in annual-crop systems.

The Turf Profile

Examination of the vertical profile of a newly established turf reveals the soil and roots of the young plant community growing within it. Where a rhizomatous turfgrass is used, the upper portion of the soil also contains the rhizomes, usually within the top few centimeters. On some sites, a layer of organic material, called "thatch", may eventually develop above the soil surface. Examination of this turf profile reveals many rhizomes and roots growing within the thatch layer(5). In extreme cases, virtually all of the roots and rhizomes are contained within the thatch, and the turf is easily separated at the soil surface.

On greens and other turfs that receive frequent top dressing, the layer of organic material may contain so much soil that it differs little in appearance from the underlying soil. This combined medium of soil and thatch is called "mat". The frequency and amount of required top dressing soil are usually dependent upon the rate at which thatch develops. Some golf course superintendents top-dress whenever the thatch layer accumulates to the thickness of a pencil, or about 6mm. A given turf profile may contain from one to three distinct layers, including thatch, mat, and soil. Comparisons of thatch and Flanagan silt loam (soil) from a Kentucky bluegrass turf revealed that the thatch had considerably more aeration porosity, and thus retained less plant-available moisture, than did the soil(3). Measurements of the cation exchange capacity (CEC) of thatch and soil showed that an essentially pure thatch (organic matter > 90 percent) was higher in CEC, expressed as milliequivalents (me) per 100 g (1). However, since the bulk density (BD) of thatch was much lower than soil BD, CEC expressed as me/100 cc, or CEC.BD, was actually lower in thatch compared to soil. Because plants grow in a specific volume, rather than in a specific

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weight, of medium the CEC·BD is a more meaningful value for comparing different media. Therefore, the relatively low CEC·BD value of thatch indicates that its nutrient-retention capacity is also low.

Where a specific amount of soil has been incorporated into a thatch layer, the CEC·BD of the resulting medium (mat) increases in proportion to the amount of soil added [1]. Methods for incorporating soil into thatch include: top dressing; core cultivation followed by reincorporation of the soil cores into the turf; and vertical mowing to a depth that effectively brings soil up to the surface. Depending upon the thickness of the thatch layer, it may be necessary to perform several shallow vertical mowings prior to soil incorporation in order to reduce the accumulation of organic debris; otherwise, a layered condition may result due to incomplete mixing of the soil and thatch materials.

Pesticide-Induced Thatch

Several pesticides, including bandane and calcium arsenate, have been reported to induce thatch development in an otherwise thatch-free Kentucky bluegrass turf [6]. This was largely the result of the inhibiting effect of the pesticides on earthworm activity. Comparisons of adjacent thatchy and thatch-free plots revealed that the thatch predisposed the turfgrass to greater disease incidence and higher wilting proneness. Also, fewer roots and rhizomes were evident in the soil underlying the thatch layer than in the surface soil from the thatch-free turf. Physical examination of the thatch revealed the presence of numerous roots and rhizomes in the thatch layer. Therefore, where thatch develops, turfgrass rooting and rhizome growth occurs preferentially in the thatch layer.

Subsequent measurements of water infiltration rates showed considerable reductions where thatch developed [4]. However, this was determined to be the result of an altered physical condition of the soil underlying the thatch rather than the thatch per se. Physical measurements with soil cores extracted from the thatchy and thatch-free turfs revealed substantial reductions in hydraulic conductivity, aeration porosity, organic matter content, and shrinkage upon drying, but higher bulk densities, where thatch development was induced by the pesticides.

Presumably, an effective means for controlling the thatch, either through physical removal or soil incorporation, would result in an amelioration of soil physical properties and improved rooting and rhizome growth.

Nitrogen Studies

Studies were initiated in 1976 to determine relative rates of leaching and volatilization of nitrogen from urea and isobutylidene diurea (IBDU) applied to turf cores composed of either thatch or Flanagan silt loam. Results showed that leaching of the nitrogen was substantially greater from thatch than from soil, and that urea-N was much more prone to leach than was IBDU-N[2]. Measurements of nitrogen retention by the media showed that almost no urea-N was retained by the thatch under the experimental conditions while most of the IBDU-N was retained within the upper portion of the cores. Conversely, more urea-N and less IBDU-N were retained by soil compared to the same treatments applied to thatch.

These results were consistent with the conclusions of Danneberger (1) that thatch has poor nutrient-retention properties because of its low CEC·BD compared to soil. Conversion of soluble urea to ammonium ions (NH_4^+) would result in adsorption of the NH_4^+ on negatively charged sites. Because of the relatively low numbers of these sites in a specific volume of thatch, less NH_4^+ would be retained compared to a soil type with higher CEC·BD. Also, the abundance of aeration pores in thatch results in higher percolation rates and, therefore, more nitrogen leaching compared to a soil of lower aeration porosity.

With a slowly soluble nitrogen carrier such as IBDU, the rate at which NH_4^+ ions are generated is considerably slower than for urea, and is influenced by moisture, temperature, and possibly pH. Thus, regardless of the physical and chemical properties of the growth medium, nitrogen retention is induced by the fertilizer formulation; slowly soluble particles of the fertilizer become inbedded in the upper portion of the growth medium, and these "release" nitrogen at rates that are dependent upon local environmental conditions. With moisture being such an important factor affecting nitrogen solubilization from IBDU, any drying of the upper portion of a thatch medium would reduce the solubilization rate. In contrast, prolonged periods of moisture retention by a silt loam soil would favor solubilization of nitrogen from IBDU and, therefore, result in less retention.

Results from volatilization studies showed that more conversion of urea to ammonia (NH_3) occurred in thatch than in soil, and that urea was much more prone to nitrogen volatilization loss than was IBDU [2]. As with leaching, the efficiency with which nitrogen is used in turf is thus influenced by the nature of the carrier and of the growth medium to which it is applied. Further work is continuing to quantitatively determine the influence of various environmental and cultural factors on the percentages of applied nitrogen that are lost from turf through leaching, volatilization, denitrification, and other avenues.

Current Analysis of Nitrogen Fate in Turf

The efficiency with which nitrogen is utilized in turf is influenced by the type of nitrogen carrier employed, and the environment immediately surrounding the turfgrass community. Slowly available nitrogen carriers, including slowly soluble and slow-release forms, are less susceptible to leaching and gaseous (volatilization) losses than are quickly available carriers, especially in coarse-textured media (thatch, sand) from which these losses are most likely to occur. Therefore, greater reliance upon slowly available nitrogen carriers in a fertilization program should improve nitrogen efficiency. Furthermore, any effective measures for increasing the CEC·BD, and reducing excessive aeration porosity, of coarse-textured media should result in an increase in nitrogen efficiency due to increased NH_4^+ and water retention.

In thatchy turfs, such measures would include core cultivation followed by reincorporation of the soil, top dressing with soil from a foreign source, and deep vertical mowing to bring soil up through the thatch layer.

Removal of clippings from mowing also removes the nitrogen contained within the leaf tissue; however, returning the clippings does not necessarily mean that all of the tissue nitrogen becomes available to the turfgrass. Depending upon environmental conditions, much of this nitrogen may be lost to the atmosphere as NH_3 in conjunction with decomposition of the clippings.

Additional research is required to quantitatively determine the influence of genotypic, atmospheric, edaphic, and cultural factors on nitrogen losses, and to develop cultural strategies for optimizing nitrogen efficiency in turf.

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BERMUDAGRASS TRANSITIONS

by

James B. Moncrief*

More bermudagrass than usual has been lost the past 3 years in the upper south. In 1977-78 most of the loss was east of the Mississippi and the worst loss in 1979 was west of the Mississippi into Oklahoma and Texas.

There have been many explanations offered for this loss from shade of trees to a lack of cold hardiness. We will discuss several reasons for loss of grass and offer some alternatives for better survival.

Bermudagrass is a warm season grass and has a higher photosynthetic capacity than cool season grasses. It's maximum rate of photosynthesis occurs at a higher light intensity than those plants with a low photosynthetic capacity.

This characteristic of bermudagrass could be involved in the transition from dormancy to active growing conditions in the spring. Bermuda greens are usually overseeded with cool season grass, such as perennial ryegrasses, creeping red fescue, bluegrasses and bent either singly or in a blend.

Preparation for overseeding in the fall can influence the transition in the spring. Preparation should begin in the summer, being sure the bermudagrass has been kept in a healthy growing condition with all nutrients in the proper ratio. A 3-1-2 to a 4-1-2 ratio of the 3 major nutrients of N, P, & K are very important; however, at time of overseeding a minimum amount of N prevents overstimulation of the bermudagrass and being too competitive with cool season grasses.

Aerification 3 to 4 times during the year should be a common practice. Grooming the bermudagrass to minimize thatch can be accomplished with frequent light vertical mowing and topdressing very lightly at 6 week intervals for an excellent putting surface.

There is a very wide choice of excellent grasses for overseeding greens and you may have to buy the one that will fit into the budget at your golf course. There is an excellent selection of ryegrass strains that are giving excellent putting surfaces. You have to judge this at your golf course and give the golfers the kind of putting surface they want or should have. The rate of seeding can vary and for quick cover in the early fall, heavy rates can be used or less seed per 1,000 square feet <u>can</u> be used for slower coverage. Purchase the best seed you can preferably treated with fungicide.

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In the spring start disk spiking the greens depending on the location and continue weekly until there is complete coverage of bermudagrass. Aerify the greens with a punch type aerifier before applying pre-emergence; remove the soil cores and leave the holes open. If this is objectionable topdress to fill the holes and it may take more than 1 topdressing to accomplish this.

Aerification could be timed with the first application of pre-emergence to control goosegrass or other obnoxious weeds that begin to come into the greens when the temperatures become warmer. Goosegrass usually germinates when the temperature is between 20 to 30^{o} C.

There are several types of disk spikers. The one that does the best job or that you have on hand would be advisable. I have seen rows of bermudagrass come into the greens when the disk spiker has been used regularly.

Start vertical mowing very lightly or brushing to suppress the overseeded grasses. There should be a gradual transition from cool season grasses to bermudagrasses rather than an abrupt one which would disturb play. Most players will be on bermudagrass several days before they realize the transition has already taken place.

It appeared that we had an excellent transition in May; however, some areas had as much as 12 & 14 inches of rain in the same number of days and immediately following the rain, the temperature zoomed into the 90s. With such lush growth and excess moisture in the soil, the overseeding began to die faster than the bermudagrass could fill in the void. We observed much of this along the Gulf and Atlantic Coasts.

WINTER KILL

Winter kill has been attributed indirectly to the loss of turf. In most cases, thatch is almost always confined to well managed turf and yet most researchers agree that a small amount of thatch is very beneficial. Beneficial effects are lost when the thatch layer exceeds ½ inches or more. There are several undesirable problems that can recur from high accumulation of thatch, such as maintaining moisture, and especially rewetting an area that has dried out. You can have problems with surface application of fertilizer and other nutrients if you have a dense turf or thick thatch. Nitrogen that volatilizes easily, will cause more loss when there is a thatch condition.

There will definitely be more insects and a higher disease incidence where thatch offers protection. When all of these factors are involved there will be a decline in turf vigor, quality, and appearance. Practices that promote growth and vigor also will promote thatch development. Therefore, you have to manage all factors, including the selection of cultivars, blends, and mixtures with the fertilizer program, lime and pest control and cultivation. When cultivating there may be some points to consider for better control of thatch. There is a necessity for constant practice to minimize thatch and at the same time, you want to avoid severe dethatching. Cultivation should be restricted to the time of the year when the turf is making its fastest recovery or when the grass is making the best growth. If there is too much thatch, there is a need to denude the bermudagrass area. Start aerifying and topdressing and it may take several aerifications to minimize the thatch. I have seen thatch so bad that it takes more than one growing season to get the grass to a healthy, normal condition.

WINTER INJURY ON HOME LAWNS

BY

Dr. James McAfee*

Until the past three winters, winter injury had not been considered a serious problem in Texas. However, the extensive loss of turfgrass in home lawns, particularly St. Augustine grass, over the past three winters has shown that this is a major problem facing those individuals involved in the lawn care industry. Loss of turfgrass causes unsightly lawns and in many cases results in customer cancellation. This paper will review some of the different types of winter injury, where the problem is most likely to occur, and what influence we as lawn care professionals can have on this problem.

Winter injury or winterkill can be divided into three types: (1) direct low temperature injury, (2) winter dessication, and (3) low temperature diseases. Direct low temperature injury involves the formation of ice crystals, either intracellularly or extracellularly. Intracellular ice crystals cause a disruption of protoplasmic structure in the cell which results in death of that tissue, while extracellular ice crystals cause a dessication of affected plant tissue. This dessication or dehydration can result in tissue death or injury. During periods of near freezing, the plant leaves continue to lose moisture while the plant root system is unable to take moisture from the soil. This can cause low temperature dessication and if it occurs over an extended period of time can result in plant tissue injury and/or death. The major temperature disease associated with low temperatures in the south is Spring Dead Spot of bermudagrass.

Certain areas or certain turfgrass species seem to be more prone to winter injury. Heavy shade, slopes (particularly northern slopes), low lying areas, and St. Augustine lawns infested with St. Augustine Decline, seem to be more easily damaged by low temperature stress. As lawn care professionals, we can have a direct influence and an indirect influence on the amount of winter injury that might occur in a lawn.

A direct affect would be through the materials, mainly fertilizers, that we apply to the lawn. Excessive fertilization, particularly with soluble nitrogen sources, causes too much rapid, lush growth of the turfgrass plants. This excess topgrowth is accomplished at the expense of the root system. A lawn that has been continually overfertilized throughout the growing season will contain leaves high in moisture content and also will have a very shallow, weak root system. Both of these factors will enhance winter injury problems. The key is to avoid over stimulation of turfgrass growth and to use a balance of slow release and soluble nitrogen sources.

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Ratio of nutrients, N-P-K, is just as important as rate. Researchers have shown that adequate potassium levels in the plant is very important for winter hardiness. The ideal ratio of nitrogen to potassium for winter hardiness appears to be around 2 - 1 or 1 - 1. Your fall application of fertilizer should have adequate amounts of potassium to insure that the plants have the necessary potassium available for winter hardiness.

Avoid going into winter dormancy with any nutrient deficiency problems. A major problem with many St. Augustine lawns across the south is iron chlorosis. A turfgrass plant going into dormancy with a nutrient deficiency will be more subject to low temperature stress than a plant that is properly fertilized.

As lawn care specialists, we can indirectly influence winter hardiness by recommending proper maintenance procedures to our customers. Factors such as proper turfgrass selection, mowing, watering, and cultivation are very important in winter survival. Make sure the customer is using the proper turfgrass for his environmental conditions. Example: a bermudagrass growing in shaded conditions would be more subject to winter injury than St. Augustine growing in the same condition. Improper mowing is also a problem with many customers. Dr. Beard and associates at Texas A&M found that St. Augustine mowed at 1.5 inches in shaded conditions received more winter injury than St. Augustine mowed at 3.0 inches. Mowing the lawn at the recommended height will help to increase hardiness of turfgrass plants.

Watering by the homeowner is another cultural practice which can influence winter hardiness. Lawns that become dry in the winter months are more likely to become injured by low temperature dessication. If rainfall or other precipitation does not occur every 3 - 4 weeks during the winter, you should advise the customer to water his lawn. On the other hand, areas where standing water occurs are highly subject to direct low temperature stress (ice crystal formation). If drainage is a problem, steps should be taken to improve drainage of the lawn before winter arrives.

Thatch and compacted soils are two other lawn problems that enhance winter injury problems. In a heavily thatched lawn, most of the plants of root system is contained in the thatch layer. This thatch layer dries out rapidly and thus subjects the plants root system to dessication problems during cold weather. Removal of thatch should be conducted in late spring to early summer to help prevent this problem. Compacted, tight soils limit the plants root growth as well as the movement of air, moisture, and nutrients in the soil. Aerification will enhance the movement of soil, air, water and nutrients which will result in a healthier plant.

Spring dead spot is a disease of bermudagrass that is associated with low temperature conditions. While it is not exactly known how this problem occurs, it is known that factors such as thatch, and high nitrogen fertilization contribute to the problem. Lawns with a history of spring dead spot problems should be maintained on a minimum fertility program and kept well thatched. St. Augustine Decline, while not caused by low temperature disease, does weaken the St. Augustine so that it is easily damaged or killed by low temperature stress. Lawns containing SAD should also be maintained on a minimal fertilizer program and kept well watered and mowed to help prevent any further stress problems.

In summary, winter injury is becoming more of a problem throughout the south, particularly in lawns containing St. Augustine. Proper fertilization, maintenance, and species selection are factors that can be used to help reduce winter injury.

ACCIDENTIAL POISIONING OF PETS

by

E. Murl Bailey, Jr., D.V.M., Ph.D.*

Pesticides have been used in American agriculture for over 20 years. Subsequently, their use in and around homes has increased the hazard for intoxication of pets. Although a great deal has been published concerning the toxicity of insecticides in small animals, very little has been published on the toxicity of herbicides and fungicides in these animals. To date, intoxications in small animals caused by insecticides are common occurrences. The occurrence of intoxications caused by herbicides and fungicides is rare, even with the application of the agents to plants, especially in animals which do not rely upon plants as foodstuff. With improper storage of these toxic agents, there is an ever present hazard of poisoning in cats and dogs because of the inquisitive nature of these animals. The reported distastefulness of most chemicals even further reduces the amount ingested.

