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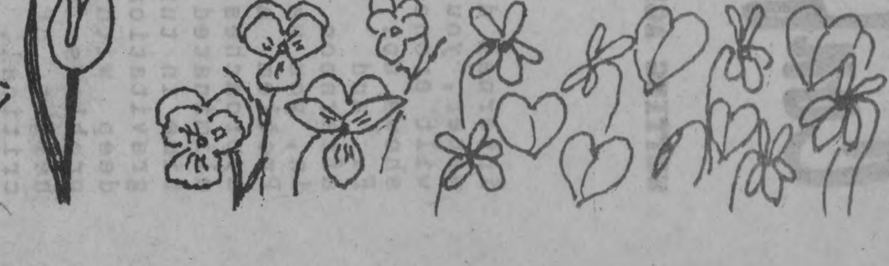
Harvests

Volume 33 Number 1

THE HARVEST MIX

Does too much reading tend to keep you behind ? If so, use Harvests to keep up-to-date on all that's going on in high-tech turfgrass science and then single out those topics that offer good prespects for follow-up reading. These topics are discussed fully in the technical journals and trade magazines cited.

For example, this Harvests Mix features a review of eighty-nine turfgrass related papers presented at the December 1985 Annual Meeting of the American Society of Agronomy. These research reports are grouped in fifteen subject matter sections established to focus attention on new information of value to you. A harvest of ideas and information is yours in each issue of Harvests.



New Grounds Maintenance Manuals

From: Allan Shulder
PGMS
3701 Old Court Road Suite 15
Pikesville Maryland 21208

301/653-2742

The Professional Grounds Management Society is pleased to announce that two manuals are now available. The Grounds Maintenance Estimating Guidelines, 4th Ed, 20 pages, is a convenient 8 1/2 x 11" size. It includes information on cost generation, estimating worksheet, maintenance task chart, new job form, labor cost worksheet, capital cost calculations, machine cost worksheet and appendices. The Grounds Maintenance Management Guidelines, 2nd Ed, 28 pages, is the same size. It provides a reasonable guideline of standards of maintenance being met around the country.

Each manual can be purchased for a price of $9.00 a piece [if check is sent with order] or $12.00 per book [if billed]. If both are purchased at the same time, the total price for the two books is $15.00 [if check is sent with order] or $20.00 [if billed].

To place your order, send to PGMS Headquarters, 3701 Old Court Road, Suite 15, Pikesville, MD 21208.

Another manual will be available within two months which will cover job descriptions, contract samples and job forms.

International Turfgrass Society Research Conference Proceedings

From: Dr R E Schmidt
Turfgrass Research
Agronomy Department
Virginia Polytechnic Institute
& State University
Blacksburg Virginia 24061

Proceedings of the ITS Research Conference are available from this office. Cost of 1st, 2nd, 3rd, 4th, and 5th are: $10, $17, $18, $20 and $35, respectively. [Advance payment and $1.00 postage is required on all orders outside the USA]. The 5th Proceedings may also be purchased from INRA Publications, Rte de St-Cyn 78000, Versailles, France for 300 French francs.

Lawn Management Video Tapes

From: Dr Paul E Rieke
Extension Specialist - Turf
Department of Crop & Soil Sciences
Michigan State University
East Lansing, Michigan 48824

A series of 6 videotapes of Turf Tips for Lawn Care have been developed jointly by the Cooperative Extension Service at Michigan State University and the Michigan Turfgrass Foundation. An outline of each tape and a short-answer self-test with answers is available for each tape. These can be used by lawn care companies, golf course superintendents and other grounds supervisors for training new employeees as well as in various educational programs. All tapes are copyrighted and are not to be copied. Videotapes available are listed below.

Tape No.	Topic
1	Lawn Establishment - 14 minutes
2	General Lawn Care - 26 minutes
3	Lawn Grasses - 16 minutes
4	Lawn Fertilization -- 16 minutes
5	Lawn Weed Control - 17 minutes
6	Lawn Maintenance Equipment - 19 minutes

Tape format: Tapes can be purchased on VHS, 1/2 inch Beta or 3/4 inch broadcast quality.

Pricing: General public - $60 per tape or $300 for the set of 6. Educational institutions: $35 per tape or $175 for the set of 6; 3/4 inch tapes are broadcast quality - $80 per tape or $400 for the set of 6.

Ordering: The Michigan Turfgrass Foundation
P O Box 275
Okemos MI 48864

or call Kathy 517/355-0270.

Tree, Turf and Ornamental Pesticide Guide

From: Lori Thomson
Marketing Director
Thomson Publications
P O Box 9335
Fresno California 93791

209/291-2900

The Tree, Turf and Ornamental Pesticide Guide is one of the few references on the market today designed as a guideline to pesticide usage in the specialized ornamental field.

This newly revised book from Thomson Publications is a fast, efficient guide providing useful information as to which pesticide should be used to control a certain pest on a specific ornamental, tree or shrub. Information has been obtained from the basic manufacturers labels and the EPA pesticide summaries. The Tree, Turf and Ornamental Pesticide Guide is a valuable tool for pest control operators, grounds superintendents, turf specialists and more.

For ordering information, contact Thomson Publications, P O Box 9335, Fresno CA 93791; 209/435-2163.

Turfgrass Water Conservation

From: Dr Victor A Gibeault
Extension Environmental Horticulturist
Plant Sciences Department
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Riverside California 92521

714/787-4429

After the droughts of 1976-77 and 1977-78 in the western United States, it became clear to experts in turfgrass cultivation and water conservation that a comprehensive source of information was needed on conserving and using water to assure turfgrass survival and maintenance.

To meet the need for comprehensive information, a symposium, sponsored by the American Sod Producers Association [ASPA] was held in 1983 in San Antonio, Texas. The result of that meeting was the writing of Turfgrass Water Conservation. Sixteen world-renowned authorities took on the project, dividing it into 11 chapters that range from the size, scope and importance of the turfgrass industry [chapter 1] to designing turfed sites that will utilize water economically [chapter 11].

Chapter 2 through 10 cover:

- Water: Whose is it and who gets it ?
- Water resources in the United States
- Physiology of water use and water stress
- An assessment of water use by turfgrasses
- Turfgrass culture and water use
- Influence of water quality on turfgrass
- Soil/water relationships in turfgrass
- Irrigation systems for water conservation
- Influence of water on pest activity

Turfgrass Water Conservation is a "must read" for professionals in the industry: landscape architects, designers, contractors, suppliers, and consultants, as well as sod growers and turf managers. It will also prove useful to educators, students, researchers and civic leaders. Its aim, successful water management, can bring about successful turf management, and successful turf management offers the possibility of a healthy, attractive environment for us all.

Technical editors of Turfgrass Water Conservation are Victor A Gibeault, Cooperative Extension Environmental Horticulturist, and Stephen T Cockerham, Superintendent of Agricultural Operations, University of California, Riverside.

Turfgrass Water Conservation is a 156-page, 8 1/2 by 11" softbound book, illustrated with 29 black and white photographs, 47 drawings and 38 tables.

ORDERING INFORMATION:

To order your copy of Turfgrass Water Conservation :

ANR Publications
University of California
6701 San Pablo Avenue
Oakland, California 94608-1239

Publication Number: 21405

Price: $10.00 ISNB 0-931876-69-9

Research Synthesis

[Analysis of Research Reports and Interpretation of Results]

Eighty-nine Turf Type Topics Reviewed by Agronomists at 1985 Convention

Eighty-nine turfgrass related research reports were presented at the 1985 annual meetings of the American Society of Agronomy in Chicago, Illinois. This was about the same number [85] released in 1984. These reports were submitted by scientists from thirty one landgrant universities [including USDA-ARS cooperating] and from 3 private industry research stations as follows:

Six Northeastern Universities -

University of Rhode Island	[4]
Cornell University	[4]
University of Delaware	[1]
University of Maryland	[1]
Penn State University	[2]
Virginia Polytechnic Inst	[2]
Total	14 papers

Eight Southeastern Universities

University of Florida	[6]
University of Georgia	[5]
Auburn University	[4]
University of Tennessee	[1]
University of Kentucky	[1]
Clemson University	[1]
North Carolina State Un	[2]
Mississippi State University	[1]
Total	21 papers

Nine Midwestern Universities

Iowa State University	[3]
Ohio State University	[2]
University of Illinois	[6]
University of Nebraska	[7]
University of Missouri	[3]
Southern Illinois University	[3]
Kansas State University	[2]
Michigan State University	[3]
Purdue University	[1]
Total	30 papers

Four Southwestern Universities

Texas A & M University	[9]
University of Arizona	[1]
Oklahoma State University	[4]
University of Arkansas	[1]
Total	15 papers

Four West-Northwestern Universities

University of California	[1]
Colorado State University	[2]
Oregon State University	[1]*
Washington State University	[1]*
Total	3 papers

* - co-sponsored

Three Industry Research Stations

Pure Seed Testing Inc Hubbard Oregon	[1]
Monsanto Agricultural Prod Co, St Louis, Missouri	[5]
3-M Company St Paul, MN	[1]
Total	7 papers

These reports are referenced in the following fifteen subject matter sections:

Subject Matter Section	Papers
- Water Use by Turfgrasses	13
- Tall Fescues	11
- Maintaining Warm Season Grasses	10
- Growth Regulators	9
- Zoysiagrass	8
- Turfgrass Fertilizers & Nutrition	7
- Poa annua	6
- Turfgrass Selection & Breeding	5
- Putting Green Turf	4
- Maintaining Cool Season Grasses	4
- Turfgrass Morphology/Physiology	3
- Buffalograss	3
- Information Systems	2
- Seed Science	2
- Soil Cultivation	2
Total	89

NOTE: page numbers [ ] in Agronomy Abstracts, 1985 Annual Meetings are provided for further reference.

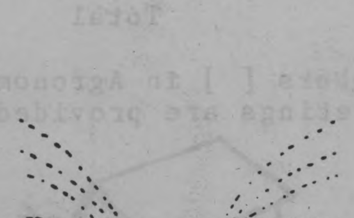
WATER USE BY TURFGRASSES

Most turfgrass research specialists are in agreement that water, or lack of it, is the greatest problem facing the turfgrass industry today. Water quality and water quantity provide serious limitations in humid as well as arid regions of the United States. This is because the amount of available water in the world is fixed, yet demands on this limited supply are increasing continuously because of increasing world population. Recycling has led to increased pollution and mineralization of our rivers, lakes and underground resources. Overpumping of underground water has caused land settlement and salt intrusion problems. Water management districts are placing increased restrictions on the use of water for turf irrigation, especially during periods of extended drought [4].

