Proceedings

Of the

46th Northwest Turfgrass Conference

September 21-24, 1992

Sunriver Lodge and Resort
Sunriver, Oregon

PREFACE

One of the primary objectives of the **Northwest Turfgrass Association** (NTA) is to disseminate the most current turf development and maintenance information available from research, study and experimentation to interested persons. The annual NTA **Northwest Turfgrass Conference** and publication of the proceedings from each conference is one of the ways the association has chosen to accomplish this objective.

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Blair Patrick, Managing Editor

1991/92 PRESIDENT'S MESSAGE

On behalf of the 1991/92 Board of Directors of the Northwest Turfgrass Association, it gives me great pleasure to thank the many members, employees, spouses and friends who attended and supported this year's Northwest Turfgrass Association **46th Northwest Turfgrass Conference and Exhibition**.

This year's conference at Sunriver Resort in Sunriver, Oregon was an excellent program thanks to the hard work of Don Clemans (education program committee chairman and hospitality/spouse program committee chairman); Jon Hooper (commercial exhibit committee chairman); David Jacobsen (golf tournament committee chairman); and, Blair Patrick and Jerry Crabill (staff). Each of these chairmen chaired strong committees and to each chairman and committee member, my sincere thanks.

We had another year of outstanding speakers that covered a wide-range of topics relating to turf management. I would like to extend special thanks to our featured speakers Steve Cockerham from the University of California; Jim Latham with the USGA; and, Larry Helms of Dr. Lawrence Sherlock-Helms Presents, as I thank all those who served as presenters for our conference.

It gives me great pleasure to offer a special thank you to all exhibitors who participated at the trade show and the suppliers who sponsored a hole during the golf tournament. 100% of all profits from those activities go directly to support of NTA's research and scholarship fund.

My best to the 1992/93 NTA President, Becky Michels, and board for a successful year.

Tom M. Wolff
1991/1992 President

Board of Directors
1991/1992

TABLE OF CONTENTS

EDITOR'S NOTE

The following papers presented at the 46th Northwest Turfgrass Conference were not submitted for publication in this **Proceedings:**

CONSTRUCTING THE USGA LYSIMETER	Dr. Stanton E. Brauen Research and Extension Center Washington State University Puyallup, Washington
TEN ENVIRONMENTAL CONCERNS ON GOLF COURSES	Mr. Larry W. Gilhuly US Golf Association Lake Forest, California
IDENTIFICATION OF GRASSES	Mr. Thomas W. Cook Oregon State University Corvallis, Oregon

RESPONSIBILITY: YOURS, MINE AND OURS[1]

Dr. Jon H. Arvik[2]

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[1] Presented at the **46th Northwest Turfgrass Conference,** Sunriver Lodge and Resort, Sunriver, Oregon, September 21-24, 1992.
[2] Environmental Affairs Manager, Monsanto Agricultural Company, Roseville, California.

I must begin with a few definitions: "yours" refers to applicators, supervisors, managers, or others, who may in the course of their business or in private operations, use pesticides. "Mine" refers to agrichemical industry representatives in any capacity: salesmen, managers, supervisors, field development reps, public relations, governmental relations, regulatory affairs, environmental affairs staff, and so on, and "ours" refers to all of us, together.

My assumption for this discussion is that somehow you are involved in the management of the use of pesticides. It doesn't matter what kind of pesticide; safe use of pesticides is not bound by the kind of material used.

Here's some issues that have impacted your job:

1. The public fear of pesticides in general.

2. The spill of chemicals into waterways.

3. Attempts to ban spraying of chemicals in public areas.

4. School use of pesticides.

5. Wetlands.

6. Disposal of pesticide wastes.

7. Endangered species.

8. Posting of treated areas.

9. Local preemption of regulations.

I could go on at length; these will do for now.

Do you see any common threads in these issues? I do...all of them could have been prevented from becoming emotional issues, from having an effect on your businesses, and all of these resulted from the public perception of how pesticides are handled. Frankly, at this point, that really doesn't matter: the perception is there, and looking back at how it happened would make a good case study but won't cure anything. Let's look forward, and discuss how we can improve things, and how to prevent more bad things from happening.

Webster defines "manager", "management", and things like that in several ways, but it boils down to this: a manager is one who through sound judgement, conducts, supervises, and uses means to accomplish an end. The "end" here is the safe and effective use of pesticides: safe to the worker, safe to the public, and safe to "the environment", by whatever definition you wish to use for that.

As a manager, here are some of "your" responsibilities:

1. YOU are responsible if injury occurs to workers or passersby, if damage occurs to "the environment", and if damage occurs to desirable vegetation such as crops or ornamentals, or to animals such as pets or wildlife. If such damage does occur, your organization/employer may accept responsibility for your actions: probably not. You will end up with the liability alone, responsible for your actions, the actions of your staff, and for the actions of those over whom you may even have no direct control. That's not fair, but its real.

Your responsibilities extend into moral and ethical issues: to the public, to the families of those injured, to the families of your crews, to your own family, and to yourself. These responsibilities extend beyond pesticide safety, to the financial and emotional impact on a family of an injured worker. As a manager, you have to ask yourself..."What if...", and have a good answer.

Whatever your job, your first responsibility is to get home safely, then to provide no increased risk to your family, to the public, and to the environment. How do you protect those you must, and yourself? The University answer is "plan, organize, direct, coordinate, and control all aspects of your operations". The working man's answer is "prior planning prevents ____ poor performance".

The real issue is preparation: being prepared will *help* prevent incidents. Note I only said help. Here's some more questions to ask yourself:

1. Why are you doing that operation? Does the result justify the means? Does the job need doing at all? Are there better and less risky ways to do it?

2. Really, really, what is the desired result? Does it have to be done to that level? Can it be less intensive?

3. About your crew: do you have enough manpower? Do they know what you want? Do they know how to do it? Are they properly trained in vehicle operation, the use of power equipment, sprayers, application techniques, cleanup after the job?

4. Does your crew know first aid for physical injury, exposure to chemicals such as gasoline, pesticides, cleaning materials, *etc.*? Do they know how to handle an emergency? Do they know who to call for help?

5. Do you have the right equipment for the job? Do you have *enouqh* equipment, is it in good working order, is it ready to go (how was it used last time: was it cleaned, gassed up? What was in it last time that might injure something this time?).

6. What pesticides and other products are available for this job? Which best fits the job: performance, cost, cleanup, threat to the crew, public, neighbors, "the environment"? What regulations govern the use of the products?

7. Have you planned enough time to do the job? To schedule it properly, to prioritize the workload, to obtain and prepare the equipment, to reach the job site safely, to provide the proper training, to *do* the job safely, and get home safely? To properly maintain the equipment, and to do the paperwork?

I have mentioned "prioritize the workload". Know this law of nature: you will *always* be short of time, money, or manpower. Since you know that, plan for it. Match your work to your resources, and when *one* runs out, STOP! before you hurt someone. List the jobs, put them in priority order, go down the list with resources in mind, and when you are out of time, out of money, or out of manpower, draw a line through the list. Do not go below that line. If you fall into the "hurry-up" trap, the result will be poor planning, not working your plan, not being ready for the job, the job being done poorly, the job not being done at all, or accidents that could have been prevented. It's a classic case of "the hurrier you go, the behinder you get", and the more dangerous it becomes. Doing the job while short on resources does NOT decrease your responsibility, it *increases your risk of failure.* Remember, YOU are responsible for safety, above all else. There is no one else. And, there is no excuse for unsafe working conditions, or an unsafe job.

Work crews often work independently: are you/they ready for that? A good use of time is in training: on-site, hands-on OJT is the best, but classroom instruction is a good second. Practice emergency procedures...do you do that? When's the last time you went into the storage area and kicked over a bucket of water, telling the crew to handle it as though it was a toxic material? How did they react? How *would* they react? Sometimes, its a scary thing to watch, and toxic materials spill every day.

You can get help in training programs from many sources: perhaps you have someone on staff that can do it and would like to do it....have you asked? You can get help from the University and Extension Service, from City, County, State, and Federal agencies, from the Fire Department, the Police, and the Department of Health. You can get it from product manufacturers, and your (and the manufacturer's) state, regional and national associations.

Let's talk about risk:

The primary risk to your crews and to the public is from mechanical devices, and then from exposure to chemicals. The amount and degree of risk is affected by the availability of time, and by the application of knowledge.

Here's some sources of risk:

1. Mechanical devices at the job site: mowers, graders, backhoes, rollers, turfcutters, dozers, spreaders, tractors, weedeaters, sprayers, trucks, cars, and others. (When I first considered this discussion, I thought that the single greatest risk, with the least amount of your control, was in the drive to the job site. I have changed my mind: it is the drive *from* the job site, because the risk

is compounded by fatigue and the “in a hurry to get home” syndrome.

2. Exposure to chemicals on the job: gasoline, lubricating oils, antifreeze, pesticides, adjuvants, (including surfactants, spreaders, stickers), fertilizers, paints, solvents, coatings, and others. The biggest risk is from the gasoline: vapor intoxication and fire.

Now then:

-do you have a regular maintenance schedule for all of your equipment?

-do you regularly schedule training for employees using equipment?

-do you retire old equipment when you should?

-do you actively plan to obtain improved equipment, even if the old stuff isn’t broken?

-do you know the risks from commonplace chemicals: gas, lubes, solvents, paint thinner?

-do you have a drug awareness program? Do you have a drug/alcohol problem on the crew? Do *YOU* have a drug/alcohol problem? Do you know who to call if you do? Would you call?

-do you know the characteristics of the pesticides you use: safe handling procedures, symptoms, treatment? Do you know the proper disposal techniques? Do you know the environmental fate of the products?

-do you provide proper storage for equipment and pesticides? Do you know what proper storage requirements are for the products you use?

-do you provide proper training on use of pesticides: mixing, handling, safety equipment (do you provide safety equipment that is right for that job/pesticide?), applications, and emergencies?

-do you review the availability of improved pesticides: worker safety, efficacy, safety to the environment, cost, benefits of use?

OR:

-do you use equipment until it breaks down, regardless of risk? -do you use the same old products, regardless of risk?

Do you care?

Good managers do...are you part of the solution, or part of the problem?

I meet a lot of people in my travels; some of these meetings are after accidents and incidents: here's some comments that I have heard, that just don't cut it...

1. I was in a hurry....

2. I didn't know it was dangerous....

3. I didn't have enough time to do it right....

4. I didn't know he didn't know.....

5. We had a deadline...

6. It's not my fault....

7. I didn't have enough time to learn how to do it...

(I don't make these things up...these are real comments!)

"My" responsibilities (remember who "I" am:) include, but are not limited to, helping you meet your responsibilities. I can do that with resources, with support for your efforts, and through my products, like this:

Resources: information, training, and answers to your questions, on my products, policies, and positions on issues.

Support, for your associations and other organizations: money, participation in your activities as a member, with technical advice, legislative action, regulatory reviews by my staff, and by helping with public relations issues.

Products: by providing products that have full sets of data to prove their appropriateness for the job you are doing; providing data on their safety, environmental impact, and environmental fate; by providing products that are acceptable to the public, and products that work. And, it is my responsibility to provide support for those products in whatever fashion you need. You should be able to make one telephone call to your local manufacturer's rep, and get a good, candid answer to any question you may have about their products, within a reasonable period of time. Try it...if they can't, or won't, answer, use another product. You have too many choices to have to put up with that kind of treatment.

AND...my responsibility is to provide anything else you need to do your job effectively and safely. There are no bounds to that.

"Our" responsibility, yours and mine together, is to ensure that what we do in our businesses does not increase the risk to others, that it does not detract from their quality of life, and that it does not interfere with a safe and attractive environment. We know how to do that, and great strides have been made to get it done. We are working much closer together within our industries than we ever have, and we are working with our detractors, without hostility, and with high candor.

There is much yet to do. Professional behavior in our job performance will provide a solid base from which to work out differences with others who now, quite frankly, don't trust us with their safety. It will be a long trip, but together, we will take it.

ZOELITE AS A CATION EXCHANGE MODIFIER IN SAND ROOT ZONES[1]

Dr. Stanton E. Brauen[2]

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[1] Presented at the **46th Northwest Turfgrass Conference,** Sunriver Lodge and Resort, Sunriver, Oregon, September 21-24, 1992.
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The addition of inorganic and organic amendments to rootzone mixtures to enhance the water and nutrient holding capacity of sands is often recommended. Native peats, sawdust, bark and compost products are used as organic amendments. Vermiculite, calcined clay, perlite, pumice, porous minerals, ceramic products, and water absorbing polymers are alternative materials available as inorganic amendments. These inorganic amendments and products, such as cross-linked polyacrylimides, isolite and zeolite products, are not currently recommended in U.S.G.A. rootzone mixes. Several of these products have potential as inorganic amendments. However, insufficient research data or experience have been generated regarding the stability of the inorganic particles in sand rootzone mixtures to justify their use.

Zeolites are crystalline, hydrated aluminosilicates. There are many types of zeolites known, based on their chemical composition, structure and related physical properties and natural zeolites have been studied in agricultural systems for several years. However, it has only been in the last 10 years that zeolites have been studied as an amendment of sand for growing turf. Specifically, clinoptolitic zeolite (CZ) exhibits selective retention of NH^+_4 and K^+. Clinoptolitic zeolite also has a strong affinity for water molecules. Previous work at Puyallup by Nus and Brauen showed an increase in cation exchange capacity, moisture holding capacity and establishment rate of creeping bentgrass when sand was amended with CZ as compared to unamended sand. Work by Ferguson has shown both increased clipping yield and nitrogen recovery in clippings from CZ-amended sand when growing creeping bentgrass. Huang has shown that CZ-amended sand resulted in reduced nitrate and ammonium leaching losses. Thus, CZ appears to have potential as an inorganic amendment; but the question of particle stability and the question of how long (CZ) would remain effective in reducing nitrate and ammonium leaching remains to be determined .

During the construction of the U.S.G.A. lysimeters at Puyallup, we had the opportunity to install a few small lysimeters which would allow us the capacity to answer some of the above concerns and over a period of years provide some indication of particle stability. Thus, 12 lysimeters consisting of pure sand, sand amended with 10% CZ (v/v), 90% sand and 10% sphagnum peat (v/v), and 80% sand, 10% CZ and 10% sphagnum peat (v/v/v) were developed. The lysimeters were seeded to 'Putter' creeping bentgrass during October, 1991 and leachates were collected daily from the lysimeters beginning in mid-December just after fertilization and preserved for nitrate analyses.

The answer to the question of CZ particle stability in the root medium over time will remain obscure for some time since these lysimeters were only constructed one year ago and I am not aware of long-term studies currently in progress on turf. However, nitrate-N leaching has been shown to be strongly affected by the presence of CZ in the mix. Figure 1 depicts the magnitude of the daily reduction of nitrate-N leached from the CZ-amended profiles in contrast to pure sand. The quantity of nitrate-N leached from the CZ profiles from December 18, 1991 to January 13, 1992 was only 32% of that leached from pure sand profiles. Table 1 shows the total nitrate-N leached from both rootzones during the 20 day period which resulted in loss of 8.3% of the applied N from sand rootzones by only 2.6% of the applied N from the CZ-amended rootzones. These data look very favorable and supportive of including potassium-based CZ in the rooting mix of putting greens. Because of the NH^{+}_{4} retention qualities of CZ, it is expected that similar reductions in NH^{+}_{4} leaching would be found although the quantitative amount of NH^{+}_{4} that may be leached would only be a fraction of the potential nitrate-N lost.