Organo Chlorine Insecticides

Organo chlorine insecticides (chlorinated hydrocarbons) include the diphenyl aliphatic (DDT, aryl and cyclodiene groups). Use of some of the more persistent chlorinated hydrocarbon insecticides has been discontinued or restricted. Their history and types of problems that developed serve as a valuable model in helping to define the relationship between plants and animals. The exact mechanism of action of chlorinated hycrocarbon insecticides is generally unknown. They are diffuse stimulants or depressants of the central nervous system. Signs expressing stimulation or depression take many forms but usually are of a neuromuscular type. The onset of signs occurs within a few minutes or a few days after exposure, usually within 24 hours. The signs displayed may be progressively severe in nature or may be explosive and fulminating. Animals may at first be apprehensive, hypersensitive, or belligerent. Fasciculation of face and neck muscles soon follow. This disease syndrome progresses to convulsions and spasms of all the muscles and then the animal goes into seizures. Abnormal posturing may be assumed while others persist in keeping the head between the forelegs. There may be a continuous chewing movement accompanied by increased flow of saliva. Some animals may continue to chew for hours or days. Poisoned animals may become comatose and remain for several hours prior to death. Or they may regain consciousness and fully recover.

Dogs and cats usually vomit following consumption of insecticides. This may result in increased salivation and frothy accumulation at the mouth. Cats are especially sensitive to chlordane and dogs have an increased susceptibility to toxaphene, therefore, when using these two agents around pets, the owner should be cautioned about the toxicity and steps should be taken to keep the animals from the sprayed or applied premises for approximately 24 hours.

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Organic Phosphate and Carbamate Insecticides

Organic phosphorus insecticides consist of aliphatic derivatives of phosphorus compounds (cyclo aliphatic and herocyclic derivatives). Some of these compounds have systemic action so that they are absorbed by the plants or animals by all routes including through the skin, and then move throughout the body in sufficient amounts to kill insects, ticks, or other pests feeding upon the tissues. The carbamate insecticides consist of cyclic or aliphatic derivatives of carbamic acid.

Organophosphate insecticides and carbamate insecticides are anticholinesterase or inhibitors of the enzyme present in the body which breaks down acetylcholine, an endogenous chemical necessary for normal body function. When the enzyme is inhibited, this allows the buildup of this chemical mediator for the nervous system and causes most of the signs and symptoms present in poisoned animals and people. In general, the signs of organophosphorus and carbamate poisoning are those of overstimulation of the parasympathetic nervous system. These may be grouped into categories muscarinic, nicotinic, and central nervous system effects. The signs included in the muscarinic group are profuse salivation, gastrointestinal hypermotility, severe pain, abdominal cramps, vomiting, diarrhea, sweating, respiratory difficulties, and incontinence of urine and feces. The clinical signs included in the nicotinic group reflect excessive stimulation of skeletal muscles, manifested by twitching of the muscles of the face, eyelids, tongue--ultimately the general musculature. The central nervous effects vary with the class of animal involved. In small animals such as dogs and cats, hyperstimulation of the central nervous system may progress to convulsive seizures. Extreme central nervous system depression, however, commonly occurs in those animals poisoned with the chlinesterase inhibitors. It is important to realize that not every animal exhibits all the clinical signs when poisoned by an organophosphorus or carbamate compound. Usually death results from hypoxia due to broncho constriction, excessive respiratory secretions in the bronchial tree, and an erratic slow heart beat. Constriction of the pupils is a characteristic muscarinic sign.

Herbicides

Signs associated with herbicide intoxications in small animals are nonspecific. These signs include anorexia, muscular weakness, myotonis, vomiting, diarrhea, and death. There may be a contact dermatitis associated with agents such as trichloroacetic acid and paraquat. In addition, paraquat poisoning may induce cyanosis and convulsions. Sodium chlorate, a methemoglobin former, may produce cyanosis, respiratory distress, and chocolate brown colored blood. As with other agricultural chemicals, the majority of problems are associated with human error or accident. Poisoning is not likely to result if proper application and withholding times are observed. The likelihood of poisoning or hazard depends largely upon whether enough herbicide is applied to plants to allow sufficient intake for toxicosis to develop.

TABLE I

Some Common Herbicides

Chemical Group	Common Names
Chlorophenoxy compounds	2,4-D, 2,4,5-T
Chlorinated aliphatic acids	Erbon, Trichloroacetic acid
Amide compounds	Bensulide, Chlorthiamid
Carbamate	Chlorpropham
Thiocarbamate	Pebulate, Vernolate
Phenyl urea	Norea, Chloroxuron, Linuron
Arsenicals, inorganic	$K_3As_3O_3$
Arsenicals, organic	Monosodium methanearsonate (MSMA) (DSMA)
Substituted Dinitroanaline compounds	Trifluran, Benefin
Dipyridyl compounds	Paraquat, Diquat
Phthalmic acid compounds	Naptalam, Dinoseb
Sodium chlorate	Sodium chlorate
Triazines	Atrazine, Prometone
Dinitrophenols	Dinitro-o-cresol

TABLE II

Some Common Fungicides

Chemical Group	Common Names
Chlorophenols	Pentachlorophenol
Organomercurials	Ceresan-M
Organotin	Triethyltin
Chloroneb	Demosan
Organozinc	Zineb
Organosulfur	Captan
Volatile Fumigant	Methylbromide

Fungicides

The class fungicides are all those chemical agents used to prevent or eradicate fungal infections in plants and animals. The types of fungicides used in agricultural and food processing range from those of relative low toxicity to mammals to those which are highly lethal and tend to persist for long periods. The recommendation and restrictions concerning fungicides generally preclude poisoning in animals. Accidents and careless use constitute the major source of hazard to mammals. Problems arising from direct exposure to fungicides are rare, but these compounds are often combined with insecticides, thus, intoxications associated with fungicides might be due to the other pesticides involved. In addition, many of the carriers or solvents of fungicides are themselves toxic. Animals housed in closed confinement near a treated grain may suffer from vapors of these volatile compounds. Clinical signs observed with fungicide poisoning may be similar to those observed with fungicide poisoning may be similar to those observed in herbicide intoxication. In addition, there may be greater involvement of the central nervous system including ataxia, tremors, collapse, depression, and rapid respiration.

Prevention of Intoxications in Pets Due to Pesticides

Proper storage of lawn, garden, and agricultural chemicals is the best preventive measure against pesticide intoxication in pet animals. This precaution will help to keep poisonings caused by these agents to a minimum. In addition, proper use of these agents and proper warning procedures concerning pets will also keep pet poisonings to a minimum.

SPORTSTURF All-Weather Fields

Natural Grass At Its Best!

by

Melvin J. Robey

Not too many years ago every natural grass playing field was at the mercy of the weather. No one seemed to be able to do anything about the dilemma of overcoming Nature's stormy moods. In 1972 an all-sand based natural grass system - the PAT field - was developed for the sports world. At last, a breakthrough in natural grass field construction occurred which was imaginative. The PAT system, an excellent idea, was readily accepted but immediately ran into a stumbling block. It was too expensive for the average high school field and even most colleges, universities and professional sports complexes could not afford it either.

Today, a more innovative concept has been developed which offers all the old advantages of a PAT field plus newer technology which allows the sand based fields to be installed at a lower cost to the sports world. The name of the new field design is the SPORTSTURF All-Weather Field, and is a brainchild of one of the inventors of the original PAT concept.

Eight years has passed since the first PAT sand based field was installed and as with the Model T newer technology quickly outdates old ideas. On-going research at the leading universities in the United States, Canada and Eurpoe has produced new information on the sand based natural grass athletic field construction techniques. The SPORTSTURF agronomists have drawn from this worldwide research network to design a unique natural grass field that meets all the necessary criteria for providing the best possible playing surface under prevailing weather conditions. And at an affordable price!

Ten Problems Solved By A

SPORTSTURF All-Weather Field

1. Soft, muddy fields, caused by rain and snow.
2. Water puddling on the playing field due to poor drainage.
3. Poor footing as a result of improper drainage and muddy field conditions.
4. Hard, compacted surface, creating an unsafe playing field.
5. A wornout strip down the center of the playing field.

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6. Costly resodding jobs after every season.

7. Limited use of the field due to the grass being unable to withstand heavy scheduling.

8. Cancellation of scheduled events because of wet, unplayable grounds.

9. Inadequate irrigation system, limiting the development of a thick, tough natural grass playing surface.

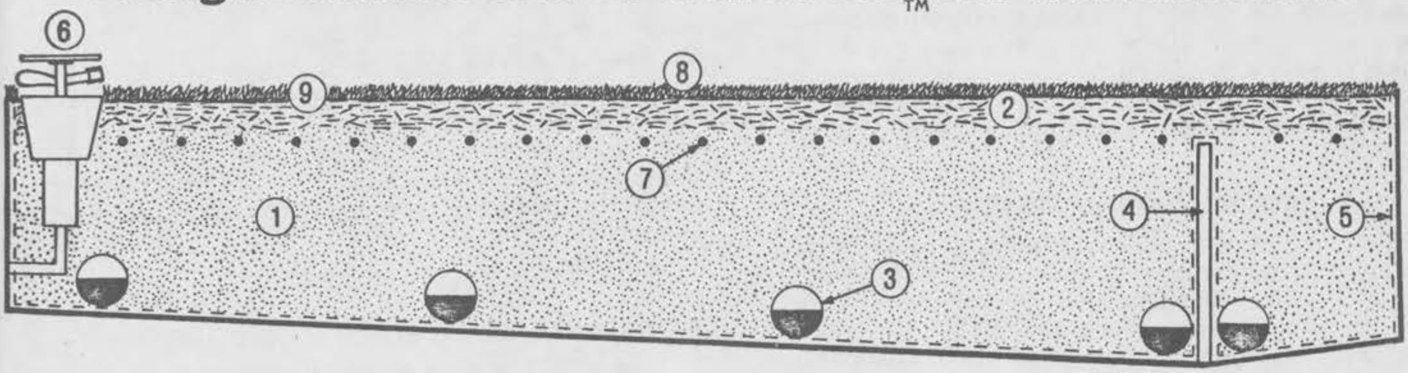
10. Unpredictable maintenance costs.

Design Features Of A SPORTSTURF All-Weather Field

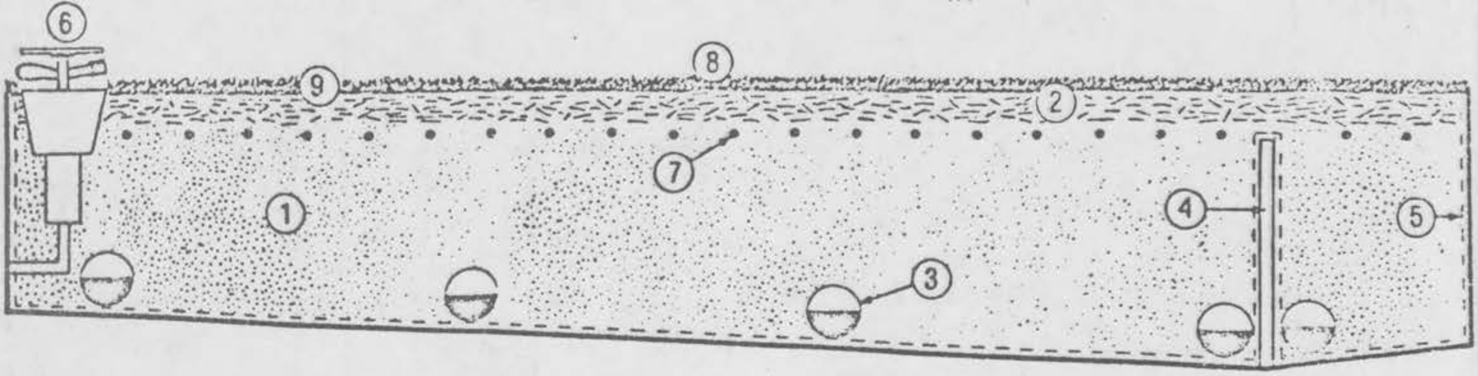
(follows on next page)

Insert picture of the design for a SPORTSTURF All-Weather Field as shown on page 4

Design Features of a SPORTSTURF™ All-Weather Field



Design Features of a SPORTSTURF™ All-Weather Field



1. 100% SAND ROOTZONE

To overcome the problems of water control in athletic fields the SPORTSTURF All-Weather Field has replaced the soil with an all-sand rootzone. This allows for rapid water infiltration through the sand and away from the surface, providing a firm, dry playing field. At the same time the sand is able to store sufficient quantities of water in the rootzone to provide a dense turf.

2. SPECIAL SURFACE MIX (Optional)

A scientific mixture of sand and special amendments insures a rooting zone where the grass will form a tight bond that is able to stand up to any type of cleat action during a game. The amendments also help to hold nutrients, store moisture and give added resiliency to the playing surface.

3. FIELD MOISTURE CONTROL SYSTEM

The network of pipes beneath the field play a key role in the control of the moisture in the sand. It is this piping system, with a unique modification contained within the pipe, that forms the nucleus of the SPORTSTURF All-Weather Field. A patent has been applied for covering the revolutionary concept in water movement that is used in the design of a SPORTSTURF Field.

4. BAFFLES (Optional)

To control the water movement within a field the all-sand rootzone is divided into several individual compartments. Moisture levels within these compartments are separately controlled and can be varied to meet the specific needs of the sporting event, the coach and the game.

5. PLASTIC BARRIER (Optional)

To allow for total control of the water within the sand matrix a plastic liner is frequently incorporated into the design of the SPORTSTURF Field. This liner aids in the conservation of water and plant nutrients, reducing the overall expenses of supplying these essential elements to the grass. Another important function of the plastic barrier is to prevent external water from the surrounding subsoil from contaminating the all-sand rootzone.

6. SURFACE IRRIGATION

Supplemental surface watering is an important feature in the design of a natural grass field. The duplication of Nature's rainfall plays a significant role in the normal growth and development of a good athletic field grass. Where it is required, special techniques for burying the sprinkler heads beneath the surface of the grass have been developed.

7. TURF WARMING SYSTEM (Optional)

In the colder regions, frozen fields increase the chance of sports participants becoming seriously injured. Different turf warming techniques are available to keep the ground from freezing and the fields playable.

In addition to thawing the field the heating system also extends the growing season, allowing the grass to heal during cold weather use. The spring sports schedule can also begin earlier due to the ability of the heating system to produce an environment favorable for the growth of the grass.

8. FLAT PLAYING SURFACE

A new dimension is available in athletic field design. The excellent internal drainage characteristics of the all-sand rootzone permits the playing surface to be level. Gone is the need for the traditional 18 to 24 inch crown that is necessary on all other types of athletic fields. Now everyone — coaches, players, spectators — will have an unobstructed view of the game.

9. NATURAL GRASS PLAYING SURFACE

Selecting the correct grass for the playing surface is extremely important. SPORTSTURF Systems, Inc's. professionally trained agronomists personally select and inspect the grass varieties specified for each installation.

Every grass variety must exhibit those special characteristics needed for the development of a good athletic turf before being selected for use with a Field. The standards used in selecting a grass are:

- resistance to wear
- provide good traction for firm footing
- forms a dense, tough turf
- produces a resilient playing surface
- ability of damaged areas to heal quickly
- adapted to low mowing heights
- easy to maintain
- displays a dark green color
- compatibility with other grass varieties
- tolerant to temperature extremes
- disease and insect tolerant

The SPORTSTURF All-Weather Field is designed to fit the specific needs of each installation. The basic elements; the sand, drainage pipes, sod and irrigation system form the nucleus of the concept. While the optional features are available, the nucleus of the SPORTSTURF Field provides an excellent, free draining playing surface every team can be confident playing on at anytime, regardless of the weather.

San Francisco's Candlestick Park Has A New Look

And Its A Natural Grass SPORTSTURF All-Weather Field! After several years of putting up with the hard, wornout ASTRO Turf playing surface at Candlestick Park the City of San Francisco decided it was time to return to nature. One hundred and thirty thousand (130,000) square feet of deteriorated ASTRO Turf was ripped up.

The SPORTSTURF Field was installed at a fraction of the price it would have cost the City to replace the shabby ASTRO Turf playing surface with a new artificial turf carpet and pad.

Candlestick Park is the home of two professional sports teams. Baseball's National League Giants played over seventy home games in the park and the Forty Niners of the National Football League use the field for their twelve home games. The natural grass is able to withstand this heavy use due to the excellent drainage of the field. The ability of the grass to form a tough, wear-resistant playing surface allows both teams to concentrate on a winning season, rather than worrying about the condition of the field.

A unique underground sports system was developed to allow the baseball park to be converted to a football stadium at the end of the baseball season. The dirt baseball infield can easily be removed, exposing a sandy sub-base with its network of drainage pipes. Sand grown sod is put down in place of the dirt, providing a free draining turf in this area of the football field. Football no longer has to be played on a muddy infield.

SPORTSTURF Systems, Inc.

Over two million square feet of design experience with sand-based natural grass sports fields makes SPORTSTURF Systems, Inc. the leader in this profession. The SPORTSTURF staff were the turf consultants for the VIII Pan American Games held in San Juan, Puerto Rico and too the Olympics in Montreal, Canada.

More information on the SPORTSTURF Fields can be obtained by writing to the following address: SPORTSTURF, Suite 200A/ Lindbergh Plaza 1, 221 Charles Lindbergh Drive, Salt Lake City, Utah 84116.

ATHLETIC FIELD RENOVATION

by

J. R. Watson[1]

To renovate means to renew, restore, or to invigorate. The definition does not mean to rebuild or redesign, but may include modification--of the soil, of the grasses used on the field, of the cultural practices applied in past seasons, or, of the use (frequency, number of games) --at least I shall include these as renovating techniques or procedures. Thus, to renovate athletic fields means to restore them to a presumed former state of excellence: where the condition of the grass and the firmness and uniformity of footing are satisfactory and acceptable to all involved: the groundskeeper, the coach, the players and all management or supervisory personnel involved with the operation of the facility. Additionally, that presumed state of acceptability must meet the demands for "spectator" appeal and, in the case of some schools and some parents, "public" or "parental" approval. Here, acceptability relates to "color" and growing aspects of the field. How, then, may we best describe a good condition? Specifically, from a playing standpoint, good athletic field turfgrass should be tough, wear-resistant and not easily torn by cleats. It should be soft and resilient enough to prevent abrasions when players fall, yet firm enough to permit good footing. It should be clipped short enough to prevent hanging of cleats, yet tall enough to ensure healthy plant growth and rapid recovery when torn by shoe cleats. A good, healthy and vigorous stand of bermudagrass, or bermudagrass overseeded with ryegrass, clipped between 3/4 and 1-1/2 inches in height, will meet these qualifications.

