RIEKE

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Of The

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September 18-21, 1989

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Tacoma, Washington

PREFACE

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

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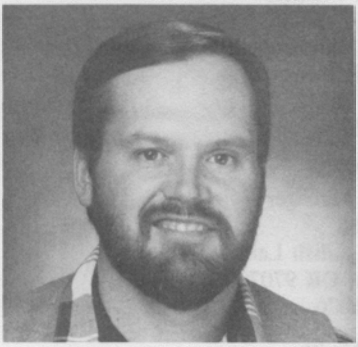
PRESIDENT'S MESSAGE



Mike L. Kingsley

The 1989 Conference at Tacoma was a fitting close to the Decade of the 80's. Over 400 people attended the educational sessions, with "employees" making up over one fourth of the audience. Quality speakers have been a proud tradition at the Northwest Turfgrass Association Conference for 43 years, and this year's conference speakers were among the very best. These proceedings will help you retain what was presented, and be a valuable reference source.

In 1989 we started the annual NTA Summer Turfgrass-fest, with our second golf tournament for research, our first summer hands-on equipment show, and a steak barbecue to boot. This, in conjunction with the turfgrass field day at the WSU Puyallup Research and Extension Center, makes it an event destined to become one of our finest.

The Conference and Turfgrass-fest could not have been a success without the contribution and support of our suppliers, our dedicated board of directors, our executive director, and our membership as a whole. I thank you for the opportunity to serve as president, and for your support over the past year.

We have a new Turfgrass Research and Extension Specialist, in the form of Dr. Gwen Stahnke, to help us usher in the Decade of the 90's. This, together with the leadership of our new president, Dr. Bill Johnston, and the tremendous support from our membership and staff, makes the NTA's future look very bright.

Good luck to Bill and the new board of directors. We hope to see you at the Rippling River Conference in 1990.

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1988/89 President

1988/1989
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Houston B. Couch [2]

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[1] Presented at the 43rd Northwest Turfgrass Conference, Sheraton-Tacoma Hotel, Tacoma, Washington, September 18-21, 1989.
[2] Professor of Plant Pathology, Department of Plant Pathology, Physiology and Weed Science, Virginia Tech, Blacksburg, Virginia

The various procedures used to apply spray formulations of fungicides to turfgrass are more the outgrowth of the expediency of the moment than the product of systematic research and development. In the early years, spray equipment that had been developed for use in fruit orchards and vegetable fields served as the means of applying fungicides to golf course greens and fairways. Although in recent years, equipment has been developed for use in turfgrass spraying situations, for the most part, the background used in the design of the basic delivery systems and selection of pumps and nozzle types has come from principles developed for fruit tree and row crop spraying.

As a general rule, field research programs on turfgrass disease control have given little or no attention to determining the most efficient procedures for applying fungicides. The basic assumption seems to have been that the dilution levels, nozzle types, and nozzle pressures could be developed more or less empirically, or at least they could be interpolated into turfgrass spraying systems from the experience gained from other crop management systems.

In 1977, a field research program was initiated by the members of the turfgrass pathology laboratory at Virginia Tech to investigate the comparative effectiveness of turfgrass fungicides when used as granular and spray formulations, and to determine the most efficient procedures for applying granular fungicides. This program was expanded in 1981 to include the testing of procedures for applying spray formulations.

These experiments have included trials to determine (i) the optimum amount of water per 1,000 square feet of turf, (ii) the appropriate nozzle types and nozzle tip sizes, and (iii) the most suitable pressure at the nozzles for the control of turfgrass diseases under management conditions of 1½ to 2 inch cutting heights and under golf course putting green and bowling green mowing heights.

Also, at Virginia Tech, trials have been conducted to determine the effect of pH of the spray mixture and length of time the material has been held in the sprayer on fungicide stability, and the effectiveness of the sticking agents that are formulated with the various fungicides. In the latter series, the objective of the tests were to find out how much fungicide can be washed off of turfgrass leaves if a rain shower occurs before the application dries, and how effective the sticker is in holding material on the leaf after the spray has dried.

The diseases included in these trials were Sclerotinia dollar spot (incited by Sclerotinia homoeocarpa), melting-out of Kentucky bluegrass (incited by Dreshslera poae), and Rhizoctonia blight (incited by Rhizoctonia solani). The fungicides tested included both contact and systemic materials. The following is a summary of the results of these trials.

