Proceedings

of the

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Texas Turfgrass Conference

TEXAS A&M UNIVERSITY

and

THE TEXAS TURFGRASS ASSOCIATION

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P R E F A C E

The 30th Annual Texas Turfgrass Conference was an overwhelming success if attendance was used as a standard for measurement. In the last 5 years Conference attendance has grown from less than 300 to over 500. The number of educational sessions have increased, an educational and commercial exhibit has been added and special training programs have been added. However, the most important measurement criteria for the Conference is the educational value of the program to the professional turf managers, commercial representatives and students who attended the Conference. The educational sessions, exhibits and informal meetings were all designed to keep you abreast of the developments in the turf industry. These *Proceedings* are an additional effort to keep you informed and to provide a useful reference for turfgrass management information.

These *Proceedings* could not be produced without the dedicated effort of those making the presentations at the Texas Turfgrass Conference. We are indebted to each of these authors for their contribution to the Texas Turfgrass Conference.

Special appreciation is extended to Barbara Stipanovic, my secretary, for her assistance with the Conference program and these *Proceedings*.

Richard L. Duble
Program Chairman

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WELCOME REMARKS

Daniel C. Pfannstiel*
Associate Director
Texas Agricultural Extension Service
Texas A&M University

It is indeed an honor for me to have been invited to meet with you here this morning. I trust that this conference you are attending this week is one which you find both interesting and useful. We want to welcome you to the Campus of Texas A&M University and hope that you will return just as often as possible.

As I am sure many of you know, Texas A&M University is the designated land-grant university for the State of Texas. As such, it is responsible not only for academic teaching but also for carrying out comprehensive statewide programs of research and Extension education. In fact, it is the significant commitment to research and Extension teaching functions which distinguish land-grant universities from other publicly supported institutions of higher education. I might also point out in passing that Texas A&M University is a designated sea-grant university and as such is only one of seven in the United States.

It may be of interest to you to know that today you are on the campus of what is the fastest growing university in the entire nation. The current enrollment is around 25,000. To indicate something to you about the rate of growth, back in 1972 the enrollment was 15,000; in 1973 it jumped to 18,000; and last year in 1974 it was 21,000. From this you can see there has been about a two-thirds increase in just three years. Also it may surprise you that there are now 7,000 female students enrolled at Texas A&M University. When you consider that some 12 or 13 years ago this was an all male institution, I think you would agree that this is quite a significant development. In fact, the female enrollment alone exceeds the total enrollment of such schools as Texas Woman's University, Rice University, Texas Christian University, and is almost as great as the total enrollment of Baylor University.

I would also like to point out that within the last year or so, Texas A&M has the largest agricultural student enrollment of any university in the United States. At the present time, this enrollment is just under 5,000;

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3,842 of whom are undergraduate students and 1,112 of whom are graduate students. Interestingly, of the total number of students in the College of Agriculture, 986 are females. The University conducts many and varied programs and at the present time has ten different colleges and a large graduate student enrollment.

I note from the program that this is the 30th Annual Turfgrass Conference. This is most commendable. To me a conference like this speaks very highly of any occupational or professional group, because it demonstrates concrete interest in gaining additional skills and knowledge which will enhance the ability of the members of the industry to better serve its clientele or public. Secondly, your full participation in a conference such as this will help you do a better job back home. In glancing through the program, it appears that a most excellent one has been assembled for your benefit. The Texas Agricultural Extension Service is proud to be one of the sponsors of this conference along with the Texas Turfgrass Association, the Texas Agricultural Experiment Station, and the Soil and Crop Sciences Department of Texas A&M University.

Your industry clearly is a most important one and becoming more so with every passing day. With the heightened interest and awareness of the public in beautification, environmental enhancement, and leisure time activities, you are destined to have a bright future. We of the Texas Agricultural Extension Service, the organization which I represent, and the other units of the Texas A&M University System, remain committed to support the further development of the turf industry in Texas. A considerable amount of research on all phases of turf management and grass breeding is being conducted by our sister agency, the Texas Agricultural Experiment Station. The Texas Agricultural Extension Service through its county Extension agents, who are back-stopped by our core of subject-matter specialists both here at College Station and in the field, are dedicated to carrying the results of research to you and all the people of the State who can possibly benefit from it.

Back about the time you were beginning to have these annual turfgrass conferences, we had only one part-time staff member who was devoting his efforts to serving the needs of your industry. Since that time we have established a full-time position of Turfgrass Specialist which of course is being ably filled by Dr. Dicky Duble. Additionally we have now about seven other staff members who are devoting a majority of their time to meeting the needs of your industry as well as many other specialists who devote part of their time to supporting your industry. We also know that our county Extension agents are involved to a considerable extent in conducting educational programs in the whole area of turf management and related matters.

In addition to the research and Extension educational activities being conducted by units of the Texas A&M University System, you recognize that Texas A&M University has a strong academic program relating to turf. I am told that over 100 students have been graduated in our turf program at Texas A&M University and are presently involved as practitioners in the turf industry. Indications are that interest in academic programs in turf is likely to increase.

Again, may I say how very please we are to have you on this campus. If there is anything we can do to be of help either while you are here attending this conference or at any other time, please let us know. We are hopeful that you will gain a great deal from your participation in this conference. I look forward to participating in other parts of this program this week and to the opportunity that this will afford to become personally acquainted with many of you.

TURFGRASS MANAGEMENT:
Progress and Predictions

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The purpose of this Conference is to bring you the latest information on turfgrass culture. It is up to you to "put it all together" and incorporate pertinent information into your management system. Your maximum professional development is dependent upon how you use your warehouse of knowledge, and more importantly on how much knowledge you gain today and in the future, and how you are able to use it.

The turfgrass manager is facing a technical revolution. As a professional you realize that turfgrass culture is becoming less an art, and more and more a science. Today, turfgrass publications are scientific, and the students major in turfgrass science. The future will, perhaps very shortly, see our generally agrarian occupations change into ones of a hard-core, complex scientific nature.

Many changes seem to be eminent in the turfgrass professional's future. One can foresee computer systems that will assist or control management programs. It is conceivable that a central system, perhaps located at this university, will provide satellite systems with directions for maintenance and establishment, viz. the correct time to mow, when and what pesticides to apply, etc.

The difficulties that the professional faces in striving to produce a perfect turf cannot be over-emphasized. Aspects of an ideal turf, such as pure and pest-free stands, a uniform appearing turf, and continuous optimum growth are not natural. Achieving such ideals demands that the turf professional have an in-depth understanding of the cultural system and how to manipulate it.

The following discussion of various aspects of turfgrass culture is presented to give some idea of the complexity, diversity and interdependence of knowledge needed to develop successful management programs.

SOILS

In the past, both people and turf, primarily because of an agrarian society, were located on good land. And, many old turf areas are still

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excellent and easy to maintain because the soils were not inverted nor denuded during construction.

Recently much attention has been devoted to devising ways to improve the physical quality of soils for turf. Most of the research with artificial media has led to rather consistent recommendations: use a high percentage of quality sand. U.S.G.A. and Purr-wick greens, and PAT fields are primarily sand medias. The advantages of a porous media with rapid drainage and good aeration are quite evident, and may leave few alternatives on the media to use in constructing heavy use athletic turf areas. Such artificial systems are not expected to solve all turf problems. Such systems can dramatically increase the turf professional's control of the environment; however, to take full advantage of the system he must understand it and manipulate it to full advantage.

In the future more attention will be given to the preservation of existing good soils. Stringent laws will be passed to preserve and protect our valuable soils, and buildings and turf will continue to be relegated to lower and lower quality land. These trends will necessitate more in-depth research on turf soils, and the use of the more sterile soils will call for increased knowledge and more manipulation by the turf professional. As in the past, a dependence will need to be placed on a rather inexhaustible organic matter supply to improve soil quality.

In the future significant improvements will be made in conventional methods of topdressing and cultivating the soil below the turf surface. And, complex chemical and physical developments will make it possible to turn poor soils into those quite desirable for turfgrass production.

TURFGRASSES

Early turfs were primarily a mixture of several perennial grasses and forbs, and mixtures of cool season grasses continued as a mainstay of the industry until recently. Recent trends have been toward the use of only one kind of grass for turfing areas. Today, warm season grasses are established primarily as single varieties. Whereas, blends of two or more varieties of the cool season grasses, especially of Kentucky bluegrass, are in vogue.

The current deluge of turf varieties seems to have caused undue concern in the turf industry. After all, turf is the most widely grown crop in the country with Kentucky bluegrass, bentgrass and bermudagrass all grown under an extremely wide range of conditions. Many other important agronomic crops have a multitude of varieties, and these have been successfully handled for years. Today, as in the past, there is little effort to regionalize the use of varieties according to their best adaptability, or to adapt turf varieties to adverse environmental situations. True, the wide choice of varieties requires that the turfgrass professional keep abreast of variety development, performance and availability.

Early literature suggested turfgrasses such as redtop, crested dogstail and Wood meadowgrass, which are hardly considered for use today. And, in those days grasses such as tall fescue and bahiagrass were not suggested nor available for turf use. Future work on the development of outstanding turfgrasses will continue at a rapid pace, and today's varieties, which would have been considered near perfect a generation ago, will be phased out.

In the immediate future major input will continue toward the development of turfgrasses that have outstanding qualities such as high densities, high levels of disease resistance, and a low growth habit. Drought and salt tolerance, resistance to wear and pollution, and the ability of grasses to remain green under cold conditions will become more important considerations. In addition to the development and introduction of grasses for the South, the arid West and the extreme North, one might foresee the use of bentgrasses with extensive rhizome systems, and turfgrasses with a wide range of color.

ESTABLISHMENT

Present and future turf quality is often dictated by practices implemented at the time of establishment. The importance of an ability to properly water turfgrass during establishment cannot be over-stressed. In cool, humid regions the preferred time to seed has long been late summer or early fall; however, in the past an inability to properly irrigate and natural spring precipitation often caused seeding to be done in the spring. In the not-too-distant past factors that often contributed to establishment difficulties were poor seed and seeding equipment, non-use of starter fertilizers, and lack of pesticides to use at the time of establishment.

Presently, there seems to be little research and industrial development directed toward the improvement of establishment techniques. Today, starter and post-establishment fertilization and pest control, seed and vegetative material quality and handling are continuously stressed. But, too often these and other important establishment factors are afterthoughts, and they are not plugged into turf management systems.

Significant and rapid developments in turf propagation procedures seem less likely than for improvements in maintenance. Answers to basic and current questions, such as what are the best seeding (or sprigging) rates for various conditions for the most rapid development of a mature sod or useable turf, need to be more precisely worked out. Once the best depth and placement for various plantings are known, equipment will need to be developed to do the job. Development and selection of varieties that germinate and establish rapidly should become added performance criteria for new turfgrasses. Pre-plant treatment of seed to speed germination and enhance seedling vigor should become common practice. Also, even more sod will be used and development of more efficient sod laying and handling techniques are eminent.

MAINTENANCE

As the demands for better quality turf have evolved, more and more effort has gone into maintenance. These demands have caused the development of sophisticated turf maintenance equipment, and practices such as vertical mowing, aerification, etc. are included in virtually every maintenance program. Recent work by Dr. John Madison and others in California has combined several turfgrass maintenance practices. The procedure is one of making frequent, light topdressing applications of sand (less than 1.0mm), with seed, fertilizer (and when appropriate, an insecticide and/or fungicide) to golf greens. And as we move ahead, this technique and others like it may become deeply instilled into turf maintenance programs.

IRRIGATION

In recent years tremendous strides have been made in developing turf irrigation equipment. In part, these advancements have resulted from the demands for the ultimate in turf. Also, the turfgrass economy has generally been quite good, and unlike many other segments of agriculture, results were of primary consideration and costs were secondary.

Today, there seems to be an adequate choice of sprinkler equipment. And sub-irrigation (or at least partial sub-irrigation) is being utilized only to a limited extent. However, there are currently several problems that must be faced. Principal among these seems to be a general shortage of water. Also, the use of poor quality ground and surface water, and effluent water presents problems that need to be handled with care (constant monitoring of soil and water, etc.). In the future, in arid and semi-arid regions of the U.S., because of the influx of people and water required to develop natural resources, water used for turf will need to be justified, and little will be used on roadsides, golf course roughs, etc.

An increased use of drip irrigation for turf and the development and use of drought tolerant grasses are in the offing. Every turf manager, regardless of his location, will become more aware of the problems associated with water.

MOWING

Since man first began using sheep to keep a short turf, there have been many methods employed to mow grass. Reel mowers and their continued refinement, and the relatively recent development and heavy use of rotary mowers have revolutionized the industry.

Current mowing practices have been a result of the kind of equipment available, the demands of the people, and the kind of grass grown. Several turfgrasses used in the past and at present are poorly adapted to current mowing practices. The ability of the new turfgrasses to tolerate current mowing practices has been an important consideration in determining whether or not they will be introduced. Many of the recently introduced turfgrasses may make it possible to change a mowing program. Some of these grasses, depending on your needs, may produce a satisfactory turf with less frequent or even only an occasional mowing.

Mowing equipment will continue to be refined. Larger and larger air cushioned mowers, devices that cut via wave emission, and the availability of more and more sophisticated growth retardants could greatly affect equipment and mowing procedures of the future.

FERTILIZATION

Early turf fertility programs often relied upon the use of compost, manure and leachate from manure to supply nitrogen to the turf. And, the use of sewage sludge has been successfully employed for years. While more recently the ready availability of inexpensive manufactured inorganic and urea fertilizers greatly changed turfgrass management practices. For several years there seems to have been too little attention paid to developing comprehensive fertilization programs, and poor fertilization procedures (too much, imbalances, etc.) may have been more of a problem than was realized at the time.

The synthetic organic fertilizers, such as IBDU and urea-forms have offered effective means of providing slowly available nitrogen for plant growth. Another recent means of controlling nutrient availability has centered around coating fertilizer prills. The coating will allow nutrients to slowly ooze into the root zone where they are available for plant use.

Some recent fertilizer program changes have been influenced by the availability of more efficient applicators. Recently more effort has been given to controlling nutrient availability of soluble materials by making frequent fertilizer applications at light rates. Thus, a more constant growth rate, and the benefits derived from this, have been achieved.

There is a serious need for research that will lead to a better understanding of the nutritional needs of various turfgrasses and to the development of more refined fertility programs. In the past fertilizers were applied primarily to green and thicken the turf. However, recent research and observations are pointing more and more to some rather subtle turf responses effected by fertilizer practices. The effects of various nutrients on factors such as winter hardiness, disease susceptibility and mowing quality, etc. will become more important in developing future fertility programs.

In the future high priority will be given to the selection of grasses that will do well at low soil fertility levels. Development of varieties for specific regions could make it possible to greatly reduce or eliminate the need to apply specific nutrients. For example, the need for application of iron-containing fertilizers on turfgrass grown on the alkaline soils of the West might be greatly reduced or eliminated.

The future for the development and utilization of fertilizers designed specifically for turf use is bright. In the near future, if turf is tending to grow too rapidly, it may be possible to "turn it off" by applying a chemical to regulate nutrient availability in the soil. Fritted fertilizers that will release nutrients, especially micronutrients, over a period of 10 to 20 years or more may become widely used for turf. And, because of the evolution of more sophisticated irrigation equipment and higher quality fertilizers aqueous fertilization will become commonplace.

In the future legumes such as improved white and strawberry clover, because of the nitrogen fixing abilities, may again become widely used for turf. More and more attention will be given to the use of organic wastes as nutrient sources. And, fertilizer use will be well planned, with major consideration given to long term effects, and not just to tomorrow.

PESTICIDES

Highly selective chemicals are now available for the control of virtually any turf pest problem. Only a few years ago there was no satisfactory selective chemical control for annual grasses in new seedings of Kentucky bluegrass, nor Pythium blight in bentgrass. Today, however, because of available pesticides, grasses are grown well beyond their accepted range of a few years ago.

The effects that certain pesticides may have on the turfgrass system have been and are currently under investigation. Research findings to date indicate that certain pesticides may materially reduce root systems, increase thatch, etc. Also, research and observations have indicated a wide variability in varietal tolerance to specific herbicides and to fungicide-resistant strains of fungi. Thus, future pesticides will be subjected to even more rigorous testing. And, the turf manager will be concerned with much more than immediate pesticide effects.

There will always be a need for better pesticides. However, the current availability of outstanding products will likely restrict efforts for and the introduction of new pesticides. For several years activated charcoal has been used to inactivate specific pesticides. Future significant developments in inactivation of pesticides would open a new era for pesticide use in turf management. Pesticides of the future are likely to become much more specific, and the turf manager will have to become even more knowledgeable about pests and pesticides.

In the future pest problems will be greatly restricted through the introduction and use of improved varieties. The future turfgrasses will have combined resistance to most common insect and disease pests.

Turfgrass management practices are continually changing, and many factors will influence turfgrass management decisions. Successful management programs are developed through an in-depth understanding of the turfgrass system and its many complexities. The future of the turfgrass industry depends upon the professional's ability to supply and utilize technical information. The turfgrass manager's job is not going to get any easier.

T U R F   M A N A G E M E N T   S H O R T C O U R S E

BERMUDAGRASS MANAGEMENT

WEED CONTROL IN BERMUDAGRASS

SPRING DEAD SPOT

ST. AUGUSTINE GRASS MANAGEMENT - CULTURAL PRACTICES

DISEASE CONTROL ON ST. AUGUSTINE GRASS

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THE OPERATION AND MAINTENANCE OF MOWING EQUIPMENT

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TROUBLESHOOTING IRRIGATION SYSTEMS

BERMUDAGRASS MANAGEMENT

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Athens, Georgia — College Station, Texas

Bermudagrasses in general are drought tolerant, i. e., they will survive dry soil conditions longer than most turfgrasses. However, the drought tolerance of bermudagrass is based on the ability of this plant to become semi-dormant and to resume growth when moisture is adequate. The grass does not provide a desirable turf under drought conditions, but responds readily to irrigation. On the other hand, bermudagrass will not tolerate poorly drained soils. Thus, irrigation practices are critical for the maintenance of fine bermudagrass turf. On poorly drained soils overwatering can result in the loss of turf.

WATER REQUIREMENTS

In general, the water requirements for bermudagrass turf, for a particular area of the state, are dependent upon the water-holding capacity of the soil and the evapotranspiration rate of the site. The water-holding capacity of a clay soil (heavy soil) is greater than that of a sandy soil. Thus, a clay soil will require less frequent watering than a sandy soil. The evapotranspiration rate changes from day to day, but is primarily dependent upon temperature. Obviously, the evapotranspiration rate will vary considerably between seasons and between areas of the state. It may range from less than 1/100 inch of water per day during the winter to greater than 1/3 inch of water per day during the summer. Thus, under extreme conditions 1/3 inch of water per day might be required to maintain adequate soil moisture. Watering systems for golf courses must be designed to meet the requirements for bermudagrass turf during stress periods.

FERTILITY

The frequency of application and quantity of fertilizer required for bermudagrass turf depends on the length of the growing season, the soil type, the variety, the desired appearance and growth rate, and the

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source of nitrogen used. In Texas, the length of the growing season for bermudagrass varies considerably from north to south. In general, South Texas has a 9 to 12 month growing season for bermudagrass; whereas, North Texas has a 6 to 8 month growing season. The quantity of fertilizer required increases with the length of the growing season.

Soil type also influences the frequency and quantity at which fertilizer is required. Some soils are inherently low in one or more plant nutrients. Soil tests provide one means of detecting nutrient deficiencies. Efficient fertilizer practices can only be made on the basis of soil tests. The frequency of application of fertilizer also depends on the soil type. Sandy soils are generally more subject to leaching of fertilizer nutrients than clay soils. Thus, nitrogen fertilizers need to be applied in smaller and more frequent applications on sandy soils than on clay soils.

Bermudagrass varieties differ in their requirements for nitrogen. In general, the fine-textured varieties need to be maintained at a higher level of nitrogen than common bermudagrass. The desired color, density and growth rate of bermudagrass largely determines the amount of fertilizer required. The dense, dark green turf demanded for putting greens requires higher levels of fertilizer than fairway turf where the same color and density is not essential. Likewise, tees require a higher level of fertilizers than fairways because of the heavier traffic and greater injury from clubs on golf tees. The rate of recovery of bermudagrass turf on golf tees is directly related to the level of nitrogen fertilizer applied.

The source of nitrogen used largely determines the frequency and quantity of fertilizer applications required to produce a uniform appearance. Nitrogen from inorganic sources such as ammonium nitrate and ammonium sulfate is readily available to the grass. Thus, inorganic nitrogen sources produce a rapid growth stimulation followed by a sharp decline in growth rate and color. Therefore, it is necessary to apply inorganic nitrogen sources in small, frequent amounts. Nitrogen from organic sources such as sewage sludge and ureaformaldehyde is not as readily available as nitrogen from inorganic sources. Consequently, larger and less frequent applications can be made. Organic nitrogen sources are often used on putting greens where a uniform growth rate is important. Frequently, a combination of organic and inorganic nitrogen sources is used to obtain the advantages of both materials.

MOWING

Mowing requirements for bermudagrass turf are dictated by variety, usage, and maintenance intensity. In general, fine-textured bermudagrasses require closer and more frequent mowing than common bermudagrass. Turf usage largely determines the mowing height and frequency required to maintain desirable characteristics. Putting green turf is mowed at a height of 1/8 to 1/4 inch and from 4 to 7 times each week. Fairways and tees are mowed at a height of 3/8 to 5/8 inch from 2 to 3 times each week. In general the shorter the mowing height the more frequent the grass should be mowed. Mowing requirements, obviously, are dependent upon the maintenance level imposed on the turf. Nitrogen fertilization and watering practices largely determine the frequency of mowing required to avoid excessive accumulation and injury to turf.

VERTICUTTING

Bermudagrass, like creeping bentgrasses, spreads by stolons and becomes quite grainy during the growing season. Vertical mowing on a regular schedule will prevent grain and provide an excellent putting surface. Vertical mowing in two directions at two-week intervals with the blades set to cut only the grass runners will not noticeably discolor the turf and will help produce a true putting surface. The same practice on a weekly schedule will eliminate grain and reduce thatch accumulation and produce a fast, smooth putting surface. The vertical mower may also be used following aerification to breakup and scatter the soil cores. The vertical mower should be used routinely as a management tool and not on an emergency basis as a renovator. It will be the responsibility of the individual superintendent to adjust the height of the vertical mower to achieve the desired result.

AERIFICATION

The need for aerification of putting greens must be determined on an individual basis. Again, we must go back to the green construction and soil mixture to arrive at a recommendation for aerification practices. Greens constructed according to USGA Green Section specifications will have adequate aeration for deep root growth. However, it may still be necessary to aerify greens to encourage bermudagrass transition in the spring, to reduce thatch accumulation during the summer and to alleviate compaction resulting from heavy traffic. A minimum of two aerifications each year is essential to good bermudagrass putting greens. Aerification should be accomplished with 1/4 to 1/2 inch hollow tines that remove a 2 or 3 inch soil core at relatively close intervals. One-half inch tines may be used during the spring and fall to remove maximum soil and thatch accumulation. Smaller tines should be used during the summer months.

Soil cores may be shredded with a vertical mower and dragged with a steel mat to provide top-dressing, or they may be picked up and removed from the green. If thatch removal or compaction is the purpose of the aerification, the cores should be removed from the green and replaced by a good top-dressing mixture. If the aerification is to encourage bermudagrass transition in the spring or to destroy surface crusts, the soil cores may be shredded and dragged.

Putting greens constructed of material with a rather large percentage of fine sand, silt and clay tend to be hard and compacted when subjected to heavy traffic. These greens will require more frequent aerification than properly built greens to overcome compaction and to hold a golf shot. Putting greens constructed with a mixture of sand, organic matter, and soil (5% clay soil) will not require frequent aerification.

TOP-DRESSING

To take the place of cultivation the golf course superintendent has three practices to prevent accumulation of organic residues and compacted soil conditions - vertical mowing, aerifying, and top-dressing. Neither superintendents nor golfers look forward to these operations, but all are essential to the maintenance of fine bermudagrass turf. Top-dressing is an expensive and arduous task and requires advanced planning and organization. Equipment to shred, blend and screen the top-dressing material is essential, as is an automatic top-dressing machine. All of this equipment is expensive, but saves labor and does a better job than hand mixing and spreading. The success of the top-dressing operation depends largely on the choice of material to use in the mixture. If the soil present in the greens provides good drainage, water and nutrient retention and aeration, the top-dressing material should be of the same general nature. If the soil or soil mixture present has not performed satisfactorily, a more desirable mixture should be used for top-dressing. In this case a physical analysis of the materials available for use should be made by the U.S.G.A. Soil Testing Service*, or another competent soil testing laboratory. The service will include a recommendation for a suitable mixture for top-dressing or green construction. This mixture should become the permanent top-dressing material. For the complete study and recommendation, a charge of $100 is made payable to Soil & Crop Science Department, Texas A&M University.

After the proper top-dressing material is shredded, blended and screened, it should be sterilized with methyl bromide or another sterilant

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* Send samples of material to Dr. K. W. Brown, Soil & Crop Science Department, Texas A&M University, College Station, Texas 77843.

and composted for 8 to 10 months prior to use. Top-dressing should be stored in a dry place to insure free flow at the time of application.

If the equipment and material for top-dressing is on hand, the operation can be carried out routinely. Light, frequent applications of top-dressing are more beneficial than heavy, infrequent applications. Tifdwarf bermudagrass, in particular, will not tolerate heavy top-dressing. The application of 1/2 to 3/4 cubic yards per 5,000 square feet of putting surface at least 4 times during the growing season is recommended. Certainly, a top-dressing should never be so heavy as to cover the grass.

The benefits of top-dressing are pointed out by William Bengeyfield in the January, 1969 issue of the USGA Green Section Record. "Top-dressing does more than smooth the putting surface. It encourages new growth, resulting in dense, upright and fine-bladed turf. Top-dressing helps prevent thatch accumulation by encouraging organic matter decomposition. It also increases water and nutrient retention in the soil profile; thus, localized dry spots are reduced. Top-dressing adds resilience to the surface; thus, top-dressed greens 'hold' a golf shot better. On heavily played greens, this point is of particular importance. Greens top-dressed just prior to the winter also have fewer problems from desiccation and winter injury."

