PROCEEDINGS OF THE 50TH NORTHWEST TURFGRASS CONFERENCE

Sept. 29 - Oct. 3, 1996 Victoria, British Columbia

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PRESIDENT'S MESSAGE

Leadership in information, research and support of turf and grounds professionals.

The 50th conference of the Northwest Turfgrass Association took place in 1996. This milestone event for the NTA was held at the Empress Hotel and Conference Centre in Victoria, B. C., Canada. On behalf of the Board of Directors and the management of the NTA, I would like to thank all of our conference attendees and presenters for making the 50th annual meeting a memorable affair.

Our keynote speakers, Dr. Roy Goss and Al Law, reviewed and helped us all to relive some of the wonderful history of the Northwest Turfgrass Association. Following presentations focused on our 1996 theme of the "Past, the Present and the Future of Turfgrass Management." A two way, live video presentation with Dr. Joe Vargas of Michigan State University gave conference attendees a possible glimpse into the future of turfgrass information exchange. Mr. Jim Connolly and Mr. Don Clemans can be very proud of the educational program they produced for the Victoria Conference.

The Roy Goss Golf Tournament for Turfgrass Research was held at Cordova Bay Golf Course. Golf course superintendent Dean Pillar and his staff had the course in perfect condition and even arranged for warm and sunny weather. We offer our most sincere thank you to the Cordova Bay Golf Course management and staff. Thanks to their support and from the generous contribution of our many sponsors, we were able to raise over $15,000 for turfgrass research at the golf tournament this year. Our thanks to Mr. Jim Dusin for organizing this outstanding event.

The production of the annual conference of the Northwest Turfgrass Association is the culmination of tremendous time and effort from and by our Board of Directors and staff. I cannot thank enough each and every one of these people responsible for the many details required for a successful event. Special thanks also to Bob Wick, Executive Director of the Western Canada Turfgrass Association, and to his wife Charlotte for all of their assistance in helping us plan and conduct the Victoria Conference.

1996 was a year that saw the NTA welcome a new Executive Director, Mr. Don Clemans, (and his lovely and helpful wife Linda). Their efforts have already improved nearly every aspect of NTA operations, We also retained Mr. Greg Crawford to assist us with media, communications and public relations, areas that are becoming more and more important to the industry.

1996 was a year that saw the NTA reach new heights in both fund raising and contributions to turfgrass research and scholarship. Mr. Mike Erb should be singled out for his contribution as Research and Scholarship Committee Chairman in both 1995 and 1996. The R&S Committee has had to make difficult choices and decisions in both scholarship and research financial support and they have made them well.

1996 was a year that saw the turf industry come a little closer together through NTA supported programs such as the Columbia Cup Golf Tournament, Regional Summit Meetings and through The T.U.R.F Program and T.U.R.F. Advisory Committee Meetings.

Mr. Tom Wolff was elected President of the Northwest Turfgrass Association at the Victoria Meeting. All best wishes to Tom and to the 1997 Board of Directors. I hope to see all of you at the 1997 conference at Sunriver Resort.

Thomas A. Christy, CGCS
President, Northwest Turfgrass Association

HISTORY OF THE PUTTING GREEN[1]

by Jim Connolly, Director NTA, Jacklin Golf [2]

There exists numerous historical accounts on the game of golf from every perspective and point of view. Authors of different persuasions write about Golf And The Golf Club, Golf And The Golf Ball. Golf and the Rules, Golf's Great Players, ad infinitum . . ., each offering their opinion depending upon point of view. This account, quite different from other accounts, addresses golf and golf course turfgrass maintenance and how the condition of the putting green influences the game. Changes in maintenance have influenced other areas of the golf course as well, not just putting greens. However, the putting green is the "heart" of the game and very sensitive to change.

Other developments that have had a profound effect upon the game include the development of a more lively golf ball, steel shafts instead of hickory shafts, graphite shafts instead of steel shafts, better athletes, (a debatable subject) and increased technology in the area of equipment, player training, etc. The USGA department in charge of balls and implements can document these changes. Indeed, the discussions on such subjects are plentiful and often very spirited. But why is there such a lack of discussion on course conditioning, save the few comments about turf being "better conditioned today than in the past," or the common complaint about slow greens.

Turfgrass conditions are so closely linked to the character of the game that I believe the manner in which the course is maintained has more impact upon the game than any development in equipment, design, or player skill.

The writings of Wind, Ouimet, Jones, Hutchinson, Hagen, Snead, Old Tom, et al supply one with enough information to make an intelligent correlation between course conditions and playing strategy. The change in turfgrass conditions over the years is boldly apparent. Every new playing philosophy is closely linked to the maintenance of that time period.

[1] Presented at the **50TH Northwest Turfgrass Conference,** Victoria Conference Centre, Victoria, British Columbia, Canada, September 30 - October 3, 1996.

[2] Jacklin*Golf*, Chief Agronomist

History records change. Everything is constantly changing, some for better - some for worse. Change in itself is not bad, but I believe we should understand and be aware of the reasons for change and the direction the change is taking us. The game of golf has definitely changed, although the basic principle has remained; get the ball in the hole with the fewest possible strokes, and don't cheat while your doing it!

It is important to realize that knowledge of the game and its past is fundamental to the success of proper Green Keeping (modern English - Superintendent). The person in charge of the golf course grounds has been given various titles from Custodian of the Links, to Caretaker, to Green Keeper. to Golf Course Superintendent. Whichever title you prefer doesn't really matter, proper maintenance of the golf course requires a dedicated. knowledgeable individual. After all, Old Tom Morris (regarded as the father of superintendents) was revered and respected by many and thought it appropriate that he be called Custodian of the Links!

Willie Park, a great golfer and amateur architect at the turn of the century, said "Golf design starts with the green and goes backward to the tee." Officially, the putting green is that area specially prepared for the part of the game known as putting. Although golf had its beginning some 600 years ago, putting, as we know it, began about 450 years later! Studying the gradual changes that have occurred over the last 600 years will give you a better understanding of the game, and golf maintenance.

Golf to some people is more than a sport, it' s a religion. Tommy Armour said "Love and putting are mysteries for the philosophers to solve - both subjects are beyond golfers." The putting green is definitely a focal point on the golf course and the superintendent is often judged on his overall ability based upon the condition of the putting green.

> *"The most fertile source of adverse criticism on the part of a club membership against the greenkeeper is that in relationship to the conditions that prevail upon the putting green."* W. K. Gault, 1913.

For simplicity and clarity, I will divide the historical account into four eras, or periods, separated by changes in maintenance, technology, or other influences to the turfgrass.

I. The period 1457 to 1832

"Decreed and ordained . . . that fute ball and golfe must be utterly cryitdune" King James II, March 6,1457.

The King believed that playing golf and fute ball (soccer) interfered with archery practice which was the common defense at that time. His decree went largely ignored and his loyal subjects continued to play golf in spite of possible punishment. It is reported that Mary Queen of Scots, perhaps the Alice Dye of her day, was playing golf immediately after her husband' s death. She claimed it eased her mourning. Sometime later, in 1603, King James I decreed that golf could be played, but church must also be attended. Forbidding the game may have slowed its growth, but their hearts and souls were branded with balls in flight and swishing clubs.

The game spawned some very serious followers as well. In 1637, a young boy was hung for stealing golf balls and in the same year, a golfer bludgeoned his caddie with a niblick club for giving bad advice.

The Royal and Ancient Golf Society of St. Andrews was formed in 1754, and in all their pomp and ceremony, formalized the game by creating a small number of basic rules. In its raw form, golf was and still is, a game that consists of the golf course, clubs, and a ball. Balls and implements used to strike the ball were similar for all golfers, but the differences between golf courses was great! This makes the game of golf unique in that the player is called upon to adapt to a number of situations. Unlike baseball or football where the playing field is fixed, the varying course conditions test the skills and mental fortitude of the player. Conditions on golf courses varied greatly, depending upon rainfall, wind, the presence of grazing animals (the first lawn mowers), the type of grass - if any, and a number of other vastly different land features.

Golf courses varied greatly because there were no uniform methods of maintenance between the golf courses. This all changed in 1832 with the invention of the mechanized lawn mower. The mowers equalized the playing fields somewhat, but big differences still existed due to differing geographic location. Ransomes, Simms, and Jeffries began marketing the first reel mower introducing a dramatic change to the game of golf. The height of the grass was no longer dependent upon animals' appetite. Still, conditions varied greatly because this was the only form of maintenance available.

The golf clubs manufactured at this time are evidence of the conditions that prevailed on the golf course. There were clubs for hitting out of wagon ruts, deep holes, and all kinds of imperfect situations. Different golf clubs today are primarily manufactured with different lofts for distance and height. When was the last time you selected a club for hitting out of a wagon wheel rut or a horses hoof print? The given environment and ball position forced the golfer to adapt in club selection and execution of the golf shot. It should be noted at this time that putting, and the putting green as we know it today, did not exist.

II. The period 1832 to 1900

During this period, the putting green began to take on a more familiar shape and could be considered a "separate" part of the golf course. A brief account of how the game was played would help to clarify how this came about. In the days of early golf, the golfer played to an area where a stick or pole, sometimes a hole in the ground, marked the finishing point of a single golf hole. The golfer finished the hole by either hitting the ball into a hole of nondescript size, or against a pole in the ground. The golfer could then start the next hole by teeing from an area only a few yards away from the previous finishing point. The "putting green" and "tee" in those days were very close together, and difficult to distinguish one from the other. The lawn mower, and better maintenance technique, eventually led to the distancing of tees and greens. In 1836 the literature mentions a special club designed for "putting" and aptly named the *putter*. It was desirable for the green to have closely cut grass, if there was any grass and golfers became experienced at putting with specially designed clubs suited for this purpose.

Possibly the first, and certainly most famous, *greenkeeper* was born in 1821 and maintained golf courses from the time period 1850 to the early 1900's. His name was Tom Morris and was affectionately known as "Old Tom". Old Tom believed that the proper maintenance of the putting green involved frequent, light sand top dressing and no play on Sundays! Old

Tom understood the benefits of regular mowing, top dressing to keep the surfaces true and predictable. Ironically, Old Tom was known around the country as a terrible putter! One of his golfing competitors used to send him mail addressed "Misser of short putts". Old Tom was normally mild mannered, but was occasionally given to breaking golf clubs after he missed short putts. Fortunately for him, he preferred lemonade over Scotch!

Putters were becoming the acceptable club for use on greens, but conditions were still quite variable and players used a number of different clubs on the green. From the book *Golf-Badminton Library, 1870*, it is written: "He was unable to use a cleek for the bad lying putt, these he negotiated with his iron."

After finishing a hole, golfers reached into the hole on the putting green to gather a handful of soil to use as a "tee" on the next hole. This led to a wide range of hole sizes and must have been cause for many ruling problems. In 1891, an ingenious greenkeeper found a piece of four and one-quarter inch clay drain tile that he pushed into the hole thus setting the size of the hole at four and one-quarter inches. This occurrence leads one to believe that today' s golf course evolved often by happenstance. The hole remains the same diameter today.

Golf courses being built at the turn of the century were designed with separate tees and greens and this was the form of architecture brought to the United States in the late 1800's.

III. The period 1900 to 1974

Many of the traditions of golf and golf course design were brought to the United States from England and Scotland at the turn of the century. Early Americans were familiar with golf but did not adopt it as a priority recreation. There are brief accounts of "attempted" golf in the early 1800' s but the first real golf course was not built until the 1890' s.

Charles Blair MacDonald, the son of a Scottish father and Canadian mother, designed the famous National Golf Links of America in 1911. Although he grew up in Chicago, he eventually returned to the University of St. Andrews in Scotland where he learned the game of golf and golf design. He brought this talent to the United States and put it to work designing golf courses. He believed a first class golf course should be constructed from good material, preferably a sandy loam that drained well. He believed in somewhat large, undulating putting greens with "fine" turfgrass so the ball will run perfectly true. MacDonald coined the title Golf Architect and is considered by many to be the "Father of American Golf Course Architecture". Some said he had an ego the size of Lake Michigan; and a slice that would traverse 3 counties! Many say he is the mold for today's golf architect.

There were other architects who brought a design flavor from overseas including Dr. Alister MacKenzie, Donald Ross, Willie Park Jr., Herbert Strong, and Walter Travis (Australian), just to name a few.

Some key developments in history had an obvious impact on the way golf courses were maintained.

1902 - the invention of gasoline powered lawn mowers.

1916 - architect, Donald Ross builds modified soil greens.

1918 - use of heavy equipment, such as bulldozers and steam shovels.

1920 - production of putting green mowers that could be accurately adjusted to one-eighth of an inch cutting height.

Circa 1920 - the development of underground irrigation systems.

1921 - formation of the United States Golf Association Green Section. The Green Section was solely dedicated to turf research and methods of developing healthy turf and good playing conditions.

1926 - the formation of the Golf Course Superintendent Association of America.

1945 - the end of World War II and the benefit new pesticides and chemicals developed during the war years. 2,4-D, Mercury, Cadmium, and Chloropicrin (tear gas) were all available for the control of turfgrass disease and insects.

1960 - wide popularity of riding triplex greens mowers that allowed "poor" golf courses to mow greens on a regular basis. USGA sponsored research leading to exact specifications for putting green construction.

Not all of America' s golf courses benefited equally during this period of advanced technology and information. Golf courses still varied tremendously, depending upon budget, construction technique, location, etc. For example: In 1898, the Montreal Golf Club had putting surfaces that were defined as "fine and closely cut putting greens". The same description is given of the Quebec Golf Club. The local golf professional was given credit for his maintenance skills. However, other courses didn't have grass on the greens! Pinehurst No. 2 had sand greens until the 1920's.

It is interesting to note that while players of today extol the virtues of ultra fast putting greens, putting greens of the past could also be mowed low to achieve similar speeds. A newspaper clipping from the 1935 US Open at Oakmont describes the greens as:

"Putting the greens at Oakmont is like putting down a flight of stairs and trying to stop the ball on the third step down . . . . "

Mowers of that day could be adjusted to l/8 of an inch and the greens "shaved" down to the dirt. A variety of turfgrass rollers were also available, ranging from weights of 150 tons to 3 pound wooden rollers. The maintenance instructions of the day cautioned against the extended use of rollers because they pressed and compacted the soil and limited turfgrass growth. Cutting heights below 5/16 of an inch were also frowned upon because the turf suffered from a myriad of diseases and stress-related problems. With the help of pesticides, irrigation, and special maintenance practices, greens were mowed at lower heights. Today, championship putting greens are mowed at 7/64 inch! The health of the grass is maintained at great expense.

Techniques for good turfgrass management were largely left up to experimenting individuals and architects. C.B. MacDonald, Donald Ross, Walter Travis, and others wrote about methods of greenkeeping. Some had good ideas — while others were highly suspect.

> *"Do not put fertilisers of any kind on a green except, perhaps, some bone dust, and then only once every three or four years."*
> *Walter Travis, 1906.*

Famous individuals associated with the game of golf fill the historical accounts. Their personalities and comments reflect the quintessence of the game at that time. The players of the first era viewed the sport as exercise and exhilaration. It was strictly personal satisfaction and a form of recreation at a time when most of the peoples attention was on survival. It was a welcome pastime, although viewed by many as frivolous. It was known as the game of kings and queens and seemed to offer leisure to those who could afford the time.

During the second era, golf became a more organized sport, giving a chance for friendly competition and camaraderie. In these first two eras, little attention was given toward the condition of the turf. The players fully realized they must adapt to the weather conditions and be satisfied with whatever their fate. Thus the axiom, "Play the ball where it lies". During the years of Old Tom Morris, there was a beginning of small expectations in regard to the condition of the turf. After all, mowers, top dressing sand, and labor were all available for conditioning of the links. Golfers placed their demands upon Old Tom, but he maintained his commanding position by proclaiming "Nae gaulf on Sundae!" This was perhaps the first and last time a greenkeeper had such power.

