James B Beard

Proceedings Of The 38th Northwest Turfgrass Conference

Sept. 17 - Sept. 20, 1984

Sheraton Hotel

Spokane, Washington

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PRESIDENT'S MESSAGE

Ray McElhoe

As my term as president of the Northwest Turfgrass Association comes to a close, I would like to thank all the members of the NTA for carrying on the tradition of a great conference.

The split sessions worked out well this year and the program was one of the best we have had. Many good comments were heard concerning the suppliers exhibition night. All in all, the conference was very well attended.

These kinds of conferences, however, don't just happen. A lot of planning and hard work goes into the making of a conference. But, that's not enough! We need the input from the membership. You can make the difference between a fair or good conference.

You must give your time and input if you want a good conference. You need to speak up and let the board know what speakers you would like to hear and the subjects or problems you want to learn about. Make it a personal challenge to get involved!

In closing, I would like to thank everyone who helped make the Spokane Conference a success—from you the membership, and also the board of directors. I hope that everyone will support Gary Sayre and his board in the same manner they supported me in 1984.

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THE POLITICS OF PESTICIDES[1]

David Dietz[2]

[1] Presented at the 38th Northwest Turfgrass Conference, Sheraton Hotel, Spokane, WA, September 18-20, 1984.
[2] State Director, Oregonians for Food and Shelter, Salem, OR.

The politics of pesticides is a rather humorless topic, as I am sure most of you know. I have always been told that when you start an address or make a speech you should have some kind of humor, if for no other reason than you at least get your audience to listen to you for two minutes during any presentation.

For those of you who may be members of the Audubon Society of members of the Sierra Club, I will, in advance, make my apologies for the joke I am about to tell. It is not really meant as a put down if you happen to be a member of one of those esteemed groups, but I think it is indicative of what we face today. The only endangered species on the face of the earth today are those of you who happen to use synthetic chemicals to try to benefit mankind.

Now, the joke goes something like this. It seems that two Martians landed outside a small U.S. desert town (not too awfully far from here, if you want to know the truth), and the Martians descended from their spacecraft and walked into this town and the first thing they ran into was a deserted gas station. Here are the gas pumps all sitting in a row, and one of the Martians mistook one of the gas pumps to be a human being and, interestingly enough, one of the Martian's name was Sierra Club and the other was named Audubon Society.

Sierra walked up to the gas pump and he said, "I am here from Mars and I am here to make sure we do not have an inter-galactic space war. It is imperative that we have peace throughout the galaxy. Take me to your leader . . ." and he went on for about five minutes. Of course, he got no answer from the gas pump whatsoever. He turned around to Audubon and he said, "You know, Audubon, that is the most uncommunicative human being I have ever met in my life. I am going to blast that turkey." Audubon looked at Sierra and he said, "You know, Sierra, I just don't think I would do that. That guy looks kind of mean. I would hold off on that if I were you and I would try talking to him again." Sierra shurgged his shoulders, walked back to the gas pump, went through his speech again for five more minutes and got nothing in response from the gas pump, turned back to Audubon and said, "That's it! I have had it!". So he pulled out his ray gun and shot the gas pump.

The gas station erupted in an explosion and the Martians were hurdled for 100 yards into the air. They came to rest in a vacant lot. Sierra shook his head and said, "You know, Audubon, you said there was something about that guy that made you nervous, you told me to be cautious. What on earth gave you that hint." Audubon shook himself off and said, "You know, Sierra, any guy with arms that long and hands that big that goes by the name Ethyl has got to be one tough son-of-a-bitch!"

In a sense, I guess you can call us Ethyl because part of what we try to do with Oregonians for Food and Shelter and part of what I want to introduce you to (and there will be brochures on this group, the Pesticide Public Policy Foundation, at the back of the room today, and the brochure is called simply "A Pesticide Short Story") is designed to get a common sense reassertion among ourselves, in the public's mind and in the minds of the decision-makers that rule our livelihood that a new pesticide perspective is absolutely necessary.

Those of you who work with pesticides probably understand what I am about to tell you as well as anyone in the world. We have lost the benefit perspective when it comes to pesticides. Today, in this country, and in other nations around the world, our perspective is entirely risk-oriented. We no longer have a balance in the mind's eye of the media, nor in the mind's eye of the public as a whole, when it comes to talking about pesticides.

We talk, instead, about the risk to man, the risk to the environment and the risk to wildlife that is wrought by the very use of the modern tools that have brought us production and health protection miracles. And, until that risk perspective is reasserted in a balance, folks, we are going to lose the very tools that we depend on today to produce quality food, economical fiber and the good health of this nation.

You know, it is absolutely amazing to me that we can ban the use of an EDB and restrict its contamination in ready-to-eat products to 30 ppb, when at the same time we allow aflotoxin, which is a mold in peanut butter, to be present to the tune of 15 ppb knowing full well that aflotoxin has 1,000 times the carcinogenic potential of EDB.

That is the consistency and logic of our federal government. That is the consistency and logic of the states in this nation and until that consistency and logic is changed from a perception of truth to fact, we will continue to lose the very tools that have brought us the finest standard of living that the world has ever known.

If you listen to the chemagogues, and that is what we talk in terms of when we talk about those that are radically anti-pesticide, (if you look up the definition of demagogue and substitute "chem" for "dem", you will understand what I mean) you would be led to believe that people are dropping left and right, dying from pesticide exposure, of cancers, dying because of birth defects, dying because our population's health is immediately threatened. We are told that pesticide uses are creating more spontaneous abortions and dooming our future generations from mutations. That is what you would be led to believe if you were a member of the public reading the newspaper articles or seeing the TV shows that you or I are exposed to.

The truth is something else. The truth is that life expectancy in these United States continues to increase. The truth is there is no cancer epidemic (all cancer rates, except for lung cancer, are in decline or stable in the United States of America) and that is based on 50 years of data. But the fact is that we have to deal with public perception, because perception is truth. It is what the public perceives that we must come to grips with. And, what the public perceives is that you and I are out poisoning America today. We know that is not true, we know that is not fact. But God bless the poor public, they don't have a chance to know otherwise.

Two and a half years ago, I made a presentation before the Second Annual Symposium on Dioxin. It was a symposium composed of the world's foremost experts with that particular chemical. It was held in Washington, DC. I got up and I gave a speech and I said, "Folks, if you don't get off your rear ends and start telling people the truth, you are going to condemn the public to an emotional, fear-wrought paranoia and hysteria about their exposure to various chemicals in the United States of America and around the world."

I nearly got skewered by some in the audience because those scientists said, "That is not our task." So now we watch moon-suited EPA'ers in Times Beach, Missouri and the impression left with the public is not what's justified: That what we deal with is so very dangerous that you have to be dressed up like you are going into outer space if, in fact, you want to expose yourself to the chemicals we use. And, dioxins get linked to pesticides. It is that simple.

Folks, the public doesn't remember anymore what you people do for us. They have forgotten the diseases you control, they have forgotten that you bring us food that is safe to eat, they have forgotten that you are the people that allow restaurants to meet sanitary codes, they have forgotten that we can walk into a doctor's office or a hospital and not be fearful of walking out with a secondary infection because hospitals and doctors have learned to use pesticides wisely to prevent disease.

Those are the things we need to talk to people about. We need to remind the homeowner that the headlice breakout in their school is prevented by pesticides. We need to remind the regular folks that the reason they enjoy their environment, in their home and in their yard, is because they have pesticides available to control the very things that we rebel against. And, until we do that, our tools are going to be taken away.

Now, if you don't think that's happening, please give it another thought. Congress is considering Harpers Ferry. If you have never heard of it, John Brown knows about it, but our Harpers Ferry Bill, HB 3818, will so radically change the registration and re-registration of pesticides that no manufacturer, none, would be able to meet the new registration requirements. Not one! The language of that bill says that to register a pesticide, we have to do behavioral testing.

I debated the author of that bill down in Texas a few months ago. I looked at Tom and I said, "Tom, what in the world is behavioral testing? Does that mean if we have got mental impairments or education impairments or a mental slowness or a speaking disability, that these are the behavioral effects we have got to test?" He said something to the effect that, "that sounds good to me!"

The point is they have written language into a bill that is so vague that no one knows what it means. But we do know it can and will be used to tieup the system forever. That will be the end of pesticides.

There are 80,000 municipalities in the United States. Local government wants to get into the act of registering and controlling the use of pesticides. Name one manufacturer of our chemical tools that will try to meet 80,000 different registration dictates. But, it is happening in Montgomery, Maryland; Surfside, Florida; Wauconda, Illinois; Clatsop County, Oregon; Mendocino County, California (they are before the Supreme Court right now trying to decide the question of who has regulatory authority).

The courts of this country, woe be to them, are also being faced with the question, "What can we do with pesticides?"

I regard this question as my profession's Full Employment Act of 1984, because the fact of the matter is that you can sue and sue and sue on pesticides and never exhaust the legal possibilities you have. Last Thursday in a federal district court in the State of Oregon, all herbicides were banned from further use by the United States Forest Service and the Bureau of Land Management in the States of Oregon and Washington. Every use was banned from roadside vegetation management to progeny sites to test sites. Every use! Noxious weed control, specifically, said the court, will be prohibited until a worst case analysis is done by the federal government under the National Environmental Policy Act.

Do you know what the worst case analysis has to be? When it comes to the chemical 2,4-D, not a proven carcinogen, you must assume it is a carcinogen and then extrapolate the number of cancers that will be created in the United States by the use of 2,4-D before we can go ahead and use that chemical.

That's illogical in the extreme, but that's what the courts of this country have now told us we must do. That is why you are an endangered species. The politics of pesticides is coming at us like a ton of bricks and unless we figure out how to put mortar to the bricks to build our own wall, or figure out a way to get out of the way, we are going to lose the tools that we have to have to maintain this country's liveability.

Pesticides are not endangering this nation. They are the environmental promotion, health protection and food and fiber production tools that are absolutely essential to the health and well-being of this country and to the people of this country, and that is the story we have got to start telling.

I am sick and tired of politicians using the pesticide issue to fearfully make their constituents react so they can buy votes through fear. It has got to end.

The way to end the illogic is to turn it around and talk in terms that are as vigorous and as emotional and as vibrant as the terms that are now being used against us. Because the fact is, we will lose our ability to use pesticides unless we go forward, hard, with our message. That is part of what we try to do with Oregonians for Food and Shelter. It is what we have started to do with the Pesticide Public Policy Foundation which is an interesting creature, because 3PF (the Pesticide Public Policy Foundation) was created by the arbor, lawn care and landscape industries.

The reason they wanted a national network among all of us is very simple. They are the urban environmentalists, they are the people who keep the acres of trees available to eat five to six tons of carbon dioxide a year and produce four tons of oxygen. They are the people who add 20% to the value of homes. They are the people who give us an aesthetic balance that you and I demand and must have if we are to be productive and work in a healthy environment. Those folks know that they are threatened. You have just gone through the 1080 debaucle. You know what it means to have the government making decisions for you based on perception rather than fact. That is why you are threatened.

That is why we have got to align perception with fact, because unless we do and until we do, the politics of pesticides are going to win, and the politics of pesticides are: Take these dangerous tools away, don't let people have access to them.

Politically, it is wiser to air on the side of zero risk than it is to try to explain risk relationships. Politicians find it easier to say, "You can have a riskless society." But you can't have it. I can't walk across the street today and guarantee you I won't be hit by a car. But, a politician will sell the idea of zero risk before he will take the time to explain the risk relationships, because that *is* hard.

Why? Well, number one, because he or she might not know any better. And, number two, it is tough to do and it takes time. That is what you folks, as professionals, are able to do. That is what people like me try to do. Because we are the ones that must do it, now! If we pull together and all work down the same path, I think we *can* make the difference.

That difference will be having the chemical tools still there when we need them. Not only to produce the food and fiber that this society demands, but to protect the health and the environment of the American public in our country. I frankly remain convinced that if we work together and talk in concert, with strength and unit, we can succeed. But it will take all of us.

I urge you today, as you go through the rest of your conference, to listen carefully to what is being told to you and relate what you hear to how you can talk to your friend or neighbor in terms of how you benefit their health, how you protect their environment, how you assure their children of a better world in which to live. Because those are the messages that are going to make sense. I think if we all do that, we will get common sense back into the question of the politics of pesticides.

PHYSIOLOGICAL ASPECTS OF MOWING TURFGRASSES[1]

Tom Cook[2]

[1] Presented at the 38th Northwest Turfgrass Conference, Sheraton Hotel, Spokane, WA, September 18-20, 1984.
[2] Associate Professor, Dept. of Horticulture, Oregon State University, Corvallis, OR.

In recent years, due to lack of money, many park and school districts have been forced to curtail mowing frequency and, in many cases, raise mowing heights in attempts to maintain their turf with less input. At the other extreme, golf courses are under increasing pressure to lower mowing heights on tees, fairways, and putting greens to improve the playing surface for golfers. Selection of mowing height and frequency has generally been taken away from turf managers and is now dictated by budget or green committees.

Since mowing is the fundamental stress we apply to turf, it is important to understand what impact our mowing practices will have on vigor, appearance, and persistence of our turf. The following sections highlight some of the important physiological and developmental changes that occur when turf is mowed. Understanding these changes will allow you to predict what effect your mowing practices will have on your turf.

HOW GRASSES TOLERATE MOWING

In general terms, turfgrasses tolerate mowing because initiation and development of leaves, tillers, and other secondary shoots are not disrupted by periodic clipping. Two factors in particular account for this: 1) The stem apex remains close to the ground because internode elongation does not normally occur to a great extent in turf adapted species, and 2) the pattern of leaf development via intercalary meristems allows leaves to continue growth in spite of clipping.

To appreciate how turfgrasses respond to mowing, it helps to visualize the turf plant as a very simple machine. The shoots, via photosynthesis, provide carbohydrates to very young lateral shoots and the root system. The roots supply the shoots with water and minerals. Surplus fuel (carbohydrates) is stored primarily in the crown region. If something happens to the shoot system (eg., it is removed via mowing), the immediate source of carbohydrates for the roots decreases. If enough of the shoot system is removed, roots will dieback. Storage carbohydrates are preferentially used by the injured shoot system to regenerate itself via axillary buds or existing, partially defoliated shoots. Normally, we can generalize that shoots have priority for available carbohydrates over roots.

Alberda (1960) showed very clearly that percent total soluble carbohydrates dropped in leaves, stubble, and roots of perennial ryegrass during the first four days after cutting. In this test, it took nearly 14 days for carbohydrates to return to precutting levels. Davidson and Milthorpe (1965) showed root extension of orchardgrass dropped dramatically following severe defoliation. While both of these tests were done under forage management conditions where infrequent severe cutting is the rule, other work indicates similar phenomena occur when turfgrasses are clipped. Crider (1955) noted that if more than 40% of the leaf surface area of Kentucky bluegrass is removed in a single mowing, the impact on root growth is severe. Removing smaller percentages of foliage resulted in continued root growth, although not as great as in unclipped plants.

TURF RESPONSES TO MOWING HEIGHT AND FREQUENCY

Most turfgrasses seem to perform best when mowed within a relatively narrow range of mowing heights. Optimum mowing height for a given grass will vary depending on where it is grown and under what site conditions. As mowing height is lowered within the optimum range for a grass, several developmental and physiological changes will generally occur. Invariably, leaf area index will decline. This is offset somewhat by an increase in shoot density. There is a decrease in carbohydrate synthesis and storage and as a result a decrease in total root production (Beard, 1973).

Mowing frequency affects turf in much the same way as cutting height. As frequency increases, shoot density increases, carbohydrate reserves decrease, rooting decreases, and there is less dry matter production (Beard, 1973). In general, the effects of frequency are more subtle than the effects of mowing height on these factors.

Optimum mowing height ranges for several common turfgrasses are list in Table 1. These heights are based on bench settings and on observations of turf performance in the Pacific Northwest. Because of our generally mild climate, we can get away with lower mowing than many other areas in the United States.

Several problems may develop when grasses are mowed above their optimum height range. Colonial bentgrass will develop false crowns at mowing heights above 1 inch. This is due primarily to internode elongation which yields a tree like plant with a tuft of foliage at the top. When this condition develops, the turf tends to scalp badly and generally looks brown after mowing. This trait is one of the reasons many turf managers don't

Table 1 Optimum mowing height ranges for turfgrasses in the Pacific Northwest.

Creeping bentgrass	3/16″ - 1/2″
Colonial bentgrass	1/4″ - 1″
Annual bluegrass	1/8″ - 1-1/2″
Perennial ryegrass	3/4″ - 2″
Kentucky bluegrass	1″ - 2″
Chewings fescue	3/4″ - 2″
Hard fescue	1″ - 2″
Spreading fescue (Red)	1-1/2″ - 2+″
Tall fescue	1″ - 2+″

care for bentgrass. To avoid false crowns all you have to do is lower the mowing height. Another problem occurs when Kentucky bluegrass is mowed too high. Stripe rust, *Puccinia striiformis*, which is severe on bluegrass during cool weather, is worse when the turf is mowed at 2 inches or higher. At higher mowing heights there is simply more mature leaf tissue in the canopy. These older leaves are definitely more susceptible to rust than young leaves. Perennial ryegrass generally shreds worse when mowed above 2 inches than at lower mowing heights. This is probably due to greater size and degree of vascularization in developing leaf blades under high mowing conditions. Finally, all grasses prone to thatch accumulation. such as Kentucky bluegrass and the fine fescues, tend to produce more thatch at higher mowing heights than at lower heights.

Mowing below the desirable lower limits for a turfgrass generally will result in reduced density and increased rate of invasion by better adapted grasses. Kentucky bluegrass, fine fescues, and even perennial ryegrass will generally be rapidly invaded by bentgrass, annual bluegrass, and/or *Poa trivialis* when mowed too low.

SUMMARY

Several generalizations can be made regarding mowing practices. Mowing under any circumstances is a stress. Low, frequent mowing generally yields attractive turf that is under a high level of stress. Higher, less frequent mowing (within the optimum range) will yield healthier turf able to tolerate greater stress in terms of temperature, drought, etc. Mowing above the optimum height range will often result in poor turf quality. Mowing below the optimum range will generally lead to increased invasion by weedy species. Optimum frequency for mowing still appears to be that which will remove no more than 40% of the total leaf surface area of the turf. Infrequent, severe defoliation results in a depletion of carbohydrate reserves and temporary stoppage or even dieback of roots.

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CHEMICAL CONTROL OF MOSS IN TURF[1]

Russell Vandehey and Tom Cook[2]

[1] Presented at the 38th Northwest Turfgrass Conference, Sheraton Hotel, Spokane, WA, September 18–20, 1984.
[2] Turf Student and Associate Professor, Department of Horticulture, Oregon State University, Corvallis, OR.

In the spring of 1984, a moss control test was initiated at the Lewis-Brown Horticulture farm near Corvallis, Oregon. The test was part of an ongoing effort to evaluate various techniques for controlling moss in turf.

BACKGROUND INFORMATION

In spite of the fact that moss has long been a significant problem in turf culture, surprisingly little information about lawn mosses is available. Few people can accurately identify moss and references in the literature tend to be rather vague regarding which moss species are most common in turf. Worldwide there are less than a dozen mosses that repeatedly receive mention as being turf weeds (4) (Table 1). Of those mentioned *Rhytidiadelphus triquetrus* and related species appear to be most important in turf in British Columbia, Washington, and Oregon (3). *Brachythecium albicans* was identified as a frequent component of mossy lawns in Corvallis, Oregon by Chapman and Sanborn in 1941 (1).

Table 1. Reported lawn moss species.

Rhytidiadelphus triquetrus, squarrosus, others
Brachythecium albicans
Polytrichum juniperinum
Hypnum sp.
Rhytidium rugosum
Calliergonella cuspidata
Rhodobryum roseum
Bryum rubens
Pottia davalliana

Unlike seed plants, mosses produce spores which germinate to form a threadlike structure called a protonema (Figure 1). The protonema is very tiny and closely resembles a green alga initially. Eventually buds form on the protonema and develop into the gametophyte which we typically see as moss (Figure 2). The gametophyte gives rise to the sporophyte which is composed of a stalk and capsule. The capsule contains many spores which help to further spread the moss. It appears that common species of lawn moss are not dependent on spores for propagation since small fragments of the gametophyte can spread vegetatively. In fact, vegetative propagation may be the primary source of invading moss as lawn mosses rarely produce the sporophyte stage under turf conditions.

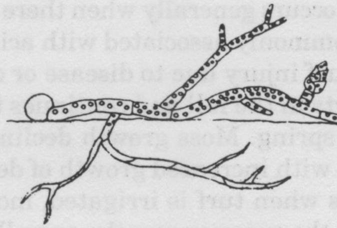

Fig. 1 A young moss plant.

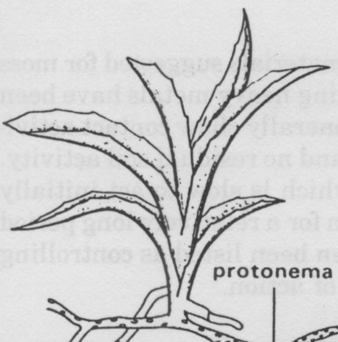

Fig. 2 Moss gametophyte

Fig. 3 Gametophyte and Sporophyte Stages

The persistent and recurring nature of lawn mosses may be due to the fact that these plants can tolerate long periods of drought in a dehydrated condition. What appear to be dead brown moss will often quickly rehydrate and resume growth with the onset of fall rains.

Moss invasion into lawns occurs generally when there is a lack of competition by the turf. This is commonly associated with acidic, infertile soils, shade, excess water, and turf injury due to disease or chemical damage. Moss growth normally starts in the fall and continues through the rainy period reaching a peak in spring. Moss growth declines with the onset of summer which coincides with increased growth of desirable turfgrasses. Under shady conditions when turf is irrigated, moss may persist in vigorous condition through the summer months as well. In western parts of the PNW, moss often grows vigorously during winter in lawns that are dense and well fertilized. This may happen because the moss grows better at lower temperatures than the turf although we are not aware of any studies that address this possibility.

CHEMICAL CONTROL OF MOSS

Our literature search indicated numerous materials suggested for moss control in turf (Table 2). Compounds containing heavy metals have been widely used to kill moss. These chemicals generally show contact activity with limited movement within the plant and no residual soil activity. The one exception appears to be mercury which is slow to act initially but does appear to prevent spore germination for a relatively long period (2). The other chemicals in Table 2 have often been listed as controlling moss but little is known about their mode of action.

Table 2. Reported moss control chemicals.