Top-dressing is expensive but, essential to maintaining fine bermudagrass putting greens. Although it does not produce immediate miracles, its long-range benefits are undeniable. Together vertical mowing, aerifying and top-dressing can do much for the maintenance of fine bermudagrass putting greens.

WEED CONTROL IN BERMUDAGRASS

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INTRODUCTION

Weed control in bermudagrass is dependent upon the following factors: (1) accurate sprayer calibration for proper herbicide rate per acre, (2) selection of the herbicide(s) for the weed species, (3) accurate timing of the herbicide treatment, and (4) water management, irrigation, for movement of certain herbicides into the weed rooting zone.

Each statement is brief in this paper about the use of the herbicides. Refer to the product labels and references cited for additional information.

DISCUSSION

Fairways, General Turf Areas, and Home Lawns

Sod renovation: Cacodylic acid in Phytar 560 and other formulations is an effective non-selective contact herbicide for top kill of perennials and control of annual weeds.

Glyphosate (Roundup) controls emerged purple nutsedge, bermudagrass, johnsongrass, and many other weeds. The chemical gives best control on undisturbed stands which are in the early boot to flower stage. More information is needed about the transplanting, planting, and seeding interval after treatment and eventual labeling.

Dormant turf: Endothall controls cool season weed grasses and broadleaves postemergence in dormant turf. Paraquat can also be used to spot treat cool season weeds.

Newly seeded turf: Dacthal (DCPA) is an effective preemergence treatment for crabgrass, goosegrass, and other species when applied in early spring after the turfgrass has exhibited a uniform greening and is about 1 to 2 inches high.

Established turf, Reseeding, and Overseeding

Preemergence: Balan (benefin), Dacthal, Betasan (bensulide), and simazine are labeled treatments, which are applied before weed seed germinate.

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Balan is the most effective for annual weed grass control in bermudagrass. Betasan and simazine are most persistent. Simazine is the most effective for both broadleaf weeds and annual bluegrass. Kerb (pronamide) is labeled for annual bluegrass control and other weeds. All of these herbicides require irrigation for adequate control of weeds. Irrigation is applied after treatment at quantities necessary to adequately maintain a good quality turf.

Follow these guidelines when the listed preemergence herbicides were used for cool and warm season weed control.

Balan: Where Balan is used for warm season grass control, reseeding should be delayed for at least 6 weeks after treatment. When Balan is used for control of cool season grasses, reseeding should be delayed 12 to 16 weeks after application.

Kerb: Where Kerb is used for annual bluegrass control, overseeding should be delayed for 90 days after treatment. Avoid using around the margin of greens to prevent movement into the green when irrigated.

Dacthal: Where some spring seeding is necessary, delay seeding about 60 days after the Dacthal application. Fall sowing of permanent grasses can follow early spring application of Dacthal.

Betasan: Allow 4 months after treatment before overseeding areas treated with Betasan.

Simazine: Do not reseed or overseed areas treated with simazine until additional research has established timing and safety.

Postemergence: Kerb is excellent for control of annual bluegrass when treated after emergence. Avoid spraying near the green margins, to prevent movement by irrigation into the overseeded green.

MSMA, DSMA, AMA (organic arsenicals) are selective weed grass herbicides. These chemicals are useful for control of seedling and mature dallisgrass, crabgrass, goosegrass, sandbur, purple nutsedge, carpetgrass, and others in bermudagrass turf.

Broadleaf weeds are controlled postemergence either with 2,4-D, silvex, mecoprop, Banvel (dicamba), bromoxynil (Buctril), or a two-way mixture of mecoprop + 2,4-D, dicamba + 2,4-D, 2,4-D + silvex, or a three-way mixture of 2,4-D + mecoprop + dicamba, or 2,4-D + silvex + dicamba. The tri-mixtures are superior where a variety of species are infesting the turf. These chemicals except bromoxynil are hormone-type and should be used as a granule alone or as a herbicide and fertilizer combination.

Liquid sprays of these herbicides are potentially hazardous because of spray drift.

Golf Greens

Preemergence: If the greens are not to be overseeded with a cool season species, either Balan or Betasan can be tried as discussed for fairways, general turf areas, and home lawns. Dacthal may cause injury and increase dollar spot during cool damp weather in late September or early November. For overseeded greens, Kerb could be evaluated for control of annual bluegrass. Overseeding should be delayed for 90 days after either treatment is made about 2 weeks before annual bluegrass germinates. These treatments may be useful on greens with severe infestations and in areas where the public will tolerate the absence of a cool season grass in the first month of winter. For warm season annual weed grass control, Betasan is suggested if the treatment is applied as the granular formulation before weed seed germinate probably February 15 to March 15. Betasan will reduce the vigor of the cool season overseeded grass. Either Dacthal or Balan applied at these dates probably will delay the bermudagrass in breaking dormancy by 2 to 4 weeks.

Postemergence: For control of goosegrass, spots of purple nutsedge, and other sedges, and other annual grasses, the same treatments as discussed for fairways, general turf and home lawns can be used. The warm season weeds are usually in spots and can be selectively sprayed instead of broadcast sprayed. The organic arsenical herbicides are very effective for weed grasses with wide leaves. The hormone-type herbicides are used for broadleaf weeds.

In putting greens not to be overseeded in the fall, Kerb can be evaluated for annual bluegrass control.

New Herbicides for Purple Nutsedge Control

Probe (methazole) Velsical + MSMA

Probe at 0.15 to 0.25 lb/A in combination with MSMA at 1 and 2 lb/A controls mature goosegrass with minimum turf discoloration. This treatment is also effective for purple nutsedge control.

Detsun (perfluidone) 3M

Destun at 4.0 lb/A gives control of purple nutsedge. Cyperquat (S-21634) Gulf at 4.0 to 6 lb/A is excellent for purple nutsedge control. Basagran (Bentazon) BASF at 1 to 2 lb. is good for yellow nutsedge control but poor for purple nutsedge control. The chemicals are safe to bermudagrass, but are in the testing stage. Do not use without additional information.

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Table 1. Summary table of Herbicides for weed control in bermudagrass.

Herbicide common name	Product name(s)*	Chemical Company
	Sod Renovation	
Cacodylic acid	Phytar 560	Ansul
Glyphosate	Roundup	Monsanto
	Dormant Turf	
Endothall	Penco Endothall Herbicide	Pennsall
	Newly Seeded Turf	
DCPA	Dacthal	Diamond Shamrock
	Established Turf - Before Weed Seed Germination	
Benefin	Balan	Elanco
Bensulide	Betasan	Stauffer
DCPA	Dacthal	Diamond Shamrock
Simazine	Sta-Green	
Pronamide	Kerb	Rohm & Haas
	Established Turf - After Weedy Grasses Are Growing	
DSMA	Ansar DSMA Liquid DSMA Liquid	Ansul Diamond Shamrock
MSMA	Ansar 529 HC Mesamate 600 Daconate-6- Turf Herbicide + surfactant	Ansul Crystal Diamond Shamrock
AMA	Super-Dal-E-Rad + 2	Vineland

Table 1 Continued

Herbicide common name	Product name(s)*	Chemical Company
	Established Turf - After Broadleaf Weeds Are Growing	
2,4-D	Several manufacturers	Several manufacturers
Silvex	Several manufacturers	Several manufacturers
Mecoprop	Chipco Turf Herbicide Cleary's MCPP	Chipman W.A. Cleary
Dicamba	Banvel	Velsicol
Mecoprop + 2,4-D	Several manufacturers	Several manufacturers
Dicamba + 2,4-D	Several manufacturers	Several manufacturers
2,4-D + silvex	Several manufacturers	Several manufacturers
2,4-D + silvex + dicamba	Several manufacturers	Several manufacturers
2,4-D + mecoprop + dicamba	Trex-San Broad-Spectrum Broadley Herbicide Wipe Out Broadleaf Killer	 Mallinckrodt Green Light

*Product names included in this paper are not intended as endorsement of the product of a specific manufacturer nor is there any implication that any other formulation containing the same active chemical is not equally as effective.

SPRING DEAD SPOT

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In almost every audience of turfgrass managers, there are some to whom a discussion of spring dead spot is quite new. Assuming this to be true here today, perhaps we should review very briefly how spring dead spot started, and how it has reached it's present status of a rather severe problem and perhaps in some parts of the south, the most serious problem of Bermudagrass turf.

Spring dead spot is a cool season, die-back condition of bermudagrass that has become quite prevalent in the northern portion of Texas. In other states, namely Oklahoma, Arkansas and Georgia, the occurrence of spring dead spot has been found associated with commercial turf and home lawns. It has been my observation in Texas that spring dead spot is much less noticable in home lawns than with commercial turf.

Spring dead spot is the descriptive term chosen which describes the dead spots that are noticable in the spring as bermudagrass begins to green up. Although the spring dead spot is thought to have been observed near Tulsa, Oklahoma about 1936, there is still some uncertainties as to the primary cause. The first professional turf people observing dead spots on bermudagrass turf thought the phenomenon to be just a freakish prank of nature.

The condition has been investigated in other states for a number of years. Drs. Wadsworth and Young have been studying the spring dead spot condition in Oklahoma since about 1954. They report the occurrence of spring dead spot throughout most of Oklahoma on lawns, golf courses and many public and private turf areas. In 1964, Drs. Dale and McCoy reported a similar condition occurring on bermudagrass in Arkansas. These workers report the spring dead spot condition occurring in bermuda lawns. In

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Georgia, Dr. Kozelnicky, et. al., have made isolations from roots and rhizomes of bermudagrass attempting to determine if a specific pathogen could be consistantly recovered. Several organisms were recovered: Fusarium, Curvularia, Rhizoctonia, Helminthosporium, Pythium and Gliocladium.

Since the study by Kozelnicky in Georgia and Wadsworth, et. al., in Oklahoma, they have consistently found Helminthosporium spiciferum associated with rotted roots with the spring dead spot of bermuda. In isolation studies conducted by this author in Texas from rotted rhizomes of bermudagrass, a Helminthosporium species was consistently recovered. However, the specific species was not identified. Soil samples from dead spot areas have been collected and analyzed for the presence of plant parasitic nematodes. Nematodes are not believed to be associated with the spring dead spot condition.

Various ways have been sought to control the spring dead spot condition as a disease. Massive doses of insecticides and fungicides have been used with limited degree of success. In Oklahoma, doses of the insecticide Dieldrin gave a degree of success. The fact that Dieldrin gave a measure of control led some observers to postulate that spring dead spot was an insect problem. However, insects were never found. Then it was discovered in old literature that Dieldrin had fungicidal properties, as well as insecticidal properties. But when Dieldrin was tried in areas beyond Oklahoma, it just did not work. Furthermore, it's success in Oklahoma could not be reproduced elsewhere.

Management practices were thought to be a part of the problem. It was noted that only highly maintained turf seemed to be attacked by spring dead spot, and then quite often, the disease hit areas that contained excessive mat and thatch. Mat and thatch removal met with moderate success. Fertility levels were varied, wetting agents were added to chemicals, bermuda turf and overwatered and underwatered, different proportions of fertilizers were tried, all to no avail.

In recent years, a definite pattern of activity of spring dead spot has been observed and earlier hypothesis confirmed, among these are: 1) a dead spot will appear in spring as the new grass begins to green up, the spots will range in an area from 3 inches to 4 inches in diameter up to 2 feet to 3 feet in diameter; 2) runners that extend into the dead spots from surrounding healthy areas are weak, put down weak roots and will not peg down in the spots. The roots will not survive the winter and the spots may or may not reappear in the same locations the following spring; 3) the causal organism, if perhaps an organism is involved, is active during the growing season, but is not so pathogenic that symptoms appear on the leaves; 4) this disease activity in the fall, if not halted with a fungicide before the bermuda growth has stopped, will produce dead spots the following spring.

At the present time, Kozelnicky, in Georgia, has evidence to indicate that gypsum may be instrumental in reducing spring dead spot in the field. This basic phenomenon was observed by Jack Lair working with the spring dead spot condition in North Texas. Lair observed the incorporation of organic and inorganic materials in the spring dead spot areas seemed to reduce the severity of the condition. It has been assumed that spring dead spot is confined to the heavier soils. This has not been necessarily true, as some of the spring dead spot reported from Georgia has occurred on sandy greens, and likewise, this has been true in parts of Oklahoma.

At this point, you will probably ask "So, what's new with spring dead spot?". Well, there have been some interesting developments during the past few years that are worthy of at least a brief mention: 1) spring dead spot may run in cycles; 2) after several years of caution and hesitancy, turf managers are finding that routine use of fungicides in the fall will help reduce the spring dead spot severity; 3) while thatch removal several years back did not ease the spring dead spot problem, the presence of excessive thatch has been a real deterrent to control of the disease; 4) adding potash seems to have no effect on spring dead spot, one way or the other.

Where do we go from here, as regards to the spring dead spot problem? Time and results from current studies will supply the answer. Certainly more will be learned about the disease itself. Also, much less cumbersome control methods and chemicals can be expected in the future. For example, drenching in fungicide is always a problem, especially during the winter months when water lines may be drained. To solve this problem, perhaps dry granular chemicals may be offered. Then there will arise the problem of how to get these into the soil with the fungus organisms. Following a preventive disease control program will help reduce the loss from the spring dead spot problem, just as this excellent management practice has helped us cope with other turf disease problems.

ST. AUGUSTINE GRASS MANAGEMENT - CULTURAL PRACTICES

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INTRODUCTION

Turf management was originally considered an art rather than a science. Many turf management practices evolved through experience and observation were passed from generation to generation. Most of the scientific developments in turf such as new grass varieties, speciality fertilizers, pesticides and mowing and cultivating equipment occurred after 1946. Although grasses, chemicals and equipment are continuously changing to meet the needs of the turf manager, the cultural aspects of turf management remain the same. Through experience and observation, trial and error or research and development basic principles have been developed for the culture of St. Augustine grass lawns. The cultural aspects of turf management considered here include mowing, watering, fertilizing and cultivation.

MOWING

Mowing practices affect the growth and development of the turfgrass perhaps more than any other maintenance practice. Density, texture, color, root growth and other measures of turf quality are influenced by mowing. Mowing at the proper height and frequency is essential to having a well manicured lawn. Close and infrequent mowing results in scalping and burning of the turf. Mowing too high results in thin, spindly turf. St. Augustine grass should be mowed at a height between 2 and 3 inches depending on the degree of shade.

St. Augustine growing in heavy shade should be mowed higher than when grown in full sunlight. Reduced light (shade) promotes plant cell elongation. Thus, both leaf and intermode (stem) length are greater and the grass develops a weaker turf than under full sunlight. Close mowing under these conditions removes much of the leaf tissue and further weakens the turf. Raising the mowing height under shaded conditions increases the leaf area of the grass and helps it maintain growth.

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Mowing frequency is another factor that affects the appearance of a turf. When a turf is mowed frequently only a small percentage of the leaf area is removed at each mowing. Consequently, the growth and development of the turf is not greatly interrupted. On the other hand, infrequent mowing removes a large percent of the growth and severely shocks the turf. As a general rule, the shorter the mowing height, the more frequently the grass should be mowed. Thus, St. Augustine grass mowed at 2 inches or less requires mowing at 4 to 5 day intervals; whereas, grass mowed at 3 inches requires mowing about every 7 days. However, mowing frequency will depend primarily on the growth rate. During spring and early summer the grass will grow much faster than at other times. Another general guideline is to remove no more than 30 to 40 percent of the growth at any single mowing. Thus, grass mowed at 2 inches should be mowed when it reaches 3 inches in height.

Grass clippings contain valuable plant nutrients and add organic matter to the soil when left to decompose in the turf. Removing these clippings depletes the soil of nutrients and organic matter. However, if the mowing frequency is not adequate, large amounts of clipping are left on the surface after mowing and should be removed to prevent smothering the grass. Mowing height and frequency should be adjusted so that the grass clippings may be left to decompose and recycle nutrients through the turfgrass. If mowing practices are adequate the grass clippings will decompose very readily and will not significantly add to thatch accumulation. Fertilization rates may be reduced when grass clippings are not removed.

WATERING

Watering St. Augustine grass lawns is essential to maintain a green turf in many areas of the State. If lawns are watered, thorough and infrequent watering is a better practice than light and frequent watering. Lawns watered thoroughly and infrequently develop a deeper root system and have a lower water use rate than lawns watered lightly and frequently. Light, frequent watering results in shallow-rooted turf that is highly susceptible to drouth injury. Only during very hot, dry days when the grass shows signs of wilt is light watering beneficial to the grass. Then, the purpose of the water is only to cool the grass through evaporation. Under these conditions only the grass should be wet, the soil should not be soaked. Evaporation cools the temperature around the leaf several degrees and reduces the rate at which the grass utilizes water.

Lawns with a thatch layer present a special watering problem since dry thatch resists water and causes localized dry spots. Water tends to run off of heavily thatched turf rather than move into the soil. Under these conditions light, frequent watering may be necessary during the summer. Also, the use of a wetting agent may improve water penetration through the thatch layer.

The time of day to water a lawn is a question still open for discussion. In mid-summer less water is lost through late evening watering than day-time watering since evaporation is reduced during the night. However, early morning watering is best from a disease development standpoint since the leaf surface drys more rapidly. Thus, if water conservation is the primary concern, evening watering is recommended. On the other hand, if lawn diseases are the main concern, early morning watering is recommended.

FERTILIZATION

Nitrogen is the fertilizer nutrient required in the largest amount by turfgrasses. Turfgrasses normally contain from 3 to 4% nitrogen on a dry weight basis, providing nitrogen is not deficient in the soil. Nitrogen is considered deficient in the leaf tissue of turfgrasses when the level is below 2.2%. Turfgrasses respond to nitrogen in a number of ways including increased density, darker green color, greater drought resistance, faster recovery rate and greater traffic tolerance. However, excess nitrogen fertilization can lead to problems such as decreased drought tolerance, thatch accumulation, increased insect and disease susceptibility and excessive mowing requirements.

As a general guideline St. Augustine grass requires 2 to 3 pounds of nitrogen per 1000 square feet per year to maintain desirable color and density. Most of the nitrogen should be applied in the spring and late fall. Mid-summer and early fall applications generally encourage chinch bug and brownpatch problems. Sandy soils require more frequent fertilizer applications than clay or clay loam soils since nitrogen is readily leached through sandy soils. Also, if grass clippings are removed, fertilization rates must be increased to compensate for the nutrients removed in the clippings.

Brownpatch and chinch bugs are two major pests of St. Augustine grass that are encouraged by excess nitrogen fertilization. The succulent tissue produced by the soluble nitrogen materials is particularly susceptible to insect and disease attacks. Turf fertilized with organic and slow-release nitrogen sources is not as susceptible to chinch bugs and brownpatch.

Late fall fertilization of St. Augustine prolongs winter color and promotes early spring recovery. Fall fertilization should consist of a complete fertilizer or should conform to soil test recommendations.

CULTIVATION

Nature has provided numerous organisms to aerate the soil. Earthworms, mole crickets, gophers, ants and other organisms continuously cultivate the surface inches of the soil by repeatedly bringing the soil to the surface. Elimination of these organisms from the lawn and the addition of traffic create compacted surface layers in many lawns. Likewise, the use of water high in sodium for irrigation disperses the soil aggregates and increases surface compaction. To alleviate compaction and increase the movement of air and water into the soil, mechanical aerators may be necessary. Coring, spiking and grooving equipment is available for aerification of compacted lawns. This equipment may be rented or purchased or the service may be contracted in some localities. Aeration in the spring and fall to correspond with fertilization dates would be ideal from the viewpoint of root development, thatch decomposition and water infiltration. However, where good quality irrigation water is available and traffic is limited, annual, or less frequent, aeration may be satisfactory.

Chemical aerators such as wetting agents may be practical in special circumstances. For example, water infiltration in a turf that has developed a heavy thatch layer may be increased by a wetting agent, since a dry thatch layer is very difficult to wet. Also, gypsum may improve aeration in a soil that has developed a high sodium content due to poor quality irrigation water. However, these materials are effective only when special conditions exist.

Mechanical dethatching of a turf with vertical mowing units or by scalping the turf in the spring is also an effective cultivating practice. Dethatching should be done in early spring after the last expected frost. Vertical blades on the dethatching unit should be 3 to 4 inches apart for St. Augustine grass. Also, the unit should be operated in only one direction on St. Augustine grass. The material brought to the surface by the vertical mower should be removed from the turf. Scalping the turf by lowering the mowing unit by ½ to 1 inch at the first mowing in the spring and removing the residue is also an effective method of dethatching. Dethatching by one of these methods should be done on an annual basis for best results.

Adequate research information on chemical dethatchers is not available on which to base recommendations. However, none are currently recommended by the Texas Agricultural Extension Service for thatch control in St. Augustine grass.

Top-dressing with a soil or a soil mixture is another effective cultural operation. Top-dressing helps to reduce surface compaction, to encourage thatch decomposition and to improve water and air movement into the rootzone. A sandy loam soil, a soil-organic mixture or a sand-soil-organic mixture should be used for top-dressing a turf. Generally 3/4 to 1 cubic yard of top-dressing per 1000 square feet is recommended. Top-dressing is only recommended for intensively managed turf, since it requires considerable labor where mechanical equipment is not available.

DISEASE CONTROL ON ST. AUGUSTINE GRASS

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St. Augustine grass is a basic lawn grass for south, central, and east Texas. Numerous diseases can and do affect this species of grass, and, in some cases, constitute a limiting production factor. In other cases, they affect the appearance of the grass and result in an undesirable condition.

One of the most common problems on St. Augustine grass is brown patch. This disease is caused by a fungus known as Rhizoctonia solani which is omnipresent. In addition to causing brown patch on St. Augustine grass, it also causes seedling disease on many types of field and garden crops. Rhizoctonia sp. always seems to be present in St. Augustine grass stands. Even when no symptoms are apparent, one can find the organism on the stolons.

The most notable symptom is a circular brown patch in the green lawn. At times one may also see individual blades affected throughout the lawn, and the general lawn area will have a yellowish cast. One can easily pull the blades from the stolons. This results because the fungus deteriorates the sheath of the plant and causes it to turn loose from the stolon very easily.

Typically, brown patch occurs when nights become cool in the fall of the year. It can also occur in the spring when the days are warm and the nights are cool. Traditionally, one learns to expect the disease at a given time each year. It also has a tendency to occur in the same areas year after year.

Control has traditionally been accomplished by use of PCNB (Terraclor). Several other materials are also effective but must be applied more often in order to get effective control. A number of observations have also been made on Floratam, indicating it has some degree of resistance to this disease organism.

Another disease which is often observed is downy mildew. This causes light colored streaks in the leaves but usually does not represent a serious problem on St. Augustine grass. It is more of an oddity and may cause people to become concerned thinking that it may become more severe. No chemical control is effective at this time.

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Several leafspots affect St. Augustine grass and among these are Helminthosporium and Piricularia. Helminthosporium is not a common leaf spot disease but can be quite severe when conditions are favorable for its development. The broad spectrum fungicides have been effective in controlling this condition.

The brown spot or gray spot condition caused by the fungus, Piricularia, is widespread and extremely common. Spots from this fungus can be found in almost any St. Augustine grass lawn at any time of the year. It usually causes severe damage in shaded areas and in areas where the lawn is newly established. Under these conditions chemical control may be necessary. Fortunately, it is easy to control with most of our turf fungicides.

Fairy ring is another problem that often is observed in turf areas. Mushrooms appear in a circular area and may raise considerable curiosity. As a general rule, we do not need to use fungicides on this problem in this part of the country. In the more northern areas they do have a serious problem with it. The fungus develops in an organic matter source in the soil and produces the fruiting structures or mushrooms at the edge of that source. If chemical control is needed holes will need to be punched and strong concentrations of fungicides placed in these holes.

St. Augustine decline is a virus condition of St. Augustine grass. It can cause serious devitalization of lawns, and lawns do not respond as favorably as they should to lawn management. Even though the grass may be maintained in a reasonable fashion over a period of years, it requires a heavier degree of maintenance. If this maintenance is not given the grass may completely die.

The most reasonable approach to controlling St. Augustine decline is to re-sod with Floratam. This type of St. Augustine grass has not become infected to this point, and it seems to be a reasonable solution to the problem. There are no chemical controls for virus diseases of plants at this time.

Fading out is a common problem on St. Augustine grass occurring in the summer. Secondary organisms are involved; however, this problem usually boils down to being one of an adequate maintenance. Usually, thick thatch condition is present when fading out is a problem. If this is avoided, fading out usually can be prevented. The maneb type fungicides have been most effective in controlling the fading out process. The use of cultural practices to prevent the condition from occurring are more satisfactory than trying to approach control from a chemical standpoint.

Nematodes often cause problems in St. Augustine grass. Since nematodes are microscopic, laboratory procedures are required in order to observe this particular organism. The Plant Nematode Detection Laboratory is maintained for the purpose of running analyses for this organism. A charge of $2.00 per sample is made. A pint of moist soil taken from the root zone is needed to check for this condition. Forms for submission of samples to the Plant Nematode Detection Laboratory are available from each county Extension agent's office.

Diseases of St. Augustine grass can be diagnosed and controlled. Suggestions given in the fact sheet entitled "Control of Diseases in the Home Lawn" will give information on cultural and chemical control of these problems.

CULTURAL PRACTICES - BENTGRASS

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Temperature and humidity are two major factors that control the growth of bentgrass. Throughout most of Texas, especially the Northeast, Central and Southern areas of the state, the high summer temperature with its attendant adversity probably is the controlling factor in limiting satisfactory growth of bentgrass on putting greens. To overcome these effects the superintendent must exercise as much control over the plants' environment -- macro and micro -- as is possible. In fact, success with bentgrass greens depends to a large extent on the capability to develop a soil to manipulate through modification and cultural practices so as to create an environment favorable for growth in spite of climatic adversity.

Soil. To ensure favorable air-water relationships, greens must be constructed with good drainage characteristics. This would include tile and a permeable soil (sandy texture with at least 50% of the sand fraction in the medium range, 0.25 mm to 0.50 mm, and 25% in the 0.50 to 1.00 mm range) to handle internal drainage and a surface contoured to conform to that of the sub-grade in order to handle surface drainage. Without these basic components and considerations, it is unlikely that good greens will exist or persist during periods of heat stress, especially in the areas where bent is only marginally adapted.