Firmness and uniformity of footing are usually present when the condition of the turfgrass is satisfactory. But, with or without good grass, a firm, even and resilient footing is absolutely necessary and should be mandatory on all playing fields. Skinned areas of baseball infields provide these conditions. The same general techniques and procedures may be employed to assure footing on football fields. Players recover from skin abrasions relatively easily--certainly more easily than from twisted knees and ankles. Dust may be controlled on bare areas by the use of water. Turf cover is, of course, preferred.

Spectator Appeal: With the advent of colored telecasting of major sporting events, field color and grooming have taken on new significance. Spectators have come to expect uniformity and compatibility of color. Color is important from an aesthetic standpoint and, right or wrong, is apparently one of the major criteria by which the general public judges the quality of turf.

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To be successful, a renovation program must include three steps:

1. Identification of the problem or condition responsible for deterioration of the turf. In this step, all possible reasons for the less than satisfactory conditions must be identified, listed in writing, studied and reviewed -- then reviewed again. For example, was the condition brought about by poor soil, improper drainage, poor cultural practices or simply too much use or too many games for the soil and grass conditions obtaining?

2. Once the problem has been identified, the corrective action needed to restore the field must be developed, studied, all alternatives costed and evaluated, then compared with costs for rebuilding the facility. To evaluate this situation properly one must have information on future schedules and anticipated uses -- especially multi-use situations. This information must be applied to the known status or basic construction details or components (soil - grass - irrigation).

Failure to prepare properly the basic data, to make good cost comparisons and to project annual renovation costs against costs for rebuilding often results in unduly high operational costs. There is one exception: since renovation could be carried as an operating cost and rebuilding would be classed a capital expenditure, an ongoing annual renovation program may be the most expedient from the standpoint of stability of the financial structure.

3. The third step in the program is implementation -- doing the job. The nature and extent of the job will determine who will do the work. For example, topdressing to restore the crown and to level out depressions with subsequent seeding or sprigging may be handled by the crew; whereas, a complete change of soil, changeover to a superior cultivar, or installation of an irrigation system may be best handled by a contractor. Regardless of who does the work, successful operation of the system will be dependent upon the installation.

Once the renovation of the field is completed, keep in mind the reasons why the job was necessary and, insofar as possible, avoid development of similar conditions or situations on the newly renovated area.

GOLF COURSE MAINTENANCE COSTS

by

J. R. Watson[1]

There are a number of very good reasons why golf course managers should examine their costs. Among them:

* The use of private, public, and governmental golf courses and recreational areas is at an all-time high and appears to be growing at an accelerating rate.

* Turfgrass areas serve very important functional and aesthetic roles in our communities -- roles that are essential to our way of life.

* In many areas, new courses are not being constructed at a rate rapid enough to absorb the growing demand and in some areas, taxation is forcing many golf courses to subdivide.

* Inflation continues to erode our purchasing power. For example, the cost of groceries has doubled in the past 10 years, up from $100 to $210.

For these and other reasons, it is imperative that golf courses operate at maximum efficiency.

Efficient turf maintenance will help ensure the best possible conditions for recreation and protect the heavy investment in the facility, whether it be privately or publicly owned.

The golf course and turfgrass manager -- the superintendent -- must regularly analyze every facet of his job: the performance of his equipment, his operating procedures, his maintenance programs and his personnel policies, in order to ensure efficiency at all levels.

Equipment and people are, of course, two key elements of golf course maintenance costs, and I want to concentrate on them today. I shall leave other areas and aspects to other speakers.

Equipment. To save money in today's environment demands the conservation of energy. Let me list some steps that will help to conserve fuel and promote economy in the use of motorized equipment, while, at the same time, enable a superintendent to maintain quality turf.

* Choose the most efficient machine for each job. Generally, reel mowers are more efficient than rotary or flail mowers. The scissors

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action of the reel mower cuts better and requires less power, thus consuming less fuel. With the same mowing speed, reel mowers will use up to 50 percent less fuel per acre than rotary mowers.

For example, our 70-inch Professional, a triplex steel mower, is capable of cutting a 70-inch swath with a 6.25 horsepower engine, while a 60" rotary has a 14 horsepower engine. The 70-inch unit cannot be used for all trimming operations, but where fuel supplies are critical, it makes good sense to use the smaller engine whenever possible.

The number of blades in a reel affects both the quality of cut and fuel economy. A five-bladed reel will use 8 to 12 percent less power and fuel than a six-bladed reel.

* Use diesel fuel, rather than gasoline. Diesel fuel generally costs less than gasoline and the diesel engine is 20 to 25 percent more efficient than the gasoline engine. This means fewer gallons and less dollars to perform a given task. This increase in efficiency may be reason enough to choose diesel power when purchasing new equipment.

* Whenever possible, use higher capacity, labor-saving equipment. Labor comprises the largest part of every maintenance budget and the costs of labor are increasing as fast or faster than equipment costs.

* Keeping all equipment clean and properly adjusted effects a 5 - 6% reduction in power according to Dr. Bob Sherman. Proper adjustment of belts, bearings, chains and shafts will reduce friction, resulting in more power for work production. Frequent lubrication of vital parts will also reduce friction.

* Tire pressure also should be maintained at recommended levels to reduce rolling resistance.

* With reel mowers, the bedknife adjustment is critical. Over-tightening the bedknife will waste power. Insufficient pressure will not allow the slight contact between metal that is essential for maintaining sharp edges. A sharp reel mower will improve the quality of cut, which may prolong the mowing interval. Grass which is shredded and torn by dull mower blades becomes brown and unsightly. This unkempt appearance may dictate a more frequent mowing interval. Sharp edges also will permit a slower engine while still producing a good quality cut.

Proper maintenance of vital parts of any machine will conserve fuel and extend the functional life of the machine. No part of the machine is as critical as the engine. Just as with an automobile, a properly maintained, well-tuned engine on a turf maintenance machine operates more economically. Adjust the carburetor to best fuel-to-air ratio. Check the ignition system to ensure clean points and plugs, correct timing and maximum power availability. The engine air cleaner is crucial. A clogged air cleaner can change the air-to-fuel ratio and use excessive amounts of fuel. Proper adjustments and maintenance of these combustion regulators also affect long engine life.

* Mowing practices can help one to economize. Here are a few tips:

- Plan the mowing patterns for the least amount of transport between locations.

- Use the least amount of overlap consistent with the skills of your operators.

- Select the height of cut best suited for each area. You may be able to increase heights and add one or two days to your mowing cycle.

- Where possible, eliminate mowing of steep slopes.

* Consider an accelerated depreciation schedule. There may be some real advantages in a different schedule. Check with your accountant to see if there are possibilities in this area.

The second area that affects efficiency and economy is people. Especially important are the supervisory personnel. And, the training or updating of skills for all employees is very important.

Efficient maintenance means using equipment that will cut more acres per day per man. It means equipment with greater capacity, more durability and longer life. Such equipment is complex and may require a higher level of training for the mechanics who service such equipment. Thus, training operators and mechanics becomes a vital and necessary step to ensure maximum results with minimum expenditures -- efficiency -- economy.

Proper or economical equipment use involves planning and supervision. Planning for the most efficient way to use the equipment and to keep it operating. As early as the turn of the century Frederic Taylor made intensive studies of industrial operations and concluded that anywhere from 10 to 50 percent of a man's day may be spent in idleness or non-productive work. Interestingly enough, roughly two-thirds of that idle time is the result of inadequate supervision. Initiating methods to correct this situation is a challenge for all turf facility managers and supervisors. The manager of a turfgrass facility must carefully study all aspects of the work to be done and provide proper and adequate supervision.

A third area -- employee relations -- also has an impact on the largest single budgetary item -- labor. Since labor accounts for approximately 70 percent of maintanance budgets on most turf facilities, it is the first major area to attack when one embarks on a program to economize. This percentage level has been about the same for some 30 to 40 years, even though the number of people employed at a given facility may have dropped from 25 to 30 down to 10 to 12. Yet turf facilities today have better playing quality than in the past, and they are used by more people more intensively.

One final suggestion when considering golf course maintenance costs: Take a careful look at your golf course and determine how much you might be losing in efficiency due to design, landscape characteristics or special terrain features.

For example, a highway that divides the course, narrow bridges, small streams, drainage ditches, small greens, small sand traps and heavily wooded roughs all make maintenance more difficult and more costly by increasing the time factor and limiting the areas where high performance equipment can operate at peak efficiency. The same may be true for parks and playgrounds.

An investment in redesign might easily pay for itself in reduced maintenance costs. This has been demonstrated dramatically at Oakland Hills Golf Club which has two courses and where the superintendent is Ted Woehrle.

The north course was redesigned in 1969 and automatic irrigation was installed. The south course was unchanged.

On the north course, greens and tees were enlarged to accomodate triplex greensmowers and large capacity sprayers. The 90 sand traps were rebuilt with gentle slopes to accept power equipment for raking and to prevent erosion from heavy rain; thus, little hand work is required.

The old south course has severely contoured greens and closely packed bunkers. The traps are small with steep banks. The tees are too small for large mowers. The greens and tees are watered with hoses.

The south course has a crew of 12 to 14. The north course has four. Both share the services of one mechanic.

Redesign--modernization--to accomodate the most efficient machines available, certainly should be explored on all turf facilities. This may provide an avenue for both short and long term economy.

Update. Finally, I suggest that you keep current -- keep undated on factors affecting your operation. I don't have to tell you that fuel, fertilizers and chemicals -- all things derived from petroleum -- are costing you more and you can expect the costs to continue to increase, probably at a much faster rate than inflation overall.

Everything you spend money on now will cost more in the future than it does today.

This means that you are going to have to find ways to reduce your input and consumption of labor and materials without a significant reduction in the quality of your turf.

To do that we are going to need three things:

* More research to develop turfgrasses that will resist disease, will thrive with less water and less fertilizers and grow at a slower rate, thus require less frequent mowing.

* Greater reliance on compost and organic fertilizers.

* Better equipment -- equipment that will offer a whole range of advantages, a combination of advantages.

It is not many years since greens were kept in good condition with hand-pushed greenmowers. Today powered greensmowers will do a better job in one-tenth of the time or less, compared with manual mowing.

And powered sandtrap rakes certainly have reduced the amount of time spent to keep your bunkers in playing condition.

I believe that manufacturers are going to continue to compete fiercely for your attention by developing products to make your job easier, so I think new equipment will continue to be available. You must assume responsibility for updating -- which means you must be aware and keep current.

U S G A Green Construction

by

Dr. Douglas Hawes*

U.S.G.A. Green Construction consists of building a green to U.S.G.A. specifications. These were first published 19 years ago and were refined and republished in 1973. Building a green to U.S.G.A. specifications consists of following the directions in the article, "Refining the Green Section Specifications for Putting Green Construction" available from the U.S.G.A. Green Section at the above office.

In order to correctly follow these specifications the sand, soil and organic materials you intend to use must be sent to the Soil Physics Section of the Soil & Crop Sciences Department at Texas A&M well in advance of construction so that they may determine what mixture by volumes of these materials will best meet U.S.G.A. specifications for infiltration rate, percolation capacity, porosity, bulk density, water retention capacity, and particle size. Then this soil mix must be prepared off site and carefully applied on the gravel and sand base to the proper depth (12 inches after compaction).

Many golf greens are built "like" U.S.G.A. greens, very few are built to U.S.G.A. specifications. In most non-USGA greens the drainage tile in the bottom is next to useless because the soil mix on top has such a poor percolation rate after several years of moderate use that very little water moves through the soil mix.

The movie, <u>The ABC's of Putting Green Construction</u> is available for a $10 fee from Golf House, Far Hills, N.J. 07931 to show at your next meeting. Remember: building greens correctly insures lower maintenance costs and less headaches in the future.

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Effects of Preemergent Herbicide Residues on Turfgrass Quality and Performance

by

R. C. Shearman*

Preemergent herbicides are commonly applied to turfs for the control of annual, weedy grasses such as crabgrass, goosegrass, and annual bluegrass. Warm-season, annual grasses like crabgrass are generally controlled with preemergent herbicides applied in the early spring. Cool-season annual grasses like annual bluegrass are typically controlled in the fall. In some cases when annual, weedy grass populations are high and conditions are favorable for extended periods of germination, it is not uncommon to make repeated preemergent herbicide applications in a single season to obtain the desired level of control. These repeated applications within a growing season and successive yearly applications raise some concern about their potential detrimental effects on desirable turfgrass species, especially during periods of heat, drought, disease, and traffic stress.

One of the most obvious detrimental effects of preemergent herbicides is that they also reduce the germination of overseeded cool-season turfgrasses. Siduron (Tupersan) is one exception, since it is recommended for application to seedbeds of certain turfgrass species and cultivars. However, it is generally not recommended for use on warm-season turfgrasses. Juska and Hanson (1964) reported that April applications of DCPA (Dacthal) at 10 and 20 pounds of active ingredient per acre reduced germination of Kentucky bluegrass overseeded six months after the initial application. At the same time, they reported that the lower rate did not significantly reduce germination of perennial ryegrass, tall fescue, or creeping red fescue. Perkins et al. (1975) reported that prosulfalan (Sward) should not be applied in the spring to turfgrasses that were seeded the previous fall, indicating possible harmful effects from the herbicide even after seedling emergence. Preemergent herbicides even after seedling emergence. Preemergent herbicides used in turf are relatively immobile in soil. This is due in part to their low water solubility and their tendency to be absorbed by soil colloids. Care should be taken when using these materials to apply them according to the label recommendations.

Research at Nebraska has pointed out that thatch influences the potential detrimental effects of preemergent herbicides on desirable turfgrass species. Benefin applied at 2.0 pounds active ingredient per acre on a common-type Kentucky bluegrass resulted in high temperature and drought stress injury when applied to a thatchy turf but not when applied to a thatch-free site. Hurto and Turgeon (1979) reported that the absorption of benefin, bensulide and DCPA from solution was greater in thatch than in soil. They also reported injury during periods of summer stress from

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benefin, oxadiazon (Ronstar), and prosulfalin in thatchy turf. Only prosulfalin caused injury on thatch-free sites. DCPA and bensulide caused no injury on either site. They concluded that injury on the thatchy site was due to increased mobility of preemergent herbicides in thatch as opposed to soil and the increased potential for these herbicides to contact absorptive tissues of the grass plant in thatch.

Effects of preemergent herbicides on desirable turfgrasses seem to be subtle in nature and are not as obvious as those involved in reducing seed germination. Ahrens, Lukens, and Olson (1962) reported that dacthal at 7½ pounds and 15 pounds active ingredient per acre applied in April to a mixture of Kentucky bluegrass, colonial bentgrass and chewings fescue resulted in 5 and 30% stand thinning in July. They also reported that by September, the grasses that received the lower treatment rate had recovered but the grasses that received the higher treatment rate remained thin. Gaskin (1964) demonstrated that dacthal at 10 and 15 pounds active ingredient per acre reduced tiller and rhizome numbers as well as rhizome length on Merion and a dwarf selection of Kentucky bluegrass. Smith and Callahan (1969) studied the effects of herbicides on Kentucky bluegrass root regrowth. Sod plugs were transplanted on soils freshly treated and soils from turfs that were treated ten months earlier. All herbicides tested reduced root growth significantly on the freshly treated soils when compared to the check. The 12 pound active ingredient per acre application of siduron (Tupersan) caused the least inhibition. Simazine and atrazine applications were the most phytotoxic. All herbicides reduced regrowth in the soil residue study. Terbutol (Azak) and bensulide (Betasan) caused the greatest reduction and siduron, benefin (Balan) and DCPA (dacthal) caused the least significant effect on Kentucky bluegrass plant height and dry weight after 12 months following the second of two yearly applications. In fact, dacthal treated turfs had significantly greater root length and dry matter production when compared to the untreated check. Shearman et al. (1979) studied the effects of herbicides on sod transplant rooting of three Kentucky bluegrass cultivars. The results of these investigations indicated that herbicide effects on sod transplant rooting interacted with cultivars. The results of this study indicated that bensulide at 12 pounds active ingredient per acre reduced transplant rooting of Park, Merion, and Baron Kentucky bluegrass when applied either to the sod or to the sodbed. Benefin applied at 2 pounds active ingredient per acre reduced sod transplant rooting of Baron only.

Bingham (1974) studied the effects of several preemergent herbicides on transplant rooting of tall fescue, Kentucky bluegrass, and bermudagrass. He reported that DCPA and siduron produced little effect on rooting of tall fescue and Kentucky bluegrass. However, siduron caused complete inhibition of rooting in 'Tifgreen' bermudagrass. Normal rates of DCPA reduced transplant rooting of bermudagrass by thirty percent. Bensulide and benefin reduced transplant rooting by as much as 50% for Kentucky bluegrass. Bingham in an earlier study (1967) reported that applications of preemergent herbicides for crabgrass control prevent rooting of bermudagrass from stolon nodes. He reported that placement of DCPA was an important factor in root inhibition. This could be even more critical on thatchy bermudagrass turfs. Gaskins (1964) indicated that Kentucky bluegrass turf treated with DCPA had fewer rhizomes and tillers present but that established root systems were not appreciably altered by the treatments. Troutman and Jagschitz (1971) found that applications of benefin inhibited sod tensil strength of treated sods up to two months after treatment. Sod tensil strengths are positively correlated to rhizome number and development.