The idea of accepting conditions dealt by fate was as much part of the game as the golf ball and golf club. Putters were manufactured with varying degrees of loft for putting on greens of multiformity. Golfers were noted for their ability to overcome such conditions. Walter Travis was able to "putt a ball in from 40 feet over peanut brittle." In 1900, James Braid wrote, "Good putting can be learned from hard toil."

The major philosophies of this period were summed up in two quotes from two great golfers.

"You must adjust to the conditions." Walter Hagen, 1930

"Golf is a religion and it exposes in a man things which ordinarily he is at considerable pains to conceal." W. J. Travis, Circa 1910

Many golfers had a great insight about changes over the years and knew precisely where to give credit. In 1930, Horton Smith said, "Of course putting is much better than it used to be, greens are much truer than they used to be. Golfers can thank greenkeepers for that part of the improvement."

It is certain there was some grumbling about turfgrass condition, and golfers, both amateur and professional, were no doubt disgruntled about playing on crudely or ill-maintained golf courses. During the 1950's and '60's, golf was played by every class of American. The golfing boom continued unabated on the heels of Arnold Palmer, Jack Nicklaus, and the miracle of televised golf. Thousands of people who had never played golf - and probably never would - watched television and became enamored and eventually attempted the sport. An entire generation of golfers flooded the courses with little knowledge or awareness of golf' s great past. Looking back at the changes that occurred from 1900 to 1974, we can see changes influenced by developments in technology and the growing numbers of people playing golf. The growth supplied more money for development, research, and better golf course construction technique. Better grasses and methods of construction led to a dramatic increase in turfgrass uniformity and playability. The definition of a "good" putting surface would be one that was maintained at approximately 3/16 to l/4 of an inch, mowed on a regular basis, and was firm - but not too hard.

A note on grain, since it seems to be so misunderstood today. Grain in a putting green is a result of two things: The natural tendency of some grasses is to grow in a prostrate pattern. and the height at which the grass is mowed. Higher cut bentgrass greens will have a tendency to "lay over" forming a grain that effects the role of the golf ball. Bermudagrass grows aggressively in a lateral habit. Left alone, bermudagrass can achieve a high degree of graininess. Bermudagrass runners must be regularly vertically cut to keep grain to a minimum. Putting greens of this era were naturally grainy and golfers had to adapt to this condition. In 1941, Patty

Berg said, "You must make allowances for grain."

Byron Nelson walked all of the greens before a major tournament so he could evaluate the direction of the grain. He would then attempt to hit his shots to that side of the hole which would give him the "with the grain" advantage. It was much easier to putt a golf ball with the grain than against it. Great putters of the day were characterized by their ability to read greens. Bobby Locke, the great South African golfer, had a superior ability to read the grain in putting greens.

Golfers of this era were ready to accept any playing condition, and in fact, regarded this as an innate part of the game.

IV. FINAL ERA - 1974 TO THE PRESENT DAY

During the 1930's, a device was conceived by a Boston amateur golfer that would impact the game some 45 years later. Mr. Stimpson played golf in the Boston area with great regularity and was involved with several golf organizations. He noticed there were differences in putting greens from golf course to golf course. Mr. Stimpson was surely not the first to recognize this variability, but perhaps he spent more time lamenting over the situation which led to his invention of the "speed stick". Even though Mr. Stimpson was an accomplished golfer, winning the 1935 Massachusetts Amateur Championship, he felt there must be some way to measure, and perhaps control, the condition of putting surfaces.

Mr. Stimpson states, ". . . there is no standard set for the speed of putting greens. I believe there is a need to establish quantitative limits to certain conditions, still recognizing that growing grass can never be given an absolute measurement." Perhaps unknowingly, Mr. Stimpson's statement is an oxymoron. In one breath he states the need for a standard, then says it can't be done! This tool (the Stimpmeter) may have been conceived without full knowledge of its ultimate use, or abuse. The concept of placing a numerical figure on ball roll had its genesis in the 1930's, but was not officially adopted by any organization until 1974.

The USGA was embracing a philosophy that uniformity of greens was paramount in the selection of champion golfers. Throughout this report, I have stated that championship golfers were selected based upon their ability to adapt to the playing field. The shifting focus from player ability to course conditioning was slowly changing. The introduction of the Stimpmeter placed a greater focus on the condition of the putting green.

In the USGA Stimpmeter Booklet, the Stimpmeter is promoted as a tool "which makes it possible to make a standard measurement of - and place a numerical figure on - the speed of a putting green." Two purposes for the Stimpmeter are:

It aids in the identification of inconsistencies from green-to-green on the same golf course.

Places a numerical figure on - the speed of the putting green.

The Stimpmeter has such a profound effect upon the game today, that it is worth spending more time evaluating the usefulness of this tool. In reviewing the above objectives, some very interesting facts come to light. The first objective "uniformity'. can be evaluated with a Stimpmeter or a number of other methods. Any test device that rolls a golf ball over the green surface allowing distance to be measured would suffice. Functionally, the Stimpmeter is a good tool for this purpose. The question then becomes, "Is non-uniformity a major problem on golf courses today, and if so, what is the cause?'.

Tests by Cook College at nine different golf courses in 1979 showed "remarkable uniformity" among greens at the same golf course. Remember, this is in 1979 when maintenance practices and cutting heights were not as advanced as today. Cutting height exerts the primary influence upon putting speed. Research at Penn State shows the major influence on green speed is mowing height and frequency. It is reasonable to assume that if all the greens are mowed at the same time, they will be fairly consistent. Inconsistencies would arise from a number of conditions, most of which are easily corrected through common sense management. Inconsistencies among putting greens comes from poor drainage, shade, turfgrass health, and other identifiable deficiencies.

The second objective, "Placing a numerical figure on ball roll" has been the subject of much clamor and debate when discussing putting green management. The USGA states in the Stimpmeter instruction booklet, ". . . it is not the intention of the USGA to standardize putting green speeds . . ." But, Mr. Stimpson states ". . . there is no standard set for the speed of putting greens." The fact is, the standard **has been set** and the USGA's published chart on green speeds has set the benchmark for a good green, and a bad green. The chart actually does not say "'good" is fast and ""bad" is slow, but ambiguous statements to support this philosophy can be found throughout USGA literature. For example, Al Radko states in an article, *How Fast Are Your Greens?,* "Fast greens are considered to be a better test of ones skill and in general eliminates some of the many variables one experiences on the putting surface." In the USGA Championship Manual it states, "Fast greens are desirable because they require a player to have a delicate putting touch. . . ."

The official introduction of the Stimpmeter in 1974 has resulted in the quest for perfectly smooth, ultra fast putting surfaces. This is based upon the aforementioned theory that fast equals good. In addition, a high degree of emphasis is placed upon the condition of the golf course, moving the attention away from the ability of the player to adapt to any type of playing surface.

The quest for the fast and perfect putting surface has paved the way for specialized equipment designed to accomplish these high-lofted objectives. Maintenance budgets for golf courses that strive to achieve faster putting surfaces have increased accordingly.

The rebirth of turfgrass rollers is a direct result of the need to satisfy today's requirement for fast greens. More than ever, good agronomics are sacrificed for green speed. Lower cutting heights, heavy rollers, and intense grooming undoubtedly increase the need for water, fertilizer, and pesticides. This fact does not seem to have shifted the focus off of fast greens, nor slowed the pursuit of fast greens. Surprisingly, very little research has been done on pesticide use and the relationship to cutting heights.

The current standards for a good golf course are much different than the standards of 100 years ago. Some would argue that change is necessary and good for the game of golf, while others are more traditional and feel the backbone of the game is being severed. Tom Watson and Ben Crenshaw are advocates of the "old game". They enjoy the whimsical game of chance that golf used to be. An unlucky lie, a funny bounce, and an element of chance are viewed by them as a great part of the game of golf.

There is no question that the putting green represents a large part of the game. I believe it is important to place all parts of the game in perspective and realize that all changes are not good and that parts of this great game should be protected from unnecessary change. Governing bodies such as the PGA, USGA, the Royal and Ancient, should be protecting the game and not enforcing standards for maintenance based upon what is considered a good golf course. "Play the ball where it lies" has lost its meaning. Perhaps Bobby Jones summed up the putting green best when he said, "Worrying about rough spots in the green has no effect except to make the stroke indecisive, and I believe that bad putting is due more to the effect the green has upon the player than to the action of the ball."

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SAND BASE FIELDS DON'T WORK![1]
(But They Could)
by Tom Cook [2]

INTRODUCTION

It seems like I spend a lot of my time doing autopsies on failed athletic fields. Many if not most of the sand base fields I look at are failures. Either they don't drain or the grass won't grow or the grass wears out faster than it should. I can honestly say I have never visited a field and had the caretaker say, " This is the best thing we ever did. The kids love it and it is so easy to take care of." More often I hear, " This piece of s—t is the worse thing I have ever tried to maintain! I'd give anything to have our old soil field back." So, what is going on here? Are sand fields a nightmare waiting to happen? Is it inevitable that all sand fields will fail? Are sand fields so difficult to work with that only the pro's with unlimited budgets can possibly make them work?

I believe the real problems stem from a basic misunderstanding of why we build sand fields and a failure to see these fields as a special breed that requires a different style of management than the old soil fields. I guarantee that if you maintain your sand fields the same way you maintain your soil fields, they will fail every time. Further, if you use your sand fields the way you use your soil fields they will also fail every time.

What I want to do in this paper is discuss the ideas behind sand based fields, some of the critical factors in design and construction that make a difference, and the critical maintenance procedures that will maximize the chance that your field will drain and provide a playable surface for many years. I will also comment on the impact that use patterns have on short and long term field performance.

[1] Presented at the **50TH Northwest Turfgrass Conference,** Victoria Conference Centre, Victoria, British Columbia, Canada, September 30 - October 3, 1996.

[2] Associate Professor, Oregon State University

Why Sand?

We build fields out of sand to take advantage of the natural drainage properties of sand. Sand fields are meant to perform when conditions are too wet for soil fields. We don't use sand because it is easy to grow turf on (its not!). We don't use sand because turf will hold up better under traffic (it doesn't !). We do use sand because it can provide a firm surface even when the rain is pouring down.

During the dry times of the year soil fields are much easier to irrigate, they don't require a lot of fertilizer, and they wear like iron. When the wet season arrives, soil fields fall apart real fast. The surface becomes mushy, water penetration drops almost to zero, and the result is a nearly impossible surface to play on. With sand based fields kids can play right through the wet season on firm tight surfaces (at least in theory).

What this all means is that in our quest for firm playable surfaces in the fall and winter we have to accept a new set of problems in the summer. Rule number one is: "Sand fields are built for drainage and require different maintenance strategies than soil fields." Later in this paper we will look at just what these maintenance strategies are.

Avoiding Construction Failures

I honestly feel that relatively few field failures are due directly to construction screw ups. Don't get me wrong, I do see my share of drainage failures due to poor construction. Poor construction is often the result of poor inspections by the company who designed the field. If we review the critical steps in building a field you will see the role inspection plays in the process.

I like to view a sand based field as a layer cake with three components. The first component is the drainage zone which consists of the sub-base, the drain trenches, and the drain pipes and gravel envelope used to surround the drain pipes. The second component is the rootzone mix (the sand base) for growing grass and managing water that has entered through the surface. At the top we have the third zone made up of the top 3 or 4" of the rootzone mix and the actual turfgrass that covers the surface of the field. Each of these zones can cause problems so lets look at key mistakes to avoid for each one.

The drainage zone is intended to receive water that comes through the rootzone mixture. In other words it is the last zone to see applied water. The goal for the drainage zone is to move large quantities of water rapidly. In order to do this we install drain trenches with the base of the trench sloped downward towards an out fall. To insure unimpeded water movement we install drain pipes. To keep the drain pipes open we enclose them in a gravel envelope so that the pipe has gravel below it, on both sides of it, and on top of it all the way to the top of the drain trench. (Details for drain construction can be found in the extension publication PNW 0240. This publication can be obtained at county extension offices throughout Washington and Oregon.) To make sure drains have a chance to work consider the following list of Do's and Don'ts:

Do these things and the drains will work:

Dig trenches parallel to each other so they are 15-20 ft. apart.

Clean the trenches of loose soil and construction debris before placing gravel in the trench.

Unless you have used a laser guided trencher, put a bed of gravel in the bottom of the trench 2+ inches deep to enable you to adjust the grade of the trench.

Lay the drain tubing on the gravel bed so that it is centered and has a constant grade of 1/2 to 1%.

Place gravel around and over the drain pipe until it is covered up to the subgrade. Be extremely careful to avoid contaminating the gravel with soil as it is being placed in the trenches.

Use uniform gravel that is free of fines (fine sand, silt, and clay). Small gravel in the range of 1/8 to 1/4 inch, 1/4 to 3/8 inch, or 1/4 to 1/2 inch will all work well if they are free of fines. Larger gravel will allow too much migration of the topmix down to the drain lines.

Use either slotted rolled drain tubing 4" in diameter or rigid drain pipe of the same diameter. If you use rigid pipe place it in the trench with the holes facing down.

When placing the gravel over the drain pipe constantly check the grade to make sure the gravel does not flow under the pipe and raise it up.

Have someone from the design office inspect the entire procedure from start to finish to make sure installation is done correctly.

<u>Do not do the following:</u>

In the design phase do not stretch spacing of drain lines, specify drains smaller than 4", or eliminate drain pipes completely.

Do not lay drain pipes on the surface of the subgrade instead of in trenches. While this may be appealing because of reduced costs and fewer steps, it is a sure fire way to end up with crushed pipes that won't drain.

Do not use pipe covered with fabrics, do not cover pipes and gravel with filter fabrics, and do not encase the pipe and gravel in filter fabrics. The fear of fine particles migrating has caused many to cover pipes which may result in plugging of the filter fabric and consequently reduce flow of water through the pipes. Experience has shown that if drains will work with fabrics, they will work without them. Conversely, if drains won't work without fabrics, they won't work with them. Fabrics are an unnecessary expense in properly constructed drains.

Do not allow trucks and other heavy equipment to drive across drain lines before, during, or after drain line and gravel installation. Once trenches are dug, vehicles should drive between the lines or straddle the lines.

Do not assume that contractors who have been building roads all their lives understand the importance of building a sports field properly. It is the designers responsibility to make sure the contractor is aware of proper construction procedures and in fact builds the field in a manner that will allow the field to work. The designer or a person knowledgeable about the design should be onsite during the entire installation period and should make sure the work is done properly.

The top mix zone goes over the drainage zone. You have several things that are important to remember when working with top mix. The quality of sand is critical and the depth of the sand is very important. Details on rootzone mixes are presented in the extension publication PNW 0240 mentioned earlier in this paper. Here I want to focus again on what you should do and what you should not do with this zone.

Things to do to insure a functioning rootzone layer

Use the best sand you have available that meets the criteria in PNW 0240. Experience has taught me that rarely do we get to use sand that actually meets the specifications outlined in the bulletin. The key when using substandard sands is to err on the side of drainage. For example, reject concrete sand may be acceptable if it is free of fines (silt & clay). Remember, our goal is to move water through the profile and we can do that with sand that is coarser than desirable but not with sand that is finer than desirable. The trade off with coarser than desirable sands is they require more irrigation and dry out faster in hot weather. The trade off with finer sands is that they seal up and the surfaces become wet and mushy so we spend our time trying to keep them open and draining.

Make the profile depth as deep as possible up to about 16 inches max. We always shoot for 12 to 16 inches of rootzone mix but since sand can be expensive there is a tendency to try to get by with less. When you go below 12 inches there may not be enough depth to insure that the field will drain freely in the winter. There is a tendency for shallow fields to remain too wet during winter and we are right back where we started with a mudhole.

Check sand regularly as it arrives to make sure the sand quality stays constant. This is particularly important if the sand is coming from a pit rather than a screening plant. The only way to check the sand is to run it through a set of screens upon arrival at the site. A set of small hand held screens is a good investment.

Rootzone mixes composed of sand and organic matter should be premixed away from the construction site. Materials should only be placed on site once uniform mixing has occurred.

Trucks should straddle drain lines and dump their loads directly over the gravel covered drains. When all the rootzone mix is in place the site should look like a series of windrows of sand.