Grass. Penncross, Seaside and Emerald are the three seeded bents available for putting greens. Where traffic and play is heavy, Penncross, because of its vigor, probably is the better choice. For the most part, seeded types are preferred because of the ease with which damage can be repaired. Also, to ensure strong vigorous turf year after year, it is suggested that a light annual overseeding in the early fall (or spring if needed) will be most beneficial. This annual introduction of new young plants seems to produce a more vigorous tolerant turf with less weed infestation, especially Poa annua.

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For those who prefer the vegetative types of bentgrass, Cohansey (C-7) would appear to be the best choice. Its maintenance, as well as other vegetative selections, once established, is similar to that of the seeded types, except for the introduction of new plants (stolons), and the repair of damaged areas is not as easily accomplished as is the case with seeded bents.

Cultural practices. The cultural practices applicable to turfgrass, including bentgrass, may be listed. They are: fertilization, watering, cultivation, mowing and programs to control pests -- disease, insects and weeds. The application, control and timing of these practices is critical to the survival and satisfactory maintenance of bentgrass putting greens. Each has a direct impact on the favorable (or unfavorable) growth of bent. Also, each has an indirect impact on the health and condition of the grass. This indirect impact stems from the direct influence each cultural practice has on the other. For example, excess fertilization at times when temperatures are too high to be conducive to good growth may be partially counteracted by an adjustment in watering practices, the application of a pesticide, spiking or modification of mowing practices. Control, or the ability to manipulate cultural practices to modify an unfavorable environment or to counteract unexpected adversity, is dependent upon the resources in the form of equipment, tools, materials and supplies available to the superintendent and upon his ability to anticipate, react, direct and control the resources available to him. Such is the art and the science of turfgrass management.

No effort will be made to discuss in depth each cultural practice as it relates to the other or as they in total relate to the growth of bentgrass greens. Rather, a brief summary of each is presented.

Fertilization practices for bent greens have to be keyed to the growth characteristics as related to response to temperature and balanced against the soil reserves (soil test) and degree of play. Nitrogen applications during the summer months must be kept to a minimum. Preferably the program would not call for the use of nitrogen during July and August. Slowly available sources of nitrogen -- organic or synthetic that act like organics -- are the best choice for summer treatments when they are made. Even with these materials it is best to use small amounts -- 1/2 to 3/4 pounds per 1,000 square feet. This provides the superintendent with a greater degree of control.

The maintenance fertilizer applied in the fall or late winter should be based on a properly interpreted soil test. Supplemental feedings of nitrogen should be based on the color and growth response of the grass keeping in mind the relationship of temperature and growth.

In a number of areas of the state, pH levels are high enough to cause iron chlorosis. Spraying with iron sulfate or one of the chelated irons corrects this deficiency. Since this is a temporary correction repeated sprayings may be required.

Watering practices need to be programmed to provide maintenance levels of moisture and to assist in temperature regulation. Maintenance irrigation is based on water use rates (a reflection of temperature) and on soil water-holding capacity. Syringing to counteract excessive transpiration and to avoid wilting is an essential factor. An automatic irrigation system, properly designed, installed and programmed, provides the superintendent an opportunity to exercise the greatest degree of control.

Cultivation of greens is accomplished by the use of coring, slicing and spiking devices. Coring and, under most conditions, slicing should be done only when the grass is growing most actively -- spring and fall. Care must be exercised to avoid wilting or drying out (burn) around the holes. Greens may be spiked at any time. This is the recommended practice during summer months when it becomes necessary to correct a crusted condition.

Mowing with a sharp properly adjusted mower that receives good servicing and good maintenance is essential for production of good bentgrass greens. Height of cuts from 3/16 to 1/4 inch are standard for bent greens. During periods of prolonged or extreme heat stress it may be beneficial to raise the height of cut 1/32 or 1/16th of an inch. And, where play and club policy permit, skipping a daily mowing also will be most helpful.

Programs to control pests and eliminate and control thatch must be developed and programmed on basic considerations. Disease producing organisms are universally present. Bentgrass serves as a host for the organism and when environmental conditions (particularly temperature and moisture) are optimum for growth of the organisms, disease will result. Identify the disease and select the appropriate fungicide. To control insects, identify the nature of the feeding habit -- whether a root or a leaf feeder. Know the life cycle, then choose the appropriate insecticide and apply it in accordance with the feeding habit of the insect and the manufacturer's recommendation. In the control of weeds, identify the weed; then choose the appropriate herbicide and apply it in accordance with manufacturer's recommendation. Select pre or post emergence material based on type of weed and time of the year.

Develop thatch prevention programs, then eliminate the condition and control it by (a) mechanical means (verti-cutting lightly, combing, and good mowing practices), (b) chemical means (adjust fertilization practices) and (c) biological means (topdressing).

Cultural practices associated with care and management of bentgrass greens must be developed and implemented with care. They are critical to good bentgrass growth especially in those areas of the state where the plant is marginally adapted. To a large extent success with bent greens depends upon the air-water relationships of the soil. In this respect it is mandatory that greens be constructed with permeable materials and tiled to ensure good drainage.

BENTGRASS MANAGEMENT - ANNUAL BLUEGRASS CONTROL

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Annual bluegrass, Poa annua L, is one of the most widely distributed weed grasses, being found in nearly all parts of the world. Perennial types of annual bluegrass are commonly found in association with annual types. Perennial types persist in bentgrass golf greens for a number of years and form distinct patches in the turf. The general appearance and uniformity within these patches indicate that they developed from a single seedling. A survey conducted in Oregon indicated that in excess of 50% of the annual bluegrass plants collected had perennial characteristics. Whether a site has the annual or perennial plant type or a mixture of the two types will certainly influence the management and control of the stand.

Hitchcock describes Poa annua as tufted, erect to decumbent (spreading), sometimes rooting at the lower nodes and thriving in the winter in the warmer parts of the U. S. Annual types tend to have an upright growth habit, few secondary tillers, prolific seedhead production, minimum rooting on the tiller and six nodes or less per tiller. Perennial types have a creeping growth habit, numerous secondary tillers, minimal seedhead production, several secondary roots on the prostrate tillers and more than six nodes per tiller.

Because of the plants' decumbent tillers, annual bluegrass is able to flower and produce seed under conditions which would prevent most grasses from doing so. Seedheads may be initiated throughout the growing season, but profuse seeding occurs in late spring. This profuse seeding is one of the main objections to annual bluegrass. The seedheads create an unsightly contrast with bentgrass and can interfere with the trueness of the putting surface. Most of the seed are dormant following their formation, but germinate readily the following fall. Thus, the annual types are readily re-established even when mowed close and frequently.

Establishment and maintenance of annual bluegrass is influenced by a number of environmental factors. Light and temperature are of primary

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importance to the germination and growth of annual bluegrass. Germination is increased by increasing light penetration. Practices such as close mowing, aerification and vertical mowing stimulate annual bluegrass germination. In studies at Texas A&M University, a bermudagrass putting green mowed at a height of 1/8 inch had a significantly higher population of annual bluegrass than an adjacent green mowed at a height of 3/16 or 1/4 inch. Work at the University of California demonstrated that vertical mowing and/or aerification of bentgrass turf in the fall increased the population of annual bluegrass.

High soil moisture is another factor important to the germination and maintenance of annual bluegrass. Allowing the soil surface to dry between irrigations will decrease the survival of germinating seedlings. Also, high soil moisture is necessary to the survival of annual bluegrass throughout the summer months. Again, if irrigation frequencies permit the surface soil to dry between irrigations, the population of annual bluegrass will be reduced.

Soil nutrient levels also influence the maintenance of annual bluegrass. Annual bluegrass appears to be more susceptible to low phosphorus levels than bentgrass. Where managers wish to control annual bluegrass, phosphorus levels should be kept as low as possible. When trying to maintain annual bluegrass, frequent phosphorus applications will encourage the survival of annual bluegrass plants.

Annual bluegrass and bentgrass have similar growth patterns and both are susceptible to severe injury and thinning during environmental stress periods. Consequently, the elimination of annual bluegrass from a bentgrass turf requires very close control of cultural practices and some modification of environmental stresses. The degree of annual bluegrass infestation must be considered in any management program. For example, if a bentgrass turf consists of greater than 40% annual bluegrass, elimination of the bluegrass in late spring or summer would result in a very poor putting surface. Under these conditions the turf should be managed to maintain the annual bluegrass through the summer with renovation delayed until fall when the environmental conditions favor bentgrass recovery. In contrast, if only 10 to 15% of the turf is annual bluegrass, measures should be taken to remove this during the summer.

Where the decision has been made to eliminate the annual bluegrass the management program should include the following cultural practices:

1) Irrigate only when the bentgrass needs water (allow the soil surface to dry between irrigations),

2) Syringe only when needed by the bentgrass,

3) Apply low rates of nitrogen and potassium during the growing season (including summer),

4) Keep soil phosphorus levels low, if possible,
5) Aerate bentgrass in the spring and summer,
6) Raise mowing height to 1/4-inch during summer months,
7) Verticut greens only in the early spring, and
8) Apply preemergence herbicides in early fall to reduce annual bluegrass germination.

If perennial types of annual bluegrass are dominant, preemergance herbicides will have little immediate effect. However, their use over a period of years should reduce the population of annual bluegrass. Cultural practices such as infrequent irrigation, nitrogen applications throughout the growing season and reducing phosphorus levels will help to eliminate the perennial type plants.

In situations where it would be desirable to maintain annual bluegrass throughout the summer, the management program should include the following cultural practices:
1) Light and frequent irrigation,
2) Syringe as necessary to prevent wilting,
3) Fertilize only during spring and fall,
4) Keep soil phosphorus levels high,
5) Avoid summer aeration and verticutting, and
6) Mow at 1/4-inch or 5/16- inch height.

Where preemergence materials are used to prevent annual bluegrass establishment from seed, they should be applied prior to annual bluegrass germination in early fall and again in mid-winter. Herbicide recommended for annual bluegrass control in bentgrass greens include bensulide (Pre-San, Betasan) and DCPA (Dacthal). Timing of the early fall application is critical since it should not be applied prior to the time that bentgrass recovers from summer stress; yet, it must be applied prior to the germination of annual bluegrass. In Northwest Texas the time of application would be September 1; whereas, in the Dallas-Ft. Worth area it would be about the third week of September. The second application should be made 90 days after the initial treatment. The use of bensulide in the fall and winter for annual bluegrass control will provide some control of crabgrass the following spring.

In summary, annual bluegrass can be controlled through intensive management practices that favor bentgrass and through the use of preemergence herbicides. However, if annual bluegrass is the dominant species in the turf, management practices should favor the survival of the bluegrass through the stress period of midsummer.

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SUB IRRIGATION OF BENTGRASS GREENS

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Natural underground barriers which restrict the rootzone of turfgrasses have been an important part of turfgrass culture for several decades. The most common natural barrier is provided by soil compaction which results from the breakdown of soil structure. Although compaction may occur in the top several inches of soil, the condition is usually alleviated near the surface by cultivation practices such as spiking and aerification. Below this depth of cultivation the soil remains compacted and then functions as a natural barrier. Usually this kind of barrier is detrimental to turfgrass management because it is too near the surface and restricts root and water penetration. This natural barrier is common to heavily trafficked turf (such as golf tee and putting green areas) grown in medium and fine textured soils and has been of great concern to golf course superintendents for many years.

The recent increased use of sand or sandy soils for the growth medium in areas subject to compaction has been a major development in eliminating compaction problems. Since sand has no structure which will break down, it provides ample pore space for water and air movement even under maximum compaction. The disadvantage of using sand is that water moves through it too freely and its capacity to retain water is too small. Attempts to circumvent this problem have resulted in providing a coarse gravel layer or a plastic barrier below the sand to restrict or eliminate downward water loss from the sand. Use of either type of barrier increases the amount of available water held in the sand rootzone.

Research was initiated in 1972 at the University of Arizona to investigate the merits of subirrigation of 'Penncross' bentgrass utilizing a plastic barrier two feet below the surface. The research compared subirrigation and nitrogen fertilization from a static water table (SWT) one foot below the surface; a water table which was allowed to fluctuate (FWT) between about 4 and 20 inches; and conventional sprinkler irrigation (SI). Washed sand and a 2:1:1 mixture of washed sand, sandy loam soil, and Loamite[1] were compared in conjunction with the irrigation treatments. A detailed description of the research is provided elsewhere.[2]

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[1]A product formerly processed from wood by the Loamite Corp., Santa Rosa, Ca.

[2]Krans, J. V. and G. V. Johnson. 1974. Some Effects of Subirrigation on Bentgrass During Heat Stress in the Field. Agron. J. 66:526-530.

Results and Discussion

Growth. Clipping yields tended to decrease from the initial sampling in early July until a minimum was reached in mid-September. This minimum was followed by a slight general increase through October (Fig. 1). These general variations in yield appear to be related to variation in daily temperature maximums. The highest temperatures occurred in late July and early August and coincide with the smallest or lowest yield. Yields continued low in July and September as temperatures remained high. As temperatures decreased in October, yields tended to increase. These trends in apparent temperature related yield variations suggest that the periods of greatest heat stress on yield occur in August preceded by about 2 months of daily temperatures above 32^{o}C (90^{o}F).

During the initial stress period in early July, clipping yields remained highest from the turfgrass grown in the sand-soil-Loamite mixture. These plots, however, tended to produce the lowest yields during the period of greatest stress in September. Within these two soil materials, the subirrigation FWT treatment produced significantly more clippings than the surface irrigated plots during both the period of initial heat stress and the period of acute heat stress. Recovery from heat stress was greatest for the surface irrigated plots.

Color. Variations in color appeared to be associated with temperature variations in a manner different from that for growth. Turf color was not reduced as markedly as yield by high temperatures early in the summer (Fig. 2). The amount of color was least in late July and early August, followed by a general increase thereafter. Color differences associated with the two artificial soils were not consistent throughout the study. Surface irrigated plots were consistently greener, however, than subirrigated plots. Of the subirrigated treatments, plots with a FWT tended to recover faster from the early heat stress than did SWT plots. Individual plants on the subirrigated plots exhibited symptoms of N deficiency during the period when overall color was low. Additional fertilizer applied on the subirrigation treatments increased the amount of available N present in the root zone, but did not improve color. Detection of nitrate-nitrogen levels in the soil solution as high as 2.5 ppm in early August suggest that the poorer color of the subirrigated plots was a result of anaerobic conditions which adversely affected N assimilation and/or metabolism. This was further evidenced by the fact that when levels of available N much higher than normally considered adequate were provided by injection of N 5 cm below the surface, a dark green color resulted.

Root Distribution. Total root mass and its distribution with depth in the soil influences the degree to which turfgrasses can tolerate periods of head related moisture stress. Root distributions for the six treatment combinations are presented graphically in Figure 3. The root mass was greater and its extension deeper (growth to 50 cm or 20 in) in the sand material than in the mix. This difference may be explained by the greater % air-filled pore space and lower levels of available N associated with the sand material (Tables 1 and 2). Greater root masses resulted from subirrigation with the FWT than with an SWT which in turn was greater than with surface irrigation. The large root masses associated with the FWT treatment are likely a result of the excellent moisture and aeration conditions provided by this treatment. Likewise, the decreased aeration and increased wetness of the SWT treatment may account for the reduced mass of roots associated with surface irrigation is likely a reflection of the amount and distribution of available moisture under this treatment, as well as the higher concentration of nitrogen in the top 5 cm (2 inches) which encouraged top growth at the expense of root growth. Surface applied water on the sand material quickly moved downward resulting in an even distribution with depth of available water and air filled pore space, whereas, in the mix, sufficient available water was held in the upper 5 cm to supply the plant's needs. The most favorable aeration in the mix also occurred in the upper 5 cm and would tend to encourage root growth at that depth.

Consumptive Water Use. Consumptive use of water by bentgrass irrigated from a stable water table for a one year period totaled 59 inches for the sand and 53.5 inches for the sand-soil-Loamite mix. These values are considerably less than the amount of water normally used for sprinkler irrigation and indicate that subirrigation may provide a means for substantial water savings. On a daily basis, use ranged from about 0.2 inch in August to 0.05 inch in January.

Additional Observations. Damage to the turfgrass from insects or disease was not apparent nor was there evidence of any nutrient deficiencies or disorders (aside from that already discussed in relation to N) on any of the plants. Moisture stress, manifested as temporary wilting, was most apparent on the surface irrigated plots especially those in which the turfgrass was grown in sand. Soluble salts did not accumulate to a degree harmful to the turfgrass.

SUMMARY

Bentgrass turf which was subirrigated with a fluctuating water table was less subject to summer heat stress than surface irrigated turf. A major problem experienced with the subirrigated turf was that of providing an environment conducive to proper nitrogen assimilation and metabolism. This problem seemed to be most severe when irrigation was from a stable water table. Since it did not occur until after several weeks of high temperatures, it may be unique to hot desert climates. The problem was avoided the following summer by surface fertilization of N. Dessication occurred more frequently in the surface irrigated turf than in that which was subirrigated.

Subirrigation appears to have some potential for maintaining bentgrass greens in regions characterized by several weeks of high temperature.

Table 1. Vertical distribution of NH_4^+- plus NO_3^-- N in two artificial soils irrigated by three different methods.

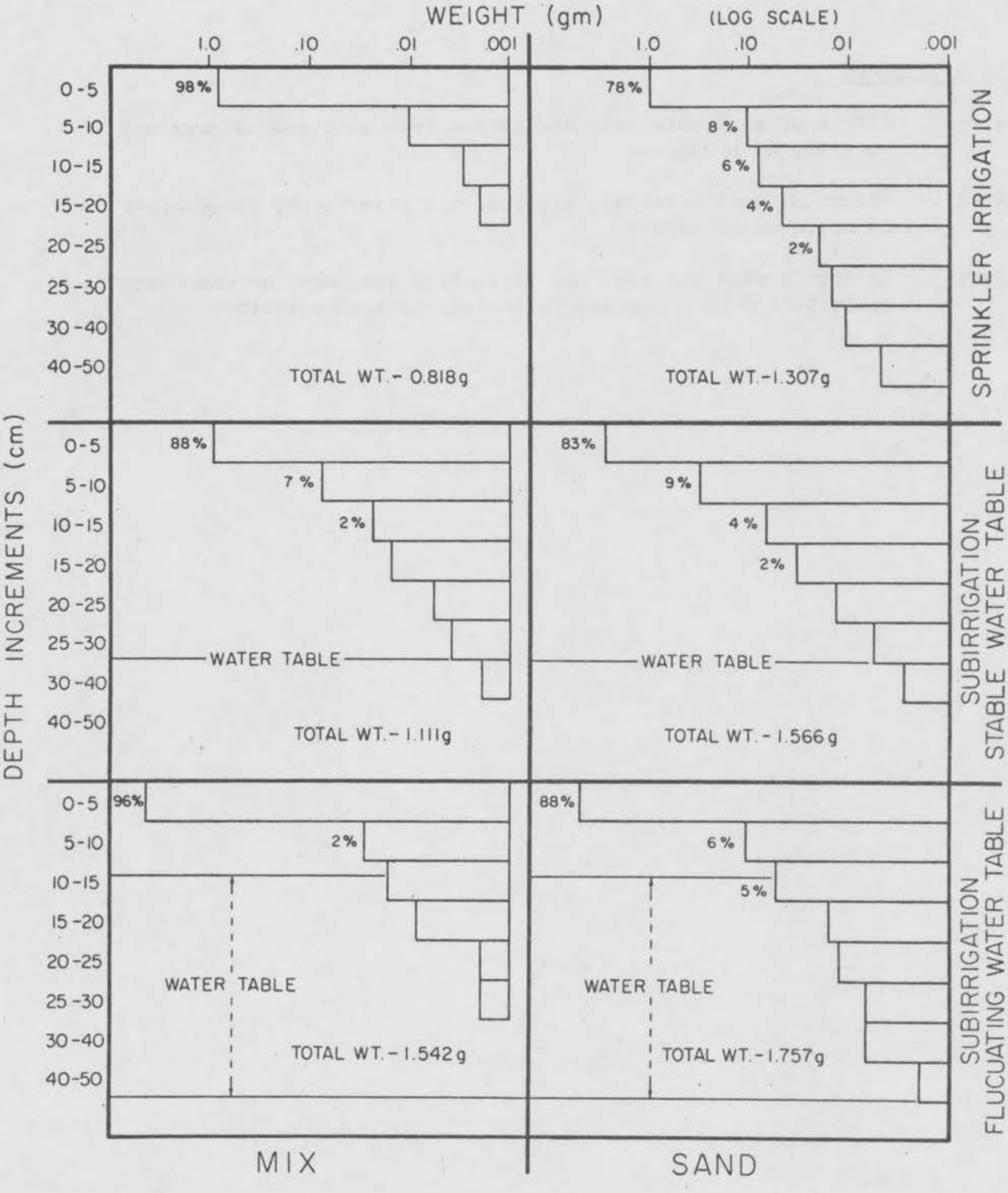
	IRRIGATION METHOD					
	Surface Irrigation		Subirrigation Stable H_2O Table		Subirrigation Fluc. H_2O Table	
Depth	Sand	Mix	Sand	Mix	Sand	Mix
cm	- - - - - - - - - - - - - - - - - -ppm N- - - - - - - - - - - - - - - - - -					
0-5	5.3	13.9	4.4	6.3	4.1	5.9
5-10	4.0	8.7	4.7	6.8	4.2	5.5
10-15	3.9	8 9	3.7	8.0	5.2	7.5
15-20	3.4	7.0	4.0	8.0	4.9	6.1
20-25	3.3	8.2	4.7	7.3	4.4	5.7
25-30	3.6	6.7	5.4	6.6	4.7	6.3
30-40	3.7	3.8	6.8	7.1	8.5	10.3
40-50	3.0	2.2	15.0	12.7	13.3	15.5

Table 2. Total and air filled pore space* in two artificial soils irrigated by three different methods.

Depth (cm)	Surface Irrigated				Irrigation Method: Subirrigation, Stable Water Table				Subirrigation, Fluctuating Water Table			
	Sand		Mix		Sand		Mix		Sand		Mix	
	Total	Air Filled	Total	Air Filled	Total	Air Filled	Total	Air Filled	Total	Air Filled	Total	Air Filled
	% Pore Space											
0-5	46	36	52	33	49	40	51	32	48	40	54	44
5-10	42	34	46	28	41	27	43	18	42	32	44	30
10-15	43	35	44	25	42	26	46	18	43	32	47	30
15-20	40	32	44	23	43	23	42	9	42	30	44	23
20-25	38	28	44	24	41	17	41	6	41	27	44	19
25-30	40	30	41	20	38	8	41	5	38	22	42	14

* Air filled pore space calculated as a percentage of total pore space.