Comparative Effectiveness of Equivalent Active Ingredient Levels of Spray and Granular Formulations of Fungicides

The research on the comparative efficiency of granular and spray formulations of turfgrass fungicides was conducted over a six year period. The fungicides included in these trials included spray and granular formulations of anilizine (Dyrene), benomyl (Tersan 1991), chlorothalonil (Daconil 2787), iprodione (Chipco 26019), quintozene (Terraclor), phenylmercyry acetate + thiram (PMAS + Tersan 75), thiophanate methyl (Fungo 50), and triadimefon (Bayleton). The results of these studies showed that:

1. Granular formulations of non-systemic fungicides require 2-3 times the active ingredient level of spray formulations to produce the same degree of disease control.

2. Granular formulations of non-systemic fungicides require a longer time to bring the target diseases under control, and they hold their established levels of control for a shorter period than the same active ingredients as spray formulations.

3. There can be a significant difference in efficiency of disease control among various granular fungicide product lines of the same active ingredient.

4. Application of granular fungicides to wet leaves improves their disease control effectiveness.

5. Watering immediately after the application of granular fungicides reduces their effectiveness in disease control. The extent of this reduction can vary among the various granular product lines.

6. Mowing and collecting the clippings immediately after the application of granular fungicides reduces their effectiveness in disease control. The extent of this reduction can vary extensively among the various granular product lines.

Optimum Dilution Rates and Flat Fan Nozzle Tip Size

One group of experiments tested for the relationship between dilution rates, flat fan nozzle orifice size and fungicidal efficiency. Concentration of the various fungicidal treatments ranged from 0.5 to 32 gallons of water per 1,000 square feet of turf.

The nozzle type used in this series of experiments was the Uni-jet flat fan (manufactured by Spraying Systems Co., Wheaton, Illinois). The variables consisted of different spray tip sizes in combination with different water gallonages. In these tests, all applications were made with a nozzle pressure of 30 psi. The various dilution rates and corresponding nozzle tip sizes used in these experiments were as follows:

Tip Size	Gallonnages/1,000 sq. ft.
T-80005	0.5, 1.0, 2.0, 4.0
T-8002	0.5, 1.0, 2.0, 4.0
T-8008	4.0, 8.0, 16.0, 32.0

The fungicides included in these tests were triadimefon (Bayleton), iprodione (Chipco 26019), propiconazole (Banner), vinclozolin (Vorlan), chlorothalonil (Daconil 2787), and anilizine (Dyrene).

The results of these experiments showed that with the flat fan nozzle, there is a direct relationship between nozzle tip size, the dilution level and the effectiveness of individual fungicides. Where tip size is concerned, with each fungicide, optimum disease control was consistently achieved with the T-8002 tip. The optimum dilution levels for maximum disease control for the respective fungicides were as follows:

Fungicide	Dilution/1,000 sq. ft.
Daconil 2787	1 gallon
Dyrene	1-2 gallons
Bayleton	2 gallons
Chipco 26019	0.5 - 4 gallons
Banner	2 gallons
Vorlan	1-2 gallons

Optimum Nozzle Types and Nozzle Pressure

Experiments were performed to test the relative effectiveness of certain fungicides when applied with differently nozzle types and at varying pressures at the nozzle. The nozzle types included in this series were (i) the Uni-jet flat fan with T-80005, T-8002, T-8004 and T-8008 tips, (ii) the Uni-jet flood iet TK-30, and (iii) the swirl chamber 'Raindrop' RA-15. The individual nozzle pressures for the flat fan nozzles were 10, 30, 60, and 90 psi, while with the flood jet and raindrop nozzles, the pressures at the nozzles were 20, 30, 40, and 55 psi. The fungicides tested in these trials were Bayleton, Chipco 26019, Dyrene, fenarimol (Rubigan), Daconil 2787 and Acti-dione TGF.

With the flat fan nozzle, maximum disease control with all fungicides tested was obtained at 30 - 60 psi at the nozzle. A significant drop in disease control effectiveness occurred with all fungicides when they were applied at 10 psi at the nozzle. Maximum disease control with the 'Raindrop' swirl chamber nozzle was obtained at 30 psi at the nozzle.

The flood jet nozzle was most effective at 30 - 40 psi at the nozzle. Of the three nozzle types, the flat fan equipped with T-8002 to T-8004 tips and the swirl chamber RA-10 and RA-15 gave comparable levels of disease control. The performance of the fungicides applied with the TK-30 flood jet nozzle was significantly less than applications made with flat fan or swirl chamber nozzles.