The research reported here supports concern about potential detrimental effects of preemergent herbicides on desirable turfgrasses. The subtle influence of these materials on root and rhizome development, disease susceptibility, and environmental stress are important aspects for the turf manager to understand. Conflicts exist in the various reports of preemergent herbicide effects on turfgrass species. It is apparent that detrimental responses are influenced by turfgrass species and cultivar, the herbicide, soil, thatch, and environmental stress. More research is needed to help turf managers understand how to best use these materials to maximize their benefits and minimize their potential detrimental aspects. Preemergent herbicides have improved the quality and function of turfs. At the same time, we cannot excuse the evidence that they may cause damage especially under stress conditions.

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SPECIFYING FOR SEED QUALITY

by

Wallace Menn*

How many of you pay particular attention to seed quality when buying planting material for overseeding? I'm afraid that many of us don't look closely enough at such factors as Purity, Viability (germination), or Weed Seed Content when purchasing seed for planting.

To increase your chances of receiving top quality seed always insist upon buying only certified material. However, this alone does not guarantee that you are getting top quality seed. Have you ever read the statement on the Seed Certification Tag? Is the tag affixed to a bag of seed actually a certification tag or is it a Seed Inspection Fee Tag? It is probably the latter, which only evidences the payment of an inspection fee by the Seed Company and does not actually verify the quality or condition of the seed in that particular bag.

Do we all understand the terminology used on a seed certification tag and how can we use this information to get the best buy?

First, let's look at Purity. Purity refers to the actual percentage of pure seeds of a particular species, variety, or specific mixture. Purity is affected by the presence of trash, hulls, weed seeds, etc. and usually indicates the cleanness of the seed.

Another term, Germination percentage, refers to viability or the percent of seed that is alive and that will germinate. This is probably one of the more important items to observe when determining seed quality. After all, you are paying for pure live seed; and as germination percentage goes down, the cost of pure live seed goes up. For example, last year I bought Sabre, *poa trivialis*, for $1.75 per pound; and it had a germination percentage of ninety (90%). This year, I purchased the same variety for $1.80 per pound and thought that I had really gotten a deal. Upon examining the inspection tag, I found that I had bought seed whose germination had dropped to 77 percent. After computing the cost of pure live seed (PLS), I found that in 1978 I had paid $1.94 per pound for PLS while in 1979 (when the cost per pound of seed had only increased 5 cents) I was paying $2.34 per pound PLS. So, we find that what appeared to be only a 2.7 percent increase in price actually turned out to be in excess of 17 percent. You can see that I really did get a DEAL. Upon discussing this drop in germination with specialists in Seed Technology I became even more concerned with their comments about seedling vigor. It was their feeling that anytime germination drops this much in one year, the seedling vigor must surely drop off considerably.

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We should also pay considerable attention to the term Weed Seed Content. Even though this percentage may seem very low, when considering that some grass species have millions of seeds per pound, a figure of one or one-half percent will amount to a sizeable weed seed content.

Even though the seed companies should inform the buyer of the condition of the seed they have for sale, it is our responsibility as consumers to specify the quality of seed we desire. When ordering seed, we should specify minimums in purity, germination, weed seed content, and freshness to insure that we get that for which we are paying, It would probably be wise to check with several companies to find out what minimums in the aforementioned quality factors are available before determining your specifications. You would not want to specify yourself out of the market.

REGROWTH OF BERMUDAGRASSES AS INFLUENCED BY NITROGEN RATES

by

Garald L. Horst and Arden A. Baltensperger*

Increased population pressures are straining the resources of the United States, particularly those of the Southwest where water is limited. This has put increased emphasis on the need for economically optimum turfgrass management systems in the Southwest. Both the professional and the homeowner are looking for ways to minimize expenditures while still providing adequate, useful turfgrass areas.

There is a need to better understand the nutrition of bermudagrass and how related cultural practices may affect grass physiology and other management practices. Techniques used to make these evaluations must also be refined.

Objectives of this research were to develop more complete information on bermudagrass nutrition, physiological responses, morphology, and management practices subsequent to fertilizer application. In addition, methods used to evaluate turfgrass responses to nutritional practices were investigated for improvement.

Materials and Methods

Two bermudagrass cultivars, Tifgreen and Arizona common, were established on an alluvial soil in the Rio Grande flood plain in extreme southern New Mexico. Sprigs were planted and established during the 1977 growing season.

In May 1978, monthly nitrogen fertilizer applications of 0, 16, 33, and 49 kg/ha were started. Six applications were continued through October of the 1978 growing season. The plots were mowed and irrigated weekly and the clippings were removed.

When possible, sod cores were harvested monthly from each plot. Excess soil and plant material was trimmed back and the sod core placed in a glass jar. Distilled water was added to bring the soil moisture to field capacity. The core samples were placed in a controlled environment chamber maintained at a constant 31 degrees celsius and 100% relative humidity. The samples were continously in the dark.

Weekly harvests of the above ground level regrowth were made by hand clipping the plant material from each sod core sample in the growth chamber. The harvested plant material was then over dried and weighed. Harvests were continued until we were unable to measure regrowth for three consecutive weeks.

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Results and Discussion

Measurement of stored energy reserves in rhizomes is one method of evaluating turfgrass response to various levels of nutrition. Levels of stored energy available for regrowth vary throughout the year in response to seasonal conditions. We obtained a response in regrowth to changing factors such as temperature and day length in addition to nitrogen fertility level (Table 1.). Regrowth harvested from samples taken in the winter (Feb., 1979) was lower than that harvested from sod samples taken in the spring (April, 1979), summer (July, 1979), and fall (Sept., 1979). The results were similar for Tifgreen except that the winter samples produced less regrowth than samples taken in the fall. Dormancy level, growth habit, and maintenance energy depletion during dormancy for the two cultivars may explain the differences. We must also consider that this method of evaluating stored energy reserves does not account for the energy expended in new root production. Our method only gives an estimate of the energy diverted to the production of top growth. The observed reduction in regrowth in the fall may be due to diversion of energy reserves to root growth.

There was a cultivar response to optimum nitrogen level (Table 1). The maximum regrowth generally occurred with a nitrogen fertilization rate of 16 kilograms per hectare per growing month. This was true for both cultivars.

The length of time the sod samples of each cultivar grew using stored energy reserves (regrowth duration) was influenced by the level of nitrogen fertilization (Table 2). Lower levels of fertilization generally, but not always, resulted in longer periods of time in which the grasses were able to maintain themselves using stored energy, until the late summer growing period. These results support earlier research findings, that excessive nitrogen levels may increase turfgrass susceptibility to stress conditions. This is presumed to be due to increased top growth which is less likely to furnish energy available for recovery from an environmental stress condition.

These results may explain, in part, why some cultivars are able to recover from stress conditions which other cultivars are unable to withstand. Nitrogen levels above two kilograms per hectare usually resulted in shorter periods of time in which these bermudagrasses expended their stored energy reserves. It is noteworthy that Tifgreen bermudagrass was able to maintain regrowth for much longer periods of time than Arizona common. Tifgreen bermudagrass was able to convert a larger portion of energy reserves into top growth, expressed as average daily regrowth energy (mg/day), (Table 3.). Conversely, Arizona common was converting a larger portion of it's reserves into either root growth, respirational losses, or both. It is also possible that genetically it does not convert energy reserves as readily into measurable top growth.

Conclusions

Nitrogen nutrition influences both top growth and stored energy levels in turfgrass tissues. Excessive nitrogen levels appear to lower the stored energy reserves in the spring and throughout the entire growing season. Based on these results, management practices should be structured to apply the minimum amount of nitrogen fertilizer that will maintain turfgrass vigor and the necessary energy reserves.

RESISTANCE TO DOWNY MILDEW IN ST. AUGUSTINEGRASS

by

B. D. Bruton and R. W. Toler*

INTRODUCTION

Controlling plant disease by use of host resistance and tolerance contributes significantly in maintaining a quality turf at minimum costs. Host plant may express resistance through immunity to infection while others are susceptible to infection with varying degrees of resistance to pathogen development. Under field conditions, the level of susceptibility or the rate of disease development on a given host genotype to a fungal pathogen may be due to (1) the amount of penetration, (2) rate and amount of mycelial growth, (3) incubation period, (4) number and size of lesions, and (5) rate and amount of sporulation. Thus, even though a host plant is susceptible to infection, it can be considered to have some degree resistance. Therefore, we undertook this research to determine the disease reaction of 12 St. Augustinegrass cultivars and accessions to Scleropthera macrospora. The following experiments were designed to determine: (1) resistance to infection, (2) percent of systemic colonization by the fungus, and (3) inoculum (zoospore) production.

Host resistance. Twelve St. Augustinegrass cultivars and accessions (Table 1) were artifically inoculated with Scleropthore macrospora. Mature St. Augustinegrass, clipped at 3.8 cm height, was used in the inoculation procedure. Each treatment was replicated six times. The plants, in one liter plastic pots, were flooded by immersion in a larger container filled with tap water. The plants in the individual pots were restricted in the flooded container by a plastic cylinder fitted inside the one liter pots. The water was adjusted to a level just covering the leaves with the cylinder extending above the water surface. With this technique, the inoculum was restricted to the immediate area of each plant to be inoculated. Mature 'Floratam' St. Augustinegrass leaf blades showing typical downy mildew symtoms were used for the inoculation. Five leaves were floated or submersed inside each cylinder surrounding the plants. The inoculation procedure was performed in a dark environmental chamber for 24 hours at 20C. Plants were removed from the environmental chamber after 24 hours and placed on a bench in the greenhouse for disease development. Percent infected leaves were evaluated 30 days following inoculation.

Disease development. Percent colonization by the downy mildew fungus was evaluated in 12 St. Augustinegrass cultivars and accessions (Table 2). Test plants, in 1 liter plastic pots, were inoculated with the St. Augustinegrass downey mildew using the same method as previously described. Following inoculation, each of the test plants were transplanted into a large wooden container box (1.5 X 5m) in the greenhouse for 60 days. Extent of systemic colonization of the leaves was noted on 50 leaves taken at random on each test plant.

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Inoculumn production. Grain sorghum (incred TX 2536) was used as a bioassay host to determine sporangia and zoospore production and subsequent infection using downy mildew-infected leaves from 12 different St. Augustinegrass cultivars and accessions (Table 3). Six replicates of each cultivar and accession were used in the inoculation phase. Five downy mildew-infected excised leaf blades of approximately the same size (24 cm^2/leaf area) and percent colonization (75%) were obtained from each test plant. Ten grain sorghum plants/1 liter plastic pot were exposed to the inoculum at 15C for 24 hours, following the previously described technique. Plants were subsequently placed in the greenhouse and percent infection noted.

RESULTS

Host resistance. Thirty days following inoculation with the downy mildew fungus, each cultivar or accession was evaluated for percent infection. No single cultivar or accession demonstrated superior resistance to infection, although infection did range from 14.50% in 'Floratine' to 36.33% in 'New Zealand Red Leaf' (Table 1). The two commonly grown Texas cultivars, 'Texas Common' and Floratam, had 21% and 27.83% infection respectively.

Disease development. Colonization of leaf blades, by the downy mildew fungus ranged from an average of 27.26% of the leaf colonized in Floratam Mutant #10 to 65.68% in Garrett 141 (Table 2). A number of the cultivar and accessions segregated into classes showing significant differences. Floratam had significantly more fungal colonization than Texas Common with 62.56% and 43.94%, respectively.

Inoculum production. The ability of each cultivar and accession to serve as a source of inoculum was evaluated using a bioassay host (grain sorghum TX 2536). No single cultivar or accession was a demonstratably superior source of inoculum although, infection of the bioassay host ranged from 30.66% by Floratam Mutant #10 to 86.50% by 'Floratam' St. Augustinegrass (Table 3). 'Texas Common,' the other commonly grown cultivar besides 'Floratam,' produced 71.00% infection.

CONCLUSION

Superior host resistance was not demonstrated in any of the 12 St. Augustinegrass cultivars and accessions tested. The parameters used to determine host resistance were: (1) resistance to infection (Table 1), (2) percent of leaf colonized by the downy mildew fungus (Table 2), and (3) inoculum producing potential utilizing a bioassay host (Table 3). 'Scott 516' was the only St. Augustinegrass cultivar or accession that ranked in the top three in each study. 'New Zealand Red Leaf' ranked in the bottom three in 2 of the 3 studies, with Floratam ranking in the bottom three in each study. Floratam Mutant #10, which is a gamma irradiated 'Floratam' selection consistently ranked higher than the parent, Floratam. Thus, irradiation could potentially be used to impart at least some resistance in St. Augustinegrass. These studies demonstrate varying degrees of resistance to Scleropthora macrospora in St. Augustinegrass, although none of the cultivars and accessions tested exhibited outstanding superiority, this is not an uncommon phenomenon with a fungus of such a wide host range.

Table 1. Comparative host resistance to the downy mildew fungus in twelve St. Augustinegrass cultivars and accessions.

Cultivar/accession	Disease development[a] (%infection)
Floratine	14.5 a[b]
Scott 516	15.3 ab
Florida Common	20.0 abc
Texas Common	21.0 bcd
Floratam Mutant #10	21.2 bcd
Bitter Blue	22.0 cde
NCSA-21	23.5 cde
Garrett 141	24.7 cdef
TX-33	26.8 def
Floratam	27.8 ef
P.I. 410355	29.8 f
New Zealand Red Leaf	36.3 g

[a]Percent leaves infected when evaluated 30 days following inoculation, mean of 6 replications.

[b]Values followed by the same letter are not significantly different (P = 0.05) using Duncan's multiple range test.

Table 2. Percent of leaf blade colonized by the downy mildew fungus on twelve St. Augustinegrass cultivars and accessions.

Cultivar/Accession	Leaf colonization[a] (%)
Floratam Mutant #10	27.0 a[b]
Bitter Blue	27.4 a
Scott 516	35.6 b
Tx-33	35.9 b
Floratine	36.1 b
Florida Common	39.8 b
P.I. 410355	43.1 b
Texas Common	43.9 b
NCSA-21	51.9 c
New Zealand Red Leaf	52.2 c
Floratam	62.6 d
Garrett 141	65.7 d

[a]Percent colonization of leaves by the downy mildew fungus, mean of 50 observations.

[b]Values followed by the same letter are not significantly different ($P = 0.05$) using Duncan's multiple range test.

Table 3. Ability of twelve St. Augustine cultivars and accessions to produce inoculum using a bioassay host.

Cultivar/Accession	Bio-assay host[a] (% infection)
Floratam Mutant #10	30.6 a[b]
Scott 516	39.6 ab
NCSA-21	49.1 bc
Tx-33	53.8 c
Florida Common	61.6 cd
Floratine	61.6 cd
Bitter Blue	62.6 cd
New Zealand Red Leaf	68.8 de
Texas Common	71.0 de
P.I. 419355	74.1 def
Garrett 141	80.5 ef
Floratam	86.5 f

[a]Percent infection in bio-assay host (grain sorghum Tx 2536) using downy mildew infected St. Augustinegrass leaves, mean of 6 replications.

[b]Values followed by the same letter are not significantly different ($P = 0.05$) using Duncan's multiple range test.

GROWTH AND DEVELOPMENT OF TURFGRASSES

by

James B. Beard*

Turfgrass culture is essentially the manipulation of the environment surrounding the grass plant to provide the most favorable growing conditions. Thus, a basic understanding of the growth and development processes of the turfgrass plant is essential in order to achieve this objective. Growth involves an irreversible increase in size that is quantitative in nature and can be measured in terms of length, area, volume, or weight. In contrast, development involves changes in the form, structure, and general state of complexity of the grass plant that are primarily qualitative in nature. The growth processes of leaves, stems, and roots involve primarily cell division and elongation; while the developmental processes involve differentiation of specific tissues or structures such as flowers. Varying types and rates of growth are occurring in various tissues throughout the plant at any one time. Thus, growth and development are very dynamic processes which are constantly shifting in relation to the particular atmospheric, soil, and environmental conditions as well as in relation to the specific cultural practices imposed.

For the purposes of this discussion, the major plant structures critical in turfgrass processes will be discussed individually. These are the root, shoot, stem, tiller, and leaf along with the carbohydrate reserve. However, one should be ever cognizant that these growth and development processes do not occur independently, but are closely interrelated with shoot growth.

ROOT

Roots function in water absorption, nutrient uptake, and anchorage of the grass plant. The dimensions of root growth can be expressed in terms of number, depth, and rate of root extension. Grass roots are very fibrous, with the majority of the root system located in the upper 6 to 8 inches of the soil profile. Functioning roots of some grass species can be found to depths of 6 feet or more. In contrast, root systems under putting greens during stress periods can be as short as 2 inches. The root systems of most turfgrass species are replaced on an annual basis, with the spring root die-back phenomenon of warm season perennial grasses being particularly significant. This new discovery is discussed in a separate paper within this conference proceedings.

There is a tendency to manage turfs strictly in terms of shoot growth responses since this is the most easily observed dimension.

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However, the most successful turf manager is the one that is equally cognizant of the effects of cultural programs on root growth. Thus, it is appropriate to review the factors influencing root growth. There are nine environmental factors which can have varying degrees of influence on root growth on a particular site:

A. Environmental Factors:

(1) Temperature - Root growth of cool season grasses is favored by soil temperatures in the range of 50 to 60°F; while root growth of warm season species is best at temperatures of 80 to 90°F.

(2) Soil pH - Soil pH's in the range of 6 to 7.5 are generally desired, with acidic pH's of 5.0 or below being particularly detrimental to root growth.

(3) Soil Compaction - Increasing soil compaction results in a reduced water infiltration rate and impaired soil aeration which can adversely affect root growth and overall turf performance. It is a particularly serious problem on intensely trafficked sports fields, and thus is the main reason that soil modification with a sandy root zone is practiced.