Amendments are added to sand to improve both nutrient and moisture retention. Nus and Brauen have shown that the addition of CZ to sand significantly improved the water retention at all soil matrix potentials compared to sand alone. Even so, for this purpose alone, sphagnum peat would provide a superior moisture status in the root zone mix relative to CZ. CZ-amended sand would be expected to have a higher cation exchange capacity as compared to sand. The selective retention of nutrients in CZ-amended sand has been credited for the more rapid seedling establishment accredited to sands amended with CZ. CZ used in this study would have a cation exchange capacity of approximately 150 meq/100 g in comparison to sand at roughly 2 to 4 meq/100 g. Thus, the capacity of CZ-amended sand to hold nutrients may be greatly enhanced and particularly selective for the NH^+_4 ion and K^+ ion.

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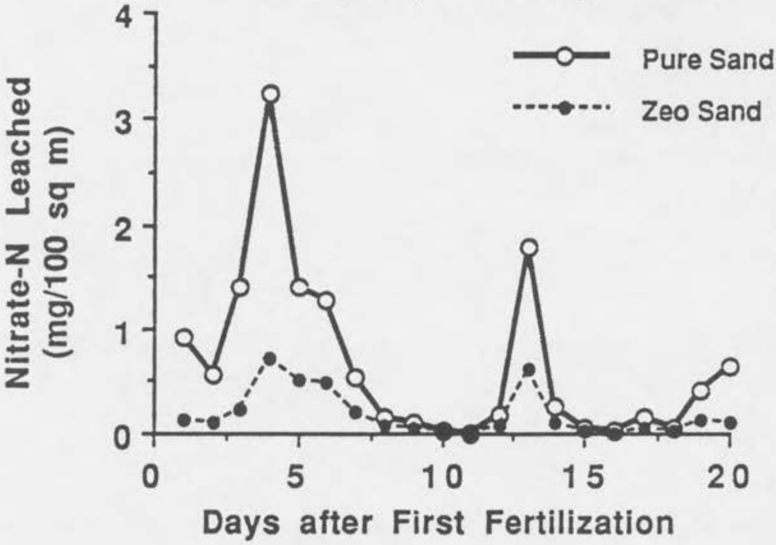
Huang, Z. T. 1992. Evaluation of clinoptolite as an amendment for sand for turfgrass use: Il. Ammonium retention and nitrification in acidic sands as affected by clinoptolite particle size. Ph.D. dissertation. Cornell University, Ithaca, NY.

Nus, J. L. and S. E. Brauen. 1991. Clinoptolite zeolite as an amendment for establishment of creeping bentgrass on sandy media. HortScience 26(2):117-1 1 9 .

Table 1. Total nitrate-N leached from pure sand and zeolite-amended sand putting green rootzones during 20 winter days at Puyallup, WA. (Brauen).

Rooting medium	Gram nitrate leached	Percent of applied N leached
	- $g/100\ m^2$ -	
Pure sand	14.73	8.3
Zeolite-amended sand	4.67	2.6

Fig. 1 Milligram of Nitrate-N Leached Daily from Pure Sand and Zeolite-Amended Sand Putting Green Rootzones during Winter at Puyallup, Washington *Brauen*



DETERMINATION OF NITRATE CONCENTRATION IN SOIL LEACHATE WITH A NITRATE ELECTRODE[1]

Mr. A.J. A. Ekuan[2] and Dr. Stanton E. Brauen[3]

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[1] Presented at the **46th Northwest Turfgrass Conference,** Sunriver Lodge and Resort, Sunriver, Oregon, September 21-24, 1992.

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In foresight of regulations regarding nitrate pollution and the establishment of nitrate monitoring the following details a method of determining nitrate concentration in leachate samples.

The preparation of standards and calibration of the ion specific meter is critical to accurately determine nitrate (NO_3) concentration. Digital meters with concentration modes such as the Orion 290A are readily available and reduce the hassle of converting millivolt potentials into concentrations. Equip the unit with a nitrate electrode (Orion #93-07BN) and reference electrode (Orion #90-02). Follow the manufacturer's instructions to fill and prepare the electrodes for use.

Preparation of Nitrate Standards and Preservative Solutions. In leachate samples containing low nitrate concentration, less than 13µg of nitrate per ml (13 ppm), a five point calibration of standards ranging from 1 to 10 ppm is required and provides adequate basis for calibration. Begin with a 1,000 ppm nitrate standard solution (Orion #920707). Make sure that the standard and distilled water are at room temperature. Replace the standard if crystals have formed around the mouth of the bottle. A 0.10 M sodium nitrate solution is a suitable substitute. Convert 0.10 M sodium nitrate to 1,000 ppm nitrate standard by diluting 71.4 ml of sodium nitrate solution with distilled water to 100 ml. Refrigerate the 1,000 ppm nitrate standard when not in use.

Preservative Solution. Prepare a lM boric acid preservative solution by dissolving 6.2 g of boric acid into 100 ml of hot distilled water, allow to cool and bring up to volume. Add 1 ml of this solution to every 100 ml of sample and standard, this will inhibit growth of algae and microorganisms. Boric acid has a tendency to crystallize upon cooling. Shake the solution well to dissolve as many of the crystals as possible.

Nitrate Standards. Begin by making a 100 ppm nitrate standard. To prevent contamination pour out about 20 ml of 1,000 ppm nitrate standard into a small clean beaker. Pipette 10.0 ml of standard into a 100 ml volumetric flask. Add 1 ml of preservative solution and bring up to volume with distilled water. Indicate clearly on the flask the concentration, the specific ion, and date of preparation, use a label which can be transferred to the standard's final container. Stopper the flask tightly and invert several times to ensure complete mixing. Use volumetric flasks opposed to graduated cylinders for greater accuracy and consistent standards.

Further dilutions will be made from the 100 ppm nitrate standard. Make a 1.0 ppm nitrate standard in a 250 ml volumetric flask by pipetting 2.50 ml of 100 ppm nitrate standard. Add 2.50 ml of preservative solution and bring up to volume with distilled water. An adjustable digital pipettor like the Brinkman Macro Transferpettor is a convenient alternative to glass pipettes. Always check the calibration of every adjustable pipettor with water and an analytical micro balance.

Prepare nitrate standards from the 100 ppm standard. Save the remainder of the 100 ppm nitrate standard for temporary (2-3 day) electrode storage. Standard instructions are summarized in Table 1.

Preparation of Standards and Samples for Nitrate Determination. Determination of low nitrate concentration demands the use of a low-level ionic strength adjuster (ISA) to provide a uniform ionic background in all standards and samples. Make a low-level ISA by diluting the nitrate ISA (Orion #930711) at a 1:5 ratio. Store this at room temperature in a clearly marked plastic bottle. Add 2 ml of low-level ISA to every 100 ml of sample or standard before taking readings. Also use the low-level ISA as the outer filling solution in the reference electrode. When working with a large quantity of samples a repeating pipettor such as the Manostat Minipet is an efficient tool for quantitative transfer of liquids.

Calibrate the ion sensitive apparatus. Begin by pouring 50 ml of 1.0 ppm standard into a 150 ml plastic beaker. Add 1 ml of low-level ISA and a Teflon coated magnetic stir bar. Stir standards and samples at a uniform rate, about 100 RPM. Fast stirring will change the temperature of the solution creating erroneous readings. It is advisable to insulate the plastic beaker from the magnetic stirrer. Work from low to high nitrate concentration standards, rinsing the electrodes with distilled water and blotting dry with a Kimwipe tissue between standards and samples. Securely cover the plastic beakers to prevent evaporation, they will be used for recalibration throughout the day. Periodically run random standards to check for deviation and recalibrate every two hours or 25 samples. Begin with fresh 50 ml portions of standard each morning. Fresh standards should be prepared every month. Making 250 ml volumes of standards will ensure that they will be replaced frequently with regular use.

Nitrate Materials. Table 2 lists a cost breakdown of essential equipment to begin monitoring nitrate concentration in soil leachate. While this list is by no means comprehensive it represents the basic materials from which variations can be made to adjust to personal needs or taste.

Table 1. Standard Directions

ppm NO_3	ml of 1,000 ppm NO_3 standard	ml of 100 ppm NO_3 standard	ml of preservative solution	final volume (ml)
1.0		2.5	2.5	250
2.5		6.25	2.5	250
5.0		12.5	2.5	250
7.5		18.7	2.5	250
10.0		25.0	2.5	250
100	10.0		1.0	100

Table 2. Nitrate Determination Supplies

Item	VWR Scientific[3] #	quantity/price
Orion pH/ISE 290A meter	34104-122	1/$775.00
electrode stand	34104-752	1/$115.00
nitrate electrode, Orion #9307BN	34117-315	1/$475.00
1,000 ppm nitrate standard, Orion #920707	34184-618	1/$35.00
nitrate ionic strength adjuster, Orion #930711	34185-600	1/$40.00
Teflon magnetic stir bar	58948-218	1/$2.00
VWR Dylastir magnetic stirrer	58935-250	1/$144.35
Tri-Pour graduated plastic beakers	13915-250	100/$29.00
Pyrex 100 ml volumetric flask w/ stopper	29619-234	1/$20.30
Pyrex 250 ml volumetric flask w/ stopper	29619-256	1/$25.20
VWR brand 500 ml wash bottle for distilled water	16651-181	6/$16.85
boric acid 500g	EM-BX0870-1	1/$32.60
pipet pump 0-10 ml	53502-233	1/$11.03
polystyrene sample containers (20 dram)	66015-632	144/$39.60
Kimwipes tissue (box of 200 sheets)	21905-010	15/$56.95
1 ml glass measuring pipet	53103-089	12/$53.50
10 ml glass measuring pipet	53103-147	12/$62.50
Brinkman Macro Transferpettor 2-10 ml	53512-419	1/$190.00
Manostat Minipet 10 ml	53505-129	1/$160.00
distilled water- see local grocery store		

[3]VWR Scientific stocks a wide range of laboratory apparatus. Their catalog numbers and prices have been provided for informational and cross-reference purposes.

MEASURING NITRATE MOVEMENT IN SAND AND MODIFIED ROOT ZONES[1]

Mr. J. Eric Chapman/Dr. William J. Johnston[2]
Dr. Stanton E. Brauen/Dr. Gwen K. Stahnke[3]

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[1] Presented at the **46th Northwest Turfgrass Conference,** Sunriver Lodge and Resort, Sunriver, Oregon, September 21-24, 1992.
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INTRODUCTION

In recent years, the turf industry has been seen as a potential threat to environmental quality for the excessive use of nitrogen (N) in order to maintain high turfgrass quality and appearance. In response to this, a study jointly funded by the United States Golf Association (USGA) and the Northwest Turfgrass Association (NTA) is being conducted at Washington State University's Research Center in Puyallup, WA to provide greater information concerning the quantification and movement of nitrate N in sand-based and amended sand profiles. The Pacific Northwest has a unique climate which includes long, mild, wet winters. Because of this, there is a history of constructing golf course putting greens, tees, and other athletic turf areas using sand, some with coarse particle sizes and without amendment in order to reduce construction costs and improve drainage during the seasonal rains. This practice has led to the concern that leachate of nitrate-N may reach levels that could influence the quality of local ground water. Although nitrate leaching studies have been reported from midwest, eastern, and southern locations in the United States, no research on this subject has been conducted in the Pacific Northwest.

The current study has been designed to address the issue of nitrate-N leaching in the Pacific Northwest. The objectives of the study are:

•To quantify the fate of nitrogen in sand-based and amended sand putting greens.

•To assess the effect of N rate and application timing on wear and play ability of trafficked putting turf.

•To identify critical seasonal N loss.

•To provide best management practices for N fertilizer on pure and amended sand greens which promote environmental safety without sacrificing playability.

MATERIALS AND METHODS

The study is being conducted on thirty-six research lysimeters built similar to United States Golf Association putting green specifications. Each lysimeter measures 1.2 by 2.44 meters. The lysimeters are lined with reinforced chlorosulfonated polyethylene and fitted with a 37.5 mm perforated drain tube. The rooting medium consists of either pure sand, or an amended sand containing 88% sand, 10% spaghum peat, and 2% sandy loam. The lysimeter area was seeded with 'Putter' creeping bentgrass on October 10, 1991.

Fertilizer applications are made either 11 or 22 times per year. This corresponds to a once per month, or every two weeks, with no applications being made in February.

Fertilizer rates for the study are 4, 8, and 12 lb N/1000 ft^2. The fertilizer is a granular blend of soluble and slow release nitrogen consisting of ammonium sulfate, representing a soluble N source, and equal parts IBDU, sulfur coated urea (SCU), and methylene urea (MU) representing the slow release N source. Phosphorus, potassium, and sulfur are supplied with each N application, and micronutrients are applied at regular intervals to all lysimeters.

Irrigation for the study is computer controlled to maintain field capacity and eliminate leaching except during natural rainfall. Samples are drawn from each lysimeter only when natural precipitation exceeds the moisture holding capacity of the lysimeter. Lysimeter volume data is recorded for each sample period. Each sample is preserved in 2 M KCI for storage. Nitrate analysis is conducted using segmented flow analysis for nitrate in ground water as established by Environmental Protection Agency methods. Clippings are sampled weekly for use in grow out and plant nitrogen levels.

RESULTS AND CONCLUSIONS

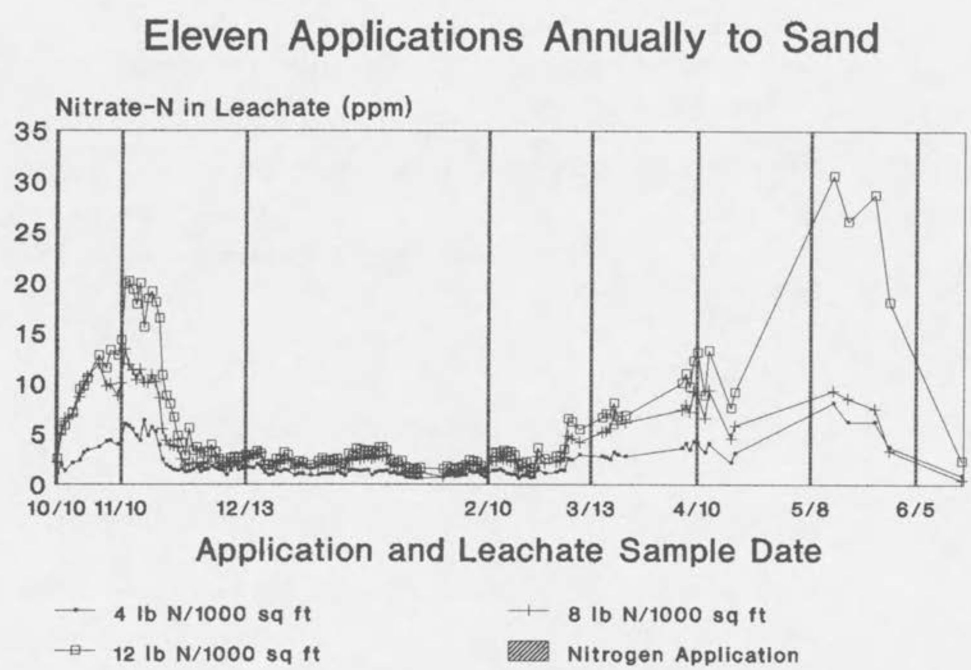
The preliminary observations presented here are from very young, immature turf which would be subject to leachate movement because of the lack of a mature root system and/or organic matter accumulation. These turf areas would likely represent the most susceptible systems to nitrate-N losses. Data from the 1992-93 winter season should provide a better perspective of this concept in more mature sand profiles. Preliminary trends have been noted, and show some interesting observations.