Pennsylvania State University has developed 12 runoff areas for conducting water quality research. Suction lysimeters collect percolated water. Flow rates on each slope are monitored. Fertilizers and pesticides will be applied to the turf at rates in accordance with label recommendation and evaluations of runoff made [13].

Average 1984 concentration of inorganic nitrogen in leachate from Kentucky bluegrass at the University of Rhode Island was 0.65, 0.49 and 0.55 parts per million for the 0, 2 and 5 pounds of nitrogen per 1000 square feet [0.97 and 244 Kg/ha] respectively. Average runoff concentration of inorganic nitrogen increased with additions of nitrogen to a maximum of 1.52 ppm [7].

Nocturnal transfer of water through roots and lateral stems from soil in one place to that in another has been observed repeatedly. Calculations of water movement are based on the difference in water potential between the two root zone soils and on the independently measured hydraulic resistance of bermudagrass, such that flow could take place in either direction. Results of research at Texas A and M University suggest that passive flow of water through plants can be a significant component of water movement in soils [3].



Mean daily evapotranspiration from June through September in well watered turf at the University of Rhode Island has been found to be 1/7, 1/7, 1/8, 1/8, and 1/10 inch of water [0.35, 0.34, 0.33, 0.33, 0.22 centimeter of water] for Baron Kentucky bluegrass, perennial ryegrass, Enmundi Kentucky bluegrass, red fescue and sheep fescue, respectively. Evapotranspiration rates declined in all species in response to drought stress [1]. With Touchdown Kentucky bluegrass, Sabre rough bluegrass, Pennfine perennial ryegrass, Pennlawn creeping red fescue, Jamestown Chewings fescue, Scaldis hard fescue and Kentucky 31 tall fescue, evapotranspiration rates in a uniform cultural regime vary by as much as 18,17 and 22 percent during spring, summer and fall, respectively. Optimum cultural regimes, based on species requirements and evapotranspiration related to these variables, vary by as much as 26, 15 and 23 percent during spring, summer and fall, respectively. Bluegrasses rank highest, fine fescues intermediate and perennial ryegrasses lowest in rate of evapotranspiration. Tall fescue has a low evapotranspiration rate under uniform cultural conditions, but a high rate under its optimum cultural regime. This has been related to cutting height [11]. When grasses are irrigated to replenish 100 percent of maximum evapotranspiration, tall fescue uses more water than other grasses studied during June, July and August. Kentucky bluegrass and perennial ryegrass use approximately the same amount of water and fine fescues use least water. Under deficit irrigation [75 percent of maximum for Kentucky bluegrass] fine fescues remain green and viable longer than Kentucky bluegrass, perennial ryegrass or tall fescue, because they have a lower water use rate. Irrigation at 50 percent of maximum evapotranspiration results in unacceptable turf quality for all four cool season species [6].

A surface moisture density gauge with a radioactive source and slow neutron dectector is being used at the University of Florida to provide a rapid non-destructive method for determining soil moisture in turfgrass. Measurements have been found linear from field capacity to wilting point. Although gauge readings are influenced by moisture in the above ground biomass, moisture in the upper soil layers has the greatest impact on gauge readings [2].

Maximum turgor pressure and relative water contents, turgid weight: dry weight ratios, osmotic potentials at full turgor and incipient plasmolysis, relative water content at incipient plasmolysis, elastic modulii, and leaf extension rate after water stress is relieved are all leaf parameters that can be studied before and after water stress treatments. A temperature-controlled hydroponic system ultilizing a polyethylene glycol nutrient solution has been developed at Washington State University [8].

WATER USE BY TURFGRASSES Continued

Agricultural production, hydrological and ecological studies regarding the input of grasses on drainage water quality have involved nitrate, phosphorus and pesticides. At the watershed scale, the role of grasslands as buffer strips and riparian zones for chemical sources and sinks are important [12]. Potential inorganic pollutants from effluent include nitrate nitrogen, phosphorus, boron and sodium. Nitrate leachate concentrations are related to effluent loading rates for any given soil. Biological hazards in effluent include virus particles and coliform bacteria. These are efficiently removed by soil turf filters in the arid southwest. Tifgreen or common bermudagrass grow well when irrigated with effluent, while tall fescue does not do as well [10]. Development of turfgrasses which will utilize water of reduced quality is considered feasible. Osmotic potential, ion toxicity and nutrient uptake inhibition are just a few of the complex problems associated with poor quality watter, salinity and high pH. Plant adaptive tolerance and avoidance mechanisms have an effect on turfgrass persistence in the presence of heavy metals and soil salinity [5]. Turfgrass species show differential tolerance and/or resistance to salinity problems associated with either saline soils or irrigation water. These problems may affect selection of species for various uses or methods of establishment or cultural practices [9].

References:

1. Aronson, L J, A J Gold, J L Cisar and R J Hull. Water Use and Drought Responses of Cool-Season Turfgrasses. [113] University of Rhode Island.

2. Augustin, B J and G H Snyder. Measuring Turfgrass Soil Moisture With a Surface Nuclear Gauge. [113] University of Florida.

3. Baker, J M and C H M van Bavel. Water Transfer by Plant Roots from Wet to Dry Soil. [138] Texas A & M University.

4. Dudeck, A E. Turfgrass Water Resources - An Overview. [116] University of Florida.

5. Horst, G L. Physiological Effects of Non-Potable Water on Plant Growth. [116] Texas A & M University Research and Extension Center, El Paso.

6. Minner, D D and J D Butler. Cool Season Turfgrass Quality as Related to Evapotranspiration. [119] University of Missouri and Colorado State University.

7. Morton, T G, A J Gold and W M Sullivan. Waterborne Losses of Nitrogen and Herbicides from Turfgrasses. [119] University of Rhode Island.

8. Nus, J L, S E Brauen and R L Goss. Evaluating Turfgrass Response to Water Stress Using Moisture Release Curves. [86] Kansas State University and Washington State University.

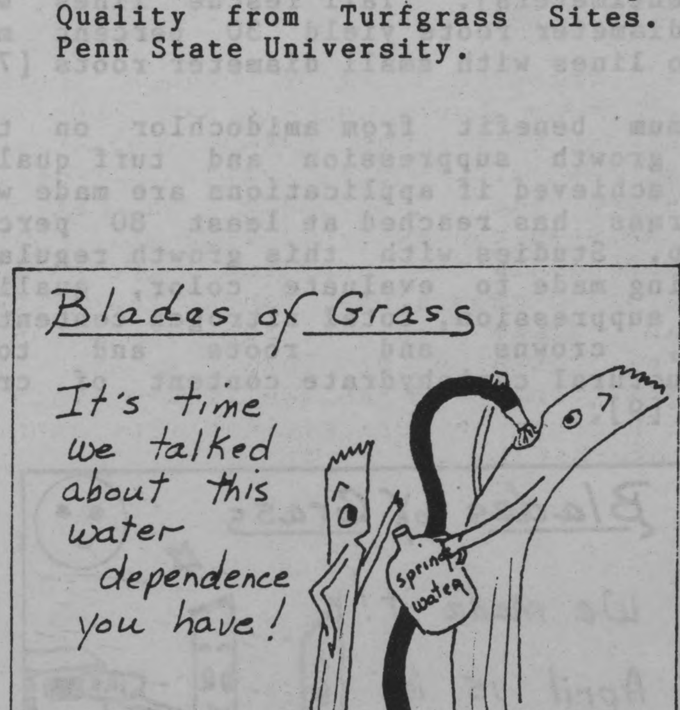
9. Peacock, C H. Salinity Tolerance of Turfgrass Species. [120] University of Florida.

10. Pepper, I L. Water Quality Aspects Related to Irrigation of Turfgrass with Sewage Effluent. [120] University of Arizona.

11. Peterson, M P, E J Kinbacher and R C Shearman. Evapotranspiration Rates of Cool-Season Turfgrasses. [120] University of Nebraska.

12. Pionke, H B. Quality of Drainage Waters from Agricultural Watersheds with Implications for Turfgrass Areas. [120] Penn State University - USDA-ARS.

13. Watschke, T L. Documenting Runoff Quality from Turfgrass Sites. [122] Penn State University.

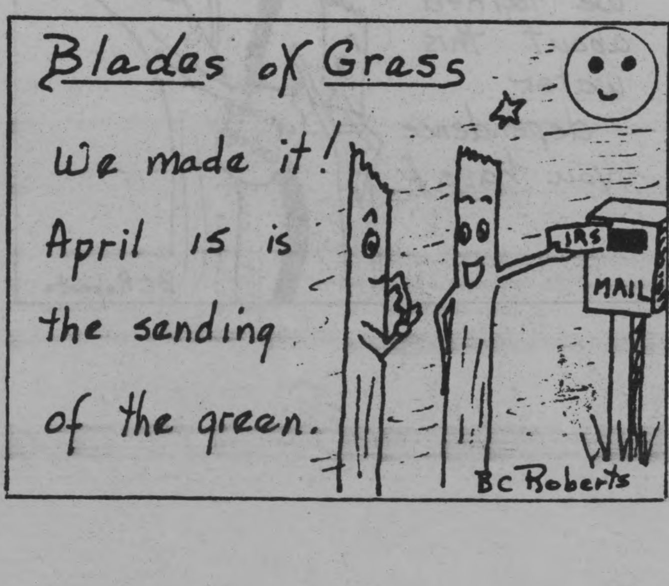


TALL FESCUES

Annual bluegrass is less heat tolerant than tall fescue or Kentucky bluegrass. Most cultivars of tall fescue are equal in heat tolerance to Kentucky bluegrass. No real differences in heat tolerance are evident among tall fescue cultivars. The superior performance of tall fescue compared to Kentucky bluegrass within the temperature range 104 to 122 degrees F [40 to 50 degrees C] is probably related to its greater drought tolerance [8]. Evapotranspiration rates based on soil moisture depletion are greater among 36 tall fescue clones at specific soil depth and for the entire soil profile until accumulated drought stress severely reduces evapotranspiration. The degree of genetic determination values derived from components of variance are moderate to low depending on seasonal stress and depth. Visible wilt symptoms are related to soil moisture in the profile, showing that certain clones express drought avoidance through superior soil moisture extraction. There appears to be sufficient clonal variation to improve soil moisture extracting capability of mowed tall fescue [4].

Tall fescue does not persist well in the lower coastal plains region of the southeast. The sandy soil of the region is susceptible to traffic pan formation by tillage implements that restricts root depth and reduces water availability to tall fescue. Tall fescue lines with root diameters between 0.77 and 0.66 millimeters influenced soil water content below 24 inches [60 centimeters]. Tall fescue lines with large diameter roots yield 30 percent more than do lines with small diameter roots [7].