Effect of Post-Spray Rainfall on Fungicide Effectiveness

The fungicides included in this trial were Dyrene 4-F, Dyrene 50 WP, Acti-dione Thiram, Chipco 26019, Daconil 2787, Rubigan, and Bayleton. The variable in the experiment was the time of watering of each plot after it had been sprayed with the fungicide in question. The watering schedule was as follows: (i) in one series, the plots were watered with the equivalent of ⅛ acre inch of water while the leaves were still wet from the spray application, (ii) in a second group, as soon as the spray dried on the leaves, the plots were watered with ⅛ acre inch of water, (iii) while in a third series, all watering was withheld until the third day after the spray had been applied.

The results of these tests showed that if leaf washing from rainfall or sprinkler irrigation occurs before the spray dries on the leaves, non-systemic fungicides are rendered completely ineffective in disease control. However, once these sprays have dried on the leaves, the leaf washing operation will not alter their disease control effectiveness.

The systemic fungicides are not as vulnerable as the non-systemics to reduction in disease control effectiveness by rainfall or watering before the spray dries on the leaves. However, there can be a significant difference among systemic fungicides with respect to the degree of reduction in disease control efficiency brought on by leaf washing before the spray dries. For example, leaf washing before the spray dried reduced the effectiveness of Rubigan in the control of Sclerotinia dollar spot by 50 percent. On the other hand, the effectiveness of Bayleton in dollar spot control was not reduced if leaf washing occurred before the leaves dried.

Effect of pH of the Mixture and In-Tank Storage Time on the Stability of Turfgrass Fungicides

The pH of the spray solution can have a significant effect on the performance of certain pesticides. A pH range of 7.5 to 8.5 is common in untreated water throughout the North American continent. The pH of treated, urban water often falls between 9.0 and 9.5.

In the alkaline range, some fungicides undergo hydrolysis. This is an irreversible chemical reaction in which the hydroxyl ions in the water interact with the pesticide in such a manner as to break it down into a different compound. In instances where a fungicide itself is stable under alkaline conditions, there is still the possibility that in this pH range, the makeup of the formulation itself may become altered.

Of the various pesticide groups, insecticides are more prone to alkaline hydrolysis than fungicides. The organophosphate, carbamate and synthetic pyrethroids are particularly sensitive to breakdown when the spray solution is alkaline. Among the fungicides used on turf, Acti-dione, Dyrene and Daconil 2787 will hydrolyze to varying degrees if the spray is alkaline.

The purpose of this trial was to determine the effect of varying the pH of the tank preparation on the ability of eight standard fungicides to control Sclerotinia dollar spot of 'Penneagle' bentgrass. In addition, the effect of allowing these tank preparations to remain in the tank for one day, as opposed to using them immediately, was tested.

The fungicides tested were Acti-dione, Dyrene, Rubigan, Daconil 2787, Chipco 26019, Banner, and Bayleton. The pH values of the tank preparations of each fungicide were 3.5, 6.5 and 9.5 respectively. The 9.5 value was obtained by use of a sodium carbonate/sodium hydroxide buffer, and the 3.5 and 6.5 values were developed by use of the adjuvant ''Spray-Aide'' (Miller Chemical and Fertilizer Co., Hanover, PA). A portion of each spray preparation was applied to the grass immediately, and the remainder stored for 21 hours at 71 degrees F and then used.

Four consecutive ratings at 7 day intervals were made for disease control. This system evaluated the impact of pH of the preparation on the initial 'knock-down' effect of the fungicide and on its longevity of control. These readings showed that:

1. The initial preparations of Chipco 26019, Vorlan, Banner and Bayleton are tank stable in the pH 3.5 - pH 9.5 range. Also, storage for a period of 24 hours at these pH levels apparently does not alter the disease control effectiveness of this group of fungicides.

2. Dyrene is alkaline sensitive. At pH 9.5, the effectiveness of the initial tank preparation drops rapidly. However, if the spray preparation is in the acid range (pH 3.5 to pH 6.5) and if it is used at the time it is made up, there will not be a reduction in disease control potential. If Daconil 2787 is allowed to stand for 20 hours before being used, regardless of the pH of the preparation, it will lose a significant amount of its fungicidal properties.

3. The pH of the spray preparation does not have an immediate effect on the disease control potential of Dyrene. However, if these preparations are allowed to stand for 20 hours before use, a major drop in their disease control effectiveness can occur at both acid and alkaline pH levels.