The first observation is that nitrate leaching was rate related, and was influenced by the amount of rainfall. This trend was expected.

The second, and most striking observation noted was that the rate of nitrate-N leached was strongly effected by the presence of the soil amendments. Nitrate levels were much lower in the amended sand Iysimeters, falling well below the E. P. A. safe levels for nitrate in the ground water (10 mg/l), in all but the most extreme rainfall.

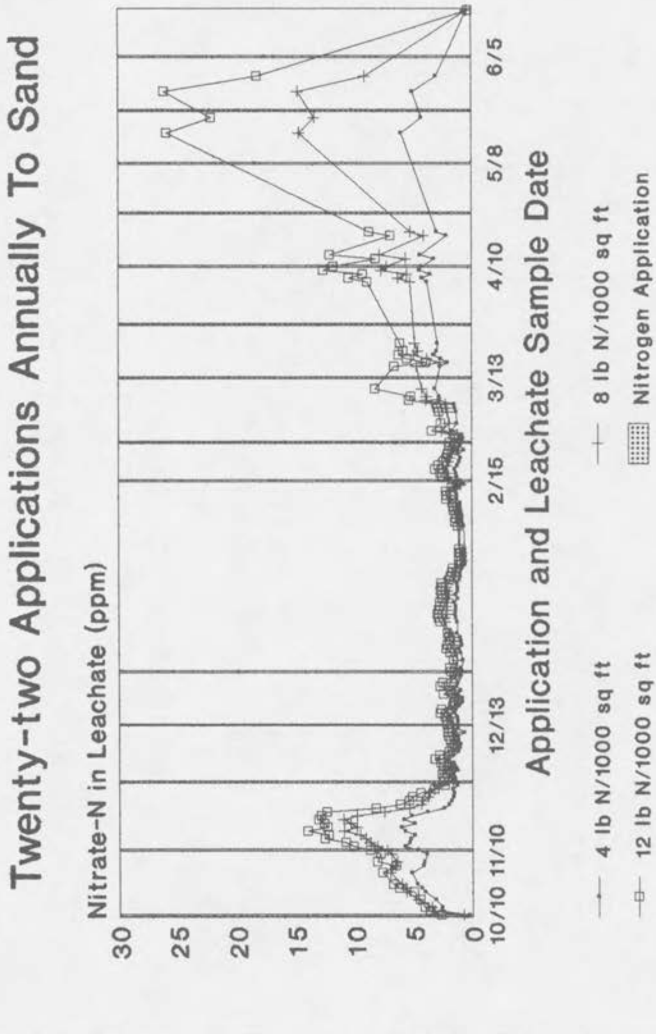
The third observation is that application timing has an effect upon nitrate leached. The data indicated that nitrate is more likely to leach from the 11 applications annually as opposed to the 22 applications. While this effect is less than that caused by the amendment, it still consistently influenced the amount of nitrate leached.

Since this study has been under way a relatively short time, conclusions drawn at this time would be premature. However, some preliminary recommendations for newly established putting surfaces may be made. These would include using an amended sand root zone when constructing new putting greens, lowering the rate of N used during initiation of the turf, and using light, frequent fertilizer applications.



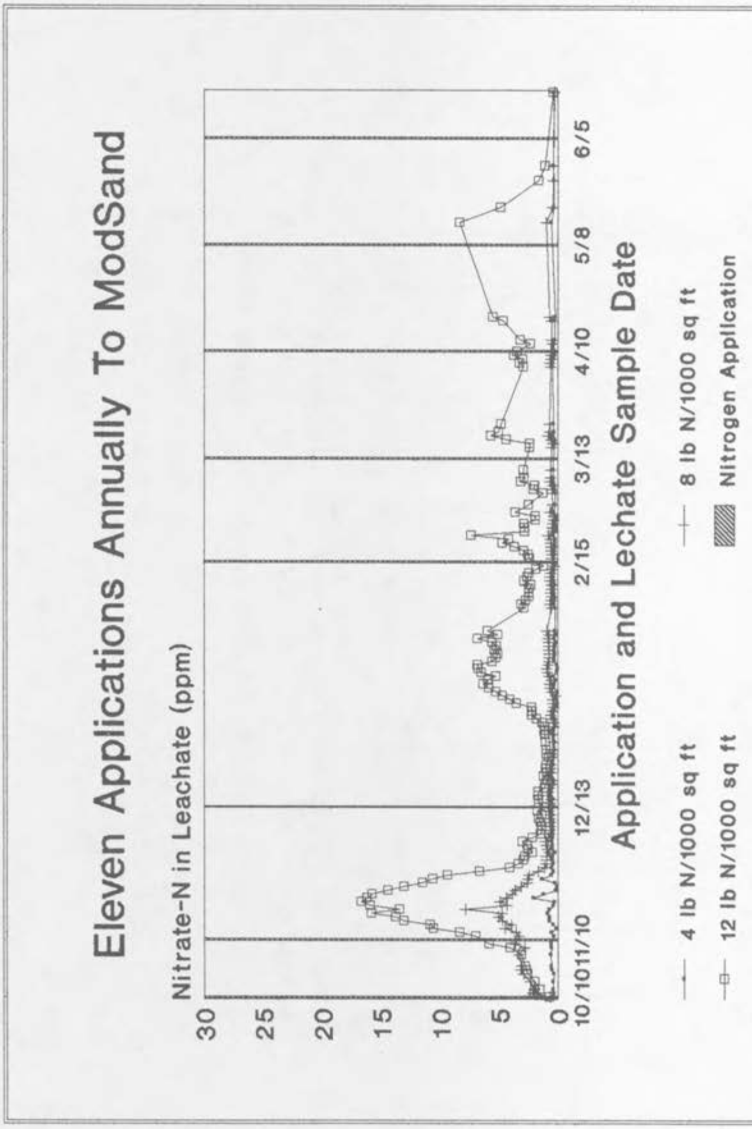
Eleven Applications Annually to Sand
Nitrate-N in Leachate (ppm)
35
30
25
20
15
10
5
0
10/10 11/10
12/13
2/10
3/13
4/10
5/8
6/5
Application and Leachate Sample Date
4 lb N/1000 sq ft
12 lb N/1000 sq ft
8 lb N/1000 sq ft
Nitrogen Application

Figure 1



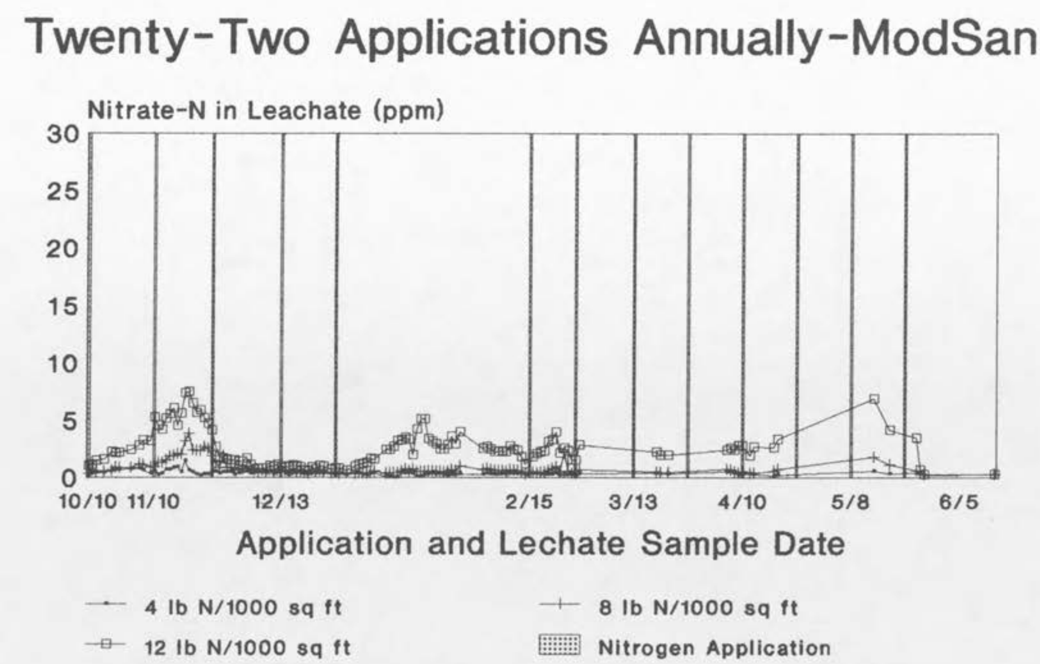
Twenty-two Applications Annually To Sand
Nitrate-N in Leachate (ppm)
30
25
20
15
10
5
0
10/10 11/10
12/13
2/15
3/13
4/10
5/8
6/5
Application and Leachate Sample Date
4 lb N/1000 sq ft
8 lb N/1000 sq ft
12 lb N/1000 sq ft
Nitrogen Application

Figure 2



Eleven Applications Annually To ModSand
Nitrate-N in Leachate (ppm)
30
25
20
15
10
5
0
10/10
11/10
12/13
2/15
3/13
4/10
5/8
6/5
Application and Lechate Sample Date
4 lb N/1000 sq ft
8 lb N/1000 sq ft
12 lb N/1000 sq ft
Nitrogen Application

Figure 3



Twenty-Two Applications Annually-ModSan
Nitrate-N in Leachate (ppm)
30
25
20
15
10
5
0
10/10 11/10
12/13
2/15
3/13
4/10
5/8
6/5
Application and Lechate Sample Date
4 lb N/1000 sq ft
8 lb N/1000 sq ft
12 lb N/1000 sq ft
Nitrogen Application

Figure 4

Effect Of Sand Or Amended Sand Medium

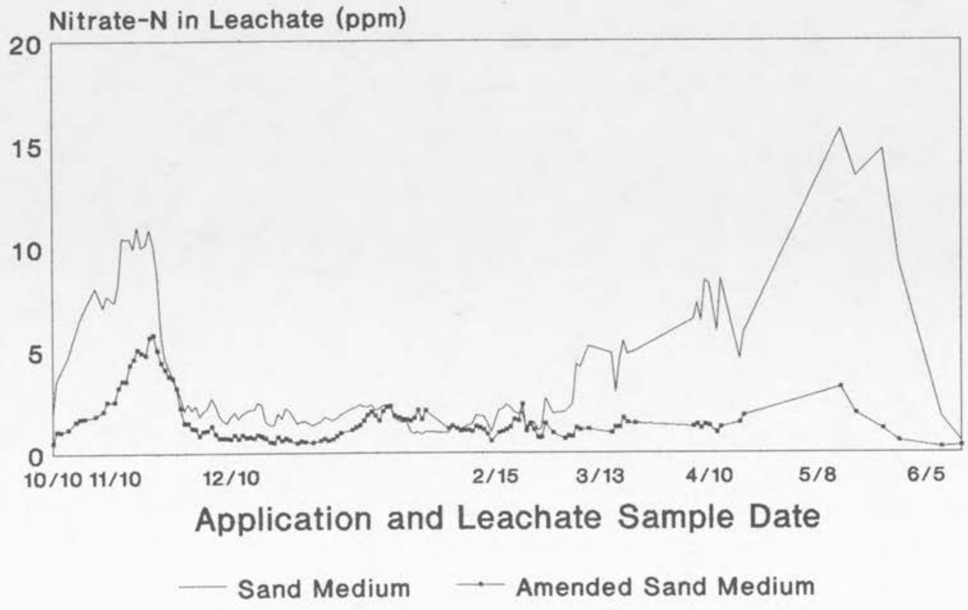


Figure 5

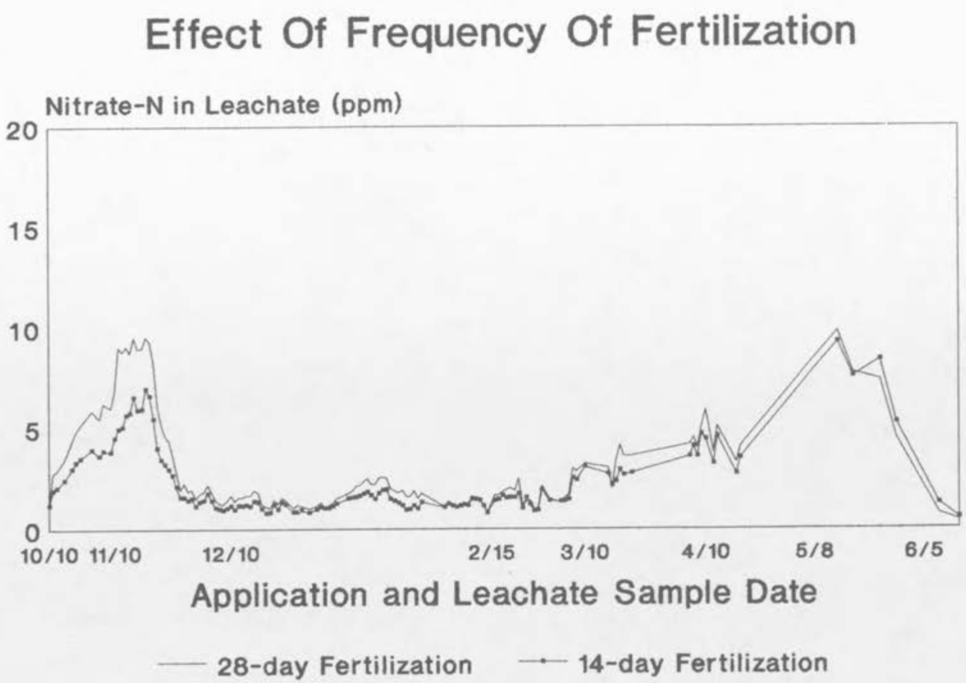

Effect Of Frequency Of Fertilization
Nitrate-N in Leachate (ppm)
20
15
10
5
0
10/10 11/10 12/10 2/15 3/10 4/10 5/8 6/5
Application and Leachate Sample Date
28-day Fertilization
14-day Fertilization

Figure 6

POTENTIAL REDUCTION IN PESTICIDE USAGE THROUGH CULTIVAR SELECTION[1]

Dr. Gary Chastagner[2]

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[1] Presented at the **46th Northwest Turfgrass Conference,** Sunriver Lodge and Resort, Sunriver, Oregon, September 21-24, 1992.