Sand should be spread initially using a track vehicle rather than a wheeled vehicle to avoid crushing drain lines by driving over them during the spreading process.

Final grading can produce a slight crown in the center of the field of no more than 6 to 12 inches or a flat field. Flat fields are utilitarian because you can situate fields anyway you like. Unfortunately it seems to be difficult for contractors to grade a level surface so we often end up with low areas scattered throughout the field. A slight crown is appealing because it makes the field look flat rather than concave. It also seems to be easier to grade for contractors. Beyond that, crowns serve no functional purpose on a sand field.

Do not do the following:

Do not assume the contractor understands what you want. His job is to get in and out as fast as possible. As the saying goes, " Once its buried, everything looks the same." Realistically you only get one chance to have your field built properly.

Do not allow the contractor to cheat on the depth of rootzone mix. Specifications list a number and that is the depth the field should be when its finished.

Do not make casual inspections. Nobody I know can tell depths or grades just by looking.

Do not budge on sand quality. Being a nice person will leave you with a poorly drained field unless you are very lucky. Remember that to most people sand is just sand.

Maintaining a Free Draining Field

Now we come to the final layer of a sand field. The 3 to 4 inches where the grass is growing is the zone the turf manager is responsible for.

Perfectly built fields will fail eventually unless this zone is properly managed. Poorly built fields will fail faster if this zone is not well managed. Once the field is constructed what you do to this surface zone will determine how long and how well the field will perform.

The drainage theory on sand based fields is simple. What we want to do is move water vertically into the surface, down through the rootzone mix, and out through the drains to an exit point. I think of it as three words, "INTO, THROUGH, & OUT." Once the field is built we can really influence only the first step. Maintenance strategy number one is: Work the surface constantly to keep it open. Working the surface involves hollow tine coring 3 to 4 times per year, deep solid tine aerating (vertidraining) one to two times per year, and surface slicing weekly during each major use period. Allied practices such as slice seeding and surface scarification via a flail or similar machine help to insure a porous surface that will take water rapidly.

Lets look at a hypothetical soccer field and see how a maintenance schedule might work out to insure a healthy turf and good infiltration. Assume for this example that the field is located in a metropolitan area west of the Cascade mountains.

<u>Mowing:</u> This field should be mowed at least once per week and preferably twice per week for most of the year. Peak mowing periods will run from March through November. December through February plan on mowing about every other week to every third week.

Total number of mowings will range between 45 and 75 depending on the year and labor resources. Clippings should be removed during the period between March and November to avoid accumulation of fresh organic debris that can be ground in by players cleats.

<u>Fertilization:</u> Sand base fields need regular fertilization with products containing both soluble and controlled release nitrogen. In an ongoing fertilization program plan on one pound of total N per 1000 sq ft of turf each month during March through October. A mid winter application of N from a controlled release source such as IBDU, Polyon, ESN, Poly-S, Tricote, or other polymer coated products at 2 lbs N/1000 sq ft should

improve winter turf color and improve early spring growth. Total N rates will be as much as 1/3 to 1/2 less on fields where clippings are left after mowing.

Actual nitrogen rates can only be determined by observing turf performance. Consider the above numbers as a starting point but trust your own judgment and keep accurate records. Also keep in mind that sand is nutrient deficient and will require complete N-P-K fertilizers at each application. N-P-K ratios in the range of 5-1-2 to 5-1-4 will work fine. Apply N-P-K fertilizers plus complete micronutrients at least twice per year (spring and fall), or as dictated by tissue analysis. Remember also that sand fields may need periodic applications of calcitic or dolomitic lime to provide adequate Ca and Mg or to raise pH to the 6.0+ level. Need for these elements are best determined by tissue analysis or soil testing.

Irrigation: Sand fields need to be irrigated frequently and kept slightly moist to prevent development of localized dry spots. The best advice is to apply water daily or every other day to match water use rates or evapotranspiration (ET). This is best accomplished by utilizing an onsite weather station that can communicate directly with the irrigation controller to determine daily run times. If that isn't possible, use a soil probe to determine field water content and irrigate by your best guess. Plan on irrigating 3 to 4 times per week during the season and try not to apply more than 1/2 inch of water per application to avoid wasting applied water due to excess leaching. In fall, run the field as dry as possible prior to the onset of fall rains.

Coring: Core at the end of the fall season with either a conventional hollow tine machine with 3-4 inch tines or a vertidrain with solid shanks set at least 8 inches deep. Core again in March with either the standard hollow tine machine or the vertidrain. Around late May to early June Core with hollow tines one more time. Depending on the field conditions, core again in late August. Coring should be regular and consistent on sand fields. The vertidrain should be used at least once per year as noted above since it can penetrate deeper and break up the subsurface which will enhance water movement through the rootzone mix.

Slicing: Slicing is a valuable tool for maintaining surface infiltration during the season when practices such as coring or vertidraining might be too disruptive. Slicing works well on sand fields and should be done at least weekly during the fall winter and spring use periods. Slicing effects are very short lived which is why this practice needs to be done consistently through the use season. I can't emphasize how valuable this procedure is.

Dethatching: Thatch rarely forms on sand fields as we think of it on lawns. What we most commonly see is organic debris that gets ground in to the surface. If this material is not removed periodically, it will eventually plug the surface and impede water movement into the surface. Plan on dethatching at least every spring in association with coring or vertidraining. On heavily worn fields dethatching with a tractor mounted flail device may be needed to prepare the surface for reseeding.

Topdressing: Topdressing with sand identical to that used in construction will help maintain a uniform surface profile and keep a smooth grade for maintaining a safe surface for players. Topdressing should be done spring through summer to prepare the surface for fall and winter play. Late fall topdressing after the season is over is appropriate whenever reseeding is done. Plan on 4 to 5 topdressings per year at 4-5 week intervals during periods of active turf growth. Individual topdressings should never exceed 1/4 inch to avoid smothering of turf and turf thinning.

Slice Seeding: Sports fields are constantly worn and abused by players. Turf on these fields is always temporary so you need to replant regularly to keep the surface covered with desirable grasses. The slice seeder is an effective tool for overseeding because it is relatively none disruptive and plants the grass in grooves where they have a chance to germinate and establish. Overseeding is useful for thickening weak stands or filling in areas where turf has been destroyed completely. Target the late fall period for overseeding worn areas. Overseed again in mid spring and if needed again in early June. Don't ever plan on being finished. Just plan on overseeding regularly for the rest of your working life.

Adjust these practices as needed to fit your budget and climate. Always remember that we build sand fields so they will drain. Your number one job is to do whatever you can to keep the surface open and free draining. The maintenance practices listed above will accomplish this goal and give you excellent turf as well. Its a winning combination that has been proven in the field and really does work. Plan for it and then carry out the plan. The result will be the best field you can achieve at your site.

What about use of the field?

The hardest part of maintaining fields is getting users to schedule the fields intelligently so there is a chance that you can keep grass on all of the field most of the time. I've proposed lots of different solutions to the perennial problem of overuse and abuse. Designing fields square to allow for field rotation, moving goals regularly to avoid excessive wear in goals, practicing in a manner to avoid wearing out field centers or goal areas etc.,etc.,etc. never seem to happen. What is the solution? There may not be one but if it exists it will end up being your responsibility. I have all but given up trying to enlist the aid of user groups. They just don't see the connection with how they use the fields and how the fields look and hold up over time.

When it comes to sand fields I try to get clients to build a limited number of sand fields and as many soil fields as they can. My advice is always to use the soil fields in summer and as late into fall as possible before the fall rains turn them to mush. At that time switch to the sand fields and get the most mileage from them as possible during the time when soil fields are useless. A few people listen but most destroy the surface of the sand fields early on in the fall and end up playing out the fall or winter on fields void of turf.

Whatever approach you take on your sand fields remember that it will happen because you want it to. Don't expect cooperation from users and don't be disappointed if they refuse to help you out in your quest to give them better surfaces to play on. Just be persistent and don't give up!

THE GOLF INDUSTRY - 2000 AND BEYOND[1]

By Jim Gibbons [2]

In order to obtain a proper perspective on the future, it is usually best to look back and review the changes that transpired over the last few years. As we look into the possibilities for the next many years, there will be some ideas presented that may seen realistic while others will be more obtuse. It is my hope that this presentation will trigger a thought or idea that might promote or develop a new product in the industry. If what is presented today helps inspire someone to invent a new turfgrass product that should make a lot of money, we could possibly create a millionaire.

What was the past like? There have been meetings such as this for many years. I found a picture of the 1913 Scottish Section of Golf Greenskeeping Association meeting. They certainly were concerned along similar lines as today in the effort to produce the best possible playing surfaces. Early on the equipment was primitive. Often animals were used for power for construction and maintenance. In his 1912 The Book of the Links, Martin H. F. Sutton wrote about sheep grazing on golf courses: "Unless cake-fed, sheep return no benefit to the ground, but in sufficient number, they help to keep down the expense of mowing and rolling. In this sense they prove an asset, especially to a struggling club. Against this must be set the damage done to the greens by "scalding" the turf, the breaking down of the face of the bunkers and the objectionable fouling of the fairway, to which must be added the nuisance they invariably are to players, Altogether the advantages of sheep are far outweighed by the disadvantages."

Also, take note of the present. The industry has made great strides over the years. We have modern facilities and equipment to make the job more efficient. The ability to groom courses is available to most everyone. The northwest is to be congratulated for being recognized as capable hosts for the US Amateur, US Junior, US Public Links, US Senior Women's, US Senior Men's, US Mid Amateur and next year the US Women's Open.

[1] Presented at the **50TH Northwest Turfgrass Conference,** Victoria Conference Centre, Victoria, British Columbia, Canada, September 30 - October 3, 1996.

[2] Executive Director, Oregon Golf Association

The game of golf reaches all segments of society from presidents to celebrities to the general public. Golf is for women and men, junior and seniors. It is a game of traditions ranging from caddies, juniors, amateurism, and a basic respect for the game that will hopefully continue to be important in the future.

And what of that future. It is an opportunity for making money by creating solutions to problematic situations that occur within the industry. Creative thought can make it happen. Let's look at some possible future innovations. In order to open the thought process, some of these will be very unusual, others reasonable.

Let's approach this in three areas relating to turf and golf: equipment, turfgrass and the industry in general. First, look at where equipment might be evolving. In mowing, there could be remote controlled mowers programmed for greens that would be housed in underground shelters. They would elevate for mowing and would be controlled by programming and an "invisible fence" similar to pet control fences. The same process could be expanded into some type of bunker rake apparatus. With the changes in vehicle tires to larger sizes, (tires have gone from 8 1/2 to 10 1/2 inches), it only seems a matter of time until most maintenance vehicles will operate on cushions of air like hovercraft. Additionally, all equipment will be operable at night time. It will be ergonomically designed and climate controlled with electric power rather than gas. Imagine working on the course in the recliner chair behind the wheel inside the temperature controlled cab.

These pieces of machinery will have computer diagnostic capability and the capability to hook up to the maintenance shop computer which will go online to order any part directly from the supplier. Also, all communications will be far more sophisticated than present. Everyone on site will be able to communicate with everyone else.

Other innovations might include automatic controlled hazard and OB stakes which pop up and retract through a garage door opener type control with a 40 foot range. The mower operator can press a button before and after passing by. Irrigation heads will not just pop up when watering, but someone will invent an adapter to trim the grass at the edge of the plate using the power of the motion of the sprinkler. There will be a laser grid system similar to that used on boats for locations that would send an exact cup location back to a computer in the pro shop to be printed out on a hole location sheet for all golfers. Speaking of hole locations, if you refer to the handout, I'd like to explain how the chart we give the golfer relates to where you as the hole cutter would locate the hole. Remember the golfer views the target green as a circle. That player wants to know the hole locations in yards relative to the front of the green and how close to the edge of the green the flagstick is. The accurate way to find the correct spot is to walk straight back from the front center of the green the number of paces from the front. After that, count from the side the right amount of paces. You're there.

There is a great opportunity for new ideas to take effect in the area of disease treatment and prevention. How about new dynamic temperature sensors that, through inline applications, would sense changes in weather or plant levels that would trigger automatic applications of materials to reduce or eliminate problems prior to them being observable. Or why doesn't one of the chemical companies invent a clear benign product that could be spread over a turf area. When a pathogen or other designated problem initiates, this product would turn a bright color to alert staff of pending problems with an early warning.

As related golfing associations are becoming aware of the aspects of the turfgrass industry, more of these organizations will be allocating funds to assist with improved playing conditions. These will support new and continuing studies to reach those goals. Now insects are being used to combat problems. With the major earthworm dominance for years on golf courses, why not reach some way of reducing the earthworm population. Since worms eat organic debris, why not develop a sterilizing agent that would be mixed into that debris to reduce the reproduction levels.

Artificial turf in certain playing areas will possibly become more popular. Quality may be improved and stress taken off other turf areas. There may be a movement to center the problematic cart path, moving it to the middle of the fairway. Then a green artificial surface would make a nicer view that the regular paved surface.

As the industry advances, we start to see new technologies emerge like the weather tensiometer stations to assist with irrigation. Why not have nutrient analyzer capability on site along with complete soil and disease analyzing potentials. There should be computers that have the complete "as builts" of the course irrigation system with a complete parts and equipment inventory. If a break in the system occurs, the computer shows what happened where, and which parts are needed for repair. Even the supply companies would be logged onto the network and you could highlight the parts and order them directly through the computer. The same situation could be in place for maintenance equipment with CD disks for a blow up diagram of the tractor or other piece of equipment broken down. Again, go on line to order the parts needed without leaving the comfort of the office.

Other annoyances are solved with better inventions all the time. And more will come. There will be some easy effective way of marking out of bounds and hazard lines more permanently. Other markers will help with pace of play. Upright 150 yard posts in the middle of the fairway are in use at some courses. They locate the center of the driving target as well as giving distances. With the increasing demands upon daytime play, there will be a trend to night time only maintenance. Also, there will be more compact facilities being built. Complete courses are now designed on 15 acres with separate sections for driving, approaches, chipping and putting. As the availability and cost of land put pressure on developers, these compact courses will start to show up.

There will be more cooperation among all golf related organizations. Environmental situations will become very favorably tied to golf. We are seeing the adversarial role being reduced as golf courses place more areas into Environmentally Sensitive Areas. This procedure is allowing courses to be built where consideration in the past was declined.

Golfers may push for ways to make the game more enjoyable. Placing larger holes on the greens for higher handicaps might be one thought. Building a complete course inside a biosphere-type building is a possibility. Controlled climates and perfect playing conditions all the time would garner higher fees. The tolerance for spiked shoes will decrease as more non-metal spike options are created. Some inventor may find a new material that will gently cling to grass plants to be used on the soles of golf shoes. The recent USGA Journal has an in-depth article relative to this topic.

And the future may answer one of the often asked queries, "Do we put the rakes in or out of the bunkers?" Miscellaneous Decision #2, page 593 in the USGA Decisions on the Rules of Golf Book, strongly recommends that rakes be placed OUTSIDE bunkers. Putting rakes in bunkers can cause situations for playing that create extra penalties for players when the rakes are at the edges of the bunkers. (See following handout information.)

From the USGA Rules of Golf Book, "Rule 24 Obstructions, 24-1. Movable Obstruction

A player may obtain relief from a movable obstruction as follows:

If the ball does not lie in or on the obstruction, the obstruction may be removed. If the ball moves, it shall be replaced, and there is no penalty provided that the movement of the ball is directly attributable to the removal of the obstruction. Otherwise, Rule 18-2a applies.

If the ball lies in or on the obstruction, the ball may be lifted, without penalty, and the obstruction removed. The ball shall through the green or in a hazard be dropped, or on the putting green be placed, as near as possible to the spot directly under the place where the ball lay in or on the obstruction, but not nearer the hole. "

"20-3d/2 Ball in Bunker Moves Closer to Hole When Obstruction Removed and Ball Will Not Remain at Rest When Replaced; All Other parts of Bunker Are nearer Hole.