(4) Waterlogging - Excessive irrigation or rainfall which cause the soil to be water saturated and thus lacking in the needed pore space, can have very adverse effects on root growth.

(5) Deficient Soil Oxygen Levels - Roots require oxygen for life processes, with the oxygen being obtained from within the soil. Fine textured soils with a high bulk density, compacted soils, or soil waterlogging due to excessive water applications or poor internal soil drainage can result in oxygen deficiencies which restrict root growth.

(6) Toxic Gases - Anerobic conditions caused by waterlogging can result in the production of organic gases which are toxic to the root system.

(7) Pesticide Toxicity - Certain pesticides, especially the pre-emergence herbicides, tend to injure the root systems of most turfgrass species. For this reason, it is important when using pre-emergence herbicides that the material is applied only as needed to correct a potentially serious problem and at rates no higher than needed to achieve control of the problem pest.

(8) Soil Salinity - Soils possessing a high salt content typically have a reduced root system as well as increased proneness to wilt and desiccation associated with the condition. The severity of root restriction increases as the salt level increases.

(9) Insects, Nematodes, and Diseases - A number of turfgrass pests feed specifically on the root system. When significant amounts of injury threaten, it is important that appropriate control steps be taken.

B. Cultural Factors:

(1) Mowing Height - The closer the mowing height, the shorter the resultant root system. The shoots are responsible for producing carbohydrates needed for root growth. The shorter the mowing height, the less the photosynthesis capability and thus, the shorter the root system.

(2) Excessive Nitrogen Level - Nitrogen stimulates shoot growth. Under close mowing and rapid shoot growth rates, there may not be a sufficient supply of carbohydrates available to support the minimum requirements for both shoot and root growth. Since the shoots have preference over the root system for the available carbohydrates, excessive nitrogen applications result in a reduced root system. This response is much more striking in the case of cool season grasses compared to certain warm season species such as bermudagrass.

(3) Nutrient Deficiency - A minimal nutritional level is required to support turfgrass growth, including the root dimension. Potassium has a particularly strong influence on root growth while positive responses can also be achieved with phosphorus and iron.

(4) Excessive Thatch Accumulation - Thatch, which elevates the crowns and nodes of lateral stems well above the soil surface, results in a root system that tends to grow predominantly in the thatch layer. This situation results in a substantially reduced zone from which water and nutrient uptake occurs.

This discussion of factors affecting root growth emphasizes the specific cultural practices that can be utilized to avoid development of these problems. Quite frequently, the most serious problems occur where a combination of these factors culminate in a serious negative effect on root growth.

SHOOT

The shoot consists of the central stem with leaves or lateral branches which are born alternately at successive nodes. The majority of the shoot system is located above ground, although rhizomes are shoots which are characterized by undergound growth.

A key portion of the shoot is the crown which includes the stem apex, the unelongated internodes, and the lower nodes from which adventitous roots are initiated. The crown is a key tissue responsible for the initiation of new leaves, lateral stems, and roots. Typically, the crown is located just above or in close proximity to the soil surface. The location of the crown above the soil level can dictate the mowing height of certain species. In addition, mower scalping which removes the stem apex from the crown can cause serious thinning or total loss of the turf.

Under stress conditions the turf can lose a majority of the shoot and root system and will recover so long as the crown is not damaged. Thus, when assessing the potential for recovery from stresses, it is important to inspect the crown for potential damage. For example, in the case of low temperature kill during the winter, dormant plants can be sampled, the leaf blades and outer sheaths removed, and a longutidinal cross-section cut through the crown by means of a razor blade. Then, the crown itself can be examined under a hand magnifying glass. If the crown is firm and appears white, this is a good sign that no damage has occurred. However, if the crown is soft with mushy extensive browning visually evident, these are signs that it is in an advanced state of decomposition from serious injury.

STEM

Stems function in translocation of water, nutrients, and carbohydrates as well as being a primary storage site for vital carbohydrate reserves. Equally important, the stem possesses meristematic sites, termed nodes, from which a new shoot and associated root system can be initiated. Thus, lateral stems such as rhizomes and stolons can serve as sites for recuperation from injury or stress dormancy in species possessing these structures.

Stem development can be intravaginal or extravaginal in nature. Intravaginal growth involves the erect growth of young, vegetative stems upward within the enveloping basal sheath. It produces a bunch type growth habit typical of tall fescue, colonial bentgrass, and the ryegrasses. Bunch type species generally have inferior recuperative potential and must be seeded at fairly high rates since the rate of lateral spread to fill in void areas is very slow (Table 1).

In contrast, extravaginal growth involves the outward growth of lateral stems by penetration through the basal leaf sheath. It produces a prostrate, or creeping growth habit. Extravaginal growth may be or a rhizomatous or stoloniferous type. A rhizome is a secondary lateral stem that arises extravaginally with underground stem elongation. An example of rhizomatous growth is Kentucky bluegrass. The rhizomes contribute to strong sod formation characteristics which are very desirable in sport fields. The presence of these dormant rhizomes and associated nodes within the protective soil zone allows these species to survive extended periods of heat, drought, and cold stress and permits the turf to recover once favorable environmental conditions for growth reoccur. A stolon is a secondary lateral shoot that arises extravaginally with aboveground horizontal stem growth. Examples of stoloniferous species include creeping bentgrass and St. Augustinegrass. Stoloniferous species do not form as strong a sod and are not as tolerant of environmental stresses as rhizomatous types.

There are also species such as bermudagrass and zoysiagrass that have an integradation of both rhizomes and stolons. Soil cultivation, such as coring, slicing, and spiking, can cause severing of these

Table 1. The comparative recuperative potential of 14 turfgrasses.

Recuperative Potential	Turfgrass	Growth Habit
Excellent	Bermudagrass	Rhizomes & stolons
	Zoysiagrass	Rhizomes & stolons
Good	St. Augustinegrass	Stolons
	Kentucky bluegrass	Rhizomes
	Creeping bentgrass	Stolons
Intermediate	Red fescue	Rhizomes
	Carpetgrass	Stolons
	Colonial bentgrass	Bunch-type
Poor	Centipedegrass	Stolons
	Meadow fescue	Semi-bunch-type*
	Bahiagrass	Semi-bunch-type*
	Tall fescue	Semi-bunch-type*
Very Poor	Perennial ryegrass	Bunch-type
	Timothy	Bunch-type

(From Turfgrass: Science and Culture by James B. Beard, Prentice-Hall, Inc., 1973. 658 pp.)

*Possesses short lateral stems, but functionally is essentially a bunch-type species.

lateral stems. This is significant in that, once severed, the node on each side of the severed stem initiates a new shoot and root system. Thus, a rejuvenation of young shoot growth can be stimulated by spiking during periods when normal new shoot and root production has been impaired.

TILLER

A tiller is a primary lateral shoot that arises intravaginally from the stem with limited elongation. Tillering is the primary process by which turfgrass density is achieved, whereas lateral stem growth by rhizomes or stolons functions in sod formation and rapid lateral extension of vegetative growth. Tillering is enhanced by moderately close mowing, higher nitrogen fertility levels, high light intensities, and high shoot carbohydrate levels.

LEAF

The leaf is the primary site for photosynthesis by means of chlorophyll. It is also the tissue through which gaseous exchange of oxygen and carbon dioxide occurs. In addition, this tissue is important from a turfgrass standpoint in terms of it giving the desired appearance which contributes to turfgrass quality and surface smoothness. The leaf itself can be divided into the upper leaf blade and the lower leaf sheath which envelopes the crown and stem apex. The important characteristics of leaf blades include basal growth, which allows close mowing, and maturation from the leaf tip downward. The rate of replacement of leaves is biologically adjusted so that the death rate in a given environment is about equal to the rate of new leaf appearance.

There are three cell arrangements occurring in a leaf which are especially important from a turfgrass standpoint. Fiber cells are located adjacent to the vascular bundle. Their highly schlerified tissues contribute to leaf stiffness and turfgrass wear. The ryegrasses have extensive fiber cell development. Silica cells contain a substantial silica content which results in an accelerated rate of mower dulling, but at the same time contributes to improved wear tolerance. The zoysiagrasses are known to have a high silica cell content. Finally, the bulliform cells occur in rows parallel and on each side of the midrib, or veins, on the leaf blade. These large, thin walled cells lose water very rapidly during internal plant water stress and, in turn, cause leaf rolling or folding, depending on the particular species involved. This response is a form of water conservation and drought resistance.

FLOWERING

In contrast to the previously discussed processes which are primarily growth oriented, flowering is a very striking developmental process which changes the total physiology and growth habit of the plant. Flowering is induced primarily by day length. Many turfgrass species are induced by the short, cool days of the fall. The actual initiation of flower formation typically occurs in the early part of the summer when temperatures and moisture conditions become favorable. The subsequent development of the flowers and seeds themselves is contingent on adequate amounts of carbohydrates and nutrients.

CARBOHYDRATE RESERVE

The growth and development of the tissues just discussed is dependent, during portions of the growing season, on the carbohydrate reserves found within the plant. Carbohydrate reserve consists of the carbohydrates that accumulate in more permanent organs of the plant in non-structural forms that are available for subsequent utilization in plant growth and development processes. The bulk of the carbohydrate reserves occur in the crowns and lateral stems. They consits primarily of starches, in the case of warm season turfgrasses, and as fructosans and short chain oligosaccharides in the case of cool season grasses. Carbohydrate reserves are reduced under conditions of optimum temperatures for shoot growth, shaded environments, close mowing, high nitrogen fertility levels that force shoot growth, and irrigation which enhances continuous shoot growth. The turfgrass manager should be sure that cultural conditions are maintained which allow adequate levels of carbohydrate reserves. This insures that the plant is in the proper physiological condition so that when injury from pests or environmental stress occurs, it has the capability to recover from that stress as rapidly as possible.

REFERENCE:

Beard, J. B. 1973. Turfgrass: Science and Culture. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. 658 pp.

WINTER INJURY CAUSES AND PREVENTION

by

James B. Beard*

[Most winter injury is the result of direct low temperature kill, winter desiccation, or low temperature diseases. All three major causes of winterkill can occur on either cool season or warm season turfgrass species. There are adjustments in specific cultural practices that can be made which will produce a turf having better physiological and morphological properties to survive the winter stresses.] Keep in mind though that even if all preventive steps are taken this will not guarantee freedom from some injury should extremely severe winter stresses occur.

Table 1. Chronology of cool season grass responses occurring as soil temperatures are lowered.

Soil Temperature (°F)	Plant Status
75 to 60	Optimum shoot growth
60 to 45	Shoot growth gradually declines
45 to 35	Plant hardening to low temperature stress
35 to 32	Conditional winter dormancy
<(25 to-15)*	Low temperature kill

*Specific lethal temperature varies with species.

Winter Dormancy. Shoot growth will gradually decrease as fall soil temperatures drop. This occurs on cool season grasses in the cool climatic zone and on warm season grasses in the northern two-thirds of the warm climatic zone. Eventually, shoot growth ceases and the turf enters winter dormancy.

Cool season turfgrasses usually remain green, while warm season turfgrasses lose chlorophyll and turn tan or brown below 50°F. Cool season turfgrasses may initiate shoot growth periodically during the winter if favorable temperatures occur. This is fairly common in the southern one-third of the cool humid zone. Usually, the turf survives the winter in a dormant state and initiates new shoots and roots from crowns, rhizomes, and stolons the following spring when temperature and moisture are favorable for growth.

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Low Temperature Kill. Low temperature kill involves the formation of large ice crystals in the plant that cause destruction of the delicate cellular organization. Plants containing a high water content are prone to larger, more extensive ice crystal formation and therefore a greater chance of low temperature injury. Those cultural practices which ensure that the grass plant enters the winter without an excessive internal water content are beneficial.

The northern adaptation limits of warm season turfgrasses are controlled by low temperature kill. The northern adaptation of ryegrasses and tall fescues in the cool humid zone is also restricted by low temperature kill. Injury is associated with ice formation within the tissue and it usually kills the plant. The turf will survive leaf and root kill. However, death of the crown and nodes on rhizomes and stolons will mean a total loss of the turf. Grass is most susceptible to low temperature kill during the late winter-early spring period.

A high water content in the tissue will increase the potential for low temperature kill. Thus, it is important to avoid areas of standing water. The best guard against kill is the use of a cold tolerant species. Cultural practices that minimize low temperature kill include (a) providing adequate surface and subsurface drainage; (b) avoiding excessive nitrogen, particularly during fall hardening; (c) ensuring high potassium levels through a fall K application; (d) avoiding excessive late fall irrigation; (e) controlling thatch; (f) raising the cutting height about one inch to provide increased insulation against low temperature extremes; and (g) cultivating to enhance soil water movement in compacted soils. Strategic placement of shrubs and/or fences to enhance snow accumulation will also protect the turf in those regions and winters when a significant snowfall occurs.

Winter Desiccation. The turfgrass will dry up during an extended winter drought. At temperatures above 32°F, the leaves are losing water to the atmosphere but the soil water is still frozen and unavailable. Even dormant, brown, warm season turfs are subject to winter desiccation. It usually occurs on elevated sites that are exposed to intense drying winds and in regions where there is little snow.

A certain degree of winter desiccation occurs on turfs every year. This results in a "wind burn" to the leaves that makes the turf brown. The brown leaves are mowed off as new growth is initiated in the spring. However, severe drought which dries out the crown and nodes of the grass plants can cause serious loss of turf.

You can prevent winter desiccation by watering the turf. Strategic placement of shrubs, trees, and fences which provide windbreaks and encourage snow accumulation also protect the turf. Cultural practices which minimize winter desiccation include (a) avoiding excessive fall nitrogen applications, (b) ensuring adequate potassium levels, and (c) controlling thatch. The use of mulches, brush, or synthetic winter protection cover could also help; especially on exposed sites that are subject to repeated winter desiccation.

Low Temperature Diseases. There are a number of diseases associated with the winter period that occur on dormant warm season grasses and semi-dormant cool season species. Perhaps the most widespread as the so-called "snow mold" diseases, although their occurrence does not necessarily require the presence of snow. *Typhula* blight (gray snow mold) occurs primarily in the northern third of the cool climatic zone while *Fusarium* patch (pink snow mold) occurs in a slightly more moderate intermeduate cold zone. A third less common winter disease of the cool region is known as winter crown rot. It is caused by a unidentified low temperature basidiomycete and has occurred most commonly in the plains regions of the Canadian provinces. The main winter problem on warm season species, especially bermudagrass, is spring dead spot. It appears to be a greater problem during dry winter conditions and especially where thatch problems have developed. No reliable chemical control has been found for spring dead spot.

Heaving. Repeated freezing and thawing, which pushes plants out of their normal position in the soil and exposes roots and crowns to desiccation, is called heaving. Seedlings planted in late fall often do not root well and are particularly susceptible to heaving. The best approaches to minimize heaving are mulching and enhancing snow accumulation. Established turfs are seldom damaged by heaving, but you may need to lightly roll the area in early spring to push the turf down into its normal position.

Ice Covers. Ice covers seldom cause injury to perennial cool season turfgrasses. Most of the damage is done when standing water surrounds the individual grass plants and then freezes. When this happens, the turf may winterkill. Unless the ice remains more than ninety days, you probably won't need to remove it. But, you should drain any excess water from the ice as it thaws.

Serious kill has occurred on wet, slushy turfs when subjected to heavy traffic followed by a freeze below 20°F. Do not allow traffic on a wet, slush covered turf.

The use of snowmobiles on turf areas creates no problem as long as there is a protective layer of snow beneath the the soil is frozen solid. Avoid snowmobile traffic on wet, slush covered turfs.

Ice Rinks on Turfs. You can make an ice rink on a turf is you use a few pracautions. First, the ice rink area should be contoured so that the turf will readily drain when thawing occurs. Standing water must be avoided. Second, there should be about two inches of compacted snow between turf and ice. Also, if snow mold disease is anticipated, you should apply a preventive fungicide before the first snow.

SUMMARY GUIDELINES FOR PROTECTING AGAINST WINTER INJURY

1. Provide good surface and subsurface drainage. The latter involving primarily drain tile, where needed.

2. Ensure that the turf and underlying soil root zone contains adequate but not excessive amounts of water when entering late fall and winter dormancy.

3. If a soil compaction problem has developed during the summer, correct by soil cultivation - coring, slicing, etc. - in early fall. This will also aid in drainage.

4. Raise the cutting height and/or stop mowing prior to shoot growth stoppage in order to allow an additional insulation and enhance both rooting and carbohydrate accumulation that aid in winter survival. However, do not allow too much leaf growth to accumulate to the extent that is increases the potential for snow mold disease problems.

5. Be sure that any excessive thatch is controlled prior to entering the winter period. This is particularly important in the case of disease and winter desiccation problems.

6. Be sure that the turf enters the fall hardening period with an adequate nutritional level; but avoid nitrogen fertilization during the cold hardening period when deep rooting, carbohydrate accumulation, and decreased water content need to be encouraged.

7. Ensure that adequate potassium levels are provided. A minimum ratio of nitroten-potassium of 2 to 1 in suggested.

8. Provide adequate proventive protection against winter disease by applying the appropriate fungicide.

9. Provide an appropriate winter protection cover where desiccation and/or low temperature kill are particularly severe problems and winter play does not occur. In some locations this may involve enhancing snow accumulation.

10. Do not allow traffic (foot, ski, or vehicular) on turfs during periods of warming thwn the snow cover is in a wet-slushy condition and a subsequent severe freeze is possible.

Table 2. Types and symptoms of winter injury that most commonly occur on turfs.