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There are a number of diseases which can severely damage turfgrasses. The importance of any given disease varies from one area to another, from year to year and at various times within a year. Most turf diseases are caused by fungi. Fungi are microscopic organisms that are incapable of producing their own food. Must fungi, such as those that produce the mushroom you might buy in a store are beneficial in that they live on and break down dead organic material.

There are two groups of fungi however, that cause plant diseases. The first can exist on dead material and is capable of attacking living plant tissues under specific condition. Most of the fungi that cause turf diseases belong to this group. The second group can only grow on living tissues. These are know as obligate parasites and leaf rust would be an example of a turf disease caused by an obligate parasite .

There are four basic conditions that must occur for disease to develop. They are: 1) a pathogen must be present; 2) a susceptible host must be present; 3) favorable environmental conditions must exist, and 4) these conditions must exist for a sufficient length of time to allow symptoms to appear. If any one of these four conditions do not occur, disease will not develop.

Most of the disease management practices used by turf managers involve efforts to modify No. 3. Changing the irrigation practices to reduce the length of time foliage stays wet, pruning or removing surrounding plants to improve air movement and protecting turf from temperature extremes through the use of various cultural practices are all examples of management practices that affect the environmental conditions necessary for development of various turf diseases.

Nutrient deficiencies and/or imbalances are known to affect a number of turf diseases. Red thread and the dollar spot that has recently been found in Washington and Oregon are two diseases likely to be more severe on turf that received minimal levels of fertilization, particularly nitrogen. The addition of sulfur to fertilization programs has clearly been shown to be beneficial in suppressing the development of Fusarium and Take-all patch in the Pacific Northwest. It is thought that most of this benefit is the result of making the soil environment unfavorable for the growth and/or survival of the fungal pathogens that cause these diseases.

Fungicides are a common management tool used to control turf diseases. Most common, if not all of the fungicides that are used only protect the plant from infection by the pathogen. Although you commonly hear people say that I am using a fungicide to kill the pathogen, in reality the fungicide is only suppressing the development of the pathogen. The length of time the fungicide will control the development of the pathogen depends on the activity of the fungicide, the rate applied, the frequency of application and disease pressure.

With the increasing concern about protection of the environment, turf managers need to maximize the cultural conditions that help reduce the potential for disease and thus lessen the need to use fungicides. One method of potentially reducing the use of fungicides is through the use of cultivars of turfgrass that have some resistance to the economically important diseases in your area. There are basically two types of host resistance that can occur in turfgrass cultivars. Cultivars with vertical resistance are no longer susceptible to a given pathogen. Examples of this type of resistance can be seen in Kentucky Bluegrass with diseases such as strip smut, rust and leaf spot. The use of a cultivar with vertical resistance to say, leaf spot will eliminate the need for fungicides to control this disease.

Probably the most common type of resistance that is found in other plants is known as horizontal resistance. Although cultivars with horizontal resistance can still have disease, the rate of disease buildup is generally much slower than on a susceptible cultivar. Under normal disease pressure, it may be possible to maintain acceptable turf quality without using any fungicides.

At the very least, by using turf with horizontal resistance, turf managers should be able to minimize the need to use fungicides against the disease or diseases for which the cultivars are resistant.

Of course, there are other factors that must be considered when choosing or selecting a cultivar. First of all, the cultivar has to be well adapted to the area that you will be using it. In addition, it has to be adapted to the management style and intended use for the turf area. When selecting turf cultivars for establishing new turf areas or use in overseeding or renovation programs, ask your University turf specialists or seed suppliers for information about the susceptibility of cultivars to the important diseases in your area. Selecting cultivars with even partial resistance to diseases that frequently require applications of fungicides should enable you to reduce the amount of fungicides necessary to maintain acceptable turf quality.

EFFECTS OF LIGHT INTENSITY ON TURFGRASSES SUBMITTED TO SPORTS TRAFFIC[1]

Mr. Steven T. Cockerham/Dr. V. A. Gibrault[2]
Dr. M. Borgonovo[3]

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[1] Presented at the **46th Northwest Turfgrass Conference,** Sunriver Lodge and Resort, Sunriver, Oregon, September 21-24, 1992.

[2] Superintendent of Agricultural Operations and Extension Environmental Horticulturist of Botany and Plant Sciences, respectively, College of Natural and Agricultural Sciences, University of California, Riverside, California.
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The Light Intensity Turf Evaluation (L.I.T.E.) facility is designed to submit turfgrass cultural-practices to four light intensity regimes and simulated sports traffic. The research objectives are (1) to determine the best management practices of durable, low light requirement grasses for light restricted sports field and (2) to investigate the minimum light requirement for sports turf.

Sensor packages are set within each light intensity treatment. Each sensor package contains a remote quantum sensor measuring photosynthetically active radiation (PAR), a temperature probe, and a relative humidity probe. The sensor data is transmitted via infrared telemetry to a computer dedicated to remote sensing data collection.

The light intensity variable is provided by using shade cloth rated by the manufacturer at 30%, 55%, and 73% shade, plus full sun.

A structure using cables and winches has been built to allow access for turf maintenance and experimental treatment. The shade cloth is lifted completely off the surface to a height above the pattern-throw of the sprinklers. The entire treatment/maintenance procedure including traffic application, mowing, and irrigation can be done by one person in about two hours.

Bonsai tall fescue, Manhattan II perennial ryegrass, Manhattan II perennial ryegrass (60%) plus Jaspar creeping red fescue (40%), and El Toro zoysiagrass were established when the four light intensity treatments were installed. Half of each plot was submitted to simulated sports traffic.

SIMULATED TRAFFIC. Cleated-shoe traffic on a sports field is composed of three components: (1) wear from friction and scuffing, (2) compaction from the shoe sole and the concentrated weight distribution of the cleat, and (3) shear injury to the grass plant from the twisting of the embedded cleats.

To conduct research for sports fields it is necessary to use a device to uniformly simulate traffic imposed by sports that use a cleated shoe.

The Brinkman Traffic Simulator (BTS) was developed to uniformly simulate the traffic of American football when applied to turfgrass research plots. The BTS consists of two cleated rollers in a frame connected by chain and sprockets which is pulled by a small tractor. The size of the cleats is approximately that on the shoe of professional football linemen.

The BTS provides wear just by being pulled over the turf. Compaction is accomplished by the weight of the machine on the cleats. The rollers are forced to turn at different speeds because of the differential sprocket size creating shear and tearing of the turf and soil. The BTS has been calibrated for professional football traffic simulation through a study of actual football games to determine the location and quantity of the traffic.

In the study of the effects of light reduction on turf submitted to BTS sports traffic, the turf received an average of four football game equivalents per week from October through the following May.

SENSOR DATA. Temperature measurements showed differences between the various light treatments at the highs and lows. The shade cloth retained heat and insulation was apparent with increasing density. Daily maximum temperatures did tend to be cooler under the denser shade.

Relative humidity measurements showed differences between treatments with the 73% treatment slightly higher at night and lower in the daytime.

Measurements of actual light were in PAR recorded as microEinsteins (mE). The unrestricted light level ranged from around 1200 mE to 1900 mE with the most severe restricted treatment in a range from 300 mE to a little over 400 mE. In Table 1, the variation in light intensity is shown for a four month period taken at 2:00 in the afternoon.

The number of hours per day the turf was exposed to a particular light intensity indicates the potential accumulation of radiant energy. Light energy accumulated by the plant is utilized in photosynthesis which supports growth. In the turf in the most restricted light treatment, 73% shade, accumulation was quite low with a few hours at the range between 300 and 400 mE, about that experienced in a moderately lighted room. Table 2 shows the accumulation of light for one day.

RESULTS Turf scores are visual ratings which include turf density, vigor, and quality. The turf scores of the turfgrasses under traffic in full sun and with the 73% light restriction in Table 3 show the tall fescue to initially rate as the highest cool season grass with the perennial ryegrass/creeping red fescue mixture maintaining resistance, followed by perennial ryegrass alone.

The early performance of the zoysiagrass was superior. In the winter months the recovery was minimal, and by the end of spring, the turf was nearly gone.

The seed mixture consisted of Manhattan II perennial ryegrass (60%) and Jaspar creeping red fescue (40%). Plant counts made at the end of the study are shown in Table 4. Creeping red fescue did not tolerate the simulated traffic. Perennial ryegrass plant counts reflect the turf score.

Red fescue plant counts were highest at 55% shade with no traffic. Light restriction at the 73% treatment reduced the red fescue plant counts.

The tall fescue deteriorated over time with traffic and in response to the light restriction, Table 5. Perennial ryegrass tended to tolerate traffic up through the 55% treatment. At the 73% treatment tall fescue and perennial ryegrasses exhibited some turf cover, but were severely injured by the traffic.

The Clegg Impact Tester measures the peak deceleration of a missile dropped onto a surface. Harder surfaces record a higher number of units (gMAX), indicating a lower capability of absorbing impact. In Table 6 all of the grasses were worn considerably and were much harder after several months of traffic.

El Toro zoysiagrass is a stiff, upright growing warm season grass. As long as cover persists, impact absorption remains high. Traffic influenced the impact absorption capability of the cool season turfgrasses more than light intensity.

Footing or traction is measured using a traction plate. The traction plate is a cleated steel plate dropped onto the turf surface and rotated horizontally. The force required to break the cleats loose is recorded as meter-kilogram torque (m-kg).

In Table 7, the traction remained fairly consistent throughout the treatments. Perennial ryegrass alone and in the mixture lost traction in the first evaluation 73% treatment. Zoysiagrass characteristically has rather strong stolons and tends to provide greater traction than the cool season grasses evaluated.

There is a continuing interest for natural turf sports fields in conditions of light restriction. The L.I.T.E. facility at the University of California, Riverside, is just beginning to help develop some of the information needed to meet the low light challenge.

TABLE 1 - ACTUAL LIGHT AS PAR (mE)

	DATE (2:00 P.M.)			
SHADE	3/23	4/3	5/31	7/5
73%	321	353	413	376
55%	525	588	708	662
30%	832	925	1267	972
0%	1223	1348	1883	1528

PAR = photosynthetically active radiation
mE = microEinsteins

TABLE 2 - HOURS PER DAY OF LIGHT INTENSITY (3/28) (PAR)

mE	SHADE TREATMENT 0%	30%	55%	73%
100	12	11	11	10
200	11	10	9	8
300	11	10	7	6
400	10	9	6	1
500	9	8	6	
600	9	7	3	
700	9	6	1	
800	8	6		
900	7	5		
1000	7	3		
1100	6	2		
1200	6			
1300	5			
1400	4			
1500	3			
1600	1			

PAR = photosynthetically active radiation
mE = microEinsteins

TABLE 3 - TURF SCORES OF GRASSES IN VARIOUS LIGHT INTENSITIES SUBMITTED TO SPORTS TRAFFIC

	SHADE	12/10	2/26	4/5	5/31
TALL FES.	0%	6.8	5.0	5.0	3.3
	73%	4.5	3.5	3.8	2.8
P.RYE/CRF	0%	6.5	6.0	5.8	4.3
	73%	3.3	3.5	4.3	4.5
PER RYE	0%	6.3	6.0	5.3	4.8
	73%	3.3	3.3	3.3	3.5
ZOYSIA	0%	9.0	6.8	6.5	5.5
	73%	8.8	4.3	3.0	1.3

Turf scores: 9 = excellent turf; 1 = no turf

TABLE 4 - TRAFFIC AND LIGHT EFFECTS ON A PERENNIAL RYE-GRASS/CREEPING RED FESCUE MIXTURE (6/1) (PLANTS/100 SQ.CM)

	TRAFFIC		NO TRAFFIC	
SHADE	PR	CRF	PR	CRF
0%	125.0	2.2	159.5	17.6
30%	119.9	2.0	129.8	21.6
55%	72.8		105.8	33.4
73%	67.8		101.9	8.8

TABLE 5 - TURF SCORES OF TALL FESCUE AND PERENNIAL RYE-GRASS IN VARIOUS LIGHT INTENSITIES SUBMITTED TO SPORTS TRAFFIC

	SHADE	12/10	2/26	4/5	5/31
TALL FES.	0%	6.8	5.0	5.0	3.3
	30%	6.0	4.8	4.5	3.8
	55%	5.8	4.0	3.5	3.5
	73%	4.5	3.5	3.8	2.8
PER RYE	0%	6.3	6.0	5.3	4.8
	30%	5.8	5.5	5.0	5.0
	55%	4.8	4.5	4.8	5.3
	73%	3.3	3.3	3.3	3.3

Turf scores: 9 = excellent turf; 1 = no turf

TABLE 6 - CLEGG IMPACT ON GRASSES IN VARIOUS LIGHT INTENSITIES SUBMITTED TO SPORTS TRAFFIC (gMAX)

		SHADE			
	DATE	0%	30%	55%	73%
TALL FESCUE	1/23	52.3	51.8	50.4	54.8
	5/16	87.2	84.7	68.6	81.4
PER RYE/CRF	1/23	64.9	61.6	53.3	50.0
	5/16	90.7	102.1	88.8	80.7
PER RYE	1/23	57.3	60.9	54.3	46.1
	5/16	85.8	86.2	93.1	77.7
ZOYSIA	1/23	31.1	31.0	31.7	29.0
	5/16	54.5	61.9	48.3	45.9

2.5 kg. missile

TABLE 7 - TRACTION PLATE ON GRASSES IN VARIOUS LIGHT INTENSITIES SUBMITTED TO SPORTS TRAFFIC (m-kg)

		SHADE			
	DATE	0%	30%	55%	73%
TALL FESCUE	1/23	4.7	4.9	4.3	4.2
	6/1	5.0	5.1	4.9	4.7
PER RYE/CRF	1/23	4.0	4.2	4.2	3.6
	6/1	4.5	5.2	5.0	5.3
PER RYE	1/23	4.4	4.3	4.2	3.6
	6/1	4.3	4.7	4.5	4.4
ZOYSIA	1/23	6.3	6.1	6.5	7.1
	6/1	6.9	6.6	5.7	4.8

42 kg. traction plate dropped 10 cm.

SPORTS TURF MANAGEMENT ON MODIFIED ROOT ZONES[1]

Mr. Steven T. Cockerham[2]

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[1] Presented at the **46th Northwest Turfgrass Conference,** Sunriver Lodge and Resort, Sunriver, Oregon, September 21-24, 1992.
[2] Superintendent of Agricultural Operations, College of Natural and Agricultural Sciences, University of California, Riverside, California.

The successful management of turf subjected to high traffic requires the application of certain fundamental cultural practices. As the demand for facility quality goes up, the respective demand for turf quality also increases, requiring cultural practices and resource input well beyond the basics.

Good management will allow the maximum number of games on a sports field, but a heavily used turf will eventually wear out. The number of games a given field can take before the turf is gone and the footing becomes marginal is somewhat predictable based upon the history of the field and its care.

The majority of sports fields are built simply and on native soil. Sand, unlike soil, resists compaction under load, even when wet. For this reason, most turfgrass authorities in the world consider the full sand profile to the be state-of-the-art in sports field construction.