Maximum benefit from amidochlor on tall fescue growth suppression and turf quality can be achieved if applications are made when the grass has reached at least 80 percent greenup. Studies with this growth regulator are being made to evaluate color, quality, height suppression, total nitrogen content of leaves, crowns and roots and total nonstructural carbohydrate content of crown tissue [9].



The tall fescue endophyte, Acremonium coenophialum has been identified in South Carolina pastures. Infection rates from 107 samples ranged from 0 to 100 with a mean infection rate of 73.5 percent. Infection rates were abnormally distributed with 75 percent of the samples being 60 percent or more infected [3]. The amount of endophyte Acremonium coenophialum present is different among plant parts. The highest concentration of endophyte is in the rachis and the highest concentration of formyl and acetyl loline [FALA] is in the spikelet. There are positive correlations between amount of fungus and FALA in stem, rachis and leaf blade, but not in spikelet or sheath. Clipping at 3 week intervals affects both level of fungus and FALA. Maximum fungal presence is found in 3 week regrowth tissue of plants grown from seed for 11 weeks before the initial harvest. Fungal levels are drastically reduced in the regrowth from third and fourth harvests [1].

All tiller sample sizes from 6 to 30 provide approximately the same Acremonium coenophialum infection percentage estimates; however, the smaller the sample size, the greater the variability. Ten tillers from an area of 10 to 20 acres [4 to 8 hectares] will adequately determine the percent of infection [5].

Leaf blades of vegetative tall fescue plants elongate about 60 percent faster during the dark than during the light period. Increased dark elongation is related to proportional increases in elongation of subsegments of the growth zone [26 millimeters] being unchanged. Dry weight of the growth zone increases during the light and decreases during the dark period. This is caused partly by increases and decreases, respectively, in the content of water-soluble carbohydrate-free dry matter. Thus, the dark rate of structure synthesis in the growth zone of leaves does not appear to be stimulated to the same extent as leaf elongation rate. Most of the diurnal weight change is related to water-soluble carbohydrate, the concentrations in tissue water increasing from 5.8 to 8.0 percent during the light period, and decreasing to 6.2 percent at the end of the dark period. Relative contributions of mono-, di- and oligosaccarides [fructans] to water-soluble carbohydrate remain similar throughout, about 70 % being fructans. Fructans with 3 to 6 monomers are most prominent [42 percent of the water-soluble carbohydrates]. This suggests a contribution of the fructans to the osmotic potential of cells in this region [6].

TALL FESCUES CONTINUED

Genotypic differences in tall fescue tillering may be related to size and organization of the vegetative shoot apex. Total cell numbers in the apex have been found to be 63.9 for slow tillering, high weight per tiller genotypes and 50.4 for the rapid tillering, low weight per tiller genotypes. The slow tillering genotype has longer subapical internodes, but both genotypes have about 4 leaf primordia associated with the shoot apex. Results of these studies suggest that genotypic effects on tiller production are not a result of anatomical differences [11].

Numbers of tall fescue rhizomes produced per plant have been positively correlated with plant area. There are significant entry, location and year effects as well as a significant genotype by environment interaction effect for both rhizome production and plant area [10].

Tall fescue clones differ for total topgrowth and total root production and distribution. Top growth and root growth vary by 34 and 44 percent respectively. The following clonal growth characteristics have been identified:

- Highest percentage of total root growth supporting the top growth;
- Highest production in total top growth, total root growth, and the percentage of root growth supporting the plant;
- Lowest total topgrowth but high total root growth production and percentage of root growth supporting the plant [2].

References:

1. Burham, W and L Bush. Development of Acremonium coenophialum and Accumulation of N-acetyl and N-formyl loline in Tall Fescue. [123] University of Kentucky.
2. Erusha, K S, R C Shearman and D M Kopec. Rooting Expression of Tall Fescue Genotypes in a Hydroponic System. [116] University of Nebraska.
3. Hill, N S and W C Stringer. Surveying for the Funal Endophyte Acremonium coenphialum in Tall Fescue Pastures in South Carolina. [18] Clemson University.
4. Kopec, D M, R C Shearman and T P Riordan. Soil Moisture Depletion by Mowed Tall Fescue Clones.[118] University of Nebraska.
5. Pegues, M D, C C King Jr, J F Pedersen and J C Williams. Number of Tiller Samples for Determining Levels of Acremonium coenophialum in Tall Fescue. [128] Auburn University.
6. Schnyder, H and C J Nelson. Diurnal Carbon Economy in the Growth Zone of Tall Fescue Leaves. [87] University of Missouri.
7. Torbert, H A, J H Edwards and J F Pedersen. Effects of Root Diameter of Tall Fescue on Water Absorption. [89] Auburn University, USDA-ARS.
8. Wehner, D J and D L Martin. Heat Tolerance of Tall Fescue. [122] University of Illinois.
9. Welterlen, M S, and J Marshall. Influence of Amidochlor and Nitrogen Application Timing on Growth and Total Nonstructural Carbohydrate Content of Tall Fescue Turf. [122] University of Maryland.
10. Whitehead, F C and J H Bouton. Heritability of Tall Fescue Rhizomes. [74] University of Georgia.
11. Vassey T L and C J Nelson. Morphometric Studies of the Vegetative Shoot Apex of Tall Fescue Genotypes. [90] University of Missouri.

MAINTAINING WARM SEASON GRASSES

Low temperatures at which 50 percent of the turf is killed [LT-50 values] for Tifway bermudagrass range from 22 to 25 degrees F [-5.6 to -3.9 degrees C] depending on sampling date. Tifgreen bermudagrass [LT-50] values ranged from 22 to 27 degrees F [-5.6 to -2.8 degrees C] depending on sampling date. Wilmington bahiagrass, common bermudagrass, common centipedegrass and Raleigh St Augustinegrass are also being evaluated [2]. Photosynthesis is disrupted by exposure of bermudagrass to non freezing temperatures below 59 degrees F [15 degrees C]. Foliar application of sodium iron diethylene pentaacetate to Tifgreen and Midiron bermudagrass caused higher carbon dioxide exchange rates during chilling stress and following a short term recovery from chilling. Following recovery from chilling stress, Midiron bermudagrass returned to within 70 percent of prestress daytime carbon dioxide exchange rates. Tifgreen returned to only 30 percent. Iron fertilization will enhance bermudagrass vigor during exposure to chilling temperatures. Cultivar differences in response are to be expected [10].

Increasing nitrogen on Tifway bermudagrass lawn turf improves quality and color while reducing dollar spot infection. Secondary cultural practices, such as coring, verticutting and topdressing, on lawns not heavily trafficed do not improve turf quality on sandy clay loam soils in Georgia [1].

Diuron, sulfometuron methyl, atrazine and oryzalin reduce stolon length by 23 to 79 percent and numbers of nodes per stolon by 30 to 81 percent. Oryzalin had no effect on number of rooted nodes or on node ratio per stolon. These preemergence herbicides may inhibit bermudagrass growth and development [6]. Timing of herbicide and growth regulator applications is of critical importance. Use of sulfometuron methyl on common bermudagrass had minimal effects on the turf when applied 4 to 6 weeks before greenup. Applications made 4 to 6 weeks after breaking dormancy had much more pronounced effects in relation to greenup and dwarfness. In general, all rates of application and application times caused a delay in greenup. The most pronounced effects occurred from applications made at greenup and 2 weeks before and 2 weeks after the breaking of dormancy [5].

Studies with Tifgreen bermudagrass and Texas common St Augustinegrass have shown that a 92 degree F [33 degrees C] temperature can cause death of the root system with reinitiation of all new root replacements occuring from the nodes on crowns and lateral stems. In contrast, a 75 degree F [24 degree C] temperature did not induce spring root decline with the existing roots surviving and new root growth observed from the lower tips of existing roots. The threshold temperature for spring root decline was found to be 82 degrees F [28 degrees C] [7].

With both Tifway bermudagrass and Floratam St Augustinegrass, the relative ranking of heavy metal toxicity from most to least at 50 percent yield reduction is cadmium equal to nickel, then copper, zinc and lead. Approximately 60 parts per million cadmium or nickel reduces yields by 50 percent. It took some 220 parts per million lead to bring about a similar yield reduction. St Augustinegrass has greater nickel tolerance while bermudagrass has greater lead tolerance. Less than 7 parts per million cadmium and copper reduces shoot growth 5 percent. Only 3 parts per million nickel were required for a 5 percent reduction in shoot growth. Heavy metals have a greater effect on shoot growth than root growth. Verdure and crown growth are affected even less. Heavy metals applied as micronutrients, or in solid waste, such as sewage sludge, or in effluent water may accumulate over time to the detriment of the turf [3].

Bahiagrass in centipedegrass turf is subject to initial injury from flauzifop-butyl and sethoxydim. Injury, although substantial, is usually temporary. Recovery is essentially complete within 4 weeks after treatment. Fluazifop-butyl produces 70 to 80 percent injury to centipedegrass and this persists into the following spring. Two applications of sulfometuron methyl and metsulfuron methyl effectively control bahiagrass. There is little or no injury to centipedegrass from sulfometuron methyl, metsulfuron methyl or sethoxydin applications [9]. Ninety percent of Pensacola bahiagrass and 100 percent of common bahiagrass has been eliminated from Tifway bermudagrass and from centipedegrass using Oust. No growth suppression is observed on either bermudagrass or centipedegrass [8].

MAINTAINING WARM SEASON GRASSES CONTINUED

Centipedegrass decline occurs frequently because of overfertilization, accumulation of thatch and/or a combination of these and other poor management practices. Nitrogen, phosphorus and potassium applications in April alone are generally better than repeat treatments. Vertical mowing does not improve turf quality or density [4].

References:

1. Carrow, R N, B J Johnson and R E Burns. Influence of Cultivation and Fertility on Tifway Bermudagrass. [114] University of Georgia.

2. DiPaola, J M, W B Gilbert and A H Bruneau. Seasonal Fluctuations in the Cold Hardiness of Warm Season Turfgrasses. [115] North Carolina State University.

3. Dudeck, A E. Heavy Metal Effects on Bermudagrass and St Augustinegrass. [115] University of Florida.

4. Johnson, B J, R E Burns and R N Carrow. Influence of Fertilizer and Cultural Treatments on Centipedegrass. [117] University of Georgia.