A ball came to rest against a movable obstruction, a rake, in a bunker. When the rake was moved the ball rolled nearer the hole. According to Rule 24-1, the ball had to be replaced. Due to the slope and the fact that the sand was firm, the ball, when replaced rolled closer to the hole.

Under Rule 20-3d, if a ball will not come to rest on the spot where it originally lay, it must be placed at the nearest spot not nearer the hole where it can be placed at rest. The spot where the ball originally lay was farther from the hole than any other part of the bunker. This, there was nowhere to place the ball at rest in the bunker which was not nearer the hole. What is the proper procedure if:

The only way the ball would remain at rest at the spot where it lay would be to press lightly into the sand?

The sand is so hard that it is impossible to replace the ball?

There is nothing in the Rules of Golf Permitting a player to press his ball lightly into the sand or ground to make it remain at rest. Accordingly, in either case, since the player could not place the ball in conformity with the Rules, he should, in equity, (Rule 1-4), have dropped the ball, under penalty of one stroke, outside the bunker, keeping the point where the ball lay directly between the hole and the spot on which the ball is dropped. (Revised)"

"Miscellaneous Decisions

Misc./2 Whether Rakes Should be Placed In Or Outside the Bunkers

Should rakes be placed in or outside bunkers?

It is recommended that rakes be placed outside bunkers, as far away from the bunkers as is practical and in positions where they will be least likely to affect play.

NORTHWEST TURFGRASS ASSOCIATION - YOUR PROFESSIONAL ORGANIZATION - THE FIRST 50 YEARS[1]

By Roy L. Goss, Ph.D. [2]

Prior to 1948, and in fact for another decade or two thereafter, most turfgrass managers had their own knowledge, experiences, and secrets that were not freely shared when it came to managing quality turfgrasses. The golf courses had their greenkeepers who, for the most part, kept their secrets at home. There were few open forums, conferences, or seminars for learning and sharing of ideas and turfgrass research at universities was, indeed, scarce and far between as well as any teaching programs in turfgrass science. Turfgrass scientific reading materials were almost nonexistent with the exception of a few bulletins and eventually a book by Professor H. B. Musser from Pennsylvania State University.

During the winter of 1947, Wilfred Brusseau, Down River Golf Course, Spokane, John Harrison, Hayden Lake, Idaho, Glen Proctor, Manitou Golf Course, Spokane, and Lewis Schmidt, Indian Canyon Golf Course, Spokane, met with Professors E. G. Schafer, Dean of College of Agriculture at Pullman, and Alvin Law, Department of Agronomy at Washington State College at Pullman. These greenkeepers described the problems that they did not have answers for and Al Law worked these out into topics and scouted around for people to address these problems to be held in a conference in May of 1948. Some of the problems that were troubling the greenkeepers in those days included: arsenic in greens, principally used for worms and weed control, fertilizers, and 2,4-D, which was a new weed control agent. During 1948, two conferences were held on the Pullman Campus, one in the spring and one in the fall. One conference has been held each year without an interruption since those first two conferences in 1948.

[1] Presented at the **50TH Northwest Turfgrass Conference,** Victoria Conference Centre, Victoria, British Columbia, Canada, September 30 - October 3, 1996.

[2] Executive Director Emeritus, Northwest Turfgrass Association

The initial steps for forming a nonprofit corporation were taken during 1950. Directors were elected and included E. P. Townsend, Edward Fluter, H. T. Abbott, Phil Page, Mavor Boyd, James O'Brien, Glen Proctor, Milt Bauman, Everett Potts, and E.G. Schafer. The Articles of Incorporation were completed in 1951 and filed at Olympia, Washington under the name of the Northwest Turf Association. The first officers after the formation of the nonprofit corporation were Ivan Lee, President, Ed Fluter, Vice President, Roland Wade, Secretary-Treasurer, and E. G. Schafer, Honorary Director and Executive Secretary.

It is interesting to point out at this time that the Association was incorporated under the name of Northwest Turf Association, and due to the confusion between this organization and horse-racing organizations, a change was made in the charter and bylaws to change the name to the Northwest Turfgrass Association during that late 1950s.

At the risk of becoming monotonous, I think it is important for us to follow the development of the Association from its beginning in 1948 with some of the highlights that happened each year. Some of the records of the early years are nonexistent and have been reconstructed since the middle 1950s from my records and the best recollections of people like Alvin Law, Glen Proctor, Johnny Harrison, Milt Bauman, Louis Schmidt, Wilfred Brusseau, and others.

1948 - First Conference, Spring

Glen Proctor was the President, and the conference was held at Pullman, Washington. Topics that were discussed included the uses of arsenic for the control of worms and weeds, fertilizers for golf courses, and the uses of the new herbicide, 2,4-D.

1948 - Second Conference, Fall

Glen Proctor was the President, and again the conference was held at Pullman.

1949 - Third Conference

Louis Schmidt was the President, and the conference was held at Pullman. It should be pointed out at this time that for many years, the conference was held in the old Washington Hotel in downtown Pullman, which brings back many nostalgic memories for people who were there at that time.

1950 - Fourth Conference

Ivan Lee was the President and the conference was in Pullman. The directors included: E. P. Townsend, Ed Fluter, H. T. Abbott, Phil Page, Mavor Boyd, James O'Brien, Glen Proctor, Milt Bauman, Everett Potts, E. G. Schafer (honorary director)

1951 - Fifth Conference

Ivan Lee was President and the conference was held in Pullman. The Articles of Incorporation for a nonprofit corporation were completed and filed at Olympia, Washington under the name of the Northwest Turf Association. Al Law was elected Executive Secretary , Ed Fluter was Vice President and Roland Wade was the Treasurer.

1951 - Sixth Conference

Ed Fluter was the President and the conference was held in Pullman. Items discussed at the conference were pearlwort control, chickweed control, the control of gray snowmold and Fusarium patch disease. Henry Land, Sr. was elected Treasurer and continued in the capacity from 1952 to 1961.

1952 - Seventh Conference

Ed Fluter was the President and the conference was held in Pullman. Tom Mascaro from West Point Products Corporation, a frequent conference speaker, agreed to publish, at no charge to the Association, the proceedings, and continued to do so for the next few years. Other speakers who appeared on the programs during those days were O. J. Noer, Charlie Wilson, Fred Grau, G.O. Mott, and H. B. Musser.

1954 - Eighth Conference

Sam Zook was President and the conference was held in Pullman.

1955 - Ninth Conference

Sam Zook repeated as President and this conference was also held at Pullman.

1956 - Tenth Conference

Milt Bauman was President and the conference was held in Pullman. Dr. Ken Patterson was elected Executive Secretary. Some of the conference speakers that year included Alvin Law, Ken Patterson, Roy Goss, and Chuck Gould.

1957 - Eleventh Conference

Milt Bauman was again elected President and the conference was held in Pullman. Speakers included the following people: Bill Bengeyfield, Chuck Gould, Bert Brink, Roy Goss, and Al Law.

1958 - Twelfth Conference

Don Hogan was President and the conference was at Pullman. Roy Goss was appointed to the Turfgrass Research position during that year and the position was to be funded at Puyallup, Washington. During that year, the first British Columbia Turfgrass Conference was held.

1959 - Thirteenth Conference

Don Hogan was elected President and the conference was held at Pullman. The first printing of "The Turfgrass Topics" was begun in 1959, Roy Goss, editor. Byron Reed agreed to write the Oregon Compost Heap with news about Oregon. The first turfgrass field day was held at Puyallup on August 20th, and the second British Columbia Turfgrass Conference was held that year. Roy Goss' appointment was changed during that year to 50:50 research and extension specialist.

1960 - Fourteenth Conference

Don Hogan was elected President again and the conference was held on the University of Washington Campus -Seattle. Highlights of the year included Ophiobolus patch was first observed and identified by Dr. Maksis Eglitis at Puyallup. The first pre-emergence crabgrass controls were applied and we were all saddened at the death of Bob Finley, a long-time greenkeeper and golf superintendent.

1961 - Fifteenth Conference

Glen Proctor was elected President and the conference was held at Pullman at the Compton Student Union Building. We were saddened in 1961 at the loss of Bernice Land, the wife of Henry Land, Sr., who was his righthand for performing the duties of Treasurer. Henry could no longer continue in that respect and retired as Treasurer that year. Dr. Ken Patterson also died in 1961. Dick Haskell was elected Treasurer and Al Law, once again, filled the position of Executive Secretary. Athletic fields were a hot topic during that year, which is the same time that Jo Albi Stadium was refurbished in Spokane.

1962 - Sixteenth Conference

Byron Reed was President and the conference was held in the Compton Union Building in Pullman. Highlights of this conference included frosted and frozen turf. The Fifth British Columbia Turfgrass Conference was held during this year. The turfgrass field day was held at Puyallup on May 15 and Roy Goss was elected Executive Secretary and continued in this position through 1987 for a total of 26 years.

1963 - Seventeenth Conference

Henry Land, Sr. was the President and the conference was held at the Thunderbird Motel in Portland, Oregon. The turfgrass field day was held on June 11, with over 200 attendees.

1964 - Eighteenth Conference

Milt Bauman was elected President and the conference was held at the Villa Motel at Burnaby, B.C., September 23-25. We were saddened in 1964 with the loss of A. Vernon Macan, golf course architect, who designed many golf courses throughout the Pacific Northwest. The groundsprayers association also made a grant of $300.00 that year for speedwell control.

1965 - Nineteenth Conference

Ken Putnam was elected President and the conference was held at the Hayden Lake Country Club at Hayden Lake, Idaho. John Harrison was the host superintendent. Paul Brown, a noted television personality and turfgrass and grounds manager at Evergreen Washeli Cemetery in Seattle, died. MH-30 was one of the first growth retardants that was tested in 1965.

1966 - Twentieth Conference

Harvey Junor, Portland Golf Club, was elected President and the conference was held October 26-28 at Salishan Lodge at Gleneden, Oregon. The conference attendance was 178, which set a record at that time.

1967 - Twenty-first Conference

Dick Malpass was elected President and the conference was held at Harrison Hot Springs, B.C. Highlights of the year included the introduction of Tersan 1991 (benlate) for experimental purposes for disease control. DCPA (dacthal) was found to control speedwell.

1968 - Twenty-second Conference

George Harrison was elected President and the conference was held at the Alderbrook Inn at Union, Washington. Art Elliott, from Turf and Toro, was appointed membership chairman to start a new membership drive. The chlorinated hydrocarbons were axed during this year, and John Escritt, from the Sports Turf Research Institute of Bingley, England, was our guest speaker.

1969 - Twenty-third Conference

George Harrison was elected President and the conference was again held at Hayden Lake Country Club, Hayden Lake, Idaho. During this year, the First International Turfgrass Research Conference was held at Harrogate, England in July 1969, and the first Washington Turfgrass Survey was completed that year. The first artificial football turf, called Tartan, appeared that year also. Poa annua seedhead inhibitors were introduced during 1969.

1970 - Twenty-fourth Conference

Tom Keel was elected President and the conference was held at Salishan Lodge at Gleneden, Oregon. During this year Manhattan ryegrass was the first improved turf type perennial ryegrass to be tested. This year also saw Tersan 1991 (benlate)registered for turfgrass use for disease control.

1971 - Twenty-fifth Conference

Tom Keel was, again, elected President and the conference was held at the old Chinook Hotel in Yakima, Washington. During this year, full-scale tests were initiated on Ophiobolus patch disease and it appeared that ammonium sulfate, sulfur, and Fore were the best treatments. It all boiled down to the sulfur factor.

1972 - Twenty-sixth Conference

Dick Schmidt was elected President and the conference was held at Ocean Shores, Washington. During this year, the highlights included Milt Bauman introducing high flotation tires on golf course tractors and the prescription athletic turf procedure developed by Dr. Daniel first appeared. Jim Chapman began writing the Thatch Patch for the Turfgrass Topics. Tom Cook, a WSU senior in agronomy, was awarded the GCSAA scholarship, which was presented to him by Dick Malpass, who was a GCSAA director at that time.

1973 - Twenty-seventh Conference

John Zoller elected President and the Conference was held at Harrison Hot Springs, B.C. The highlights of this year the first joint Northwest Turfgrass Association/Western Canada Turfgrass Association Conference. Dr. Marvin Ferguson was awarded the USGA Green Section Award. Winter damage to all turfgrasses was again stressed during this year. Diane Ritthaler began assisting the NTA by typing the "Turfgrass Topics", conference proceedings, and mailing both. She kept the membership list, billed for dues and ran the conference registration (on her vacation time) through the fall of 1987. We owe Diane a sincere vote of thanks!

1974 - Twenty-eighth Conference

Milt Bauman was again elected President and the conference was held at Sun River, Oregon. Discussions were held by the Association and action initiated to develop a research fund for a research associate to be stationed at Puyallup. During this year, we experienced the first of our gas shortages which curtailed travel significantly.

1975 - Twenty-ninth Conference

Cliff Everhart was elected President and the conference was held at Yakima, Washington at the old Chinook Hotel. Highlights of the year were Tom Cook was hired for the research associate position at Puyallup.

1976 - Thirtieth Conference

John Monson was elected President and the conference was held at Spokane, Washington. The highlights of this year were Dr. Chuck Gould retired as Plant Pathologist after many, many years at the Puyallup Station

1977 - Thirty-first Conference

Joe Lymp was elected President and the conference was held at Salishan Lodge at Gleneden, Oregon. During this year, Tom Cook terminated his position as research associate at Puyallup and was hired by Oregon State University to teach turfgrass and ornamental science at OSU. During this year, Gary Chastagner, Plant Pathologist, was hired at Puyallup to fill the position vacated by Chuck Gould.

1978 - Thirty-second Conference

Sam Angove was elected President and the conference was held in Richland, Washington. Highlights of the year included John Roberts being hired as research associate and Roy Goss received the GCSAA Distinguished Service Award.

1979 - Thirty-third Conference

Joe Pottinger was elected President and the conference was held at Port Ludlow, Washington. The golf superintendents made a tremendous effort during this year and had a car raffle that made over $5,000 for research. During this year, Roy Goss took a six-month sabbatical leave to New Zealand. Winter damage was severe all over the Northwest during 1978-79.

1980 - Thirty-fourth Conference

Earl Morgan was elected President and the conference was held at Sun River, Oregon. Highlights of the year included the Mount St. Helens eruption and Dr. Bill Johnston was hired for research and teaching at Pullman. Dr. Stan Brauen was moved into the research position at Puyallup and Dr. Goss took the full time Extension specialist position until his retirement. This year also saw the beginning of European crane fly research.

1981 - Thirty-fifth Conference

Dick Schmidt was elected President and the conference was held at the Tyee Motor Inn at Olympia, Washington. The highlights of the year included the death of Cliff Everhart This year also saw the closing of the Soil Testing Laboratory at Pullman.

1982 - Thirty-sixth Conference

Norm Whitworth was elected President and the conference was held at the Towne Plaza Motel in Yakima, Washington. This was a sad year for all who knew Wilfred Brusseau, who died, and also Dr. David Allmendinger, former Superintendent at the Puyallup Research Station.

1983 - Thirty-seventh Conference

Dick Malpass was elected President and the conference was held at Kah-Nee-Tah Resort, Warm Springs, Oregon. We were saddened by the death of one of our old-time superintendents during this year, Louis Schmidt. Dr. Jeff Nus was hired as a research associate at Puyallup. During this year, Larry Gilhuly, who was an assistant superintendent at Seattle Golf Club, became the USGA Green Section agronomist for the West.

1984 - Thirty-eighth Conference

Ray McElhoe was elected President and the conference was held at the Sheraton Hotel in Spokane, Washington. This was the year for retirements - Milt Bauman, Sam Zook, Dick Malpass, and Ed Jennings all retired. It was found during this year that elemental sulfur significantly reduced Fusarium patch disease.

1985 - Thirty-ninth Conference

Gary Sayre was elected President and the conference was held at Rippling River Resort, Welches, Oregon. Harvey Junor, longtime superintendent at Portland Golf Club, retired this year.