But even full sand constructions can, and do, fail if key design and management rules are ignored. All sands are not created equal, and the type (particle size and shape) and depth of sand used must meet defined specifications. Furthermore, sand management must be precise. The medium is less forgiving than soil when it comes to irrigation and nutrient supply.

New sand sports fields are unstable at the surface. Much as on a beach, the sand moves with traffic causing injury to turf roots and rhizomes. Over time, the development of biomass, the formation of organic matter, and settling of the particles "matures" the pure sand field allowing it to become more stable.

The amount of sand used in sports fields varies from pure sand to mixtures of sand, soil, and organic amendments. Traction potential is inherently low in rootzone mixes with very high sand content and the effect grass has on traction increases as sand content in the rooting medium increases.

Reference is often made to the "art and science of turfgrass management." The full sand profile is an example of the science. The art is in providing a world class sports field on it.

SPECIES SELECTION. Traffic tolerance of turfgrass species varies a great deal including often wide variability within species. Where adapted, the new perennial ryegrasses have superior durability and the Kentucky bluegrasses have good ability to recover from injury. The elite tall fescues are still considered to have a coarse texture, but have proved to be the more durable species in selected climates.

Turfgrass species for sports fields are not selected for low water use. They are chosen for their ability to efficiently use resources to meet the stress demands of traffic and provide a safe, impact absorbing playing surface. Low water use or water conserving grasses are not necessarily good for sports traffic.

FERTILIZERS. Traffic, durability, playability, aesthetics, recovery ability, and field safety require high vigor in turf. To get that vigor, plant nutrient requirements are high. A common recommendation for nitrogen is 1.0 lb. of actual N per 1000 square feet per month of growing season. This is probably the highest practical rate for most sports fields. The rootzone mixture may allow the manager to modify this recommendation one way or another.

On both sand and soil sports fields high nitrogen turf is less wear tolerant, but has greater recovery potential. Nitrogen levels that are too low on soil or sand do not produce enough turf biomass to sustain traffic. Determination of the compromise for the best level of nitrogen management starts with recommendation guidelines followed by trial and error modifications for a specific site.

The other nutrients most needed on turf are phosphorus, potassium, and iron. On well-drained (e.g. sandy) soils the sports turf will require as much potassium as nitrogen applied at the same time. Various turfgrass authorities recommend ratios of 4:3 and 3:2 nitrogen to potassium on sand sports fields.

When the soil temperature is high enough for root and rhizome growth, the total nutrition available to the plant should be high. The recommended soil pH for high traffic turf is about 6.5. At that pH level most nutrients present in the soil will be available to the turf. If pH is too high or too low the appropriate adjustments should be made to the soil.

IRRIGATION. As "quality demands" of high traffic turf increase, more attention is given to irrigation. Water stress from drought, summer heat, or wind can be devastating to this kind of turf. Because of these demands, turf managers go to considerable effort to provide the turf with adequate levels of nutrients and water for optimum durability. Sports fields do not perform satisfactorily when maintained at minimum levels for the species. Upgrading an irrigation system to the best distribution uniformity possible and increasing water penetration efficiency by aeration are the most effective means of sports field water conservation.

AERATION. High traffic turf soils are subject to severe compaction. Core aerification with hollow tines is the most effective technique with the longest term benefit for compaction relief of sports fields. Core aerification is just as important on sand fields as on soil fields. The soil interface and the compression under traffic of the organic matter forming the thatch sealing the surface are relieved by coring.

Solid tine, sometimes called shatter coring, is becoming accepted. In solid tine aerating, slitting, and spiking holes are made with little surface mess to clean up.

Because core aeration is slow, labor intensive, and messy, there are practical limits as to the frequency. Slitting and spiking are possible in between core aerating. On loams or heavier soils, coring should be done after every fourth or fifth football game or eighth baseball or soccer game. In youth soccer where there may be eight games per day it may only be practical to aerate once per month. Sandy soils need aeration much less often, but the frequency depends upon the rootzone content, turf species, use pattern, and climate.

TOPDRESSING. If the field is to be topdressed it is usually done after aerating with the hollow tines. This has the effect of adding a loose soil to the effective rootzone. Topdressing also helps keep a true playing surface. The topdressing material should be either the same as the rootzone or lighter with more sand.

MOWING. Mowing is the most common practice and must be done on nearly all turf installations. The frequency of mowing is determined by removing less than one-third of the blade length at any one time. For example, if the mower is set to 1.0 inches, the grass should be mowed before it is 1.5 inches tall. If that takes a week then, that is the proper frequency. Mower height should be measured from a hard level surface to the top of the bedknife on a reel mower and to the bottom of the blade on a rotary.

The density of turfgrasses decreases with the increase in mowing height, however, the root and rhizome production increases. This creates a compromise decision for the sports turf manager in choosing a mowing height for the specific site and use.

Patterns of lines, squares, and cross-hatching can be made with skilled use of the mowers. When well done, patterning leaves a good impression with players and spectators and helps instill pride in the facility. It is pretty inexpensive P.R.

THATCH. Thatch is a layer of undecomposed organic matter developed from clippings and the natural accumulation of plant leaves and roots. Thatch can prevent water and fertilizer from going into the soil and may also stop oxygen exchange in the root zone resulting in shallow roots and weak turf. A good program of aeration on sports fields prevents the thatch from becoming a problem.

Thatch on high traffic turf is a valuable impact absorbing safety pad and mass for wear resistance. Undesirable on most turf thatch is an asset to be nurtured on high traffic turf. The players do a more than adequate job of preventing the thatch from becoming excess.

OVERSEEDING. Most high traffic turf has limited capability for recovery from injury during intensive play seasons. This is especially true of the perennial ryegrasses and fescues. The fields can be overseeded with the predominant species after vertical mowing or before a game if cleated shoes are worn by the players. Overseeding is a valuable technique for managing a field of high quality. Very quick cover is possible by pregerminating or presoaking the seed prior to overseeding.

Moisture is critical to overseeding success. The turf surface should be kept as moist as is practical. Irrigation will be required as rainfall is rarely adequate. Once soil temperatures drop below 50°F overseeded species are not likely to germinate.

VENTED TARP. A vented tarp can be used to keep the soil temperature up for grass growth. This "greenhouse effect" is particularly useful in the late fall for germinating overseed and filling in divots. Once the air temperatures average near freezing the tarp is no longer of any value. Condensation forms under the tarp and is normally adequate for seed germination. Consistent moderate air temperatures under the tarp with the constant high humidity will provide a near ideal environment for diseases. Removing the tarp for mowing is usually performed frequently enough to reduce the disease problem.

If the daytime air temperature under the tarp gets above 95° F there is a risk of injury to the turf. Soluble nitrogen fertilizers should not be used on a field that is to be tarped without allowing several days for the ammonia to dissipate.

SOLVING PROBLEMS. Nutrition deficiencies in turf are often expressed as discolored grass. Symptoms may not be apparent on worn turf, but could be observed on turf at the edges of the damaged area. If the edges are growing well, nutrient deficiency may not be a problem.

Fertilizer distribution patterns as arcs, lines, and strips show up quickly and are sometimes slow to correct. Apply 1/2 lb. N per 1000 square feet of a soluble, quick acting fertilizer uniformly. It would be difficult to try to match the deficiency pattern.

Irrigation patterns are usually distinguished by shapes that contain arcs and wear is excessive. The turf stand is usually clumpy and the ground very hard. Wilting turf has a gray-blue color before turning brown. Wet areas are often due to a leaky irrigation valve with drainage at the lowest sprinkler head in the system.

Patterns often show up from misapplications of herbicides or any other applied material. When diagnosing turf problems, the observation of patterns provides clues to what has happened and how to correct the situation.

Turf that is growing rapidly must be mowed frequently. Yellow grass can result from cutting too much leaf off either by not mowing often enough or by lowering the mowing height too much too quick. Thinning of turf density can be caused by mowing too high. Turf that is kept growing under a tarp in the fall, will be set back dramatically by scalping with the mower.

There is a tendency to rely on science in the form of instrumentation and computer models in the management of modified rootzone sports fields. That is fine if the science is merely considered another tool to be used in the art of sports turf management.

WHERE HAVE WE BEEN, WHERE ARE WE NOW AND WHERE ARE WE GOING?[1]

Dr. Roy L. Goss[2]

[1] Presented at the **46th Northwest Turfgrass Conference,** Sunriver Lodge and Resort, Sunriver, Oregon, September 21-24, 1992.
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WHERE HAVE WE BEEN?

We may also look at this subject heading as the period of excesses. I would like to reflect back on many years of turfgrass progress, particularly in the Pacific Northwest, with a few points on D0 YOU REMEMBER WHEN?

1. Do you remember when urea was applied at 20 Ib N/1000 ft2 on putting greens? This was the rate of application by golf superintendents at the time that the research program was initiated at Puyallup in June 1958. As you can see, the nitrogen picture has changed significantly since those times and will be discussed more later.

2. When 12 to 14 applications of PMAS/Caddy were applied annually for Fusarium control? Today, there is very little of these materials used for disease control.

3. When phosphate applications were 1/3 of the nitrogen? At the time of the inception of the turfgrass research program at Puyallup, most turfgrass soils, including lawns, sports fields, golf putting greens, etc., were all excessively high in phosphates.

4. When potassium was hardly ever mentioned? Soil tests revealed in the early days that most of our soils were deficient in potassium for turfgrasses.

5. Sulfur wasn't even invented or discovered?

6. Highland/Astoria bentgrass were the only bentgrasses for putting greens? This picture has changed tremendously.

7. When all soil tests were high in phosphate and low in potassium?

8. When sand was a dirty word as a grass-growing medium? Any fool knew at that time that you couldn't grow turf on pure sand.

9. When football fields were all mudholes? Due to the advent of the use of sand, this picture has changed.

10. When the recommended turf for football was bentgrass/fescue (the same as lawns) west of the Cascades, and common Kentucky bluegrass was used for everything except putting greens east of the Cascade Mountains?

11. When 18 temporary greens were common to all western Washington and western Oregon golf courses? This was due to the use of heavy soils that had accumulated high amounts of organic matter, which caused them to hold excessive amounts of water and were unstable during the high rainfall periods of winter.

12. When mowing heights of putting greens was 1/4 inch and never less than 3/16 inch, and the *Poa annua* always seemed to survive?

13. When greens were softened by the use of excess water to hold shots due to soil compaction and the only aerifier was the West Point Junior.

14. When golf courses were always closed on Monday?

15. When John Harrison, Glen Proctor, Louie Schmidt, Wilford Brusseau and Cliff Everhart started the Northwest Turfgrass Association along with Al Law?

16. When Al Law was the Executive Secretary and the Northwest Turfgrass Association had less than 60 members?

17. When Don Hogan, as one of the early presidents, could name every conference participant and their wives at the annual banquet?

18. Before "Black Layer" was invented? We just called it anaerobic soils, and no one had ever heard of Joe Vargas at that time.

The list could go on and on, but this is enough to remind us of the days past.

WHERE ARE WE NOW?

1. We now have better grasses for everything including the ryegrasses for sports fields, ryegrasses for lawns, better Kentucky bluegrasses for dry areas east of the Cascade Mountains, better bentgrasses for putting greens, but we still have not achieved the goals that we need to attain, which include more drought tolerance, grasses that do well on less fertility and, of course, those that have greater disease resistance.

2. More realistic fertilizer formulas, sources and ratios. We now have a handle on what grasses need for fertilizers on an annual basis and the ratios required for maintaining good turf on pure sand mediums.

3. Sophisticated irrigation systems - those that allow us to apply only the water used and replace as required to prevent excessive overwatering and leaching of nutrients and pesticides.

4. Where E_t is a common word on all turfgrass manager's lips - evapotranspiration must be practiced in order to do a better job of irrigating and managing our irrigation systems.

5. Sand is in common usage - the savior for sports fields. There is no reason why with good management that sports fields today cannot withstand at least 50 football games without destroying the turf on a good sand-based sports field with underdrains.

6. Sophisticated and expensive maintenance equipment. I will leave this to your imagination because you know the equipment that is out there. We essentially have nearly any kind of equipment necessary to perform in job in good turfgrass maintenance.

7. Practical and safe controls for weeds, diseases and insects. The materials we have at hand have low toxicity, slow leaching rates and are safe for the environment with a little judicious use in application.

8. We are being dissected and eviscerated by environmental activists and the ignorant masses. It will take a lot of education on the part of our turf managers to help provide information to this group to help them understand and not be afraid of turfgrasses.

9. We are at a point where costs can double while waiting for necessary permits due to the many roadblocks, injunctions, etc., placed against the construction of new golf courses around the country.

10. We are facing water shortages everywhere and this is affecting the entire industry. A number of maintenance companies were significantly affected financially during the summer of 1992 because there was no green grass to manage. Perhaps the major reason for this problem is that the population has grown and the water companies have not kept up with the demand by increasing storage for water. We do not have a shortage of water. We have an excess in nearly every year, but we do not store it.

11. IPM is the "IN" thing and high time. It is time that we used a good integrated pest management program and not apply a preventative program when the problem does not exist.

12. Black layer has hopefully been put to rest as long as we practice good agronomic management. Black layer is not caused by sulfur, it is caused by poor drainage and excess water in the soil. Sulfur is only the culprit that is reduced under anaerobic conditions and causes the foul, smelly condition in the soil; but if we provide adequate oxygen to the root zone, this condition disappears practically overnight. Therefore, practice good soil drainage.

13. We are at a point in our programs today where everybody is an expert and that is why much of the industry is being criticized and, again, it will take education on our parts to help overcome this.

WHERE ARE WE GOING?

1. We are going mostly in the direction we are now- to avoid excesses under careful application of all of our materials and using minimum quantities to maintain quality turfgrasses.

2. Greater accountability in the use of fertilizers and pesticides.

3. Refining IPM.

4. Geltetic engineering for drought tolerance, disease and insect resistance and other pests.

5. Greater safeguards to prevent soil, water and atmospheric contamination with pesticides and fertilizers (Iysimeters, filters, waste disposal).

6. More restrictive licenses.

TURFGRASS RESEARCH UPDATE: SUMMARY FOR THE 1990 TURFGRASS SURVEY AND BUFFALOGRASS UPDATE FOR 1992[1]

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INTRODUCTION

In the fall of 1990 and the spring and summer of 1991, turfgrass surveys were sent out to 140 golf courses, 180 landscape, lawn care, school districts and parks, as well as 14 sod operations. The surveys were quite lengthy and took 4-5 hours to complete. As a result of lengthiness of the form and limited funds for extensive follow-up, the responses were fewer than expected and data have been tabulated slower. The summary of responses will be broken down into the three major categories of surveys sent. This paper will cover strictly the responses from golf courses, parks and school districts.