5. Rogers, J N and J W King. Sulfometuron Methyl on Dormant Bermudagrass Turf. [120] University of Arkansas.

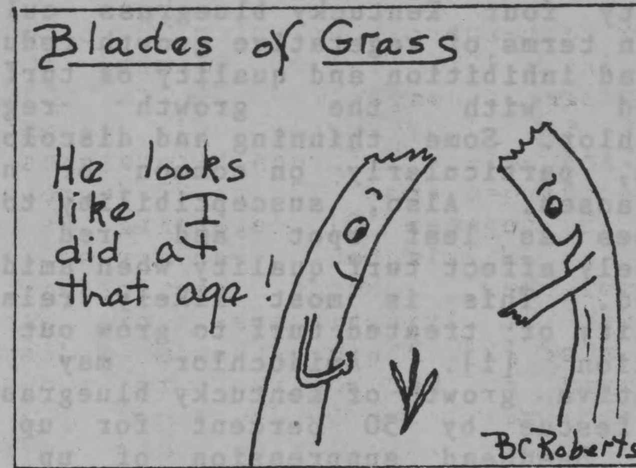
6. Samples, T J and A D Brede. Effect of Selected Preemergence Herbicides on Bermudagrass Stolon Patterns. [121] Oklahoma State University.

7. Sifers, S I and J B Beard. Induction of Spring Root Decline in Cynodon and Stenotaphrum Species. [121] Texas A & M University.

8. Swann, C, W Hanna and P Utley. Control of Bahiagrass in Bermudagrass and Centipedegrass. [121] Coastal Plain Experiment Station, Tifton, Georgia.

9. Turner, D L and R Dickens. Herbicides for Control of Bahiagrass in Centipedegrass. [122] Auburn University.

10. White, R H and R E Schmidt. Carbon Dioxide Exchange Rate of Bermudagrass Under Chilling Stress in Response to Iron Fertilization. [122] Virginia Polytechnic Institute and State University.



GROWTH REGULATORS

A number of undesirable side effects of growth suppressing regulators, including natural leaf aging, lack of increasing density, understory visibility, extended disease or pest symptoms and extended stress symptoms, result in a transient and sometimes belated reduction of turfgrass quality at a time when appearance of untreated turf is better. These effects are the same that occur when cool, wet or hot, dry environments slow growth. Proper timing of growth regulator application can minimize these effects and can actually enhance turfgrass quality at times when these negative conditions occur naturally [4].

March and April applications of amidochlor, glyphosate, maleic hydrazide, mefluidide and metsulfuron methyl on roadside tall fescue suppressed seedheads while maintaining acceptable stand density. Seedhead height was reduced compared to those on untreated turf. May, June or July applications of glyphosate, maleic hydrazide, sulfomethuron methyl suppressed seedheads of bahiagrass while maintaining acceptable stand density and turf quality [6].

Amidochlor, flurprimidol and mefluidide reduced evapotranspiration rates of Kentucky bluegrass for 14 days starting 21 days after treatment. As Kentucky bluegrass growth rates were enhanced, evapotranspiration rates increased in amidochlor and mefluidide treated turf. Amidochlor, flurprimidol and mefluidide treatments reduced plant heights for a period of 21 to 35 days after treatment. Amidochlor and mefluidide treated turf produced higher foliar growth than untreated turf 35 to 42 days after treatment. Evapotranspiration rates followed plant heights at 21 to 48 days after treatment - the greater the height, the greater the evapotranspiration [3].

GROWTH REGULATORS CONTINUED

Eighty four Kentucky bluegrass cultivars vary in terms of vegetative growth reduction, seedhead inhibition and quality of turf when treated with the growth regulator amidochlor. Some thinning and discoloration occurs, particularly on common or natural bluegrasses. Also, susceptibility to such diseases as leaf spot and red thread adversely affect turf quality when amidochlor is used. This is most likely related to inability of treated turf to grow out of the infection [1]. Amidochlor may reduce vegetative growth of Kentucky bluegrass and tall fescue by 50 percent for up to 10 weeks. Seedhead suppression of up to 90 percent is noted. Nitrogen fertilizer enhances early greenup of turf allowing an early amidochlor application [9]. Following applications of amidochlor, vertical growth is controlled for 4 to 5 weeks for Kentucky 31 fescue and Pennfine perennial ryegrass and for 3 to 4 weeks for Baron Kentucky bluegrass. Regrowth is from both new and preexisting tillers. In all 3 species, the growth regulator produces a 2 to 3 fold increase of crown dry weight at 2 and 4 weeks. This is diminished at 8 weeks compared with the mowed turf that was not treated. There is no increase in tiller numbers at 8 weeks following treatment, and no effect on root dry weight at 2 and 4 weeks [5]. The effect of amidochlor on vegetative growth and reproductive development of bermudagrass, bahiagrass and St Augustinegrass is less than for cool season grasses. Applications in spring are more efficacious than in summer. Thatch level and soil texture variables do not seem to affect amidochlor. Amidochlor may be injected into the soil at depths up to 5 inches [12 centimeter] and produce turf growth suppression. Vegetative response to amidochlor is detected up to 4 inches [10 centimeters] in an acropetal direction along roots and stolons from the application site. Deep rooting reduces the response noted for warm season grasses. Species differences exist as to uptake, translocation or metabolism of amidochlor. Growth rate and habit affect amidochlor activity [7].

Perennial ryegrass - Kentucky bluegrass mixed turf responded to paclobutrazol and mefluidide by turning a deeper green. Reductions in percent ground cover are noted. Annual ryegrass in mixtures is only slightly affected. Both chemicals reduce seedling height and initial clipping weights for all mixtures. No phytotoxic effects on these seedling grasses were noted [8]. Use of mefluidide by military installations is a viable alternative to mechanical mowing [2].

References:

1. Budzynski, J W, T W Fermanian, W H Mitchell and D C Riego. Varietal Differences in Kentucky Bluegrass Response to the Growth Regulator Amidochlor. [114] Monsanto Agricultural Products Company, St Louis, Missouri; University of Illinois and University of Delaware.

2. Cox, J M. Mefluidide Utilizations and Evaluations by United States Armed Forces. [7] 3 M Company, St Paul, Minnesota.

3. Doyle, J M and R C Shearman. Plant Growth Regulator Effects on Evapotranspiration of a Kentucky Bluegrass Turf. [115] University of Nebraska.

4. Kaufmann, J E. Growth Regulator Effects on Turfgrass Appearance. [82] Monsanto Agricultural Products Company, St Louis, Missouri.

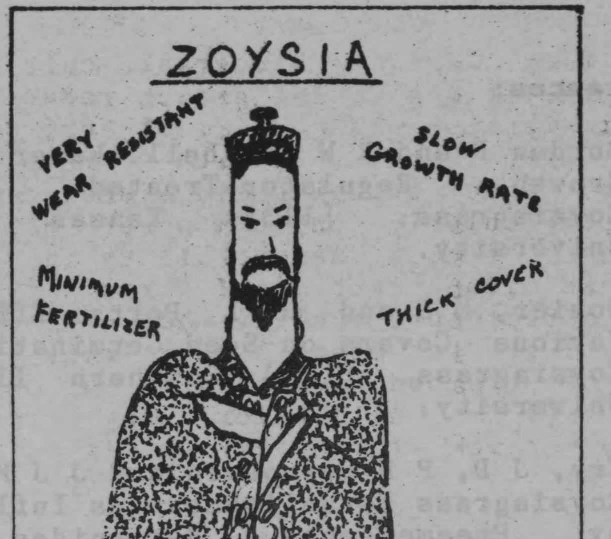
5. Kretzmer, K A and J E Kaufmann. The Effect of Limit Growth Regulator on Several Growth Parameters of Three Cool Season Turfgrasses. [118] Monsanto Company, Chesterfield, Missouri.

6. Lewis, W M, J M DiPaola, W B Gilbert and A H Bruneau. Growth Retardant Evaluations on Tall Fescue and Bahiagrass Roadsides. [118] North Carolina State University.

7. Miller, K J, J E Kaufmann, J J Sandbrink and S J Stehling. Response of Warm-Season Grasses to Limit Turf Regulator Under Greenhouse and Field Conditions. [119] Monsanto Company, Chesterfield, Missouri.

8. Montgomery, D P and A D Brede. Selective Inhibition of Ryegrass Over Kentucky Bluegrass Using PP-333 and Mefluidide. [119] Oklahoma State University.

9. Riego, D C, J W Budzynski, N Hummel and J J Sandbrink. Fertilizer Interaction and Time of Application of Growth Regulator Amidochlor to Kentucky Bluegrass and Tall Fescue. [120] Monsanto Company and Cornell University.

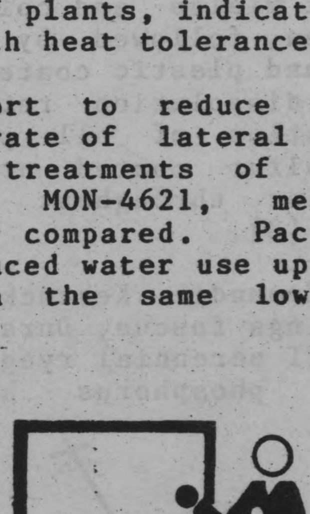


ZOYSIAGRASS

Korean common zoysiagrass can now be successfully established from seed. Alkaline scarification and light treatment improve seed germination to make this possible. Since a minimum germination temperature of 71 degrees F [22 degrees C] is required and germination continues through a temperature range to 136 degrees F [58 degrees C], use of a polyethylene cover in late April increased seedling counts. With the cover seedling counts were as high as 2.6 plants per square inch [262 plants per 625 square centimeters], without the cover seedling counts were as low as .37 plants per square inch [37 plants per 625 square centimeters] [2]. Korean common zoysiagrass, once established, requires a clipping height of 3/4 inch [1.9 cm] for golf course fairway turf. Meyer zoysiagrass is cut at 1/2 inch [1.3 cm]. Meyer zoysiagrass is fertilized with minimal nitrogen but Korean common requires more - from 3 to 5 pounds nitrogen per 1000 square feet per season [144 to 240 Kg/ha]. For lawns, the clipping height for Korean common zoysiagrass would be 1 1/4 inch to 2.0 inch [3.2 to 5.7 cm] and nitrogen requirement would amount to 1 to 3 pounds of nitrogen per 1000 square feet per season [48 to 144 Kg/ha]. Winter weed encroachment is greater when the clipping height is 3/4 inch [1.9 cm] and early spring treatment with glyphosate or simazine is required [7].

From seeded zoysiagrass, plants were selected that had not been screened for heat tolerance; others selected had tolerated temperatures of 72 degrees F [22 degrees C]; and still others, 120 degrees F [49 degrees C] for 5 weeks. Differences in numbers of stolon nodes, tillers per plant, total stolon length and weight per plant and abaxil leaf pubescence were noted among the three populations of plants, indicating differences associated with heat tolerance [5].

In an effort to reduce water use and increase the rate of lateral growth of Meyer zoysiagrass, treatments of paclobutrazol, flurprimidol, MON-4621, mefluidide and XE-1019 were compared. Paclobutrazol and MON-4621 reduced water use up to 22 percent compared with the same low water stress control [1].