Type of Winter Injury	Symptoms
Atmospheric Desiccation	Leaves turn distinctly white but remain erect; occurs most commonly on higher locations that are more exposed to drying winds; can range from small, irregular patches to extensive kill of large areas
Direct Low Temperature Kill	Leaves initially appear water-soaked, turning whitish-brown and progressing to a dark brown; the leaves are limp and tend to lay as a mat over the soil; putrid odor is frequently evident; occurs most commonly in poorly drained areas such as soil depressions; frequently appear as large, irregular patches
Fusarium Patch (Pink Snow Mold)	Pink mycelium on leaves; 1 to 2 inch, tan, circular patches (in fall); or white mycelial mass on leaves, white to pink circular patches up to 2 feet in diameter (in winter/spring)
Typhula blight (Gray Snow Mold)	Light gray mycelium on leaves, especially at the margins of the advancing ring; whitish-gray, slimy circular patches of up to 2 feet in diameter; brown sclerotia are embedded in the leaves and crowns, ranging up to 1/8 inch in diameter.

Table 3. Practices available to minimize winter injury on turfs.

Types of Winter Injury	Cultural Practices That Minimize Injury		Specific Protectants
	Turfgrass	Soil	
Desiccation	Moderate nitrogen nutritional levels. Elimination of any thatch problem.	Do not core in late fall and leave the holes open.	Conwed Winter Protection Blanket® Polyethylene (4-6 mil) Saran Shade Cloth® (94%) Topdressing (0.4 yd^3/ 1,000 ft^2) Windbreaks such as snow, fence, brush, or ornamental tree and shrub plantings. Natural organic mulches
Direct Low Temperature Kill	Moderate nitrogen nutritional levels. High potassium nurtitional levels. Higher cutting heights. Elimination of any thatch problem. Avoidance of excessive irrigation.	Provide rapid drainage by proper contours, catch basins, and open ditches. Adequate subsurface drainage by drain lines, soil modification with coarse textured materials, slit trenches, and dry wells. Cultivation, especially coring and slicing, when compaction is a problem.	Conwed Winter Protection Cover® Soil Retention Mat® Enhancing snow cover with snow fence or brush. Natural organic mulches such as straw. Soil warming by electricity.
Fusarium Patch	Moderate nitrogen nutritional levels. High potassium and iron nutritional levels. Moderate to low cutting heights. Elimination of any thatch problem.	Avoiding neutral to alkaline soil pH's.	Benomyl (Tersan 1991®) Mancozeb (Fore®) Thiophanate methyl (Funge®, Spot Clean®) PMA Mercurous + Mercuric chloride

Table 3. (continued)

Types of Winter Injury	Cultural Practices That Minimize Injury		Specific Protectants
	Turfgrass	Soil	
Typhula Blight	Moderate nitrogen nutritional levels. Moderate to low cutting heights. Elimination of any thatch problem.	Provide good surface and subsurface drainage. Cultivate when compaction is a problem by coring or slicing.	Chloroneb (Tersan SP®) PMA PMA + thiram PCNB Mercurous + Mercuric chloride

1979 TURFGRASS WEED CONTROL UPDATE AT TEXAS A&M UNIVERSITY

by

S.M. Batten, J.B. Beard, and A. Almodares*

In 1979, turfgrass weed control research was primarily aimed at the control of annual and perennial grasses. A second year's study was completed for post-emergence control of dallisgrass and goosegrass in bermudagrass turf. Due to the importance of St. Augustinegrass in south Texas, it was necessary to initiate a preliminary investigation for the control of dallisgrass and crabgrass.

Annual bluegrass is a serious weed problem on dormant bermudagrass in late winter and early spring. For this reason, a study was initiated to control annual bluegrass during spring greenup of bermudagrass with post-emergence applications of herbicides.

A pre-emergence control study for goosegrass was initiated with the first part of a two-year herbicide screening program. In order to insure an adequate goosegrass population, a bermudagrass experimental site was tilled and seeded with weed seed. Evaluations were made for the assessment of weed control.

A brief summary of the post-emergence control of crabgrass and dallisgrass in bermudagrass and St. Augustinegrass; the post-emergence control of annual bluegrass in bermudagrass; and the pre-emergence control of goosegrass will be included in this report.

Pre-Emergence Goosegrass Control

The study was conducted at the Texas A&M University Turfgrass Field Laboratory in College Station, Texas in an established bermudagrass experimental site. The site was lightly disced and tilled to form an adequate seedbed prior to seeding the goosegrass (*Elusine indica*) at 2 lbs./1,000 ft^2. Due to the eratic germination of goosegrass in late spring, the seeding insured a good weed population for this study.

The herbicide treatments were benefin (Balan), bensulide (Betasan), DCPA (Dacthal), hoelon, oxadiazon (Ronstar), metrabuzin (Sencor), methazole (Probe), prosulfalin (EL 131), and trifluralin (Treflan). These treatments were applied in three replications via a hand-held CO_2 powered sprayer at a pressure of 30 psi.

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Results. All of the treatments, except DCPA and bensulide, controlled the goosegrass. Good germination was observed in the untreated experimental plots and was consistent among all three replications.

The oxadiazon, as shown in Table 1, rated the highest for goosegrass control. The prosulfalin and metrabuzin also rated high for weed control, but the metrabuzin differed in the amount of bermudagrass recovery between the flowable and wettable powder formulations.

The high amount of control obtained with all herbicides was affected by the direct soil contact of the prepared seedbed. A second year's research is planned for 1980.

Crabgrass Control in Bermudagrass and St. Augustinegrass

Bermudagrass: A post-emergence control study of crabgrass (*Digitaria sanguanalis*) was conducted on bermudagrass in July of 1979 at the TAMU Golf Course with the cooperation of Mr. Wallace Menn, Superintendent and TAMU Instructor. The objective was to evaluate the post-emergence control of crabgrass with applications of asulam (Asulox); MSMA, alone or in combination with metrabuzin (Sencor) or methazole (Probe); as well as metrabuzin and methazole alone at various rates.

The study was conducted on a mature bermudagrass golf course fairway with a mowing height less than 1 inch. The experimental design was a randomized block with three replications and 5 X 6 foot plots. The treatments were applied via a CO_2 powered hand-held sprayer. Visual ratings of the amount of control were made at two week intervals over an eight-week period.

Results. Very small differences were observed among the herbicide treatments for crabgrass control (Table 2). Asulam at 1.5 lbs. ai/acre, two applications two weeks apart, and 2.5 lbs. ai/acre, one application, rated the same for weed control. MSMA alone at 3.0 lbs. ai/acre or in combination with metrabuzin at 2.0 lbs. + 0.125 lb. ai/acre, one application, also rated high for crabgrass control.

The results indicate that MSMA at 3.0 lbs., one application, will control crabgrass without the addition of other herbicides. Very little difference between the 3.0 lbs., one application rate of MSMA and two applications at 2.0 lbs would give the turfgrass management professional a choice of the method of application.

St. Augustinegrass: In 1979, large infestations of crabgrass became a serious weed problem in St. Augustinegrass sod production. Early spring greenup and heavy rainfall accounted for these large infestations which prohibited sod harvest through the normal growing season. A post-emergence control study was conducted in August of 1979 in order to evaluate asulam and hoelon for selective, post-emergence control of crabgrass.

With the cooperation of Mr. Arthur Milberger, an experimental site of established St. Augustinegrass was selected at the Milberger

Table 1. Effects of nineteen herbicides on the pre-emergence control of goosegrass (*Elusine indica*).

TAMU - College Station, Texas - June, 1979

Herbicide	Formulation	Rate (lb. ai/A)	Mean Visual Rating[1]
Oxadiazon	2EC [2]	2.0	8.9 [3]
Oxadiazon	2G	2.0	8.5
Prosulfalin	50W	3.0	8.3
Oxadiazon	2G	3.0	8.2
Metrabuzin	50W	0.5	8.1
Metrabuzin	50W	0.75	8.0
Metrabuzin	4F	0.75	8.0
Prosulfalin	50W	4.0	7.8
Methazole	75W	1.0	7.8
Hoelon	2EC	1.0	7.7
Methazole	75W	2.0	7.6
Oxadiazon	2EC	3.0	7.5
Metrabuzin	4F	0.5	7.5
Trifluralin	5G	3.0	6.8
Benefin	2.5G	3.0	6.6
DCPA	75W	12.0	5.8
Bensulide	4EC	10.0	4.0
Bensulide	3.6G	10.0	3.8
Untreated	----	----	1.5

[1]Average of three replications 6 weeks after treatment.

[2]Formulation Key: EC = emulsifiable concentrate G = granular
F = flowable W = wettable powder

[3]Values joined by the same line are not significantly different at the 5% level for Duncan's multiple range test.

Table 2. Effects of fifteen herbicide treatments on the post-emergence control of crabgrass (*Digitaria sanguanalis*) in bermudagrass turf.

TAMU - College Station, Texas - August, 1979

Herbicide	Rate (lbs. ai/A)	Number of Applications	Average Ratings 4 weeks	Average Ratings 8 weeks	Average Visual Rating[1]
Asulam	1.5	2	8.7	9.0	8.8 [2]
MSMA	3.0	1	9.0	8.7	8.8
MSMA + metrabuzin (Sencor)	2.0 + 0.125	2	8.7	9.0	8.8
Asulam	2.5	1	8.5	9.0	8.8
MSMA + methazole (Probe)	2.0 + 0.5	2	8.3	9.0	8.8
Asulam	2.0	2	8.3	9.0	8.7
Asulam	1.5	1	8.3	9.0	8.7
MSMA	2.0	2	8.3	9.0	8.7
Asulam	2.0	1	8.2	9.0	8.6
Metrabuzin	1.0	2	8.3	8.0	8.2
Metrabuzin	1.0	1	7.7	6.3	7.0
Methazole	1.5	1	7.5	6.3	6.9
Methazole	1.5	2	4.8	3.3	4.0
Untreated	---	--	1.0	1.0	1.0

[1]Average rating of three replications; scored 1-9, 9=complete control; July 12 through September 12, 1979.

[2]Values joined by the same line are not significantly different at the 5% level for Duncan's multiple range test.

Turf Farms in Lane City, Texas. A site with a heavy, mature infestation of crabgrass was selected and large 8 X 10 foot plots were established in three replications. The herbicide treatments were applied with a CO_2 powered sprayer at a pressure of 30 psi.

The herbicide treatments included asulam at 1.5, 2.0, and 2.5 lbs. ai/acre, one and two applications, two weeks apart; and hoelon at 1.5 lbs. ai/acre alone or in combination with asulam at 1.0 + 0.75 lbs., one and two applications.

Results. The asulam at 2.0 lbs. and 1.5 lbs. ranked highest for crabgrass control (Table 3). Asulam at 1.0 lb. + hoelon at 0.75 lb. also rated high for weed control, although the amount of control decreased between four and eight weeks similar to 1.5 lbs., two applications of asulam. At this time, two applications of asulam at 2.0 lbs. gives the best control of crabgrass in St. Augustinegrass.

Dallisgrass Control

Bermudagrass: The second of a two-year study on dallisgrass was conducted by Texas A&M University during July of 1979 at the TAMU Golf Course. A heavy infestation of mature dallisgrass in bermudagrass behind a golf course green allowed for good evaluations of post-emergence control of herbicides.

The experimental design was a randomized block with three replications with herbicide treatments sprayed on 4 X 6 foot plots. The herbicides evaluated included MSMA, alone and in combination with metrabuzin or methazole; asulam at one and two applications; and metrabuzin and methazole alone (Table 4).

Results. The MSMA combination with methazole at 2.0 + 0.5 lb. ai/acre ranked highest for dallisgrass control. MSMA alone at 3.0 lbs. in one application, or at 2.0 lbs. in two applications two weeks apart, also gave adequate dallisgrass control. The asulam at two applications temporarily yellowed the bermudagrass. The MSMA plus metrabuzin treatments gave some dallisgrass control, while metrabuzin and methazole alone gave very little control.

These results are similar to the 1978 data for post-emergence control of dallisgrass in which MSMA, alone and in combination with methazole, ranked highest for weed control.

St. Augustinegrass: Selective control of dallisgrass in St. Augustinegrass is limited to only one herbicide that is not phytotoxic to the St. Augustinegrass. Therefore, asulam was selected for a preliminary investigation evaluating various rates at both one and two applications, two weeks apart.

The rates of asulam selected were 1.5, 2.0, and 2.5 lbs. ai/acre, which were applied August 16 and September 1, 1979. Evaluations were made at four and eight weeks by visual ratings of 1-9; 9=complete

Table 3. The effects of ten herbicide treatments for the control of crabgrass (*Digitaria* spp.) in St. Augustinegrass.

Lane City, Texas - August, 1979

Herbicide	Rate (lbs. ai/A)	Number of Applications	Average Ratings 4 weeks	Average Ratings 8 weeks	Average Visual Rating[1]
Asulam	2.0	2	8.5	8.8	8.6 [2]
Asulam	1.5	2	8.7	7.6	8.1
Asulam + Hoelon	1.0 + 0.75	2	8.2	7.3	7.8
Asulam	2.5	2	8.0	7.0	7.5
Asulam	2.5	1	6.7	6.3	6.5
Asulam	1.5	1	5.4	5.3	5.3
Asulam	2.0	1	3.9	5.4	4.7
Asulam + Hoelon	1.0 + 0.75	1	2.8	1.0	1.9
Hoelon	1.5	1	1.0	1.3	1.2
Untreated	---	--	1.0	1.0	1.0

[1]Average means of three replications; scored 1-9, 9=complete control; August 16 through October 12, 1979.

[2]Values joined by the same line are not significantly different at the 5% level for Duncan's multiple range test.

Table 4. The effects of fifteen herbicide treatments for the control of dallisgrass (*Paspalum dilatatum*) in bermudagrass turf.

TAMU - College Station, Texas - July, 1979

Herbicide	Rate (lbs. ai/A)	Number of Applications	Average Ratings 4 weeks	Average Ratings 8 weeks	Average Visual Rating[1]
MSMA + methazole	2.0 + 0.5	2	8.2	9.0	8.6 [2]
MSMA	3.0	1	8.6	6.5	7.6
MSMA	2.0	2	7.0	7.7	7.3
MSMA + metrabuzin	2.0 + 0.125	2	6.7	7.2	6.9
MSMA + metrabuzin	2.0 + 0.125	1	6.5	5.7	6.0
Asulam	2.0	2	5.3	6.0	5.7
Asulam	1.65	2	5.3	5.9	5.6
Asulam	2.5	1	5.8	5.1	5.5
Asulam	1.65	1	7.8	4.0	4.8
Asulam	2.0	1	5.3	3.7	4.5
Methazole	1.5	2	1.7	1.0	1.3
Metrabuzin	1.0	1	1.0	1.3	1.2
Methazole	1.5	1	1.0	1.3	1.2
Metrabuzin	1.0	2	1.0	1.3	1.2
Untreated	---	--	1.0	1.0	1.0

[1]Visual rating average for three replications; scored 1-9, 9=complete control; July 12 through September 12, 1979.

[2]Values joined by the same line are not significantly different at the 5% level for Duncan's multiple range test.

control and 1=no control.

Results. The higher the application rate of asulam, the higher the amount of control (Table 5). The 2.5 lbs. ai/acre in two applications rate ranked highest for overall control, as well as the four and eight week scoring intervals. Two applications of asulam at 2.0 and 1.5 lbs. also gave adequate control of dallisgrass. The one application rate of 1.5 lbs. gave very little control and regrowth of the dallisgrass was observed. Because dallisgrass is a tough perennial, further investigation concerning the timing of the two application control method will be conducted during the 1980 herbicide research program.

Annual Bluegrass Control

Annual bluegrass (*Poa annua*) is a serious winter weed problem on bermudagrass in Texas, primarily because of the warm germinating soil temperatures and favorable winter weather conditions. Post-emergence control presently is used on dormant bermudagrass.

The timing of herbicide applications for this study was during the initial spring greenup of bermudagrass on a golf course fairway at Texas A&M University. Low application rates of glyphosate, as well as various rates of pronamide, metrabuzin, and paraquat, were evaluated for annual bluegrass control.

Results. Both glyphosate and metrabuzin ranked high for annual bluegrass control (Table 6). The difference was the phytotoxocity. The metrabuzin yellowed the existing green bermudagrass while the glyphosate showed no phytotoxocity to the bermudagrass four weeks after initial application on March 6, 1979. At the time of application, 10% of the bermudagrass had begun spring greenup. Paraquat controlled the annual bluegrass, but was too phytotoxic to the bermudagrass. Pronamide at both rates of 1.0 and 2.0 lbs. ai/acre ranked low for weed control. Glyphosate at 1.0 lb. ai/acre at this time is the most promising herbicide and rate for annual bluegrass control in bermudagrass.

Table 5. Effects of seven asulam treatments for control of dallisgrass (*Paspalum dilatatum*) in St. Augustinegrass turf.

Lane City, Texas - August, 1979

Herbicide	Rate (lbs. ai/A)	Number of Applications	Average Ratings 4 weeks	Average Ratings 8 weeks	Average Visual Rating[1]
Asulam	2.5	2	7.9	9.0	8.5 [2]
Asulam	2.0	2	6.7	8.8	7.8
Asulam	1.5	2	6.5	8.4	7.5
Asulam	2.5	1	6.9	7.3	7.1
Asulam	2.0	1	6.5	6.2	6.3
Asulam	1.5	1	6.5	3.3	4.9
Untreated	---	--	1.0	1.0	1.0

[1]Average of three replications; scored 1-9, 9=complete control; August 16 through October 12, 1979.

[2]Values joined by the same line are not significantly different at the 5% level for Duncan's multiple range test.

Table 6. Effects of eleven herbicide treatments on the post-emergence control of annual bluegrass (*Poa annua*) in bermudagrass.