Ferric sulfate	Ammonium sulfate
Ferrous sulfate	Lime
Ferrous ammonium sulfate	Hydrated lime
Copper sulfate	Pentachlorophenol
Zinc sulfate	Chloroxuron
Mercury compounds	X-77 spray adjuvant

In the test reported here we used several iron compounds along with lime, ammonium sulfate, copper sulfate, and zinc sulfate. Treatments and application rates are listed in Table 3. All materials were applied in dry form except for the ferric sulfate treatments which were applied in liquid form.

The test area was a perennial ryegrass turf under low fertility, maintained at a low mowing height. Summer shade from nearby trees and shrubs created a good environment for moss to grow. The test was set up as a randomized complete block design with three replicates. Individual plots were 4 x 8 feet. Treatments were applied April 5, 1984, and plots rated visually through that month. Results reported here reflect observations made during that time.

Table 3. Chemical treatments and rates.

Treatment	Rate/1000 ft_2
Ferric sulfate	1.25 lb Fe
Ferric sulfate	.60 lb Fe
20-3-5 + Fe	.63 lb Fe
20-4-6 + Fe	.60 lb Fe
12-3-6 + Fe	.83 lb Fe
Agricultural lime	50.00 lb lime
21-0-0-24	1.50 lb N
MICROCOP (CuSO4)	.34 lb Cu
ZnSO4	1.80 lb Zn

Moss control ratings are presented in Table 4. Best overall control was observed with liquid ferric sulfate at both full and half rates, and the 12−3−6 fertilizer plus iron. Fair moss control was observed with two experimental fertilizer plus iron materials, 20−3−5 +Fe and 20−4−6 +Fe. The zinc sulfate material gave reasonably good moss control but caused unacceptable injury to the turf. Ammonium sulfate, copper sulfate (microcop), and agricultural lime had no significant impact on moss in this test.

Table 4. Percentage of live moss remaining in plots one, two, and three weeks after treatment.

	Live moss, % of plot			
Treatment	4/5	4/12	4/19	4/26
Ferric sulfate 1X	28	2	0	0
Ferric sulfate 1/2X	32	0	0	0
20-3-5 + Fe	37	15	10	8
20-4-6 + Fe	35	13	8	5
12-3-6 + Fe	37	0	0	0
Agricultural lime	32	32	32	32
21-0-0-24	50	45	42	35
MICROCOP	28	22	22	20
ZnSO4	47	17	8	8

The key to moss control with iron products appears to be thorough coverage of moss foliage with the material being applied. The liquid materials and the dusty fertilizer plus iron material were very effective in providing thorough coverage and thus control of the moss. Further tests are warranted to determine the lowest effective rate of liquid ferric sulfate that provides acceptable moss control.

ACKNOWLEDGENTS

We would like to thank the students in Hort 417 who helped set up and carry out this test as part of a class project. Also, thanks to the Chas. Lilly Company in Portland, Oregon for supplying many of the products used in this test.

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NITROGEN SOURCE, RATE, AND TIME OF APPLICATION ON BLUEGRASS/ RYEGRASS PERFORMANCE[1]

William J. Johnston[2]

[1] Presented at the 38th Northwest Turfgrass Conference, Sheraton Hotel, Spokane, WA, September 18–20, 1984.

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In the past several years, there has been a dramatic increase in the use of turftype perennial ryegrass both in monoculture and in mixed stands. The use of perennial ryegrass with Kentucky bluegrass, especially for athletic turf, or other heavily trafficked areas, has been a very successful management tool. This use of perennial ryegrass with Kentucky bluegrass has come about because many of the new improved turftype ryegrasses are very compatible in appearance to Kentucky bluegrass. The newer ryegrasses have finer leaves, greater density, somewhat better mowing qualities, persist longer, and have very good wear tolerance compared to the older perennial ryegrasses. It is their excellent wear tolerance that enhances their desirability in a bluegrass/ryegrass turf.

To better learn how to manage a bluegrass/ryegrass turf, this study was undertaken. The purpose was to determine the effect of turfgrass growth and quality of nitrogen sources, rates of application, and time of application.

In April 1982, a 6400 ft^2 area was seeded at 3 lb per 1000 ft^2 with a 60:40 mix by weight of Kentucky bluegrass (Victa and Bristol) and perennial ryegrass (Derby and Loretta). The area was fertilized with 1/2 lb N per 1000 ft^2 in May and 1 lb N per 1000 ft^2 in early June 1982. Fertility treatments and programs for application (Tables 1 and 2) were initiated in late June. Individual plot size was 7 x 13 feet. All plots were mowed (approximately once per week) at 1.5 inches. Plots were watered as needed to maintain acceptable turfgrass growth and appearance. The experimental design was a randomized complete block with three replications.

Table 1. Nitrogen sources.

Fertilizer	Analysis	Program no.
Methylene urea	40-0-0	1,2,3
IBDU	31-0-0	1,2,3
Sulfur coated urea	38-0-0	1,2,3
Ammonium sulfate	21-0-0	1,2,3,4,5
Complete Formula B*	34-3-7	1,2,3
Complete Formula C**	21-3-5	1,2,3
Ammonium nitrate	33-0-0	5
Check	------	---------

* Scotts Super Fairway
** Best Turf Gold

Table 2. Fertilizer programs for time and rate of application.

	Program No.				
	1	2	3	4	5*
			(lb N/1000 ft_2)		
April	1.8	0.7			
May			0.9		0.5
June	0.7	0.7			
July					
August	0.45	0.45			
September				1.0	
October	0.7	1.8	1.4		1.0
November				2.0	
Totals	3.65	3.65	2.3	3.0	1.5

* Program 5 initiated in 1983.

The plots were evaluated for turfgrass parameters quality, color, density, species composition, and root weight. Soil tests were taken in 1983. A list of the parameters observed in the test and the number of times each observation was taken per year are given in Table 3.

Table 3. Turfgrass parameter and number of times each was recorded.

Data taken	1982	1983	1984*
Quality	5	9	6
Color	5	9	6
Density	1	4	3
Species composition	1	-	
Root weights	1	1	
Soil tests	-	1	

* 1984 as of September 1984

Before we look at the effects of nitrogen source on turfgrass quality, let's observe the importance of the programs, that is, the time of application and rate of nitrogen application when results are averaged over all nitrogen sources. These results are presented in Tables 4, 5, 6 and 7.

Table 4. Turfgrass quality as affected by program.

Program no.	1982	1983	1984	Mean
1	7.0	6.2	5.8	6.3
2	7.4	6.8	6.0	6.7
3	7.1	6.1	5.0	6.1
4	7.7	6.9	5.6	6.7
5	---	---	3.8	3.8
Check	5.9	4.0	2.5	4.1

Quality 1-9; 9 = excellent

Table 5. Turfgrass color as affected by program.

Program no.	1982	1983	1984	Mean
1	6.8	6.4	5.5	6.2
2	7.4	7.0	5.8	6.7
3	6.8	6.3	5.1	6.1
4	7.9	6.9	5.5	6.8
5	---	---	4.0	4.0
Check	5.6	3.9	3.7	4.4

Color 1-9; = acceptable dark green color.

Table 6. Turfgrass density as affected by program.

Program no.	1982	1983	1984	Mean
		(grams dry weight)		
1	66	76	88	77
2	77	84	89	83
3	70	69	72	70
4	84	88	92	88
5	--	--	33	33
Check	43	35	23	34

Density is the clipping dry weight harvested between a bench setting of 1-5/8 inch and 1 inch.

Table 7. Root weight as affected by program.

Program no.	1982	1983	1984*	Mean
		(grams dry weight)		
1	1.1**	1.0		1.05
2	1.1	1.0		1.05
3	1.0	0.9		0.95
4	0.7	0.8		0.75
5	---	---		----
Check	1.0	0.8		0.9

* 1984 data not yet taken at time of this report.
** Dry weight of five, 10 x 2 cm cores per plot.

When averaged over all nitrogen sources, programs 2 and 4 gave the best turf ratings for quality, color, and density. There was little effect of program on root weight.

In program 2, nitrogen was applied 4 times per year (April, June, August, and October) with the bulk of the nitrogen being applied in the fall (see Table 2). In program 4, plots received a total of 3 lb N per 1000 ft^2; however, all of the nitrogen was applied in the fall during September and November. It would appear that fall applications of nitrogen are very important to obtain a high quality bluegrass/ryegrass turf in eastern Washington.

Tiller counts made in the late fall of 1982 (Table 8) indicated that program 2 for complete formula C, methylene urea, and possibly IBDU gave the greatest number of Kentucky bluegrass tillers (data for interactions not presented). No fertilizer or program increased the number of ryegrass tillers above that of the check; however, methylene urea in program 1 did show reduced amounts of ryegrass as compared to the check. Methylene urea in program 1 was also the only treatment that was significantly different from the check in total tiller number (bluegrass + ryegrass). It reduced tiller number.

Table 8. Species composition as affected by program and nitrogen source.

Program number	Total tillers	Percent bluegrass	Nitrogen source	Percent bluegrass
1	235*	17	Methylene urea	21
2	291	22	IBDU	22
3	262	17	SCU	16
4	249	14	Ammonium sulfate	15
Check	246	10	Complete formula B**	15
			Complete formula C***	23
			Check	10

* Shoot counts made November 12, 1982.
** Scotts Super Fairway
*** Best Turf Gold

The bluegrass:ryegrass ratio indicated that methylene urea in programs 1 and 2, IBDU in program 2, and complete formula C in program 2 all had more bluegrass in the turf than the check. All treatments except ammonium sulfate in program 2 were numerically greater in the bluegrass:ryegrass ratio than the check. All programs for IBDU and complete formula C had ratios greater than 0.20 (check was 0.11). Since the initial ratio was approximately 10.0 (assuming 100. germination and emergence), the low ratios observed illustrate dramatically the potential domination of a bluegrass/ryegrass turf by perennial ryegrass. The effect of the various fertilizers and programs to alter this ratio over time needs to be studied. Shoot counts made in 1984, but not presented here, will help to answer this question.

Soil test results are given in Table 9. These tests indicate that there was essentially no difference among either programs or nitrogen sources in their effect on soil pH. Soil tests also indicated adequate levels of phosphorus and potassium. This is fairly common for the soils of eastern Washington and is the reason no phosphorus or potassium response was observed in the two complete analysis products used in this test.

Table 9. Soil pH as affected by program and nitrogen source.

Program number	Soil pH	Nitrogen source	Soil pH
1	6.2	Methylene urea	6.3
2	6.2	IBDU	6.3
3	6.2	SCU	6.2
4	5.9	Ammonium sulfate	5.9
5	---	Complete formula B*	6.2
Check	6.1	Complete formula C**	6.1
		Check	6.1

Soil test taken November 14, 1983
* Scotts Super Fairway
** Best Turf Gold

As an indicator of overall turfgrass performance, the results of the individual ratings for turfgrass quality, turfgrass color, and turfgrass density were pooled. The best performing nitrogen source–program combinations are presented in Table 10.

The best performing nitrogen sources were ammonium sulfate, sulfur coated urea, and complete formula C. The success of these products indicates the enhanced performance of a bluegrass/ryegrass turf when sulfur is a part of the fertility program in eastern Washington.

Table 10. Nitrogen source-program combinations giving the best overall turfgrass performance at Pullman, Washington during 1982-1984.

Nitrogen source	Program number
Ammonium sulfate	2
Sulfur coated urea	1
Sulfur coated urea	2
Complete formula C*	2
Ammonium sulfate	4
Ammonium sulfate	1
Ammonium sulfate	3

* Best Turf Gold

Numerous applications of nitrogen, or as it is sometimes called, "spoon feeding", in general produced turf of the highest overall performance regardless of whether the nitrogen source was from ammonium sulfate, sulfur coated urea, or complete formula C (Best Turf Gold). The use of ammonium sulfate as a fall only application of nitrogen did produce excellent results. Also, very good performance was produced with a spring and fall application of ammonium sulfate (ammonium sulfate in program 3) where the bulk of the nitrogen was fall applied. These tests indicate the importance of fall applications of nitrogen and the additional need for sulfur in eastern Washington.

TURFGRASS RESPONSE TO NEW SLOW RELEASE N SOURCES[1]

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[1] Presented at the 38th Northwest Turfgrass Conference, Sheraton Hotel, Spokane, WA, September 18-20, 1984.

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The turfgrass industry is constantly concerned with identifying new nitrogen sources that promote turfgrass growth, provide efficient use of nitrogen at economic levels without undesirable pollution of the environment. Field assessment studies are commonly a part of the evaluation techniques used to assess turfgrass growth and quality. Currently a number of new nitrogen-containing materials have appeared from research and development. Some are being evaluated at Puyallup on bentgrass putting green turf and compared to standard N sources.

These studies were begun in the early summer of 1983 to study the effects of oximide and melamine on growth rate, color and quality of putting turf. The experimental area consisted of Highland bentgrass putting turf established on a Puyallup fine sandy loam soil. A replicated completely randomized design with plots 5 ft x 10 ft were used. Phosphorus at 2 lb P_2O_5 per 1000 ft^2 and potassium at 6 lb K_2O per 1000 ft^2 were applied annually in split applications in the spring and fall. Total nitrogen application was applied at 6 lb of N per 1000 ft^2 annually applied at 2 lb N rates in April, July and October or 3 lb N rates in April and October. Granular applications of oximide and IBDU were hand applied to plot areas. Plots were rated monthly for color, turf quality and turfgrass phytotoxicity.

Oximide contains about 31% nitrogen. Like urea formaldehyde (UF) and isobuytylidene diurea (IBDU), oximide's release is controlled primarily by low solubility in water. Oximide, a diamine of oxyalic acid, has the solubility of approximately four times that of IBDU and the release rate is strongly influenced by particle hardness and size. Cleavage of the carbon to carbon bond by microbial action results in the formation of ammonium carbonate that can result in ammonia-N volatilization losses.

Melamine is a triamino-triazine product which contains 66.6% nitrogen. Soil-water content, organic matter level and previous treatment with melamine may all alter the rate of nitrogen availability. Primary nitrogen release is by microbial degredation into plant available forms although some melamine may be taken up by the plant and metabolize the melamine in the leaf blade.

The initial nitrogen treatments with melamine were carried out with a product containing 75% nitrogen from melamine source and 25% from urea (60-0-0). Beginning in April 1984, melamine alone and melamine urea combinations were applied as melamine powder suspensions and urea solutions.

The color ratings graphically shown in Figures 1 and 2 closely illustrate the effect of these nitrogen carriers on general turfgrass quality. Applications of granular melamine 75%/urea 25% formulations in mid-1983 caused some depression in turf quality at the 3 lb N rate as compared to the 2 lb N rate (data not shown). Application of the same material in October 1983 improved turfgrass color as compared to untreated plots; however, turf quality was in the marginally acceptable range (5.5). Turf quality was very poor during the winter months of 1983-84 after October application. Application of melamine 75% and urea 25% as fine melamine suspensions and urea solution in mid-April increased the quality of turfgrass putting turf in May and June, but was followed by a depression in turfgrass color and turfgrass quality by early July. Repeat applications of the melamine 75%/urea 25% solution improved turf quality following applications in July and October but quality declined again in September. Melamine 50%/urea 50% solutions were begun in April 1984. The effect of this combination was to raise the average turf quality of the plots with improved turf color and turf quality following the April, July and October applications as compared to the melamine 75%/urea 25% solutions applied. Melamine applied alone without urea and applied as a fine suspension did not cause a phytotoxic reaction to the putting turf in 1984, but it did not improve the turf color and quality as compared to unfertilized plots.

These data suggest melamine is very, very slowly released following application. Treatment of turf with melamine at 1.5 lb N per 1000 ft^2 in the fall was insufficient to retain good turfgrass color throughout the winter months of 1983-84. Similarly, melamine degredation and N availability appeared insufficient to retain turfgrass color during extended periods during summer which is suggested by the turfgrass color and turf quality response associated with reapplications of melamine 75/urea 25% product applied in April, July and October. Fertilizer applied in coarse granular form that contained high (75%) melamine-N levels produced phytotoxic effects on bentgrass turf in 1983. However, suspended melamine applications up to 6 lb N per 1000 ft^2 failed to produce bentgrass phytotoxicity in 1984. Thus, fine granular fertilizers containing less than 25% melamine and applied at less than 1 lb N per 1000 ft^2 could likely be used safely even on fine quality turf.

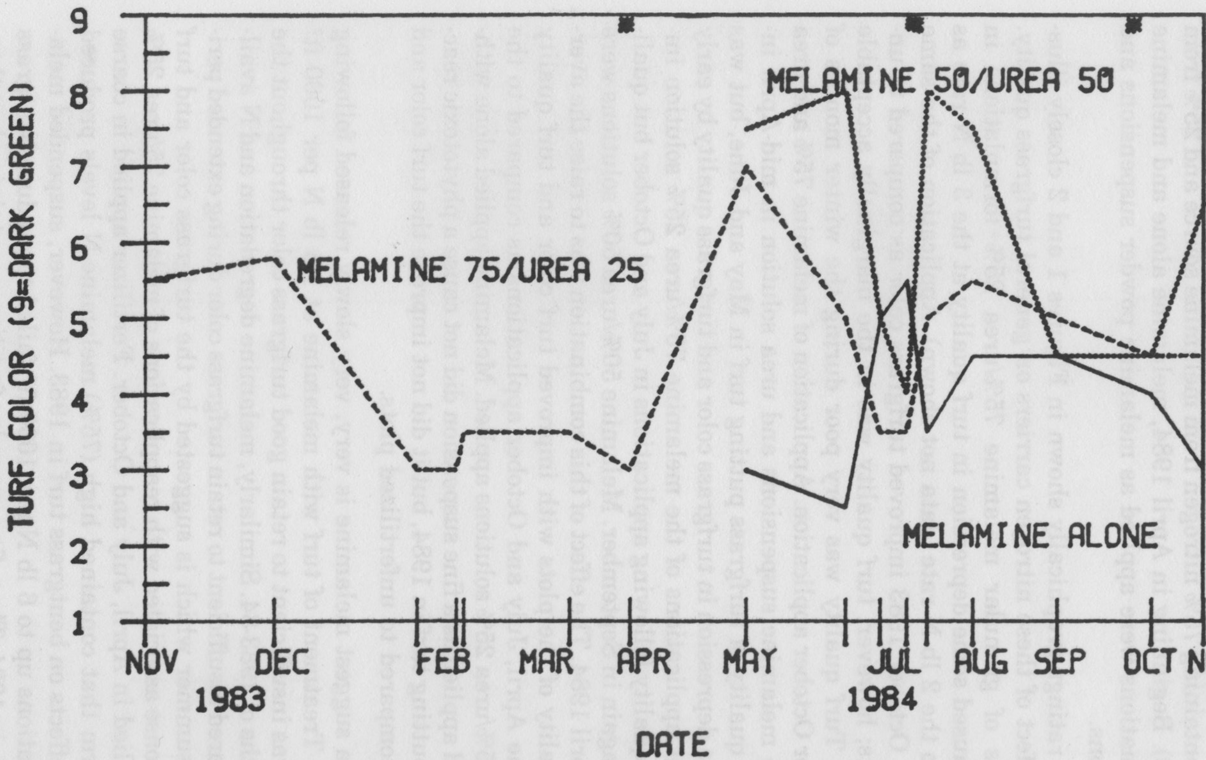

FIG. 1. EFFECT OF FERTILIZATION WITH MELAMINE ALONE AND MELAMINE/UREA COMBINATIONS ON COLOR OF BENTGRASS PUTTING TURF AT PUYALLUP, WASHINGTON. (*=APPLICATION TIME)

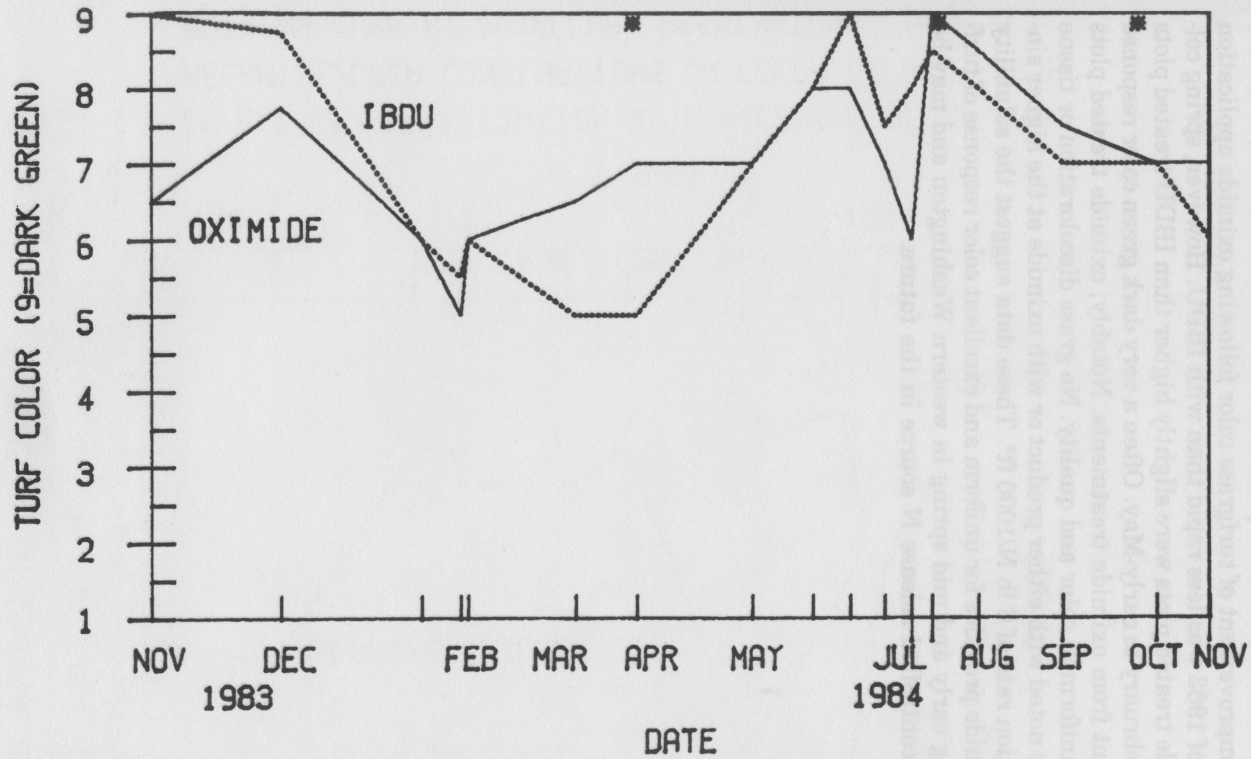

FIG. 2. EFFECT OF FERTILIZATION WITH OXIMIDE AND IBDU ON COLOR OF BENTGRASS PUTTING TURF AT PUYALLUP, WASHINGTON. (*=APPLICATION TIME AT 2 LB N/1000 SQ FT)

Oximide has produced consistently good growth with good color and turfgrass uniformity during 1984. Figure 2 compares the color ratings of oximide and IBDU treated plots from November 1983 to November 1984. The improvement of turfgrass color following oximide application in October of 1983 was less rapid than with IBDU. However, spring color in oximide treated plots were slightly higher than IBDU treated plots from late-February to early-May. Often a very dark green color response was apparent from oximide treatments. Notably, oximide treated plots were very uniform in color and quality. No grass discoloration or tissue toxicity was noted with either product or with oximide at the higher single application rate of 6 lb N/1000 ft². These data suggest the solubility level of oximide provides for uniform and excellent color response of turfgrass during early and mid spring in western Washington and may be a valuable controlled release N source in the future.