4. If Rubigan is used at the time it is prepared, its disease control potential will not be affected by pH. Also, spray preparations of this material that are stored for 24 hours at pH's from 6.5 to 9.5 will retain their initial disease control effectiveness. However, if Rubigan is allowed to stand for 24 hours at pH 3.5, it can lose a significant amount of its potential for disease control.

Summary and Conclusions

This research has shown that in the use of a boom-type spray system, there are specific dilution rates at which fungicides perform most efficiently. Also, nozzle type and nozzle pressure can have a significant effect on fungicide performance. Flat fan nozzles equipped with T-8002 to T-8004 tips and swirl chamber RA-10 and RA-15 nozzles provide optimum fungicide distribution at 30 psi at the nozzle. **The flood jet TK-30 nozzle does not give levels of disease control comparable to that obtained with flat fan or swirl chamber nozzles. Flood jet nozzles should not be used for applying fungicides.**

If the maximum potential of a fungicide is to be realized, it is important that careful consideration be given to the selection of the optimum dilution level, nozzle type and size, and nozzle pressure for its application.

Where leaf washing by rainfall or sprinkler irrigation after fungicide application is concerned, our studies have shown that:

1. Rainfall or sprinkler irrigation of a treated area before the spray dries on the leaves will significantly reduce the disease control effectiveness of non-systemic materials.

2. If the fungicide formulation contains an effective sticking agent, either rainfall or sprinkler irrigation immediately after the spray dries on the leaves will not appreciably reduce the material's initial disease control effectiveness.

3. Systemic fungicides are not as vulnerable as non-systemics to reduction in disease control effectiveness by rainfall or watering before the spray dries on the leaves.

4. The basic effectiveness of a turfgrass fungicide is established by the initial amount of water used in the spray formulation. Once the material has dried on the leaves, it can not be dislodged or redistributed on the plant by sprinkler irrigation or rainfall.

SYNERGISM . . . A NEW DIMENSION IN TURFGRASS FUNGICIDE USE [1]

Houston B. Couch [2]

[1] Presented at the 43rd Northwest Turfgrass Conference, Sheraton-Tacoma Hotel, Tacoma, Washington, September 18-21, 1989.
[2] Professor of Plant Pathology, Department of Plant Pathology, Physiology and Weed Science, Virginia Polytechnic Institute and State University, Blacksburg, Virginia

The use of tank mixtures of fungicides at their full label rates for simultaneous control of more than one disease has been a common practice in turfgrass management since the 1920's. In recent years, however, there has developed an interest in the possibility of using tank mixtures of two or more fungicides at less than their low label rates for control of a single disease.

The incentive for the use of tank mixes of fungicides at less than low label rates to control a single target disease comes from the increasing number of reports of resistance to fungicides by certain of the more important turfgrass pathogens. Fungicide resistance has been described for the Sclerotinia dollar spot pathogen (Sclerotinia homoeocarpa), the Fusarium patch pathogen (Microdochium nivalis), powdery mildew (Erysiphe graminis), and Pythium aphanidermatum. Although resistance is not a widespread problem, its development in individual stands of grass, particularly with such diseases as Fusarium patch and Pythium blight, can result in extensive damage before alternative fungicides can be placed into use. All spray programs, then, should be built around practices that reduce the possibility of resistance developing.

The most widely recommended program for reducing the risk of development of resistance to fungicides is the use of different materials in rotation with each other. Fungicides that have different modes of action but show activity against the same pathogen are applied at their full label rates on alternating dates. The rationale behind this concept is that interchanging fungicides cuts down on the risk of resistance by decreasing the frequency of application of each material.

The use of less than low label rate tank mixes of fungicides has been suggested by some as an alternative to rotating fungicides at their full label rates. Supposedly, this method will reduce resistance potential by exposing the pathogen simultaneously to two or more toxic modes of action.

Advocates of the use of reduced rate tank mixes are assuming that the level of disease control provided by the mixture will be equal to the sum of its components. For example, it is their hypothesis that two fungicides with different modes of action mixed at ½ their maximum efficacy rates will provide the same level of disease control as either material used alone at its full rate; or that three fungicides with different modes of action used as a tank mixture at ⅓ their maximum efficacy rates each will give the same degree of disease control as each material applied singly at its full label rate.