Herbicide	Rate (lbs. ai/A)	Mean Visual Rating[1]
Glyphosate	1.0	8.7 [2]
Metrabuzin	1.0	8.3
Paraquat	1.0	7.5
Paraquat	0.5	7.2
Glyphosate	0.75	6.8
Metrabuzin	0.75	6.8
Metrabuzin	0.5	6.7
Pronamide	2.0	5.5
Glyphosate	0.5	5.0
Pronamide	1.0	4.0
Check	---	1.0

[1]Average of three replications 4 weeks after treatment; scored 1-9, 9=complete control.

[2]Values joined by the same line are not significantly different at the 5% level for Duncan's multiple range test.

MINIMUM TEMPERATURE REQUIREMENTS FOR SEED GERMINATION OF TURFGRASSES

by

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One of the basic principles of turfgrass establishment from seed is to plant when soil temperatures are optimum. However, conditions not under the control of the professional turfman or landscaper may dictate the need for vegatative soil stabilization at unfavorably low temperatures. An example is residential and building construction where the project is completed during the winter period when planting of bermudagrass or St. Augustinegrass cannot be accomplished. In this situation a temporary grass needs to be planted to stabilize the area from soil erosion and to minimize mud and dust problems. The question then arises as to what grass can be utilized which germinates at low temperatures. Similar situations also arise in relation to winter overseeding of cool season grasses into dormant warm season species.

The production of a dense turf from seed has two distinct phases. One is seed germination which involves the imbibition of water into the seed followed by physiological changes which lead to the primary root and shoot initial breaking through the seed coat. At this point the seed is considered to have germinated. The next step is termed emergence. This is the point at which the initial primary leaf emerges or appears above the soil surface. Finally, there is the phase of seedling establishment. This involves successful rooting and growth of mature shoots and lateral stems, such as rhizomes and stolons, to the point where a dense, tight, strong sod has been formed. Each of these phases has a distinct and sometimes different temperature requirement.

OPTIMUM GERMINATION TEMPERATURES

The seed of each individual turfgrass species has an optimum temperature for germination. These optimums, as established by the American Association of Seed Analysts, are shown in Table 1. Under field conditions, this optimum temperature is site specific to the zone at and just below the soil surface where the seed has been placed during planting. Temperatures which are increasingly above or below the optimum cause associated delays in seed germination. The Association of Official Seed Analyst Procedures specify that all seed germination tests, as reported on the label, be based on a set of standard optimum conditions. It should be recognized that seed germination will vary with age, source, cultivar, seed lot, and duration of the germination period. It should also be noted that the optimum seed germination temperature is not a specific temperature level, but rather is associated with a rythmic, diurnal variation.

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Table 1.

THE OPTIMUM TEMPERATURES FOR SEED GERMINATION OF NINETEEN TURFGRASSES ESTABLISHED BY THE ASSOCIATION OF SEED ANALYSTS

Turfgrass Species	Optimum Temperatures for Seed Germination*	Prechilling of New Seed Suggested, 38-50°F
Bahiagrass	86 - 95	
Bentgrass:		
colonial	59 - 86	x
creeping	59 - 86	x
Bermudagrass	68 - 95	
Bluegrass:		
annual	68 - 86	
Kentucky	59 - 86	x
rough	68 - 86	x
Buffalograss	68 - 95	x
Carpetgrass	68 - 95	
Fescue:		
chewings	69 - 77	x
meadow	68 - 86	
red	59 - 77	x
sheep	59 - 77	
tall	68 - 86	x
Redtop	68 - 86	
Ryegrass:		
Italian	68 - 86	x
perennial	68 - 86	x
Wheatgrass:		
western	59 - 86	
Zoysiagrass	95 - 68	

*Temperatures separated by a dash indicate an alternation of temperature; the first numeral is for approximately 16 hours and the second for approximately 8 hours.

(From Turfgrass: Science and Culture by James B. Beard, Prentice-Hall, Inc. (1973) 658 pp.)

Table 2. Minimum temperature requirements for seed germination of 11 perennial and 4 annual grasses.

TAMU - College Station, Texas - March, 1979

Species	Cultivar	Base Temperature[1] (°F)	Days to 50% Germination[2] (Days at °F)
Cereal rye	Bonel	43	10 - 43°
Winter wheat	Sturdy	46	12 - 43°
Italian ryegrass	Common	43	14 - 43°
Winter oats	Coker 234	43	14 - 43°
Perennial ryegrass	Linn	43	13 - 46°
Perennial ryegrass	Derby	43	14 - 46°
Perennial ryegrass	Birdie	43	14 - 46°
Perennial ryegrass	Loretta	43	14 - 48°
Chewings fescue	Jamestown	43	14 - 48°
Perennial ryegrass	Citation	45	13 - 48°
Perennial ryegrass	Regal	45	14 - 48°
Perennial ryegrass	Manhattan	45	11 - 51°
Rough bluegrass	Sabre	43	13 - 51°
Creeping bentgrass	Seaside	51	14 - 56°
Tall fescue	Kentucky 31	55	10 - 60°

[1]The constant temperature below which 50% germination will not occur.

[2]Days to achieve 50% germination at the indicated temperature (°F).

MINIMUM GERMINATION TEMPERATURES

The minimum temperatures for turfgrass seed germination are very poorly defined. Due to the numerous questions being raised on this subject, it was obvious that some specific investigations needed to be conducted. This work has in fact been initiated at Texas A&M University using a specially constructed thermal gradient plate apparatus which maintains specifically controlled temperatures across the plate ranging from a low of 42°F to a high of 76°F. The plate itself accomodates a series of 3.6 cm petri dishes with 30 seeds placed in each dish on top of moist filter paper.

Five perennial grasses were included in this study: chewings fescue, creeping bentgrass, perennial ryegrass, rough bluegrass, and tall fescue. Seven cultivars of perennial ryegrass were also evaluated. The annual grass species included cereal rye, Italian ryegrass, winter oats, and winter wheat. Germination counts were made on all 324 seed lots of 30 seeds each at exactly the same time of day. A seed was considered to have germinated when the first root penetrated the seed coat and had visibly extended outward.

Results to date indicate that the four annual grasses are capable of germinating at slightly lower temperatures than the perennial ryegrasses. Bonel cereal rye exhibited the best capability to germinate at low temperatures followed by winter wheat, Italian ryegrass, and winter oats (Table 2).

A second mid-grouping included the seven perennial ryegrass cultivars plus Jamestown chewings fescue. Within the perennial ryegrasses, the ranking from best to slowest in speed of germination was Linn, Derby, Birdie, Loretta, Citation, Regal, and Manhatten. Linn was definitely the fastest followed by Derby and Birdie. There were essentially no differences among Loretta, Citation, and Regal, with Manhattan having the highest minimum base temperature of the seven perennial ryegrasses evaluated.

The group possessing the slowest low temperature seed germination consisted of rough bluegrass, creeping bentgrass, and tall fescue. Sabre rough bluegrass had a minimum temperature requirement for seed germination which was somewhat comparable to Manhattan perennial ryegrass. The two having a decidedly higher minimum temperature requirement for germination were Seaside creeping bentgrass and Kentucky 31 tall fescue.

In terms of specific data, Bonel cereal rye required 10 days at 43°F to achieve 50% seed germination; Linn perennial ryegrass 13 days at 46°F; Seaside creeping bentgrass 14 days at 56°F; and Kentucky 31 tall fescue 10 days at 60°F. This is a substantial 17°F temperature differential.

Although a 1 to $2^{o}F$ difference may not appear significant at first, it may be very important during the late fall-early winter period of declining soil temperatures. Note that it is the soil temperature that is the critical controlling factor rather than the air temperature. Observations during winter overseeding studies have revealed that a temperature difference as small as a few degrees can delay the rate of establishment by as much as 10 to 25 days.

These initial results provide some guidelines concerning the appropriate grasses to select for planting when temperature conditions are relatively unfavorable. It should be recognized that seed germination is only one phase of grass establishment. The seedling vigor, including root and shoot growth plus tillering, are of equal significance. Thus, additional studies are needed concerning seedling growth in addition to minimum temperatures for seed germination. This research is continuing.

As a result of these studies a considerable amount of cereal rye has been planted, particularly in North Texas. Results to date have been satisfactory although these plantings have not yet gone through the full winter and spring transition periods. This article is presented as a research update to keep the readership fully informed as to the latest information relating to turfgrass establishment and culture.

HIGHLIGHTS OF THE 1978-79 WINTER OVERSEEDING EVALUATIONS AT TEXAS A&M UNIVERSITY

by

S. M. Batten, J. B. Beard, A. Almodares,
G. Pittman and D. E. Chaffin*

These studies are part of a four-year investigation of cool season turfgrasses for use in winter overseeding on dormant bermudagrass turf. Locations included in the 1978-79 study were (1) the TAMU Turfgrass Field Laboratory, College Station, Texas; (2) Oak Hills Country Club, San Antonio, Texas; and (3) Corpus Christi Country Club, Corpus Christi, Texas. In this report only the College Station overseeding data ~~will~~ is ~~be~~ presented for winter performance evaluations. The winter performance data for all other locations is similar and will be included in a separate TAES Progress Report.

RESEARCH PROCEDURE

The winter overseeding study at the TAMU Turfgrass Field Laboratory included seventy-five cool season turfgrass entries in a randomized block experimental design of three replications. Two replications were planted on a dormant 'Tifgreen' bermudagrass green turf, and the third on 'Tifdwarf' bermudagrass.

Two weeks prior to planting, the surface was vertically mowed in five directions and the clippings removed by means of a mechanically powered vacuum. The treatments were seeded on October 27, 1978, with a Scotts 2-foot drop spreader and mechanically topdressed with 1/8 inch of sand. Mowing was ceased until November 6, 1978, at which time the mowing height was set at 5/16 inch. The mowing height was lowered to 1/4 inch three weeks after seeding and was maintained at this height throughout the remainder of the experiment. The experiment was irrigated as needed, with an automatic hydraulic irrigation system, and nitrogen fertilizer was applied at 1 lb. of N/1,000 ft^2/ month. An application of Koban was made two weeks after seeding for seedling protection.

The evaluations were based on turfgrass quality, two components of which were uniformity and density. The individual plots were visually estimated from 0-9 (9 being the best quality) on a fifteen day interval. The experiment was continued until June of 1979, at which time the transition from cool to warm season turfgrass was complete. Only the winter performance data from December through March will be presented in this report.

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SEASONAL PERFORMANCE STUDIES

College Station

The unusually warm fall weather allowed for a longer bermudagrass growing season, and caused more competition between the bermudagrass and the overseeded cool season turfgrasses. A sudden freeze in early December, followed by extremely cold temperatures throughout the rest of the winter, resulted in poorer overall performance of the overseeded monostands, especially the ryegrasses.

Among the 34 perennial ryegrasses, Barry, Hunter, Loretta, and Citation (Table 12) showed consistent performance through January and February, while all others decreased in overall performance. The highest ranking perennial ryegrasses were Barry, Hunter, Loretta, Yorktown, and Yorktown II, as shown in Table 12. Early establishment in December helped the total winter performance of Barry and Hunter. Most of the perennial ryegrasses showed some recovery in March.

The performance of 19 polystands tended to be higher than that of the individual ryegrass cultivars, as indicated by the average visual quality ratings in Table 13. The four highest ranking polystands: Dixiegreen + Sabre, Marvelgreen Supreme + Sabre, Medalist 300, and Winterturf I, unlike the ryegrasses, increased in turf quality throughout the winter. The polystands containing Sabre rough bluegrass ranked highest for overall winter performance.

The low temperature growth potential of the other bluegrasses was evident by the winter performance of the non-ryegrass cultivars shown in Table 14. The rough bluegrasses, Sabre, INO, and Denmark, as well as the Kentucky bluegrass, Kimono, were the four highest ranking cultivars of the 22 non-ryegrasses.

The fescues as a group were unacceptable for winter overseeding under wet winter conditions. Banner, a chewings fescue, ranked the highest for turf quality as shown in Table 14. The fescues showed very little improvement in performance during March.

Four bentgrasses were evaluated for winter performance and, as in previous years, all were unacceptable for winter overseeding. The bentgrasses were Seaside, Penncross, Emerald, and Kromi, with Seaside being the highest in performance.

TABLE 12 WINTER PERFORMANCE OF 34 PERENNIAL RYEGRASS CULTIVARS OVERSEEDED[1] ONTO DORMANT BERMUDAGRASS

TAMU - College Station, Texas - 1978-79

Perennial Ryegrass Cultivar	Winter Performance Ratings				Average for Winter[2] (9 ratings)
	Dec.	Jan.	Feb.	Mar.	
Barry	6.2	5.8	5.8	7.3	6.3[3]
Hunter	5.5	5.3	5.7	5.8	5.6
Loretta	5.4	5.3	5.0	5.5	5.5
Yorktown	4.6	4.4	4.2	5.7	4.7
Yorktown II	5.2	4.8	3.8	4.8	4.7
Citation	4.2	4.1	4.3	5.5	4.5
Goalie	4.7	4.0	3.8	5.5	4.5
Acclaim	4.6	4.5	3.8	5.5	4.5
Birdie	4.7	4.3	4.0	4.7	4.4
Caravelle	4.4	4.3	3.8	5.0	4.4
Elka	5.3	4.1	3.5	4.3	4.3
Regal	4.7	4.3	3.8	4.3	4.3
Omega	4.7	4.2	4.2	4.0	4.3
Manhattan	4.6	4.0	3.8	4.0	4.1
Veni	4.7	4.8	4.6	2.3	4.1
Arno	4.4	3.8	3.5	4.5	4.1
MP-1	3.9	3.5	4.0	4.8	4.1
Blazer	4.8	3.8	3.3	3.9	4.0
Majestic	3.8	3.3	3.7	4.0	3.7
Derby	4.3	3.0	2.5	4.0	3.4
Pennfine	4.0	3.4	3.0	3.0	3.4
Fiesta	3.7	3.0	3.0	3.7	3.3
Diplomat	4.6	3.1	2.3	3.2	3.3
NK-200	4.3	2.8	2.7	2.3	3.0
Jennifer	3.9	2.6	2.3	2.5	2.8
Rudo	4.6	2.3	2.0	1.8	2.7
Venloma	3.1	3.7	1.3	2.0	2.6
Linn	3.4	2.7	1.0	2.2	2.3
Pelo	3.9	1.7	1.2	1.8	2.2
Oregreen	3.1	1.7	1.5	2.0	2.1
NK-100	3.1	1.8	1.3	1.8	2.0
Selection 773	2.7	2.5	1.0	1.8	2.0
Pleno	3.0	1.8	1.2	1.7	1.9
Game	2.7	2.0	1.0	1.8	1.9

[1]All perennial ryegrass cultivars were seeded at 40 lbs./1,000 ft^2.
[2]Visual ratings of 9=best and 0=poorest; December 1, 1978 to March 31, 1979.
[3]Values joined by the same line are not significantly different at the 5% level for Duncan's multiple range test.

TABLE 13 WINTER PERFORMANCE OF 19 POLYSTANDS OVERSEEDED ONTO DORMANT BERMUDAGRASS

TAMU - College Station, Texas - 1978-79

Polystand	Seeding Rate[1]	Winter Performance Ratings				Average for Winter[2] (9 ratings)
		Dec.	Jan.	Feb.	Mar.	
Dixiegreen + Sabre	35	5.7	7.0	7.7	7.9	7.1[3]
Marvelgreen Supreme+Sabre	40	5.5	6.2	8.2	7.4	6.8
Medalist 300	29	4.6	5.8	6.3	7.2	6.0
Winterturf I	40	5.2	5.5	6.2	6.7	5.9
Medalist 6	40	5.1	4.3	4.7	5.4	4.9
Futura Blend	40	4.6	4.4	4.4	5.8	4.7
Birdie+Banner	40	3.7	4.4	5.0	5.3	4.6
CBS Blend	40	4.5	4.1	3.8	5.7	4.5
Marvelgreen Supreme	40	4.9	4.4	3.7	4.7	4.5
Blend 803	40	4.2	4.2	4.0	5.3	4.4
Winterturf II	40	4.0	4.4	4.0	5.1	4.4
Medalist 400	38	5.6	4.7	4.4	4.5	4.4
Marvelgreen 3+1	40	4.3	3.9	3.7	5.4	4.3
Citation+Syn W	40	4.7	3.9	4.2	4.3	4.3
Medalist 5	40	4.0	3.4	3.3	5.8	4.1
Medalist 200	32	4.3	3.8	3.8	4.5	4.1
Dixiegreen	40	4.9	4.1	2.8	4.0	3.9
Marvelgreen Economy	40	3.9	3.8	2.7	4.8	3.8
Waldorf+733	40	2.7	1.6	1.1	2.3	1.9

[1]Seeding rates listed are in lbs./1,000 ft^2.

[2]Visual rating of 9=best and 0=poorest; December 1, 1978 to March 31, 1979.

[3]Values joined by the same line are not significantly different at the 5% level for Duncan's multiple range test.