SOIL DRAINAGE SYSTEMS THAT FUNCTION[1]

Carl H. Kuhn[2]

[1] Presented at the 38th Northwest Turfgrass Conference, Sheraton Hotel, Spokane, WA, September 18-20, 1984.
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One can oversimplify the definition of drainage by saying that it is simply ridding oneself of unwanted water. Were it only that simple for the person who must maintain a golf course, a school playfield, a football field, soccer field or park; were it only so simple for the budget-makers of golf courses, school districts or park departments. Drainage might better be defined as "If you haven't got it, you also do not have a playable surface". In the area west of the Cascades in particular, and to a lesser degree in the drier areas, year-round healthy and *un-saturated* sportsturf surfaces cannot exist without proper drainage.

Before we get into the specifics of curing the problems of drainage on turfed areas, be it golf, football, soccer or whatever is played on that surface, let us review what I prefer to call the "Simplistic Philosophy of Drainage". This over-simplified explanation is intended to help us rid ourselves of the old-wives tales, voodoo, witchcraft and guesswork that permeates our professions.

THE SIMPLISTIC PHILOSOPHY OF DRAINAGE

Seldom, if ever, were golf courses, parks, playfields or school grounds ever sited because someone recognized the fantastic drainage capability of the underlying soils. Hence it is not uncommon for major drainage problems to crop up *after* the golf course, park or playfield has been constructed. One can understand why golf courses, with 90-150 acres of land are relegated to correcting many drainage problems afterwards. For parks and playfields the usual excuse for not correcting them at the time of construction is *budget!*. This is our way of life.

After many of these sporting facilities have been built, the Maintenance Staff discovers that Mother Nature, through the medium of glacial action eons ago, dropped something less than beach sand at the site. More likely here on the west slopes of the Cascades, she dropped silt, clay or both, materials that may permit water to infiltrate and percolate, but *very slowly*. Add to this dilemma an overabundance of rainfall that seems to be present continuously from October through March or April (or June in 1984), and we find two natural conditions detrimental to quick dissipation of surface moisture....*slow draining soil and an excess of water*. These are natural conditions for this area. Add to this a third, but in-direct natural condition.....mild winter weather which encourages outdoor activity for twelve months of the year. The crowning touch occurs through a man-made ingredient; heavy traffic of golf shoes, golf hand carts, golf riding carts and maintenance equipment on golf courses and football players, soccer players, intermural athletics, adult leagues and maintenance equipment on playfields. All four of these conditions combine to create untenable playing conditions on turfed surfaces. Destruction occurs through the following action.

A. Water, being inherently lazy, migrates vertically through the soil because of gravity and will continue to do so as long as the soil is not saturated.

B. If the soil is fine textured, ie. silty or clayey, the water moves through at a very slow pace. Hence we find the problem with heavy rains running off of these soils rather than down into and through them. This may all be good except when the runoff simply moves from one part of a golf course to another, we have solved some of the problem in one place at the expense of an added problem at another place. On a flat sportsfield, we simply form a lake until percolation or evaporation takes place. Even crowned fields, puddles and saturated surfaces are common.

C. When the pores of the soil are completely full of water, the material is in a saturated condition. Any activity which causes a disturbance of the material tends to change the soil characteristics and may destroy whatever natural drainage channels that might have existed. Additionally, organic material decays or rots on the surface, often causing surface sealing and slowing infiltration.

D. Old turf sometimes exhibits heavy layers of "Thatch", the longterm build-up of dead grass stems, leaves, etc. If not treated each year with appropriate equipment, water movement is further restricted.

It now can be seen that we have all of the ingredients that are necessary to slow or inhibit drainage. Take away any of the three primary ingredients, excess rain, fine textured soils, or excess traffic and you have no problem. The rain and soil are Nature's contribution; traffic is the gift of man. If we eliminate traffic, we have a nice-to-look-at-lawn but no golf course or playfield. We have no control over rain. The only variable that we can attack is the soil, its make-up or its surface. Now enters the science of corrective drainage.

DETERMINE THE PROBLEM

Each site is unique unto itself. Only in places like Palm Springs where we can find thousands of acres of contiguous land of fast draining sand from the surface to 100 feet of depth, do we chance on land similarity.

Here in the Pacific Northwest, we must treat each fairway differently and we must treat each playfield differently. We search out the vital characteristics of each individual site by ....

A. Visually identifying soil characteristic through test holes.

B. Conducting infiltration tests of the surface layers.

C. Conducting percolation tests of the underlying areas.

D. Mechanical analysis of the soil particles (sieve tests).

E. Reviewing topo conditions, runoff, etc.

Once the foregoing practices have been applied, one can identify the seriousness of the drainage problem and make recommendations for the correction thereof. The first identification must be to determine the source of the excess water. Occasionally this excess is derived from underground sources, ie. springs. More often the problem is one in which the existing soils cannot pass rainfall sufficiently. Underground water can be handled quickly and simply by intercepting it in cut-off trenches. When we have identified the problem as slow-draining soils, the cure is much more complex and certainly much more expensive. The question now arises as how much cure (and money) is it necessary to throw at the problem to bring the site up to our desired standards.

DETERMINE THE REMEDY

Often one can tell why a soil is slow draining by little more than visually identifying the clays or silts. However, until the infiltration tests, perc tests and mechanical analysis tests are conducted, the degree of corrective action cannot be properly determined. Corrective treatments for golf courses or parks or playfields may require little more than frequent sand topdressing after a prior vigorous program of verticutting and aerifying. It may be that it is necessary to strip the existing sod and overlay the area with 3 to 4 inches of clean, carefully screened sand. Or, it may require a very expensive removal of the existing soil, underdraining the area and then replacing the void with carefully selected permeables, principally sand. The depth of excavation (and sand replacement) will vary depending upon the findings obtained from the perc tests and sieve analysis.

It can be seen that there are numerous options available, all with differing price tags. *However, there is usually only one correct remedy for a given site, be it fairway, playfield or park.* This is not to say that you cannot use any of the aforementioned solutions at any site; what we are saying that there is usually only one right way to provide you with the results you want on a permanent basis. Since budgets are the nemesis of all turf caretakers, it is important that we spend absolutely no more than necessary on a site to improve the drainage. This is where the perc tests, infiltration tests, the mechanical analysis and visual soil identification through test holes pay for themselves for these tests may well provide us with the data which would permit a resolution other than a complete underdrained and reconstructed area.

Let us look at some sample problems and their resolutions.

Example A

Playfield with dirt surface to be rebuilt and made playable for soccer. Soil sieve analysis reveals 10 to 15% of the soil material passing the No. 200 sieve and perc tests which indicate average perc of 10 minutes per inch.

Solution: Grade the area, break up the base material and overlay with 4 inches of sand. No drain tile required. Seed, fertilize and irrigate. Cost per acre = $20,000*.

Example B

Playfield to be rebuilt. Underlying materials are mostly silts and clays with upwards of 50% passing the No. 200 sieve and perc tests veraging 90 minutes per inch. Field to be used for soccer and football.

Solution: Remove 14 inches of subgrade and dispose of same. Underdrain with 4-inch corrugated-perforated polyethylene at 20-foot on center and cover with 14 inches of selected sand. Seed, fertilize and irrigate. Cost per acre = $50,000*.

Example C

Golf course fairway with same material and perc rates as Example B. Constantly saturated during winter.

Solution: The option is always open to completely rebuild the fairway at $50,000 per acre. Since this is likely to be quite impractical, an alternate method of improving the playability is desired. Start a program of selected sand topdressing at the rate of 1 inch per year for a three-year period. Regrade fairway to slope if possible prior to the sanding program. Install occasional drains after the sanding program has been completed. While this remedy will not give you the results of Example B, it will improve the playability and drainage. Cost per acre =$8,000*.

Example D

Playfield with base materials of sandy nature, no more than 10% passing the No. 200 sieve and perc rates of 15 minutes per inch. Surface is constantly saturated and soft in the winter soccer/football playing periods.

Solution: The problem was determined to be a dense and impenetrable 2-inch layer of thatch that had built up over some 20 years. Field was verticut with a commercial thatcher until the surface sealing thatch was removed. Field drains well without use of drain tile, reconstruction or sanding. Cost per acre = $750*.

* These cost estimates are general in nature and will vary greatly depending upon availability and cost of permeable materials. Seek professional assistance before budgeting for a drainage project.

SUMMARY

Every turfed area that is subject to heavy winter play, be it a playfield, golf course, park or school yard, must be able to cope with the destructive nature of heavy traffic and excess moisture. Either nature provided the site with natural drainage or we must be expected to do so in some artificial manner. The degree of corrective drainage required is a function of the soils of each individual park, playfield or fairway. Before you spend dollars for treatments that may harm the drainage as much as help it (or not really help it at all), take the time to find out what types of soils you have, how they perc or how they infiltrate and then decide on a course of action. It is a well known fact that there are more dry drain tiles than functioning drain tiles in heavy soiled athletic areas. So often maintenance personnel are under pressure to "Do something about the drainage!" And so, "Something" is done whether it is drainage-effective or cost-effective or not. Take the time to learn about what you have in the way of soils on each of your parks, on each of your playfields and each of your fairways. Then and only then will you be able to address the proper remedies to your drainage problems.

MINIMIZING WINTER DESICCATION WITH SYNTHETIC COVERS[1]

Dr. John M. Roberts[2]

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[1] Presented at the 38th Northwest Turfgrass Conference, Sheraton Hotel, Spokane, WA, September 18-20, 1984.
[2] Extension Turfgrass Specialist, University of New Hampshire, Durham, NH.

Every spring golfers throughout the northern states anxiously wait for the snow to melt so they can "tee it up" once again. With a more serious look, golf course superintendents also anxiously observe their greens; to see how much green grass there will be to play on! The strong winds, bright sun and frozen soil surfaces that exist in late winter - early spring create a condition causing desiccation and damage to the turf. While all turfgrasses are vulnerable to winter desiccation, *Poa annua* is most often hit the hardest. The net result is a putting green that may take until midsummer before fully recovering.

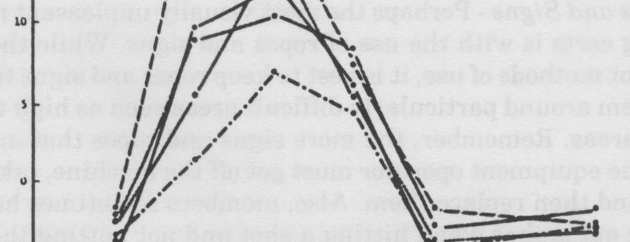
Recently, research efforts involving protecting the greens in the fall with synthetic covers and removing them the following spring has produced some promising results. Of particular interest has been the product "Reemay" which is a porous material comprised of a spunbonded polyester. In the spring, compared to uncovered greens, turf under Reemay generally contains 10 to 20 percent more leaf moisture, up to 24 percent increased root length, 80 percent more clippings and up to 10° and 14° rise in soil and surface temperatures, respectively. The elevated temperatures hasten the release of fall applied nitrogen and the rate of turf green-up in the spring by 5 to 12 days. In addition, germination rates are faster and regrowth in damaged areas is also enhanced.

Other materials including polypropylene blankets (brown, white and black colored), pine needles and composted sludge have been evaluated. The composted sludge was not effective in reducing desiccation but did accelerate the rate of ice melt in the spring compared to the other treatments. The pine needles and all the polypropylene blankets were effective in conserving leaf and soil moisture in the early spring. However, the polypropylene blankets, which weighed 5 times more than the Reemay cloth, blocked 97 percent of the incoming light, producing chlorotic growth unless the blankets were removed in early spring. This would be considered a severe disadvantage since you want the greens protected as long as possible until the course opens up for play.

A typical temperature profile during a 24 hour time period is listed in Figure 1 demonstrating the temperature increase of Reemay by 10°C as compared to a polypropylene blanket, composted sludge or pine needles or control. Notice that by mid-day the polypropylene blanket and pine needles actually *lowered* the surface temperature as compared to the control. This lower temperature under the polypropylene blankets has resulted in foot traffic damage in early spring by curious members walking over the greens. It should also be noted that under all the treatments over 80 percent of the heat captured was lost by 7:00 p.m. of the same day.

Through experience and testing we have learned how to get the best use from Reemay. First, in late fall the greens should be mowed, fertilized and treated for snow mold prevention. Secondly, secure the blankets (12 feet x 75 feet) using metal pins inserted every 2 feet along the reinforced edge. *Do not* stretch or pull the blanket tight while pinning. Finally, say "good night" to the greens until next spring and don't remove the blankets until the course is about to open for play. You will get the best results if the cover is left on as long as possible in the spring.

Fig. 1. Heat capture and retention at the soil surface using protective covers over a 24-hour period.



CARTS AND CART PATHS THE BEST OR WORST INVENTION FOR GOLF?[1]

Larry W. Gilhuly[2]

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[1] Presented at the 38th Northwest Turfgrass Conference, Sheraton Hotel, Spokane, WA, September 18-20, 1984.

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A little bit is good, a lot is better. How many times have we heard that old adage used in the field of agriculture? It has also been used in other areas. For example, an agronomist wished to go fishing on a crisp spring day. The only problem was he had no angleworms to fish with. To solve this dilemma, he went down the main street of the local town and found a small roadside stand that had a sign out front that said, "Angleworms for Sale". The agronomist inquired as to the price. "All you can take for $1", replied the salesman. "Good," said the agronomist. "I will take $2 worth!"

Although this does not represent the clearest of thinking, I sometimes wonder if clear thinking is being done in regards to carts and cart paths on golf courses. In my personal opinion, there has been no finer invention than the golf cart to produce revenue for a golf club. At the same time, there has been no worse invention made for the growing of fine quality turf on a golf course. It appears to be the "Catch 22" of the golf course operation.

Since golf carts are here to stay, let's address the means of control and techniques used to lessen turfgrass wear.

MEANS OF CONTROL

Ropes and Signs - Perhaps the most visually unpleasant method of controlling carts is with the use of ropes and signs. While there are many different methods of use, it is best to keep ropes and signs to a minimum. Use them around particularly difficult areas such as high traffic tee and green areas. Remember, the more signs and ropes that are put up, the more the equipment operator must get off the machine, take them down, mow, and then replace them. Also, members sometimes have a habit of pulling out stakes when hitting a shot and not putting the stakes back in. If your club is on a limited budget, this may be the only method of controlling carts on your golf course.

Painted Areas - This practice has been used with mixed results (depending on the membership) for control of carts in front of greens and around green surfaces. It is by far cheaper than the use of ropes and signs; however, the membership must be cognizant of your efforts and must comply with the rules put forth. At some clubs this has worked very well while at others, it has been a waste of time. Special emphasis and communication are important to make this technique work.

Curbing - Whether it be asphalt, concrete or railroad ties, the use of curbing provides the most effective method for cart control. At the very least, every club should strive for curbing around tees and especially greens. The curb should be no more than 5 or 6 inches high and the soil should be flush on the turf side to provide for normal maintenance practices. Try to avoid any extra hand labor when installing curbs. Nearly every club that has used this method of cart control has been pleased with the results and their turf quality around the cart paths by greens and tees has greatly improved.

Some clubs have gone so far as to curb all their par-3's and others have curbed nearly the entire golf course. This would be a severe monetary undertaking for most clubs and is seen very little in the western states.

Angles of Entry/Exit - On those golf courses that have paths on tees and greens only, the angle of entry onto the fairway and exit onto the green path are critical. To reduce turfgrass loss near the tee exit area, the path should be angled towards the rough. Then, by the use of signs and roping, try to distribute the wear pattern into the rough rather than the fairway area. Many times, areas that are in play are devoid of turf simply because the cart path is angled the wrong direction.

The path entering the green should also be off into the rough so that the worn area again will occur in the taller rough grass. The combination of the painted white line with a properly positioned cart path in the green area, can reduce turf loss in this vital area.

The 90 Degree Rule - Many clubs have a standard policy of using the 90 degree rule. Basically, this rule states that the golfer must drive his/her cart down the path or rough until he reaches the point 90 degrees away from the ball. At this point, he may drive onto the fairway, park his cart, hit his shot, and then return on the same line and proceed up the rough or cart path in the same manner. This method also takes good communication and understanding from the membership. However, success has been very good using this method and reducing turf loss.

Restricted Use Days - In the Pacific Northwest, as well as elsewhere, there are specific times when carts should be restricted to the paths or roughs. When the soil is frozen, excessively wet or when temperatures are too hot, the superintendent should have the right, along with the golf professional, to restrict carts to paths for the sake of the turf. If the membership is willing to accept poor playing conditions in their fairways, then this rule can be eliminated. However, if the membership desires good fairway playing conditions and demands good turf throughout the facility, then they must understand the reasons for controlling carts on these specific areas on specific days.

The Ultimate Control - Although laughed at by some, and deemed economically unfeasible by others, the ultimate in cart control is currently available today. At the TPC Course, Sawgrass, Florida, there has been a cart control technique used successfully for the last two years. This system requires installation of an electronically transmitted line under the surface. All of the electric carts have receivers and when the golfer crosses over the line, a loud beeper goes off and the player has approximately 45 seconds to return to the cart path. If he does not return in this time span, the cart will automatically shut down and the player must carry his bag or end his round of golf. After talking to the golf course superintendent, Mr. Bobby Weed, reports indicate very good compliance with this system. Several other clubs are now interested in installing such a system. The cost in 1983 was approximately $15,000.

Another alternative is currently practiced at La Costa Country Club, Carlsbad, California, and at other clubs throughout the United States. They simply tell you right up front that if you take a cart, you are not allowed to take it off the cart path. Course marshalls make sure this does not occur.

Bring Back Caddies - Isn't it interesting how the United States has been on such a health kick for the last 15 or 20 years and everyone is interested in jogging, tennis, swimming, etc. At the same time, golf carts have increased dramatically in this time period and when one goes out to play? golf, very little exercise is achieved when riding in a cart. Of course, there are many with health reasons who are unable to walk the golf course, However, I have vivid memories in the 1960's, prior to electric carts, of the large scale caddy programs that helped many young boys make a little bit of money during the summer. It is also an excellent method to introduce the youth to the game of golf. Become involved by showing these young people the proper way to fix ball marks, rake bunkers, replace divots, etc. If for no other reason, do it for the sake of your turf!

TYPES OF SURFACES

Gravel or Rock - While this type of surface may be the least expensive, it may prove the most expensive in the long run. Continual fixing of pot holes, dust problems and severe damage to fairway and rough units are just some of the reasons why many courses are going to the more permanent, harder surfaces. When a club has 25 or more carts, it is time to start considering cart paths for minimizing turf loss. For example, in 1982 at Pebble Beach, the USGA requested elimination of carts from fairways two months prior to the U. S. Open. The resulting response in fairway growth and vigor was quite astounding according to Bill Bengeyfield, National Director of the Green Section. This has also been reported at other golf courses where excessive cart use has caused problems.

Asphalt - Although asphalt is a better answer than gravel, it too has its problems. It can be easily prone to invasion from grass and weeds and can begin breaking down in a short period of time. Roots from trees can also cause problems with asphalt and resurfacing and repatching are a constant need. For financial reasons, many clubs ultimately go to asphalt paths thinking they are cheaper; this may not necessarily be the case.

Concrete - Even though the initial expense will run higher with concrete paths, they will last longer and ultimately be the most cost effective method for cart paths. On all paths, the best width is 8 feet with curbing around greens and tees. This width will accommodate all vehicles. The width from green to tee should be 7 feet. Experience has shown any path narrower than this will develop problems of weak turf and broken-down edges from carts and maintenance vehicles.

CONCLUSIONS

Installing cart paths is not an inexpensive proposition. If a club is going to spend anywhere from $50,000 to $250,000 to install paths, the main point is that they be used. Currently, many paths are not used to their fullest and resulting turf loss is the by-product. A little bit is good, a lot is better? In the case of carts, a little bit is good, control is better.

AERIFICATION A COMPARISON OF SHATTERCORE VS. HOLLOW-TINED[1]

By Dr. Roy L. Goss[2]

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Aerification has been a standard practice on all heavily trafficked turfgrass areas for many years. It is the major means of relieving surface compaction in the uppermost 2-3 inches of soil and mat. Aerification is essential not only to relieve compaction, but to promote faster water infiltration rates, maintain firm dry surfaces and to allow better gas (oxygen) diffusion into the soil. Aerification will also enhance root growth due to better oxygen relationships and a soil that has less resistance for root penetration.

Aerification is more essential on turfgrass areas that were established on soils of sandy loam texture or heavier than it is on those areas established on pure sand. We usually assume that infiltration rates of water and oxygen diffusion rates are satisfactory in sands, although this can change with the accumulation of surface organic materials that are decomposing as well as accumulating as thatch. In this case, aerification also becomes essential. Native soils, due to their fine texture, have greater compactability than sands due to greater total pore space. When fine materials become packed tightly together, air spaces are essentially eliminated leaving only capillary porosity which increases the water holding capacity of the soils as well as increasing their density. The overall effect is poor root growth conditions and surface wetness.

In recent years an old concept of soil tined aerification has been modernized where solid tines are fitted into the Ryan Greensaire aerifier. These tines are bullet-nozed, generally of 1/2 inch and possibly 5/8 inch diameter, and are literally punched into the soil with the force of the downward thrust of the aerifier. Due to the rapid insertion and withdrawal of these solid tines, it is reported that hard compacted soils have become much softer, water infiltration rates have picked up, rooting has increased and overall turf quality has significantly improved.

Hollow tined aerification is the usual means of aerifying turfgrass areas. Problem putting greens with heavy soils, fairways, and sportsfields should be hollow tine aerified up to 4 times annually to help reduce compaction and maintain a better environment for root growth. Obviously, hollow tined aerification will increase water infiltration rates as well. In general, hollow tined aerification should be followed by sand topdressing to place as much sand down the holes as possible to maintain continuity of water flow to the surface. When aerifier holes close over at the soil surface with heavier textured soils, aerification is only a temporary effect.