Where disease control effectiveness is concerned, when fungicides that are toxic to the same target organism but have different modes of action are mixed together in a spray tank, one of three conditions will result: the mixture will be **additive, antagonistic,** or **synergistic.**

When the Tank Mixture is Additive, Each Fungicide is Acting Independently.-

When the components of a tank mixture of fungicides are said to be functioning in an **additive** fashion, it means that they are acting independently of the other. In other words, the degree of fungicidal efficacy of each material in the mixture is neither increased nor decreased by the presence of the other fungicides.

This is due to the fact that since the individual sites of action within the cells of the fungus are being attacked at random by each fungicide, there will be instances in which both materials will be active in the same cell. Also, since the amounts of active ingredient are being used at less than that needed to insure the possibility of maximum impact on all sites of action, there will be fungus cells which escape the toxic effects of either fungicide. The result of all of this is that the disease control level of tank mixes of fungicides that have been prepared at rates below the amounts needed for their full efficacy will be less than the complete control either fungicide in the mixture would have produced at its full rate.

The formula for calculating the theoretical additive control values for two component fungicide tank mixes is as follows:

$$E = X + \frac{Y(100-X)}{100}$$

E = Expected control from combined effect of the two components
X = Control provided by one component of mix
Y = Control provided by other component of mix

The control values for three component tank mixes are calculated as follows:

$$E = X + \frac{Y(100-X)}{100} + Z\left[X + \frac{Y(100-X)}{100}\right]$$

Using these formulas, the theoretical additive control values for two and three component tank mixes of reduced rate fungicides are as follows:

Fungicide "A"	Fungicide "B"	Fungicide "C"	Theoretical Additive Control
50%	50%	—	75.0%
75%	75%	—	93.8%
50%	25%	—	62.5%
25%	25%	—	43.3%
90%	90%	—	99.0%
50%	50%	50%	87.5%
33.3%	33.3%	33.3%	70.4%

From this table, it can be seen that if the action of a tank mixture of reduced rate fungicides is **additive,** the degree of disease control provided by the mixture will not equal the sum of the expected control levels of the components. Put more directly, this table illustrates that **with reduced rate tank mixes, if their interaction is only additive, then neither ½ + ½ nor ⅓ + ⅓ + ⅓ will add up to 1 (i.e., full control of the disease).**

Antagonism Is A Negative Interaction Among Mixtures of Fungicides.-

It is possible for the disease control effectiveness of a tank mixture of reduced rate fungicides to be even less than the calculated additive level. This condition is called **antagonism.** Antagonism is usually brought about by a chemical interaction among the components of the mixture which results in the loss of the toxic principle of one or all of the materials. An important aspect of field research with tank mixtures of fungicides is the determination of whether or not specific combinations of fungicides, or combinations of fungicides and adjuvants, will result in antagonism.

Synergism Is A Positive Interaction Among Mixtures of Fungicides.-

With pesticides, **synergism** is the situation in which one chemical makes the target organism more vulnerable to the toxic effects of another compound. Synergism is said to exist when the level of pest (weed, disease or insect) control of a pesticide mixture is greater than its calculated additive value.

Synergism Is A New Dimension In Turfgrass Fungicide Usage.-

For several years, research on synergism has been carried out on both insecticides and herbicides. These investigations have led to a significant improvement in the effectiveness of certain insect and weed control programs. Until fairly recently, however, the potential of synergism as a means of improving the effectiveness of fungicides has received very little research attention.

Current research efforts of the turfgrass pathology laboratory at Virginia Tech have been directed toward determining whether or not tank mixtures of certain fungicides are **additive, antagonistic,** or **synergistic.** To date, tests have been conducted with 9 fungicides [Banner, Dyrene, Vorlan, Fungo 50, Fore, Daconil 2787, Chipco 26019, Bayleton, and Rubigan] in 26 combinations for the control of Sclerotinia dollar spot. Also, 5 fungicides [Subdue, Banol, Aliette, Terraneb SP, and Fore] have been tested in 8 combinations for control of Pythium blight incited by Pythium aphanidermatum. The Pythium blight study is being continued, with additional experiments testing the synergistic potential of Fore + Teremec SP, and Fore + Koban. Experiments are also underway to determine if there are any synergistic combinations among the fungicides currently being used for control of Rhizoctonia blight (incited by Rhizoctonia solani).

In the research to date, we have found synergistic tank mixtures for the control of both the Pythium blight and Sclerotinia dollar spot.

1. Sclerotinia dollar Spot.- Three fungicide combinations were found to be synergistic: Banner + Bayleton, Banner + Dyrene, and Banner + Chipco 26019. All other fungicidal combinations were additive. None were antagonistic.