Metribuzin, simazine and bensulide applications on Meyer zoysiagrass plugs may reduce establishment rate of the zoysiagrass. Oxadiazon, DCPA and siduron were effective in encouraging zoysiagrass coverage. Establishment can not be greatly enhanced by nitrogen fertilizers the first year. By the end of the second growing season, some benefit from nitrogen fertilization is noted [3].

At four weeks after seeding Kentucky 31 fescue, ground cover was 33.3 percent; Mustang was 23.3 percent; Rebel 21.5 percent; and Falcon 21.5 percent. At eight weeks after seeding a seedling/tiller count indicated that Mustang had produced 1.0 plant per square inch [1666 plants per square meter], Falcon had .70 plant per square inch [1112 plants per square meter], Kentucky 31 fescue had .69 plant per square inch [1074 plants per square meter] and Rebel had .66 plant per square inch [1028 plants per square meter]. Zoysiagrass seeded prior to the tall fescues had developed only .1 plant per square inch [173 plants per square meter] by this time [6].

Desiccation of Meyer zoysiagrass sprigs during planting can reduce the establishment rate. Desiccation for three hours or longer reduces viability. Rooting of desiccated sprigs is enhanced by treatment with cytokinin or with iron, indicating that these materials enhance establishment of zoysiagrass from sprigs [8].

In zoysiagrasses length of flag leaf, fourth leaf, inflorescence and florets, node diameter and inflorescence width contribute most to selection differences. A field nursery in Dallas, Texas contains 291 oriental accessions. These are being evaluated for plant spread, color, percent coverage, leaf type, date and rate of green-up and anthesis date. Broad sense heritability estimates suggest that faster progress in plant improvement can be anticipated for leaf type, percent coverage, plant spread and anthesis date [4].

ZOYSIAGRASS CONTINUED

References:

1. Borden P and R W Campbell. Water Use of Growth Regulator-Treated Meyer Zoysiagrass. [113] Kansas State University.

2. Dozier, M J and H L Portz. Effect of Various Covers on Seed Germination of Zoysiagrass. [115] Southern Illinois University.

3. Fry, J D, P H Dernoeden and J J Murray. Zoysiagrass Establishment as Influenced by Preemergence Herbicides and Fertilizers. [116] Colorado State University, University of Maryland, USDA-ARS Beltsville.

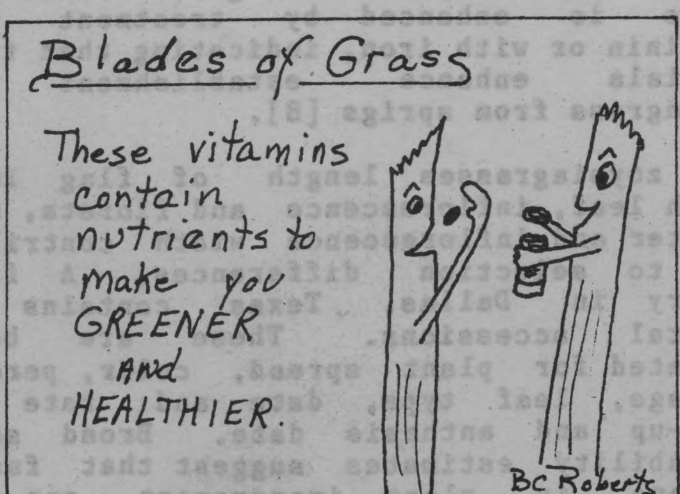
4. Kenna, M P, M C Engelke and V G Lehman. Agronomic and Morphological Characterization of Exotic Zoysiagrasses. [117] Texas Agricultural Experiment Station-Dallas.

5. Kenna, S W, M C Engelke and M P Kenna. Comparison of a Zoysia Base Population with Two Populations Selected Under High Soil Temperatures. [118] Texas Agricultural Experiment Station-Dallas.

6. Patterozzi, V R and H L Portz. Wear Tolerance and Species Compatibility of Seeded Zoysiagrass and Tall Fescue for Athletic Fields. [119] Southern Illinois University.

7. Portz, H L and V R Patterozzi. Management of Seeded Korean Common Zoysiagrass. [120] Southern Illinois University.

8. Schmidt, R E and R H White. Cytokinin and Iron Influence on Desiccated Zoysiagrass. [121] Virginia Polytechnic Institute and State University.



TURFGRASS FERTILIZATION AND NUTRITION

Municipal sewage and solid waste from some 350,000 people in the vicinity of Wilmington, Delaware amounts to 1500 tons daily. The composted product is dried and either pelleted and crumbled for use in fertilizer production or hammermilled and processed for use as a hydroseeding mulch. Forty thousand tons of finished product are available annually. The crumbled humus serves as a filler for blended fertilizer, as a carrier of dry or liquid fertilizer supplements, pesticides and growth regulators [6].

Studies in the Ohio State University rhizotron indicate that nitrogen application during the spring can reduce root elongation rate, while late season nitrogen application had no negative effect on fall, winter or spring root growth. Spring applied nitrogen caused a decline in leaf sheath total non-structural carbohydrate and fructan levels which coincided with decreased root activity. Fall/winter fertilized turf maintained higher levels of the carbohydrate and fructan during the spring. Late season nitrogen fertilization can stimulate spring root production by enhancing spring green-up, thus reducing the need for spring nitrogen application which is detrimental to root growth and the carbohydrate balance of the turf [5].

Enmundi Kentucky bluegrass has the highest leaf growth rate and the lowest leaf nitrogen content indicating highest nutrient use efficiency. Yorktown II has the highest nitrogen, phosphorus and potassium content and second lowest clipping production rate. Nitrate concentration of the soil solution was consistently lower under actively growing sods. Average nitrate concentrations under Enmundi sod were the lowest [1].

On Merion Kentucky bluegrass, the most rapid response to fertilization as measured by fresh weight yields and color ratings was produced by urea, followed by Lesco sulfur coated urea, and plastic coated ureas - 70, 100, 150 days dissolution rate. A single spring application of all plastic coated ureas and sulfur coated ureas produced acceptable color throughout most of the growing season [3].

Baron and Enmundi Kentucky bluegrass, Jamestown Chewings fescue, Durar sheep fescue and Yorktown II perennial ryegrass differed in nitrogen, phosphorus and potassium absorption [2].

Nitrogen release rates as measured by visual quality ratings of a Kentucky bluegrass-perennial ryegrass turf fertilized in November after shoot growth was minimal indicated urea equal to dicyandiamide greater than sulfur coated urea greater than isobutylidene diurea greater than Milorganite. Nitrate loss out of the root zone was independent of nitrogen source [7].

Surface-applied urea involves the risk of considerable nitrogen loss to the atmosphere as gaseous ammonia. A urease inhibitor - phenylphosphoro-diamidate and magnesium chloride both increased clipping yields of Kentucky bluegrass when used with applications of urea. Two percent phenylphosphoro-diamidate increased clippings 20 to 30 percent, and thus had an effect on nitrogen use efficiency. The magnesium produced a 13 to 25 percent increase in clippings at a lower rate of urea nitrogen fertilization. However, in the heat of July, the magnesium treatment burned foliage. Thus, the cation magnesium may have a positive effect on the reduction of ammonia volatilization and increase urea nitrogen efficiency with low ;concentration under cool temperatures [4].

References:

1. Cisar, J L, R J Hull, D T Duff and A J Gold. Turfgrass Nutrient Use Efficiency. [115] University of Rhode Island.

2. Hull R J, J L Cisar, D T Duff and A J Gold. Nitrate, Phosphate, and Potassium Uptake by Cool Season Turfgrasses. [117] University of Rhode Island.

3. Hummel, N W. Evaluation of Plastic-coated Ureas for Turfgrass Fertilization. [117] Cornell University.

4. Joo, Y K, and N E Christians. The Reduction of Ammonia Volatilization from Turfgrass Areas Treated with Surface-Applied Urea. [177] Iowa State University.

5. Koski, A J, and J R Street. Root Growth and Carbohydrate Status of Baron Kentucky Bluegrass as Affected by Timing of Nitrogen Application. [118] Ohio State University.

6. Mitchell, W H. Production and Utilization of Co-Generated Municipal Waste Products. [18] University of Delaware.

7. Petrovic, A M and N H Hummel. Nitrogen Source Effects on Nitrate Leaching From Late Fall Nitrogen Applied to Turfgrass. [120] Cornell University.

POA ANNUA

Excessive soil moisture has been found to lower annual bluegrass heat tolerance. Rainfall and soil and air temperature data are required for the prediction of annual bluegrass stress [5]. Differences in heat tolerance exist both within and among annual bluegrass populations [6].

Flurprimidol reduces net photosynthetic rates of annual bluegrass 52 % while creeping bentgrass was reduced only 29 %. This should provide the creeping bentgrass a competitive advantage [3]. Where seedlings of annual bluegrass and creeping bentgrass are being established, flurprimidol causes reduction in growth of both species regardless of the timing of application [4].

The carbohydrate status of leaf and stem tissue of annual bluegrass was not affected by mefluidide treatment. Mefluidide suppressed seedhead formation and increased the reducing sugar content of roots [4.9 percent] compared to untreated roots [1.2 percent] when untreated plants were seeding profusely. This response did not last long and was not evident three weeks after control plants had stopped seeding. Leaf and stem tissue consistently maintained more fructose, sucrose and fructans than roots. Stem tissue was higher in fructans. The carbohydrate content of mefluidide treated annual bluegrass decreased in all tissue following growth inhibition. A post inhibition growth surge was responsible [1].

Neither fenarimol or chlorsulfuron reduced annual bluegrass populations in putting green [bentgrass] turf. No phytotoxic effects due to fenarimol or chlorsulfuron were observed on fairway turf. Annual bluegrass reduction in fairway turf was attributed to a combination of chemical and environmental stresses. Initial phytotoxicity was noted on both creeping bentgrass and annual bluegrass from chlorsulfuron. Fenarimol discolored creeping bentgrass [2].

POA ANNUA CONTINUED

References:

1. Cooper, R J, A J Koski, J R Street and P R Henderlong. Influence of Spring Mefluidide Application on the Carbohydrate Status of Poa annua. [115] Ohio State University.

2. Gaul, M C and N E Christians. The Use of Fenarimol and Chlorsulfuron for Poa annua Control in Cool-Season Turfgrasses. [116] Iowa State University.

3. Gaussoin, R E, J Flore and B E Branham. Photosynthetic Rates of Poa annua and Agrostis palustris after Treatment with Plant Growth Regulators [116] Michigan State University.

4. Haley, J E and T W Fermanian. The Effect of Flurprimidol on the Germination and Development of Poa annua and Agrostis palustris. [116] University of Illinois.