We have some reservations with respect to hollow tined aerification. Therefore, we have initiated a research project to compare shatter core vs. hollow tined aerification to determine if there are any long range problems associated with shatter core aerification. It is obvious that the downward thrust of a solid instrument through the soil must create some compaction at the bottom of the thrust. When a solid object is moved through the soil, there should be displacement in all directions. Although the upward thrust of the aerifier tine may loosen the soil throughout its length, it may not loosen the soil at the bottom of the thrust creating a pan or compacted layer. No doubt, there is some compaction at the bottom of the thrust even on hollow tined aerifiers as well. Our objective, therefore, is to compare the two methods as well as combinations of the two methods. We will be measuring the parameters of infiltration and permeability rates of water, bulk density of the soil, and turf quality aspects.

There was excessive variability in the water infiltration studies, but this may change in another year, although there are some interesting trends as you can see from the table above. Bulk density of soils of this nature (silt loam) is a reasonably accurate measure of compaction. It is interesting to note from the above table that no aerification resulted in a lower bulk density than any aerification treatment. A bulk density value over 1.5 g/cc might indicate excessive compaction in a silt loam soil.

These data were developed from an area maintained as putting green turf, but without heavy traffic. It is probable that these values will change more within 2-3 years and even more so if traffic is applied.

After slightly more than one year of treatments, we have accumulated the following data:

Treatment	Timing	Means: Infiltration Rate[1] (inches/hr)	Bulk Density[2]
Shatter core	Mar,Oct	3.8	1.41
Shatter core	Mar,May,Aug,Oct	2.0	1.37
Shatter core	Mar,May,Jun,Aug,Sep, Oct	2.2	1.40
Hollow tine	Mar,Oct	2.0	1.39
Hollow tine	Mar,May,Aug,Oct	2.7	1.42
Hollow tine	Mar,May,Jun,Aug,Sep,Oct	3.3	1.40
Shatter core + hollow tine	Mar(HT),Oct(SC)	2.2	1.37
Shatter core + hollow tine	Mar(HT),May(SC),Aug(HT) Oct(SC)	2.0	1.37
Shatter core + hollow tine	Mar(HT),May(SC),Jun(HT), Aug(SC),Sep(HT),Oct(SC)	3.0	1.40
No treatment		2.2	1.32

[1] Measured in millimeters per minute for a 30 min. period and converted to inches per hour.

[2] Bulk density measured in grams per cubic centimeter (g/cc) in the 2_4-4_4 inch depth.

SOME NEW APPROACHES TO ANNUAL BLUEGRASS CONTROL[1]

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Research and Extension workers at Puyallup have developed post-emergence control methods for the control of annual bluegrass in bentgrass and bluegrass, but still annual bluegrass is the dominant turfgrass species in parks, athletic fields, fairways, tees and putting greens. Dr. Roy Goss has reviewed many times the cultural practices which encourage *Poa annua* development in turfs. Factors such as over-irrigation, excessive fertilization with nitrogen and phosphorus, improper timing of aerification, turf losses due to stresses of pests, traffic, shade, excessively low cutting heights and puddled or compacted surfaces all encourage the development of *Poa annua* at the expense of desirable turfgrass species.

Poa annua can be controlled in bentgrass and bluegrass turfs through post-emergence control with endothal and pre-emergence control with bensulide. Replacing the controlled *Poa annua* with desirable species can be accomplished through overseeding with the slicer-seeder or broadcast applications preceded by aerification and followed by topdressing during periods when adequate moisture is present to encourage good, rapid seeding development. To review the suggested procedure in bentgrass turf is as follows:

1. Apply 1 lb of available nitrogen per 1000 sq. ft. between April 15 and May 1.

2. Apply 10 lb a.i. bensulide per acre one week after the nitrogen application.

3. Apply 1 to 1.25 lb a.i. endothal per acre approximately one week after the bensulide application.

4. Immediately overseed with a slicer-seeder or apply seed broadcast preceded by aerification or spiking. The broadcast/aerification procedure works best when bensulide is used for pre-emergence control.

5. On putting greens, topdress with sand lightly and regularly.

6. Raise the mowing height on putting greens to 5/16 inch.

7. Retain a moist surface at all times to promote rapid germination and insure uniform seedling establishment.

8. Slowly reduce the mowing height on putting greens and continue light and frequent topdressings. Normally this can begin at 4-6 weeks following seeding.

These pre- and post-emergence control guidelines are demonstrated methods of annual bluegrass control (Table 1). However, in addition, attention must be paid to avoiding the daily management mistakes that encourage *Poa annua.* The use of reasonable sulfur fertilization and avoidance of excessive phosphorus application will encourage bentgrass at the expense of annual bluegrass.

Table 1. The effect of bensulide, endothal and ethofumesate on [*Poa annua*] levels in putting turf.

Chemical	1982 - [*Poa*] seedheads	1984 - Turf composition
	(No/dm_2)	(% [Poa])
No treatment	19	22
Bensulide	8	22
Endothal	1	2
Bensulide + Endothal	0	2
Ethofumesate	13	18

Still, there may be other management options now and in the future that can alter *Poa annua* survival or demise. As you know, *Poa annua* is often injured by stress from lack of moisture or excessive heat or cold. These weaknesses of *Poa annua* can be used to control annual bluegrass, but our studies suggest some growth regulating chemicals (PGR's) can injure *Poa annua* or reduce *Poa annua* populations if they become registered for use in the future. Other PGR's may increase *Poa annua* populations or not injure populations at all.

For the past two years we have observed strong and weak trends in *Poa annua* losses in turf treated with PGR's and fungicides. These PGR products are PP333 (paclobutrazol), EL500, MON 4624 and Rubigan, a fungicide.

The *Poa annua* kill or population reduction we have observed while testing these PGR chemicals seems to be increased when combined with either lack of moisture or when associated with nutritional stress. Table

2 illustrates two occasions where PP333 either greatly reduced *Poa annua* percentage in a bluegrass/ryegrass sod or moderately reduced the population rating significantly as compared to other PGR treatments. MON 4624 also has had influence in decreasing *Poa annua* levels on unstressed turf in 1984. MON 4624 is a 3.5 lb a.i. per gallon formulation containing 2.5 a.i. of 4621 and 1 lb a.i. of PP333.

Table 2. The effect of plant growth retardants on the [*Poa annua*] levels in bluegrass/ryegrass sod.

Chemical	[*Poa annua*] 1983	1984**
	(%)	
No treatment	55	5.9
MON 4621	57	4.7
MON 4623	66	-
MON 4624	-	6.3
PP333	5	6.4

** 9 = No [*Poa annua*].

In contrast, other PGR's are more effective in controlling *Poa annua* seedhead development (Table 3). Embark (mefluidide) may subtly control *Poa annua* by reducing viable seed populations since it can virtually eliminate the *Poa annua* seedhead development for a period of 6-8 weeks following application. Yet, MON 4621 (proposed name, amidochlor) has not controlled *Poa annua* seedheads well in our studies and, in fact, some repeat application studies in combination with N fertilization levels in 1983 strongly suggest *Poa annua* populations increased.

Table 3. The effect of plant growth regulants on [*Poa annua*] seedhead suppression in bluegrass/ryegrass sod.

Chemical	Percent seedhead suppression
No treatment	0
Embark	99
MON 4621	0
MON 4624	80
PP333	98

Definite changes in *Poa annua* vigor have been observed with Rubigan, a fungicide effective in controlling several turfgrass diseases. We have not observed injury at low levels of repeat applications of Rubigan (5 monthly applications of .2 to .4 a.i. per acre) (Table 4), but we have observed reductions in *Poa annua* at higher levels of application (5 monthly applications of .8 to 1.6 lb a.i. per acre). Repeat applications at the 1.6

lb a.i. per acre rate have injured bentgrass with some slight reduction of bentgrass density at 5 repeat applications of .8 a.i. per acre.

Table 4. The effect of five repeat applications of Rubigan on [*Poa annua*] percentage in bentgrass putting green turf.

	[*Poa annua*]	
Rubigan	1983	1984
a.i./A	(%)	Seedheads/dm^2
0.2	31	14
0.4	30	21
0.8	9	6
1.6	8	5
No treatment	38	9

Thus, the management decisions made daily can strongly influence *Poa annua* success. Large shifts in species composition of turfgrass can occur. Our data suggest PP333 or MON 4624 at selected rates plus stress can shift turfgrass composition toward lower composition of *Poa annua* and higher composition of more desirable bluegrass, ryegrass or bentgrass species. On the other hand, application at excessive rates or use of PGR's which exhibit less stress to *Poa annua* may shift populations toward higher levels of *Poa annua*.

INFLUENCE OF AMENDMENTS IN SAND ON BENTGRASS ESTABLISHMENT[1]

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[1] Presented at the 38th Northwest Turfgrass Conference, Sheraton Hotel, Spokane, WA, September 18-20, 1984.

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Quality turfgrass is most easily maintained on desirable root zones. Characteristics desired in a root zone include (1) minimum compaction tendency, (2) good soil water infiltration, (3) adequate aeration for deep rooting, (4) freedom from toxic chemicals, (5) an active microorganism population, (6) high cation exchange capacity, and (7) adequate water retention (Beard, 1973). Many times, however, turfgrass root zones contain much clay that does not allow for adequate aeration or water infiltration and percolation. On the other hand, root zones that are very sandy possess little capacity for retaining water and nutrients. Under either condition, root zone modification may be necessary. Coarse textured materials are added to root zones high in clay to improve aeration and water infiltration and percolation. Fine textured materials (usually organic) are added to sandy root zones to improve water and nutrient retention capabilities.

Modified root zones for golf course putting greens are essential for maintaining quality putting surfaces. Putting greens established and maintained on proper root zones provide a challenging test of skill for the golfer and make the golf course superintendent's job of maintaining that playing surface easier. It is estimated that the putting green represents only about 2% of the golf course area, but is utilized in about 75% of all golf course strokes (Beard, 1982). With all that foot traffic, in addition to machinery traffic, the tendency for root zone compaction is obvious. The root zone characteristics of primary concern for putting greens, then, are resistance to compaction while maintaining adequate aeration and water infiltration and percolation. The use of high percentage sand mixes have gained wide popularity for these reasons. Because sands offer little capacity for nutrient or water retention, however, various organic amendments have been added to sand to increase these parameters. Factors to be considered in selecting which amendments to use include (1) effect on soil texture, structure, and chemical properties, (2) long term stability, (3) availability, (4) amount required, and (5) cost (Beard, 1982). Peat is the most commonly used amendment. Other amendments that have been used include sawdust, shredded bark, calcined clay, vermiculite, perlite, and sewage sludge.

Recent research (Pepper, et al. 1982; Hershey, et al. 1980) has shown that another material, clinoptilolitic zeolite, may have promise for use as a soil amendment. Zeolites are crystalline, hydrated aluminosilicates. There are currently 40 types of zeolites known based on their chemical composition, structure, and related physical properties (Breck, 1974). Because of their specific 3-dimensional structure, zeolites can act as molecular sieves. A molecular sieve is a substance that will allow some molecules to enter and will exclude molecules larger than the substance's effective pore size. Thus, certain zeolites have affinity for specifictions or nutrients.

Table 1.

Amendment	Bulk density (g/cc)	Cation exchange capacity Meq/100 g	Meq/l
Sphagnum peat	0.1	100-500	100-150
Sawdust	0.25	10-60	25-150
Clinoptilolitic Zeolite	1.0	150-200	1500-2000

Values are as presented by Hershey et al., 1980.

Clinoptilolitic zeolite is a natural mineral that has recently been used as a root zone amendment for turfgrasses (Pepper, et al. 1982). It possesses a high cation exchange capacity, and due to its greater bulk density (see Table 1), the cation exchange capacity (on a volumetric basis) of clinoptilolitic zeolite is about 10 times that of other soil amendments such as sphagnum peat moss or sawdust (see Table 1). In addition, clinoptilolitic zeolite exhibits selective retention and gradual release of NH_4^+) and K^+ ions. Because of this, clinoptilolite can act as a slow release nitrogen (Pepper, et al. 1982) and potassium (Hershey, et al. 1980) fertilizer. Since nitrogen and potassium are the two turfgrass nutrients that are used in the highest amounts (Wray, 1974), it is reasonable to expect the addition of clinoptilolitic zeolite to sand root zones will benefit turfgrass quality. Use of clinoptilolite as an amendment for bentgrass or bermudagrass greens resulted in reductions of NH_4^+-N and NO_3^--N leaching losses, and increases in nitrogen use efficiency and water holding capacity of the root zone compared to nonamended sands (Pepper, et al. 1982).

Better nutrient retention (e.g. NH_4^+-N and K^+) is to be expected in sands amended with clinoptilolitic zeolite. Table 2 summarizes projected cation exchange capacities for sand and sand amended with 5, 10, and 20% sphagnum peat, sawdust, or clinoptilolitic zeolite based on values reported in Table 1. Instead of supplying nitrogen to bentgrass grown on high percentage sand mixes which have poor nutrient retention (low CEC) with relatively expensive slow release fertilizers, an alternative approach is to use an amendment that will not only increase the cation exchange capacity of the sand mix, but will serve as a slow release reservoir for both nitrogen and potassium. This would allow the use of relatively inexpensive forms of nitrogen (e.g., urea) to be used and still have a "slow release" effect.

Table 2.

	Projected cation exchange capacities (meq/l) Rate %			
Amendment	0	5	10	20
Sphagnum peat	28	33	38	47
Sawdust	28	31	34	40
Clinoptilolitic Zeolite	28	117	205	382

Soil topdressing adds approximately 55 meq/l CEC to the surface 1/2 inch.

An experiment was designed at Washington State University's Farm 5 Experimental Station to test the efficacy of clinoptilolitic zeolite versus sphagnum peat, or sawdust when added to sand at 5, 10, and 20% (by volume) for bentgrass establishment and quality. Sewage sludge was also used, but only at a single rate (3.5%). The experiment was arranged as a randomized complete block (three replications) and eleven treatments including a control with no amendment added. In an effort to increase cation exchange and water hold/ing capacities of the root zone surface, a thin (1/8 inch) layer of screened topsoil was added to the surface of half of each 1 x 2 meter plot and raked into the surface 1/2 inch. Although this will no doubt cause a reduction in water infiltration and oxygen diffusion into the root zone, it is hoped that aerification techniques (spiking and coring) combined with sand topdressing will quickly alleviate those problems, but leave intact the benefits of added CEC and water holding capacity of the root zone surface. Various physical and chemical properties of the mix are to be evaluated including water holding capacity, total cation exchange capacity, bulk density, percent carbon, and water infiltration and percolation. Parameters to evaluate turf response will also be evaluated including establishment and quality ratings. Since "Penncross" creeping bentgrass was planted on August 17, data are available, at this time, for establishment ratings only.

Average establishment ratings for "Penncross" creeping bentgrass are shown in Table 3. From these data, several points can be made:

1. All treatments receiving some amendment gave superior establishment to 100% sand except sawdust at 10 and 20% rates.
2. The addition of topsoil reduced establishment ratings on all plots. It must be noted, however, that no spiking or coring had been done at this time. Since extensive spiking and coring will be done before final turf quality ratings are evaluated, final judgment concerning soil topdressing on turf quality remains to be seen.

3. Clinoptilolitic zeolite shows promise as an amendment, compared to peat and sawdust, for bentgrass establishment.

4. Sewage sludge, at the rate applied, did not result in superior turf establishment compared to peat or clinoptilolitic zeolite.

5. The addition of undecomposed sawdust at 10 and 20% rates resulted in poor establishment probably due to nitrogen deficiency caused by nitrogen tie-up by decomposer microorganisms.

Table 3.

	Average establishment ratings	
Root zone mix	Alone	With soil topdressing
100% Sand	5.8	5.1
5% Sawdust	6.8	5.9
10% Sawdust	5.7	4.9
20% Sawdust	5.8	5.8
5% Peat	6.8	5.4
10% Peat	7.3	6.1
20% Peat	7.8	6.3
5% Clinoptilolite	6.9	5.2
10% Clinoptilolite	7.4	7.1
20% Clinoptilolite	8.2	8.1
3.4% Sludge	6.9	6.9
Average	6.9	6.0

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TEE AND BUNKER DESIGN AND CONSTRUCTION: FACTORS TO CONSIDER[1]

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Unfortunately, the design and construction of teeing areas and sand bunkers all too often appear to be a second thought when a golf course is being developed.

Obviously, the teeing area is where the game begins. Why then are so many tees little more than postage stamp shaped areas, more dirt than grass, wrinkled or warped and bumpy and divot scarred? Or, as a last result, merely a patch of synthetic turf or a poor quality brush to hit off?

The teeing area is a fundamental part of the game of golf! A poorly hit tee shot directly and indirectly affects all those shots which follow. Golfers have a hard enough time just hitting the ball correctly from a perfect lie, let alone trying to hit off an irregular, divot scarred patch of more or less grass.

While sand bunkers do not influence play as drastically as do the tee shots, poorly positioned bunkers can cause grief to the unlucky or careless golfer. Bunkers should certainly provide a penalty for the miss hit shot. They also can penalize unjustly. Poorly constructed bunkers frequently offer wet or soggy sand which in itself is a very unpleasant matter to content with when one has enough problem merely keeping the ball near the fairway.

Preventing problems with teeing areas and sand bunkers begins with the golf architect and the design process.

TEEING AREAS

It is an easy enough matter to design teeing areas which are functional and attractive. Tees need not resemble postage stamps. Teeing areas should be large in area and can be numerous in teeing positions. As there are more than three levels of golfing ability, consider providing four or even five distinct teeing positions. In doing so, larger surfaces result. More surface permits more movement of the tee markers. Larger surfaces help spread out the wear and tear. Larger surfaces allow more recovery time for the turf before the tee markers are returned to any given location. Larger surfaces offer the possibility of more variety and therefore more interest in the tee shot.

When considering larger teeing areas, do not be bound by rectangular or rigid, elongated shapes. An attractive arrangement of the teeing areas for each hole can provide variety in playing length and can provide the option for change in the angle of the tee shot as well. Especially with resort courses or membership clubs, variety enhances the game while stereotyped sameness brings on boredom.

Designing the positions, orientation and alignment of teeing areas must also consider safety. There are too many examples of teeing areas actually directing the golfers shot out-of-bounds, into an adjacent fairway or toward just the hazard which best should have been avoided.

Regardless of the cause, the golf architect must make every effort to assure that the teeing areas are situated so that the normal or even somewhat abnormal tee shot does not land in someone's backyard, go through a window or catch the unwary golfer on a too near adjacent green or tee. Injury does result and deaths have occurred due to careless teeing locations or inadequate concern for teeing areas and their relationship to other portions of the course or adjacent areas.

Part of this problem is due directly to the fact that many golfers do not pay attention. They line up on the tee markers or the edges of the teeing surface, not on the center of the fairway or greensite towards which they are actually wanting to aim. Misalignment of tees can be the result of inattentive design or inattentive construction. Maintenance personnel who set the tee markers do not always align the markers exactly perpendicular to the center of the intended aiming point. The design of each teeing area must attempt to direct the golfer to the center of the intended target. Every effort must be made to reduce the chances of injury resulting from the incorrect placement, orientation or alignment of teeing areas. As golf courses become ever more crowded, the possibility of injury or worse increases.

It is still common to find out-of-the-way courses on small sites where tee shots may be across adjacent greens or where two fairways cross one another. Insufficient space and too much golf therein is a separate but potentially serious safety factor. Fortunately, low golfer use on these small courses lessens somewhat the potential for injury.

Designing large tees can offer variety, safety, turfgrass management advantages and beauty. Free form teeing surface shapes, elevated teeing areas, teeing areas merely set into the existing terrain or vegetation, ornamental wall treatments and even an occasional flower bed adjacent to the tees offer wonderful scenic experiences which further contribute to the enjoyment of the game of golf.

Five distinct teeing areas on one hole could afford championship length, men's long, men's regular, men's and women's forward tees and also a teeing position for seniors, beginners and young juniors. Large and diverse teeing areas can and should result in a variety of shapes of the tee surfaces. Both to fit the design objectives and the specific site conditions, variety in size, outline shape and alignment to the target are advised. Golf is a game for all ages, both male and female. Variety in playing length through the use of multiple teeing areas is one of the surest ways to achieve fairness and equality of play.

The lesser used teeing positions, generally the professional or championship tees and possibly the forward short tees, can be of a smaller surface area than the men's regular and men's and ladies' front tees where the majority of play occurs. In total on an individual hole, a usable teeing surface of not less than 5,000 square feet is recommended. In actual fact, on par 3 holes, combined surfaces on an individual hole could easily reach 8,000 square feet or more. Par 4 and Par 5 teeing areas desirably should exceed 7,000 square feet with the shorter par 3's reaching 10,000 square feet of usable tee surface. Only on courses which have annual play of perhaps 20,000 rounds or less should smaller teeing areas be considered acceptable.

Modern maintenance equipment permits very rapid mowing of tee surfaces, thus requiring very little extra time to mow a somewhat larger area. It is certainly less expensive and time consuming to mow a few thousand extra square feet of teeing area than it is to aerify, resod or frequently overseed and topdress in an attempt to get some grass to grow.

Construction of teeing surfaces must give careful attention to the seedbed in which the grass is expected to grow. Too many worn out teeing surfaces are the result of inadequate initial soil preparation or no soil preparation at all.

Grass obviously grows in soil; however, under concentrated foot traffic and excess moisture, most soils sooner or later become thoroughly compacted. Turfgrass cannot survive under conditions of extensive soil compaction. If teeing surfaces are to provide lush uniform swards of grass, a growing medium should be provided which resists compaction and enhances root growth.

The platform upon which the turfgrass of the teeing surface is to be grown must be constructed to provide a true, flat, uniform surface. Irregular tee surfaces only magnify existing swing weaknesses in most golfers.

The tops of teeing surfaces should be absolutely flat from side to side and it is recommended that the surfaces slope rearward uniformly by one or one and one-half percent to provide surface water drainage. A flat surface side to side assures reliable and consistent footing.

The side slopes around the teeing areas should be quite long and gently. The teeing areas do need to be elevated somewhat above the surrounding terrain to prevent excess water from flowing onto the surfaces; however, the tees should not be so elevated as to represent burial mounds. The side slopes should not be steep, especially so steep that a climbing rope might be needed in order to mow the grass. Side slopes should be constructed to accept triplex type mowing equipment.

Teeing areas can be set at varying heights above the adjacent terrain for aesthetic purposes. Teeing areas can be attractively set into sloping ground. In some cases, retaining walls of stone or wood can be used to terrace a series of teeing areas. The use of ornamental walls, sometimes also with adjacent flower beds can create very beautiful teeing areas, not merely a flat patch of more or less live grass. The use of ornamental walls should occur when such treatments will appear to be of natural and local materials.