Golf Courses

There were 140 golf courses surveyed in this study. Thirtythree responses were returned. Of these courses, 13 were privately owned/members only, 12 were privately owned/open to the public, and 8 were publicly owned golf courses. The average area per golf course was 134.6 acres with 95.1 acres maintained. There were five 9-hole golf courses, 24 18-hole golf courses, three 27-hole courses, and one 36-hole golf course. The average acreage for specific areas on golf courses was 2.9 acres/greens, 2.6 acres/tees, 37.3 acres/ fairways, 44.9 acres/roughs, and two acres of other turf areas. The breakdown in acreage for 9-hole, 18-hole and 27-hole golf courses can be seen in Table 1.

The average rounds of golf played in 1990 were 40,630 rounds, with a breakdown of that being 22,400 rounds for a 9-hole course, 39,242 rounds for an 18-hole course, and 77,333 for a 27-hole golf course. If we broke that down for course types that returned the survey, public courses averaged 60,000 rounds of golf, privately owned clubs/open to the public had 33,317 rounds of golf, and the privately owned/members only course had 35,462 rounds of golf played.

In tabulating the major problems of turf areas on golf courses, the most commonly reported problem was wear and compaction, with diseases ranking a close second. Soil conditions, water drainage and weeds were all important problems, but only half as much as wear and compaction and diseases.

If we compare these turf problems with those reported from school districts and parks, wear and compaction was again the major difficulty reported on those turfed areas.

In looking at irrigation sources for golf courses, 17 of the golf courses had wells, 10 of the golf courses used lakes and streams for irrigation, 7 had municipal sources of water, 5 used reservoirs, and 2 used canals for their water source. This number obviously adds up to more than 33, so there were a number of them that had a combination of wells and municipal or wells and reservoirs or lakes and streams. The type of irrigation system on golf courses was predominantly automatic electric. Twenty-one of the golf courses reported automatic electric, 8 had manual systems (quick coupler valves), 4 had semi-automatic systems, and only 2 had automatic hydraulic systems. The average estimated overall water use for 1990 for the 33 golf courses was 32,790,000 gallons of water per golf course per year. If we break that down into gallons used per size of golf course, we found that the 9-hole golf course used an average of 4,900,000, 18-hole courses used 35,191,176 gallons, and 27-hole golf courses used 48,500,000 gallons of water per year. We can hypothesize from the amount of water used on 9-hole golf courses, that they were mainly using water on greens and tees.

Golf Course Fertilizer and Pesticide Use for 1990

We can discuss the trends which existed for the 33 golf courses that did reply to the survey. Basically, the overall average fertilizer use for golf courses was 179,469 lbs. of nitrogen. The greatest percentage of nitrogen was used on the private courses/open to the public (76,886 lbs. of nitrogen).

The private clubs used an average of 54,794 lbs., and the public courses used 47,790 lbs. of nitrogen. If we compare the total amount of quick release nitrogen used to slow release nitrogen, the average was about 89,500 lbs. each of quick release and slow release nitrogen, or a 1:1 average. We can look at some of the differences in usage between the fertilizer on the different course types and compare the pounds of nitrogen used per ft^2 on the greens, tees, fairways and roughs. Using the overall average acreage on golf courses, the average total lbs. of nitrogen used over all areas was 1. 7 lbs. N/1000 ft^2. To break it down into the actual area where the fertilizer was applied, the average was 6.7 lbs. N/1000 ft^2/yr on greens, 3.8 lbs. N/1000 ft^2/yr on tees, 2.3 lbs. N/1000 ft^2/yr on fairways, and 0.7 lbs. N/1000 ft^2/yr on roughs. The overall use of nitrogen on golf greens averaged a 2:1 ratio of quick release to slow release nitrogen, on tees the use was not quite a 2:1 ratio, and for fairways and roughs, it was approximately a 1:1 ratio of those products (Table 2).

Private member clubs' fertilizer usage was an average of 3.6 lbs. N/1000 ft^2/yr/green, 3 lbs. N/ 1000 ft^2 for tees, 1.9 lbs. of N/1000 ft^2 for fairways, and 0.8 lbs. N/1000 ft^2 for roughs. If we look at the average of quick release to slow release nitrogen, on greens and tees it was a 2:1 ratio and for fairways and roughs, it was a 1:1 ratio.

The average fertilizer use for private clubs/open to the public was 6 lbs . N/ 1000 ft^2 on greens, 3 . 9 lbs . N/ 1000 ft^2 on tees, 2.5 lbs. N/1000 ft^2 on fairways, and 0.8 lbs. N/1000 ft^2 on roughs. Again, comparing the ratio of quick release to slow release nitrogen, we see that it is about 1.5:1 on greens, 1:1 ratio on tees, fairways flip-flop with a 1.5:1 slow release to quick release, and in the roughs, it is approximately a 1:1 ratio of the nitrogen types.

On public golf courses, the average amount of nitrogen per 1000 ft^2 is 12.3 lbs. on greens, 4.9 lbs. on tees, 2.3 lbs. on fairways, and 0.2 lbs. on roughs. The ratio of quick release to slow release nitrogen on greens was a 3:1 ratio, a 2:1 ratio of quick release to slow release nitrogen on tees, a 1.5:1 ratio of slow release to quick release nitrogen on fairways, and approximately equal amounts of quick release and slow release nitrogen used on the roughs.

Comparing the 9-hole, 18-hole, and 27-hole golf courses, we see that the ratios stay much the same as what we looked at for the breakdown of the clubs themselves, with an average of about 6 lbs. of N/1000 ft^2 on greens, 3.9

lbs. N on tees, 1.2 lbs. N on fairways, and 0.6 lbs. on roughs.

Golf Course Pesticide Usage for 1990

The total pesticide usage for 1990 on the 33 golf courses who reported their data is in Table 3 in the text. There were 67,904 lbs. of total pesticides used with 7,667 lbs. of herbicides, 58,291 lbs. of fungicides, and 1,946 lbs. of insecticides. Breaking the pesticide usage for the golf courses in Washington down to course type of private, opened to public and public only, we see that the major usage of products was in fungicides. The private courses used the most fungicides, recording 29,064 lbs. of fungicides, private/opened to public used 17,502 lbs. of fungicides, and the public courses used 11,716 lbs. (Table 4).

Herbicides were the second most-used pesticide. Herbicides were predominantly used on public golf courses with 4,997 lbs. of herbicides used, while the private/opened to public used 2,615 lbs. of herbicides. The major use of insecticides, which was only 3% of the total pesticides used, was on private/opened to public courses where 1,729 lbs. of the product was used.

Parks and School Districts

In this survey there were only 4 parks who returned their surveys for a total area of 2,399 acres. The average acreage was about 600 acres, with 225 of those acres actually being maintained per site. The major turfgrass problems for the park areas were wear and compaction and water drainage, with soil conditions and weeds of lesser importance.

Sixteen school districts responded with an average area of 180.3 acres per district with 103 of those acres being maintained. The total area reported for these school districts was 2,885 acres, with 1,649 of those total acres being maintained. Wear and compaction was the No. 1 problem for school districts with soil conditions also being very serious. Weeds ran a very close third in importance for school districts, with water drainage and diseases much lower in importance. If we break down the acreage of the school districts even further, there were 182 total acres devoted to football fields, 251 acres of soccer fields, 278 acres of baseball or softball fields, and 905 acres of other grass areas they maintained. The average use areas for each school district were 11.4 acres of football fields, 15.7 acres of soccer fields, 17.4 acres of baseball/softball fields, and 56.6 acres of other grass areas (Table 5).

In looking at irrigation sources for parks, three of the parks had municipal water and two of the parks had wells to supply their irrigation water. One park used a combination of municipal water and wells. For the school districts, the irrigation sources were 8 municipal, 5 had wells and 2 used lakes and streams. The irrigation systems for school districts had 14 automatic electric systems, 7 with manual quick coupler valves, 4 with semi-automatic systems, and 2 had automatic hydraulic systems.

The quantity of water used for the parks was an average of 6,740,625 gallons for the total park areas. School districts used an average of 48,334,344 gallons in 1990. Comparing both these areas, we see that for an annual average, parks used 7,506 gallons per acre (gpa) maintained and the school districts used 29,311 gpa for maintained turfgrass areas.

Total fertilizer used for parks and schools was 687,978 lbs., with 165,625 lbs. used for parks and 469,352 lbs. for school sites. The total breakdown of these products into the amount of quick release and slow release nitrogen used is listed in Table 6. As far as ratios of the amount of quick release and slow release nitrogen used in these areas for overall use in both parks and school districts, 73% of the nitrogen used in those areas was slow release. Of the fertilizer used, the parks used 81% slow release nitrogen and school districts used 75% slow release nitrogen sources.

Parks and school districts used 1,453 lbs. of pesticides, including 1,042 lbs. of herbicide, 410 lbs. of fungicide, and only 10 lbs. of insecticides. The major usage of herbicides was in the school districts where they used 818 lbs. for weed control in those schools reporting data. The next major pesticide usage was fungicides used by the school districts, with 410 lbs. of fungicides being reported. On a percentage basis, 71% of all the pesticides used on parks and school districts were herbicides, 27% were fungicides, and 1% of the products used were insecticides.

SUMMARY

Let's summarize the trends evident on the golf course, school district and parks programs. The fertility programs on golf courses showed: 1) an average fertility on golf course greens and tees of a 2:1 ratio quick release to slow release nitrogen used, and 2) fairway and rough fertility programs showed approximately a 1:1 ratio of quick release to slow release nitrogen. Fertility programs for the parks and school districts, showed: 1) an average park used 81% slow release nitrogen in their overall fertility plan, and 2) an average school district used 75% slow release nitrogen in their overall fertility plan.

Trends in pesticide usage on golf courses showed: 1) fungicides were 86% of all pesticides used on golf courses, 2) onehalf of all fungicides were used on private golf courses, 3) herbicides were 11% of pesticides used on golf courses, and 4) insecticides were only 3% of total pesticides used on golf courses.

Trends in pesticide usage for parks and school districts showed: 1) herbicides were 72% of pesticides used in their overall program, 2) only herbicides were used in the park areas, 3) herbicides were 65%, fungicides were 32.5%, and insecticides were 1% of total pesticides used by the school districts.

This is a summary of where the turfgrass survey stands today. We would like to break this survey down into smaller portions and resubmit the survey to turfgrass professionals to try to get a better response for greater accuracy. With only 33 golf courses reporting, this was not enough of a sampling to get good statistical data. It does, however, give us some trends as to what is being done and what is being used on golf courses, parks and school district areas.

1992 Buffalograss Update

I will close with a brief update on the NTEP buffalograss program taking place at Washington State University. The major portion of this program for buffalograss, which is a warm-season, dioeceous turfgrass plant (both male and female), is taking place in the Yakima Area Arboretum. Twenty-two cultivars were planted in June 1991 and grew through a very mild first winter. We are now getting good data from these plots. We have taken 11 of the cultivars and planted them in Pullman in August of 1992, and 7 cultivars were planted in Puyallup at the same time. The 7 cultivars that were brought to Puyallup were the ones responding the best and might survive in Puyallup. With cooler soil temperatures and heavy pressure from annual bluegrass, it is likely they will not do well in Puyallup. Expectations are that they will do far better in the Pullman area.

At the original time of establishment in Yakima, there was a problem with shipping and there was a difference in how the grasses established themselves by how they came out of the shipping. The NTG series did very well in stolon length, with NTG 5 having the longest and most numerous stolon production in July of 1991. Rutgers, Bufflawn, NE 84-609, NE 85-378 and Highlight 4 also did very well. Seven cultivars had good green-up in April of 1992. They were NE 84-315, Sharps, Rutgers, NE 45-3, NE 84-436, NTG 5, and NE 85-378. Those had at least 50% greenup by April 8, with the NE 84-315 having 80% greenup at that point.

We need more data before we make any recommendations on using buffalograss. There are currently three improved cultivars of buffalograss available by seed, but the quantities of seed need to be larger so the cost will come down. I look to see more cultivars available in the near future ('93-'94) and we will continue to update you on how buffalograss might be performing within the State of Washington.

Table 1. Average maintained turf areas on golf courses*.

	Acres				
	Greens	Tees	Fairways	Roughs	Other
Overall average	2.9	2.6	37.3	44.9	2.0
9-hole	1.0	1.0	21.9	24.8	1.4
18-hole	3.1	2.8	36.7	42.4	2.3
27-hole	3.7	3.4	50.7	73.7	0.1

* Average over 33 responses to survey.

Table 2. Average 1990 fertilizer use for 33 Washington golf courses.

	lbs./1000 ft^2				
	Avg.	Greens	Tees	Fairways	Roughs
All fertilizer	9.5	56.6	21.1	11.9	3.9
Nitrogen	1.7	6.7	3.8	2.3	0.7
Quick release	0.8	4.4	2.2	1.0	0.4
Slow release	0.8	2.4	1.6	1.3	0.3
Phosphates	0.5	1.8	1.2	0.7	0.3
Potassium	1.1	4.7	2.5	1.4	0.5

Table 3. Total 1990 pesticide use for 33 golf courses in Washington.

	Total lbs.
Total pesticides	67,904
Herbicides	7,667
Fungicides	58,291
Insecticides	1,946

Table 4. Pesticide use for 1990 on private, private/public and public only golf courses in Washington.*

	Private only	Private/public	Public only
	lbs.		
Herbicides	55	2,615	4,997
Fungicides	29,064	17,502	11,726
Insecticides	199	1,729	18
Total	29,318	21,845	16,741

* Average over 33 responses to survey.

Table 5. School district average turf areas.*

	Avg. area	Total area
	----------- Acres ---------	
Football field	22.4	182.1
Soccer field	15.7	251.0
Baseball or softball field	17.4	278.0
Other grass areas	56.6	905.5

* Averaged over 16 responses to survey.

Table 6. Fertilizer usage in 1990 for parks and school districts.*

	Overall uses	Parks	School districts
	-------------- lbs.	-----------------	
Total fertilizer	687,978	165,626	469,352
Nitrogen	131,619	29,512	86,627
Quick release	35,828	5,629	21,860
Slow release	95,791 (73%)	23,884 (81%)	64,767 (75%)
Phosphates	32,681	6,428	24,693
Potassium	88,581	29,490	54,032
Lime	600	0	600

* Averaged over 20 responses to survey.

Table 7. Average pesticide usage for 1990 parks and school districts.*

	Overall use	Parks	School districts
	-------------- lbs.	-------------	
Herbicides	1,042	224	818
Fungicides	410	0	410
Insecticides	10	0	10
Total pesticides	1,453	224	1,229

* Averaged over 20 responses to survey.

AGRONOMICS OF SAND CONSTRUCTION AND TOPDRESSING[1]

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[1] Presented at the **46th Northwest Turfgrass Conference,** Sunriver Lodge and Resort, Sunriver, Oregon, September 21-24, 1992.
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Sand greens are not new in the inland west, although the oiled type are disappearing rapidly. The environmental agencies fear that the used oil required for their maintenance will contaminate the groundwater supply.

The sand greens referred to in this discussion are <u>not</u> 100% sand and, hopefully, not oiled. They are greens which have evolved through research and experience over a span of almost 40 years. It all began with the boon in golf popularity after World War II when the old soil-based greens became unable to cope with the compactive traffic they received, even though the height of cut was twice as high as many greens today.