5. Martin, D L and D J Wehner. Predicting Annual Bluegrass Heat Tolerance. [119] University of Illinois.

6. Wilsey, J, D L Martin and D J Wehner. Heat Tolerance of Selections of Annual Bluegrass. [122] University of Illinois.

TURFGRASS SELECTION AND BREEDING

A greenhouse heat bench has been designed for evaluation of turfgrass germ plasm. This bench features a sand base over gravel, copper pipes that circulate hot water from an electric heater, and subirrigation. Temperatures can be adjusted from 95 to 150 degrees F [35 to 65 degrees C]. A temperature gradient up to 18 degrees F [10 degrees C] can be created along the length of the bench. Initial testing with Seaside creeping bentgrass resulted in tolerance of soil temperatures exceeding 104 degrees F [40 degrees C]. Korean zoysiagrass was tolerant of soil temperatures in excess of 130 degrees F [55 degrees C] [2].

Increased salt resistance in thirty-seven St Augustinegrasses and twenty-seven buffalograsses is being sought. Four levels of calcium and sodium chloride salts cause varying top and root growth decline. Buffalograsses are more salt resistant than St Augustinegrasses [3]. Tissue culture techniques are also being used to select for increased salt tolerance in creeping bentgrass. Plantlets selected in tissue culture at 2 % salt have survived whole plant evaluations at 2 % salt in hydroponics. These salt tolerant plants are being evaluated in field plots for environmental stress hardiness and turfgrass quality [4].

On the basis of fifty-one first-generation composite crosses of bahiagrass evaluated for seedhead height and seedhead number, simultaneous clonal selections for prolific seeding and dwarf characteristics were made. Fifteen progeny selected produced 84 % more seedheads in June and July than Pensacola bahiagrass and 9 % shorter seedheads than Pensacola [1].

Genetic differences have been found between four perennial ryegrass parental sources for stem rust. Cultivars with greater and more durable resistance to stem rust should be obtained from these parental sources. Resistance is likely predominately quantitative. Transgressive segregation towards susceptibility and slow rusting types is evident. Selection for resistance is likely to be more effective in the bootstage prior to anthesis. And seedling reactions are different from adult plant responses indicating that selection for resistance may be more successful if carried out in later growth stages [5].

References:

1. Busey, P. Selection for Seedhead Characteristics in Bahiagrass. [114] University of Florida.

2. Engelke, M C, M P Kenna, V G Lehman. Soil Temperature Bench for Turfgrass Germ Plasm Evaluation. [53] Texas Agricultural Experiment Station, Dallas.

3. Horst, G L and N B Dunning. Selection of Turfgrass Cultivars for Salt Resistance. [117] Texas A & M University Research and Extension Center, El Paso.

4. Krans, J V and F C Blanche. Selecting Turfgrasses for Improved Salt Tolerance in Vitro. [118] Mississippi State University.

5. Rose-Fricker, C A, W A Meyer and W E Kronstad. The Inheritance of Stem Rust [Puccinia graminis Pers. subsp graminicola Urban] Resistance in Perennial Ryegrass. [121] Pure Seed Testing Inc and Oregon State University.

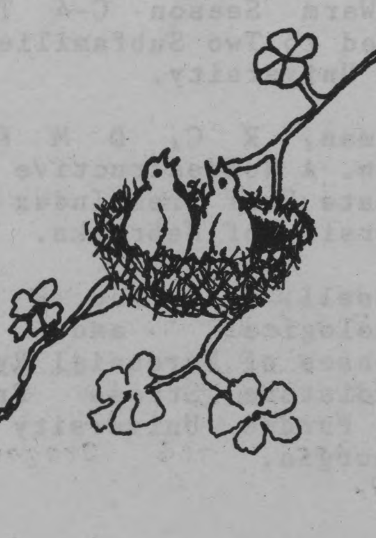
PUTTING GREEN TURF

Using conservation-of-energy physics equations, a formula that can be used for measuring greenspeed on sloped greens has been derived. Mean speed = $2UD(U+D)^{-1}$, where U = the greenspeed reading taken directly upslope, D = greenspeed taken directly down slope. The mean speed is analogous to readings taken on a flat surface [1].

Frequent applications of benomyl alone under low and high nitrogen and DCPA alone under low nitrogen increase incidence of Rhizoctonia solani on creeping bentgrass golf greens. Benomyl and triadimefon, each in combination with bensulide, DCPA and oxadiazon under low and high nitrogen predisposed bentgrass to Rhizoctonia solani. Naturally occurring disease was greater under low nitrogen in the spring. Disease resulting from inoculations was greater under high nitrogen. Both high temperature and high nitrogen stress were noted [4].

The scanning electron microscope has shown an organic coating completely or partially covering sand particles taken from the top 1 to 2 inch [2.5 to 5.0 centimeter] depth on golf greens. Sand from depths greater than 2 inches [5 cm] showed no evidence of an organic coating. More coating was found on hydrophobic sand than on sand from adjacent areas where localized dry spot was not observed. There were no differences in physical and inorganic chemical properties between sands from healthy and dry spot areas [3].

Tifdwarf bermudagrass putting greens covered with white, grey or black nonwoven polypropylene; grey nonwoven polyester or pine straw are provided good insulation during the night period. Pine straw reduced temperature fluctuation most. More green foliage the first of March was noted where white or grey polypropylene covers were used. Pine straw caused less green foliage to develop. By mid-April, all greens that were covered had excellent stands of bermudagrass. Full turf recovery from the winter did not occur until early June on greens left uncovered [2].



References:

1. Brede, A D. Stimpmeter Measurement of Sloped Putting Greens. [114] Oklahoma State University.

2. Dickens, R and D L Turner. Comparisons of Turf Covers for Bermudagrass Golf Greens. [115] Auburn University.

3. Karnok, K, K Tucker, G Landry, D Radcliffe, R Roncadori and E Brown. The Cause of Localized Dry Spots on Sand Putting Greens. [117] University of Georgia.

4. Lester, L D and L M Callahan. Pesticidal and Nutritional Predisposition of Creeping Bentgrass to Rhizoctonia solani. [118] University of Tennessee.

MAINTAINING COOL SEASON GRASSES

The use of cultivation treatments such as vertical mowing and core cultivation [1 to 3 passes] immediately after application of benefin, bensulide and DCPA and four weeks after treatment did not reduce the ability of the herbicides to control germinating crabgrass plants in an annual bluegrass turf [1]. Soil temperature and moisture levels affect the soil microbial activity that regulates degradation of herbicides such as DCPA. Temperatures within the range 77 to 86 degrees F [25 to 30 degrees C] caused the most rapid degradation [9 % of initial DCPA remained 5 weeks after treatment]. Temperatures within the range 50 to 59 degrees F [10 to 15 degrees C] caused very slow degradation [70 % of initial DCPA remained after 5 weeks]. From this type of data, degradation predictions can be made [2].

Creeping bentgrass, hard fescue, quackgrass and smooth bromegrass are most tolerant of chlorsulfuron treatments. Tall fescue and perennial ryegrass are most sensitive. Variations in annual bluegrass biotype are believed responsible for differences observed in the sensitivity of this species [4].

MAINTAINING COOL SEASON GRASSES CONTINUED

Citation perennial ryegrass responded to soil inoculation with a single VAM fungi [Glomus macrocarpus var macrocarpus] and mixtures of 4 VAM fungi [Glomus macrocarpus var macrocarpus, G fasiculatum, G mossease and Gigaspora margarita] where soil phosphorus was low by increasing shoot growth 28 to 40 percent. Where soil phosphorus was high, VAM inoculation depressed growth 32 %. Surface placed inoculum increased shoot growth more rapidly than when inoculum was banded at different levels below the soil surface. Foliar nutrient levels were not elevated where VAM inoculations were made [3].

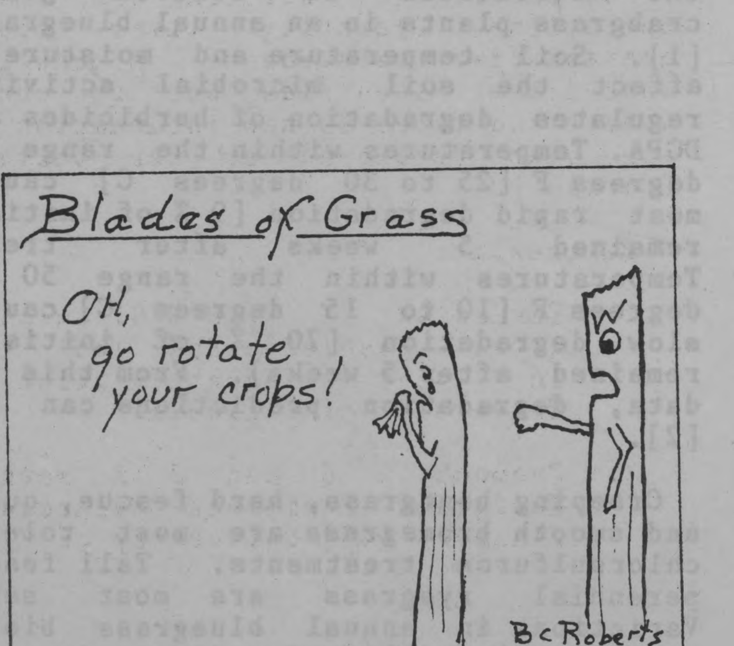
References:

1. Branham, B E and P E Rieke. Effects of Cultivation Treatment and Preemergent Herbicide on Crabgrass Infestations. [113] Michigan State University.

2. Choi, J S and T W Fermanian. Effects of Soil Temperature and Moisture on the Degradation Rate of Dacthal [DCPA]. [114] University of Illinois.

3. Frank, J B, A M Petrovic and K W Mudge. Growth of Perennial Ryegrass as Influenced by Vesicular-Arbusculor Mycorrhizal [VAM] Fungi. [116] Cornell University.

4. Maloy, B M and N E Christians. Effects of chlorsulfuron on Seven Cool-Season Grasses. [118] Iowa State University.



Spring

TURFGRASS MORPHOLOGY/PHYSIOLOGY

Leaf area index has been estimated indirectly by measuring canopy shading of light. Light transmission on film at a series of angles from horizontal provides a measure of leaf area index and mean canopy leaf angle values. This technique is being used to assess turfgrass canopies to measure physiological responses on a leaf area basis and to help explain turfgrass growth [2].