The teeing surface seedbed should be constructed to provide subsurface drainage. Depending upon the climate and rainfall of the specific area, an extensive subsurface drain pipe and gravel layer can be used or a less elaborate arrangement of gravel encased perforated pipe can be used. Unless the existing subsoils are naturally very porous, some amount of subsurface drainage facilities should be installed within each teeing area. The gravel used should be of uniform small diameter and washed free of silt and clay.

The seedbed mixture of the teeing surface should be similar to that which is generally used for putting greens; that is, a uniform mixture of carefully selected sand and organic humus.

The seedbed mixture need be only between 6 and 8 inches in thickness. The important factor is the uniform consistency of the sand used. A correctly sized sand material will greatly resist compaction and provide good drainage. Existing sandy soils may only require the addition of organic humus to be acceptable as the teeing surface seedbed.

The final teeing surface must be properly smoothed before turfgrass planting. All too often the top of even newly constructed tees are carelessly or unknowingly finish graded to an irregular surface. Occasionally, even the architect specifies a crowned surface or one banked at a particular angle or one sloping totally forward along the line of play. In each instance, the results do not favor the majority of golfers. Furthermore, a forward sloping and draining tee deposits the excess water right where the golfers will walk, thereby enhancing the likelihood of compaction problems.

It may seem economical to construct teeing surfaces of limited size or using only the available local soils with no seedbed amendments; however, such actions are short sighted and self defeating. There is no more justification for building an undersized teeing area or building the tee of some local soil or 'dirt' than using a similar procedure to construct a putting green. The results will be inferior and sooner, rather than later, remodeling will become necessary to correct the earlier built-in problems, at a substantially greater cost.

Driving range teeing areas deserve the same attention as any other teeing surface. The main criteria, however, is to provide the largest amount of usable surface which available space will permit. The width of the tee to accommodate some number of golfers must be addressed, yet it is the depth of the teeing surfaces which allows frequent and regular repositioning of the tee markers to permit adequate turfgrass recovery.

The selection of the particular turfgrass to be used for teeing surfaces remains a site specific decision. There are numerous varieties of bluegrass, ryegrass and fescues, as well as several creeping bentgrasses, which alone or in mixture provide excellent turf surfaces in the cool or temperate and northern climates. The specific objectives and anticipated maintenance budget can directly influence the particular species or varieties selected. In any case, select only certified and very pure seed of the highest quality attainable and of the most recent crop available. There is no such thing as "bargain prices" on seed. The cost of seed relative to the cost of the overall project is minimal. Weed infested seed is a disaster. Purchase only the finest seed from a reputable supplier.

In tropical locations and in regions where year round temperatures are mild, the hybrid Bermudagrasses provide the most desirable turf for teeing surfaces. Tifgreen is the longtime standard and has been used widely on both fairways and putting greens. The variety Santa Ana has shown good vigor and surprisingly so in rather cool subtropical climates. There are several other hybrid Bermudagrasses available with some area specific adaptations. The recently introduced hybrid Paspalum species shows promise as a vigorous and wear resistant possibility for warm climates.

Teeing areas are vitally important to the game of golf. It is high time more attention is directed to providing proper teeing surfaces!

SAND BUNKERS

Sand traps or sand bunkers originated, as did so much of golf, within the spontaneous actions of nature. The locations of the early bunkers were not due to man's calculations but to the instincts of sheep or rabbits. The appearance of the early bunkers were, too, the result of spontaneous forces, not preconceived contrivances. The impact of these natural sand traps upon the golfers' efforts were not cosmetic or superficial. The early bunkers were a definite hazard, something to be avoided at all cost as the potential for exit from one of these bunkers was not always easily assured.

The origins of sand bunkers and their incorporation in the game of golf as that game evolved in the early and formative times was such that a bunker was unquestionably a penal hazard to be judiciously avoided at all costs. It is no longer the case that sand bunkers are a penal hazard or even much of an intimidating factor at all on many courses. Sand bunkers have become an ornament - more aesthetic than intimidating or penal. The design of the sand bunkers into the overall golf hole layout concept has been standardized and stereotyped by many architects. The wishes of many golfers, to be able to recover from a sand bunker with the same ease as from the fairway, also has contributed to the lessening of the role once played by sand bunkers as hazards or penal elements.

Individual golf architects tend to have their own ideas regarding the size, shape, number and appearance of the sand bunkers on their own projects. The range of design style easily runs from the round and flat to the very large and very deep. The specific design objectives of each individual hole should determine the use or absence of a bunker on that hole. There is no fixed size or number of bunkers which must be found on any hole or any course. When design philosophy or natural site conditions dictate large and deep bunkers, that should be the solution. Natural vegetation, hillocks or hollows, slopes and mounds can replace bunkers in many instances. To always design small, unintimidating sand traps merely dilutes the traditional nature of the game. In many instances, superficial sand bunkers are better filled and converted to mounds.

The design and use of sand bunkers as a means of guiding the golfer, for definition along a fairway or at a greensite, can be necessary. To strategically position bunkers, and to use them in definitive ways, is highly desirable. To use bunkers more for show or without definite function is to be avoided. Placement of bunkers should test the better golfers and not intimidate the inexperienced or high handicap type golfers. Position and placement of the sand bunkers should almost always insure visual identification by the golfer prior to hitting the golf shot which is to be influenced by that sand bunker. Blind sand bunkers, as with any hazard, should be avoided; although it is easy enough to point to properly fine golf courses where the occasional sand bunker is totally obscured from even the most exacting of approach shots.

The sculpturing of the outline of a bunker can provide a very pleasing aesthetic appearance. "Noses" or "capes" of turf flowing down the side of the bunker basin can be quite attractive. In some instances, the use of retaining walls of railroad ties or vertical faces of sod, called revetiments, add a factor of uniqueness or special character. The use of such ornamental treatments should be carefully done to maintain balance and purpose. Careful attention to the impact of the ball against a retaining wall must be considered for safety purposes. The design of sand bunkers must allow for practical and reasonable means of maintenance.

Sand bunkers must be constructed so as to present that necessary element of visibility to the oncoming golfer. Flat bunkers with no elevated portions blend too often into the adjacent terrain. Sand bunkers should be constructed in such a way as to be elevated above the adjacent terrain. This is to minimize the flow of water from surrounding areas into the basin as well as to provide for golfer visibility. Also, when elevated, the basin area has more opportunity for gravity flow drainage assistance. An elevated bunker also permits more latitude in the contour sculpturing of the basin and the surrounding adjacent mounding in order to achieve a more natural and pleasing appearance. Steep faces of sand cannot be maintained in areas of high or intense rainfall. The use of grasses slopes can compensate for this erosion effect. The construction must consider maintenance and the climate's effect.

The construction process to shape the bunker sand holding basin should also provide for drainage from within the basin. Soggy sand or a pool of water rather detracts from the purpose of the sand bunker as a fair hazard. The drainage may be accomplished through the use of vertical holes or sumps excavated beneath the basin to a depth where a permeable subsoil strata is intercepted. Backfill this vertical sump with a uniform mixture of well washed, silt and clay free crushed gravel or river run small stone.

A trench to contain perforated drainage pipe and an encasement of clean uniform, small diameter gravel offers a means of draining bunkers on heavy soils. The trench and drain line should follow the flow line of the bunker basin. The pipe, now non-perforated, should carry the drainage water from the edge of the basin to a discharge point out of the area of normal play.

The tendency to create saucer shaped depressions in the earth and call these bunkers is a grave deviation from the origins of the true sand bunkers. Practical expediency precludes creating sheep wallows; yet there needs to be a continued effort to protect the grand traditions of golf and natural appearing, sometimes deep sand bunkers are one part of that tradition. To remove bunkers, to make them shallow and defenceless at the whim of some golfer, who in all likelihood is not even near average or better in ability, contributes to the lessening of the standards of the game. A bunker which is flat and formless is monotonous.

The problem with golf today is that there are too many mediocre golf courses. As one learns to play the game - if the learning experience occurs only on mediocre courses - the tendency is to expect all courses to follow suit. Is it not time golfers were expected to raise their abilities to play the game, not lower the quality of the courses to match the golfers?

Creating dramatic and variable teeing areas and fearsome, yet beautiful and strategically functional sand bunkers are two means of enhancing the challenge and true enjoyment of a game whose rich traditions should be carefully protected and perpetuated. Remember - in its origins, golf was never meant to be easy!

THE EFFECTS OF ENDOTHAL, ETHOFUMESATE, AND FENARIMOL (RUBIGAN) ON ANNUAL BLUEGRASS SEEDLINGS[1]

J. L. Gullikson and W. J. Johnston[2]

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[1] Presented at the 38th Northwest Turfgrass Conference, Sheraton Hotel, Spokane, WA, September 18–20, 1984.

[2] Turfgrass Management Student and Assistant Professor, respectively, Washington State University, Pullman, WA.

The use of the herbicides Endothal (Endothall) and Nortron (Ethofumesate) have been popular chemical control methods for annual bluegrass *Poa annua* L. for many years. Recently, interest has been generated about the use of the fungicide Rubigan (Fenarimol) for controlling annual bluegrass. In a study conducted at WSU, Rubigan, Endothal, and Nortron were tested for control of annual bluegrass seedlings, and for their effects on bentgrass turf.

The experiment was divided into two areas of study; a greenhouse study and a field study. The objectives of the greenhouse study were to compare annual bluegrass control with Rubigan, Endothal, and Nortron, with different application rates and at various growth stages.

The application rates selected for each of the compounds were based on the manufacturers' recommendation for control of annual bluegrass. Each compound was sprayed at the recommended rate, half the recommended rate, and twice the recommended rate. Specifically for Rubigan, these rates were 1 oz, 1 oz, and 4 oz per 1000 ft². Endothal and Nortron were both applied at rates of 1/2 lb, 1 lb, and 2 lb per acre.

The annual bluegrass seedlings were individually planted in small tubes and grown under ideal conditions in the greenhouse. They were then sprayed pre–germination, and at the 1–leaf, 2–leaf, 3–leaf, and 4–leaf stages.

The annual bluegrass seedlings were rated for vigor two and four weeks after being sprayed. The ratings were based on the percent injury of a healthy untreated check.

The data in Table 1 illustrate that Rubigan was the superior compound in controlling annual bluegrass, followed by Endothal and Nortron. Also evident is the fact that all three compounds showed better control at the younger growth stages than at the older stages.

Table 1. Percent control of annual bluegrass.

Leaf Stage	Rubigan 1oz*	Rubigan 2oz	Rubigan 4oz	Endothal 1/2lb	Endothal 1lb	Endothal 2lb	Nortron 1/2lb	Nortron 1lb	Nortron 2lb
1	100	100	100	44	63	69	100	85	85
2	91	94	94	30	40	76	0	30	33
3	83	90	90	24	27	54	0	29	44
4	100	75	80	58	13	62	60	25	60

* % of check at 4 weeks.

Germination rates were also affected by the use of Rubigan, Endothal, and Nortron, as seen in Table 2. Rubigan and Nortron completely inhibited the annual bluegrass from germinating at all three rates, while Endothal was less effective at preventing germination.

Table 2. Effect on annual bluegrass germination.

Rate	Rubigan 14	Rubigan 30	Endothal 14	Endothal 30	Nortron 14	Nortron 30
	-----------(Time after application (days)---------					
X	0*	0	33	33	0	0
X	0	0	67	67	0	0
2X	33	0	0	33	0	0

*%of check

A field study was conducted to observe the bentgrass injury caused by Rubigan, Endothal, and Nortron. The field study also looked at the applications of nitrogen and iron to mitigate the turf injury caused by these compounds.

For the field study, a Penncross bentgrass green was used. The green was mowed at 3/16 inch and was watered as necessary to maintain a fine quality turf. Due to a space limitation, Rubigan, Endothal, and Nortron were only applied at the recommended and twice the recommended rates.

The mitigators that were used consisted of nitrogen ($(NH_4)^2SO_4$), and iron ($FeSO_4$). Nitrogen was applied at a rate of 1 lb N/1000 ft², while iron was applied at a rate of 1 oz/1000 ft². The mitigators were applied at one of three intervals; either four days prior to the herbicide treatment, four days after the herbicide treatment, or in split applications with half of the mitigator being applied before the other half going out four days after the herbicide treatment.

Table 3 shows the injury caused by the herbicide treatments without regard to the use of mitigators. It can be seen that the Rubigan plots showed an initial green up, and then decreased in appearance as time progressed. Endothal had the opposite effect, and initial turf decline followed by an increase in quality as time progressed. The Nortron plots seemed to decrease in appearance as the study progressed. At the end of the 30 day test period, the Endothal plots looked better than the untreated check plots; whereas the Rubigan and Nortron plots remained damaged by the herbicide treatments. Application rate differences for each of the compounds were also evident with the higher rates receiving the most damage.

Table 3. Injury caused by compounds without regard to mitigators.

Days after treatment	Rubigan 2oz	Rubigan 4oz	Endothal 1lb	Endothal 2lb	Nortron 1lb	Nortron 2lb	Non treatment check
8	7.2	7.2	5.2	3.8	6.2	6.2	6.9
16	7.0	6.8	6.6	6.0	6.1	4.7	6.9
30	5.4	4.7	6.5	6.5	4.9	3.8	6.0

Appearance 1-9; 9 = excellent

Both iron and nitrogen were successful in masking the bentgrass injury caused by the use of Rubigan, Endothal, and Nortron. Table 4 illustrates this fact by comparing the mitigator treated plots to the treated checks which received neither iron nor nitrogen. It can be seen that nitrogen was the most effective mitigator of the Rubigan and Endothal injury, while iron showed slightly better results on the Nortron treated turf.

Table 4. The effects of iron and nitrogen as mitigators without regard to rates.

Days After trt.	Rubigan N	Rubigan Fe	Rubigan Trt. ck.	Endothal N	Endothal Fe	Endothal Trt. ck.	Nortron N	Nortron Fe	Nortron Trt. ck.	Check
8	7.4	7.0	6.4	5.4	4.9	3.2	6.0	6.4	6.2	6.9
16	7.2	6.8	5.8	7.1	6.2	5.2	5.0	5.3	5.1	6.9
30	5.6	5.2	3.8	7.3	5.7	5.6	4.9	4.9	4.6	6.0

Appearance 1-9; 9 = excellent

The effects that timing of mitigator applications had on the recovery of the injured turf, over the 30 day period, were only slight and depended on the herbicide and mitigator used. The results presented in Table 5 show no difference in the time of mitigator application affecting Rubigan injury for iron treatments, and only slight improvements for nitrogen applications that were applied prior to the Rubigan being sprayed. Endothal injury, on the other hand, (Table 6) was best mitigated when nitrogen was applied after the Endothal was sprayed. Iron applications for masking Endothal injury were not affected by timing of application. Nortron injury (Table 7) was best mitigated when either the iron or nitrogen was applied prior to the Nortron treatment.

Table 5 Timing of mitigator applications afffecting Rubigan injury.

	Nitrogen			Iron			
Days post trt.	Pre	Post	P + P	Pre	Post	P + P	Trt. ck.
8	8.0	6.4	7.7	7.4	7.1	7.1	6.4
16	7.4	7.3	7.2	6.7	6.7	6.8	5.8
30	5.5	5.1	5.1	5.1	5.1	5.1	3.8

Appearance 1-9; 9 = excellent
Values equal means without regard to Rubigan rates.

Table 6. Timing of mitigator applications affecting Endothal injury.

	Nitrogen			Iron			
Days post trt.	Pre	Post	P + P	Pre	Post	P + P	Trt. ck.
8	5.3	4.2	4.0	4.3	4.4	4.4	3.2
16	6.9	6.8	6.8	5.8	6.1	5.9	5.2
30	7.2	7.7	7.0	5.7	5.9	6.0	5.6

Appearance 1-9; 9 = excellent
Values equal means without regard to Endothal rates.

Table 7. Timing of mitigator applications affecting Nortron injury.

	Nitrogen			Iron			
Days post trt.	Pre	Post	P + P	Pre	Post	P + P	Trt. ck.
8	6.4	5.7	6.2	6.3	6.1	6.6	6.2
16	4.8	4.9	4.7	5.0	4.9	5.0	5.1
30	4.9	3.8	4.3	5.1	4.3	4.3	4.6

Appearance 1-9; 9 = excellent
Values equal means without regard to Nortron rates.

In conclusion, Rubigan, Endothal, and Nortron were all successful in controlling annual bluegrass. It should be remembered that the rates of Rubigan used were the recommended rates for the control of annual bluegrass, and are much higher than the recommended rates for disease control. Annual bluegrass was better controlled at the early growth stages than at the older stages.

While Rubigan, Endothal, and Nortron were successful at controlling annual bluegrass, they also had an effect on bentgrass turf. Endothal caused the least amount of turf injury over the 30 day test period, followed by Rubigan and Nortron. Nitrogen and iron were successful in mitigating the injury caused by the herbicides, with the effects dependent upon the timing of the mitigator application and the herbicide used.

INVOLVEMENTS OF A CITY PARKS FOREMAN[1]

Bob Teufel[2]

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[1] Presented at the 38th Northwest Turfgrass Conference, Sheraton Hotel, Spokane, WA, September 18-20, 1984.
[2] Parks Foreman, City of La Grande, La Grande, OR.

Having attended different conferences over the years, the Northwest Turf Conference, in my opinion, is the cadillac of them all. The speakers and timing are great and splitting the session adds another plus.

After attending a conference, talking with others in our field, listening to speakers on different subjects and relaxing, we can't help but get pumped with ideas and facts. Then we head home with our brains buzzing only to face reality.

I am interested in how other first line supervisors do the: WHAT, WHEN, WHERE, WHY'S AND ANSWER ALL THE "HOW COMES".

I contacted Dr. Roy Goss about giving a presentation titled "Involvements of a City Parks Foreman".

The City of La Grande is located in northeastern Oregon. Portland is 260 miles to the west, Boise is 185 miles to the east, Tri Cities is 130 miles to the north. We are located in Union County with a population of 26,000, with 11,000 living in La Grande.

We have an elevation of 1700 feet, surrounded by hills, with elevations running up to 7100 feet. Average rainfall is 20 inches with low temperatures of 0° and highs of 100°. Snowfall is 18 inches and we have a growing season of six months. Our operating budget is $137,000 which breaks down to $58,000 for personnel, $32,000 for materials and services, and $47,000 for capitol projects.

La Grande city limits cover an are of 2 x 2-1/2 miles. As Park Foreman, my job is to take care of 35 acres located in 19 different areas with about six different types of soil.

AREA BREAK DOWN

Area 1	9 acres Athletic complex	Heavily used 7 days a week April through August
Area 2	7 acres Family Orientated	Heavily used 7 days a week June through September
Area 3	City Hall 4,000 sq. ft. turf 2,000 sq. ft. shrub beds	High visual
Area 4	Public Library 3,000 sq. ft. turf High visual Public Library 2,000 sq. ft. shrub bed	
Area 5	Bernie Park	3 acres
Area 6	Connerdale Park	2 acres
Area 7	Benton Park	2.5 acres
Area 8	Pioneer Park	2 acres
Area 9	Pioneer Tennis Court	2-2 units
Area 10	High School Tennis Courts	1-4 unit
Area 11	Public Swimming Pool	(Mechanical functions)
Area 12	Public Restrooms	2 double units
Area 13	Public Parking Lots	2 - Planters and weeds
Area 14	Riverside Pavilion	
Area 15	Morgan Lake	70 acres 6 pit toilets
Area 16	Garden Club Park	.5 acre
Area 17	Viaduct	2,000 sq. ft. shrub bed
Area 18	Gangloft Park	2.5 acres unimproved
Area 19	Unimproved and future parks	6+ acres 3 different locations

To check these 19 areas is an 8+ mile round trip drive.

I am also responsible for snow removal in the winter on 10,000 sq. ft. sidewalks and 1,000 steps in various areas with heavy pedestrian traffic, plus some park areas.

The La Grande Parks and Leisure Department is made up of a Director and Foreman who are full time, one part-time secretary and a seasonal crew of 7 people working four 10-hour shifts.

POSITION		Work Schedule M	T	W	T	F	S	S
#1	6 months April/September	x	x	x	x			
#2	6 months weekend May/October				x	x	x	x
#3	6 months May/October	x	x	x	x			
#4	3 months June/August		x	x	x	x		
#5	3 months June/August			x	x	x	x	
#6	3 months June/August	x	x	x	x			
#7	weekend May/July						o/c	o/c
Foreman	Full time	x	x	x	x	on-call		

40 hour week. Seasonal pay scale $3.55 to $5.57.

Other help for the 83/84 season consists of 200 hours Community Service, 500 hours Work Release from County Jail and 400 hours CETA.

We maintain these areas (try to) with a line of equipment that runs in age from 1956 to 1984 models. We have a rolling stock of 2 tractors, 1 front deck mower, 3 pickups (with graders) and 1 Cushman truckster. I believe that each piece of equipment has to be universal for maximum efficiency. Our tractors are adaptable to various pieces of equipment such as, one 6-foot rear deck mower, one 12-foot reel mower, backhoe, spreaders, sprayers, aerators, blades, drags, etc.

As a grounds keeper you are aware of all the time-consuming jobs we are faced with, along with the ones we personally want and are expected to accomplish. We can be summed up in an old phrase: "JACK OF ALL TRADES AND MASTER OF NONE".

I have always found it interesting how a first line supervisor can attend a conference, listening to a number of professionals in their prospective fields, grasp some of the information, return to reality and fill in ideas and facts in an already over-loaded maintenance program.

In closing, I would like to thank the Association for this opportunity to speak on my job as a grounds keeper. I urge all of us attending to support and pass the word around to others in our field about this great program. I am sure that all of us would like to be more open about our situations. Let's get to know each other and exchange ideas. We are all different individuals, working under different situations, some from large complex areas and some from small towns. We are all valuable resources of information and can learn a great deal from each other.

UNDERSTANDING AND USING NITROGEN[1]

By Dr. Roy L. Goss[2]

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[1] Presented at the 38th Northwest Turfgrass Conference, Sheraton Hotel, Spokane, WA, September 17-20, 1984.

[2] Extension Agronomist-Turfgrass Specialist, Western Washington Research and Extension Center (WSU), Puyallup, WA.

With the exception of two products, melamine urea and oxamide, nitrogen sources for turfgrass fertilization have remained rather constant over a number of years. Nitrogen sources are classified as [organics], [synthetic organics], or [inorganic]. Organic or synthetic organics contain carbon as part of their molecular structure while organics do not. Inorganic forms of nitrogen are soluble and so is the synthetic organic, urea. True organic forms of nitrogen (derived from plants and animals) are not soluble until the source material is completely broken down by soil microorganisms and proteins and other N-containing compounds are converted to plant useable nitrogen - $NO3-$ (nitrate ion) or $NH4+$ (ammonium ion). This is a slower process.