<u>List of Figures</u>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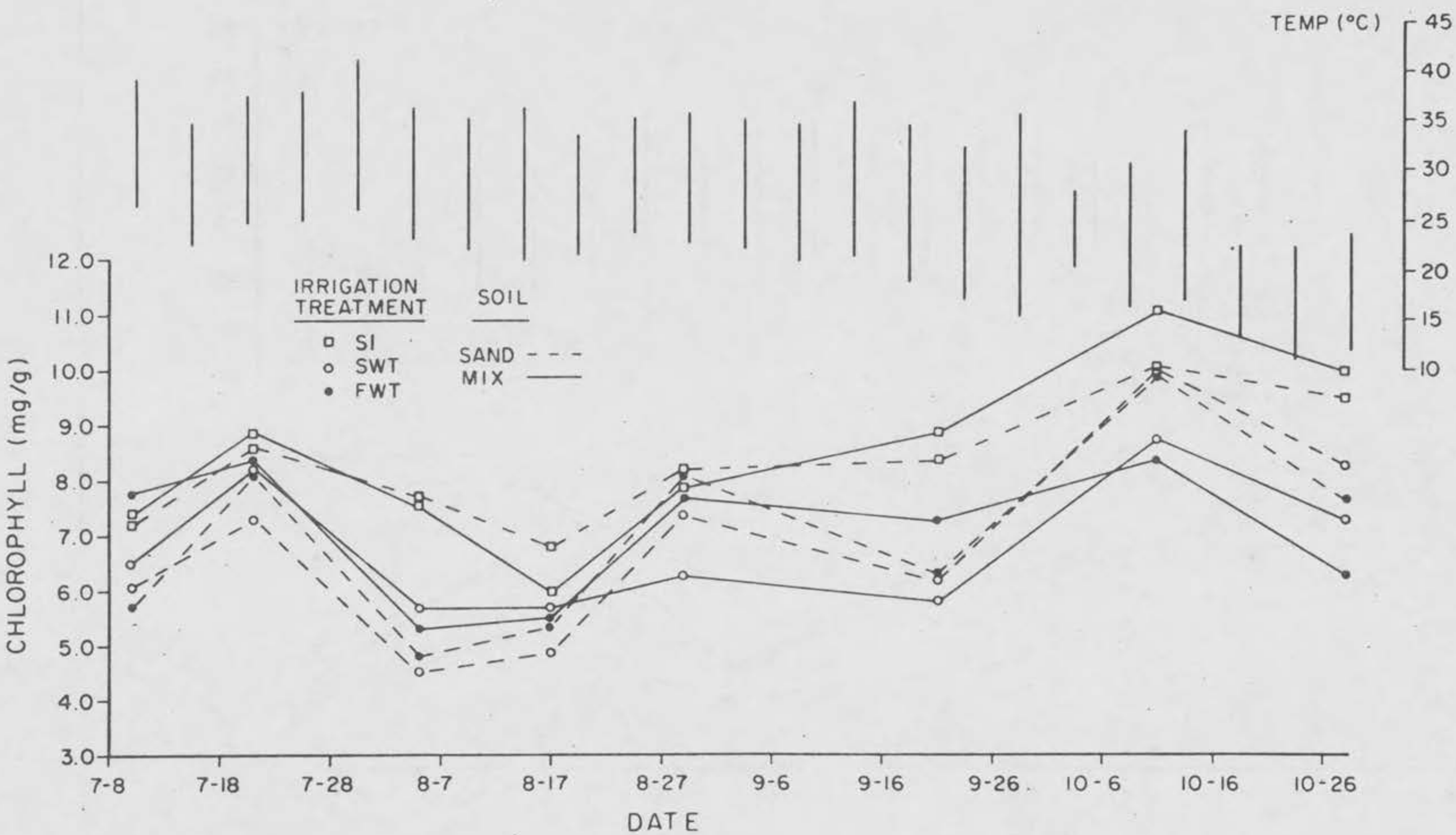
.01
.001
1.0
.10
.01
.001
DEPTH INCREMENTS (cm)
0-5
5-10
10-15
15-20
20-25
25-30
30-40
40-50
98%
TOTAL WT.- 0.818g
78%
8%
6%
4%
2%
TOTAL WT.-1.307g
SPRINKLER IRRIGATION
88%
7%
2%
WATER TABLE
TOTAL WT.- 1.111g
83%
9%
4%
2%
WATER TABLE
TOTAL WT. - 1.566g
SUBIRRIGATION STABLE WATER TABLE
96%
2%
WATER TABLE
TOTAL WT. - 1.542g
88%
6%
5%
WATER TABLE
TOTAL WT.-1.757g
SUBIRRIGATION FLUCUATING WATER TABLE
MIX
SAND


TEMP (°C)
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40
35
30
25
20
15
10
IRRIGATION TREATMENT
SI
SWT
FWT
SOIL
SAND
MIX
CHLOROPHYLL (mg/g)
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
7-8
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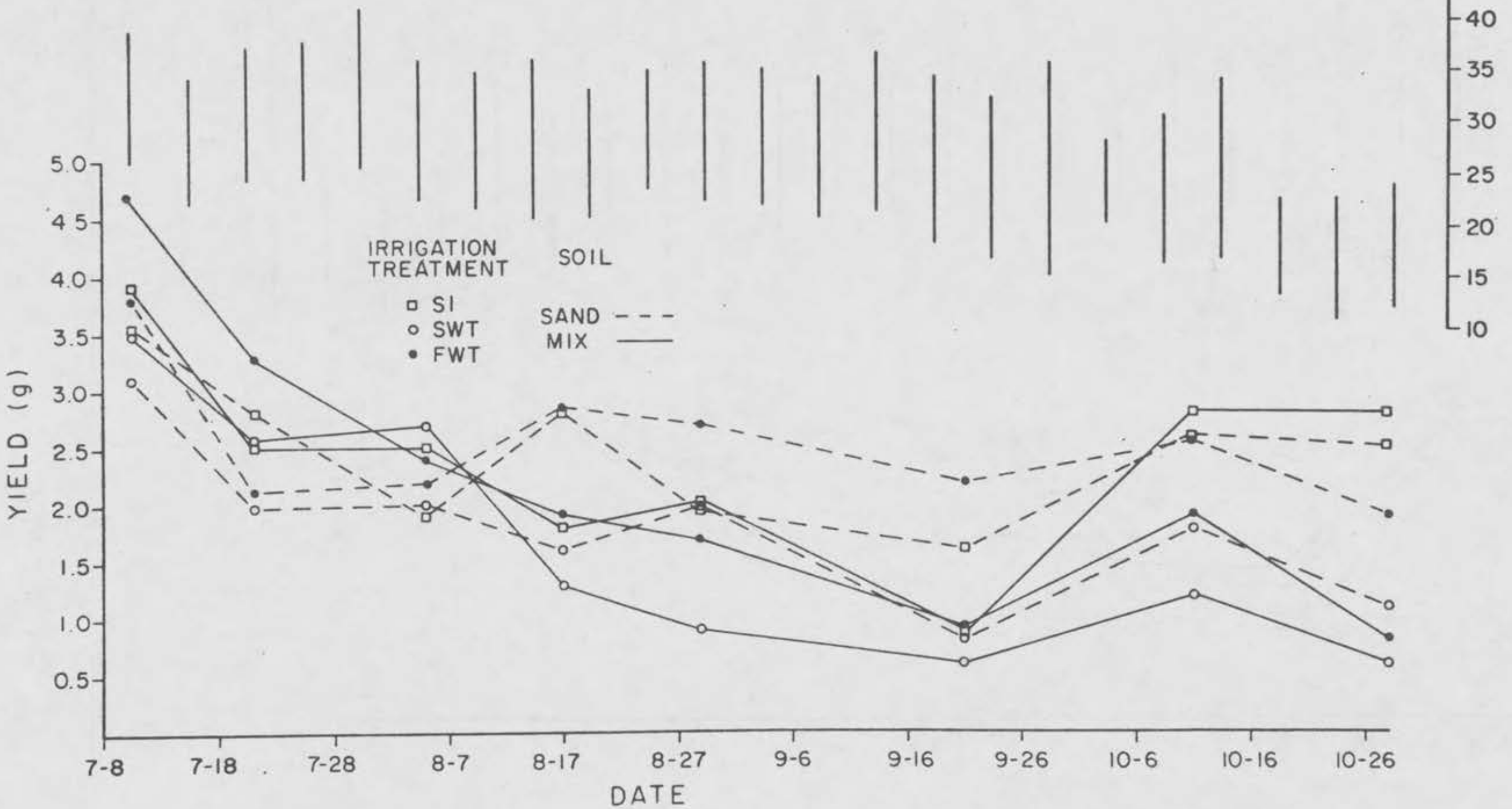
10-6
10-16
10-26
DATE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4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
YIELD (g)
IRRIGATION TREATMENT
□ SI
○ SWT
● FWT
SOIL
SAND - - -
MIX ——
7-8
7-18
7-28
8-7
8-17
8-27
9-6
9-16
9-26
10-6
10-16
10-26
DATE

THE OPERATION AND MAINTENANCE OF MOWING EQUIPMENT

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Introduction: I would like to thank Dr. Duble, Dr. Beard and the Turfgrass Association for inviting me to speak--

There are a few things you have to think about before you have any problem with operating or maintaining the equipment for mowing turf.

1) The turf area to be mowed!
2) Why do you want to mow it?
3) The proper equipment needed!
4) The personnel to operate and maintain it!

In 45 minutes there is no way that we can cover my topic in detail. But there are many points to be considered and many views we may take in solving operating and maintenance problems.

1) For example "<u>The area to be mowed</u>".

Basically for the selection of the equipment needed, you must consider the terrain and condition of the area. Steep hills, marshy areas, trees and other permanent obstacles may alter your thinking on the type of equipment needed to maintain the area.

Outside influences you may have to consider are: people in a park, children on school grounds, or the proximity of automobiles or windows to the area.

These may preclude using the rotaries and you must consider something safer like reels or flails.

Even the turf cover that you hopefully wind up with, can be a great influence on the equipment and the amount of maintenance needed on it.

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2) "Why do you want to mow?"

First of all, I'm sure, your aim is esthetic value. How pretty you can make it. This goes for every area whether it's a golf course, park, right down to the roughest highway or industrial site mowing.

In highly maintained areas such as golf courses and other athletic fields, selecting the correct mowing equipment could easily help you in controlling other problems such as weeds, insects, and turf diseases. The use of catchers, the night rollers, or vertical mowers for example will help keep down thatch build up and thus keep down those other problems.

Other reasons for mowing would include safety or visibility such as highway or street mowing.

Helping destroy insect habitat and breeding areas for better health conditions.

Mowing to knock down tall weeds and grass is also a good fire prevention tool.

3) "Selection of the mowing equipment."

If you have given every consideration to area and desired results, then selecting the equipment necessary to do the job becomes easier.

There is specialized equipment available for almost every need and every budget. Everything from 20" push rotaries to 20' hydraulic mowing tractors, and every conceivable thing in between. Even ones that float on air and some that cut with fishing line. But if there is one overriding thing I, as a representative of an equipment manufacturer, would advise you to consider, it would be "Where to buy it".

The distributor, his service and dependability of parts supply are major factors. No manufacturer makes a machine that from time to time won't need service and parts. Manufacturer's warranty is also important. Know what it is and use it. Manufacturers use warranties to your advantage. No, we don't want our machines to fail nor do we like to pay out money, but by the warranty method, we can find out the weaknesses and better engineer the product to eleviate it. Making a better product available to you.

4) Last but certainly not least in this list of pre-requisites is the personnel you have available to you for operating and maintaining

the machines. Of course, budgets and other circumstances will have vital bearings on this, but the success of your operation surely depends on the highest quality, best trained personnel you can find and afford. A 5-$6.00 per hour mechanic can more than save you the difference over a $3.00 per hour tinkerer. At the cost of parts, not to mention down time, you don't have to have many machines to maintain and service to save the 2-$3.00 difference in those two guys.

Operators should be trained too. Just because a guy can drive it without falling off don't make him an operator. He should be taught how to make the piece of equipment perform efficiently at the job it's designed to do. It's a working piece of equipment, not a toy. Not a race car.

Now we will discuss a little about some things I don't know a lot about and a lot of things I know a little about.

We will discuss four types of mowing equipment. Sickle bar, flail, rotary, and reel.

Some general information about sickle bars.

Operation:

For maximum efficiency it must be used slowly. No more than 2-3 m.p.h.

Can be used for extremely tall grass and weeds. Quality of cut at very best is poor. Mostly used by agriculture now but can be utilized by highways and industrial sites.

Problems and maintenance:

Hard to keep sharp.

Very hard to keep clean. It operates in dust and dirt and parts have great wear factor.

Under constant use, service consists of at least 1-2 times per week you have to straighten fingers, adjust wear plates forward, and tighten down hold down plates. Along with sharpening sickle and lubrication.

Advantages:

Safe.

Relatively low initial cost.

Operates in almost any type of grass or terrain.

Types:

Small self propelled units and tractor mounted.

Flails

Operation:

Relatively slow operation. For best quality of cut, run at 2-3 m.p.h. If you are not too concerned about quality of cut it can be operated at from 4-5 m.p.h. Can operate in 12-18" grass and weeds, but gives much better quality cut at 6-8" heights.

Problems and maintenance:

Many users of flails report some problems with bent or vibrating knife shafts. Most times they have to be replaced. Usual wear on bearings and spindle ends where you have a high speed shaft such as this.

As with other types of mowing units, knives must be sharpened to give good cut. If not, they will whip off the grass and leave grass in terrible shape. Good access for insects and disease.

Advantages:

Safe; cuts relatively high grass.

Types:

Small engine powered units. P.T.O. on tractor - P.T.O. on override needed on large.

Rotaries

Operation:

The fastest of all mowers. Many rotaries give acceptable quality of cut at 6-8 m.p.h. Blade tip speed is the key here. The faster the blade tip speed, the faster ground speed you can obtain in mowing. Does good job in cutting in 12-18" high grass. Dispersal of cut material may be problem at this height.

Problems and maintenance:

Rotaries have few cutter problems

Spindles, shafts, bearings, get wear.

Keeping blades sharp is key. If blades are kept sharp, acceptable quality can be obtained. Whipping off the grass can be problem with dull blades and insects and disease can have greater access.

Advantages:

Fast - manuverable.

Acceptable quality of cut at relatively fast speeds. Can go into most terrains.

Types:

Push - self propelled walk units, riders, tractor drawn.

Again on large P.T.O. tractor drawn units a P.T.O. override is advised.

Reels

Operation:

Depending on terrain, reels can be operated at from 3-6 m.p.h. In our turf grass industry there are many sizes and types of reels. From greensmower reels which are 9 or 10 blades and 4 3/4-5" in diameter to blitzer or rough types that are 4 to 5 blades and 10-11" in diameter. They are designed to cut in turf of 1/2 to 3/4" up to 8-10" for rough mowers.

Problems and maintenance:

Here we will make separate points as to ground driven units and powered reels.

Ground driven or direct drive units:

Lubrication - whether gears run in oil or grease points are available, this takes most of major repairs out of gang mowers.

Reels must be sharpened and backlapped.

Different methods are advised for reel sharpening depending on the manufacturer.

Backlapping is also a more personal thing.

Greensmowers - every use? every week?

Fairway and rough units: ever? twice a year?

Recommendation when needed! If you have to lap over 2-3 minutes you have a bigger problem than only grinding and resetting reel and bedknife will cure.

Grinding and keeping bedknife with a sharp leading edge is also important. You can have the sharpest reel on earth and if the leading edge on bedknife is rounded off, the quality of cut will decrease.

Keep end play from reel. Adjust rollers when used.

Reel and bedknife wear on direct drive units are at a minimum if units are kept in good repair and not overadjusted.

Advantages:

Highest quality of cut - safe - relatively lower initial cost compared with powered reel units.

Types:

Pull gangs - gangs on self contained tractors - hydraulic.

Power driven reels

I use the term power driven to cover the following:

1) Hydraulic motor drive
2) Electric motor drive
3) Belt drive

4) Mechanical drive (P.T.O. shaft) normally through gear boxes
5) Cable drive

Lubrication still necessary.
The afore mentioned problems of sharpening and backlapping apply.
Some of these units are able to reverse the reels and be backlapped without use of backlapping machine.
Reel and bedknife wear has been experienced to be greater than on direct drive units.
Even more care is needed in adjusting reel and bedknife on these units because the reel turns even when it's not cutting grass.

Advantages:

Highest quality of cut. Safe, little or no "marcelling cut". Can be used on wet or soft grounds because units have no ground drive wheels. Combine reel speed to ground speed for greater efficiency.

Types:

Walk behind units, riders (greensmowers), newest tractor mounted. Even though most of these units are medium size riders.

SOME OTHER TIPS ON OPERATION

Transmissions

1) Gear types - most tractors. Most accidents happen when driven too fast for conditions or grades.

2) Hydraulic drives and hydrostatic drives. Most serious and usual mistake is operating these types of units at lower than required engine rpm. They should be operated from at least 3/4 to full throttle that drive must have the fluid that the pump puts out. If engine is at low rpm it ain't agonna get it.

3) Torque converter. Most common mistake is trying to shift it while it's still moving. You will tear out the gear box if you do.

Now you people that have not been caught up with this most interesting speaker can take your short nap. We'll see a few slides.

1 As far as operation goes, excessive speed is the greatest danger. Just
2 ask this operator. Excessive speed is not only dangerous, but when you are pulling mowing units you increase the wear and damage to them, too.
3 Make sure you have your operators aware of safety when using a machine.

One slip and this guy could lose a foot.

4 You can help your operators and reduce your maintenance by fixing areas to reduce opportunities for machine breakdowns.

5 You could keep an operator longer if you alleviated this bridge
6 crossing. You certainly could reduce maintenance on spring arms, botched up reels, etc. if he gets stuck like this guy.

7 Have your operators use the right machine for the job. This old F 8 don't make a good trap rake.

8 While we are discussing using the right machine for the job, I've seen some really dumb things done by supposedly smart managers. This old rotary mower, turned on its side may make a wonderful two man trap edger. But can you think what OSHA would do to this?

9 This guy just couldn't understand why he couldn't get this three gang to adjust to an even cutting height. Take the 150 pound tool box and tools off one unit and it was easy.

I must make you aware that most manufacturers will void any warranty if their equipment is altered in this way.

10 As far as maintenance goes, a little cleanliness goes a long way.

11 Any piece of equipment left in this condition can't operate long efficiently. Dirt is as important in the parts wear factor as lack of lubrication.

12 I won't talk about maintaining engines, but dirt inside or out is trouble. Water and dirt in this gas tank for lack of a $2.00 cap could cause an expensive breakdown.

13 Keeping foreign material out of hydraulic systems is a must. This paper cup in an E 10 hydraulic reservoir gave a service man fits. Every so often it would block the outlet line and shut everything down. Before he could check everything out, it would move and everything would seem to be O.K., until the next time.

14 With OSHA it's even more important now to have your mechanics aware of safety. His hand under a machine without the plug wire off, just might be cut before his cigarette ignites the fuel can.

15 Remember how simple life used to be?

16 During that next rainy day, maybe you should have some training meetings instead of your usual activities.

17 Our company and most of the other manufacturers offer materials other than just owners manuals. Engine repair, grinding manuals, lubrication charts, etc. that can be studied. Jacobsen and Toro offer factory schools for mechanics. Our distributors offer factory supervised service schools in your local areas.

18 I realize I may not have answered any of your specific questions and that we didn't go into the nuts and bolts as such, but I hope you got some general information from it.

INSTALLATION OF IRRIGATION SYSTEMS

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Development of a good irrigation system begins with careful design in which all components of the system are selected to meet all requirements of the specific installation. A good design with good materials can only be successful if the system is installed properly. Good installation of a poor design will result in a poor system. Successful irrigation systems are the result of good installation of carefully designed systems. It is not possible in a 30-minute presentation to cover in detail all aspects of irrigation system design and installation. However, I will attempt to discuss some of the factors which must be considered in developing a successful irrigation system.

DESIGN

The designer must determine the specific requirements of the irrigation system and translate these into a system which will apply the right amount of water at appropriate times. The system must operate efficiently with as little labor and attention as possible.

Information needed by the designer includes an accurate plot plan (map) of the area to be irrigated. The map should include ground surface elevations so that elevation differences can be properly considered in the hydraulic design of the system (an elevation change of 2.31 feet causes a pressure change of 1 pound per square inch). Soil types must be evaluated to determine allowable rates and amounts of water application. Water requirements of grasses (and possibly other irrigated plants) must be determined. The designer also should know the source of irrigation water and any special requirements of the irrigation system. All of these factors must be considered in selecting sprinklers, pipelines, pumps, controllers and valves which fit together in an efficient irrigation system "tailor-made" for the specific job.

SPRINKLERS

A wide range of sprinkler sizes and types are available from small spray nozzles to small pop-up sprinklers to moderate-size cam, gear or impact drive sprinklers to very large impact sprinklers. Manufacturers

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provide recommended operating pressures for their sprinklers. Optimum operating pressure depends primarily upon sprinkler type and nozzle size. Sprinkler discharge varies directly with operating pressure, that is, discharge increases with increased pressure and decreases as pressure decreases.

Sprinkler operating pressure affects stream break-up and area of coverage as well as sprinkler discharge. When pressure is too low, stream break-up is inadequate, droplets are large and water distribution is poor. On the other hand, when pressure is too high, spray droplets are very small, wind severely affects sprinkler patterns and area of coverage may be reduced. As a general rule, all sprinklers on a lateral or branch circuit should be the same type and size. In addition, pipe sizes should be selected carefully to maintain operating pressure at all sprinklers on the lateral or branch piping circuit within reasonable limits.

PIPE SELECTION

Selection of pipe for irrigation systems involves a choice of several materials and pipe sizes. Steel, asbestos - cement, polyethylene (PE) and polyvinyl chloride (PVC) pipe are the most commonly used types in irrigation systems. Overall cost, including the cost of the pipe and the cost of installation, and serviceability are prime factors in selecting the type of pipe.

The high overall cost of steel pipe limits its use in irrigation systems. Corrosion, both inside and outside the pipe, is also a deterrent to the use of steel pipe. Asbestos - cement pipe is available in several pressure ratings and is used extensively, especially in larger sizes. Polyethylene pipe is flexible, easily installed and available in several pressure ratings but it is used primarily for low pressure applications requiring small sizes (½ to 1 or 1½- inch diameter).

Polyvinyl chloride (PVC) pipe is today probably the most widely used type in irrigation systems. It is available in a wide range of sizes and pressure ratings. It is non-corrosive and smooth providing good flow characteristics and lower friction losses than most other types of pipe. Ease of installation using either rubber gasket (or rubber ring) joints or solvent-welded joints is another advantage of PVC pipe.

PVC pipe is available as Plastic Irrigation Pipe (PIP) in pressure ratings up to about 100 pounds per square inch and sizes of about 4 inches and larger. Pressure rated, Standard Dimension Ratio (SDR) PVC pipe is available in pressure ratings of 100 to more than 300 pounds per square inch. PVC pipe is also available in Iron Pipe Sizes (IPS) such as Schedule 40 and 80. Some care must be exercised in mixing PIP and SDR pipe in an irrigation system since outside diameters of the two categories is different and special fittings or adapters are required to make the transition from one category to the other.

Pipe sizes must be selected carefully to keep pressure losses caused by friction within allowable limits. Generally recommended procedure is to select a pipe size so that velocity of flow will be less than 5 feet per second. Velocity of flow is more important in plastic pipelines than in steel because of possible rupture of plastic pipes caused by water hammer when valves are closed rapidly or when a pipeline is filled suddenly.

The rate of friction pressure loss is usually expressed in terms of feet of head (2.31 feet equals 1 pound per square inch) or pounds per square inch per 100 feet of pipe. The rate of pressure loss due to friction increases as the rate of flow increases in a particular pipe size. Total pressure loss due to friction in a pipeline is directly proportional to pipeline length.

The effect of friction pressure loss in a sprinkler lateral or branch circuit is a change in operating pressure at the sprinklers. A change in operating pressure produces a change in sprinkler discharge. Ideally all sprinklers on a lateral would have the same operating pressure and discharge, however, this ideal situation is seldom attainable. Standards have been developed which allow a 10 percent variation in sprinkler discharge. Pressure must not vary more than 20 percent to maintain discharge variation at 10 percent or less. For example, if the discharge at the first sprinkler on a lateral is 20 gallons per minute, the last sprinkler should discharge at least 18 gallons per minute. If the pressure at the first sprinkler is 75 pounds per square inch, the pressure at the last sprinkler should be at least 60 pounds per square inch.

INSTALLATION

Most turf irrigation systems have underground pipelines so that installation involves trenching, pipeline assembly, backfill, testing, flushing and sprinkler installation. Pipelines should be buried deeply enough to protect them from mechanical damage and freezing and provide adequate soil cover for protection from vehicular traffic. The Sprinkler Irrigation Association "Minimum Installation Specifications for Turf Irrigation Systems" provides recommended depths of cover for pipelines of various sizes. These recommendations can be used if local experience or manufacturer's guidelines do not provide more localized, specific requirements.

Care should be exercised in pipeline assembly. Rubber gasket (or ring) joints in PVC and asbestos - cement pipe are easy to install and provide one of the most satisfactory connections available today. Solvent-weld joints in PVC pipe are also easy to install, but manufacturer's recommendations for use of solvent (and cleaner, in some cases) should be followed closely. Pipe ends should be cut squarely when necessary to cut the pipe. Burs should be removed, solvent applied (following cleaner, if recommended) evenly, the pipe end inserted completely into the socket, pipe rotated one-quarter turn and the joint left undisturbed until it is "set". Excess solvent should be wiped cleanly from the joint.

PVC pipe expands as temperature increases and contracts with cooler temperatures. Snake the pipeline in the trench to allow some extra length of pipe to prevent the pipeline pulling apart at the joints. When pipelines are installed during warm weather, placement of the pipe in the trench early in the morning is recommended. Backfill the trench at least partially (do not cover joints) to keep the pipe cool.

Backfill carefully, making sure the pipeline is bedded properly. Backfill material should be free of stones and other sharp objects until the pipeline is covered 4 to 6 inches. Stones in contact with plastic pipe may eventually wear through the pipeline. Leave joints exposed until the pipeline is flushed to remove foreign materials and tested for leaks. After flushing, testing and repairing any leaks, install sprinklers and/or quick coupling valves making sure they are set plumb and level with the turf.

Careful installation of well planned sprinkler irrigation systems helps assure years of satisfactory irrigation system operation.

TROUBLESHOOTING IRRIGATION SYSTEMS

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This topic is divided into three parts: sprinkler coverage, piping system problems, and automatic control equipment.

Sprinkler coverage is the most obvious problem in an irrigation system. Normally it is noticeable by dry spots in turf areas. The main problem with sprinkler coverage is usually a blocked nozzle. This can be caused by a stone or other debris getting into your irrigation system either through a recently repaired pipe break or debris coming from your water source. When this happens the sprinkler will cease to rotate because the turbine or driving arm has been blocked. There are many other sprinkler coverage problems related to nozzles. After a number of years corrosion and pitting will cut down the distance and break-up the precipitation patterns. One of the solutions to this problem is the use of plastic nozzles which some manufacturers have gone to.

Another thing you should watch for is the damage done to sprinkler nozzles either by mowing equipment or when the sprinklers are manually thrown back and forth in maintenance vehicles, often times the nozzles are chipped or banged up - thereby greatly distorting the water pattern.

Another item to check in the nozzling of the sprinkler is the back nozzles which may have pins in them to distribute the water in a certain direction; make sure the nozzles haven't been rotated or twisted in some way.

One other thing which is very handy to have in analyzing coverage problems is a pitot tube which can be stuck into the orifice of the nozzle so you can actually get the sprinkler running pressure.

You have to remember that in most sprinklers - the turning speed is very important when you consider the distance that the sprinkler is supposed to throw. You will find that if the sprinkler turns too fast, the distance

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will be cut down. Also as the sprinkler turns faster, you may find that the precipitation pattern from the head out to its furtherest distance gets distorted and in some places we have too much water and in other places we do not have enough. So make sure that the sprinkler is turning within the specifications of the manufacturer.

In analyzing sprinkler coverage problems consult the manufacturer's recommended coverage - spacings that are published for the different sprinkler models - they will give you the approximate footage whether it is triangular or square spacing so that you know the proper pressure, the proper nozzles for you to get good distribution. Remember that for the majority of sprinklers you should have head to head coverage to get good uniform sprinkler performance.

The second problem involved in irrigation system maintenance applies to the piping system. Often times problems relating to the piping systems can be very frustrating in that they lead to wet spots in the turf areas that you are maintaining. Many times these wet spots can be several feet away from the actual leak in the system. One of the major sources of leaks in an irrigation system is the swing joints which are placed under the individual sprinklers or quick coupler valves. As the years go by these swing joints can be loosened by being hit by tractors and fairway gang mowers. Often time the swing joints which are made out of galvanized steel nipples will start to corrode in the threaded areas. In threading the galvanizing was stripped away from the pipe. Tar should be painted over this area for hot soil will be attacking the unprotected steel rapidly.

The next place where we may find leaks is the lateral connections to our main line piping system. Often times this is where we have a solvent weld fitting going from a large main line to a smaller PVC lateral. Again, here it is possible over a period of time to have a leak which may spin sand around and cut a hole into the pipe. This is particularly true in desert areas where the soil is very sandy.