During a 6 week preconditioning period of increasing moisture stress Derby perennial ryegrass decreased in shoot density, verdure, leaf area index and visual quality. Total root dry weight and root distribution were not altered by moisture stress. Then during a dry down cycle turf previously exposed to well watered conditions had lower canopy temperatures than turf exposed to slight or moderate stress conditions. [3]

Stomatal arrangements for bermudagrass, zoysiagrass and buffalograss were similar for both leaf surfaces, with 2 parallel rows of stomata between any 2 adjacent veins. With St Augustinegrass, centipedegrass, bahiagrass and seashore paspalum, there were from 1 to 6 parallel rows of stomata between 2 adjacent veins either on the adaxial, abaxial or both leaf surfaces. Stomatal densities were higher in bermudagrass, zoysiagrass and buffalograss. Under non-limiting moisture conditions these latter grasses had lower water use rates in comparison with St Augustinegrass, centipedegrass, bahiagrass and seashore paspalum. [1].

References:

1. Casnoff, D M, J B Beard, S D Griggs and D G Verwers. Stomatal Arrangements of Ten Warm Season C-4 Turfgrasses as Related to Two Subfamilies. [114] Texas A & M University.

2. Shearman, R C, D M Kopec and J N Norman. A Nondestructive Technique to Estimate Leaf Area Index in Turf. [121] University of Nebraska.

3. Throssell, C S and R N Carrow. The Morphological and Physiological Responses of Perennial Ryegrass Exposed to Moisture Stress Preconditioning. [121] Purdue University and University of Georgia.

BUFFALOGRASS

Buffalograss is heat, cold and drought tolerant; and is adapted to low fertility and alkaline soils and to infrequent mowing. Expensive seed, seedlings slow to establish, short growing season and color of light green to brown are recognized limitations to use. New buffalograsses for low maintenance turf are being developed through breeding projects at The University of Nebraska [3].

Increases of monoecious buffalograss plants may result from selection during the process of plant breeding. Sex expression is consistent ;for dioecious and some monoecious types. This may be affected by environment factors and seems to be genotype dependent [2].

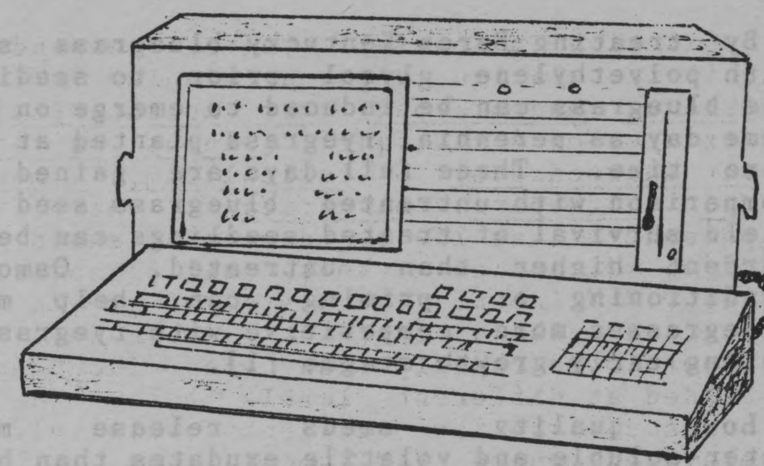
Applications of 2,4-D and dicamba cause reduced quality of buffalograss up to 40 days after treatment. Benefin and siduron were most injurious of preemergence herbicides tested at Colorado State University [1].

References:

1. Butler, J D, D D Minner and J D Fry. Weed Control in Buffalo Grass. [114] Colorado State University and University of Missouri.

2. Huff, D R, L Wu and W Kneebone. A Study of Sex Expression in Buffalo Grass. [58] University of California and University of Arizona.

3. Riordan, T P, E J Kinbacher and R C Shearman. Buffalo Grass - A Drought Tolerant Alternative Turfgrass Species. [120] University of Nebraska.



INFORMATION SYSTEMS

Expert systems technology offers a new approach to weed or other pest identification. With this system, fragmented or partial information can be used to make a knowledgeable decision on the identification of an unknown pest. Forty one common grassy weeds found in turf throughout the United States are entered into the PLANT/tm program for the IBM PC. This was developed in the Artificial Intelligence Laboratory at the University of Illinois at Urbana-Champaign [1].

A computer program designed to handle record keeping of turfgrass equipment maintenance logs, including daily maintenance operations, operating times, repairs and preventative maintenance scheduling with menu-driven inquiries and to continuously update the files as new information is needed has been developed at the University of Florida [2].

References:

1. Fermanian, T W, R S Michalski and B Katz. A Knowledge Base Tool to Assist in Weed Indentification. [43] University of Illinois.

2. Peacock, C H and J A Wetherington. Turfgrass Equipment Maintenance Log Planner. [45] University of Florida.

SEED SCIENCE

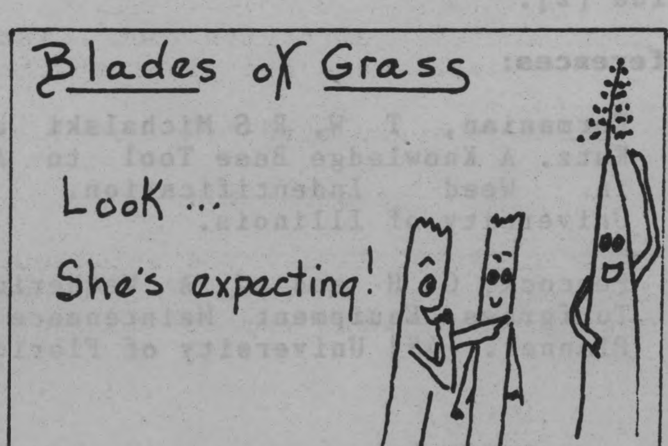
By treating Baron Kentucky bluegrass seed with polyethylene glycol prior to seeding, the bluegrass can be induced to emerge on the same day as perennial ryegrass planted at the same time. Three full days are gained in comparison with untreated bluegrass seed and field survival of treated seedlings can be 27 percent higher than untreated. Osmotic conditioning or priming can help make bluegrasses more competitive with ryegrasses during early growth stages [1].

Low quality seeds release more water-soluble and volatile exudates than high quality seeds. This causes greater stimulation of colonizing and pathogenic microorganisms. Low quality seeds remain susceptible to attack longer because they germinate slower, and are less able to respond with physiological defense mechanisms. Low quality seeds have decreased membrane integrity and damaged chromatin. During germination, protein synthesis is reduced, mitochondria activate slowly and ATP synthesis is altered. Thus, seeds stimulate the activation and growth of soil borne microorganisms [2].

References:

1. Brede, J L, A D Brede and S W Akers. Seed Priming and Its Effects on Kentucky Bluegrass-Perennial Ryegrass Mixtures. [114] Oklahoma State University.

2. Harman, G E and T E Stasz. Influence of Seed Quality on Seed Rot and Soil Microbes. [110] Cornell University.



SOIL CULTIVATION

Soil improves with cultivation treatments. Core cultivation is better than slicing in lowering soil temperature and in keeping oxygen levels favorable for root growth. Plants react quickly to compaction stress but are slow to recover from it [1].

No differences from solid or hollow tine coring devices were found in research at Michigan State University. Coring under wet soil conditions reduces water infiltration rates when compared with coring drier soil. Both types of coring reduce soil penetration resistance. This suggests a loosening of the surface one and one half inches [.04 m] of soil [2].

References:

1. Barber, J F and R N Carrow. Evaluation of Cultivation Techniques for Soil Compaction. [113] University of Nebraska and Kansas State University.

2. Murphy, J A and P E Rieke. Solid and Hollow Tine Coring as Affected by Soil Moisture and Bulk Density. [119] Michigan State University.

TWENTY-THIRD ANNUAL NEBRASKA TURFGRASS FOUNDATION CONFERENCE

OMAHA, NEBRASKA

JANUARY 1985

BENEFITS OF AERIFICATION PROGRAMS

Dr M L Agnew
Iowa State University
Ames, Iowa

Generally soil aeration is taken for granted and often is inadequately provided. Mike Agnew, Extension Turfgrass Specialist at Iowa State University emphasises the following:

- Any type of soil cultivation involves techniques that improve aeration. Some more than others. Coring improves soil aeration. Slicing or grooving involves a different type of soil manipulation and spiking still another.

- In each instance, the system must replace air in the soil with air from the atmosphere. This air exchange must be sufficient to stimulate and maintain plant growth.

- Flooding of a soil restricts aeration. Soil compaction is the most influential condition that restricts soil aeration.

- In well aerated soils, root activity and growth and microbial activity are enhanced.

- Aerobic respiration involves:

  $(CH_2O)_n + 12O_2 \dashrightarrow 12\ CO_2 + 11H_2O$ + energy + carbon skeletons

- Without adequate oxygen, anaerobic respiration involves:

  $(CH_2O)_n + 12O_2 \dashrightarrow 4CO_2$ + ethanol + energy

  The carbon dioxide and ethanol build up in the soil.

- Poorly aerated soils cause:

  * shallow roots;
  * sparse plant density;
  * reduced turf vigor.

- Microbial activity is reduced when soils are poorly aerated. This has an effect on:

  * thatch accumulation;
  * nitrogen fixation;
  * availability of essential nutrients in the soil.

- Soil aeration has an effect on the formation of humus in the soil. This involves the breakdown of carbohydrates, cellulose, proteins, lignins and other organic compounds.

- Soil aeration has an effect on oxygen diffusion rates which are a measure of how well plants grow.

- Shallow root systems caused by poor soil aeration result in:

  * a less effective root system to absorb water and plant nutrients;
  * less dense turf;
  * less vigorous turf.

- In a normal well aerated soil, water and oxygen enter easily. In a compacted soil, water and oxygen do not enter easily.

BENEFITS OF AERIFICATION PROGRAMS Continued

- Compacted soils generally cause plants growing on them to have increased temperatures. Often the turf is warmer by 1 to 13 degrees F.

- Core aerification leaves holes in the ground that function as follows:

  * release toxic gases;

  * increase infiltration;

  * accelerate drying;

  * promote root and shoot growth;

  * decrease thatch formation;

  * increase fertilizer penetration.

- Coring causes injury to turfgrasses at some times of the year. Consider:

  * tine diameter - 1/4 to 3/4 inch;

  * tine spacing - 2 to 6 inches;

  * tine depth - 3 to 8 inches;

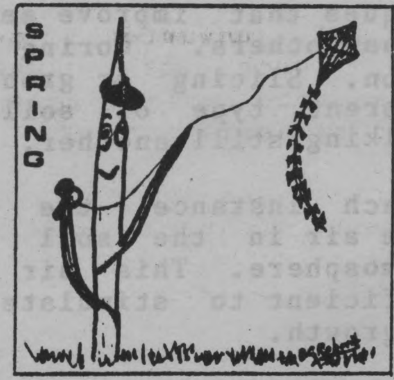
  * topdressing - use of cores;

  * timing of coring to cause least damage to the turf.