Chemists have learned that reacting soluble urea with formaldehyde, isobutraldehyde, and other materials can alter the structure of urea so that it is no longer soluble and nitrogen is released over a long period of time. Hence, we have slowly soluble nitrogen. Urea formaldehyde (Nitroform methylene urea, Formolene, etc.), oxamide, melamine urea, and IBDU are all slowly soluble forms of N. Methylene urea is the fastest acting form of these slowly soluble sources due to shorter "molecular chains'. Materials such as sulfur coated urea (urea prills coated with molten sulfur) and Osmocote (urea prills coated with a plastic-like material) are slow release since urea inside the "shell" becomes liquid when water is applied and is slowly released through microscopic pores or cracks in the shell.

WHAT HAPPENS TO THESE PRODUCTS AFTER APPLICATION?

There are many myths and false claims made about slowly soluble and slow release products and with the foregoing description, let's briefly examine the factors that influence release of plant available N.

Water: All nitrogen-containing compounds require water "the universal solvent" to dissolve and carry the nitrogen to a position for plant uptake. This reaction is hydrolysis. If the nitrogen is not in solution, a plant cannot absorb it.

Favorable Soil Temperature: All organic or synthetic organic forms of N require soil temperatures over 50°F for optimum N release (may be as high as 70°F). Soil microorganisms that decompose organic matter and nitrifying bacteria are sluggish or relatively inactive at low temperatures. These soil microorganisms supply an important [enzyme] - [urease] which is essential for breaking the complex molecule urea into simpler N compounds. Nitrifying bacteria do the rest, taking simple N compounds through a series of reactions to NH4+ and NO3-. The NH4+ is not stable in the soil and is rapidly converted to NO3- when all conditions are optimum (water, temperature and bacteria). At low soil temperatures the NH4+ may remain in this form and does not leach readily if the soil has any cation exchange capacity (organic matter or clay) but can be utilized by grasses in this form. The NO3- is not bound or attached to clay or organic matter and is readily utilized or leached.

Soil microorganisms: Soil microorganisms must be present in large numbers to provide the functions discussed above. Sands devoid of organic matter or recently fumigated soils may be devoid or have low populations of microorganisms and explains why ammonium nitrate or ammonium sulfate provide faster plant response.

Leaching Responses

For simplicity I shall categorize the most commonly used N compounds into fast, intermediate and slow leach rates.

[Fast]: (Solubles)
Ammonium nitrate 33.3%
Calcium nitrate 14%
Sodium nitrate
Potassium nitrate
Urea 46%
Ammonium sulfate 21%

[Intermediate]
Methylene urea - variable N
IBDU 31%
Sulfur-coated urea 32-36% (depending on sulfur shell thickness)

[Slow]
Urea formaldehyde 38%
Natural organics including sewage sludges - variable N

SOME KNOWN FACTS ABOUT NITROGEN SOURCES

To help guide you in making judgments in the use of nitrogen and in purchasing, I have listed some facts you may find useful.

1. Urea is the least expensive form of nitrogen, followed by ammonium nitrate and ammonium sulfate.

2. Organic nitrogen is usually the most expensive followed by urea formaldehyde (including methylene urea), IBDU, melamine urea and sulfurcoated urea.

3. IBDU and SCU - slowly soluble and slow release, respectively, become soluble in the presence of water at temperatures above freezing, BUT DO REQUIRE HIGHER TEMPERATURE for the conversion of urea to NH4 or NO3. They are both ureas.

4. All forms of urea, ammonium nitrate and sulfate will lower soil pH. Calcium nitrate will raise soil pH.

5. Leaching losses are higher from urea, ammonium nitrate and sulfate, calcium nitrate, potassium nitrate and sodium nitrate than from UF, IBDU, SCU, melamine urea and natural organics.

6. Plant tissue burning is greater from solubles than slowly soluble and slow release due to higher salt indices, and should be applied in smaller amounts more frequently.

7. Plant nitrogen availability during the first 10 days is greater for solubles than slowly soluble or slow release. SCU and methylene urea releases faster than IBDU and UF.

8. IBDU releases N over a slightly longer period of time than SCU, but not as long as UF.

9. Ammonium sulfate reduces incidence of Fusarium patch and take-all patch (Ophiobolus) more than urea sources.

In conclusion, the purpose of this paper is to show comparative differences among various N sources and their modes of action. Some sources are more expensive than others considering purchase price per pound of N but may not cost significantly more when you consider labor costs of application, leaching losses and mistakes made by inexperienced operators. These are some of the facts and individuals must make their own judgments based upon their relative positions and budgets. Also remember that blends are often good compromises.

REEL VERSUS ROTARY MOWERS[1]

Roger J. Thomas[2]

[1] Presented at the 38th Northwest Turfgrass Conference, Sheraton Hotel, Spokane, WA, September 18-20, 1984.
[2] Jacobsen Division of Textron Inc., Racine, WI.

The age old controversy of reel mowers versus rotary mowers continues on and on. Areas to be maintained vary so much between cities, school districts, county highways and parks and institutions, that the most one can do is present a few guidelines for thought.

LEVEL OF MAINTENANCE

To determine the proper machines to use, a level of maintenance must be determined. Formal turf can be defined with the following concepts in mind:

A well groomed area mowed weekly or more often during the good growth period of the turf. Another view may be if the appearance of the area is important as a showplace, for example, schools, municipal buildings, parks, and athletic fields, the classification can be, formal turf. Another element to test is whether there is a weed control program, or are clippings being collected. In any event, if the quality of cut *is* important, then the level of maintenance can be considered, formal turf.

Semi-formal turf generally is defined as a mowed area a distance from general viewing, weed control in itself does not seem to be the most important element, and even some skip/mow programs can be initiated. Higher cut of the grass is generally acceptable, yet suitable to walking traffic and the appearance is not quite as important as for formal turf.

Informal turf would be considered for areas of weeds and grasses that may well adapt to a skip/mow program. They are viewed by the public from some distance, and quality of cut is not the most important element. It could almost be defined as "It's green so it is satisfactory". Informal turf is mowed at cutting heights of 3, 4, or 5 inches, and generally not a walking traffic area.

ENGINE HORSEPOWER REQUIREMENTS

84″ Triplex Reel Versus 72″ Riding Rotary

For our determination, consider an 84″ triplex reel mower versus a 72″ riding rotary. On the market today, the 84″ reel mowers are equipped with 12 or 14 H.P. engines. The 72″ rotary machines are equipped with 20-23 H.P. engines. The reel type mower requires less power at slow speeds because the top speed of the reel blade is approximately 900 feet per second. Compare that with the top speed on rotary mowers that is between 18,000 and 19,000 feet per second. Generally, the rotary mower engines operate at higher speeds, even though in the last few years riding rotaries have variable traction speeds so that the engine can operate at a "fixed" speed.

ECONOMICS

The 84″ triplex mower requires less horsepower; hence, less fuel. Indicative of this is the 84″ triplex at operating speed uses approximately 1.03 gallons of fuel per hour. Consider also that the 84″ unit is cutting a 16% wider swath than the 72″ rotary. The cost of the 84″ machine runs about 15% to 25% less than a 72″. Somewhat on the negative side, bedknife adjustments are necessary by people familiar with the unit. Repairs at the end of the season include grinding.

The 72″ riding rotary, since it is equipped with a higher horsepower engine, uses more fuel. A 20 H.P. engine uses approximately 2.18 gallons per hour during operation. The 12″ less swath results in just under 3 acres per day of less cutting. While reel grinding is not necessary on a rotary, rotary blades must be kept sharp, and require sharpening or replacement more often. Air and oil filters must be changed more often in rotary operations because of the dusty atmosphere in which it works. Engine fins, radiators, or filter screens must be cleaned often to avoid overheating, which is an enemy of the life-span of an engine.

LARGE TURF REELS VERSUS LARGE ROTARIES

It is difficult to discuss the 11- to 15-foot reel versus rotary as there are few rotaries of this size on the market at this time and the history of the performance of 11- or 15-foot rotaries is limited in the self-contained units. The pull type P.T.O. driven bat wing rotaries have been around for a long time, but the self-contained have only been out for a few years.

The first determination must be whether we are going to be cutting formal, semi-formal, or informal turf. It is simple to say that formal turf should be cut by reels for appearance sake, and informal turf should be cut by rotaries. The broad area of semi-formal turf for parks or large areas that do serve as playgrounds, etc., requires more analysis. Again, coming into play in the semi-formal turf is the height of cut desired, whether a skip/mow plan can be installed, and how important is the quality of turf on a particular area.

The most effective method of mowing turf would be by ground driven gang mowers on formal or semi-formal turf. It is by far the least costly method of maintaining large areas. Most manufacturers have frames for transporting these units with standard tractors. By the use of hydraulics to mow, lift, and go, one important element is that any tractor can be used for towing and the tractor can be used for other applications.

Self-contained units, while they limit the use of the tractor, are extremely efficient when cutting large areas of turf in remote areas, i.e., school districts, municipal park applications, etc. Transport requirements have to be considered, and generally the self-contained units will travel up to 25 mph so as not to delay traffic. It is very easy to use selfcontained units to cut a 15-foot swath, unless the area is broken up with trees, bushes, or shrubs. Consider also the safety of reel type mowers versus the rotary operations at parks, schools, or areas where people are present during the mowing operations.

Because of the relatively short time that the self-contained rotaries have been on the market, life cycling is very difficult to achieve: however, we do have the experience that the self-contained reel units sometimes last between 8 to 12 years. So, while the initial purchase price may be higher, the cost is more than made up by the efficiency of operation, the time that the unit lasts and, of course, time saving of the 15-foot cut.

RECOMMENDATIONS

Based on cutting quality, it appears to be fairly obvious that for formal turf, reel type mowers should be used. For semi-formal turf, much depends on the area, its location, and the quality of turf desired. To mow informal, or "rough turf", the rotary machines are definitely more desirable.

From a standpoint of economy, the reel type mower apparently uses less fuel, and could be the monetary difference in the subject of repairs and/or initial costs. It is apparent that with rotary mowers, one would have less problems with rough areas but more problems with filters and dust. The reel type mowers do need occasional sharpening, and some simple skills in blade adjusting must be taught. So, in conclusion, the best recommendation that can be made is to analyze the turf areas involved, determine the level of turf maintenance required, consider life cycle and fuel usage, and adopt the most efficient maintenance equipment to meet your plan.

TLC FOR A HIGH-USE ATHLETIC FIELD[1]

Sonya K. Watts[2]

[1] Presented at the 38th Northwest Turfgrass Conference, Sheraton Hotel, Spokane, WA, September 18-20, 1984.
[2] Grounds Supervisor, Whitman College, Walla Walla, WA.

Ankeny Field on the Whitman College Campus is approximately five acres of turfgrass that is bordered by academic buildings, dormitories, and tennis courts. It sustains heavy foot traffic throughout the school year as students travel between classes and to and from the dormitories. It is also used extensively for men's and women's soccer practice, lacrosse, flag football (for 6-8 teams), rugby, and ultimate frisbee!

For the past five years this area has received little consistent care except for regular watering and mowing. (We are currently mowing with a Jacobsen Turfcat II set at 3 inches, and watering by means of a Toro automatic irrigation system using 630 and 650 series heads.)

The soil in this area is heavy and readily compacted under conditions of high usage. The problem of proper care for the field came to a head in the fall of 1983 when several adverse conditions and playing practices combined to turn the center and west portions of the field into muddy quagmires.

The area was mowed too short in September and the field was given no additional care to compensate. There had been no regular fertilization program and the grass wasn't growing much at all.

By mid-October, under the heavy use conditions described above, the field was looking ragged. Then the fall rains began and we had nearly one inch of rain on a Friday night. The following weekend, the field was subjected to a full round of soccer games. The result was a muddy mess. In addition, most of the scheduled flag football games were played on the west end of the field, again with no additional care.

By spring the field was showing the full effects of its neglect and hard use. It was the only area on campus that failed to "green up" and begin to grow with the warming weather. In fact, the only greening areas on the entire field were those places where the soccer area had been lined with heavy applications of ammonium sulfate the fall before. Most of the field was so highly compacted that the less soluble fertilizer applied that early in the spring could not penetrate to the roots.

We knew that we would have to embark upon some kind of intensive care program in order to avoid the problems experienced in 1983. With some research, consultations with experts, and attendance at an athletic field management seminar, we set up the following program:

1. Proper fertilization program, 4-6 lb nitrogen per 1000 $ft.^2$ applied in 1 lb or 1/2 lb amounts throughout the year. (We are currently using Turfgo's Wondergreen 26-7-15.).

2. Proper irrigation and mowing practices, both closely monitored.

3. Aeration at least 6 times per year. (We have used both the core-type Ryan and the aerway slicer-type aerators and have purchased a slicertype.)

4. Topdressing with sand 4 times per year. (Planned but not accomplished. We have made only one application so far this year.)

5. Overseeding twice a year with a ryegrass-bluegrass blend. (We overseeded successfully in June, and hope to apply more seed this fall after soccer season.)

The area showed immediate improvement after aeration, beginning to green-up and grow like it should. The fertilization program proceeded normally with applications being made in April, June, and September. The rest of the program was stalled as we waited for permission to expend considerable amounts of money on equipment and supplies.

At this time, the field has been aerated a total of 4 times, and has been topdressed once with 1/4 inch of sand. Mowing and irrigation have proceeded on schedule. Except for the west end of the field and a few "holes" here and there, the condition of the field has improved considerably.

We hope to continue with this program until the field is in the best possible condition given the demands made upon it.

IRRIGATION INSTALLATION DO IT RIGHT THE FIRST TIME[1]

Donald A. Hogan[2]

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[1] Presented at the 38th Northwest Turfgrass Conference, Sheraton Hotel, Spokane, WA, September 18-20, 1984.
[2] Professional Engineer, Seattle, WA.

Why do it right the first time? Obviously if we do not have our irrigation system installed correctly, we will have the result of less than satisfactory performance. Then you are faced with the unpleasant situation of having to continuously repair and modify the system or be put in the position of having to explain why you cannot grow acceptable turf and plants, even though there has been a substantial investment.

We used to refer to the three legged stool - (design), (material and equipment) and (installation). All three of these components must be properly satisfied for a successful installation. Let us examine some of the necessary functions before we actually start work.

The first step is to review the plans and specifications. Do they meet the following criteria?

1. Accurate plot plan and irrigation design to scale.
2. Reference points easily identified in the field to lay out the system.
3. Design provide for uniformity of distribution.
4. Flexibility of control.
5. Adequate isolation valves for construction and operation.
6. Proven reliable equipment with standard replacement parts available.
7. Specific descriptive construction requirements.
8. Protection of existing underground and surface facilities.

The method of attack. Basic two approaches of performing the work:

1. Contractor installed.
2. Owner installed.
   A. Contractor installed.
      1. Is he experienced in the installation similar to your facility?
      2. Does he have a verifiable good reputation?
      3. What are his assets relative to personnel and equipment?
   B. Owner installed.
      1. Has the crew had previous experience to the type and magnitude of this installation?

2. What are the regular maintenance requirements of the crew to be performing during the construction period?
3. Do you have available the required general and special equipment to perform all of the work?
4. How does owner installed effect warranties?
   a. Equipment and materials
   b. Workmanship

Next we shall review the various component parts of the system.

A. Mainline piping and electrical
   1. Trench to an acceptable depth.
   2. Provide grade to drain points where potential freezing conditions exist.
   3. Bed properly to fully support the pipe.
   4. Install thrust blocking.
   5. Include pull and junction boxes.

B. Bedding and Backfill
   1. Select material
   2. Proper compaction to prevent settling
   3. Thrust support

C. Control valves
   1. Unions or flexible couplings
   2. Protective boxes

D. Lateral piping
   1. Trench or vibratory plow, depending on conditions.
      a. Soil conditions
      b. Roots
      c. Future plans, such as drainage piping, etc.
   2. Backfill requirements same as mainline.

E. Sprinklers
   1. Swing joints
   2. Impact resistant vertical risers
   3. Must be flush with finish grade except for special high-pop
   4. Backfill with sand and settle to stabilize to prevent future settlement.
   5. Keep foreign material out of cases

F. Controllers
   1. Protect from vandalism
   2. Install to electrical codes
   3. Protect field units from lightening
   4. Mount properly
   5. Install in accessible well lighted location

G. Completely test the entire system
   1. Piping - hydrostatic
   2. Valves
   3. Sprinklers
   4. Controllers
   5. Miscellaneous such as pumping facilities, etc.

H. Provide accurate updated as built drawings.

There is only one acceptable way to install an irrigation system - do it right the first time.

SOILS AND PLANTING LANDSCAPE PLANTS[1]

Dr. Ray Maleike[2]

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[1] Presented at the 38th Northwest Turfgrass Conference, Sheraton Hotel, Spokane, WA, September 18-20, 1984.

[2] Extension Horticulturist, Western Washington Research and Extension Center (WSU), Puyallup, WA.

There has been increasing mortality of plants planted into the landscape in the last thirty or more years. The reason being recommendations that were valid years ago may not be valid today with most of the compacted, disturbed soils encountered. Soils which are disturbed are by nature variable. Variability of soils means that growing conditions for the plant will also be variable, even though the plants may be in close proximity.

Plant stresses develop when plants are grown under less than optimum conditions. When plants are stressed, other insect and disease problems ensue. It is important to understand that many pathological problems are secondary to the real cause—cultural problems. Planting a plant correctly will avoid the stresses and other problems associated with stress.

Soils are generally composed of about equal portions of pore space and solid material. The pore space may be filled with water and/or air. Coarse-particled soils generally contain a greater proportion of air to water and the reverse is true of fine-particled soils.

Soil particles strongly attract water. The initial very thin layers of water are held very tightly to the soil particle. Successive layers are less tightly held to the point where at the very outer layers the water is held so loosely that gravity will pull the water off. The outer layers of water (loosely held) are easily used by the plant, but as the water layer gets thinner (more tightly held to the soil particle), the water cannot be as readily taken up by the plant.

In order for water to move through a soil profile, it has to move on a film of water. At fairly wet conditions, this film of water is continuous and connects via the soil particles. If a soil or plant growing medium is very dry, water will just run off because there is no film of water.

Water movement in soils is downward by gravity and some capillarity. Movement laterally and upward is by capillarity. Capillarity is water movement through very fine pores in the soil and moves from wetter regions to drier regions. As water evaporates from the soil surface, it becomes a drier region and more water will move into that area. Mulching will reduce water loss by breaking the film of water between the fine soil particles and the coarse mulch material particles; that is, a mulch will break the continuity of the capillary "tubes" between the coarse and fine particles.

Soils into which plants are planted may not be uniform as to particle size distribution through the soil profile, but layers or strata of fine and coarse soils may be encountered. When there are layers, drainage through these layers is usually not what one might expect. If there is a fine-particled soil, which is above a coarse-particled soil strata, water movement through the fine soil will procede until it hits the coarse soil and then stop. The flow across the fine-coarse interface is impeded because of the discontinuous water film and/or capillaries carrying the water. The water may be backed up into the fine soil, leaving saturated conditions (lack of air) which may make the plant more susceptible to root rots and other stresses.

Conversely, if a coarse-particled soil is above a fine-particled soil or compacted soil, drainage through the coarse-particled soil will be fairly rapid. Drainage into the fine soil will be slow, leaving saturated conditions in the coarse soil. In either case, fine particles over coarse or coarse over fine may result in low infiltration of water into the lower soil. The end result of a saturated condition in the upper strata is the same in either case but for different reasons.

Increasing aggregate size of a soil is most easily accomplished by *tilling* organic matter into the soil. Organic matter, by various means, has the ability to flocculate clay particles. The large aggregate is made up of smaller particles. Within the large aggregate there is water and nutrients which are available for plant growth. Air is found between the larger particles for normal root metabolism. Adding some sand to a clay or fineparticled soil decreases water-holding capacity, air space, and pore space.

Recommendations for planting plants *have* been to dig the planting hole twice as large and use a backfill material which has been amended with either good soil or 50 percent organic matter. When this is done, one of two things can happen. 1) Infiltration into the amended backfill material will be rapid. Drainage out of the planting hole will be slow, especially if the native soil is of a clay nature or compacted. The net result is the planting hole will fill with water (perched water table) (Fig. I-B), greatly reducing the amount of air around the roots. This causes severe stress or death of the plant. 2) If the plant has been grown in an organic medium (bedding plant or container plant), or the backfill is highly organic, the native soil may pull the water away from the soil in the planting hole because the native soil may have a greater affinity for water than

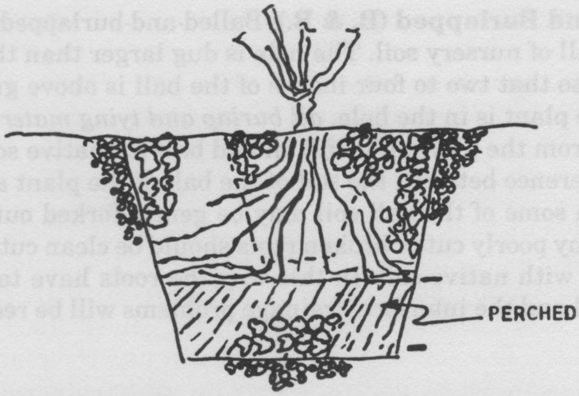

Fig. 1. Drainage out of the planting hole impeded because of interface between amended backfill and compacted/fine particled soil. This may leave a perched water table at the bottom of the planting hole.

the soil in the planting hole. Also, if the planting hole has been backfilled with either very good soil or organic matter amended soil, the roots may never leave the planting hole.

Plants for landscape purposes may be purchased as bare root, balled and burlapped, containerized, or field potted. Although each of the above is planted about the same way, special attention to certain details for each type is necessary to reduce plant mortalities.

1) **Bare-root (B.R.)**: Bare-root plants are dug out-of-leaf without soil. They should be kept from drying out from the time they are dug to the time they are planted. Any broken, poorly cut, or kinked roots should be cut with a clean cut. The hole is dug slightly larger than the root system and deep enough so that the plant in the landscape will be no deeper than it was in the nursery row. Backfill should be the *same soil* that was taken out of the hole. In this way, drainage and interface problems will be avoided (Fig. 2).