1986 - Fortieth Conference

Mark Snyder elected President and the conference was held at the Red Lion Inn, Pasco, Washington. Clip Collard retired during this year. Black layer, alias anaerobic soils, was "invented". The vertidrain, a significant addition to our turfgrass equipment, appeared during this year. During this year, the R. L. Goss Turfgrass Endowment Fund was initiated.

1987 - Forty-first Conference

Bo Hepler was elected President and the conference was held at Salishan Lodge, Gleneden, Oregon. Roy Goss retired as the Northwest Turfgrass Association Executive Secretary after 26 years. Blair Patrick, Organization Management Company, was appointed and hired as the Executive Director. We were saddened during this year at the loss of Dr. Ken Morrison, Extension Agronomist from Pullman, and Ed Jennings, former golf course superintendent. Drs. Roy Goss and Ron Ensign were both awarded NTA lifetime membership during this year.

1988 - Forty-second Conference

Jim Chapman was elected President and the conference was held at the Sheraton Hotel, Spokane, Washington. Roy Goss retired from Washington State University and also received the USGA Green Section Award this year.

1989 - Forty-third Conference

Mike Kingsley was elected President and the conference was held at the Sheraton Hotel, Tacoma, Washington. The highlight of this year was that Dr. Gwen Stahnke was hired by WSU as the Turfgrass Extension Specialist for Puyallup.

1990 - Forty-fourth Conference

Dr. Bill Johnston was elected President and the conference was held at the Inn at the Mountain (Rippling River), Welches, Oregon. During this year, the Northwest Turfgrass Association awarded $34,000 for research projects.

1991 - Forty-fifth Conference

Bill Griffith was elected President and the conference was held at Coeur d'Alene, Idaho. We were saddened during this year at the death of Sam Zook. Stan Brauen received the Ken Morrison Award and $2,000 was granted by NTA for three scholarships. The Turfgrass Endowment Fund also got a big financial boost during this year.

1992 - Forty-sixth Conference

Tom Wolff was elected President and the conference was held at Sun River, Oregon. The Northwest Turfgrass Association awarded $35,000 for research and $5,000 for college scholarships during this year. We were saddened at the death of Milt Bauman during this year. Milt contributed greatly to the Turfgrass Association over the years. The Northwest Turfgrass Conference set new attendance records at Sun River.

1993 - Forty-seventh Conference

Becky Michels was elected President and the conference was held at

Yakima, Washington. We were saddened this year also with the loss of Dr. Steve Fushtey, who was the Turfgrass Research Pathologist at the Agassiz, B.C. Research Station. The Northwest Turfgrass Association awarded $30,000 for research and $5,000 for scholarships this year. Tom Christy received the Golf Course Superintendents Association of America Environmental Steward Award. This is the year also that the T.U.R.F. Program began.

1994 - Forty-eighth Conference

Tom Christy was elected President and the conference was at Salishan Lodge, Gleneden, Oregon. We were saddened at the death of Arden Jacklin during this year. Arden was the founder of Jacklin Seed Company in Spokane and was known by practically all in the turfgrass industry nationwide. This year the Northwest Turfgrass Association awarded $28,470 for research and $5,000 for scholarships. This year was a great year for golf courses with the advent of soft-spike golf shoes.

1995 - Forty-ninth Conference

Randy White was elected President and the conference was held at Skamania Lodge, Stevenson, Washington. During this year, $30,000 was awarded for research and $6,000 for scholarships. The first funds for the T.U.R.F. program were also received during this year. We were saddened at the death of Dr. Ron Ensign.

1996 - Fiftieth Conference

Tom Christy was elected President and the conference is at Victoria, B.C. at the Empress Hotel. Three of our long-time members died during 1996. These included Ken Putnam, Norris Beardsley, and Dick Malpass. Don Clemans, C.P.Ag., was appointed for the new Executive Director's position with the termination of Organization Management. Washington State Golf Association made its first payment to T.U.R.F.

This information was developed from the records at hand and my own recollection of events as they have happened. I extend my apologies for any errors or events not mentioned. All people who have served this great organization in the past challenge you to make the next 50 years better.

GETTING IN TOUCH WITH YOUR ROOTS[1]

F.B. Holl Ph.D., P.Ag. [2]

INTRODUCTION

The title of my presentation was intended to evoke a variety of images - not the least of which was the "New Age" idea of understanding our past history as an indicator of our current perceptions and responses. For turfgrass, as for people, that past history may provide important clues about future responses. Our target in the golf industry, as in other areas of turf management, is to provide a playable, attractive turf appropriate to the use. My intent today is to raise your awareness of the importance of the plant root ecosystem [roots and the rhizosphere soil influenced by those roots] in turf management.

Iceberg management

How do we approach that attractive, playable turf target ? Just as the captain of the Titanic focused on that portion of the iceberg above the surface of the ocean, our primary strategies for managing turf have traditionally been directed to the above ground portion of the grass plant. But that focus represents approximately 4% of the turf plant ecosystem [see Figure 1].

- Shoot [3.2 mm]]4%]
- Thatch [6.0 mm] [8%]
- Roots [65 mm] [88%]

Turf management involves the application of a variety of mowing, fertility and irrigation strategies, as well as a range of secondary cultural activities (e.g. aeration, topdressing) to turf stands using as the primary evaluative tool - the appearance and functionality of the visible shoots. We manage for a minority component of

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the plant (albeit an important one), but often ignore the root system - a critical factor in plant growth and health, as well as a primary point of contact with many plant pathogens.

Roots - Who putts on them anyway ?

The plant shoot is what we see; the plant shoot is what we play on; why should we concern ourselves with that elusive root zone ? Surely if we manage the aboveground part of the plant effectively, the roots will take care of themselves. Before we accept that philosophy too easily, let us consider first what roots do, and why we might consider a more proactive role in their management.

Roots are the major plant organ involved in nutrient and water uptake.

Water is essential for plant growth and as the primary carrier for nutrient uptake. An adequate supply of nutrients is essential for the production of quality turf, particularly under the intensive use patterns on a modern golf course. In a "normal" soil, organic matter represents the natural capital that feeds raw materials into the pool of available nutrients. This organic matter also contributes to the aggregation of soil particles which provides improved structure, and effective distribution of water and air in the soil profile. Good soil structure also creates the microhabitats essential for the development of many beneficial soil microorganisms. In sand-based turf ecosystems, organic matter may be lacking, especially in a young profile, and the system lacks intrinsic water-holding capacity and effective nutrient cycling systems. In sand-based ecosystems, healthy roots, and the management of root growth, root turnover and rhizosphere microbial are likely to become essential features of good management.

Roots are a major site of interaction with plant pathogens.

Few understand better than the turfgrass professional, the lurking danger of plant pathogens - they're out there - waiting for the opportunity to attack a stressed grass population. Our challenge is to many for reduced stress - not always an easy task when the turf is confronted with unusual situations [planned or unplanned]. When traffic demands are increased significantly, the consequences to the turf may be severe wear.

Not all such occurrences may be as extreme, but grass under stress of heavy use, low mowing heights, sudden low or high temperatures, excessive shade, waterlogging, ice cover - will be more susceptible to damage and disease invasion, particularly if the stand has a poorly developed root system and associated rhizosphere microbial population.

While diseases are usually detected by their aboveground symptoms and impacts on the turf, the initial problem has often arisen in the root zone as a result of a complex interaction involving plant stress, and imbalances in the rhizosphere ecosystem.

Roots respond to management of the aboveground part of the plant.

We often forget that management of that visible plant shoot has both direct and indirect impacts on the root and rhizosphere environment. The most commonly accepted connection between roots and management is the contribution of phosphorus at seeding to stimulate root growth in the establishing grass plant.

Another important relationship is demonstrated by the root response to mowing. While it is generally understood that removing aboveground photosynthetic leaf area will reduce the ability of the plant to support growth, including root growth, it is less commonly appreciated that removal of topgrowth results in an immediate "loss of root" response belowground. Root hairs and root biomass die back in response to defoliation. Mowing thus not only reduces the ability of the plant to synthesize new carbohydrate, it also results in a decrease in the ability of the grass plant to take up nutrients and water. The turnover in root biomass also contributes carbon and nitrogen to the nutrient pool available to rhizosphere microorganisms, influencing population size and composition.

Changes in root development in response to management may also be critical; frequent light applications of water encourage shallow root growth and reduce the ability of the stand to withstand drought conditions. Droughtier soils are also generally less active microbially.

Roots are the focus of activity of many beneficial microorganisms in the soil.

While we most often associate microbes in the soil environment with pathogens and disease, there are a multitude of organisms in the soil that are both essential to sustainable plant growth, and which contribute to plant health. Bacteria, actinomycetes and fungi make a significant contribution to the living biomass in a soil. From a plant management perspective, it is also interesting to note the population size differences which have been observed between rhizosphere and non-rhizosphere soil. Rouatt et al. (1960) (Proceedings of the Soil Science Society of America 24: 271-273) reported rhizosphere populations of fungi and bacteria showing 12- and 24-fold increases, respectively, compared to their non-rhizosphere counterparts.These organisms contribute to plant growth and health via their contributions to mineralization and nutrient cycling, through solubilization of minerals such as phosphorus, by direct hormonal stimulation of plant growth, and by acting as biological control agents.

Increasingly, the focus of an environmentally-based management program will be to design strategies and develop inputs that will encourage the development of the beneficial rhizosphere microbial populations in sand-based systems. These strategies will require an increased understanding of such populations, and an appreciation of how they respond to seasonal and management changes.

Characterization of Rhizosphere Microbial Populations

Our primary interest in looking more closely at these rhizosphere microbial populations is to try to determine the size and composition of the populations, and how they function in interacting with their respective grass plant partners. We are interested in numbers, diversity and function - but these are complex populations in a heterogeneous environment. Logistically, scientists have a limited capability for the accurate isolation, culture, identification and enumeration of these populations. It is also more widely accepted that functional activity in the rhizosphere is not necessarily linked to our ability to isolate and characterize members of these soil populations, nor is it necessarily affected by the addition or exclusion of specific bacterial types.

In the last decade, considerable progress has been made in addressing the functional nature of soil microbial populations [Garland, J.L. and A.L.

Mills(1991) Appl. & Environ. Microbiol. 57: 2351-2359]. One aspect of that progress has been the application of redox technology to the assessment of community-based carbon source utilization characteristics. Technology developed by BIOLOG, Inc. for strain identification uses a tetrazolium dye colour change as an indicator of microbial respiration with a range of 95 carbon sources. Organisms which are capable of metabolizing a particular carbon substrate cause the dye to be chemically reduced forming a purple colour. Direct incubation of environmental samples [for e.g. a water or soil sample] produces a pattern of metabolic activity which should be reflective of the particular microbial community at that point in time.

We have used the BIOLOGÔ test plates to investigate the carbon use patterns of microbial communities in a series of golf greens sampled over a period of months. These analyses have shown that functional patterns as reflected in the range and degree of substrate utilization vary over time, reflecting changes which occur in response to time of year (season), construction (sand, soil, age) and management (water, fertilizer and pesticide use). We are still analyzing the data to determine whether there are specific substrates or substrate groups that can provide a guide to managers about these rhizosphere changes and their potential impact on the associated grass plants. We are also attempting to determine if this technique has some predictive capability to forecast susceptibility to disease and/or aboveground plant responses.Can We Manage Microbes ?

These kinds of studies begin to tell us something about the way rhizosphere populations behave in response to a variety of external management and climatic perturbations. But are we any closer to actually managing microbial populations for the benefit of grass growth and survival?

There are four general areas where I believe we are making (or could make) some progress in manipulating rhizosphere populations:

• <u>design/construction</u> - the evaluation of new amendments for sand profiles. There has been considerable interest in recent years regarding a variety of inorganic amendments for sand-based profiles. These include zeolites, diatomaceous earth, and calcined clays. These products may contribute to improved aeration porosity, contribute to greater water holding capacity and/or retain nutrients as a consequence of high cation exchange capacities. As a consequence of their impact on the soil environment, such amendments may contribute to improved soil structure and the development of microhabitats which encourage root and microbial development.

• water management - the free draining characteristics of most sand-based greens encourages the regular use of water to ensure that the profile retains sufficient supply of moisture for plant growth. As a result, sand-based turf often receives an abundance of water at intervals more frequent than desirable for either healthy grass or the development of a stable rhizosphere ecosystem. Frequent watering encourages shallower root growth, increased sensitivity to drought and other external stresses, and very likely supports a rhizosphere microbial population which is less resilient.

• fertility management - sand-based turf is most responsive to a fertility management program to ensure a relatively uniform supply of nutrients over the growing period. While this can be effectively accomplished on established sand-based systems with a program of controlled release fertilizer applications, there remains the challenge of new construction and the initial establishment phase (up to two years). During this period, the controlled release nutrient supply is often supplemented with soluble sources to create conditions for more vigorous grow-in. Regardless of the source, the potential for leaching losses is higher during this establishment period.

The more rapidly a stand can develop an extensive root system and a healthy associated rhizosphere microbial population, the sooner those leaching concerns may be alleviated. The use of amendments which contribute to retaining nutrients in the profile, and the contribution of organic fertilizers to enhancing microbial population development may improve our ability to move more rapidly toward a stable ecological system in these sand-based turf stands.

Recent reports of experiments with carbohydrate (sugar)-based fertilizers to enhance microbial activity [T. Parent, Golf Course Management March

1996. pp. 49-52] reflects the active interest in the industry with respect to enhancing soil microbial function. While we don't have a clear scientific picture of the nature of responses to such management approaches, there is clear potential for a simple management strategy to exert a significant impact on the turf root ecosystem.

• biologicals - A survey of recent turf industry publications will reveal an increasing number of "biological" products for fertility management, as well as disease and pest control. While I suggest some caution in assuming that all such products will necessarily live up to their claims, they represent the first generation of materials which are likely to become an increasingly important part of the manager's arsenal of tools for effective turf production. Research scientists and industry partners are taking a more active role in trying to develop appropriate products to work in conjunction with natural ecological processes, rather than to compete with them. In the intensively managed sand-based profile, this type of ecosystem management will help to create an enhanced rhizosphere environment which will contribute to overall plant health and a more robust turfgrass ecosystem.

The turf management world is changing. Increased regulation, increased emphasis on "natural" turf management, and the continuing pressure of maintaining turf to the (often) unrealstic expectations of user groups make the manager's task a challenging and, at times, unenviable one. Broadening the focus of our management attention to include the root/rhizosphere ecosystem will not necessarily make that task any easier, but it will play a significant role in the development of sustainable turfgrass ecosystems.

ARE USGA GREENS BEST FOR ALL SITUATIONS?[1]

by Dr. Norman W. Hummel Jr. [2]

A few years ago a golf course developer in Myrtle Beach, South Carolina was planning on building three golf courses. All of the greens were going to be built to USGA Recommendations, and all of them grassed in bentgrass. Myrtle Beach has a climate that is hot and humid in the summer, and has the potential to dump over 100 inches of rainfall in a year.

The first course was built, and the bentgrass greens struggled; the course experiencing severe turf loss in the summer. When it came time to build the other two golf courses, the owner and superintendent were looking at all of their options in terms of designing a better root zone mix. Porous ceramics were considered, as was a soil addition to the mix. When they approached us for advice, we considered their climate, grass species, and water supply, and suggested a green construction method that did not include the perched water table. While skeptical, they followed our advice. The greens on the two new courses have been in for almost two years, and the superintendent says he will not build a USGA green again in Myrtle Beach. To quote the superintendent, "The greens are phenomenal".

Is the USGA method of greens construction the best method for all situations? I think not, and the story above is just one example where we have recommended what we call a simplified greens profile. A compromise between the California (pure sand) and USGA methods of construction, the simplified greens profile does not compromise performance.

The simplified greens profile eliminates the gravel blanket and perched water table, as does the California greens system. Unlike the California method of construction, however, we still recommend that a USGA root

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[2] President, Hummel & Col., Inc.

zone mix be used in this simplified profile. This means that you still use a sand that meets a well defined particle size distribution, the USGA Recommendation to be specific, this sand blended with a quality organic matter source. Performance testing, to include infiltration rates, porosity, and pore space distribution should be conducted to determine the optimum mix ratio. Quality control testing during blending and construction assures that you receive the mix that the lab designs. There is no compromise here, lest you risk greens failure.