Of course with the advent of the PVC piping a number of years ago, they were able to eliminate many of the corrosion problems associated with cast iron and galvanized systems. Unless care is taken in the installation of the PVC piping system we can also have problems. One of the areas which leads to problems is the joining of two lengths of pipe. There is a couple of different ways this can be done. You can either get couplings which are welded to the pieces of pipe or you may have pipe which had an expanded bell formed on one end of the pipe when it was manufactured. The installer simply uses his PVC cement and paints the two ends of the pipe then pushes it together. In many cases you will find that too much cement was used on the PVC pipe and when it was shoved together you will have an excess amount of cement on the inside of the pipe and it will lay there for three or four months finally weakening the bottom of the form bell, consequently a leak will develop through the pipe joint and then we have a major repair job.

A lot of this has been eliminated with the use of rubber ring couplings which go under a couple of different trade names. This has the advantage of eliminating the mechanical workmanship of putting the right amount of cleaner and cement on the PVC pipe. One thing if you do use the gasset type connections, it is important that proper thrust blocking be done when the piping system has a change in directions. Because if it isn't properly thrusted, the pipe will blow apart.

In larger size pipe the ring type connections seem to be the most trouble free if properly installed and properly thrusted.

Another source of leaks in piping systems can be traced to the installation of gate and angle valves on the mains and laterals of an irrigation system. It is important that these valves be properly installed as far as thrusting goes because remember when the valves are shut off you are temporarily plugging pipe and unless you have the pipe valve properly supported, there is a tendency for the valves to move down the pipe thereby causing a leakage at this point. Often time leakage around valves will not be from the packing nut but will be coming from a leak where the valve was connected to the pipe.

Remember if you are involved in a repair of a large sized AC or PVC pipe, thrust block, you repair work with cement so it will not be forced apart when the water pressure is turned back on the main line.

The next thing involved in troubleshooting an irrigation system is the automatic control equipment which consists of timing mechanism and the automatic valves.

The automatic controller is usually run by standard 110 volt AC current, many of the problems with the timers used in today's irrigation systems are traced back to micro-switches which get out of adjustment or small fractional horse power motors which may stall out in real cold operating conditions like in the early spring or late fall and also these motors after many years service may run out of lubrication and you may have a frozen bearing which will cause the motor to burn out. It is important to occasionally take the entire mechanism apart, check it to make sure it hasn't accumulated sand or dirt in the operating switches, if it has take it in and use an air hose to blow it out, be careful not to use oil because it collects dust and dirt once you re-install the entire mechanism out in the field.

The next thing to check in the controller is the condition of the contacts in the electric rotary switch. From the rotary switch in the sprinkler controller you have a control wire leading from the terminal block to the various automatic electric valves in your system. Check to make sure that all the connections are tight and that there hasn't been any corrosion built up in the rotary switch.

The next portion of the automatic control systems to check is often the most frustrating as far as trying to find out what the problem is in both electrical systems and hydraulic systems. This is checking out the wire or the tubing leading from the controller to the valves. Often times in electrical systems you will find that you will have intermittent operating and non-operating of different stations. At times this can be finally traced back to insulation being stripped off the wire or being eaten off the wire underground by squirrels and rodents to the point the wire will short itself out. If you have the wire going through an area where you water heavily or if you get a lot of rain, you may find the wire temporarily shorting itself out and blowing a fuse in your clock and a few days later you may turn the same station on and it will temporarily run without blowing the fuse. The reason it blows out is when the ground gets wet you have a dead short between the wire and ground.

Another thing you find in electrical systems is often times the wire splices were not made properly and that after a number of years or or months, the moisture will collect at the connection point, corrode it and again cause a short between the wire and the ground.

In the hydraulic system instead of using wire, we use tubing as our method of communication between the controller and the valve; here again we can have problems such as the tubing being cut by underground animals or the connection at the valve may come loose due to corrosion or due to a man made error in not getting the connection properly tightened. Then the leaks get worse instead of repairing themselves and you will finally have to dig up the valve and tighten your connection or replace the part that has corroded away.

When wire or tubing is put in the ground, care should be taken not to put sharp rocks on top of it. Rocks will damage both electrical wiring and tubing. In large turf installations people are buying tone type troubleshooters.

Another problem in the troubleshooting of the 24 volt electric irrigation system can be the sometimes operation of the automatic valves. Occasionally you will find the valves will come on and other times they won't come on. Let me give you a reason for this. It can be a change in the incoming voltage from your power company, which can fluctuate during the hours that you are running the system and effect the voltage which you are getting out of your controllers.

On a hot summer evening when everybody has got their electric refrigeration and dishwashers on you will find a temporary lowering of the voltage in the electrical distribution system. Later on at night when these appliances are shut off, you will find your system will operate properly. This can be checked by the use of the voltage recorder, which can be attached to your incoming power line. If you run into this problem, there are devices made by General Electric and other companies, called line voltage stabilizers which automatically boost the voltage up to 117 volts. A handy thing to remember if you are having a problem.

In a hydraulic normally open system, it is always advisable to have as much or more pressure in your control tubing than you have in your main line piping. It is advantageous to run a separate supply from the source of your irrigation system to the controllers. We normally recommend running a half inch line from the pump house if you are using a pump or from the water meter if you are irrigating a large park area on city water. This way you can isolate and filter the control water better and you can leave the control tubing pressurized where you turn off your irrigation system to make pipe repairs.

One thing which should be checked periodically in a hydraulic system is the tubing supply water filter. This filter should be serviced every three to four months to see that it isn't plugged up with fine sand which can come from the city water system. Check to make sure that you are getting a good supply of water to the rotary pilot block of your controller.

A basic tool in checking an automatic hydraulic system is a pressure gauge with a tube fitting it on every three to four months - go back to the controller - insert this gauge into the discharge tube and turn the clock from station to station to see if you are holding pressure from the controller to the valve. Obviously, if the discharge tube is plugged with the gauge and you turn it to station number 1, station 1 should not come on because you are trapping water from that gauge all the way out to the valve. If the pressure starts to slowly leak away, then you know that you are either losing water through the pilot block of the clock or in the tubing or in the underground automatic valve. Start at the clock which is the simplest to check; you look for obvious leaks there, you next go out to the underground block valve or the valve-in-head sprinkler, you can again insert a gauge at the end of the tubing and see if you are holding pressure from the clock out to the particular valve that you are interested in. In a hydraulic valve, you are operating the piston or the diaphragm directly by the hydraulic tubing while in most electric valves, you are overriding the piston or the diaphragm with an electric solenoid porting off the water. In both electric and hydraulic valves you should fully understand the operating mechanism of the particular valve you have in your installation and have repair parts on hand so that if you do have a problem on Saturday, you will be able to make the correction without having to turn your whole system off waiting for the supply house to open on Monday to be back in operation.

P E S T I C I D E   S E M I N A R

SAFE USE OF PESTICIDES

CALIBRATIONS AND CALCULATIONS

PRINCIPLES GOVERNING THE EFFECTIVE USE OF HERBICIDES

FUNGICIDES AND NEMATICIDES

PESTICIDE LAWS, REGULATIONS AND TESTING PROCEDURES

SAFE USE OF PESTICIDES

Jack D. Price
Project Leader in Pesticide
Chemicals and Agricultural Chemist

Safe use is a combination of attitude, effort, and action resulting in use that accomplishes the intended purpose with a minimal hazard to the individual and the environment. An understanding of the reasons behind the safe use practices will promote a better attitude.

Exposure of the individual may occur through one or more of three routes. Pesticides can enter the body through the skin, through the digestive tract, and through the lungs.

It follows then that safe use in large measure is primarily a function of avoiding or minimizing exposure. The more toxic the chemical, the smaller the margin for error.

Protective equipment is one means of reducing exposure. However, it can't work if it isn't used. Basic protection against pesticide exposure includes a cap or hat, long sleeves and trousers worn outside waterproof gloves and boots. Avoid cloth gloves and leather shoes. Actually, natural rubber is the only readily available material that most pesticides do not penetrate.

The skin protects, regulates body temperature, receives sensations, secretes, absorbs, and manufactures pigment. It is in fact the largest organ of the body. Absorption through the skin is more rapid if the skin is damaged. Variation exists in the rate of absorption through skin at various sites in the body.

Good practice includes:

- Following all label directions
- Covering up before exposure--not after
- Using clean clothes daily
- Bathing at least daily
- If exposure to the lower trunk and legs is anticipated, such as in mixing, use a waterproof apron

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If you spill pesticides on the skin, wash and wash again. Wash immediately, or as soon as possible, if contamination of skin is known to have occurred. If you wait for 30 minutes or more, the efficiency of washing as a means of decontamination is considerably reduced with some pesticides.

There is good reason for eye protection, particularly during the mixing operation when handling concentrated materials; liquids can splash, and dusts can blow into the face.

If respiratory protection is required, choose the proper equipment as referenced on the product label. Filters are used to remove particles by trapping air as it is inhaled through the filter. Membrane filters do not provide protection against gases, vapors, or oxygen deficiency. No matter how well a respiratory device is designed, unless it is properly cared for and maintained, it may fail to provide protection. As a general rule:

- Change filters twice a day or whenever breathing becomes difficult
- Change cartridges after 8 hours of actual use and whenever any odor of the pesticide is detected

Oral exposure and absorption through the digestive tract can be minimized by following the usual practices associated with good hygiene.

1. Never eat or drink while spraying or dusting
2. Do not touch lips to contaminated objects or surfaces
3. Do not wipe the mouth with hands, forearms, or clothing
4. Do not expose lunch, lunch container, beverage, or drinking vessel to pesticides
5. Wash thoroughly with soap and water before eating or drinking

The label is an important source of information and should be thoroughly reviewed prior to each use--learn to recognize active ingredient terminology--brand names can be confusing.

Equipment in good operating condition is also an essential of safe use. Items such as gauges, nozzles, and hoses should receive special attention. Hoses should be tested at twice the anticipated operating pressure. In testing hoses at two times the anticipated operating pressure, be sure to use only water.

Back siphoning can occur and may result in poisoning of people and livestock through contamination of water supplies.

Droplet drift is a function of many factors; however, one of these which is controllable is the size of the spray droplet. Pressure affects the size distribution of spray particles. Generally, the higher the pressure, the greater the percentage of small particles. The smaller particles are more subject to movement by wind. As a general rule, one should not attempt to spray when the wind speed is in excess of 8 miles per hour. The Texas Herbicide Law and Regulations, in effect in certain counties, prescribes conditions of use involving both wind speed and distance to susceptable crops.

Disposal of waste pesticides and "empty" pesticide containers is a problem and represents a hazard if the user permits an accumulation of wastes. The rinse and drain procedure is not only a good safety practice, but an economical one as well. Pesticide disposal by burial can present problems, such as ground water contamination. However, a decontaminated container is less likely to represent a hazard. Burning empty containers can be hazardous and, in fact, may be in violation of laws and ordinances.

In summary, safe use is the responsibility of the user; and in view of new Federal and State laws, the label is the primary source of information. An understanding of the reasons underlying safe use practices translates into attitude, effort, and action.

CALIBRATIONS AND CALCULATIONS

Rupert D. Palmer*
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INTRODUCTION

Accurate sprayer and granular distributor calibration is essential for safe and efficient performance of herbicides. The accurate rate calculation must be done for herbicides mixing, and conversions of rates from one basis to another. Always double check your calculations with someone to avoid mistakes. Preplanning and working out problems before going to the job is helpful in understanding the job needs, and making adjustments after the herbicide application is underway.

DISCUSSION

The following formulas should be useful for calculating amounts of pesticides to use or mix.

Equivalents: 16 oz./1 lb., 128 fluid oz./gal., 43,560 sq. ft./acre, 5,280 ft./mile, 1,000 sq. ft. = $\frac{1}{43.560}$ acre

Formulas:

(1) $\frac{\text{1,000 sq. ft. rate (oz.) x 43.560}}{\text{oz./lb. or gal.}}$ = Acre rate in lb. or gal.

(2) $\frac{\text{lb./A. of product x oz./lb.}}{\text{43.560}}$ = oz./1,000 sq. ft.

(3) $\frac{\text{Tank capacity (gal.)}}{\text{gal./A.}}$ x lb. or gal. product/A. = lb. or gal. product/job

(4) $\frac{\text{Active rate x 100}}{\text{\% active in product}}$ = Product rate (WP)

(5) $\frac{\text{Active/rate}}{\text{Active ing. or acid equiv./gal. product}}$ = Product rate (liquid)

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EXAMPLE PROBLEMS

I. Granular Spreader

Apply 103.5 lb./A. of a 12.5% active granular herbicide (Betasan) for control of annual bluegrass in bermudagrass.

A. Calibrate the 10 ft. granular spreader pulled at 4 MPH.

1. Calculate quantity of Betasan for 1,000 sq. ft. (10' x 100') at ½ rate and full rate (oz. and lb.) (See formula 2 above.)

Calculation: $\frac{103.5 \text{ lb./A.} \times 16 \text{ oz.}}{43.560}$ =38 oz. or 2.4 lb. or ½ = 1.2 lb.

Either read from the label the setting for the granular applicator which you are using, or set the spreader by trial. Pull the applicator at 4 MPH over a 100 ft. course. Weigh the collected herbicide, and if necessary, adjust the rate controls on the applicator until it delivers 1.2 lb. (19.2 oz.)/1,000 sq. ft. Note: Double treat this area at ½ rate to avoid failure to overlap the swath with a single treatment.

2. Determine total Betasan needed for 33 acres.

Calculation: 33 A. x 103.5 lb./A. = 3,415.5 lb.

3. Determine active ingredient rate/A.

Calculation: 103.5 lb./A. x 0.125(12.5%) = 12.9 lb./A.

II. Sprayers

The example problem is for weed control, but the principles discussed are applicable to insect and plant disease control.

A. Apply 1.75 lb. of Kerb 50W in 30 gal. water/A. for crabgrass and grassbur control in turf.

1. Calculate the quantity of product needed to treat 50 acres.

Calculation: 1.75 lb./A. x 50 A. = 87.5 lb.

2. Determine quantity of herbicide per 30 gal. of mixture.

Calculation: 1.75 lb. in 30 gal. water.

3. Determine quantity of herbicide for a 250 gal. tank. (See formula 3 above.)

Calculation: 250 gal. ÷ 30 gal. = 8.33 tanks x 1.75 lb./30 gal. = 14.6 lb./250 gal.

4. Determine number of fill-ups for treatment of 50 acres.

Calculation: 50 A. x 30 gal./A. = 1,500 gal.; 1,500 gal. ÷ 250 gal./tank = 6 fill-ups.

B. Apply the herbicide mixture with a boom sprayer with 8 nozzles. The nozzles are spaced 20 inches apart. The speed is 5 MPH. The sprayer is to apply 15 gal. of mixture per acre, but double spraying is planned to give more uniform application. Use flat spray nozzles. Calibrate the sprayer.

1. Verify that the equipment is traveling 5 MPH.

Formula: $$\text{MPH} = \frac{204}{\text{seconds to travel 300 ft.}}$$

Calculation: 204 ÷ 5 MPH = 40.8 seconds to travel 300 ft.

Run the equipment over a 300 ft. course in the gear for spraying and adjust throttle so that it travels 300 ft. in 40.8 seconds. Mark throttle and gear setting on engine pulling the equipment.

2. Determine the nozzle size in gallons per minute (GPM) for the sprayer.

Formula: $$\text{GPM per nozzle} = \frac{\text{GPA* x MPH x W*}}{5{,}940}$$

*GPA - Gallons per acre applied on the area actually treated.

Example: 15 gallons per acre broadcast

*W = Nozzle spacing in boom spraying, or spray swath in broadcast boomless spraying measured in inches.

Calculation: $$\frac{\text{15 x GPA x 5 MPH x 20 inches}}{5940} = \text{0.25 GPM/nozzle.}$$

Select an 80 degree or 95 degree flat spray nozzle to deliver 0.25 GPM at suggested psi for weed control. Notice that in Figure 1, either an 8003 or an FS-6 is marked as the correct nozzle for the boom for this sprayer problem. Also, either an 80015 or an FS-4 is marked at half rate, and only used in each end of the boom to allow overlap on throughs.

Always select nozzles which will deliver the calculated volume (GPA) at a pressure less than 40 psi for weed control. Notice on the nozzle chart (Figure 1) that either 8003 or FS-6 will spray near 15 GPA at 5 MPH at 30 psi with nozzles spaced 20 inches apart, and that 0.25 gal. or 1 qt. is delivered in one minute as determined with the GPM per nozzle formula above. For insect control, 50 to 60 psi is required, and plant disease control requires 100 psi. The spray volumes for insects and plant disease may be higher than 15 gal./A. but substitute the GPM, MPH, and nozzle spacings for insect and disease jobs into the formulas for calculating GPM per nozzle for these jobs and select nozzles to deliver needed volumes at pressure equipments.

3. Determine the number of seconds to collect a quart of spray mixture, or 32 fluid ounces from each nozzle.

Formula: $\text{Sec./qt./nozzle} = \dfrac{15}{\text{GPM per nozzle}}$

Calculation: $\dfrac{15}{0.25} = 60$ sec. or 1 minute

With the tractor engine running out of gear at the throttle setting for 5 MPH, adjust the pressure regulator so that one quart is delivered by each nozzle in 60 seconds or one minute. If two engines are on the equipment, the engine pulling the equipment should be adjusted for speed, and the engine running the sprayer pump should be run to allow one quart to be collected from each nozzle in 60 seconds or one minute when the pressure regulator is adjusted to about 30 psi.

Adjust height and direction of nozzles so that the patterns slightly overlap in boom spraying. Notice figure 1 shows a 17 to 19 inch setting.

4. Determine pump capacity (PC) for the weed control problem with a 250 gal. tank on the sprayer.

Formula: PC = (3 GPM/50 gallons mixture) + (GPM/nozzle x number of nozzles)

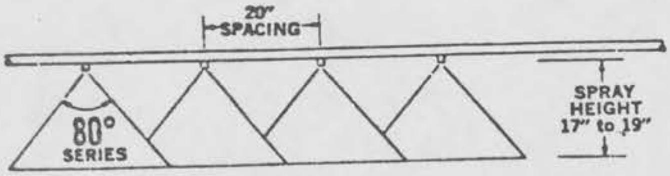
Calculation: PC = (3 x 5) + (0.25 x 6 + 0.125 x 2) = 18.25 GPM

DERIVATION OF CONSTANTS USED
IN SUGGESTED METHOD OF SPRAYER CALIBRATION

1. <u>Constant 204</u>

$$\text{MPH} = \frac{204}{\text{seconds to travel 300 feet}}$$

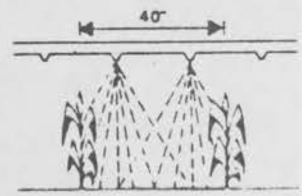
5280 feet in 3600 seconds (60 seconds x 60 minutes) 3600 ÷



	Liquid Pressure in p.s.i.	Capacity 1 Nozzle in G.P.M.	GALLONS PER ACRE 2 M.P.H.	3 M.P.H.	4 M.P.H.	5 M.P.H.	7.5 M.P.H.	10 M.P.H.
800067 4.3 GPA (100 MESH)	20	.05	7.0	4.7	3.5	2.8	1.8	1.4
	25	.055	7.8	5.2	3.9	3.1	2.1	1.6
	30	.06	8.6	5.7	4.3	3.4	2.3	1.7
	40	.067	9.8	6.6	4.9	4.0	2.6	2.0
	50	.07	11.0	7.4	5.5	4.4	3.0	2.2
	60	.08	12.0	8.1	6.0	4.9	3.3	2.5
8001 6.4 GPA (100 MESH)	20	.07	10.5	7.1	5.3	4.3	2.8	2.2
	25	.08	11.8	7.8	5.9	4.7	3.1	2.4
	30	.09	12.9	8.6	6.4	5.1	3.4	2.6
	40	.10	14.9	10.0	7.4	6.0	4.0	3.0
	50	.11	16.7	11.2	8.3	6.7	4.5	3.4
	60	.12	18.2	12.2	9.1	7.4	4.9	3.7
80015 9.7 GPA (100 MESH)	20	.11	15.7	10.5	7.8	6.3	4.3	3.2
	25	.12	17.5	11.7	8.8	7.1	4.7	3.6
	30	.13	19.2	12.9	9.7	7.7	5.2	3.9
	40	.15	22	14.9	11.1	8.9	6.0	4.5
	50	.17	25	16.7	12.4	10.0	6.7	5.0
	60	.18	27	18.2	13.6	10.9	7.4	5.5
8002 12.9 GPA (50 MESH)	20	.14	21	14.0	10.5	8.4	5.6	4.2
	25	.16	23	15.7	11.8	9.4	6.3	4.7
	30	.17	26	17.2	12.9	10.3	6.9	5.2
	40	.20	30	20	14.8	11.8	7.9	5.9
	50	.23	33	22	16.5	13.2	8.8	6.6
	60	.25	36	24	18.1	14.4	9.7	7.2
8003 19 GPA (50 MESH)	20	.21	32	21	15.7	12.6	8.4	6.3
	25	.24	35	23	17.6	14.1	9.4	7.1
	30	.26	38	26	19	15.4	10.3	7.7
	40	.30	45	30	22	17.8	11.8	8.9
	50	.34	50	33	25	20	13.2	10.0
	60	.37	55	36	27	22	14.4	10.9
8004 26 GPA (50 MESH)	20	.28	43	28	21	16.8	11.2	8.4
	25	.32	47	31	24	18.7	12.5	9.4
	30	.35	51	34	26	21	13.7	10.3
	40	.40	59	40	30	24	15.8	11.9
	50	.45	66	44	33	27	17.7	13.3
	60	.49	73	49	36	29	19.4	14.6
8005 32 GPA (50 MESH)	20	.35	53	35	26	21	14.0	10.5
	25	.40	59	39	29	23	15.7	11.7
	30	.43	64	43	32	26	17.2	12.9
	40	.50	74	49	37	30	19.8	14.9
	50	.55	83	55	42	33	22	16.5
	60	.61	91	61	45	36	24	18.2
8006 39 GPA (50 MESH)	20	.42	63	42	31	25	16.9	12.6
	25	.47	70	47	35	28	18.7	14.1
	30	.52	77	52	39	31	21	15.5
	40	.60	89	59	45	36	24	17.8
	50	.67	100	66	50	40	27	20
	60	.73	109	73	55	44	29	22

See reference 1

TYPE-FS 80°
STANDARD RATING @ 40 PSI 4 MPH



TWO NOZZLES PER 40" ROW

Tip Number	Pressure (PSI)	Capacity 1 Nozzle (GPM)	Standard Rating	3 MPH	4 MPH	5 MPH	7.5 MPH
FS-1 80°	20	.035	4 Gallons per acre	3.3	2.5	2.0	1.3
	30	.043		4.3	3.2	2.6	1.8
	40	.050		4.9	3.7	2.9	2.0
	60	.061		6.0	4.5	3.6	2.4
	80	.071		7.1	5.3	4.2	2.8
	100	.079		7.7	5.8	4.6	3.1
FS-2 80°	20	.049	5 Gallons per acre	4.8	3.6	2.9	1.9
	30	.059		5.8	4.4	3.5	2.3
	40	.069		6.8	5.1	4.1	2.7
	60	.084		8.3	6.2	5.0	3.3
	80	.098		9.7	7.3	5.8	3.9
	100	.109		10.8	8.1	6.5	4.3
FS-3 80°	20	.076	8 Gallons per acre	7.5	5.6	4.5	3.0
	30	.093		9.2	6.9	5.5	3.7
	40	.107		10.6	7.9	6.4	4.2
	60	.131		13.0	9.7	7.8	5.2
	80	.150		14.8	11.1	8.9	5.9
	100	.168		16.6	12.4	10.0	6.6
FS-4 80°	20	.099	10 Gallons per acre	9.7	7.3	5.9	3.9
	30	.121		12.0	8.9	7.2	4.8
	40	.140		13.8	10.4	8.3	5.5
	60	.171		16.9	12.7	10.1	6.7
	80	.198		19.6	14.7	11.7	7.8
	100	.221		21.8	16.4	13.1	8.7
FS-5 80°	20	.145	15 Gallons per acre	14.3	10.7	8.6	5.7
	30	.178		17.6	13.2	10.5	7.0
	40	.202		20.0	15.0	12.0	8.0
	60	.245		24.2	18.1	14.5	9.7
	80	.283		28.0	20.9	16.8	11.2
	100	.318		31.4	23.6	18.8	12.5
FS-6 80°	20	.193	20 Gallons per acre	19.1	14.3	11.4	7.6
	30	.236		23.4	17.5	14.0	9.2
	40	.273		27.0	20.2	16.2	10.8
	60	.331		32.8	24.5	19.6	13.1
	80	.386		38.2	28.6	22.8	15.2
	100	.431		42.6	31.9	25.5	17.0
FS-7 80°	20	.238	25 Gallons per acre	23.6	17.6	14.1	9.4
	30	.291		28.8	21.6	17.2	11.5
	40	.336		33.2	25.0	19.8	13.3
	60	.411		40.6	30.4	24.4	16.2
	80	.475		47.0	35.2	28.2	18.7
	100	.531		52.5	39.4	31.4	20.9
FS-8 80°	20	.280	30 Gallons per acre	27.7	20.8	16.6	11.0
	30	.360		36.6	26.6	21.3	14.4
	40	.405		40.0	30.0	24.0	16.0
	60	.498		49.4	36.9	29.5	19.6
	80	.570		56.4	42.2	33.8	22.5
	100	.630		62.4	46.6	37.3	24.8
FS-9 80°	20	.380	40 Gallons per acre	37.6	28.2	22.5	15.0
	30	.475		47.0	35.2	28.2	18.7
	40	.540		53.5	40.0	32.0	21.3
	60	.665		65.8	49.2	39.4	25.2
	80	.760		75.2	56.3	45.0	30.0
	100	.845		83.6	62.5	50.0	33.4

See reference 2

Figure 1: Flat spray nozzle data showing spacings, spray height, tip description, liquid pressure, capacity in GPM, speed and gal./A.

5280 = 0.681 seconds per foot at 1 MPH, 300 feet x 0.681 seconds per foot = 204.5 seconds/300 feet.

2. Constant 5940

The derivation of the constant 5940 is a short cut in determining application rate of a sprayer.