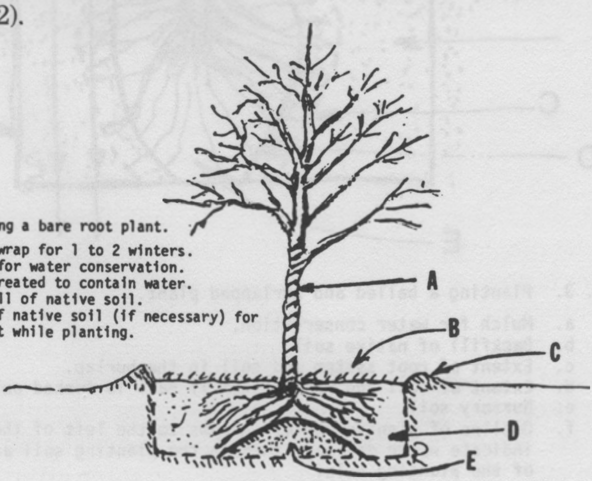

Fig. 2. Planting a bare root plant.

a. Trunk wrap for 1 to 2 winters.
b. Mulch for water conservation.
c. Dish created to contain water.
d. Backfill of native soil.
e. Cone of native soil (if necessary) for support while planting.

2) **Balled and Burlapped (B. & B.)**: Balled-and-burlapped plants are dug with a ball of nursery soil. The hole is dug larger than the ball and deep enough so that two to four inches of the ball is above grade. After the ball of the plant is in the hole, *all burlap and tying materials* should be cut away from the plant. Backfill should be with native soil. If there is a large difference between the soil of the ball of the plant and the native soil, then some of the ball soil may be gently forked out, exposing some roots. Any poorly cut or broken roots should be clean cut, and backfill should be with native soil. In this way the roots have to grow into the native soil and the interface/drainage problems will be reduced (Fig. 3).

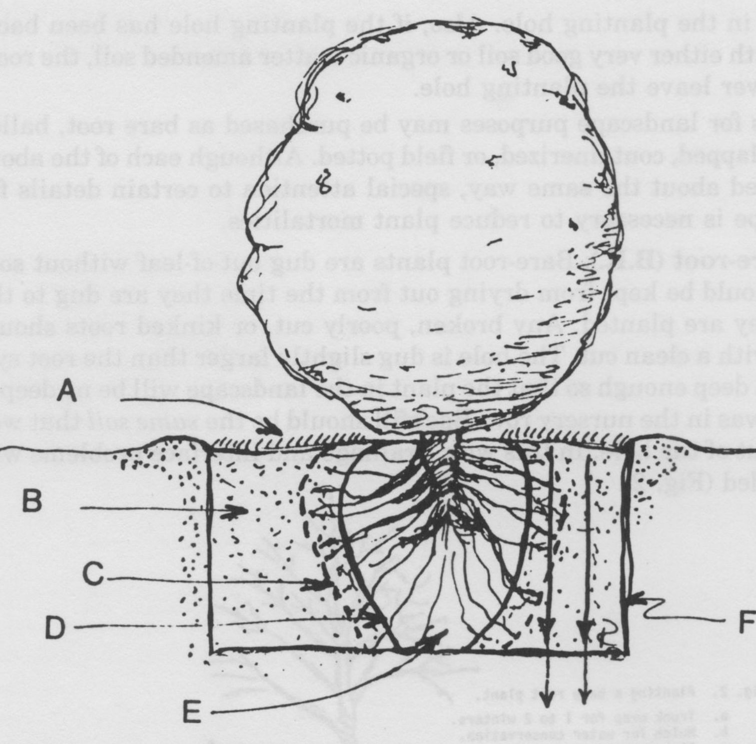

Fig. 3. Planting a balled and burlapped plant.

a. Mulch for water conservation.
b. Backfill of native soil.
c. Extent of root system and soil in the burlap.
d. Extent of soil and root system if ball is forked out. See text.
e. Nursery soil.
f. Outline of planting hole. Arrows to the left of the ball indicate water drainage through the planting soil and out of the planting hole.

3) **Containerized Plants**: Plants grown in containers are grown in a medium which is highly organic, i.e., usually does not contain soil. Plants grown in containers should have their roots out to the edge of the container, and they should be circling. However, if the roots are not spread out, they will continue to circle and become girdling as the plant grows, leading to a very stressed or dead plant some years after the planting date. After the plant is taken out of the container, the roots have to be spread out (Fig. 4). If they are woody and not pliable, then four- to six one-inch-deep vertical cuts should be made in the side of the container root ball. An alternative method is to lay the plant on its side and drive a spade or shovel all the way through the root ball about one-half way up from the bottom of the root ball. This creates two flaps which are spread outward when the plant is planted. In the top half of the container root ball, which has not been sliced, one-inch deep vertical cuts should be made to slice through any circling woody roots. The hole is dug wide enough to accommodate the "butterflied" spread root system. The plant should be planted so that it is about two inches above grade. Backfill should be native soil.

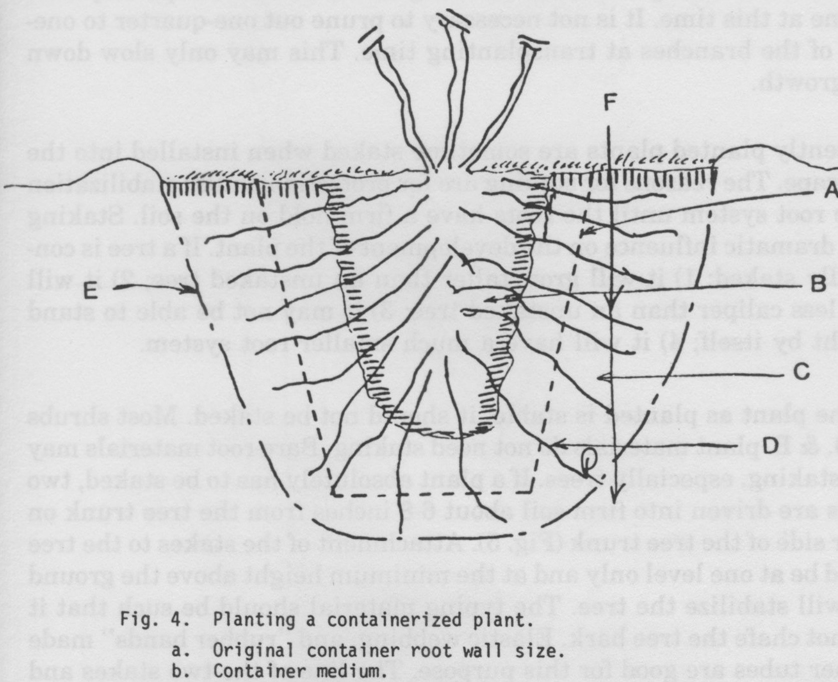

Fig. 4. Planting a containerized plant.

- a. Original container root wall size.
- b. Container medium.
- c. Backfill with native soil.
- d. Roots in contact with mineral soil.
- e. Plant hole outline.
- f. Water percolating <u>through</u> the planting hole and past the roots.

4) **Field Potted**: Field potted plants are dug with soil and then put into a container which may be plastic, metal, or composition such as paper mache. It is important that the container, no matter what type, be removed. This includes the composition types. Planting procedures are then as for B. & B. plants above.

In any planting procedure, it is beneficial to create a two- to threeinch high soil saucer around the edge of the planting hole for watering purposes. Watering right after planting is necessary and a two-inch deep organic mulch will help to conserve water.

If the drainage in the planting soil is very slow to non-existent, it may be beneficial to put the plants on top of the ground and fill in around them. This is called "creating a berm". In this case, the fill may be reasonably good soil.

Watering after planting and for some time after is essential. The soil around the roots should be moist but not soggy wet. Pruning after planting should be limited to removal of dead wood, and wrongly placed, rubbing and interfering branches. Pruning to the desired shape may also be done at this time. It is not necessary to prune out one-quarter to one-third of the branches at transplanting time. This may only slow down root growth.

Recently planted plants are sometime staked when installed into the landscape. The reasons for staking are for protection and/or stabilization of the root system until the roots have a firm hold on the soil. Staking has a dramatic influence on the development of the plant. If a tree is continually staked: 1) it will grow taller than an unstaked tree; 2) it will have less caliper than an unstaked tree; 3) it may not be able to stand upright by itself; 4) it will have a much smaller root system.

If the plant as planted is stable, it should not be staked. Most shrubs and B. & B. plant materials do not need staking. Bare-root materials may need staking, especially trees. If a plant absolutely has to be staked, two stakes are driven into firm soil about 6-8 inches from the tree trunk on either side of the tree trunk (Fig. 5). Attachment of the stakes to the tree should be at one level only and at the minimum height above the ground that will stabilize the tree. The typing material should be such that it does not chafe the tree bark. Elastic webbing, and "rubber bands" made of inner tubes are good for this purpose. The line of the two stakes and the tree trunk should be perpendicular to the direction of the prevailing wind (Fig. 5). As soon as possible, remove the stakes to ensure good root growth.

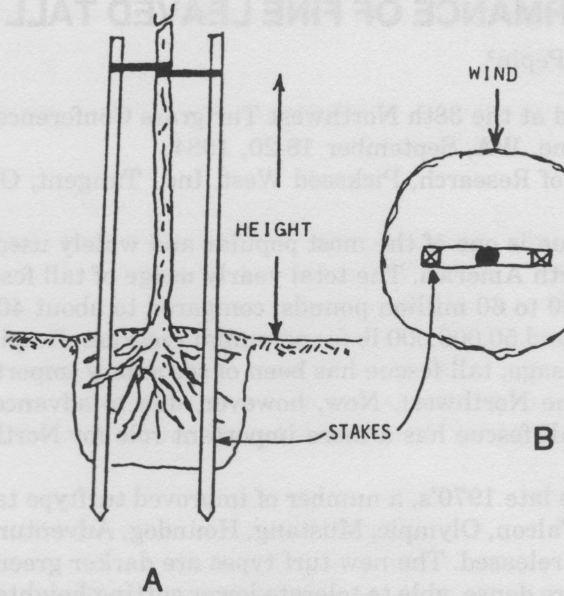

Fig. 5. Staking. Staking a landscape plant is accomplished by driving two parallel stakes into firm ground (A) so that the line of the stakes and the tree is perpendicular to the prevailing wind. (B) Top view.

In most cases, the demise of many landscape plants is due to cultural and environmental stresses imposed on the plant. Correct planting, staking, and pruning techniques will greatly increase the survivability of these plants for many years.

PERFORMANCE OF FINE LEAVED TALL FESCUES[1]

Dr. Jerry Pepin[2]

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[1] Presented at the 38th Northwest Turfgrass Conference, Sheraton Hotel, Spokane, WA, September 18-20, 1984.
[2] Director of Research, Pickseed West, Inc., Tangent, OR.

Tall fescue is one of the most popular and widely used turfgrass species in North America. The total yearly usage of tall fescue for turf approaches 50 to 60 million pounds, compared to about 40,000,000 lb for bluegrass and 50,000,000 lb for perennial ryegrass. Despite the large nationwide usage, tall fescue has been of secondary importance as a turfgrass in the Northwest. Now, however, due to advances in breeding, turftype tall fescue has a more important role for Northwest turf.

Since the late 1970's, a number of improved turftype tall fescues such as Rebel, Falcon, Olympic, Mustang, Houndog, Adventure, Jaguar, etc., have been released. The new turf types are darker green in color, finer leaved, more dense, able to tolerate lower cutting heights, and have better disease resistance than the old forage type tall fescues such as Kentucky 31, Fawn, and Alta. Except possibly for use along roadsides or four erosion control, the older varieties such as Ky 31, Fawn, and Alta should no longer be used for turf.

For well-maintained, top quality turf in the Northwest, perennial ryegrass, fine fescue, bentgrass, and Kentucky bluegrass are superior to tall fescue. However, for some turf uses, the new varieties of turftype tall fescue have significant advantages over the other species. Some of the strong points of tall fescues include:

1. Better heat and drought tolerance than other species.
2. Excellent wear tolerance once established.
3. Good turf performance under low to moderate fertility levels.
4. Good summer color retention with no supplemental irrigation in areas west of the Cascades.
5. Good resistance to rust and red thread.
6. Good shade tolerance.
7. Good tolerance to a wide range of soil conditions such as excessive acidity, alkalinity, salinity, and poor drainage.

8. Produces very little thatch.

Although the new turftype tall fescues have been a remarkable success since their introduction, they do have weaknesses that limit their use. Some of the disadvantages of tall fescue turf in the Northwest include:

1. A coarser leaf texture than other turf species.
2. Less tolerance to lower cutting heights. Then cut lower than 1-1/2 inches, they may thin out and become susceptible to encroachment by other species.
3. Poor winter color under low fertility levels.
4. Poor compatibility with other fine leaf turf species.

Tall fescue is mainly a bunchgrass and produces very few rhizomes. The bunchgrass growth habit is an advantage in that little thatch is produced. However, it is also a disadvantage in that thin areas and bare spots must be overseeded. Due to a lack of plant competition, tall fescue turf on the border of bare spots or thin areas often has an unattractive coarse texture.

Seed germination and rate of establishment of tall fescue is intermediate between Kentucky bluegrass and perennial ryegrass. Seeding rates as low as 4 $lb/1000\ ft^2$ can be used in areas where rapid utilization is not necessary or weed competition is not a problem. However, for most uses, a seeding rate of 6-8 $lb/1000\ ft^2$ is recommended. Turftype tall fescue is best used alone or blended with other varieties. When mixed with other species such as Kentucky bluegrass or perennial ryegrass, tall fescue should comprise 90 to 95% of the seed mix by weight.

Turftype tall fescue requires less nitrogen fertilizer than most other species. In the Northwest, about 204 lb of actual nitrogen/1000 ft^2/year is recommended. About 65% of total nitrogen applied in a fall application and 35% in mid-spring will maintain a good green color year around in mild areas. Tall fescue turf is tolerant to all the commonly used turf herbicides.

Due to the success of turf breeding programs, the new turftype tall fescues have a more important sale in Northwest turf. However, they are still secondary in importance to the other well adapted species such as perennial ryegrass, fine fescue and to some extent Kentucky bluegrass. Breeding improvements are continuing and as a result tall fescue will become an even more important turfgrass in this area.

NECROTIC RING SPOT: RESEARCH ON A NEW DISEASE OF BLUEGRASS TURF AND ITS CONTROL IN THE PACIFIC NORTHWEST[1]

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[1] Presented at the 38th Northwest Turfgrass Conference, Sheraton Hotel, Spokane, WA, September 18-20, 1984.

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Necrotic Ring Spot is the name of a newly recognized disease of bluegrass turf in North America. In the Pacific Northwest, this disease has been referred to as an Ophiobolus patch or take-all-like patch disease. Researchers in the northeastern and central portions of the United States now recognize that a lot of what has commonly been referred to as Fusarium blight has actually been Necrotic Ring Spot. Symptoms of this disease resemble take-all patch on bentgrass turf and the classical Fusarium blight on bluegrass turf. Patches range in diameter from a few inches to several feet. Individual patches frequently coalesce to form large, irregular shaped areas of affected turf. Symptom development is generally most prevalent during late spring and early fall (Figure 1). Actively expanding patches generally have a border of reddish-brown turf. The centers of patches generally contain grasses and broadleaf weeds and the disease generally appears within 3-5 years of the establishment of turf. In most cases, affected turf was established using sod.

Examination of the roots and crowns of diseases plants reveals the presence of fungus mycelium resembling those found on turf affected by take-all patch. Limited numbers of small black fruiting bodies called pseudothecia have been found on roots and crowns of diseased plants. Based on the morphological characteristics of the fungus associated with diseased plants, the fungus has been identified as *Leptosphaeria korrae*. Pathogenicity tests have shown that our *Leptosphaeria* isolates are pathogenic on Baron bluegrass and that individual isolates vary in their ability to cause disease.

The disease was first observed in 1979 on turf in Benton and Spokane Counties. Since 1979, the disease has been confirmed in 10 other counties in Washington. This disease has also been observed on turf in Idaho and Oregon. The disease occurs on turf grown in the arid portions of eastern Washington as well as the mild, moist portions of western Washington. The disease is occurring on turf with pH's that range from 5.0 to 8.0.

One of our research objectives has been to evaluate the effectiveness of fungicides in controlling Necrotic Ring Spot on bluegrass turf. Initially, we have screened fungicides by incorporating them into media and then growing the fungus on this media and evaluating the effectiveness of specific fungicides in suppressing growth of the fungus. Utilizing these laboratory tests, we have found that Benlate, Rubigan, and Ciba-Geigy's Banner were highly effective in inhibiting the growth of the Necrotic Ring Spot fungus under our laboratory conditions. Chipco 26019 and Bayleton were not effective in inhibiting the growth of the *Leptosphaeria*. Field testing to evaluate the effectiveness of fungicides in controlling this disease has been done during 1983 and 1984 in eastern and western Washington. In 1983, applications of fungicides were applied at 4-week intervals during May, June and July. Treatments consisted of sulfur, Bayleton 25W, Banner 1.1EC and Rubigan 50W. Results from the 1983 trials indicated that applications of Rubigan at 2 or 4 oz/1000 ft^2 and Banner at 7 and 14 oz/1000 ft^2 were highly effective in controlling this disease. Applications of sulfur and Bayleton were generally ineffective. Applications of Bayleton, Rubigan and Banner also resulted in a dark green turf at all the test locations and this was evident after two applications. During our 1984 tests, we tested the effectiveness of Bayleton, Rubigan, Banner, Tersan 1991, Chipco 26019, and a coded material from Mobay that is similar to Bayleton called Bay-Kwg. Results from this trial indicated that a single application of Rubigan at 2 oz/1000 ft^2 applied in late May provided effective disease control during late summer and early fall. Applications of Banner at 14 oz/1000 ft^2 were also effective. During these trials, the disease has been active at the time our first applications were made. We have not noticed any disease control from any of the fungicides tested until late summer or early fall. Because of this, additional trials need to be conducted to determine if a single application of either Rubigan or Banner prior to symptom development in the spring will provide effective disease control during both late spring and early summer and late summer and early fall. Applications of Bayleton, Bay-Kwg, Tersan 1991 and Chipco 26019 were generally ineffective.

DROUGHT RESISTANCE [1]

Dr. Jeff Nus[2]

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In an attempt to gain an overall perspective of drought resistance in plants, it is important to realize that the relative ability of plants to survive an extended period of low rainfall is dependent upon many morphological and physiological adaptations. No single factor is responsible for drought resistance. It is certainly a combination of beneficial adaptations that will enable certain plants to survive conditions that are dry enough to kill plants which do not possess these adaptations.

Another important aspect in understanding drought resistance is to differentiate between the terms drought and water stress. Drought is a meteorological term. It may be defined simply as an extended period of low rainfall (3). Water stress, however, refers to the plant directly, and occurs to varying degrees during the entire life of the plant. Drought is always accompanied by plant water stress. Water stress, on the other hand, may occur even when soil moisture is plentiful due to high evaporative demands caused by wind, radiative heat load, and low relative humidity. Levitt (8) defines water stress as a lowering of the water potential of plant tissues. Water potential is a term describing the energy level of water held in the tissue and thus reflects how tightly water is held in the plant. A lowering of water potential means that less energy is held within the tissue water due to a loss in turgor pressure or a concentration of solutes in the cells. Solutes become concentrated due to a decrease in water content or an active accumulation from the soil solution. Nus and Hodges (10) were able to demonstrate a marked diurnal fluctuation in turgor and water potentials in Kentucky bluegrass as plants were grown hydroponically in growth chambers. Similar diurnal fluctuations in water and turgor potentials are also seen in field-grown plants. As plants develop more severe water stress (lower turgor and water potentials) during the afternoon hours, however, they are able to regain their water status (more positive turgor and water potentials) during the night as heat load is removed, winds decrease, relative humidity increases, and stomates close. (Stomates are tiny pores in the surface of leaves that regulate gaseous exchange and water loss by transpiration.) However, during a period of little rainfall, the level at which turgor and water potentials may be regained during the dark becomes limited because soil moisture normally used to replace tissue water lost via transpiration simply isn't there in sufficient amounts. As a result, as a drought continues, plant water stress may increase markedly.

Drought affects the morphology of plants—that is, the way in which plants grow. For instance, leaves that develop during drought possess thicker cuticles (a waxy layer on the leaf surface to prevent water loss) and fewer stomates. This reduces the rate of water loss from the leaves and better conserves the remaining plant and soil moisture. In addition, older leaves may die and contribute a "mulching effect" to the soil. Senescence of older leaves due to severe water stress is particularly rapid in grasses (4). The remaining turfgrass leaves may fold up or roll up by the action of bulliform cells located near the leaf midrib (2). During prolonged water stress, these large cells collapse which results in leaf folding of most cool season grasses (most fescues, bluegrasses, ryegrasses) and leaf rolling of warm season grasses (bermudagrass, St. Augustine, centipede, zoysia). This reduces leaf area, so both radiative heat load and transpiring leaf surface is reduced. Moisture is again conserved.

Drought also affects the relative proportion of photosynthates being distributed in leaves, roots, tillers, and rhizomes. Root-shoot ratios are used to characterize the relative amount of dry matter of roots compared to the dry matter of shoots (leaves, sheaths, crowns, tillers, and rhizomes). Root-shoot ratios have been used to evaluate drought resistant plants in some crops (13), because higher root-shoot ratios are usually characteristic or more drought resistant genotypes. In addition, it is a common observation that root-shoot ratios of plants increase during drought (3). This is also true of turfgrasses, and is due to the differential sensitivities to water stress of different fractions of the plant. Nus and Hodges (9) have shown that tillers and rhizomes are very sensitive to prolonged water stress, and this sensitivity accounts for much of the increase in root-shoot ratios of Kentucky bluegrass during drought (11).

Plants can be divided into three general categories concerning mechanisms of drought resistance: (1) drought escapers, (2) drought tolerance with high tissue water potential, and (3) drought tolerance with low tissue water potential. Drought escapers refer to annual plants that can germinate quickly and complete their life cycles (seed to seed) before the onset of drought. The plants escape drought by surviving those periods of little rainfall as seeds. Many desert annuals have evolved that strategy for drought resistance. In some ways, *Poa annua* is like that. *Poa* germinates during the fall when there is plenty of moisture. It sets seed profusely during late spring and early summer before severe water stress occurs. During hot, dry summer months, *Poa* growing under unirrigated conditions may be severely thinned because the plant itself possesses little drought resistance. The survival of species is assured, however, because life cycle was completed, seed was produced, and will germinate when the fall rains return. It should be kept in mind, however, that *Poa annua* exhibits a great deal of genetic diversity. The growth habits of *Poa* range from tufted, bunch type annuals to perennial, prostrate, creeping types (2). This genetic diversity in growth habit suggests that *Poa* genotypes may also differ widely in the level of drought resistance of the mature plant.