The Perched Water Table

The major difference between USGA greens and the simplified greens is in the under drainage. Since its inception, the USGA method of construction has always been a tiered or layered system. Drainage pipe is installed a specified spacing, the trenches filled with stone, and then a 4 inch gravel blanket placed across the entire subgrade. If necessary, an intermediate (choker) layer is installed to prevent root zone mix migration into the gravel.

Many believe that the role of the gravel blanket in a USGA green is to improve drainage. It is true that the open pores of the gravel move water quickly to the drains once drainage water enters it. The gravel blanket in a USGA green, however, is present by design to impede drainage from the root zone. We often refer to this as a perched water table.

The perched water table forms because the capillary forces in the finer textured root zone mix are stronger than the capillary forces of the coarser gravel, and stronger than the force of gravity. Thus, water "hangs up" in the root zone mix, forming the water table. As water accumulates, the weight of the water finally becomes greater than the capillary forces, and water moves out of the root zone mix and into the gravel. This incomplete drainage increases the water retention in a growing medium that would normally be droughty.

But do we need this extra water retention in all climates, and with all construction materials? Many parts of the United States have an excess of precipitation much of the year. The major complaint with USGA greens in some areas is that they are slow to dry out. Is it worth it then, when you're more interested to remove excess water, to have a perched water table present for the few weeks when it may actually be beneficial? That is a decision you will have to make, but we are finding widespread acceptance of the simplified profile in some parts of the country.

The simplified profile has root zone mix placed directly on the sub-soil, with a drainage system installed within the compacted sub-soil (see diagram). A water table will form in the profile because the subsoil is likely to be less permeable than your root zone mix. Unlike a USGA green, however, water continuously moves out of the profile, both by moving laterally to the drain pipe, and by draining into the sub-soil. The drainage of the root zone mix is actually more complete than in a perched water table system.

Unlike a USGA green, a simplified profile requires that the contours of the subsoil follow the contours of the finished grade. Since water has to move laterally in the mix, drain spacing should be closer than the 20 foot spacings recommended for a USGA green. While actual spacings can be calculated from water removal requirements and the permeability of the root zone mix, a spacing of 15 feet is normally adequate. You must be sure that all low areas in the subgrade are identified, and drain pipe placed in those areas.

It is important that the drain pipe be placed deep enough in the drainage trench to protect it from crushing. A crushed drain in a USGA green may not be noticeable, but it is a sure bet that it will in the simplified profile. We also recommend that the gravel be mounded slightly above the trench, this simply to protect the trench from wash-out contamination prior to root zone mix placement

The gravel used to bed the drain pipe should be sized so as to prevent root zone mix migration into the stone and pipe. The criteria required for the gravel blanket in a USGA green are appropriate in selecting a drain envelop gravel used in this simplified profile.

When or Where Should a Simplified Profile be Considered?

The use of the simplified greens profile should be considered in areas prone to high precipitation for expended periods of time. Areas of the

Pacific Northwest, New England, and much of the Great Lake states would be good candidates for this method of construction. Other areas where the simplified profile may be considered includes much of the mid-Atlantic area and the Southeast coastal areas.

We have also recommended a simplified profile where the local sands were on the fine end of the recommended range. Simulating a perched water table system, the lab testing in these cases suggested that the water retention in these mixes would be high. The choices the owners had in these situations was to import a coarser sand at great expense, greatly reduce or eliminate the organic matter, or build the greens without a perched water table. By eliminating the perched water table, they were able to have better drained mixes, without decreasing the organic matter in the mix.

We believe that you may in fact be able to use a richer mix without compromising aeration and water retention in a simplified profile. Research on-going at Ohio State University is actually addressing this theory by looking at hydrological properties and air-water relationships in both the simplified and USGA profiles.

The USGA method of greens construction has a track record that can't be denied, and still is the preferred method of construction in most situations. Our experience, however, has suggested that it may not always be the best method of construction for all situations. There is more than one way to construct greens successfully, and in the right situations, the simplified method of construction may be the better option.

BALANCING THE PHYSICAL CHARACTERISTICS IN SPORTS FIELDS[1]

by Dr. Norman W. Hummel Jr. [2]

The physical properties of natural turf sports field soils profoundly impact the performance of the turf growing on them. Soils that are compacted, have poor structure, or are fine textured will likely be poorly drained, have high water retention, and poor aeration. Because these soils are poorly aerated and wet, the turf develops shallow roots and has low density.

The physical properties of a soil such as infiltration rate, aeration porosity, and water retention are influenced by three factors: soil texture, soil structure, and soil density. Modifying any one or more of these will result in a better soil environment for your turf.

Soil Texture

The soil texture refers to the percentage of sand, silt, and clay present in a soil. Sandy loam soils, which will contain from 50 to 85%, are generally preferred for topsoil sports fields. Finer textured soils tend to be very prone to compaction and poorly drained.

It is commonly thought, then, that simply by adding sand to a soil that you will improve the drainage and performance characteristics. Unfortunately, some of the worst sports fields we have seen were where people made attempts to modify the texture of the soil through sand additions.

Small additions of sand to a soil will actually do little good in terms of improving soil physical properties. In fact, we have seen sports field soils

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[2] President, Hummel & Co., Inc.

with as much as 85% sand in them that were better suited for road bases than sports fields. What went wrong, and why don't sand additions make the expected improvements in a soil?

In order to see any improvement in a soil by adding sand, you must add a sufficient amount so that the sand particles bridge or come in contact with one another. When this occurs, you get the creation of large pores between the sand grains. It is only then that you see improvement in the physical performance and compaction resistance of the soil. In most cases, you are looking at having to add at least 80% sand to soil; in other words a sand based system. Failure to do so will almost always results in very hard, compacted fields that don't drain.

The particle size distribution of the sand you use to modify the soil is important as well. Coarser, uniform sands will do a better job of bringing about improvement in your soil. We would recommend a sand with the following particle size range:

Sand Classification	Particle Diameter	(mm)% retained
Gravel	> 2.0	0 - 5%
Very coarse sand	1.0 - 2.0	5 - 20%
Coarse sand	0.5 - 1.0	30 - 60%
Medium sand	0.25 - 0.5	30 - 60%
Fine sand	0.10 - 0.25	0 - 15%
Very fine sand	0.05 - 0.1	0 - 3%
Silt and clay	< 0.05	0 - 3%

Aside from selecting the best sand for modifying your soil, you also need to know how much sand to add to the soil to bring about improvement. Soil physical testing labs such as Hummel & Co. specialize in this type of testing. Performance testing involves making mixes with different proportions of your sand and soil (and perhaps organic matter), and running them through standard tests for infiltration rate, porosity, and the distribution of air and water filled pore space.

The bottom line is that modifying the texture of your soil is an all or nothing proposition. Failure to follow the steps outlined will likely result in a disappointing outcome.

Soil Structure

Do you ever wonder why some native soil fields perform well while a poorly conceived and constructed sand based fields don't? It is probably due to the native soil field having good soil structure, where sand based root zones are single-grained structureless soils. Soil structure is the arrangement of the finer mineral components of a soil into larger clusters or aggregates.

A granular type structure, which is very desirable, has the soil particles arranged into pea sized or smaller little aggregates. Collectively, these particles act much like a coarse sand would, the pore space between the aggregates providing aeration and infiltration. Unlike sand, however, these soil aggregates also have small pores within them that hold water. How nice it would be if we could all have granular structured soils in sports fields.

Unfortunately, as these finer textured soils become compacted because of heavy use, the soils lose their structure or actually develop into undesirable blocky or platy type structures. Routine core aerification will help break these larger aggregates up. At some point in time, however, it may become necessary to plow, disk, and harrow the soil to restore good structure. This obviously will put a field out of commission for a while, but if you can work out some type of rotation, even if its on a ten year cycle, it may be one of the best long term practices for reinvigorating your soils.

The addition of organic matter to a soil, especially one that is low in organic matter, will help in the long term to maintain aggregate stability. Well decomposed organic matter, or humus, is actually a good cementing agent that holds the aggregates together. Working coarse textured organic matter sources such as sphagnum peat or good quality composts will actually help open the soil matrix up some.

Density

The third physical property that influences the soils ability to support good turf is the soil density. Soil density is another term for compaction;

the denser the soil, the more compacted it is. It is also one factor that you have some degree of control over.

Very dense soils have a low total pore space within in them. In other words, a larger percentage of the volume of soil is made of the sand, silt and clay, and less is pore space. Of the pore space that is present, the majority of it will be smaller capillary pore space, which tends to be occupied by water. The larger, air filled pore space occupies a very small percentage of the soil volume. Therefore, roots remain very close to the soil surface where they can obtain at least a small amount of oxygen. In some severely compacted fields, turf shearing may be a problem because of a lack of rooting.

The most common approach to managing soil density is core cultivation. Core cultivation alleviates compaction by physically removing a soil core. If the cores are allowed to dry and they are dragged back in, the soil placed back into the hole is of a much lower density than the soil removed. Any part of the hole not filled will eventually cave in, which will lower the soil density in the area around the aerification hole.

A 1/2 inch diameter tine on 2 inch spacings removes only about 7% of the surface area; a 3/4 inch tine about 12%. You can see then how little area is actually affected by conventional aerification, pointing out the need to do it frequently.

In time, conventional core cultivation may not be enough. We have seen hard pans develop in fields and greens at about the depth of the core cultivation tine. This is where deep tine aerification, using machines such as the VertiDrain can be a great help. Utilizing longer tines (up to 16 inches) and a pitch fork type action, the VertiDrain appears to be affective for relieving sub-surface compaction.

As mentioned earlier, despite your best efforts, there may come a point in time when aerification is not enough. Again, total reestablishment, to include cultivation of the field may be the best approach to reinvigorating your soils.

SOME NOTES ON THE EARLY GROWTH OF TURFGRASS RESEARCH IN WASHINGTON [1]

by Alvin G. Law [2]

In May 1948, a group of Golf Course Superintendents came to Pullman, Washington, to talk with Professor Schafer, Dean of the College of Agriculture, about their need for research to help solve some management problems on the golf courses and playfields of the Inland Empire region. This group included John Harrison of Hayden Lake, Idaho; Wilfred Brusseau, Louis Schmidt, and Glen Proctor, all of Spokane, Washington. The results of this visit were truly startling.

At the time they were faced with severe snow mold damage, water penetration and drainage problems on the greens, as well as fertilizer and miscellaneous weed problems. Information was needed on the best varieties and sources of turfgrass seed.

As we met with the fearsome foursome at Pullman, it became clear that there were people in the university systems in the Pacific Northwest who already had information on water movement in soils, weed control, soil texture effects on water availability and fertilizers that could be adapted to specific turf problems. Turf conferences were immediately initiated to bring this information to practical turf managers responsible for golf courses, cemeteries, parks and road sides. In addition, it was clear that feedback at these conferences would clearly point out new areas of research needed to sharpen the focus on new problems.

Some time prior to 1948, my good wife had conned me into attempting this difficult game of golf. Somehow Dean Schafer knew that I was on the golf course at Pullman more than anywhere else, so he reasoned that I might as well be assigned to help these "greenkeepers" with their problems. Perhaps he knew even then that I would never be a golfer so this was his way to salvage a career.

[1] Presented at the **50TH Northwest Turfgrass Conference,** Victoria Conference Centre, Victoria, British Columbia, Canada, September 30 - October 3, 1996.

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The net result of these events was the initiation of some research, sponsored in part by the forenamed people and their golf courses. Dr. Otis Malloy began trials on disease control, R. L. Goss started trials on fertilizer rates and clipping heights on varieties of bluegrass.

After revision of State Highway 195 between Spokane and Pullman was completed, there were massive cuts through some of the Palouse hills that were exposed. I took my turf class to the one adjacent to the entrance to Pullman to seed a number of plots of different turf grasses. We broadcast seed and mulched in with hay from bales we salvaged from a hay barn fire. In this area various varieties of hard fescue were outstanding. Since then the highway engineers have initiated a seeding program.

Before long we had organized a Turf Option in the curriculum in Agronomy which included courses in Soils, in Horticulture, in irrigation principles and small engine repair. This option is still growing under the able leadership of Dr. Bill Johnston. It has the distinction of being the first such program west of the Mississippi.

Dr. Goss was the first Ph.D. student in Turf at WSU. Upon graduation he moved to Puyallup and organized the outstanding research program underway there. He became Executive Secretary of the NTA in 1962.

Meanwhile, the Inland Empire Golf Course Superintendent Association was the direct outgrowth of the 1948 meeting with Dean Schafer. This group has met regularly during the summer months, usually hosted by a different golf course each month. These meetings have included discussions of the current information on water movement in soils, fertilizer rates and timing, weed control, insect control, equipment maintenance and repair, and budget and personnel management. Many of the superintendents and industry representatives were involved in their presentations, hence there was a massive exchange of good information over the years.The 1950 Turf Conference was the third held at the State College of Washington.

Following the pattern set by the earlier conferences, the 1950 conference dealt with such topics as soils, irrigation, weeds, insect control, turf diseases, equipment, the care of trees, and design principles for golf courses.

Featured speaker was Dr. G. O. Mott, Professor of Agronomy at Purdue University, and Secretary of the Midwest Regional Turf Foundation. The program was planned particularly for golf course greenkeepers, superintendents of parks, and cemetery superintendents, but also for others interested in turf improvement.

The conference was regional and people attended from Oregon, Montana, Wyoming, Idaho, British Columbia, and Washington.

Steps were taken to organize the Northwest Turf Association and the following Directors were elected: E. P. Townsend, Edward Fluter, H. T. Abbott, Phil Page, Mavor S. Boyd, James O'Brian, Glen Proctor, Milton Bauman, E. G. Schafer (Honorary), and Everett Potts.

As with any successful effort, the people who emerge as leaders determine its success. I give you R. L. Goss, Tom Cook, Larry Gilhuly, Jim Connolly, Milt Bauman, the Proctor and Schmidt families, Bill Griffith, Bo Hepler, J. L. Gullikson, and all the people Dr. Goss will mention. We are really a great bunch and the industry is massive. Your influence as managers of that industry is far reaching. You can be a tremendous positive force if you continue working together with only the good of the total industry in mind.

VISION FOR THE FUTURE OF TURF RESEARCH, EXTENSION AND TEACHING IN THE PACIFIC NORTHWEST [1]

by Dr. Thomas A. Lumpkin [2]

Turfgrass in Washington is approximately a $2 billion industry. We have about 260 golf courses, 1.75 million homes, 470 lawn care companies, 4,500 sports fields, 14,050 miles of roadsides, 24 sod operations and 40,000 acres of Kentucky bluegrass seed production. The turfgrass industry has been represented by a tri-state organization (WA, OR, and ID), the Northwest Turfgrass Association, which has worked closely with WSU for almost 50 years.

State and federal support for turf research and extension has diminished significantly over the past ten years. All current support for turf research comes from proposals funded by groups such as the Northwest Turfgrass Association. Governmental support for personnel has diminished again this year and will necessitate a reduction in technician support for the turf program. With continuing cuts anticipated, the Department of Crop and Soil Sciences (CSS) must decide to either eliminate the turf program or develop it as one of our few areas of excellence, with support from the turf industry. WSU is holding discussions with the turf industry and would like to develop a strong turf program in the Pacific Northwest if the industry can organize a system of financial support significantly beyond current levels.

The NTA has made a remarkable improvement in its financial support though fund raising efforts of the T.U.R.F. program and a major commitment from the Washington State Golf Association. The current NTA support to WSU has been committed towards hiring a research associate by January of 1997 to be housed at WSU-Puyallup and shared by WSU and OSU. The associate will further scientific and practical research.on golf courses in the Pacific Northwest. This associate will work closely with

[1] Presented at the **50TH Northwest Turfgrass Conference,** Victoria Conference Centre, Victoria, British Columbia, Canada, September 30 - October 3, 1996.