GPA = gallons per acre on the area actually treated.

A-GPM = gallons per minute

B-MPH = miles per hour

W = nozzle spacing(in boom spraying), spray swath (in broadcast spraying) or row width(in band spraying) in INCHES.

Assume each nozzle discharges A-GPM and the sprayer travel B-MPH and the nozzles were spaced W-INCHES apart.

$$GPA = \frac{A \text{ gal.}}{\text{min.}} \times \frac{\text{hr.}}{B \text{ mile}} \times \frac{60 \text{ min.}}{1 \text{ hr.}} \times \frac{43{,}560 \text{ ft.}^2}{1 \text{ acre}} \times \frac{1 \text{ mile}}{5280 \text{ ft.}} \times \frac{1}{W\text{-In.}} \times \frac{12 \text{ in.}}{1 \text{ ft.}}$$

$$GPA = \frac{A \times 60 \times 43{,}560 \times 12}{B \times W \times 5280} = \frac{A \times 5940}{B \times W}$$

Gallons /acre: $GPA = \frac{5{,}940 \times GPM}{MPH \times W}$, then both sides $\times \frac{W}{GPM}$, then $\times \frac{GPM}{1}$

$$GPM \text{ (per nozzle)} = \frac{GPA \times MPH \times W}{5940}$$

3. Constant 15

$$\text{Seconds per quart per nozzle} = \frac{15}{\text{GPM per nozzle}}$$

At one gallon per minute one quart is collected in 15 seconds.

60 seconds - ¼ gallon = 15 seconds per quart.

ADVANTAGES OF THIS METHOD OF SPRAYER CALIBRATION

1. An awareness of speed(MPH).

2. The capacity of the nozzle is determined for different spraying situations at desirable pressures.

3. Accurate calibration is accomplished by collecting the fraction of a gallon or GPM calculated.

4. Each nozzle can be checked for accuracy, and avoid different nozzle sizes in the boom.

5. The pressure gauge is checked for proper performance.

6. The variables are employed and help the operator understand the fundamentals of sprayer calibration. Changes in application rate is evident by variance of either MPH, pressure, or nozzle size.

7. Pump capacity and agitation requirements are determined.

SELECTED REFERENCES

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2. Annonymous. 1965. Agricultural Spray Nozzles and Nozzle Accessories. Delavan Manufacturing Company, West Des Moines, Iowa.

3. Annonymous. 1971. L-764 Pesticide Application Ground Equipment Calibration Guide. Department of Agricultural Communications, Texas Agricultural Extension Service, College Station, Texas 77843.

PRINCIPLES GOVERNING THE EFFECTIVE USE OF HERBICIDES

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Herbicides are widely accepted tools for controlling unwanted vegetation on many acres of agricultural and recreational lands. In fact, USDA figures indicate that the dollar value of herbicides sales in the U. S. now exceeds the value of all other pesticides combined. Yet often the herbicides are applied without an understanding of the principles which allow the chemicals to be used safely and effectively.

Principles relating to selectivity. The most important principle to remember is that the closer the weed and the crop become genetically, morphologically or physiologically, the more difficult it is to control the weed without injuring the crop. Generally, herbicides are selective between (1) dicots (broadleaved plants) and monocots (grasses), (2) annual plants and perennial plants, or (3) large seeded plants and small seeded plants. Thus, one should be able to control chickweed in bermuda grass lawns with little trouble because the weed is an annual broadleaf plant while the crop is a perennial grass. It would be more difficult to control crabgrass in the bermuda grass lawn because both are grasses. However, the crabgrass is an annual plant while bermuda grass is a perennial plant so control would be possible. Control of common bermuda in a tif-green bermuda lawn would be extremely difficult because of similarities between the weed and the lawn. Regardless of means of selectivity, herbicides may lose their selectivity when applied at excessive rates or at certain stages of growth of the crop.

Principles relating to mode of action. In broad terms, herbicides control weeds by contact activity, hormone-like action, photosynthesis inhibition or growth inhibition. Frequently an herbicide exhibits one mode of action at a low rate of application and another mode of action at a high rate of application.

In general, contact herbicides are applied post-emergence in large volumes of carrier and a surfactant is essential for maximum activity.

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Except at high rates of application, they have little soil activity and consequently are not used pre-emergence. Also, they have little activity against weed seeds and repeated applications are necessary to control newly emerged weeds following each rain. When compared to herbicides with other modes of action, contact herbicides are low in selectivity and are likely to have a high mammalian toxicity. Paraquat, Phytar-560, and Dow General are examples of commonly used contact herbicides.

Hormone-like herbicides are also usually applied post-emergence. However, they do have soil activity and may be absorbed by the roots of plants. These herbicides are generally selective between broadleaved plants and grasses, are translocated within the plant, and are low in mammalian toxicity. A principal limitation is the drift hazard associated with their use and many counties restrict their application during seasons when susceptible crops such as cotton, soybeans or tobacco are being grown. Dicamba, Tordon, and 2,4-D are examples of commonly used hormone-like herbicides.

Herbicides which inhibit photosynthesis are most effective against weed seedlings and often are applied to the soil before the weeds emerge. However, certain photosynthesis inhibitors will control small weeds post-emergence if a surfactant is added. Photosynthesis inhibitors are frequently used to control annual weeds in perennial crops or small seeded weeds in large seeded crops. They are extremely active through the soil and residues may persist for a year or more. In fact, certain photosynthesis inhibitors are used as soil sterilants. Aatrex, Princip, Diuron, Cotoran, Milogard and Hyvar-X are examples of commonly used photosynthesis inhibitors.

Growth inhibitors are most effective against germinating seeds and are consequently applied pre-emergence or they are incorporated into the soil by watering or mechanical means. These herbicides have little post-emergence activity even when a surfactant is added. Usually growth inhibitors are somewhat more effective against grasses than broadleaved weeds but they are most selective between annual and perennial plants. Lasso, Balan, Cobex, Dacthal, and Treflan are examples of commonly used growth inhibitors.

Principles relating to surfactants. By definition, a surfactant is a substance which alters the surface tension of water. Any chemical which has a hydrophylic (water loving) and lipophylic (oil loving) group in its molecular formula, should act as a surfactant. In general, surfactants increase activity and decrease selectivity of herbicides applied post-emergence. Consequently, when herbicidal safety is marginal, care should be exercised in the use of a surfactant. Surfactants do not usually affect the performance of pre-emergence herbicides. The rate of surfactant is normally determined by the volume of carrier rather than the rate of herbicide. One gallon of surfactant for each 200 gallons of carrier is commonly recommended. Surfactants are classified as non-ionic, cationic or anionic depending on their chemical composition. Non-ionic herbicides are sometimes preferred in areas having "hard" water. Certain commercial formulations contain mixtures of non-ionic, cationic and anionic surfactants. Surfactants increase herbicidal activity by increasing the spreading of the spray droplets on the waxy leaves and by increasing the absorption of the herbicide through the leaves. Surfactants are most beneficial when the herbicide is a salt and when the weeds are mature. Tronic and X-77 are commonly used surfactants.

Principles relating to drift. Drift may be defined as the movement of a substance from the site of application into a non-target area. Basically there are two types of drift - vapor and physical. Vapor drift is generally considered as secondary drift because it occurs after the initial spray particles are deposited. Since the herbicide must volatilize before vapor drift can occur, the use of salt formulations when available will essentially eliminate vapor drift. Physical drift is sometimes called primary drift because it occurs during the fall of the spray droplet from the nozzle tip to the place of deposition. Droplet size, nozzle height and wind velocity influence physical drift. Low pressure nozzles, foams and inverted emulsion all help to reduce physical drift by increasing the droplet size but they do not eliminate it. The drift from contact and hormone herbicides is especially hazardous, and these herbicides should not be sprayed near susceptible plants on windy days regardless of formulation.

Principles relating to soil sterilization. In some situations, there is a need for total vegetation control. This need may be only temporary as when a lawn or putting green is being renovated and a new sod is to be established. Methyl bromide is the most commonly used chemical for this purpose. It controls weeds and weed seeds as well as many soil borne insects and diseases. Since methyl bromide is a gas, it must be applied under plastic or some other sealant. The plastic is commonly removed after 72 hours so that the remaining gas may escape. Methyl bromide is also toxic to man and the fumes should not be inhaled. Attempts are being made to perfect temporary sterilants which can be applied as granules and later converted to toxic gasses in the soil. Vapam and sodium azide are examples of such chemicals. When total vegetation control is desired for an extended period of time as in a fence row or parking lot, then herbicides such as Hyvar-X or Pramitol are used. Under cold, dry conditions, control may be obtained for five years from a single application but as temperature and soil moisture increase, the period of control becomes shorter. It should be mentioned that almost any chemical including table salt, will sterilize the soil when applied at extremely high rates.

FUNGICIDES AND NEMATICIDES

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Turf production is an intensive type of agriculture. We expect to see more disease problems occurring because of this intensive moniculture production. With field crops we can rotate with non-related crops, but with turf this is not a feasible alternative. Consequently, we expect to rely more heavily on chemical control in turf than in most other types of production. Ideally, we would rather use biological control, but it is not a practical reality at this time. Biological control works constantly; however, we cannot manage it to the point of controlling the organisms we want to control. The question then naturally arises, "How can we get the most out of chemical control". We can do this by correctly identifying the disease problem, understanding how diseases develop, and how disease control chemicals actually work.

In relation to correct identification, guessing is a major sport. While it is an interesting pastime, it may be an expensive way to manage a turf area. Knowing exactly what the problem is may require laboratory identification. Most private concerns do not have diagnostic facilities, however, these are available at university operated laboratories. We have Extension plant pathologists at College Station, Overton, Dallas, Stephenville, Lubbock, Fort Stockton, and Weslaco. A trained plant pathologist operates a laboratory at each of these locations.

Surprisingly, we have not had many requests for identification from the turf industry. We know, of course, that the needs are great, but apparently a need for specific identification has not yet surfaced. We can be more effective in training programs if we are completely aware of the problems that occur. We certainly encourage submission of samples to our laboratories for problem identification. We allocate our time on the basis of need. If additional need is expressed from the turf grass industry, we can meet those needs.

In order to get effective control from chemicals we need to understand how diseases develop. There are many diseases of turf grasses, and this adds to the difficulty in always understanding exactly how problems develop. Some organisms require cool conditions while others require a warm environment. Fortunately, since this is the case, not all diseases occur at the same time of year.

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Disease organisms may be present in the soil in which we are growing turf, or they may be introduced on seed or from wind-borne spores. We certainly do not live in a sterile world, and we do not have much chance of preventing entry of these organisms or eradicating them once they occur.

Different disease organisms affect different plant parts. Some cause root rots while others cause spots or blights on the leaf surface. This is important to know because we may need to alter the method of chemical application. If we are dealing with a crown and root rot organism, we may need to use a drench; whereas, a foliar pathogen may require only application to the above ground portions.

Most disease causing organisms produce spores, and these germinate to penetrate plant parts. We have a better chance of controlling diseases if we can prevent infection from occurring. Most fungicides are protective in nature and should be called fungistats. They stop the development of fungi instead of actually killing them in most cases. This will help to reduce the inoculum potential and prevent infection of plant tissue.

Inoculum potential is a term that should be understood in order to get the best effects from chemical control. If we can use chemical control prior to severe disease development, we have a much better chance than if we wait until conditions are severe. This simply permits us to reduce the units of the organism present and not have to deal with such huge proportions.

Fungicides cannot be substituted for good management. Disappointment will likely result if they are used to try to bail us out of a condition that could have been prevented by good management. While they do the job they are intended to do, they do not have the ability to erase symptoms that have already occurred.

Some fungicides are specific for control of certain organisms while others are in the category of being broad spectrum materials. Narrow spectrum materials include Terraclor, Dexon, Terrazole, and Tersan 1991. If we have correctly identified our problem, we can use the rifle approach instead of the shotgun approach.

Most fungicides have a relatively low level of toxicity. This does not mean, however, that they should not be used in accordance with label recommendations. They will be more effective in the first place if they are used according to recommendations and potential hazards can be avoided if they are applied as they should be.

Perhaps it would be well to consider the difference between a suggestion and a recommendation. We associated with the University usually make suggestions for chemical control of certain diseases. The actual recommendation is embodied in the label. This label warrants the product for effectiveness and indicates its capabilities. A label contains much information that will be very helpful to the user. It should be followed in every regard.

Nematicides should be used where nematodes represent a limiting production factor. This determination can be made by sending soil samples to the Plant Nematode Detection Laboratory at College Station, Texas. A charge of $2.00 per sample is made for these samples and the sender is furnished with information related to nematodes present as well as suggestions for control. Selection of a nematicide is extremely important because different types of turf grasses vary in their susceptibility of these chemicals. It would be well to use these materials on a trial bases first to see if any plant damage is occurring. Nematicides most often used on turf are Nemagon, Fumazone, OXY-BBC 12, Sarolex, Dasanit, and Nemacur. Other materials are available and may be equally effective to those that have been mentioned.

Fungicides and nematicides should be used when needed and in accordance with the most effective methods of application. This includes correct identification of the primary problem along with consideration given for intervals of application. Diseases of turf can be effectively controlled. Every means of control, either cultural or chemical, should be utilized to the best advantage.

PESTICIDE LAWS, REGULATIONS AND TESTING PROCEDURES

Charles R. Holt*
State Entomologist
Texas Department of Agriculture

I. FIFRA (Fiasco) as amended 1972

A. Mandates of Congress
B. Controversial
C. Federal Registry
D. Means of retaining (Nitty Gritty) pesticides for production of food and fiber
E. Certification of applicators who apply a pesticide which has restricted uses
F. Move Forward
G. Change attitudes
H. Create positive attitudes
I. Pass legislation (a vehicle) which would comply with federal regulation.
J. Texas Pesticide Control Act
Sec. 1: Title - Texas Pesticide Control Act.
Sec. 4.0: The Pesticide advisory Committee consists of the Deans of the Department of Agriculture of Texas A&M University and Texas Tech University, the Executive Director of the Parks and Wildlife Department, the Director of the Texas Department of Health Resources, and the Commissioner of Agriculture or their designated representatives.

(A) If any of the above named Committee wishes to designate a representative he may do so by notifying the Commissioner in writing giving name, title, and address of their representative. He may also change the representative at anytime, by notifying the Commissioner.

(B) Committee meetings:
(1) all meetings shall be called by the Commissioner and he may select a time and place that is most convenient to the majority of the members.
(a) At least one meeting anytime during a year is required.
(b) Other meetings may be called when the Commissioner determines he needs the advice of the Committee.
(c) Notice of all meetings will be given in the Texas Register.

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(2) (a) The Committee shall elect a permanent chairman and a a secretary to serve for a term of two(2) years. If the chairman or secretary is absent from any meeting then a temporary replacement will be selected for that meeting from the members that are present.
(b) The chairman shall report the findings of the Committee to the Commissioner within seven (7) days after the meeting.
(c) The secretary will keep the minutes of all meetings and assist the Commissioner in arranging the meetings.
(3) The Committee may request outside assistance when it is needed.

Sec. 5: Registration of Pesticides

(A) Every pesticide or device which is distributed within the State or is delivered for transportation or transported within this State must be registered with the Commissioner. Such registration shall expire annually on December 31.

(B) All applications for registration of a pesticide shall be on forms prescribed by the Commissioner and shall include the following:
(1) the name and address of the applicant, and the manufacturer if different from the applicant, and/or the name and address of the person whose name will appear on the pesticide label if not the applicant or manufacturer.
(2) The name of the pesticide, either the well known accepted common name or the chemical name or both.
(3) A list of dealers who will be distributing the pesticides where samples of the product may be obtained.
(4) Other information requested by the Commissioner to use in determing the eligibility of a pesticide for registration such as:
(a) the complete formula including active and inert ingredients.
(b) a full description of tests made and the results of the tests used to support the claims made for registration.
(c) the location on the container of the lot or batch number.
(5) Designation of a resident agent if the registrant is located outside the State.
(a) the resident agent shall be a citizen of this State and maintain a permanent address within this State where where documents dealing with the administration and enforcement of this law may be served.
(b) the registrant may designate the Secretary of State as the recipient of service of process in lieu of a resident agent.

(c) the registrant shall notify the Commissioner in writing within ten (10) days of any change in his resident agent. Failure to make this notification is grounds for suspending the registration of the registrants pesticides.

(C) The annual registration fee is Thirty Dollars ($30) for each pesticide to be registered. The registration fee shall not be prorated.
(1) If the registrant distributes a pesticide under more than one brand name or more than one formulation, then each brand and formulation must be registered as a separate product.
(2) In case of a renewal application made after March 1, of any year, an additional late registration fee of Five Dollars ($5) must be paid for each label to be registered.

(D) A custom mix is defined as a formulation produced on request for a specific customer. It shall be unlawful for any person to sell custom mixes without the identification of the purchaser and without an ingredient statement attached as required elsewhere in this ACT and so labeled as soon as formulated. The labeling shall be marked with an indelibel pen or stamp only and may be sold only to those persons whose name appears on the container and shall not be placed on the shelf for resale.

Sec. 5-1: Special Local Needs - The Commissioner has the authority under this ACT to register a pesticide to meet special local needs for uses and methods of application not covered by its federal registration. Before approving such registration, the Commissioner shall determine:
(A) That a special local need exists.
(B) That the applicant meets the other requirements for registration of a pesticide.
(C) That the particular use of the pesticide has not been denied, suspended, or cancelled by the EPA.

Sec. 7: Experimental Use Permits
(A) Experimental use permits may be issued by the Commissioner to any person to accumulate data necessary to register a pesticide in this State.
(B) Application for experimental use permits will be on forms prescribed by the Commissioner and shall contain the following information:
(1) the name and address of the person making application
(2) the name of the manufacturer of the product
(3) the name and address of the person responsible for the experimental program if different from the applicant

(4) the name of the pesticide and the ingredient statement.
(5) the use or uses requested for the experimental permit
(6) the estimated amount of the product to be used.

(C) A registration fee of Thirty Dollars ($30) must be paid for the products covered by an experimental use permit if it is not currently registered for other uses in the State.

Sec. 9: Pesticide Dealers

(A) All persons distributing restricted-use or state-limited use pesticides are required to have a valid pesticide dealers license for each location used for distribution. All licenses shall expire annually on December 31.

(B) Application for a dealer's license shall be made on forms prescribed by the Commissioner and shall include the following:
(1) the name of the business
(2) the mailing address and location of the business
(3) the name and address of the applicant's manager or agent. Business location outside the State must designate a resident agent.

(C) Fees - All applicants shall submit an annual license fee of Twenty-five Dollars ($25) for each license requested. This fee will not be prorated. Dealers that are licensed under the Texas Herbicide Law will not be required to pay an additional fee as long as the herbicide license covers only one outlet, a license will be issued to one at no charge. Each additional outlet licensed must pay the license fee.
(1) If an application for renewal of a pesticide dealers license is not filed by March 1, a late license fee of Five Dollars ($5) is required in addition to the annual fee.
(2) Dealers license are not transferable and in case of a change in ownership, a new application and fee are required.

(D) Records of sales of restricted use or limited use pesticides.
(1) All pesticide dealers are required to maintain records of sales for a period of two (2) years.
(2) These records will be submitted to the Commissioner at his request.
(3) Information to be recorded in the register shall include:
  (a) name and address of the person to whom the pesticide was sold or delivered.
  (b) date of sale
  (c) brand name and manufacturer of the pesticide
  (d) quantity of pesticide sold

(4) Invoices with above information will be accepted as record as long as they are kept separate from other sales records.

Sec. 15.1: Training Programs. Any person or educational institution may develop programs to train pesticide applicators in any phase of pesticide use.

(A) Training programs that must be approved by the Commissioner are any training program in one or more categories conducted:
  (1) As a part of the official certification process.
  (2) To maintain applicator certification in lieu of retesting
  (3) That claims to be "approved" or "accepted" or uses any term in its name or advertising that would lead the public to believe that it is approved.

(B) Submission of Training Programs for approval. Any person or institution may request the Commissioner to approve their training program. The request should include:
  (1) The categories or sub-categories that will be included in the program.
  (2) A complete description of all information to be presented, and the methods used for presentation.
  (3) Who is eligible to attend.
  (4) An estimate of the number of applicators to be trained.
  (5) The location of the training sites, and if a similar program is already being offered in the area, a statement why another one is needed.

  The Commissioner may consult with officials of the other regulatory agencies before he approves a training program for applicators in categories under their department.

Sec. 15.2: Applicator Certification

(A) The Texas Department of Agriculture will cerfity commercial and non-commercial applicators in the following categories and sub-categories:
  (1) Agricultural Pest Control
    (a) Field Crop Pest Control
    (b) Fruit and Vegetable Pest Control
    (c) Weed and Brush Control
    (d) Predatory Animal Control
    (e) Farm Storage Pest Control
    (f) Fumigation
  (2) Forest Pest Control
    (a) Insect and Disease Control
    (b) Weed and Brush Control

(3) Ornamental and Turf Pest Control
    (a) Plant Pest Control
    (b) Greenhouse Pest Control
    (c) Weed Control
(4) Seed Treatment
(5) Right of Way Pest Control
(6) Regulatory Pest Control
    For any category or sub-category listed in these regulations.
(7) Demonstration and Research Pest Control
    For any category or sub-category listed in these regulations
    Certification in (6) and (7) above will be made on the basis of a test administered by the regulatory agency responsible for the category requested.

(B) The Texas Animal Health Commission will certify commercial and non-commercial applicators in the following categories and sub-categories:
(1) Animal Pest Control
    (a) Tick, Louse and Mite Control
    (b) Fly Control

(C) The Texas Water Quality Board will certify commercial and non-commercial applicators in the categories and sub-categories of:
(1) Aquatic Pest Control
    (a) Aquatic Plant Control
    (b) Aquatic Animal Control

(D) The Texas Department of Health Resources will certify commercial and non-commercial applicators involved in:
(1) Health Related Pest Control
    (a) Vector Control
    (b) Rodent Control
    (c) Sanitation

Sec. 16: Pesticide application: Certified applicators or people working under the direct supervision of a certified applicator may apply restricted use or state limited use pesticide for the categories in which they are certified anywhere in this state as long as they use them in accordance with the labeled directions, except that the head of a regulatory agency may prohibit certain uses or require additional precautions for applications under his authority when in his agency's opinion it is necessary to prevent unnecessary adverse effects to the environment. The agency issuing the order shall notify the public in the area affected before any order is enforced, unless it is enforced, unless it is an emergency situation.

Sec. 18: Classification of Commercial and Non-commercial licenses

(A) Classification of commercial and non-commercial licenses will be made according to the categories and sub-categories in Sec. 15.2.

(B) The certifying agency will develop a separate test for each category and sub-category. Each test will be designed to cover the information necessary for an applicant to demonstrate that he is competent to use and supervise the use of restricted use and State limited use pesticides in a safe and effective manner. Anyone who makes a passing score on one or more test will be eligible to be a certified applicator in those categories or sub-categories and shall be certified as soon as all other licensing requirements are met.

(C) The applicant must pay the certifying agency a non-refundable testing fee of Ten Dollars ($10) for each test taken. Such fee must be paid before the test is given.

Sec. 19: Commercial Applicators License

(A) It shall be unlawful for any person to apply restricted use or State limited use pesticides to the land of another for hire or compensation unless such person has a current valid commercial applicator's license for the applicable use category or sub-category, or is working under the direct supervision of such license holder.

(B) Application for an original and renewal commercial applicator's license shall be on forms prescribed by the regulatory agency, to which the application is made and shall include the following:
   (1) The name and address of the company.
   (2) Name and address of the owner or manager.
   (3) The name and address of each certified applicator employed by the company.
   (4) The categories and sub-categories for which the license is requested.
   (5) The type and number of application equipment, either ground, aircraft, or other and the serial or license number of each. The "N" number is required for all aircraft.
   (6) A statement if the applicant has ever had a previous license suspended, revoked or refused in this or any other state.
   (7) A statement if the applicant has ever been convicted of a felony. Each application must be accompanied by annual license fee of Seventy-five Dollars ($75).

(C) Before a commercial applicator license is issued, either the applicant or one or more of his full time employees must be a certified applicator in each license use category requested.

The licensee shall notify the proper regulatory agency immediately of any change of certified applicators.

(D) A regulatory agency may not issue a commercial applicators license until the applicant has filed evidence of financial responsibility. The amount of bond or liability insurance required for each license will be Ten Thousand Dollars ($10,000) property damage, Twenty Thousand Dollars ($20,000) aggregate, and Ten Thousand Dollars ($10,000) bodily injury for each piece of aerial application equipment. The requirement for each piece of ground application equipment and hand operated equipment will be Five Thousand Dollars ($5,000) property damage, Ten Thousand Dollars ($10,000) aggregate and Five Thousand Dollars ($5,000) bodily injury.
All insurance policies must include chemical drift coverage in the amount stated above for all pesticides to be applied. A certified copy of the insurance policy must be submitted to the licensing agency as proof of coverage.
If the applicant's record indicates that more coverage is needed, the licensing agency may require additional coverage as necessary. In no event will the financial responsibility be less than Five Thousand Dollars ($5,000) nor more than One Hundred Thousand Dollars ($100,000) for each license.

Sec. 20: Non-Commercial Applicator License

(A) Application for a non-commercial applicator's license must be on forms prescribed by the applicable licensing agency and contain the same information as the commercial applicator's application.

(B) Nongovernmental applicants shall pay an annual license fee of Fifty Dollars ($50) at the time of application. No fee will be charged for a license issued to a governmental entity.

(C) Non-commercial applicator's licenses will be issued only to persons who have qualified as certified applicators in the license use categories or sub-categories for which the license is requested.

Sec. 21: Private applicators are not required to be licenses or certified under this ACT.

Sec. 21.1: The Texas Department of Agriculture will establish and supervise a program to certify private applicators, on a voluntary basis, to allow them to comply with federal law. This program will be based on the minimum requirements accepted by the Administrator of the Environmental Protection Agency (EPA) for any approved State plan.