2. Pythium blight.- Three fungicide combinations were synergistic: Fore + Subdue, Fore + Banol, and Banol + Aliette. The combinations of Fore + Aliette, Banol + Subdue, Subdue + Aliette, and Subdue + Banol + Aliette were not synergistic. The combination of Teremec SP + Fore was antagonistic.

Summary.-

1. Where disease control effectiveness is concerned, when fungicides that are toxic to the same target organism but have different modes of action are mixed together in a spray tank, one of three conditions will result: the mixture will be **additive, antagonistic, or synergistic.**

2. The components of additive mixtures act independently. Therefore, in the absence of synergism, the sum of the control of a reduced rate mixture will be less than the control provided by the full label rate of the most effective fungicide in the mixture.

3. Synergistic tank mixes for the control of Sclerotinia dollar spot present an opportunity for reducing the risk of fungicide resistance. In the case of Pythium blight, the synergistic combinations that have been identified will

not only help reduce the possibility of resistance, but they will also provide a more effective level of control during seasons of heavy disease pressure, or in situations where curative control programs are needed.

4. In considering the use of established synergistic combinations, it must be remembered that these mixtures should not be used at dosages less than the low label rate for each component. Our research has shown that if the level of the synergizing component is too low, the activity of the other fungicide in the mixture will not be increased.

5. The most appropriate procedures for reducing the risk of resistance are (i) the use of tank mixes of fungicides with different modes of action that are known to be synergistic, or (ii) a system of fungicide rotation. With the later system, fungicides with different modes of action that show activity against the pathogen in question should be alternated with each other at their full label rates.

Note: One half label rate does not necessarily mean one half efficacy. The degree of control depends on the disease pressure. One half label rate at times can be 100 percent efficacy or it can be 25 percent efficacy—or it can be 0 control.

THE ROLE OF A TURFGRASS EXTENSION SPECIALIST [1]

Gwen K. Stahnke [2]

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[1] Presented at the 43rd Northwest Turfgrass Conference, Sheraton-Tacoma Hotel, Tacoma, Washington, September 18-21, 1989.
[2] Extension Turfgrass Specialist, Washington State University, Research and Extension Center, Puyallup, Washington.

The role of a turfgrass extension specialist is an important and many-faceted position. At Washington State University Puyallup, the position is a 75% extension and 25% research appointment. As 75% extension, it will be essential to develop an organized plan of attack to allow time for research to be conducted. This position fits back-to-back with Dr. Stan Brauen's appointment of 75% research and 25% extension. It will be necessary to concentrate on one major research project, and then cooperate on other existing or new projects with Dr. Stan Brauen, Dr. Gary Chastagner, and Dr. Rita Hummel.

Training programs for Master Gardener and pesticide recertification will be a large portion of my extension responsibility throughout the fall and winter seasons. The use of video-taped programs will be an area to be developed for use in the near future to make it possible for county agents to be more flexible for turfgrass training seminars. Another major area of responsibility is to support the industry with research information and recommendations. The turfgrass industry includes golf courses, lawn care operations, parks and recreational facilities, seed producers, sod producers, and sports and athletic fields. Drs. Brauen, Johnston, and I will be conducting turfgrass research in conjunction with other faculty at both Pullman and Puyallup.

Along with this, it will also be important to promote support for scholarship and research monies to be able to carry out research and educational programs. The NTA is doing a good job of providing support, but the cost of research and education have really sky-rocketed in the past few years, and we need to be aware of what it will take to adequately carry out research with the proper equipment and staff, or support a student's project.

There are excellent extension bulletins currently available for turfgrass management, but as pesticides and recommendations change, these bulletins must be revised. There may also be areas where bulletins have not been published in the past and new bulletins must be created. The turfgrass extension specialist will also act as a liaison between the researchers and the county agents, industry representatives, and homeowners.

The first year will be a time to travel and get to know the state of Washington and the concerns of each area. From these travels and through discussions and evaluations of the major concerns in the industry, a research and extension plan will be made.

I am excited about working with this supportive group of people to help make a great program at WSU even better.

PENDIMETHALIN DISSIPATION AND MOVEMENT IN A KENTUCKY BLUEGRASS ROOT ZONE [1]

Gwen K. Stahnke [2]

[1] Presented at the 43rd Northwest Turfgrass Conference, Sheraton-Tacoma Hotel, Tacoma, Washington, September 18-21, 1989.