Through the intervening years, the use of soil in mixtures has essentially been dropped, even though that means lower nutrient retention. The physical problems brought on by more than about 5% soil in a mix (by volume) were greater than those of low fertility. Nutrient management of these greens is much like hydroponic gardening, even if irrigation programs make proper use of the perched water table to retain moisture in the root zone mixture. It is surprising, though, just how little water is required by well-built Green Section greens under a properly managed irrigation program.

The basic idea for this construction method is illustrated by the time-lapse movie produced by Dr. Walter H. Gardner at Washington State University. Soil or Sand overlaying a coarser material will hold water until its weight and the force of gravity overcome the capillary tension. When that occurs, water will readily flow into and through the coarser material. This flushing feature is especially helpful in areas with poor water quality.

The movement of drainage water out of the root zone mixture has another valuable effect - it pulls air in as it moves downward. We have accepted as fact the bad effects of soil compaction and waterlogged soils. Maybe we forget why they are bad. Both conditions restrict the amount of oxygen in the soil, and without adequate oxygen, roots cease to function and/or they die. But if this be true, how can bentgrass survive while growing in nothing but water? Because the water is well-aerated. It contains a sufficient amount of oxygen which can be extracted by plant roots. The cooler the water, the more air it can retain. That is one explanation for poor turf quality in saturated greens during hot weather. The plants will be suffocating, besides their other ills associated with hot, wet soil. The same fate awaits beneficial microorganisms such as those involved in the decomposition of thatch, nutrient cycling, etc.

When sands having a uniform particle size are used in a growing medium, the spaces between them contain either water or air. Small spaces, the capillary pores, retain water. Larger, non-capillary pores do not and are the drainage-ways. The finer the sand, the more capillary pores and the slower the drainage. Coarse sand means more large pores and better drainage but less water retention. Green construction sand is in the middle, with a large percentage between 0.25 and 0.50 mm - about the size of common table salt.

The perched water table is the primary water-retention factor in this construction method. Capillary pores provide the moisture for roots, from the supply held above the drainage bed. If the root zone layer is too deep, the surface will be droughty. If it is too shallow, it will be too wet. This means that the total moisture supply for the root system is a combination of both root zone depth and particle size. The final topography of the green surface must be decided when the drainage bed is laid down. Any changes made after that will affect the depth of the top mix and that, in turn, will affect the drainage/water retention in the root zone. All factors must be balanced for optimum performance.

Grains of a sand having a wide range of particle sizes tend to nestle with each other, with smaller particles filling the space between coarser grains. This creates a very firm surface, more suitable for bunkers. Construction grade sands with uniform particle size are more like B-B's in a bean bag. The playing surfaces can be firm but have the capability of movement when subjected to the impact of a ball (or a club, after a missed putt).

It is highly desirable that these greens be topdressed with the same material with which they were built. Sometimes that can create problems. The forced growth after planting to bring them into play as soon as possible - produces a large amount of organic matter in a short time. When the organic matter in the construction mix is added to that, we no longer have a uniform profile, but one which retains a great deal of water near the surface. A worse case condition is Black Layer in the top inch or two, simply because there is not enough oxygen in the layer. Water has filled most of the air space, and the small amount that is present is used up in the microbiological decomposition of organic matter, root growth, etc.

This indicates to me that the organic matter should be omitted from topdressing as soon as strong stolon growth has covered the surface. By that time, organic matter is being added by daily plant growth. The developing "cushion" of turf should be a blend of sand and new growth which will not become a sponge that holds too much water. This is the time to begin a topdressing program which matches the rate of plant growth.

A second problem with topdressing materials is based on the sand used in construction. The bentgrass greens for today's golfers are expected to have dense, fine textured playing surfaces. But if the construction mix contains any appreciable amount of coarse particles, they will remain on the surface to bedevil golfers and the mechanics who have to keep the mowers sharp. Any sand grains over 1 mm are sure to remain on the surface, and those larger than 3/4 mm are likely to do the same. So here we are again, back to the half-millimeter size as an upper limit, but remembering that finer and very fine sands help retain water.

Most architects, contractors or owners don't care about these "little things," but a thinking superintendent has to be concerned about the environment at the green surface forevermore. This should be an incentive to obtain the best quality materials obtainable for construction. The one-time cost may be higher, but high maintenance costs go on forever.

Sometimes there are no options, so a different topdressing material may be necessary soon after construction. That requires the same procedures followed when old mud greens are put under a sand topdressing program, involving intensive aeration once or twice, so that cores of the material below can be blended with topdressing to form a sort of transition zone between the two. That helps to mitigate a sharp textural change and minimize problems with stratification.

The potential movement of nutrients and pesticides out of sand-based greens have been "viewed with alarm" by some people, but they also perceive constant overwatering. Superintendents must learn how to irrigate these greens to keep a supply of moisture in the foot-deep reservoir without overdoing it. It is also noteworthy that soilless greens have little or no capacity to retain phosphorus, so the basic fertility program should include this nutrient - perhaps in a ratio of 4-1-4.

Sand construction and maintenance techniques are firmly based on scientific knowledge and proven on thousands of golf greens (and athletic fields) world wide. Once the basic principles are understood, the procedures are simple and, actually, just common sense.

THE IMPORTANCE OF A HAZARD TREE SURVEY[1]

Mr. William L. Owen[2]

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[1] Presented at the **46th Northwest Turfgrass Conference,** Sunriver Lodge and Resort, Sunriver, Oregon, September 21-24, 1992.
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Good morning. It is a pleasure to be here to speak to you today on a most important subject. Please take note: the topic here today is not "How to Identify Hazard Trees", but rather, "The Importance of a Hazard Tree Survey." The distinction is made because the majority of you, Judging from the show of hands taken earlier, are in some way responsible for a campus, or other tree population which includes mature trees of various kinds, the care of which, either directly or indirectly, is your responsibility.

First let me tell you a few stories:

• *A man and his wife are bicycle riding in a park which has paved pathways for that purpose. It is a mildly breezy, sunny day, perfect for bike riding. They are riding in a nature park setting which is filled with untended natural trees and understory growth, all of which form a part of the park's natural beauty. The young man is in the lead. He suddenly hears a "cracking" noise, looks around, and sees a major tree starting to fall. In alarm he quickly hollers to his wife, some 20-30 feet behind him, to "look out." She looks up and sees the tree falling, swerves to her left, but not in time. The tree lands on top of her, killing her instantly. The tree had a major hazardous defect.*

• *A young mother is driving down a state highway in heavy rain, late in the afternoon at dusk, a strong west southwest wind gusting against the car on the driver's side as she heads north on the roadway. Three of her children are in the back seat of the small four door sedan. Her other child is in the front seat with her. The noise of the wind and rain blocklng any warning sound, a major Fir tree falls from the left side of the roadway, across the opposite lane from her vehicle, and lands on top of the car, just behind the front seat. The three children in the back seat are killed instantly. The woman and her remaining child are injured, but survive. The tree had a major, hazardous defect.*

• In a major city in the springtime, a citizen is walking along the sidewalk next to a major park which has mature Elm trees and other species growing in profusion. With no warning, a major tree falls from the park across a city street and lands on the woman, killing her instantly. The tree had a major, hazardous defect.

• A major cottonwood tree is in dispute in a small town with citizens who oppose its removal for a homesite development project. The tree is examined and determined to be hazardous and ordered removed. It is removed, but the citizens of the area are after the scalp of the person in the municipality who ordered its removal on the basis of safety. They think it was safe. It is determined on post mortem examination (by yours truly) that while the stem of the tree was basically sound, as was its base, it was replete in its superstructure (crown) with major decay areas, any one of which could have failed without warning and dropped a limb of hundreds of pounds (or much more) of weight on anyone or anything underneath. In this instance, no tragedy occurred. The possibility was averted by removal. The tree had major, hazardous defects.

The stories I have just told you are chilling, to say the least. I personally saw the grim evidence of the two fatalities, one where the bicycle was crushed and bloodstains were still evident, and another through photographs which I cannot forget. The third fatality I read about in the newspaper. In each of these instances, major trees failed. They were hazard trees. The definition of a hazard tree I will get to shortly. The point is, they were hazard trees but the hazards were not discovered in time. *They could have been!*

In situations such as those cited, the question I am asked as a Consultant in Arboriculture by the attorneys is always the same: "Could the defect which caused the tree to fail have been detected under normal and reasonable maintenance by a qualified professional arborist." In other words, if someone who knew trees and how they grow and develop, react to injury, etc. had been routinely inspecting those trees, would the trees have been left in a hazardous condition, set up, in a sense, for the tragedies that occurred? In the first instance the major tree was rotted out at its base, a rot which could have been discovered on examination by a qualified professional (but not by someone on the staff simply "assigned to watch over the landscape and the trees"). A mildly breezy day in the summertime, yet the tree fell down. Why? It had reached a critical point in its development. The weight mass in the crown in a slightly leaning stem suddenly over-balanced, and what had been critical for months, or even years, prior to that time suddenly failed.

In the other instance, where the Fir tree landed on the car, many years before, the tree had been topped and grown two new tops from major limbs as Conifers do typically, on either side of where the tree had been topped. Either a storm had broken out the top or someone had topped the tree. The point is that in that instance, any competent professional arborist inspecting the tree would have been suspicious of the new stem-branch unions which occurred at the old top cut and their relationship to the rot that developed at the topping which is almost inevitable. Such rot proceeds down the stem, eventually weakening the stem, causing failure when the new top is blown heavily in a high wind situation.

The large Elm tree incident was similar in nature to the first two. Thankfully, the Cottonwood tree hazard was removed before tragedy could strike.

All the proceeding leads me to the major point I want to make with you today: *If you are responsible for major trees you should request a hazard tree survey at the earliest possible moment. If you do not, you are a fool!* Believe me when I tell you, if a tree fails while it is under your jurisdiction, even though you are an employee for a city or institution or a college campus or whatever other kind of installation which may have a major tree campus, or even one tree for that matter, you can be held liable for negligence along with the institution if tragedy strikes. That is the way it works today. Anyone is fair game to be sued if that person officially has had any kind of influence on tree-management-preventing accidents such as I have described. The good news is that *hazard trees can be found and identified with preclusive safety and maintenance recommendations made by a competent professional retained to do the hazard tree survey!* But, it must be ordered. Action must be taken.

I cannot emphasize too much how many tree situations, large and small, I see regularly which are replete with major flaws in many trees which easily could result in tree failure, which can have calamitous results. It is bad enough if property is destroyed. It is tragic if lives are destroyed. Quite often both result. The protection of life and property are compelling reasons to have a survey done, let alone the matter of liability which can't be ignored.

So what is a hazard tree? While as I have said that is not the purpose of this talk today, a few major points regarding hazard trees should be made. Let me first give you a simple definition: *"A tree is considered potentially hazardous, at least, if it is situated in an area or a place which is frequented by people or is adjacent to buildings or other property, and has defects in roots, stem, or branches that may cause a failure resulting in property damage, personal injury, or death. The degree of hazard will vary with size of the tree, location and the type of defect in the tree, the species of the tree and the nature of the target.*" The key here is ***target***. Any tree can be hazardous in the sense that it has defects. But if there is no target, in other words, no property or situation which draws people into its target range if part or all of it fails, then it is not technically considered hazardous. To put it another way: In the forest where no one is supposed to be normally, there are no targets and thus no hazard trees, in a technical sense.

Time constraints today do not allow me to elaborate further, but I would be happy to take questions at the conclusion of the talk for those who may want to stay.

To close, then, let me summarize briefly:

1. If you are in any way in charge of or responsible for mature trees, or trees of any size which could do harm to persons or property if they were to fail in any part or fall down in the location in which you find them, you should request a hazard tree survey immediately, one which includes specific recommendations to eliminate the hazard. If you are not in a position of authority which allows for you to do this unilaterally, then you should put in writing a request to do so to your superior. This at least will show a responsible attitude on your part.

2. If you order a hazard tree survey, be sure you get a qualified, thoroughly competent professional with credentials which are impeccable and have been checked thoroughly to do the survey. Be sure that it is keyed to a map and a plot plan showing tree locations and giving the description and condition of each of the trees.

3. If you have done what I am recommending, and acted upon the recommendations made in the survey, and still a calamity does occur and there is personal injury, harm to property, or even a fatality, you and the powers that be may still very well be sued, but at least it would be extremely different to

show gross negligence or careless disregard for the safety of life and property in such a situation.

I urge you to consider carefully what you have heard from me here today. If you do what I am recommending, you will be demonstrating that you are a professional person in the landscape maintenance field having recognized the potential hazards which can exist in the beautiful trees we all love.

Thank you very much for your kind attention.

COMBINING THE USE OF TURF COVERS AND PLANT GROWTH REGULATORS[1]

Dr. William J. Johnston/Mr. Charles T. Golob[2]

[1] Presented at the **46th Northwest Turfgrass Conference,** Sunriver Lodge and Resort, Sunriver, Oregon, September 21-24, 1992.

[2] Assistant Professor and Research Technician III, respectively, Department of Crop and Soil Sciences, Washington State University, Pullman, Washington.

INTRODUCTION

In the Pacific Northwest, the three primary causes of winter injury to turfgrass are desiccation, low temperature kill, and winter diseases. This research report deals with mitigating the effects of desiccation injury on a bentgrass/annual bluegrass putting green. Readers are referred to previous NTA Proceedings for results from research on pure bentgrass research plots (Poitras et al., 1988; Golob and Johnston, 1989).

Winter desiccation can be particularly sever on annual bluegrass or bentgrass/annual bluegrass greens on exposed sites with frozen soil during windy, low humidity conditions. Protective turf covers have been used to prevent winter desiccation of turfgrass. A major problem associated with the use of turf covers is the occurrence of excessive plant growth that occurs under turf covers as the weather warms in the spring. The cover often must be removed, the turfgrass mowed, and the cover reinstalled. This is a very labor intensive and costly process.

OBJECTIVE

Our research objective was to evaluate a turf cover in combination with plant growth regulators (PGRs) to suppress excessive early spring plant growth while maintaining good turfgrass quality on a mixed bentgrass/annual bluegrass putting green.

MATERIALS AND METHODS

In early December, 1989 and 1990, PGRs flurprimidol, mefluidide, and paclobutrazol were applied to a bentgrass/annual bluegrass (approximately 40% bentgrass) practice putting green at the Washington State University Golf Course at Pullman, WA prior to the installation of a 'Reemay' turf cover (Table 1). The green was also treated for snow mold with a preventative fungicide treatment prior to cover placement. Individual plots were 5 by 12 ft. and there were four replications in a randomized complete-block experimental design. The turf cover was removed March 16 or April 6 in 1990 and 1991, respectively. Several parameters were evaluated; however, only turfgrass quality and clipping dry weight will be reported.

RESULTS AND DISCUSSION

Fig. 1, a graph of the temperature difference between covered and uncovered plots, shows that the daily temperatures under the cover in the early spring (early March) were consistently warmer than those in the uncovered plots. Surface temperature under the cover was as much as 5.5°C warmer than the uncovered area. Soil temperature (1 to 3 inches) were 2 to 4°C warmer under the cover over a 24-hour period. Warmer surface and soil temperatures during early spring would promote early, vigorous plant growth.