Sec. 24: Maintenance of Records

(A) All licensed applicators shall make a record of all uses of restricted use and State limited use pesticides and keep these records for a period of two (2) years. These records shall include:
   (1) the date of application
   (2) the person for whom the work was done (owner or leasee)
   (3) the location of the land where application was made stated in a manner that would permit inspection by authorized parties.
   (4) the name of the pesticide and the amount used
   (5) the name of the pest for which it was used
   (6) what was treated, i.e., name of crop, kind of animal, etc...
   (7) the wind direction and velocity

(B) The regulatory agency may examine these records at any time during normal business hours or by written request require the licensee to submit a copy of these records.

Sec. 25. Regulation and Inspection of Equipment

(A) All application equipment used by commercial applicators must be registered with the licensing agency. The agency shall issue a decal to the licensee to be attached to each such piece of equipment in a conspicious place. The decal will contain the following information:
   (1) the year licensed
   (2) the applicator license number
   (3) the category or sub-category of license
   (4) the name of the issuing agency.
   (5) the identification number of the equipment

   The licensee shall notify the regulatory agency of any equipment changes made during the license year, and remove the decal before giving up possession of the equipment.

(B) All application equipment used by commercial applicators is subject to inspection by the regulatory agency at any reasonable time. Such equipment must be maintained in a condition that will provide for safe and proper application of the pesticide. If the inspector finds that it is not, he shall require the needed repairs before allowing the use of such equipment.

With all such restrictions, can we continue to have pesticides to produce plentiful crops? I think we can and I think we can use them in such a way that the quality of human life will be improved and the quality of the environment enhanced.

E N V I R O N M E N T A L   S T R E S S   S Y M P O S I U M

DROUGHT AND TURFGRASS MANAGEMENT

TEMPERATURE STRESS ON TURFGRASS

SALT TOLERANCE

SHADE TOLERANCE

TURFGRASS WEAR

SEWAGE EFFLUENT FOR IRRIGATION

DROUGHT AND TURFGRASS MANAGEMENT

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Turfgrass Specialist
Colorado State University

Fortunately, turfgrass managers and researchers are becoming increasingly concerned about water supply. A review of information on producing turf on dry sites or with a minimum of water indicates how limited knowledge in this area really is.

It should be pointed out that the environment and water stress vary greatly from time to time and from place to place. Thus, a discussion of drought as it affects turf management is applicable to virtually every turf producer. In the semi-arid regions of the U.S. water is most often the limiting factor in the production of a high quality turf. Even so, many present and future sites in the semi-arid West may be able to produce satisfactory turf for the situation without supplemental water.

Factors that influence drought and watering

Many environmental factors directly influence drought and water management. Therefore, a thorough knowledge of conditions on the site is valuable in developing a good water management program. A good, uniform soil condition makes for easier water management, and usually for more efficient water use. But, most turf situations, because of soil disturbances in construction and use of low quality land, have soils with great diversity in moisture storage and availability. Also, turf soils of poor quality often have very slow water infiltration rates. The preservation and use of good soils will provide a satisfactory water-air relationship for plant growth and development. Turfgrass root systems for adequate water recovery are expected to develop in good soils. Thus, in more arid regions the higher price of good land might soon be offset through a reduction in water costs.

Irrigation systems that will separately water isolated dry areas caused by poor soils can help conserve water. Too often an entire installation is completely irrigated at the first sign of drought, regardless of how small the dry area may be.

A site evaluation will point to areas of maximum exposure. For best water management south and west facing slopes, areas near reflective surfaces, etc. often need special treatment. Such areas, like poor soil conditions, can often be handled through proper irrigation or the use of more drought tolerant plantings. In some cases the use of special landscape considerations, such as an aggregate treatment, may be desirable for handling dry areas.

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Determine actual turf needs

Many areas that receive little use are often planted to grasses that require large amounts of water. Water can often be effectively saved by developing specific turf areas for heavy use while peripheral areas are handled with low water requiring plants.

Only a few grasses can be considered for turf use where drought conditions are frequently severe and irrigation is not practical or possible. And, turf that these grasses produce is usually of relatively low quality. To date very little attention has been devoted to a search for or to improving existing turfgrasses for droughty situations.

A grass may be quite drought tolerant, but without irrigation or above-average rainfall may not maintain the desired density. Also, a grass may not be satisfactory for golf courses or athletic fields since it may be dormant and brown for long periods and during times of peak use. It is commonly felt, especially in drier areas, that the ability of a turfgrass to remain alive during drought extremes is much more important than its ability to remain green into dry periods. Whereas, in less arid regions the ability of a grass to remain green into a dry period would be considered extremely important. It is important that, whenever possible, a statement or discussion about drought tolerance be qualified, that is, does the plant remain green well into a drought period; does the foliage desiccate, but the plant return to normal growth with adequate moisture; or does the plant die?

Information on the drought tolerances of turfgrasses is quite sketchy. For dry sites it would be well to consider both grasses that have historically been used for turf and that have exhibited good drought tolerance, and several others that show promise for turf where little if any supplemental water is to be used.

Common bermudagrass, buffalograss and blue grama are warm season grasses that are frequently used to vegetate dry land areas. Common bermudagrass is found to occur naturally or as cultivated turf under extremely diverse moisture and temperature regimes. Bermudagrass can be found doing a creditable job as a turf from southern Arizona to northern Colorado. Buffalograss and blue grama are common sod forming short prairie grasses. Buffalograss and blue grama are used for golf course fairways and roughs, highways and home lawns on the high plains of the U.S. In cooler areas invasion of warm season grasses by those that grow quite well at cool temperatures is not uncommon. And, a short growing season or irrigation can cause the cool season grasses to dominate in mixed stands of warm and cool season grasses.

In the cooler, semi-arid regions of the U.S. the wheatgrasses (including quackgrass), smooth brome and tall fescue are to be found growing without supplemental water.

The ability of Kentucky bluegrass to persist under droughty conditions has been surprising, and a collection of more than 100 of those that appear to do well under droughty conditions are being increased at Colorado State University.

For soil stabilization and rough turf in dry areas several grasses known to be drought tolerant may be mixed and seeded at relatively heavy rates to increase the probability of getting a satisfactory cover.

Manage the available water

Watering programs often need to be changed to decrease the amount used to produce a satisfactory turf. Lack of proper water management, even by the professional, occurs much too often in the arid and semi-arid West. Frequently, even very large turf installations are watered on a time basis (every day, every third day, etc.) with neither the soil nor grass being examined to determine that water is actually needed. As a result of excessive irrigation, a poor water-air relationship in the soil can limit root development. Through intensive irrigation succulent tissue may develop, and with drought stress this tissue may be seriously injured. As would be expected, turf kept with less frequent irrigation has a lower water use rate than that which is watered frequently.

When possible, for water conservation, care should be given to picking a good time to water the turf. In arid and semi-arid regions consider watering at night, after a brief shower, or when it is cloudy. When it is windy significant amounts of water will evaporate before getting into the soil, and most irrigation systems do not do the job properly in the wind. It is difficult to touch up dry spots after a poor irrigation, and touch ups normally waste water.

In some instances poor quality water may be about all that is available for irrigation, and such water can materially affect turfgrass management. The salinity hazard of irrigation water suspected of being poor quality should be determined. Water with 1000 - 2000 ppm dissolved salt may adversely affect many plants and require careful management. Water of 2000 - 5000 ppm can be used on more salt tolerant plants on highly permeable soils, and on more sensitive plants this water can be used only occasionally. High soil and/or water salts will greatly limit turfgrass production. Among the grasses found on the high plains where salts are a problem are common bermudagrass, saltgrass and alkaligrass, and where the Kentucky bluegrass is going out from salts, perennial ryegrass and bentgrass are often found doing well.

Maintain turf for drought tolerance

Watering turf on droughty sites has already been briefly discussed. In addition to watering, several other maintenance practices may materially influence the production of turfgrass under droughty conditions. Extensive drought studies underway at Colorado State University (and supported by the G.C.S.A.A.) indicate that mowing height may have only a slight influence on drought resistance of Kentucky bluegrass. For instance, instead of needing to water turf cut at 1½ inches every 21 days, that cut at 3/4 inch might need to be watered every 20 days. Thus, there may well be a tendency to over-compensate with water for low mowing heights.

Accumulations of thatch can influence water management. Thatch can act as a barrier to air and water movement into the soil. Also, it may cause the water to run from the area and not be stored in the soil root zone. Aerification and dethatching to assist water movement into the soil and growing deep-rooted, drought tolerant grasses can partially help offset drought problems associated with thatch.

Fertility practices can materially affect drought resistance. Excessive nitrogen fertilization should be avoided, especially in the spring, since it stimulates top growth and limits root development. Therefore, attention should be given to developing fertility programs that will help to conserve water.

Drought and water shortages present many difficult problems for the turfgrass professional. But, planning and action by the professional can solve the problems, and get a commendable job done.

TEMPERATURE STRESS ON TURFGRASS

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Temperature stress includes both heat and cold stress placed on the turfgrass by extremes in temperature. It is these extremes in temperature that limit the adaptation of certain species to different regions of the country. All plants have a temperature optimum for growth and as the temperature increases or decreases from these optimums, shoot and/or root growth is slowed. Under extremes, we get into temperature stress. Optimum temperature for growth of shoots of cool season grasses is 60-75°F., while 80-95°F. is optimum for shoots of warm season grasses. Optimum temperature for root growth is slightly lower than that of the shoots.

Heat stress usually occurs in midsummer heat and is often accompanied by drought, wear, and dessication. In fact, it is sometimes hard to distinguish between the different stresses. Heat stress makes the turfgrass more susceptible to other problems such as diseases, insects and weeds. While we don't have a great deal of control over the occurrence of high temperatures, there are several cultural practices that can be used to help reduce the stress on the turfgrass.

There are two kinds of heat stress that affect turfgrass; indirect growth stoppage, and direct kill. For the most part, indirect growth stoppage occurs most often. Symptoms of indirect growth stoppage are: a) root maturation, b) root die back, c) initiation of new roots stopped, d) reduction in shoot growth, e) open turf and finally f) a closing of the stomotal. All of the above conditions lead to a very weak plant which is highly susceptible to kill by other stresses. Closing of the stomotal causes increased leaf temperature which can result in direct kill from heat stress.

Direct kill from high temperatures does not occur as often as indirect growth stoppage. Killing of annual bluegrass by high temperature is probably the most common occurrence of direct kill. When talking about direct kill, it is the soil temperature that is most critical.

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High soil temperature will kill the root system which in turn leads to death of the plant. High soil temperature also affects shoots at the soil level. An open turf leads to higher soil temperature. A thick canopy formed by turfgrass is needed to help prevent heating of the soil.

Certain plants exhibit some tolerance to heat stress (heat hardiness). Heat hardiness will vary with: environmental conditions, age of tissue, type of tissue and cultural demands. Turfgrass grown in shady or wet conditions is less heat hardy. Excess growth, high N application, makes grass more susceptible to heat stress. Want proper balance of N-P-K. However, don't under fertilize grass during summer months. Turfgrass suffering from low fertility is more susceptible to heat and drought stress. Lethal temperature is lower at lowered cutting height. Lower cutting height places a stress on the grass and also reduces amount of canopy protecting the soil. Duration of heat stress and amount of humidity both affect hardiness of the plants. Longer heat stress periods and higher humidity will reduce the heat hardiness of turfgrass plants.

As previously mentioned, we have very little control over high temperatures. However, there are several cultural practices which can help turfgrass better withstand heat stress. Provide for good soil moisture conditions. This includes both good drainage to prevent wet conditions as well as ideal conditions for evapotranspiration to take place. Transpiration is very important in helping to cool the plant tissue. Also, provision should be made for good air circulation above turfgrass. During periods of heat stress, raise cutting height. This lessens the stress plus produces a denser canopy over the soil. During extreme heat stress, syringe grass lightly to help keep soil temperature down and reduce midday air temperature above canopy.

Low temperature stress occurs mostly during the winter months and loss of grass from it is often confused with dessication, low temperature fungi, etc. Low temperature kill of turfgrass is caused by the formation of ice crystals either intracellular or extracellular in the plant which causes disruption of the plant cells. When talking about low temperature hardiness, we are talking about ease with which ice crystals are formed in the plant.

Leaves and roots of the plant are more susceptible to cold temperature stress. Loss of leaves due to cold stress is not as critical as loss of meristematic tissue. As long as the meristematic tissue is not damaged, regrowth can occur in the following spring. Maximum winter hardiness usually occurs in early winter while the least hardiness occurs in late winter. It is late winter when the danger of thawing and then refreezing occurs most. Warm season grasses such as Bermuda and Zoysia are very susceptible to low temperature kill during this period.

There are two types of kill due to low temperature stress: complete kill and partial injury. With complete kill, there is no regrowth of grass in the spring. In partial injury, roots and crown tissue are usually damaged and when leaves start to grow in the spring, a water deficit occurs. Soil temperature is very important in winter kill since this is the area that protects the crown tissue.

Like high temperatures, there is not a whole lot that can be done to prevent occurrence of low temperatures. However, there are certain cultural practices that can be used to help reduce loss of turfgrass from low temperature stress. The key to survival of low temperature stress is to maintain a low plant hydration level during that period. To do this, both good surface and sub-surface drainage must be provided for in order to prevent standing water. Standing water around the crown increases the hydration level of the crown tissue.

Another important factor is fertilization. Avoid excess nitrogen going into the winter months. Too much nitrogen stimulates growth, which also increases hydration level of plant tissue. However, grass should not be in a stress from low nitrogen at onset of winter. Light applications of nitrogen in fall is beneficial. Adequate P and K should also be applied in the fall, especially potash. Potash (K) is very important in the hardening off process in plant tissue.

Prevention of thatch accumulation is also important in preventing low temperature kill. Thatch tends to raise the crown tissue out of the ground where it is more exposed to extremes in low air temperatures. Cutting height is also very important. Low cutting heights should be avoided during fall and early winter months. By raising cutting height, you help increase carbohydrate level in plant as well as increase amount of insulation (cover) to protect the crown tissue.

In summary, a turf manager should be aware of conditions that can lead to temperature stress problems (extremes in heat and cold temperatures). Cultural practices that can help reduce loss of grass due to heat and low temperature stress should be practiced year around. This is especially important as you move a grass into a region where it is not adapted.

SALT TOLERANCE

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Salt tolerance is the title assigned to my contribution of the Environmental Stress Symposium. However, I obtained most of my formal training in environmental stress physiology from a world famous environmental plant stress physiologist, Dr. J. Levitt. Dr. Levitt was very particular about definitions; in light of this, I would like to first make clear some basic definitions. This should help you better understand the topic and allow you to interpret other articles which may help you diagnose various plant management problems.

There are two basic kinds of stress tolerance. These two kinds of stress tolerance mechanisms are stress avoidance which is the ability to exclude the stress and stress tolerance which is the ability to survive an internal stress, (Diag. 1.).

Stress Resistance

Stress Avoidance (ability to exclude the stress) | Stress Tolerance (ability to survive an internal stress)

Diag. 1. Kinds of Stress Tolerance

As Diag. 1 indicates, stress tolerance of any kind is part of a two part definition of overall stress resistance. Therefore, for purposes of my discussion, salt tolerance will generally be referred to as salt resistance. Most of the time it is very hard to establish the difference between salt avoidance and salt tolerance anyway.

Next I need to define the various types of salt stress injury that one may encounter. Salt stress injury is also made up of two basic components. As Diag. 2 indicates, the primary stress component is the result of plant tissue damage caused by membrane distruction and metabolic disturbances. This type of salinity stress or injury is usually not reversible. In addition,

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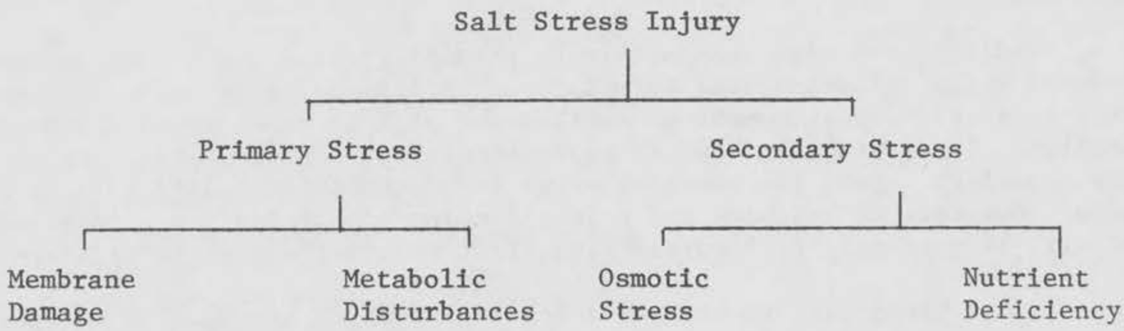
it is often times hard to distinguish it from secondary salinity stress. Secondary stress component of salt injury is caused by osmotic and nutrient deficiency stress (Diag. 2.).



Diag. 2. Kinds of Salt Stress Injury

Both of these salt stress components cause turfgrass and general golf course management problems. The environment and water quality probably influence the kinds of salt stress injury that may be found on a particular golf course or any other landscape area.

Osmotic stress or physiological drought is the result of an internal plant water deficit caused by a high external salt concentration. Physiological drought causes injury to plants in two ways. The first type of injury is due to a decrease in available water to the plant roots when there is a high salt concentration in the soil solution. Essentially plant roots could be swimming in water and still show the typical drought stress observed when the soil is dry. Physiological drought is also often observed as foliar burn. In this case, water soluble salts on the surface of leaves and stems causes water to leave the plant tissues because of the higher osmotic potentials outside the plant membranes.

Turfgrass seedlings may be particularly susceptible to physiological drought, especially under conditions which occur in arid and semiarid climates. Frequent light irrigations are usually necessary to keep newly seeded areas moist, but not so saturated that runoff occurs. Even with good quality irrigation water, continual high evaporation rates draw the soil water solution to the surface and concentrate the dissolved salts. The increased osmotic potential of the soil solution decreases the rate of seed hydration, which in turn slows down the rate of initial seed germination. As the time of initial germination increases, the number of frequent light irrigations increases and thereby the osmotic potential of the soil solution may increase that much more. So in a way, a building snowball effect of increasing salinity problems may develop in newly seeded or other areas which have poor drainage. Areas which are prone to runoff may also present problems as the amount of irrigation must be minimized to prevent erosion and seed washing.

Seedlings are also susceptible to physiological drought for the same reasons which influence seed germination. Additional salt injury may occur at this stage of development if fertilizers high in water soluble salts are applied. It is probably best to apply sufficient starter fertilizer to get new seedlings beyond the seedling stage before additional applications are made. However, if leaching and volatilization of nutrients has occurred, it will be necessary to topdress with light applications of fertilizers.

If one takes care to utilize a fertilizer which has less of a tendency to cause physiological drought, some of the hazards of nutrient application may be minimized. As Table 1 indicates, fertilizers may be rated by a ratio which measures their effect on the soil solution concentration. This ratio is called the salt index. However, an even better comparison may be made by using the partial salt index number which takes into account units of plant nutrient applied.

Table 1. The Relative Foliar Burning Tendency and Salt Index of Eight Fertilizers Commonly Used on Turfs [After, Rader, White and Whittaker (1943)]

Foliar Burn Tendency	Fertilizers	Salt Index	Partial Salt Index Number
High	Potassium nitrate, 12%N + 33%K	74	5.34
	Ammonium sulfate, 20%N	69	3.25
	Ammonium nitrate, 33%N	105	2.99
Medium	Potassium chloride, 50%K	116	1.94
	Urea, 45%N	75	1.62
Low	Potassium sulfate, 42%K	46	0.85
	Organic nitrogen carriers, 5%N	4	0.70
	Superphosphate, 8%P	8	0.39

So far we have defined salinity resistance and discussed some factors which may cause salinity injury as well as certain management practices one may use to minimize these problems. Next is a discussion of plant species and varietal salinity differences.

The list of turfgrass species (Table 2) indicates their relative salinity resistance. The salinity resistance differences should be taken into account when a new area is to be landscaped or a problem area has developed and needs to be repaired. Water quality and drainage conditions will usually be the primary factors to consider under establishment and repair conditions. In addition, there is salinity resistance variation within species, so that it may not be necessary to change plant species in apparent problem areas. Table 3 indicates salinity resistance differences in bermudagrasses which may be useful depending on particular local conditions.

Table 2. The Relative Salinity Tolerance of Seven Commonly Used Turfgrasses

Relative Salinity Tolerance	Electrical* Conductivity, ECe x 10^{-3}	Turfgrass
Good	8 - 16	Bermudagrass
		Zoysiagrass
		Creeping bentgrass
		St. Augustinegrass
Medium	4 - 8	Tall Fescue
		Perennial ryegrass
Low	4	Kentucky bluegrass

* Electrical conductivity of the saturation extract in millimhos per centimeter at 25°C (77°F).

Table 3. Tolerance to Salinity of Various Grasses

Tolerance	Bermudagrass	Creeping Bentgrass
Very high	Sunturf	Arlington
	Tifway	Seaside
	Santa Anna (RC-145)	
	Tifgreen	
High	Ormond	Pennly
	Common	Old Orchard
	U-3	Congressional
	RC-140	
Low		Cohansey
		Penncross

Recent research also indicates that considerable salinity resistance differences exist among varieties of Kentucky bluegrass. The more resistant varieties should prove to be useful in arid climates under conditions where year-round greens are desirable, but the level of maintenance is lower.

In many landscaped areas, certain plant species sustain salinity injury by conditions that are hard to control. Trees and grass around greens areas may be injured by foliar accumulation of salts caused by greens irrigation sprays and drifting mists. Most desirable trees and shrubs will show signs of foliar burn under these conditions in arid environments. There are very few plant species that are salt resistant enough to withstand these extremely adverse conditions. The best solutions to these problems are proper landscaping and irrigation equipment installation to minimize these problems. Consideration of adequate drainage will also be very useful in keeping these problems to a minimum.

As may be noted from the above discussion, salinity resistant plant species will become increasingly important as water quality levels continue to decline. However, salinity resistant species are not the entire answer to these problems as conditions caused by poor or inadequate management will quickly lead to salinity levels in the environment where even the most salt resistant species will die.

SHADE TOLERANCE

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With "tight" budgets and rising costs, free materials are a rarity. Yet, one of the most extensively used items in turf production, sunlight, is still free. At least, for the present, I know of no one who has learned how to place a charge on it.

In the course of this presentation, I want to discuss shade tolerance from two aspects: first, the basic considerations for production of turf under limited light, and secondly, practices we might consider where these conditions exist.

Trees and other types of shrubbery are desirable for many reasons but the resultant shade often creates problems in maintaining grass. It loses density, may become weak and often the stand is lost. Some type of cover is needed in these areas because of the undesirable traffic conditions that may be created. Maintenance of turf-grass in shaded or partially shaded areas presents a real test to the manager's skills.

The amount of incident light striking the grass is important. Cloudy days, smog or haze, reflection, shade and other factors interfere with the light received by the plant. This, plus a reduced rate of photosynthesis creates management problems. The process of photosynthesis is generally well known:

$$CO_2 + 2\ H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light energy}} CH_2O + O_2 + H_2O$$

Energy from light is a critical part of this reaction. As everyone knows, it is basic to our existence. If the rate of respiration begins to exceed the rate of photosynthesis for a very long period of time within the grass plant, we are in danger of losing it. Therefore, one of the important management factors is to do what we can to assure that a sufficient quantity of light strikes the turf plant or that the light intensity is high enough.

As previously mentioned, light may be lost by absorption, reflection, scattering, etc. In that respect, the question is sometimes asked, "Is

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morning light more effective than afternoon light?" The answer, in general terms, is probably yes. This can be partially explained on a net radiation basis. Considering the short wave radiation, the surface temperature would tend to be higher in the afternoon, thus the net radiation would be smaller in the afternoon.

Another important item in shade tolerance is light quality. Light is transmitted in waves of several different lengths and these taken individually have a characteristic color. When we gaze at regular light it has essentially no color and is referred to as white light. If the white light is passed through a prism then we see a visible spectrum of colors such as is seen when there is a rainbow. There are various pigments in the plant leaf, but those of immediate importance in photosynthesis are chlorophyll. It absorbs light in two general areas of wave lengths. These are in the vicinity of 420-475 m$/\mu$ (blue light) and again at around 655-660 m$/\mu$ (red light). Research here at Texas A&M University and other locations has shown that blue light will tend to minimize or reduce turfgrass elongation, thus producing a shorter, more dense turf. Red light tends to promote stem elongation, thus producing a spindly plant and more open turf.

The slides will show how blue and red light growing conditions were created in the growth chambers. A spectroradiometer, as illustrated in the slide, was used to measure both the quantity and quality of light. Various turfgrasses were grown under these conditions and their performance observed. Light measurements taken under a large post oak tree at College Station illustrate the reduction of light as we proceed from the canopy perimeter to the trunk. As the shade becomes denser, blue light penetration is reduced significantly. Although this is not the only reason, it is one of the explanations why grass grown under intense shade becomes elongated.

There are many additional factors having effects that could be considered such as temperature, light duration, fertility, and so on. Light duration is important for various reasons, but one of them is the influence on flowering. Plants grown in an area of unsatisfactory length of night and day for flowering will tend to remain in a vegetative stage. In most cases this is desirable for the person maintaining a turf area. Leaf angle is also important for interception of light. Generally speaking, in weak light, leaves should be in a horizontal position to enhance photosynthesis. At full sunlight, an inclination of about 81^{o} is desirable for efficient light use. From this, it can be stated that optimum leaf angle for the upper leaves should be nearly vertical whereas the lower ones should be horizontal.

Cool and warm season turfgrasses vary in their tolerance to shade. The varieties should be carefully selected for growth in areas of reduced light intensity. A chart showing adaptation is presented as follows:

RELATIVE SHADE TOLERANCE

Warm Season Grasses

Bermuda	Poor
Zoysia	Good
St. Augustine	Good plus
Centipede	Fair
Buffalo	Poor

Cool Season Grasses

Kentucky bluegrass	Poor to fair
Tall fescue	Good
Ryegrass	Fair to poor
Bents	Variable

There are several cultural practices we might follow in shaded areas. In addition to variety selection as mentioned earlier, some of them are:

(1). Trim as much foliage growth from trees and shrubs as possible and still be practical. The objective is to allow as much light to reach the grass as you can.