- Early spring and early fall are the best times of year for coring. The larger the tine and the closer the spacing, the more soil removed. Cores of soil are pulled out. Coring machines must be used over the same area several times with passes in different directions. Following coring, break up the cores with a vertical cutting machine. This will make a type of topdressing out of the cores. In order for best results, soil must be moist but not wet. Tines bounce off dry soil and fail to make adequate penetration.

- Silty clay loam soils are more subject to compaction than sandy loam soils and thus more attention to aeration is required.

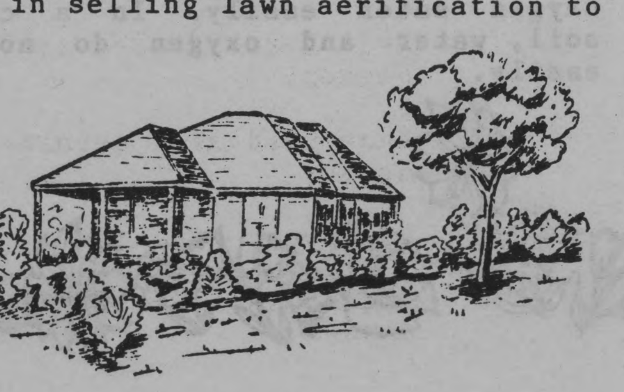
- Soil compaction during lawn and sports turf construction may be deep and difficult to overcome.



Selling Lawn Aerification

J D Mello
Nice'n Green Plant Foods
Romeoville, Illinois

Lawn aerification can be a very important part of landscape and lawn service businesses. J D Mello of Romeoville, Illinois presents these tips that have worked for him in selling lawn aerification to his clients.



- Business advantages:

  * An additional service;

  * Helps prevent lawn problems from developing;

  * Improves company image;

  * Increases late fall revenue;

  * Program is sold on an annual basis;

  * Aerify right up until the ground freezes;

  * Start aerification after the first frost in the fall.

SELLING LAWN AERIFICATION Continued

- Cultural considerations:

  * Fall is the best time for aerification;

  * This form of cultivation not only helps repair summer damage but also helps prevent continuing turf weakness;

  * This practice requires consumer education to help understand cultural benefits; extension specialists generally promote aerification;

  * Aerification must completely penetrate the thatch layer and on into the soil below in order to help relieve soil compaction;

  * Soil cores need to be broken up and used as topdressing; this is an additional expense;

  * Preventative aerification should not involve cutting up the plugs because of the additional cost;

  * Growth of unwanted perennial grasses, such as quackgrass, bentgrass and zoysiagrass, are promoted by aerification;

  * Germination and growth of annual grasses and broadleaf weeds, such as crabgrass and winter annuals, are promoted by aerification;

  * Aerification must be determined on the basis of numbers of holes made per unit area; one pass is not enough. It's difficult to get enough holes made in the ground.

- Aerification equipment:

  * Check on gate sizes on the property to make sure that equipment needed can get through.

  * Check landscape design to make sure that equipment needed can be maneuvered properly and that underground wires and pipes are located to prevent damage by aerification;

  * Walk behind units seldom penetrate well enough;

  * Riding units with 4 wheel drive or tractor mounted units work well. Fill tires with calcium chloride solution or use wheel weights or use a heavy driver to keep machine on the ground;

  * Faster the speed, within limits, the better the aeration penetration. Must move both forward and backward.

- Aerification fees:

  * Fees should be set on the basis of 1000 square feet units. Establish a minimum fee and increase from there.

- Aerification followed by slit seeding:

  * Once a poor, run-down lawn has been aerified, new improved [more disease and insect resistant and more vigorous] grasses are often required along with changes in cultural practices. This involves total renovation and establishment of new grasses.

  * Glyphosate [Roundup R] is often used to advantage;

  * The area should be slit seeded. This brings up a lot more debris but in the process, aerification cores are cut up and dispersed. There may be so much thatch that removal is necessary.

  * Spring slit seeding has some disadvantages:

    - Competition from existing grasses if glyphosate is not used;

    - Cool soil temperatures slow seed germination;

    - Hot weather is ahead;

    - Preemergence herbicides are not as easy to use;

    - There is a high potential for weeds.

  * Fall slit seeding [or at least late summer] is best:

    - Reduced competition from existing grasses if glyphosate is not used;

    - Soil temperatures are higher;

    - Less weed seed germination;

    - Less weed vigor;

    - Cooler fall weather is ahead.

Business advantages of aerification followed by slit seeding:

* Additional service;
* Corrects a soil problem that has resulted in declining turf quality;
* Presents a good company image;
* Economical solution compared to resodding;
* Retention of slit seed customers is good;
* Increases late summer and fall revenue.

- Disadvantages associated with the slitseeding operation:

  * Customer expectations are often too high;
  * Customer cooperation on past maintenance practices is variable;
  * A good customer education and communication system is required;
  * There are often increased service calls for spot seeding and weed control [without charge];
  * Weather changes can be devastating - be careful of guarantees;
  * Unpredictable local watering bans can cause failure;
  * Difficulty in collecting fees for less than favorable results.

NEW HAMPSHIRE TURFGRASS CONFERENCE

JANUARY 1986

Wetting Agents
The Rest of the Story

Robert Oechsle
Montco Products Corporation
Ambler, Pennsylvania

High mole non-ionic blends and strategies for their use are almost endless. Yearly application rates,in some instances, approach one gallon of 70 % active material per 1000 sq ft on golf greens. This is beyond anything we historically have considered for water management. Two SURF-SIDE blends illustrate the physical characteristics of these products. One is a soft paste wax, molten point roughly 85 degrees F. and the other, a hard paste wax, molten point about 120 degrees F. The purpose of adding water to the paste waxes is to get them out of the drum and into solution.

Because of the high rates of application possible with these products in soils and deposited on the leaf and crown, we can change the environment within and without the grass plant. Every cell in nature has balanced hydrophobic/hydrophilic area. Turfgrasses can now be surrounded with a surfactant solution that is not phytotoxic, one that will not dissolve the cell wall, one that will not burn, discolor, root prune, or inhibit root initiation. Grasses will react to nutrients and chemicals differently than ever before in the history of horticulture.

High rate applications of blends that are flowable at 100 % active ingredient are potentially dangerous to the grass plant. The simple fact of flowability at 100 % identifies a bracket of low mole, detergent type surfactants. The problem is the leachate with low mole materials. These phytotoxic non-ionic surfactants must be tied up on surfaces.If picked up by the plant, when actively growing, serious injury to rooting and topgrowth can result. With high mole surfactants [waxy solids], you can drench problem areas on greens to any depth required to cure most water movement problems - preferably greens that are elevated or have

WETTING AGENTS - THE REST OF THE STORY

CONTINUED

internal drainage. At an ounce in 2 gallons water, you can soak a localized dry spot or wilt prone area on the green or collar as it shows up. The temperature can be 95 degrees F. and two o'clock on a mid-summer afternoon. You drench, you don't water it in, you walk off the green and forget it. Problem areas on fairways, tees, greens, approaches, and collars can be systematically eliminated . The point is that for the first time in turfgrass management, you can control gravitational moisture at the surface and deep within the soil profile when the problems of aeration and rooting at the height of the growing season are most critical. From point to point on a green, free moisture runs your life. You aerify, topdress, verticut, drill holes, trenches; you can hand syringe and make-a-go-of-it, and many wealthier clubs do just that. But you still deal with an irrigation system on a green that delivers twice the water required to 45 to 55 % of the green surface. Now, don't think that by applying 2 to 8 ounces a month of a wetting agent you are doing more than moving water through the crust of the green. If you start increasing dosage rates with a low mole surfactant, you get into cultural problems. That's why, after 30 years, low mole surfactants are still playing to mixed reviews.

Moving the free moisture from the surface of the green is just the beginning. Once through the crust and beyond the surfactant treated soil, the gravitational moisture is faced with whatever soil composition it comes in contact with. By applying surfactant drenches to individual problem areas, you lower this soil treated interface to a point where the gravitational moisture, once on its own, can move, without restraint, out of the rootzone.

The average reduction in water use is 30 %. Nitrogen requirements are reduced about the same amount. With better aeration and control of free moisture, disease is less of a problem. Most superintendents feel safe in July and August with 2 ounces per 1000 sq ft of a low mole surfactant, or none at all. From point to point on many greens, the free moisture may be out of sight, but it is still hung-up deeper in the green. Increased rates are necessary if we wish to move it out quickly, once below the crust. Here's where the total time spent at maximum aeration is so important to the quality of the turf and for disease control. In the case of watermold diseases, as the solution strength of high mole surfactants is increased, a waxy film is left on the leaf, crown, and soil surface. The hyphae can't put their feet down without landing on a surfactant film. Some superintendents regularly use these materials at 1 1/2 gallons in 100 gallons of water. They knock off the dew at rates of six to ten ounces per 1000 sq ft and water-in when convenient - 12 to 24 hours later, depending on when the green needs water. As rates increase, there is an across the board reduction in the use of fungicides and fertilizers.

In heavy mat and thatch, high mole surfactants penetrate faster; less time is spent wetting and spreading. Conversely, the low mole surfactants are so busy wetting and spreading that they end up being absorbed after initial contact with the organic material. As a matter of fact, they have a high affinity for surfaces. In the meantime, the insecticide is bonded to the organic surfaces before it reaches the pest environment. The difference between a low mole and high mole blend at 1 % solution can be 10 to 15 times faster penetration on the high mole side. If you increase this treatment strength, there is a sharp increase again in penetration; but the point is, you can achieve results without a detrimental effect to the grass plant. Conversely, the low mole, or those materials flowable at 100 % active ingredient, can prove too hot to handle, especially when the grass is actively growing. The high mole blends give you the penetrating effect plus they need only be watered into the pest environment. That's when you turn off the irrigation - no flood drenching.

In conclusion, the following three statements are often heard. Statement # 1: "Unfortunately, most materials on the market contain some water". Statement # 2: "It follows, and the data show, that the diluted materials do not give equivalent performance". Statement # 3: "Therefore, be an educated buyer. Know the active ingredient content". All three statements are an injustice to the concept and use of non-ionic surfactants. In order: Statement # 1: Compare high mole surfactants to a bar of soap - flow they don't at 100 % active ingredient. Statement # 2: University research indicates high mole surfactants show the greatest residual after one month. Statement # 3: Active ingredient content means nothing except when comparing identical formulations. But most important, it's time we investigate the cultural differences in surfactants and allow the grass plant to be the decision maker.

Editors note: This statement on high mole surfactants is an abbreviated edited version of a talk entitled "Wetting Agent Technology - Strategies and Thoughts Concerning Their Use" presented at the New Hampshire Turfgrass Conference, January 1986.

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