The second general strategy of drought resistance includes those plants which can tolerate drought while maintaining high water potentials (high content of relatively "unsalty" water). These are the plants that most people associate with arid environments—cacti, spurges, etc. These plants have very efficient means of rapidly absorbing water when it becomes available and extraordinary modifications that inhibit water loss. These plants are characterized by thick, fleshy plant parts, low surface to volume ratios, very thick cuticles, suberized roots, and a system of photosynthesis which allows them to close their stomates during the day when evaporative demand is very high. No grasses belong to this category of drought resistance. It is important to realize the nature of various adaptative features of these plants, however, because some of these features of these plants may represent selection criteria for turfgrass breeders whose goal is to develop more drought resistant turfgrasses.

The third general category of drought resistance includes those plants which can tolerate drought at low tissue water potentials (low content of relatively "salty" water). Most grasses belong to this group. Plants belonging to this group have evolved means to react physiologically to increasing water stress. As less and less water is available in the soil, plants of this group can make their tissue water quite concentrated with various salts, sugars, and organic acids. This greatly increases the plant's ability to take up water. So, although there is less water available in the soil, the ability to extract what little water remains available is increased. This process is called osmotic adjustment and it serves a very important purpose. Plants which can osmotically adjust can maintain turgor pressure to some degree. Turgor pressure is the main driving force for growth. Without the hydrostatic pressure of turgor, cell expansion (the most basic process for growth coupled with cell division) could not occur. By maintaining turgor pressure through osmotic adjustment, roots can continue to grow into a greater soil volume to extract additional moisture, and leaves can grow increasing photosynthetic capacity. In addition, stomates stay open in the light when turgor is maintained. When stomates are open, evaporative cooling keeps the leaves from overheating. If osmotic adjustment did not maintain turgor, stomates would close rapidly and leaves would soon overheat. Several agronomically important grasses have been shown to have capacity for osmotic adjustment including corn

(6), sorghum (7), wheat (5), and rice (12). Turfgrass research is beginning to adopt techniques to evaluate for osmotic adjustment as well. Nus and Hodges (10) have shown that Kentucky bluegrass can osmotically adjust to osmotically-induced water stress.

The recent interest in osmotic adjustment in response to water stress should not lead to false hope. It must be remembered that drought resistance is the result of many adaptative features. Although osmotic adjustment is a process that may provide valuable insight in the development of drought resistant turfgrasses, it is only one process in many that deserves attention. In addition, research has shown that the capacity of osmotic adjustment is clearly limited (14). That is, there is a point which even the plants exhibiting the greatest capacity for osmotic adjustment can no longer maintain turgor. Finally, capacity for osmotic adjustment would have little value for developing drought resistant turfgrasses if it is coupled to a high water use requirement. Research is underway at the Western Washington Research and Extension Center to investigate the relationship between water use requirement and capacity for osmotic adjustment in several Kentucky bluegrass cultivars. It is hoped that this research will yield information that will prove valuable to the long range goals of the United States Golf Association to develop drought resistant turfgrasses. Until more basic knowledge concerning drought resistance in turfgrasses is gained, however, the performance of turf during drought is solely dependent upon the expertise of the turfgrass manager.

Management techniques have centered around the need to conserve water. They include limiting the use of nitrogen prior to the onset of drought, tensiometer controlled irrigation, and the use of wetting agents to improve wetting uniformity of the soil (1). Although these management strategies are certainly valuable, long range success may depend primarily on the use of drought resistant species and cultivars. Turfgrass species and cultivars that exhibit superior drought resistance and recuperative potential offer the best hope of ensuring quality turfgrass under nonirrigated conditions. It is gratifying to see that much recent turfgrass research is being conducted with that goal in mind.

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SUCCESSFUL WEED CONTROL WITH PREEMERGENCE HERBICIDES[1]

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The use of preemergence herbicides, those applied before the weeds germinate, is often not popular with managers of turf, since they often like to see the weed problem before a treatment is made. With properlyselected and -applied preemergence herbicides, the potential weed problem is never apparent, as the weeds are controlled before or soon after emergence. The secret to success is application of the herbicide before weeds emerge.

Most preemergence herbicides used in the turfgrass industry are applied primarily to selectively control annual grasses in the perennial turfgrasses, although some of the herbicides will control certain annual broadleaf weeds as well. None of the products used will control established, broadleaf or grass weeds except those used for bare ground-type control.

Herbicides should not be relied on for a total weed control program. If you consider herbicides as the only method of weed control, your weed management program will fail. Herbicides are just another tool to be used in the total program. The best herbicides will not perform satisfactorily when management is such that the desirable turf is under stress for one reason or another: insects, diseases, heavy traffic patterns, or inadequate or excessive irrigation. Stressed turf is where weed problems start and may be the most severe. A thick, healthy stand of turf properly mowed, fertilized, irrigated, and other pests controlled, will compete very well with weeds and slow or prevent their establishment in the first place. Management practices which favor turf vigor should be conducted before a herbicide program is started to ensure the most value from the herbicide selected.

Crabgrass seed normally begins germination in the spring when soil temperatures reach 55 to 60 degrees Farenheit. This usually coincides with the time forsythia blooms start to fall. Thus, for crabgrass control, herbicides need to be applied by this time. Germination of crabgrass and other summer annual grasses can extend into late summer and early fall. Crabgrass emerges 4 to 6 weeks before it is visible above the turf. The major germination period for *Poa annua* or annual bluegrass, a winter annual grass, occurs between August and October. A minor germination period also occurs in the early spring. Thus, for control, preemergence herbicide treatments in the Pacific Northwest should be applied by August 15. This grass requires higher herbicide rates for effective control than crabgrass.

Most products for preemergence weed control in turf contain one of the following products. They must be applied before the crabgrass, annual bluegrass, or other annual grasses begin germination. Carefully read and follow the instructions on the container label before using any of the following products.

DCPA (DACTHAL)

Use on established turf, although it can be applied to new seedlings after grasses have exhibited a uniform greening, preferably 1 to 2 inches in height. After application of DCPA, a minimum of 0.25 inch of moisture is required within 3 to 5 days to move the herbicide into the soil. A second application of DCPA can be made at one-half the rate 2 months later. This will give season-long control of most annual grasses and some broadleaf weeds such as spotted and prostrate spurge. Do not use DCPA on putting greens. Delay new seedlings or overseeding for at least 60 days after last application.

BENEFIN (BALAN)

Use on well-established turf. The label cautions against use in the spring on turf established the previous fall. Sprinkle with about an inch of water immediately after application to move the herbicide into the soil. Reseeding or overseeding should be delayed at least 6 weeks after a spring application or 12 to 16 weeks after an application for annual bluegrass.

BENSULIDE (BETASAN, PREFAR)

Prefar is registered for *Poa annua* control in seed fields in the Pacific Northwest. Betasan is the trade name for bensulide most commonly used in turf for annual grass control. It has a long residual in the soil and can be applied in the late winter or early spring for summer annual grasses. A second application can be made 4 to 5 months after initial application to control annual bluegrass. Bensulide is very readily tied up in organic matter such as leaves and dead grasses. Sprinkle with water for 10 to 15 minutes after application to wash the herbicide off the grass and into the soil. This product has the longest soil residual of any of the herbicides mentioned. Do not reseed or overseed within 4 months after the last application; if done, follow label directions carefully. On crop land this material has inhibited crops in the grass family the year following application.

OXADIAZON (RONSTAR)

This is the newest of the preemergence grass herbicides. The label lists it to be effective on some broadleaf species; most notably, oxalis and pigweed, in addition to crabgrass and annual bluegrass. Do not apply to wet turf. Thoroughly sprinkle turf after application to move the herbicide into the soil. Red fescue and bentgrass are not tolerant to oxadiazon. Do not apply to newly seeded areas and delay reseeding or overseeding for at least 4 months after treatment.

SIDURON (TUPERSAN)

This product can be used on new bluegrass seedings at the time of seeding as well as on established turf for crabgrass control. Siduron will not control annual bluegrass. The site of application must be irrigated with at least 0.5 inch of water within 3 days after application to move the chemical into the soil. Siduron will partially control bermudagrass.

Turf may be thinned and temporarily turned slightly off-color by any of the above herbicides. Thinning is most apparent in lawns heavily infested with annual bluegrass.

Failures of the aforementioned herbicides to control the weedy grasses can usually be attributed to one or more of the following reasons: the herbicide was applied after the annual grass has already germinated; the herbicide rate used was too low for the grass species intended; too much debris left on the soil surface, thus immobilizing the herbicide and preventing it from reaching the soil surface; soil disturbance after application resulting in microenvironments without herbicide; and inadequate watering of the herbicide into the soil.

Since, by its nature, all the annual grass seed will not germinate in one season, a total weed control program should be repeated until the desired turf is achieved. Remember, crabgrass, annual bluegrass, and other annual weeds are opportunists which will take advantage of cultural practices. Divots, disease, insects, and low turf vigor will allow the entry and growth of weeds.

EXCITING DEVELOPMENTS WITH TALL FESCUE[1]

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HISTORY

Tall fescue, *Festuca arundinacea* Schreb., has been grown in the United States for nearly 200 years. It was one of the early grasses introduced from western Europe prior to 1800 (Buckner et al. 1973). It has been noted as robust, leafy, drought tolerant but tolerates wet soils, and is a persistent, productive forage grass. In fact, tall fescue remains green for a long period of time and affords year-around livestock grazing. This was a significant characteristic responsible for the adoption of the grass in the east-central states. The species has a wide range of adaptability to soils and climate (Burns and Chamblee 1973). A related species, meadow fescue, *Festuca elatior* L. was also widely grown for forage in Europe and in the U.S. during the early 1800's but was not as productive nor rust tolerant as is tall fescue (Buckner and Cowan 1973).

Forage researchers in the central and eastern states and in Oregon devoted considerable attention to improving and selecting tall fescue types as early as 1900's. They were tested at Pullman, Washington in 1908 (Vinall 1909). The release of "Kentucky 31" in 1943 by University of Kentucky and the variety "Alta" by Oregon State University in 1945 gave prominence to the species and their growth and distribution throughout the U.S. (Buckner 1973). The fact that tall fescue is an excellent seed producer, has relatively large seed, and possessed good seedling establishment is an important attribute for the species. The two forage fescues, "Kentucky 31" and "Alta" were the forerunners of many new forage and turf tall fescue varieties of recent years. Other prominent forage varieties are shown in Table 1.

Table 1. Some recognized forage tall fescues.

Alta-1945[1]	Kenhay-1970
Asheville-1952	Kenmont-1963
Backafall-1950	Kentucky 31-1943
Fawn-1964	Kenwell-1965
Goar-1946	Melik-1972
Grasslands N.Z 4710-1975	Missouri 96-1977
Grasslands ROA-?	
	Asay, et al. 1973

[1]Indicate date of variety release.

RECENT DEVELOPMENTS IN TURF FESCUES

In recent years turfgrass breeders and turf managers have noted the advantages of tall fescue. The major favorable characteristics have been the persistence of this species to stress conditions especially temperature and moisture and its relatively wide adaptation.

In 1983 thirty improved turf types were planted in a nationwide evaluation test. Replicated trials were established by 35 states at 50 test sites to evaluate turftype tall fescue cultivars under turf management situations. Idaho established cooperative plots in September 1983 at Moscow. Table 2 lists some of the relatively new turftype tall fescues in these national tests. Standardized records are taken and transmitted to the Beltsville Research Center for analysis and reporting. Data from all cooperating states will provide new information of the range of adaptation and turf performance of these tall fescues.

Table 2. Some turf tall fescues[1].

Adventure	Houndog
Apache	Jaguar
Arid	Kenhy2
Barcel	Olympic
Brookston	Maverick
Clemfine	Mustang
Falcon	Tempo
Finelawn	Rebel
Galway	Willamette
	Rose, et al. 1983

[1]New turf tall fescue breeding programs are relatively new.
Ryegrass X fescue hybrid.

Under Idaho conditions we have noted differences in emergence, vigor, color and to a degree texture (leaf width). There appears to be some differences among cultivars for texture but none of the tall fescues in our plots have narrow leaf width compared to perennial ryegrasses of Kentucky bluegrasses. Some turftype tall fescues under our condition are not significantly different from the forage tall fescues in texture. Beard (1973) classifies grasses with leaf width greater than 4 mm as coarse leaf grasses.

Leaf width for 10 cultivars from a *regional* test planted in 1980 and the leaf width of fescues from the *national* tall fescue tests, planted in 1983, are recorded in Tables 3 and 4, respectively. There were yearly differences.

Other data will be available as additional years' data will be collected.

Table 3. Texture as measured for 10 turf and forage tall fescue cultivars[1]

Cultivar	Leaf width-mm[2] 1983	1984
Rebel*	2.6 a[3]	4.05 ab
Falcon*	2.7 a	4.12 bc
Syn 5LL*	2.9 b	3.67 ab
Ag. 125A*	3.0 b	3.43 ab
Ida 249*	3.0 b	4.83 d-f
P 149 44	3.4 b	5.25 f
Ida 41	3.4 b	4.69 c-f
Kenmont	3.5 b	4.34 b-d
Syn 55B	3.5 b	5.11 e-f
Alta	3.7 b	4.40 c-e

* Turf type.

[1]Planted 1980 at Moscow, ID. Clipped weekly at 3 inches.

[2]Average of 3 replications, 10 samples/rep., width of first leaf below expanding leaf at widest point of leaf. Leaf samples taken in August each year.

[3]Cultivars means with same letters are not significantly different at the 5% level of significance for Duncan's Multiple Range Test.

Table 4. Texture for selected cultivars in the National Tall Fescue Trials[1].

Cultivar	Leaf width-mm[2]
Olympic	4.403 a
Fine lawn I	4.99 a
Clemfine	5.06 a
Apache	5.14 a
Rebel	5.29 a
Falcon	5.33 a
Houndog	5.46 a
Kenhay	5.96 a

[1]Planted 1980 at Moscow, ID. Clipped weekly at 3 inches.

[2]Average of 3 replications, 10 samples/ rep., width of first leaf below expanding leaf at widest point of leaf. Leaf samples taken in August each year.

[3]Cultivars means with same letters are not significantly different at the 5% level of significance for Duncan's Multiple Range Test.

FAVORABLE CHARACTERISTICS OF TURFTYPE TALL FESCUSES ARE:

-Tolerant to close mowing (2-4 inches)
-Extensive basal leaves

-Short growth habit
-Dark blue-green color
-More rhizomes than forage types
-Finer leaf texture (width)
-Drought tolerant
-Tolerant to wet soils
-Wear tolerant
-Low fertility requirement
-Tolerant to wide range of pH soils
-Large seeds with good seedling vigor
-Excellent seed producer
-Relative disease-insect free
-Excellent genetic variability for improvement

SOME OF THE UNFAVORABLE CHARACTERISTICS ARE:

-Coarse leaf may limit turf use
-It is a bunch (clump) grass
-Produces an abundance of foliage
-Requires frequent mowing
-High water consumption
-May create excessive crown thatch
-Limited new varieties-approximately 30 in 1983
-Limited information available now on range of adaptability, disease problems, and management requirements.

ROLE OF ENDOPHYTES IN TALL FESCUE

Although tall fescue has been an important forage grass in much of the central-east areas of the U.S. and has expanded considerably in acreage since the early 1940's, it has also caused disorders in grazing animals. Losses of $50-200 million annually have been reported. This disorder has been referred to as fescue toxicosis causing staggering gait, muscle tremors and other psychological symptoms. Advance stages of the syndrome is termed "fescue foot" although some researchers believe fescue foot and fescue toxicity are two different maladies (Buckner and Cowan 1973). Animals with fescue toxicosis often lose weight during summer grazing periods. The disease is also called "summer syndrome". These symptoms were first described by Clifton (1913) in New Zealand and later in more detail by Cunningham (1948). Considerable research on livestock problems has been conducted in the U.S. during the past 30 years (Garner 1983). Although the animal symptoms have been well defined, the causes remain a theory (Bush et al. 1974). Much research has related to many alkaloid-like compounds in the grass which are known to cause toxicosis in animals. Some investigators theorize some mycotoxins are produced by fungi in the grass and several fungi including *Fusarium* spp., have been suspects (Yates et al. 1969).

A corollary to the fescue toxicosis problem has been a toxicosis situation of cattle, sheep, horses, and deer grazing perennial ryegrass. This has been noted for many years in New Zealand during summer and autumn grazing periods and has been termed ryegrass staggers (RGS). Clinical symptoms develop 7-14 days after livestock are placed on toxic pastures when the animals develop neuromuscular disorders of trembling, jerky limb movement and staggering. Livestock losses are not uncommon (Mortimer 1983).

It was proposed by Aasen et al. (1969) in Australia that RGS was caused by alkaloids in the pasture plants. More recently Mantle and Penny (1981) and co-workers in New Zealand have concluded that RGS is caused by "tremorgenic neuro-toxins produced by fungi (mycotoxins) associated with soil and plants." The fungi have been referred to as *Lolium* endophytes. The first positive association of these endophytes with RGS were outbreak in sheep reported near Lincoln, New Zealand in 1981 (Fletcher and Harvey 1981). These endophytes fungi, although not identified at that time were found in the leaf sheaths, flowering stems, and seeds. Staggers among sheep occurred where these endophytes were found within the growing grass plants (Harvey 1983). Mortimer and di Menna (1983) reported that perennial ryegrasses produced 3-4 fold greater forage yields when the grasses were higher in endophytes and they observed that where low endophytes occurred in the grass there were high populations of Argentine stem weevil, *Listronatus bonariensis*. Thus, vigor of high endophyte grasses was probably due to insect control.

The *Lolium* endophytes infect the ryegrass plant during seed germination and the fungi mycelium grows into the new shoots and roots. Latch (1983) reported the most common fungus of the *Lolium* endophytes to be an *Acremonium* species. At that time he was not certain that it was involved with the RGS.

The fungi seemed to be spread only through the seed. Neill (1940) reported that endophyte mycelium in the infected seed died when stored at room temperature for 18-24 months and seed so stored will not transmit the endophytes. Latch (1983) reported that seed stored at 0-5 °C (41 °F) endophytes remained viable for at least 15 years. He further reported that endophyte infected plants were freed of the fungi by treating the growing plants with a 1% solution of the systemic fungicide prochloraz. Prior to 1981 it was apparent that many commercial lines of perennial ryegrass in New Zealand had high incidence of endophytes. To ensure endophytes free seed, the parent plants need to be free of endophytes (Latch 1983). The endophytes are carried maternally by the female plant and are not transmitted through the pollen (Hurley and Funk et al. 1984).

Morgan-Jones and Gams (1982) have classified the endophytic fungi of tall fescue as *Acremonium coeophialum* Morgan-Jones & Gams. Siegel et al (1984), and Bacon (1983). It is also referred to as *Epichloe typhina*. This fungi has been the cause of summer toxicosis in grazing cattle and is widely distributed in tall fescue fields in Kentucky and other states (Bacon et al. 1977). The endophytes concentration in the infected plant (in decreasing order) are the leaf sheaths, seeds, crown, stems, leaf blades, and roots (Siegel et al. 1984). The endophytes are spread by seed, not by wind, rain or pollen, or mowing. The endophyte levels in seed plots seemed to remain the same for at least a 4-year period. They further reported that the endophyte remained viable in the tall fescue and perennial ryegrass seed for 19 months at storage temperatures of 6 °C (42.8 °F). Thus most variable storage temperatures would maintain substantial amounts of viable endophyte.

The endophyte appears to exist in the perennial ryegrass and tall fescue in a mutualistic or commensal relationship in which the plant is neither helped nor harmed by the fungus. The infection does cause the production of pyrolizidini alkaloids, their role and function with respect to livestock toxiosis is unknown (Bush et al. 1982, Siegel 1984).

ENDOPHYTES VS INSECTS

One of the most important implications of the endophytes in grasses is that of insect resistance among plants possessing a high level of endophytic fungi.

Prestidge et al. (1982) reported that perennial ryegrasses infected with the *Lolium* endophyte are resistant to the Argentine stem weevil, *Listronotus bonariensis*. Since then endophyte infected grasses have been found to be resistant to sod webworm, bluegrass billbug, southern armyworm, chinch bug, and oat bird-cherry aphid. The exact relationship between the resistance of perennial ryegrass and tall fescue to numerous insects has not been certain at this time. It is known that tall fescue, free of endophytes, is relatively tolerant to many insects that are serious pests in perennial ryegrass.

Perennial ryegrass, once freed of the endophytes, is quite susceptible to the Argentine stem weevil in New Zealand (Mortimer et al. 1983). This results in less RGS but forage productivity is reduced.

IN CONCLUSION

The role of endophytic fungi to promote certain insect resistance in ryegrass and tall fescue, and to a limited extent in other grass species, has been demonstrated. Also, it has been demonstrated that endophytes enhance vigor, heat and drought tolerance, improved persistence, increased density, and reduced invasion of weedy plants (Funk et al. 1983; Hurley and Pompei 1984; Hurley et al. 1984). The extent of other potential advantage to turfgrass seed consumers in various areas of the country are not known at this time. The techniques to inoculate seed bearing plants with endophytes and the maintenance of acceptable levels in the seed have been developed. Customers can now purchase seed that is tagged certified for endophyte performance (Hurley et al. 1984).

The implications for the forage-livestock producers remain uncertain (Hemken 1983). It has been clearly demonstrated that the physiological problems in grazing livestock are due to the level of endophytes in the forage. New Zealand workers are assured livestock toxiosis in endophyte infected perennial ryegrass is due to "tremogens (neurotoxins)". The precise origin of these toxins is not known. Read et al. (1983) have shown that endophyte enhanced fescue plants produced nearly twice the forage of endophyte free plants but the average daily gain and carrying capacity for the endophyte enhanced plants were only one-half of those of endophyte infected plants. The role of toxiosis in livestock caused by certain alkaloids should not be discounted. Recent work by Bush et al. (1982) indicate the possibility that certain alkaloids which cause fescue problems in livestock are enhanced by the presence of certain endophytes. Are there some endophytes which enhance plant growth yet do not produce toxic substances detrimental to livestock?

If further research substantiates that endophytes are the basis of livestock toxiosis in grazing forage grasses, then it may be desirable to remove these fungi from the seed which spreads the fungi. This is feasible and, in fact, endophyte free seed is available. The destruction caused by insects and diseases to endophyte free plants must be weighed against animal losses. Other genetic sources resistant to plant pest should be continued. And, lastly what is the implication of using endophytes, or what degree do they already exist, in other perennial plants in modern agriculture. Such studies on future roles of endophytes in plant culture have been proposed (Hurtley and Funk et al. 1984). The role of endophytes to control a wide array of insects, plant diseases, weeds and other plant pests warrant increased attention in the fields of biological pest control.

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