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Preemergence herbicides are an important part of a turfgrass manager's program for control of annual grasses and some broadleaf weeds. If they are applied at the proper time, with proper application procedures, their use can limit or reduce the need for postemergence sprays later in the season. With pendimethalin being used more widely as a preemergence herbicide, and the issue of pesticide movement into water being of concern, this portion of a two-year study conducted at University of Nebraska-Lincoln had two main objectives. These were to evaluate the dissipation and movement of pendimethalin in a turfgrass root zone, and to compare the trends for pendimethalin dissipation between field and rhizotron studies.

Field studies were conducted on a Sharpsburg silty clay loam and an 85/15 sand/Sharpsburg soil mixture was used for rhizotron studies. Pendimethalin was applied at 1.7 kg/ha (1.5 lb/1000 ft^2) on April 26 in both 1987 and 1988. Leachate was collected weekly from rhizotron root cells to monitor pendimethalin movement. Plant tissue, thatch and soil were sampled at 0, 10, 21, 42, 84 and 168 days after treatment (DAT). The soil was sampled at 0 - 2.5 cm, 2.5 - 5 cm, and 5 - 10 cm depths in the field and rhizotron cells, with additional sampling at 30 cm, 60 cm, and 120 cm depths in the rhizotron.

Pendimethalin concentration was highest in plant tissue and thatch and accounted for approximately 95% of pendimethalin residues detected at all sampling dates. Pendimethalin concentration decreased most between 0-21 DAT, and between 21-41 DAT. These trends were similar for both field and rhizotron studies. Under climatic conditions and irrigation amount and timing similar to the field and rhizotron studies, pendimethalin concentrations in the thatch at 7 to 8 weeks after treatment (WAT) indicated that a second application of pendimethalin would be necessary to maintain a herbicide barrier for weed control.

Trace amounts (< 0.001 mg/kg) of pendimethalin were detected in rhizotron leachate samples collected at 7-14 days after heavy rainfall in 1988. These residues were primarily associated with soil colloids filtered from leachate, indicating gravitational displacement of particulate matter.

This dissipation data is very helpful in timing herbicide applications, and in being accountable for where the herbicide is located in the environment after application. Whether it is on a home lawn, commercial property, or a well-manicured golf green, the turfgrass manager needs to feel confident that his pesticide application is going to stay in the target area and not effect other environmental concerns, as well as being able to maintain a healthy, weed-free turf.

BENTGRASS SPRING QUALITY AND GROWTH AS AFFECTED BY A PROTECTIVE TURF COVER AND WINTER APPLICATION OF PGRs [1]

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[1] Presented at the 43rd Northwest Turfgrass Conference, Sheraton-Tacoma Hotel, Tacoma, Washington, September 18-21, 1989.

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INTRODUCTION

In the Pacific Northwest, winter desiccation can be a major problem for turfgrass managers, especially in inland areas that receive little moisture and have dry windy conditions during winter months. Winter desiccation can be particularly severe on elevated, exposed putting greens. Recently, protective turf covers have been used to prevent winter desiccation of turfgrass. One problem associated with the use of a protective turf cover is the excessive plant growth that occurs under the cover during warm periods in late winter and early spring. The protective cover creates a ''greenhouse effect'' that can raise the temperature underneath them by 5 to 10 C, thus promoting early, rapid, excessive spring growth. Due to fluctuating weather conditions of early spring in the Pacific Northwest a cover is often removed and excess growth mowed off. The cover is then reinstalled if the weather deteriorates for a length of time. This can become a labor intensive and costly process.

OBJECTIVE

The objective of this study was to evaluate the use of a protective turf cover, in combination with plant growth regulators (PGRs), to suppress excessive spring plant growth under the cover while maintaining high turfgrass quality during the early spring on a bentgrass putting green.

MATERIALS AND METHODS

In early December, 1987 and 1988, PGRs amidochlor, flurprimidol, mefluidide, and fenarimol were applied to a 'Penncross' bentgrass (*Agrostis, palustris* Huds.) putting green prior to the installation of a 'Reemay' turf cover (Table 1). Prior to cover placement the area was treated with fungicides for snow mold. Experimental design was a strip-plot (strips of 3.6 m wide protective cover) with three replications. Individual plots were 3.0 X 3.6 m. Data taken were spring turf quality, shoot growth (oven dry weight), and root dry weight (1988 reported).