At the time of cover removal (March 16, 1990), all treatments showed reduced growth compared to the covered check (Table 2, Note: data for both clipping dry weight and turfgrass quality were similar for 1990 and 1991 so all data will not be presented for both years). Growth suppression would be the desired effect at the time of cover removal; however, a resumption of normal growth would be desired as traffic increased on the turf later in the spring. Approximately one month after cover removal, the low rate of all growth regulators and the high rate of mefluidide showed turfgrass growth similar to the uncovered check (Table 2).

A common phenomena observed by many turfgrass managers when using turf covers is the decline in turfgrass quality noted shortly after covers are removed (Fig. 2). Much of the decline in quality is due to mowing off of the excessive, succulent growth that occurs under turf covers. The commonly observed decline in turfgrass quality can be seen when comparing the quality of covered and uncovered check plots in this study (Fig. 3). The covered plots decline in quality and the uncovered plots rapidly increase in quality. However, when using the low rate of flurprimidol, mefluidide, or paclobutrazol turfgrass quality was initially good and a high level of turfgrass quality was maintained for more than one month following cover removal (Fig. 4). Caution must be used with this procedure because a 2x rate can cause reduced turfgrass quality (Fig. 5).

CONCLUSIONS

Results of this research indicate that the PGRs flurprimidol (0.5 Ib a.i./A), mefluidide (0.125 Ib a.i./A), and paclobutrazol (0.5 Ib a.i./A) would successfully suppress turfgrass early spring growth under a protective turf cover while maintaining a good level of turfgrass quality for more than a month following cover removal on a bentgrass/annual bluegrass green.

ACKNOWLEDGMENT

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Table 1. Plant growth regulators and rates.

	lbs. a.i./A	
Flurprimidol	0.5	1.0
Mefluidide	0.125	0.375
Paclobutrazol	0.5	1.0

Table 2. Clipping dry weight as percent of covered check on a bentgrass/annual bluegrass green at the WSUGC.

Treatment	Date		
	3/16/90	3/30/90	4/13/90
Uncovered Check	50 cd	90 a	107 ab
Covered Check	100 a	100 a	100 abc
Flurprimidol 0.5	51 cd	65 bc	109 ab
Flurprimidol 1.0	39 d	48 d	81 c
Mefluidide 0.125	52 cd	74 b	110 b
Mefluidide 0.375	49 d	56 cd	93 bc
Paclobutrazol 0.5	63 bc	74 b	102 abc
Paclobutrazol 1.0	66 b	73 b	87 c

Fig. 1. Increased Temperature During Early Spring Under Turf Cover

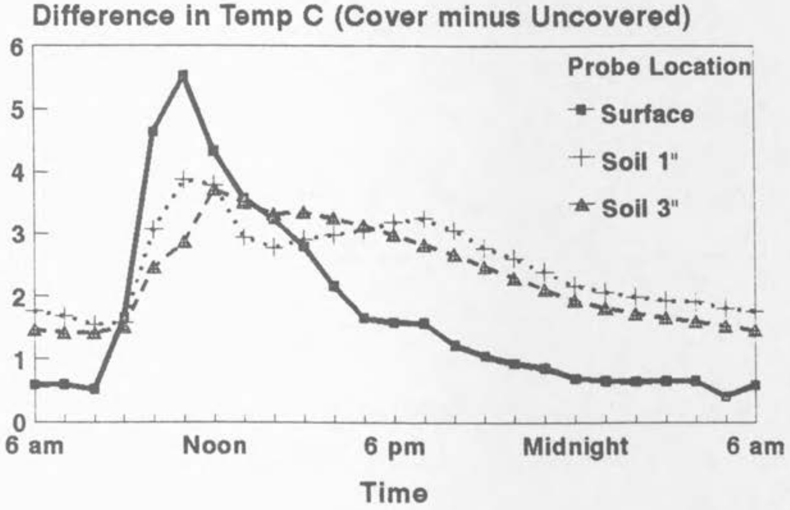


Fig. 2. Generally Observed Turfgrass Quality After Cover Removal

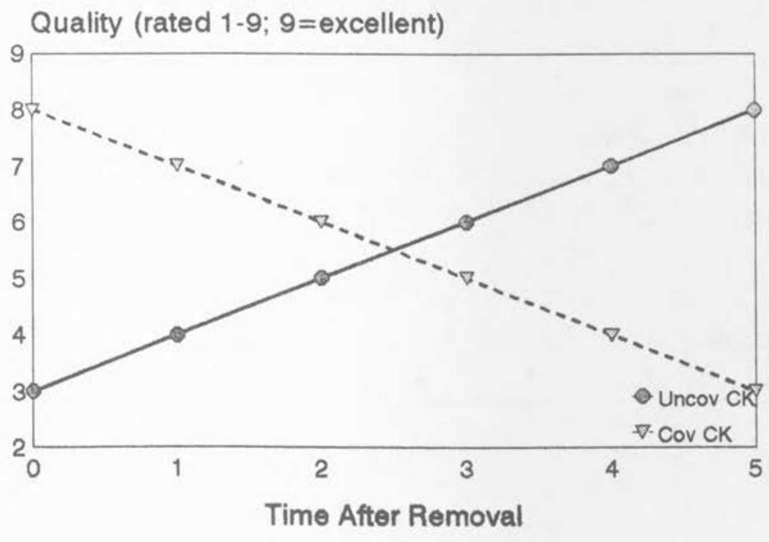


Fig. 3 Turfgrass Quality of Covered and Uncovered Check Plots After Cover Removal

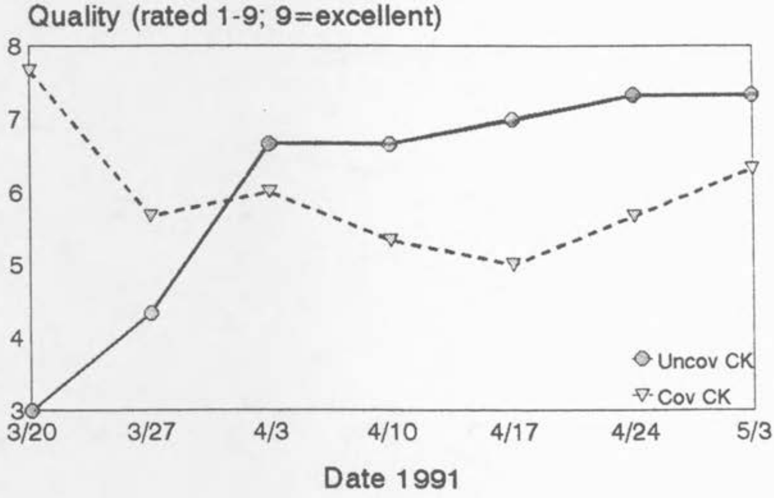


Fig. 4. Turfgrass Quality of Low PGR Rates with Turf Cover Compared to the Uncovered Check After Cover Removal

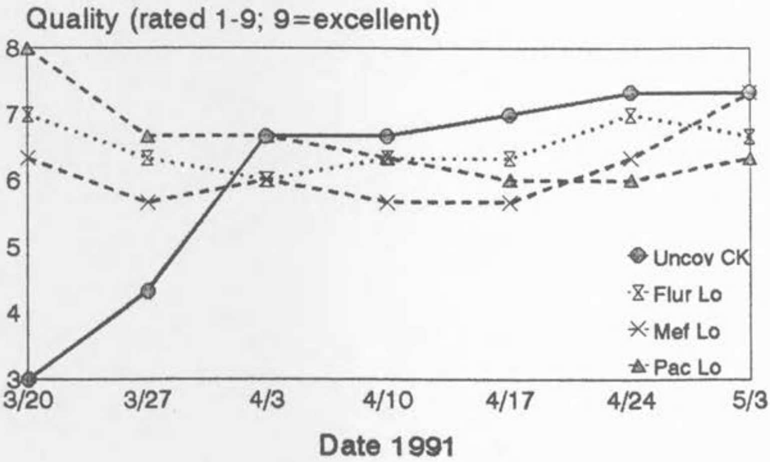
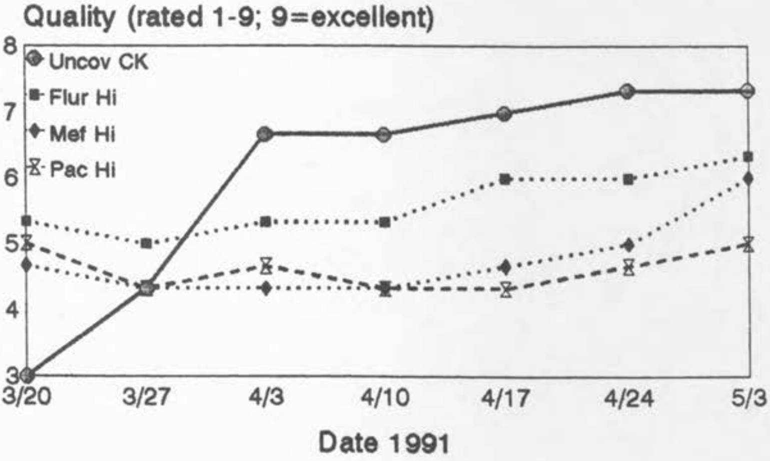


Fig. 5. Turfgrass Quality of High PGR Rates with Turf Cover Compared to the Uncovered Check After Cover Removal



DEALING WITH LOCALIZED DRY SPOTS[1]

Mr. Thomas W. Cook[2]

[1] Presented at the **46th Northwest Turfgrass Conference,** Sunriver Lodge and Resort, Sunriver, Oregon, September 21-24, 1992.

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Anyone who has ever tried to grow turf on sand or sandy soils knows the phenomena of localized dry spots. Nothing is more frustrating than nursing your turf through the heat of summer while battling these hydrophobic areas. What is confusing is that all the water in the world doesn't seem to help once these patches show up. There are many in-depth papers that cover various aspects of hydrophobic soils. My goal here is to try to summarize what we think we know at this point and specifically to prioritize some of the leading causes. At that point I'll offer some of the common control strategies.

Localized dry spots are areas of turf that seem to dry out even though they are irrigated regularly. When you cut plugs from these dry areas the soil just beneath the surface appears to be powder dry. Two inches away the soil may be moist and crumbly. Just as a dry sponge resists wetting, these patches simply will not absorb water. The pattern of patches is often irregular and large areas rarely are uniformly affected.

Symptoms tend to be most common on sand based turf but are often found on heavy soils including clay loams. If conditions are right localized dry spots can be found on any grass and nearly any soil. Symptoms may persist through fall and winter but turf damage is most severe when turf water use is high, such as during summer.

Understanding localized dry spots is harder than it might seem. A look at some of the apparent causes will illustrate this point. The most appealing explanation for localized dry spots tells us that soil particles (sand in most cases) become coated with fungal mycelium or some other type of waxy organic coating that leaves the soil hydrophobic (1,2,3,5). Wilkinson and Miller (5) produced some excellent electron micrographs illustrating just what these coatings look like. York and Baldwin (6) in an excellent review of dry patch feel that while fungal coatings are often associated with hydrophobic soils there is no direct link between microbes and the production of water repellant substances. While fungal coatings may be involved this could also be a matter of "guilt by association" rather than cause and effect.

Other explanations have to be considered since not all apparently hydrophobic soils have mycelial or wax coatings around soil particles. Poor irrigation coverage leads directly to localized dry spots. Consider the scenario of a putting green irrigated with four sprinklers placed around the perimeter. Due to the shape of the green, spacing of heads is irregular. Near the center of the green dry spots begin to develop in summer just when water use rates are highest. These dry spots have probably developed because of poor irrigation uniformity and may or may not be associated with the fungal coatings mentioned earlier.

Another common irrigation problem is related to the way we design irrigation systems and fit them around our "new age" putting greens. Irrigation systems are designed on paper (or computer screens) and distances between heads are measured in linear fashion. If the goal is head to head coverage and we achieve that with 65 ft. spacing in a triangular pattern the green should get reasonably uniform application of water. This would probably be true if greens were flat or mounds were modest in size. Unfortunately greens are rarely flat anymore and mounds have become so severe we can't keep lawnmowers on them from sliding off. The result is dry spots at the top of mounds and wherever severe elevation changes occur. In both cases we have multiple problems including increased runoff, reduced infiltration, effectively reduced precipitation rates, and excessive drainage of water that gets into the profile.

Even on relatively flat sandbase greens, tees, or sportsfields dry spots are common when irrigation lags behind water use during the transition from spring to summer. Because sandbased rootzones have poor water retention, drought stress in the form of dry spots can show up very quickly after turf water use rates increase with warmer weather.

As turf matures thatch generally develops. As thatch depth increases rooting depth decreases and a higher proportion of roots develop in the thatch. If thatch dries out because we are slow to start irrigation in spring or because of poor coverage, hydrophobic spots often develop. To complicate this, superficial fairy ring or other fungi may develop in the thatch layer and surface soil and also cause hydrophobic conditions.

On compacted heavy textured soils or any other soil prone to compaction, dry spots are common problems. Once soil is compacted water infiltration rates decline. Even with good coverage less water per irrigation actually moves into the soil and more runs off to adjacent areas. As time passes these areas may dry out completely and become not only compacted but hydrophobic as well.

The combination of sand profiles, heavy thatch forming grasses, slopes and mounds, and poor irrigation patterns add up to a turf manager's worse nightmare. I've been told more than once that dry spot problems can't be solved and there may be some cases where that is true. Fortunately on most sites we can manage around dry spots and produce functional turf.

From my perspective the first step in solving dry spots is to carefully evaluate the cause of the problem. My guess (based on field observations) is that most of our dry spot problems are related to poor irrigation coverage, severe slopes, thatch, compacted soils, or some combination of these. Adapting cultural practices to solve these problems may involve adjusting sprinkler placement, changing frequency and duration of application and soak cycles, starting irrigation earlier in the year, increasing dethatching efforts, and/or hand watering mounds and severe grade changes. Localized coring will enhance water infiltration in the short term but may be required repeatedly.

Wetting agents play an important role in alleviating dry spots but they are only part of the solution. The most common recommendation for treating hydrophobic areas includes early and consistent irrigation, frequent coring, and repeated applications of non-ionic wetting agents. The goal is to maintain a moist profile early on in the year and never have to deal with rewetting spots once they have dried out.

Remember that wetting agents' only real function is to reduce the surface tension of water. This in effect increases waters' affinity for other surfaces, including hydrophobic surfaces associated with some localized dry spots. Non-ionic surfactants are used for turf primarily because they are less apt to be phytotoxic than anionic types and are not adsorbed on clay or organic matter colloids. Commercial non-ionic products are nearly all blends of ethers, alcohols, and/or esters (4).

Selecting wetting agents is largely guesswork. According to manufacturer's literature each company has the best product. All you can do is try different products until you find one you are happy with and can afford to apply repeatedly. Most people who have used wetting agents have their favorites. Unfortunately it's hard to evaluate the effectiveness of wetting agents in the field. Other than eliminating dew there are rarely any dramatic visual responses.

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