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Dr. Stahnke and Tom Cook on designated projects such as limiting detrimental earthworm populations and diseases of annual bluegrass. If Dr. Brauen's position is refilled with a scientist in July of 1997, the research associate will work with his replacement as a team. We expect this research team to be only the beginning of an enlarged WSU effort.

Unfortunately, by making the decision to support the hiring of a research associate, other research proposals at Pullman, Puyallup and UBC were not able to be entirely funded immediately. This hard choice needed to be made at this time, but efforts are under way within the NTA to strengthen programs in Pullman and the eastern portion of the Northwest by improving ties with Montana and Wyoming to help fund research efforts with Dr. Johnston in areas where problems are similar to those of eastern Washington, Oregon and Idaho. Uniting our dollars between state organizations to make a stronger research effort without duplication of research projects will be a great benefit to all our respective turfgrass organizations. Our goal is to build a strong working team of interdisciplinary professionals (turfgrass, entomology, plant pathology and soils) to conduct practical and basic research for the turfgrass industry's needs.

Our alliance with British Columbia and the WCTA has been in existence since 1958, and this bond has continued to grow. We are working on a closer alliance of research projects with Dr. Holl and his fellow researchers to create a combined research project with WSU and OSU. This would be an important step towards building a strong integrated turfgrass program in the Northwest.

Currently, turfgrass management is the fastest growing field in agriculture and there is a need to enhance our teaching programs. Programs without strong undergraduate teaching are being targeted for elimination. Fortunately, this is not the case with turfgrass at WSU or OSU. Turfgrass management is the most popular option in the CSS Department at WSU with approximately 30% of our undergraduates. During a major curriculum revision this summer, the CSS teaching faculty determined that a strong Turfgrass Option and turfgrass teaching program were critical to our department and should be an area of emphasis and support. Industry demand for our students is high and should continue to remain so in the future.

In this light, we are in the process of revising our turfgrass teaching program. At WSU, a need has been expressed for an advanced turfgrass management course (400 level) to be taught. This will be developed and put in place by Dr. Johnston in the spring of 1998. The basic turfgrass course (300 level) is being reconfigured by Dr. Johnston so the lecture and laboratory portions of the course can be offered as separate courses. This will allow a portion of the course to be offered as a 2-credit correspondence course. The course would be available not only for college credit, but also CEUs for golf course superintendents and as a beginning turfgrass course for turfgrass professionals, master gardeners, etc. The basic course may be transmitted via microwave to western Washington and via the Internet. WSU is also making links with community colleges for turfgrass training so community college students can continue their education at WSU while living at home.

Another addition for continuing education and/or college credit will be 3 - 1 hr. modules on golf course management, lawn care and sports field management. These will be developed and taught out of WSU-Puyallup by Dr. Stahnke and Dr. Brauen's replacement via microwave and/or via the Internet for students and professionals to upgrade their skills.

Future Possibilities - we will attempt to bring information to the industry more quickly. A Northwest Turfgrass home page will be set up for research and extension information for turfgrass managers. We are already testing a system for video conferencing from the field where some problems identified by golf course superintendents and others can be dealt with on-line and even brought live into classrooms and labs or placed on CD's for teaching.

In conclusion, WSU is ready to work with the industry and our sister universities to create a competitive regional turf program that solves problems and creates opportunities with turf. This offer can only succeed in today's political climate with organized and enthusiastic industry support. All possibilities for expanding the turf research, teaching and extension must be pursued to develop this goal.

GETTING A GRIP ON PYTHIUM ROOT ROT AND TURF STRESS [1]

By Leslie MacDonald, P.Ag. [2]

The symptoms of Pythium root rot can be severe. It is in your interest to understand this disease so you can take measures to prevent it.

What is Pythium?

Previously, Pythium species were grouped in the Fungus Kingdom along with many of the other turfgrass pathogens. However, taxonomists decided it had less in common with fungi and recently moved it to the Kingdom Protista, which includes organisms such as brown and red algae. This explains why fungicides such as metalaxyl and etridiazole that are effective against Pythium are not effective against fungal diseases such as Fusarium Patch or Red Thread. There have been many species of Pythium isolated from symptomatic turfgrass. Pythium graminicola, P. aristosporum, P. ultimum, P. vanterpoolii and P. aphanidermatum are some of the species that are pathogenic on bentgrass (1,3,4,6).

One of the reasons that Pythium is grouped into the Protista Kingdom is because it has motile spores called zoospores. Zoospores have small "tails" that propel the spore through water. Zoospores can detect root exudates and respond by swimming towards them. You can appreciate that wet soils would make it easier for the zoospores to swim. In addition, anything that increased root exudates would improve the chances for the zoospores to target in on a root. The abrasion of sharp sand particles against the epidermis of roots is one way for cell exudates to leak out.

Pythium species also produce a tough overwintering structure called an oospore. This type of spore has a double wall that protects it against extremes of temperature and other adverse conditions. Oospores are produced in root tissue in the latter stages of infection. When the root tissue

[1] Presented at the **50TH Northwest Turfgrass Conference,** Victoria Conference Centre, Victoria, British Columbia, Canada, September 30 - October 3, 1996.
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is further broken down by other organisms, the oospores fall into the soil where they can survive for years. Pythium is also adaptable when it comes to food sources. It will survive on dead organic matter if there are no roots to infect. Cool temperatures slow down Pythium but it will still grow at 43 to 45°F (10) when root growth is limited.

How does Pythium spread?

The Pythium species associated with root rot spread in the soil via growth of the mycelium and movement of zoospores. However, zoospores can only swim short distances through the soil and a trip of a few inches would be a long one. Pythium also produces reproductive structures called sporangia that either germinate and infect plants directly, or else they function as containers which produce zoospores which then infect plants. Sporangia, zoospores and mycelium can spread with soil water as it moves through the root zone. Pythium is present as mycelium and spores in many native soils, and spreads as soil is moved during construction. It may be present in sand or in irrigation water pumped from surface sources although this has not been thoroughly examined.

The Pythium that causes foliar blight during hot, humid weather produces abundant mycelium and spores on turf foliage that are easily picked up and spread by equipment or traffic.

The infection process

Pythium usually attacks young roots, although in severe cases it can infect the entire functioning root system and crown. Infected roots are unable to perform their function of water and mineral uptake. Hence, plants may show foliar symptoms of nutrient defiency and water stress. These symptoms usually start to develop on the oldest leaves first. During cooler conditions, infected plants may survive if the plant water requirements stay low. However, if the evapotranspiration rate increases significantly, the plant will die if it cannot meet the need for water. Seedlings are very susceptible to infection by Pythium, especially when they are growing slowly, or are being pushed through high fertilization and use of covers. They can die even during cool weather when water requirements are lower if their root system is damaged too much.

Pythium enters through wounds or the tips of young roots. The mycelium grows through the root tissues and secretes enzymes to dissolve or break down cells. Pythium uses the cell contents as a food source. As cells rupture they release cell contents which gives the root a light brown, "water-soaked" appearance. Young root tissues are more readily invaded than older root tissue. Generally the vascular tissue is not infected by Pythium and remains intact. One can easily slide the dead cortex (outer root tissue) off the vascular tissue to produce a characteristic "rat-tail". As the Pythium uses up the food supply of the root, it produces the overwintering oospores.

Symptoms of Pythium

Pythium root rot symptoms often start as a thinning of the turf at the collar. This may be due to extra stress on turf from the abrasion of clean-up cuts. Or, perhaps the Pythium is present in the native soil directly adjacent to the collar and the less diverse microflora in the sand root zone mix is unable to suppress its movement.

Turf can also thin out in other areas of the green. Usually the turf in these areas is under some form of extra stress such as shade, compaction, high traffic, or poor drainage(5). In some cases, Poa annua will be unaffected in the patches of thin, dying turf. It is possible that the Poa annua is more resistant to the site stresses than the succumbing bentgrass but Poa annua will also be infected by Pythium under the right conditions.

Making the diagnosis

To correctly diagnose Pythium root rot, one should observe signs of Pythium in root tissue under the microscope. However, a few species of Pythium do not produce spore structures in the roots which makes the diagnosis difficult. This is where the DNA probes for Pythium will be extremely useful. In addition to observing signs of Pythium in the root, ensure that overall symptoms of the turf and individual grass plants are consistent with a diagnosis of root rot. One must also look for signs of other pathogenic fungi to determine that they are not responsible for symptoms.

Plant Stress is Needed for Disease Development

In the absence of significant plant stress it is difficult to induce symptoms of root rot with Pythium. Three unsuccessful attempts to inoculate bentgrass at UBC's Pacific Turfgrass Research Centre support this point. One must have plant stress plus a pathogenic species of Pythium to get Pythium root rot.

Pythium Root Rot = Plant Stress + Pythium

Some of the turfgrass stresses that can contribute to the development of root rot include:

nutrient deficiency
high N levels
heat stress
cold temperature
heavy traffic
shade
excess thatch
excess irrigation
drought
low mowing heights
compaction
sharp sand particles

Fertilization is very important during periods of environmental stress. It is critical to regularly provide balanced, adequate fertility when the root zone has a high sand content. Sand's low cation exchange capacity limits its ability to retain nutrients so plants will often be exposed to excesses or deficiencies of nutrients. Tissue testing is a good way to check that nutrient levels in the turf are optimal. Keep potassium and iron levels high prior to the onset of heat stress.

It is wise to avoid high levels of available nitrogen during the growing season. High nitrogen will promote shoot growth which reduces the level of stored carbohydrates. It also suppresses root growth. You end up with lots of shoot growth that you cut off anyway, few roots and low carbohydrate levels. At this point, the plant is less capable of handling significant stress.

On the other hand, late fall nitrogen fertilization has been shown to increase carbohydrate content, root development and improve turf quality (7). We know that shoot growth temperature optimums are from 60 to 75°F, while the optimum soil temperatures for root growth are from 50 to 65°F. There needs to be enough nitrogen available to the plant during these latter conditions for significant root growth and carbohydrate storage.

We may observe evidence of Pythium infection during periods of heat stress. Normally a plant will cool itself during hot spells by transpirational cooling. This requires low humidity, wind and adequate soil moisture that is taken up by functioning roots. In the Pacific Northwest, the first two conditions are usually present. However, roots damaged by Pythium cannot absorb and transport water adequately. The plant becomes water stressed. This triggers the closure of stomata which reduces transpiration. A negative cycle ensues and the plant is not able to cool itself through transpiration. Leaf temperatures increase which cause further plant stress. Syringing may alleviate some heat stress.

Shade is a problem on golf courses. Although trees enhance the beauty of a course, they are incompatible with growing grass. Not only does shade reduce the levels of photosynthetically active wave-lengths that reach the grass, but it reduces wind and causes an increase in relative humidity. These last two factors negatively affect evapotranspirational cooling. Tree roots also compete with turf roots for water and nutrients. Shaded turfgrass may have reduced heat, drought, cold and wear tolerance when compared to unshaded turfgrass (9). Pythium problems are often associated with heavily shaded turf, especially with morning shade.

The recent trend of very low mowing heights is one of the most significant turf stresses. Pythium root rot was an insignificant disease before the advent of sand root-zones and ultra low mowing heights. The closer that turf is mowed, the more frequently it must be mowed, and every time turf is mowed, there are several direct, and negative, effects (8):

root growth stops temporarily
reduced carbohydrate production & storage

wound sites for disease-causing organisms
temporary water loss from cut ends
reduced water absorption by roots

In addition to this temporary stress, the soil temperature extremes are greater at low heights of cut than higher heights of cut. Excessive mowing frequency also has the effect of decreasing shoot and root growth, decreasing chlorophyll content and decreasing the recuperative potential of turf (2). All this contributes to a situation where there is little room for major stress.

Traffic causes wear of the turf as well as soil compaction. Small green size is one factor commonly associated with development of Pythium root rot. Soil compaction increases plant stress by limiting the movement of air and water into the root zone. Under these conditions, rooting and shoot density declines.

One can see that many stresses have a role in the development of Pythium root rot. Some, such as nutrient management, thatch management, shade and irrigation can be influenced more easily than factors such as high traffic, low mowing heights, compaction and damage from sharp sand particles. It is sound management to promote healthy turf roots as the best insurance in preventing Pythium root rot. Once the disease occurs, it can be a long road to recovery.

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EVALUATING FUNGICIDES FOR SNOW MOLD DISEASE CONTROL IN TURFGRASSES UNDER CONTROLLED AND FIELD CONDITIONS [1]

J. W. Sitton, W. J. Johnston, C. T. Golob, J. T. Waldher, and G. W. Bruehl [2]

INTRODUCTION

Snow mold diseases of turfgrasses have been studied by scientists most of this century (Dahl, 1934; Ensign, 1985; Meiners, 1955; Vargas, 1985). One of the primary means of control is the use of fungicide sprays. One of the most widely used fungicides is pentachloronitrobenzene (PCNB = quintozene), which is phytotoxic to some cultivars of bentgrass (Vargas, 1986) and may be toxic to fish, aquatic organisms, and humans, if used incorrectly (EPA Reg. No. 400-399). New fungicides are being developed which are safer (Anonymous, 1996), but they need evaluation for their efficacy to control snow mold.

Less information is available on snow mold resistant turfgrass cultivars. One of the difficulties in screening turfgrass cultivars for snow mold resistance is the inconsistency in snow cover between seasons. G. W. Bruehl (1966) developed a controlled system using snow mold chambers to screen wheat cultivars for snow mold resistance during mild, snow-free seasons. This system, potentially, could be used to evaluate fungicide efficacy and cultivar resistance to control snow mold in turfgrasses.

The most serious snow mold diseases are pink snow mold caused Microdochium nivale (fr.) Samuels & I. C. Hallett (teleomorph, Monographella nivalis [Schaffnit] E. Mueller), and gray snow mold caused by one, or a combination of, Typhula idahoensis Remsberg, T.

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incarnata Fr., and/or T. ishikaiensis Imai. Typhula sp. infection is most serious when deep snow cover occurs on nonfrozen soil for a prolonged period of time; while, pink snow mold infection can occur in absence of snow cover under cool, wet conditions (Smiley, 1983). However, all of these different fungi can cause severe damage to turf when conditions are favorable for their development.

OBJECTIVES

1. Develop a test which can be used (a) in absence of snow, and (b) for small-scale research tests to evaluate snow mold severity in turfgrasses.

2. Conduct comparative studies, snow mold chamber and turf field plots at two sites, on the efficacy of six fungicides to control pink and gray snow mold in Kentucky bluegrass and creeping bentgrass.

MATERIALS AND METHODS

Inoculum source. On April 12, 1995 wheat stubble with sclerotia of T. idahoensis was collected 2 miles north of Waterville, WA. On March 28, 1996 pink snow mold infected creeping bentgrass leaves were collected from infected areas in Pullman, WA.

Snow mold chamber study. Kentucky bluegrass (Poa pratensis 'South Dakota') and creeping bentgrass (Agrostis palustris 'Putter') were grown in trays out-of-doors at Pullman, WA.

On November 17, the trays were sprayed (treatments listed in Table 1) and inoculated on November 21 with either 4 to 6 germinated sclerotia of T. idahoeneis or 1/2 ml of a 2.8x106 solution of M. nivale conidia at 22 points on each turf tray. After inoculation and fungicide sprays, each tray was covered with a 1/2 lb. layer (approx. 1 inch thick) of water saturated non-absorbent cotton. The cotton layered trays were covered with clear, polyethylene. The trays were placed in a refrigerated chamber in the dark at 0 to 0.5 C for 8 weeks. Following incubation, on February 12, 1996, the trays were removed from the snow mold chamber for evaluation of disease severity by determining the number of colonies that grew at the inoculation points.

Field studies. To collaborate the efficacy information collected from the snow mold chamber study, spray trials were initiated on bluegrass and creeping bentgrass at the Whitefish Lake Golf Club, Whitefish, MT on October 26, 1995 and the Washington State University Turfgrass Research Area, Pullman, WA on November 17, 1995. In addition to the four treatments used in the snow mold chamber study, several others were added for field studies (treatments listed in Table 1). Conidia of M. nivale were sprayed on the Pullman site at a rate of 12.3x105 conidia/sq. ft. on December 4, 1995; the Whitefish site received no supplemental inoculum. Snow cover was 1 month at Pullman and 5 months at Whitefish. Following snow melt, disease severity and turfgrass quality were recorded on February 12, 1996 at Pullman and April 4, 1996 at Whitefish.