TABLE 14. WINTER PERFORMANCE OF 22 NON-RYEGRASS CULTIVARS OVERSEEDED ONTO DORMANT BERMUDAGRASS

TAMU - College Station, Texas - 1978-79

Cultivar and Species		Seeding Rate[1]	Winter Performance Ratings				Average for Winter[2] (9 ratings)
			Dec.	Jan.	Feb.	Mar.	
Sabre	rb	12	3.7	6.7	7.7	7.8	6.5[3]
INO	rb	12	4.2	5.4	7.8	7.3	6.2
Kimono	Kb	12	3.0	5.0	6.1	5.4	4.9
Denmark (Common)	rb	12	1.7	4.7	5.3	6.7	4.6
Banner	cf	30	3.8	3.9	4.8	4.4	4.3
Satan	cf	30	4.3	3.3	4.2	3.7	3.8
Bonnieblue	Kb	12	2.6	3.7	4.2	3.8	3.6
Scarlet	rf	30	4.3	2.7	3.0	3.6	3.4
Seaside	cb	3	2.4	3.3	3.9	3.7	3.3
Windsor	Kb	12	1.3	3.3	4.2	3.8	2.9
Dawson	rf	30	3.0	2.7	2.0	3.7	2.8
Penncross	cb	3	1.9	2.0	2.3	2.7	2.2
Atlanta	cf	30	2.8	2.0	2.3	1.7	2.2
Pollux	rf	30	2.4	2.5	1.7	1.9	2.1
Emerald	cb	3	2.8	1.8	2.3	1.8	2.1
Pennlawn	rf	30	2.8	1.8	1.7	1.8	2.0
Wintergreen	cf	30	2.9	1.7	1.8	1.5	2.0
Kromi	cb	3	1.6	2.3	2.0	1.5	1.9
Scalis	hf	30	2.5	2.0	1.3	1.5	1.8
Puma	rf	30	3.2	1.7	1.3	1.2	1.8
Waldina	hf	30	1.6	1.0	1.5	2.3	1.5
Silvania	hf	30	2.0	1.4	1.0	1.0	1.4

LEGEND:
cb - creeping bentgrass
cf - chewings fescue
hf - hard fescue
Kb - Kentucky bluegrass
rb - rough bluegrass
rf - red fescue

[1]Seeding rates listed are in lbs./1,000 ft^2.

[2]Visual rating of 9=best and 0=poorest; December 1, 1978 to March 31, 1979.

[3]Values joined by the same line are not significantly different at the 5% level for Duncan's multiple range test.

SEASONAL PERFORMANCE STUDIES AND ANNUAL BLUEGRASS CONTAMINATION

San Antonio

Results of the winter performance studies at San Antonio were similar to College Station, with polystands ranking higher than monostands. The 38 entries included 20 perennial ryegrasses, 9 non-ryegrasses, and 9 polystands. The lower turf quality in March was a reflection of the annual bluegrass contamination. This was especially true with the perennial ryegrasses listed in Table 15. The higher the percent annual bluegrass, as a result of poor turf density, caused decreased turf quality. The better performing perennial ryegrasses provided enough competition to prevent the invasion of annual bluegrass.

The rough bluegrass cultivars had the ability to disguise the annual bluegrass during early winter due to their normally yellow-green color. After emergence of annual bluegrass seedheads in March, Sabre, with the highest density, had the least amount of annual bluegrass weed contamination (Table 16).

The weed invasion of the polystands was also density related, with the combination of Dixiegreen + Sabre having the lowest percent annual bluegrass (Table 16).

SEASONAL PERFORMANCE STUDIES AND NITROGEN FERTILITY RESPONSES

Corpus Christi

As with the other winter overseeding locations, the winter performance trials at Corpus Christi resulted in the polystands ranking higher than the monostands. The average visual ratings were higher than those at the other locations due to a milder climate.

The study was established with 19 cool season turfgrasses, which included 10 monostands and 9 mixture-blends or polystands. Across each cultivar plot, three different levels of nitrogen fertility were applied. These levels were 0.5, 1.0, and 1.5 lbs. of N/1,000 ft^2 applied in January, 1979. These nitrogen levels were visually rated for turfgrass quality during the first week of February.

The 6 perennial ryegrass cultivars all rated higher at 1.0 lb of N fertilizer than at 1.5 lbs. of N. The difference in visual ratings was even greater between the 1.0 lb. and the 0.5 lb., with the 1.0 lb. being higher (Table 17).

The rough bluegrass, Sabre, rated nearly the same for both 0.5 and 1.0 lb. of N, with lower visual ratings for the 1.5 lbs.fertility level. Of the monostands, the poor winter performance of the bentgrasses and the red fescue were improved little by the addition of higher rates of nitrogen fertilizer (Table 17).

TABLE 15. PERCENT ANNUAL BLUEGRASS (*Pca annua*) IN 20 PERENNIAL RYEGRASS CULTIVARS WHICH HAD BEEN OVERSEEDED ONTO DORMANT BERMUDAGRASS

San Antonio, Texas - 1978-79

Perennial Ryegrass Cultivar	Percent Annual Bluegrass[1]
Barry	15.0 [2]
Loretta	22.5
Acclaim	38.8
Yorktown	40.0
Goalie	40.8
Fiesta	41.7
Birdie	42.5
Diplomat	45.0
Citation	47.5
Pennfine	49.2
Derby	53.8
NK-200	54.2
Manhattan	54.2
Regal	56.7
Omega	60.5
Game	78.7
Oregreen	79.2
NK-100	81.2
Pelo	87.0
Linn	91.5

[1]Average of three replications; data collected in March, 1979.

[2]Values joined by the same line are not significantly different at the 5% level for Duncan's multiple range test.

TABLE 16. PERCENT ANNUAL BLUEGRASS (*Poa annua*) IN 10 NON-RYEGRASS CULTIVARS AND 9 POLYSTANDS WHICH HAD BEEN OVERSEEDED ONTO DORMANT BERMUDAGRASS

San Antonio, Texas - 1978-79

Non-Ryegrass Cultivar	Species	Percent Annual Bluegrass[1]	Polystand	Percent Annual Bluegrass
Sabre	rb	15.8 [2]	Dixiegreen + Sabre	22.5 [2]
INO	rb	26.7	CBS Blend	30.0
Denmark	rb	31.2	Medalist 300	38.3
Banner	cf	80.0	Winterturf I	42.5
Seaside	cb	82.5	Citation + Syn W	47.5
Kimono	Kb	87.5	Birdie + Banner	51.2
Emerald	cb	91.5	Dixiegreen	52.5
Atlanta	cf	92.3	Futura	58.3
Scalis	hf	94.8	Medalist 400	67.5
Pennlawn	rf	97.2		

Species Key:
cb - creeping bentgrass
cf - chewings fescue
hf - hard fescue
Kb - Kentucky bluegrass
rb - rough bluegrass
rf - red fescue

[1]Average of three replications, data collected in March of 1979.

[2]Values followed by the same line within a column are not significantly different at the 5% level for Duncan's multiple range test.

TABLE 17. THE EFFECTS OF THREE NITROGEN FERTILITY LEVELS ON THE TURFGRASS QUALITY OF 10 MONOSTANDS OVERSEEDED ONTO DORMANT BERMUDAGRASS

Corpus Christi, Texas - 1978-79

Cultivar	Species	Visual Turfgrass Quality Ratings[1] for Three Fertility Levels[2]			Average[3]
		0.5	1.0	1.5	
Pennfine	pr	6.8	8.7	8.2	7.8
Loretta	pr	6.7	8.3	8.0	7.7
Manhattan	pr	6.8	8.2	8.0	7.7
Citation	pr	6.8	7.8	7.8	7.5
Derby	pr	6.0	7.3	7.2	6.8
Sabre	rb	6.8	6.7	6.3	6.6
Linn	pr	4.5	5.7	5.5	5.2
Penncross	cb	2.2	2.7	2.8	2.6
Dawson	rf	2.2	2.5	2.7	2.5
Seaside	cb	2.0	2.3	2.3	2.2

Species Key: cb - creeping bentgrass; rb - rough bluegrass; pr - perennial ryegrass; rf - red fescue

[1]Average visual quality rating for three replications; scored 1-9, 9=best quality; data collected in February, 1979.

[2]Pounds per 1,000 square feet.

[3]Values joined by the same line are not significantly different at the 5% level for Duncan's multiple range test.

The polystands had higher ratings with higher rates of nitrogen fertilizer. At 1.0 lb. of N/1,000 ft^2 , Winterturf I rated the highest, and at 1.5 lbs. N, CBS again had the highest visual rating (Table 18). Medalist 300 and Winterturf I, which rated as two of the highest for 1.0 lb. of N, both declined in visual ratings at 1.5 lbs. of N.

SUMMARY

In the winter performance studies at College Station, Texas the polystands consistently had higher visual ratings than the monostands. The additional cost of the polystands or mixture-blends could be justified by the insurance of stable winter performance during a colder than normal winter. Of the perennial ryegrasses, the early establishment of Barry, Hunter, and Loretta helped maintain their winter performance after a sudden decline in surface temperature in December of 1978.

The invasion of annual bluegrass, as in previous years, was directly related to the density and turf quality of the individual cultivars. The light green colored cultivars and polystands also masked invasion of this weed prior to the formation of seedheads in March.

The nitrogen fertility data from Corpus Christi indicated that 1.0 lb. of N/1,000 ft^2 would be the most economical rate for best winter performance of overseeded areas. Also, Sabre rough bluegrass was best adapted to the low rate of 0.5 lb. N/1,000 ft^2 /month.

TABLE 18. THE EFFECTS OF THREE NITROGEN FERTILITY LEVELS ON THE TURFGRASS QUALITY OF 9 POLYSTANDS OVERSEEDED ONTO DORMANT BERMUDAGRASS

Corpus Christi, Texas - 1978-79

Polystand	Visual Turfgrass Quality Ratings For Three Fertility Levels			Average
	0.5	1.0	1.5	
CBS Blend	8.0	8.5	8.7	8.3 [3]
Medalist 300	8.0	8.5	8.0	8.2
Winterturf I	7.3	8.8	8.3	8.2
Medalist 5	7.0	8.2	8.5	7.9
60% Citation+30% Dawson+10% Sabre	7.3	8.2	8.0	7.8
Dixiegreen	7.3	7.5	7.8	7.6
80% Dixiegreen+20% Sabre	7.2	7.2	7.8	7.3
65% Citation+30% Dawson+5% Seaside	6.7	7.3	7.8	7.3
70% Dawson+20% Sabre+10% Seaside	5.3	5.8	5.3	5.5

[1]Average visual quality ratings for three replications; scored 1-9, 9=best quality; data collected in February, 1979.

[2]Pounds per 1,000 square feet.

[3]Values joined by the same line are not significantly different at the 5% level for Duncan's multiple range test.

SPRING ROOT DIE-BACK OF WARM SEASON TURFGRASSES

by

J.B. Beard and J.M. DiPaola*

Turfgrass managers seek to establish and maintain healthy and actively growing turfgrass plants. The health and vigor of the entire plant is essential for superior turf performance under such conditions as heavy traffic, environmental stress (heat, cold, water, etc.), and pest infestations. While the turfgrass shoot is the visible portion of the turf, both the shoot and root must be properly managed for optimal turfgrass utility.

The turfgrass root system serves several key functions in the life processes of the plant. Water uptake and transfer, nutrient absorption and transfer, and soil anchorage are important functions of the turf's roots. Turfgrass culture directed towards the development of deep, vigorous root systems is contingent on an understanding of the seasonal behavior of the turfgrass root.

Investigations concerning the season rooting behavior of Tifgreen bermudagrass and Floratam St. Augustinegrass were initiated in the Texas A&M Turfgrass Rhizotron in August, 1976. Turfs were established from sod in washed sand and received annual applications of phosphorus at a rate of 3 pounds per 1,000 square feet. Weekly applications of nitrogen and potassium were made at a rate of one pound of actual nutrient per 1,000 square feet per growing month.

Distinct seasonal patterns in root growth and activity were evident after the first three years of investigation. Summer root growth rates averaged one inch per day. This rate is some 5 times the growth rate reported for cool season turfs, such as creeping bentgrass. Declining soil temperatures during the fall were accompanied by equivalent reductions in the turfgrass root growth rate. Continued reductions in the soil temperature during the fall to 50°F or below resulted in shoot dormancy. Limited root growth was observed for approximately 2 to 4 weeks following shoot dormancy (loss of shoot green color).

During the winter dormancy period, the roots of these two warm season turfgrasses maintained the white-light tan color present during the summer and fall, and thus appeared alive. However, the root systems of these turfs turned brown about one week after the appearance of new green leaves in the spring (i.e. spring greenup). This root browning was followed by a delay in new root initiation, growth, and replacement (Fig. 1). Delayed new root initiation and

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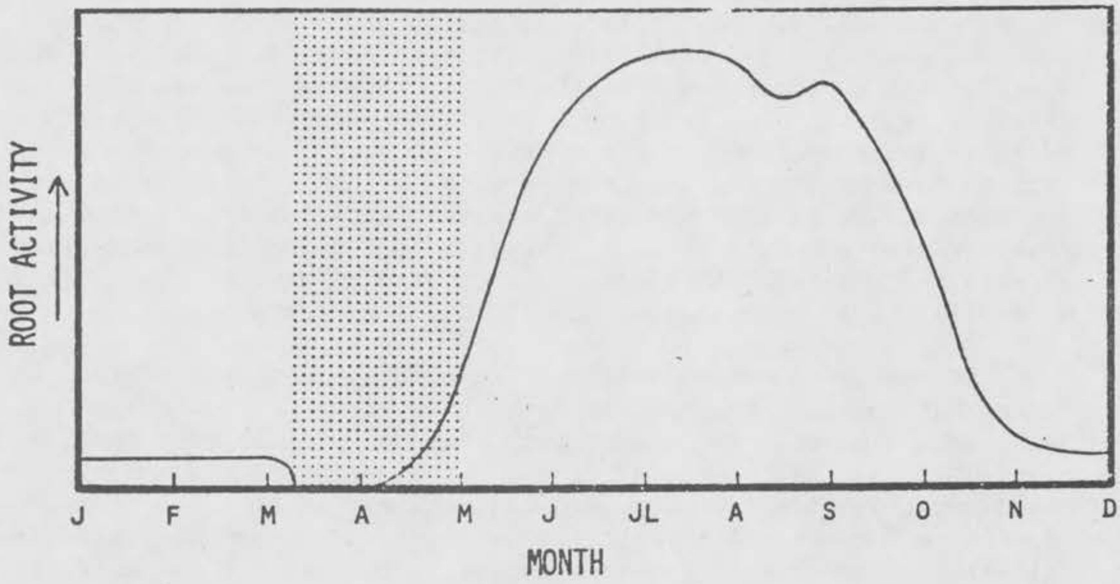
Figure 1. Typical seasonal root growth cycle of bermudagrass and St. Augustinegrass illustrating the spring root die-back phenomenon.



growth following spring greenup was accompanied by a significant new shoot development. This imbalanced shoot:root ratio predisposes these turfs to injury and possible death due to low temperature stress (late spring frosts), desiccating winds, excess traffic, disease, pesticide phytotoxicity, and insect pests. Loss of turf from such causes often results in expensive re-establishment procedures and increased weed problems from summer annuals such as crabgrass and goosegrass.

These research findings raise a host of new questions concerning turfgrass culture, particularly during the early spring. The many cultural practices that are known to markedly influence root growth and development must now be more closely evaluated with respect to spring root die-back of the warm season turfgrasses. Cultural practices of particular importance include: (a) mowing frequency and height; (b) fertilization timing, rate, and nutrient ratio; (c) timing, ferquency, and intensity of vertical cutting; (d) soil coring depth (and core diameter), frequency, and timing; (3) pesticide applications, particularly pre-emergence herbicides; and (f) irrigation.

Current turfgrass agronomics outline the general turf responses to these various cultural procedures. Mowing removes some of the green photosynthetic tissue of the turf and thus reduces the amount of leaf area present to intercept sunlight and produce food for the entire plant. When faced with limited carbohydrate production and reserves, the shoot will utilize available carbohydrates at the expense of the root system. Therefore, the typical result from increasing mowing frequency and/or decreasing the cutting height is a restriction in the depth of the turfgrass root system.

Fertilization timing and rates of application dramatically influence the performance of a turf. Nitrogen is important for many plant functions, including photosynthesis, and must be present in adequate amounts. However, excess nitrogen fertilization promotes shoot growth at the expense of the roots. Such a response may be of critical importance in relation to root die-back during the early spring. Above adequate levels of nitrogen have also been demonstrated to increase the susceptibility of a turf to many diseases, low temperature stress, and water stress. Additional potassium fertilization has been shown to increase root dry matter production of many turfgrasses. A balance in the ratio of nitrogen to potassium of fertilizer sources is also of critical importance.

Pre-emergence type herbicides are commonly utilized during the spring for control of goosegrass and crabgrass. Most of these herbicides also restrict root growth of many turfgrasses. Applications of such chemicals so as to avoid the spring root die-back period, yet provide adequate weed control, may prove to be of much importance for optimal spring turf quality. Many growth retardants will also restrict root growth. Typically root growth is restricted long after shoot growth inhibition has passed.

Root growth and distribution within the soil is affected by irrigation practices. Frequent and light applications of water will result in a turf with a shallow root system. On the other hand, more infrequent and deep irrigation will help promote a more vigorous and deep root system. Special attention to water stress problems is needed during this spring root ide-back period.

Winter overseeding of warm season turfs is a cultural practice which may have dramatic impact on the root systems of these grasses. Many of the fall establishment procedures utilized in winter overseeding, such as vertical cutting, close mowing, and late nitrogen fertilization, can reduce the winter survival of these turfs. These procedures are essential however, for the adequate performance of winter overseeded turfs. Cultural practices conducted during the spring transition for the removal of overseeded grasses will also influence the root systems of the permanent warm season turfs. While soil coring during the spring root die-back period may prove beneficial, vertical cutting during this period is likely to place an additional stress on the permanent turf. It is important to note that new spring growth of warm season turfs that have been overseeded will typically occur 2 to 4 weeks after those areas that have not been overseeded.

Many questions concerning spring root die-back of warm season turfgrasses remain to be answered. What is the cause of this root loss. It is hormonal, and/or related to carbohydrate supply? Does spring root die-back occur on all warm season turfgrasses? Is spring root die-back observed throughout the southern United States? How is root die-back influenced by the environment, particularly late frosts or early warm weather? Is there any variation in spring root die-back from year to year? What is the optimal timing of the various cultural practices which may help reduce root loss during the early spring? The answers to these and other questions concerning spring root die-back of warm season turfgrasses are currently being sought in on-going research programs at both Texas A&M and North Carolina State Universities.

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