(2). Mow at a higher level. This will leave more leaf area for light reception.

(3). Keep the area sufficiently watered. Tree and shrub roots will sap much of the moisture and possibly weaken the grass due to moisture depletion.

(4). Do not fertilize excessively with nitrogen fertilizer.

(5). Check carefully for diseases and use fungicides when needed.

(6). Avoid as much wear and tear as possible. Attempt to divert as much traffic from shaded areas as possible. Location of greens and tees away from shaded areas is a suggestion. In turfed areas, location of park benches and tables so they will receive some sunlight during the day is desirable. Consideration might be given to periodic movement of the location for tables and benches when they are placed on grass.

If the level of light intensity is below the minimum for turf maintenance, then it will, of course be necessary to use another plant such as dichondria or a more shade tolerant type. By following good management principles, however, many managers have been able to enhance the turf cover where shade is a problem.

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TURFGRASS WEAR[1]

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Turfs located on public areas such as parks, golf courses, and sport fields will be subjected to increasing traffic in the coming years. These open green areas near urban centers will be used more frequently and intensively than ever before by individuals whose mobility has been restricted by the increased cost of energy for travel to more distant outdoor recreational areas. Discretionary time available for leisure activities is projected to be similar or to increase, thus providing substantial amounts of time for outdoor recreational activities. These increasing traffic pressures on recreational and sport facilities will require that the turfgrass manager become more knowledgeable about turfgrass wear tolerance and the cultural practices that can be used to minimize damage from traffic.

Traffic has two distinct effects that should be taken into consideration when interpreting the resulting turfgrass damage. One, called turfgrass wear, is associated with damage to the above ground plant parts. Scuffing and tearing actions of foot and vehicular traffic tends to crush the leaves, stems, and crowns of the turfgrass plant. In addition to these direct effects, the injured tissues are more prone to disease infection and environmental stresses such as drought. The second aspect of traffic involves the "hidden effect" of soil compaction. In this case the soil particles are physically pushed together into a more dense soil that is characterized by reduced aeration and water infiltration rates. Both the wear and compaction components of traffic can be very detrimental to turfgrass quality.

Most research, articles, and lectures have emphasized primarily the soil compaction component of traffic. However with the anticipated increased usage of turfgrass areas, the importance of wear

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[1]Data on which much of this article was based is the result of wear investigations supported by a grant from the United States Golf Association Green Section Research and Education Fund.

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tolerance and its manipulation will have to become better recognized in the future. The following three sections will discuss in detail the major approaches utilized to minimizing the effect of wear on turfgrasses.

I. TURFGRASS SELECTION

There are wide variations in the inherent wear tolerance of turfgrass species as shown in Table 1. These differences are significant enough to justify selecting the more wear tolerant species for a particular soil and environmental condition on sites where intense traffic is anticipated. The specific mechanism contributing to this interspecies turfgrass wear tolerance is being investigated through a grant from the United States Golf Association Green Section Research and Education Fund. Allied research supported by the same agency conducted by Beard, Shearman, and Anda has been directed towards characterizing the wear tolerance among cultivars within a specific turfgrass species.

To establish controlled wear stresses across a series of turfgrass species and cultivars a wear simulator was developed for small plot use. The apparatus simulated both foot and tire wear on turfs with minimal soil compaction. Foot traffic was simulated by a sled pulled in a circular twisting pattern with a pressure of 4 pounds per square inch being applied. The tire traffic simulator was comparable to that of a riding greensmower.

The comparative wear tolerance of 18 Kentucky bluegrass cultivars was evaluated in July of 1974 by Beard and Anda using the wear simulator. The turfs were five years old at the time the wear stress was superimposed. Cultural practices included mowing twice weekly at 1.5 inches with clippings returned; irrigation as needed to prevent wilt; and nitrogen fertilization at a rate of 5 pounds per 1,000 square feet per growing season. Phosphorus and potassium were applied as needed based on soil tests. Thatch accumulation was minimal and consistent throughout all plots. No pesticides had been applied during the previous four years. At the time the wear simulation treatments were applied the treatment area was visually free of weed infestation and injury from insects or diseases.

Specific wear tolerance comparisons of the 18 Kentucky bluegrasses are shown in Table 2. There was a five fold increase in wear tolerance from the lowest to the highest listed cultivar in terms of wear tolerance. This study indicates that there are substantial differences in wear tolerance among the commercially available Kentucky bluegrass cultivars which could be effectively utilized in establishing more wear tolerant turfs for intensively trafficked areas.

A similar cultivar evaluation study was conducted on nine bentgrasses maintained under putting green conditions. The turf was six years old and possessed no visual disease or insect injury at the time the wear treatments were applied. Cultural practices included mowing six times weekly at 0.25 inch with clippings being removed; irrigated as needed to prevent wilt; fertilization at 5 pounds nitrogen per 1,000 square feet per growing season; and topdressing twice yearly for thatch control. Phosphorus and potassium was applied as needed based on soil tests.

The comparative wear tolerances of seven commercially available and two experimental bentgrasses are shown in Table 3. Among the commercially available cultivars the striking superiority of Penncross creeping bentgrass is of particular interest. The much lower wear tolerance of Emerald and Toronto creeping bentgrasses should also be noted. Plans are underway through support of the United States Golf Association Green Section to conduct comparable studies on the commonly used warm season turfgrass cultivars. Hopefully these investigations will be underway during this coming growing season at Texas A&M University.

These comparisons among species and cultivars within species are based on wear simulation of mature turfs. It should be recognized that fully established turfs are definitely superior in wear tolerance to young seedlings. Thus it is important for traffic to be withheld from turfgrass stands during the seedling establishment period. Similarly, dormant or extremely slow growing turfs do not have the wear tolerance and recuperative potential of dense, actively growing turfs.

II. CULTURAL PRACTICES

The wear tolerance of a turf increases as the green vegetation or turfgrass shoot biomass increases. Therefore, lower cutting heights increase the proneness to wear injury. Similarly moderate amounts of thatch accumulation also contribute to a cushioning effect which increases turfgrass wear tolerance.

Wear tolerance is also reduced if the turfgrass leaves are quite succulent and delicate in nature. This condition is most likely to occur under excessive nitrogen fertility levels; intense irrigation; low potassium fertility levels; or under the shaded canopy of trees. The significance of these cultural practices in turfgrass wear tolerance should not be taken lightly. For example, a turf mowed at 1.0 to 1.5 inches, with 0.3 inch of thatch, and fertilized at a moderate level of nitrogen nutrition and a high potassium level can be as much as 10 to 15 times more wear tolerant than a turf mowed at 0.5 inch, with no thatch accumulation, and maintained under high nitrogen and irrigation levels.

III. TRAFFIC CONTROL

Turfs can not be expected to persist under continuous, intense traffic. Even artificial turfs will wear out within four to five years use. Fortunately turfs have good recuperative potential if the traffic stress can be diverted, withheld, or reduced for a period of time. A preventive approach in which the traffic level is adjusted to a level that the specific turf will tolerate without excessive damage is even more desirable. This traffic control can be achieved through subtle design techniques which disperse traffic over the area or redirect it across hard surface walks or roadways. These techniques involve the proper selection and placement of trees, shrubs, walks, roadways, contour barriers, and bunkers. Designs which offer a large number of alternate routes from one location to another are particularly effective where the site permits such an approach.

Finally, traffic should be withheld from turfgrass areas during periods of severe wilt stress or when the leaves have been frosted during the early morning. This will minimize mechanical damage to the brittle protoplasm which occurs under these stress conditions. Similarly, winter traffic on turfs covered with a wet slush should be avoided just prior to periods of severe freezing. The latter situation is generally not a problem in Texas.

SUMMARY

The major points discussed in this article only touch the surface of the traffic problem. As further research is conducted, additional guidelines regarding specific turfgrasses and cultural practices that can be utilized to minimize the effects of traffic can be expected. The Texas A&M turfgrass researchers anticipate that this area will receive major emphasis during the next few years.

TABLE 1. THE RELATIVE WEAR TOLERANCE OF TWELVE TURFGRASSES WHEN GROWN IN THEIR RESPECTIVE REGIONS OF ADAPTATION

RELATIVE RANKING	TURFGRASS SPECIES	
	WARM SEASON	COOL SEASON
Excellent	Zoysiagrass	
	Bermudagrass	
	Bahiagrass	
Good		Perennial ryegrass
		Tall fescue
Medium	St. Augustinegrass	Red fescue
Poor	Carpetgrass	Creeping bentgrass
	Centipedegrass	Colonial bentgrass
Very poor		Rough bluegrass

Adapted from "Turfgrass: Science and Culture".

TABLE 2. A COMPARISON OF VERDURE REMAINING AND PERCENT REDUCTION IN VERDURE FOR 18 KENTUCKY BLUEGRASS CULTIVARS AFTER 800 REVOLUTIONS OF A TURFGRASS WEAR SIMULATOR.**

KENTUCKY BLUEGRASS CULTIVAR	VERDURE REMAINING (GRAMS WET WGT.)	PERCENT REDUCTION IN VERDURE
A-34	7.88 f*	22.7 ab*
Merion	5.68 e	24.0 ab
Baron	5.45 e	18.4 a
Nugget	4.60 de	45.8 abcd
A-20	4.51 de	31.7 abc
Georgetown	4.47 cde	47.3 bcd
Primo	3.92 cde	33.5 abc
Fylking	3.56 bcd	55.6 cd
Adelphi	3.45 bcd	58.8 cd
Newport	3.45 bcd	57.6 cd
Sodco	3.22 abcd	58.7 cd
Galaxy	3.09 abcd	62.7 d
Bonnieblue	3.04 abcd	65.6 d
Belturf	2.71 abc	53.5 cd
Campus	2.05 ab	58.0 cd
Sydsport	1.96 ab	62.7 d
Kenblue	1.90 ab	44.5 abcd
Park	1.59 a	59.0 cd

*Any two treatments with the same letter in each respective column were not significantly different from each other, at the 5% level, by Tukey's test.

**From a study by R. B. Anda and J. B. Beard

TABLE 3. THE COMPARATIVE WEAR TOLERANCE OF SEVEN COMMERCIALLY AVAILABLE AND TWO EXPERIMENTAL BENTGRASSES AFTER 410 REVOLUTIONS OF THE WEAR SIMULATOR

TURFGRASS CULTIVAR	PERCENT REDUCTION IN VERDURE	VERDURING REMAINING (GRAMS)
MSU-28-Ap	39.8	6.07
MSU-18-Ap	32.8	3.90
Penncross	53.0	3.64
Pennpar	58.7	3.07
Cohansey	65.9	2.56
Seaside	59.8	2.55
Toronto	53.6	2.46
Emerald	67.7	2.12
Astoria	64.4	1.83

SEWAGE EFFLUENT FOR IRRIGATION

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Considerable interest has developed recently regarding the use of municipal sewage effluent to irrigate golf courses. In arid regions, where irrigation is practiced most extensively, much of the interest has been motivated by the increasing shortage and/or high cost of water. Increasing national concern over indiscrimenent disposal of sewage effluent and the associated environmental hazards has also contributed to the interest in using effluent for irrigation.

As metropolitan areas such as Denver, Colorado and Tucson and Phoenix, Arizona continue growth at the fastest rates in the nation, the shortage and costs of water can only be expected in increase.

WHO GETS THE WATER?

Determining who should use existing water supplies is not always easy and may result in legal disputes among municipal, agricultural, industrial and other kinds of water users. Most people will agree that our city parks and golf courses are needed and are extensively used, yet it is difficult to assess a dollar value to them or the turfgrasses which they culture. It is much easier for agriculture or industry to show cause for meeting increasing water needs on the basis of cost-benefit ratios because definite dollar values can be associated with their products. Thus, golf courses are not in a very desirable position to compete for water which can be used for industry or agriculture.

Treated effluent from most cities is dumped into the nearest stream or large body of water. Obviously in these instances there is no current demand for the effluent, and it is available for whatever safe uses can be demonstrated. Competition for use of effluent may develop in the future, however, as awareness of its value for irrigation increases. Golf courses will be in a better position to compete for treated effluent than for good potable water because the effluent usually is not suitable for use by domestic households or in industry. There may be demand by agriculture, however, especially in critically water depleted areas. Some advantages to irrigating golf course rather than conventional agriculture with effluent are:

1) utilization of nutrient constituents (primarily N and P) on an annual per unit area basis is high and should minimize groundwater contamination by these elements;

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2) use continuity is not interrupted by cultivation, seeding or harvesting operations common to agriculture and;
3) the use is in close proximity to the source thereby minimizing transmission expenses.

Sewage effluent irrigation of golf courses may not be economically feasible for large cities which have a nearly static population because of the expense involved in building new pipelines from existing treatment plants to golf courses. Future golf courses, for rapidly growing cities, can more easily utilize effluent by obtaining sites close to existing or future sewage treatment facilities. This category of cities includes those which are currently experiencing the water shortage problems alluded to above.

EFFLUENT QUALITY

Detrimental Apsects. The quality of treated sewage effluent should not, in most instances, be a deterrent to its use for turfgrass irrigation. This statement is especially true when the principal source of effluent is from domestic household use.

Effluent quality may vary widely depending upon quality of the original water and its use prior to treatment as sewage. Quality parameters of greatest concern for irrigation are the total salt content and the ratio of sodium to calcium plus magnesium (SAR). Under good management the concentrations of salt and sodium will not normally present problems. For small non-industrial communities which do not use water softeners, the total salt content of the effluent has been found to be about 200-300 ppm greater than for the original water. For highly industrialized communities using water softeners, the increase may be as high as 600 ppm (1,4). Few thorough studies of effluent quality have been reported. Existing data indicate that total salt contents of effluent usually are in the range of 1,000 to 2,000 ppm (2,5). Effluents with salt contents in this range will be suitable even for irrigation of sensitive turf such as Kentucky bluegrass and colonial bentgrass when soil drainage is good and the salts are not allowed to accumulate in the soil. SAR values greater than about 4 (depending on total salt content) may impair turf growth because of the detrimental affect of sodium on soil structure and hence aeration and drainage.

In addition to sodium, other dissolved elements which may adversely affect the soil or turf, or be of environmental concern are boron and the heavy metals zinc, copper, nickel, lead, chromium, mercury and cadmium. High heavy metal concentrations are associated with effluents from heavily industrialized areas. Even these effluents, however, may be used for turf irrigation in arid regions where the commonly calcareous soils cause them to precipitate, reducing their uptake by plants. Boron concentrations may be high in conventional irrigation waters and in treated sewage effluent. Boron is relatively mobile in soils and accumulations can usually be removed by leaching. Concentrations of one ppm or greater in effluent should be considered potentially hazardous to turfgrass.

Beneficial Aspects. In addition to constituents which may be harmful, treated effluent contains many of the required plant nutrients which will be beneficial to turfgrass. Most important of these is nitrogen. Treated effluent generally contains between 20 to 30 ppm N, but the concentration may vary in a manner similar to that of other constituents discussed above. In arid climates where irrigation is extensive, effluent may constitute a valuable source of nitrogen for the turf. For example, at the current cost of nitrogen from urea ($0.25/lb of nitrogen), one acre foot of effluent containing 25 ppm nitrogen would be worth $16.98. The annual irrigation requirement in arid regions may be as high as five acre feet. When effluent containing 25 ppm nitrogen is used to meet this requirement, a saving of $85 per acre may be realized in reduced nitrogen fertilizer expenses. Phosphate and potassium are also found at measureable concentrations in effluent, however, their value is more difficult to assess because their deficiencies in soils are not quite as widespread.

Although the beneficial aspects will normally outweigh the detrimental aspects, the potential detriments and benefits can be assessed by periodic careful chemical analysis of the effluent by commercial or university soil and water testing laboratories.

HOW MUCH EFFLUENT SHOULD BE USED?

The amount of effluent which can be used for irrigating a particular golf course will depend primarily on the water and nutrient requirements of the turf and the capacity of the soil to receive, filter out and store these requirements from each effluent irrigation.

Lower Limit. As a first approach, the minimum rate and frequency must be at least as great as used for good quality irrigation water. The total application should not exceed the soil water holding capacity, and should be frequent enough to meet the water requirements of the turf. The experienced local superintendent should already be familiar with these requirements.

The duration of irrigation sets may have to be increased occasionally to provide leaching if the effluent has a high salt content. The extent to which this might have to be done will depend on local climate and soils, and guidance from a local Agricultural Extension Agent should be sought. Similar leaching may be necessary if B concentrations are high in the soil or effluent.

Upper Limit. When N concentration of the effluent is high or if the supply of effluent is not limiting, it is possible to provide the entire N requirement of the turf by effluent irrigation. The annual volume of effluent required to supply turf with one pound N/1000 ft^2/month has been calculated for Tucson, Arizona (3) and is included here, (Figure 1) to illustrate how the irrigation volume must be adjusted in relation to effluent N concentration.

When these volumes of effluent are received or applied at a constant rate throughout the year, then they must be viewed in relation to turf consumptive water use (Figure 2). For Tucson, Arizona the annual turf consumptive water and N use would be met by applying 56 inches per year of an effluent containing about 35 ppm N (dashed line). In order for this to be accomplished however, excess effluent received during the period from November thru March would have to be stored for use during the period from April thru October. If storage cannot be provided and the effluent must be accepted at a constant rate, then a higher rate corresponding to the peak seasonal requirement could be used. In this case the major concern would be that excess N were not applied and that soil infiltration and drainage were adequate. If the effluent contained 30 ppm N, 6.5 inches applied per month would provide sufficient N and an excess of water. The merit of excessive applications would have to be considered with regard for relative costs of effluent and supplemental N as well as the need and suitability of the soil for leaching.

EFFLUENT PURIFICATION BY SOIL AND TURF

Most types of soil will have sufficient capacity to remove the major portion of effluent impurities found in one normal irrigation with effluent. Actively growing turfgrass will absorb from the soil the major nutrient elements (N, P, and K) removed from the effluent. Thus the capacity of the soil to remove these elements is maintained by actively growing turfgrass. Of these elements, N is required in greatest amount by turfgrass, and it also is usually the most concentrated in effluents. The extent to which this removal occurs for N is indicated by the results of a 32-week study conducted at the University of Arizona reported in Table 1 (6). These results clearly show that the soil-turfgrass system is very effective in removing N from effluent (average effluent N concentration was 20 ppm), and that most of the N removed ends up in the turfgrass clippings. Obviously some of the N removed remains in the roots and unclipped portion of the turf and some is biologically incorporated in the soil organic matter. Irrigation at the high rate added an average of about one pound of N/1000 ft^2/month, which is the commonly recommended rate for actively growing turf. Although the average removal efficiency was greater than 90% for all soil-irrigation level combinations, the decrease in removal efficiency associated with high irrigation rates and coarse textured soils is evident.

Table 1. MEAN VALUES FOR REMOVAL EFFICIENCY AND NITROGEN UTILIZATION FOR SOIL-TURFGRASS SYSTEMS.

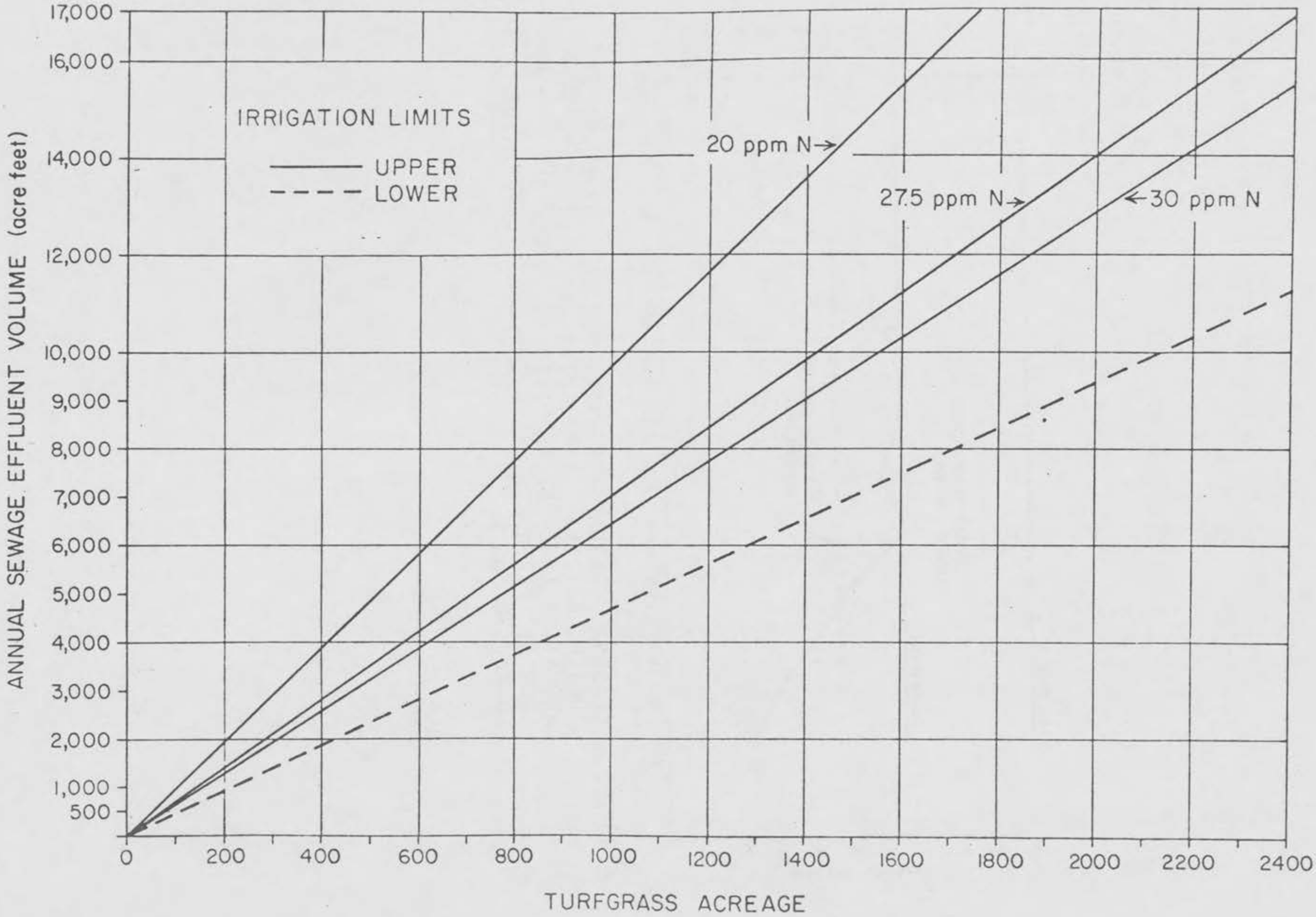
SOIL TYPE*	IRRIGATION** LEVEL	REMOVAL EFFICIENCY	UTILIZATION ON N BY GRASS
		%	%
SL	L	94.4	115.5
SL	M	94.6	83.0
SL	H	94.0	86.7
SiL	L	96.9	82.4
SiL	M	95.6	70.5
SiL	H	91.5	68.8

*SL - sandy loam, SiL - silty loam
**L, M, H. = approximately 4, 7, and 11 inches applied per month.

SUMMARY

Treated municipal sewage effluent can be and is being used successfully to irrigate turfgrass. The major differences between treated effluent and local irrigation water usually are those of increased nitrogen, phosphate, soluble salt, organic matter, and microbial content. When the effluent and its intended use meet the requirements of local, state and federal agencies such as Public Health Departments and Water Quality Control Boards, then the remaining limitations on the use of effluent will be similar to those considered for conventional irrigation. Excessive salt, sodium, boron, or nitrogen contents are major factors to be considered. These, however, will normally not be prohibitive when the source of effluent is primarily from domestic household use.

FIGURE I. SEWAGE EFFLUENT REQUIREMENT FOR TURFGRASS MAINTENANCE AT DIFFERENT EFFLUENT NITROGEN CONCENTRATIONS.



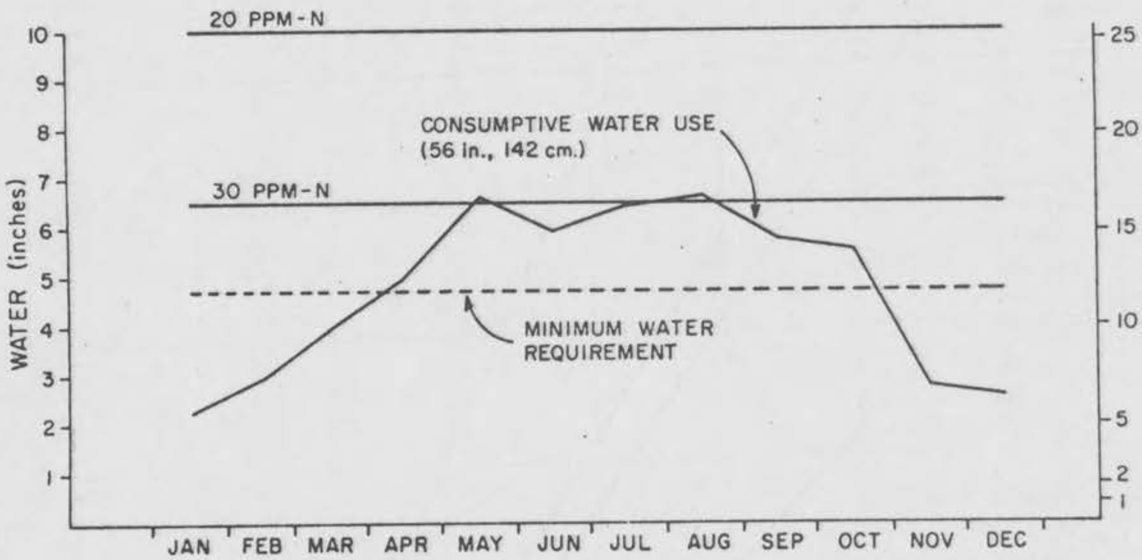


FIGURE 2. SEASONAL CONSUMPTIVE WATER USE FOR TURFGRASS AT TUCSON, ARIZONA. HORIZONTAL LINES INDICATE THE AMOUNT OF EFFLUENT REQUIRED TO SUPPLY ONE LB. N/1000 ft³ PER MONTH USING EFFLUENTS CONTAINING 20 and 30 ppm N.

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