RESULTS AND DISCUSSION

Pink snow mold. Comparisons of the efficacy of the six fungicides tested were similar between the field and the snow mold chamber on bentgrass (Table 1) and bluegrass (Table 2). The least effective fungicide for pink snow mold control was Prostar at 6 oz. Generally, significantly better control was attained with PCNB 4 oz., Daconil 2787 4 oz., Chipco 26019 4 oz., Banner 4 oz., Chipco 26019 8 oz., Medallion 0.5 oz., Chipco 26019 4 oz.+Daconil 2787 4 oz., and Banner 4 oz.+Medallion 0.5 oz., which, gave the best, but sometimes not statistically best, control.

Gray snow mold. Comparisons between field and snow mold chamber tests were not possible because gray snow mold did not develop at the Whitefish Lake Golf Club location. This is probably because the soil surface became frozen due to the -30 F temperatures that occurred during February 1996. Gray snow mold tests in the snow mold chambers (Table 3) showed that PCNB 4 oz., and the two combinations of Chipco 26019+Daconil 2787 and Banner+ Medallion provided similar, good control on bluegrass, but the two combination treatments were statistically better than PCNB in controlling gray snow mold on creeping bentgrass.

Turfgrass quality. There seemed to be differences in turfgrass quality due to treatment, grass species, and location. For example, Prostar treated bentgrass had good turfgrass quality at Whitefish, but poor bluegrass quality. The reverse was true of PCNB, which gave poor quality on bentgrass at Whitefish but good quality on bentgrass at Pullman and bluegrass at Whitefish. Generally, best quality occurred with Chipco 26019 8 oz., Medallion 0.5 oz., and combinations of Chipco 26019+Daconil 2787 and Banner+Medallion. The high turfgrass quality values for these treatment is probably related to their excellent control of pink and gray snow molds.

CONCLUSIONS

The results for this study indicate that there is a good correlation between results obtained with the snow mold chamber and field tests for the efficacy of six fungicides to control pink snow mold. Additional testing will be required for a similar comparison with gray snowmold. The new fungicides (i.e., Banner and Medallion) compare favorably with the older fungicides (i.e., PCNB, Daconil, and Chipco 26019) in their ability to control snow mold. This is good news, because until recently most snow mold fungicides were closely related (triazole types) and there was a possibility of the development of fungicide resistant strains of the pink and gray snow mold fungi. In addition, new materials like Medallion are considerably safer for humans, animals, and the environment than older materials like PCNB and Calaclor. More tests are required to better evaluate the effects of the six fungicides tested on turf quality.

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Table 1. Comparison of the efficacy of fungicides to control pink snow mold (Microdochium nivale) on bentgrass at field sites at Pullman, WA and Whitefish, MT and in snow mold chamber tests during the 1995-1996 growing season.

Treatment (rate/1000 sq. ft.)	Colony number/plot* Pullman	Whitefish	Colony size** Chamber test
Non-treated CK	50.0a***	33.5a	40.9a
Prostar, 6 oz.	36.7a	7.5bc	- - -
PCNB, 4 oz.	1.3b	0.3c	4.6b
Daconil, 4 oz.	5.7b	2.3c	- - -
26019, 4 oz.	2.7b	19.5ab	- - -
26019, 8 oz.	1.0b	4.8bc	- - -
26019, 4 oz.+ Daconil, 4 oz.	2.3	1.8c	0.0b
Banner, 4 oz.	2.0b	- - -	- - -
Medallion, 0.5 oz.	1.0b	- - -	- - -
Banner, 4 oz.+ Medallion 0.5 oz.	0.7b	- - -	4.6b
LSD (P=0.05)	14.6	16.3	17.6

*Mean of four 10x10 ft. plots.

**Mean size (mm) of 22 inoculation sites per treatment.

***Different letters within columns indicate significant differences according to Fisher's protected LSD(P=0.05).

Table 2. Comparison of the efficacy of six fungicides to control pink snow mold (Microdochium nivale) on Kentucky bluegrass at field sites at Pullman, WA and Whitefish, MT, and in snow mold chamber tests during the 1995-1996 growing season.

Treatment (rate/1000 sq. ft.)	Disease* Pullman	%Infection** Whitefish	Colony size*** Chamber test
Non-treated CK	3.0a****	96.0a	86.4a
Prostar, 6 oz.	2.0b	67.5b	- - -
PCNB, 4 oz.	1.3bcd	3.0c	40.9b
Daconil, 4 oz.	1.3bcd	26.3c	- - -
26019, 4 oz.	0.8cd	24.5c	- - -
26019, 8 oz.	0.5de	4.0c	- - -
26019, 4 oz.+ Daconil, 4 0z.	0.8cde	4.3c	27.3bc
Banner, 4 oz.	1.5bc	- - -	- - -
Medallion, 0.5 oz.	0.5de	- - -	- - -
Banner, 4 oz.+ Medallion 0.5 oz.	0.3e	- - -	13.6c
LSD (P=0.05)	0.8	25.1	25.2

*Disease rated 0=0-trace;1=1%-33%;2=34-66%;3=67-100% area of infection of four 10x10 ft. plots.

**%Infection is an estimate of the percentage of infected area in four 10x10 ft. plots.

***Mean size (mm) of 22 inoculation points per treatment.
****Different letters within columns indicate significant differences according to Fisher's protected LSD(P=0.05).

Table 3. Growth of gray snow mold (Typhula idahoensis) inoculated on Kentucky bluegrass and bentgrass turf, then place in snow mold chambers at 0.5 to 1 C for 8 weeks.

Treatments (rate/1000 sq. ft.)	Colony development (%)* Bluegrass	Bentgrass
Non-treated CK	95.5a**	86.4a
PCNB, 4 oz.	13.6b	81.8a
26019, 4 oz.+ Daconil, 4 oz.	22.7b	40.9b
Banner, 4 oz.+ Medallion, 0.5 oz.	18.2b	31.8b
LSD (P=0.05)	21.4	26.1

*Mean size (mm) of 22 inoculation points per treatment.
**Different letters within columns indicate significant differences according to Fisher's protected LSD(P=0.05).

Table 4. Bentgrass and Kentucky bluegrass turfgrass quality ratings on non-sprayed turf and turf sprayed with fungicides at Whitefish, MT and Pullman, WA on October 26, 1995 and November 17, 1995, respectively.

TURFGRASS QUALITY*

Treatments	Whitefish		Pullman
(rate/1000 sq. ft.)	Bentgrass	Bluegrass	Bentgrass
Non-treated CK	4.8bc**	1.8d	3.0f
Prostar WP, 6 oz.	6.5a	2.5cd	3.3f
PCNB, 4 oz.	4.2c	5.5a	6.3ab
Daconil, 4 oz.	6.0ab	4.3ab	4.3e
26019, 4 oz.	6.5a	3.8bc	4.7de
26019, 8 oz.	6.5a	5.0ab	5.7bc
26019, 4 oz.+ Daconil, 4 oz.	5.6ab	5.5a	5.7bc
Banner, 4 oz.	-	-	5.3cd
Medallion, 0.5 oz.	-	-	6.3ab
Banner, 4 oz.+ Medallion, 0.5 oz.	-	-	6.7a
LSD (P=0.05)	1.3	1.5	0.9

*Turfgrass quality rated 0 to 9; 0=dead, brown turf;9=dark green, healthy turf.
**Different letters within columns indicate significant differences according to Fisher's protected LSD(P=0.05).

CAN ANTAGONISTIC MICROORGANISMS CONTROL FUSARIUM PATCH OF TURFGRASS?[1]

By Gwen K. Stahnke, Ph.D., Carrie R. Foss, and Coleen Pidgeon [2]

INTRODUCTION

Fusarium patch disease, caused by the fungus Microdochium nivale, is one of the most prevalent diseases on golf courses in the Pacific Northwest. Fusarium patch disease is an important problem which can infect all cool-season turfgrass species under wet, cool weather conditions, causing severe damage. Fungicide applications are often repeated throughout the infection period which may extend from early fall through early summer. During 1979, iprodione-tolerant strains of M. nivale were isolated from a western Washington golf course (Chastagner and Vassey). Biological control of Fusarium patch disease would provide an alternative approach to fungicide applications. Antagonistic microorganisms which produce antibiotics and suppress pathogens have been studied extensively for other pathogens and other crops (Bull et al, Kobayashi et al, Nelson and Craft, Weller and Cook). This study identified bacterial antagonists suppressive to Fusarium patch disease under greenhouse conditions.

MATERIALS AND METHODS

M. nivale was cultured from turf samples diagnosed with Fusarium patch disease. Isolates were obtained from annual bluegrass (Poa annua var. annua), creeping bentgrass (Agrostis palustris), and perennial ryegrass (Lolium perenne) samples submitted to the WSU-Puyallup Plant Diagnostic Laboratory. Single spore isolates were stored in a cornmeal/silica (3%v/v) medium. Sporulation was induced by inoculating

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potato sucrose agar (Dhingra and Sinclair) with cornmeal/silica cultures. The M. nivale isolates were used to inoculate the turfgrass species from which they were isolated.

Three turfgrass species were used in the experiments: creeping bentgrass, annual bluegrass, and perennial ryegrass. Cone-tainers (1.5" diameter) tubes were packed with sterile vermiculite and seeded at 43, 160, and 16 seeds per cone-tainer for the annual bluegrass, creeping bentgrass, and perennial ryegrass, respectively. Fertilization included a weekly application of .25 lb. N/1000 ft 2 Peter's solution (20-20-20) and two applications of 1 lb. N/1000 ft 2 urea solution 9 and 5 days prior to inoculation with the pathogen (Stahnke et al). The experiments were conducted on a mist bench in the greenhouse.

Microbial antagonists were obtained from Dr. David Weller (USDA-Pullman) and screened in a series of greenhouse experiments. The antagonists tested included: fluorescent pseudomonads Q2-87, 30-84, Q29Z-80, 2-79.

Bacterial antagonists were grown on culture plates and a bacterial suspension was prepared in buffer. Three weeks after grass germination, a bacterial suspension or buffer solution was applied to turfgrass in cone-tainers. Five 3-cm grass blade samples were selected 24 hours after application with the antagonist. The grass samples were suspended in sterile buffer, diluted, and plated onto King's B medium. Colony-forming units (CFU) of foliar organisms were counted 24 or 48 hours after plating. After collecting CFU samples, turfgrass was inoculated with an M. nivale spore suspension (approximately 7 X 106 spores/ml). Three weeks after application with the pathogen, plants were rated for turf color, turf quality, and disease. Several samples were examined microscopically for the presence of M. nivale spores.

An experiment was conducted to determine the persistence of four bacterial antagonists on grass blades (Fig. 1). The fluorescent pseudomonads Q2-87, 2-79, 30-84, and Q29Z-80 were applied to creeping bentgrass and annual bluegrass in cone-tainers. CFUs were determined at 1, 2, 4, 7, and 21 days following standard dilution procedures. Grass blades were also plated directly onto media.

In a final experiment, a split application of the bacterial antagonist Q2-87 was applied 24 hours apart prior to challenge with M. nivale. Grass plants were rated for color and disease.

RESULTS

Bacterial antagonists 2-79 and Q2-87 significantly suppressed Fusarium patch disease on creeping bentgrass when compared to the inoculated control (Table 1). Q2-87 also significantly suppressed M. nivale on annual bluegrass when compared to the inoculated control.

Antagonist Q29Z-80 did not suppress Fusarium patch in the initial screening and was not tested further in greenhouse experiments. Spore suspensions of M. nivale did not infect perennial ryegrass consistently in the greenhouse. Therefore, perennial ryegrass was not used in the screening procedures for the final experiments.

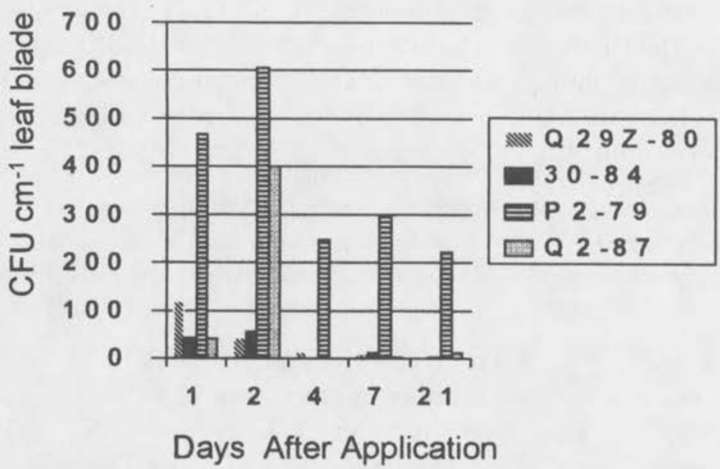
Table 1: Fusarium patch on bentgrass 3 weeks after inoculation (5/3/96) .

Treatment	Disease Rating[a]
Control/Pathogen	2.4 A
30-84/Pathogen	1.8 AB
B203/Pathogen	1.6 B
Q2-87/Pathogen	1.5 B
2-79/Pathogen	1.5 B
Control/Blank	0.2 C
Control/Untreated	0.0 C

[a]Disease Rating: 0 = no disease, 1 =100%-75% healthy plants, 2 = 74%-50% healthy, 3 = 49%-25% healthy, 4 = 24%-0% healthy

Fluorescent pseudomonad 2-79 persisted on bentgrass at the highest population after 21 days under greenhouse conditions. A bacterial population of 222 colony-forming units per cm linear leaf tissue was determined at 21 days compared to 11 for Q2-87, 0 for 30-84 and 0 for Q29Z-80 (Fig. 1). Blade sections were plated onto King's B media to compare with CFU results. Q2-87 produced many colonies directly from bentgrass leaf tissue at 7 and 21 days compared to colony-forming units determined by standard procedures of 3 and 11, respectively.

Figure 1. Persistence of bacterial antagonists on bentgrass.



In the final experiment, the split application of Q2-87 significantly suppressed Fusarium patch disease on creeping bentgrass compared to the inoculated control. The inoculated control disease rating of 3.0 was higher than the previous experiment (2.4), indicating higher disease pressure. Q2-87 suppressed Fusarium patch disease in each experiment when compared to the inoculated control.

DISCUSSION

Microbial antagonists Q2-87 and 2-79 exhibited population peaks at 48 hours following a single application. The increased population quantified on non-inoculated plants would correspond to a population peak 24 hours after inoculation with the M. nivale spore suspension. Though Q2-87 suppressed disease compared to an inoculated control with a disease rating of 2.4, it also provided protection when applied in a split application under higher disease pressure (3.0 disease rating for inoculated control). This may have resulted because the bacterial population was allowed to increase over the 48 hours prior to challenge with the pathogen. Fluorescent pseudomonads 30-84 and Q29Z-80 did not reduce Fusarium patch disease significantly in initial experiments. Colony-forming units of 30-84 and Q29Z-80 decreased or only slightly increased 48 hours after application and may not have had sufficient populations to suppress disease.

Q2-87 was observed growing from the entire bentgrass leaf margin directly onto King's B media from samples taken at 7 and 21 days. This did not compare to the low CFU counts of 3 and 11 CFU per cm linear leaf tissue. The bacteria may be adhering tightly to the blade tissue and not being removed through standard CFU dilution procedures. This biological characteristic could enhance its ability to suppress Fusarium patch disease. Sonication may improve recovery of bacteria from leaf blades in future experiments.

Combinations of microbial antagonists applied in split applications have provided effective control of plant pathogens on other crops (Duffy et al). Single applications of fluorescent pseudomonads Q2-87 and 2-79 each suppressed Fusarium patch disease on bentgrass in these greenhouse screening experiments. Combinations of these organisms applied in split applications may provide increased disease suppression and will be studied in future experiments

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