RESULTS AND DISCUSSION

At the time of cover removal (3-11-88 or 4-6-89), approximately 1 week after the first mowing at the WSU golf course, the quality of the covered treatments was superior to the uncovered control (Figures 1 and 2). At this time, flurprimidol and mefluidide in covered plots reduced growth compared to the covered control (Figures 3 and 4). Note: conversion of rates from kg a. i./ha to lb. a.i./A are given in Table 1.

When plots were rated approximately 3 to 4 weeks later the quality of most covered plots had declined while the quality of uncovered plots had increased (Figures 5 and 6). This is a commonly observed phenomenon. However, equal to the uncovered control in quality were mefluidide (0.42 kg a.i./ha) and flurprimidol (0.56 kg a.i./ha) (Figures 5 and 6). At this time there was no PGR x cover interaction and plots had resumed normal growth (Figures 7 and 8). Only flurprimidol at 1.68 kg a.i./ha continued to show an undesirable retardation of growth. Later ratings showed no differences in quality among treatments. Although not significant ($p=0.07$), root dry weight taken on 4-11-88 was most affected by fenarimol (Figure 9).

Mefluidide (0.42 kg a.i./ha) or flurprimidol (0.56 kg a.i./ha) in combination with a protective turf cover showed very good quality turfgrass, compared to the uncovered plots, at the time of cover removal and were equal to the uncovered control 3 to 4 weeks later. In effect, these treatments gave earlier spring green-up than uncovered turf without the excessive surge of growth and decline in turfgrass quality that was observed when a protective turf cover was used alone.

CONCLUSIONS

In summary, several of the PGRs or rates of application used in this study were found to give low quality turf some time after cover removal or did not suppress vegetative growth enough to justify their use. Results on bentgrass suggest that 0.42 kg a.i./ha mefluidide or 0.56 kg a.i./ha flurprimidol used with a protective turf cover can provide improved spring bentgrass turfgrass quality without an unmanageable surge of plant growth.

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Table 1. Plant growth regulators and rates applied and equivalent rates in lb. a.i./A.

PGR	kg a.i./kg.	lb. a.i./A
Amidochlor	1.12 and 2.24	1.0 and 2.0
Flurprimidol	0.56 and 1.68	0.5 and 1.5
Mefluidide	0.14 and 0.42	0.125 and 0.375
Fenarimol	1.53 and 3.05	1.36 amd 2.72 (1 oz. and 2 oz. product)

Fig. 1. Quality 3-11-88

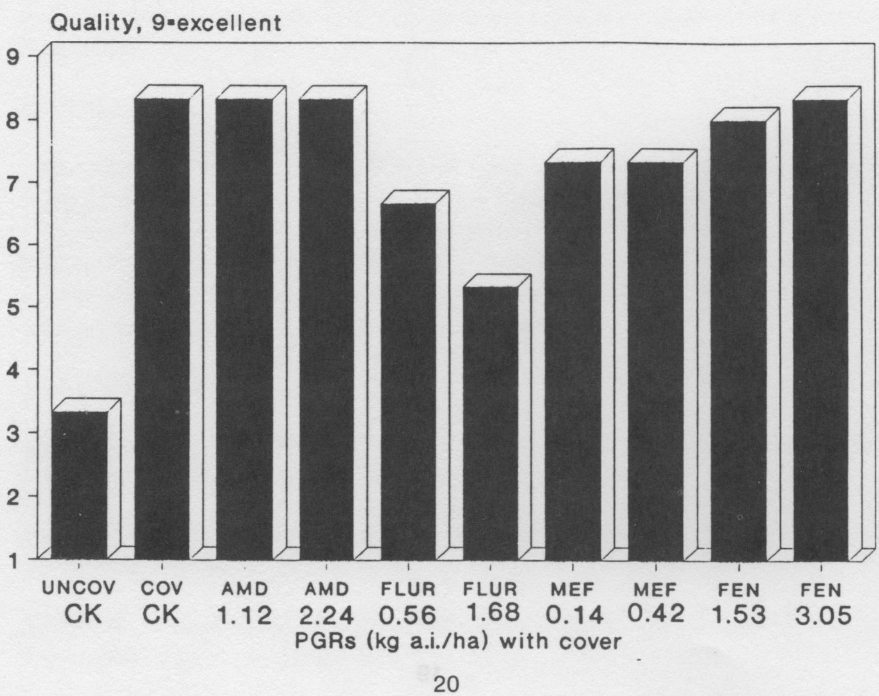


Fig. 2. Quality 4-6-89

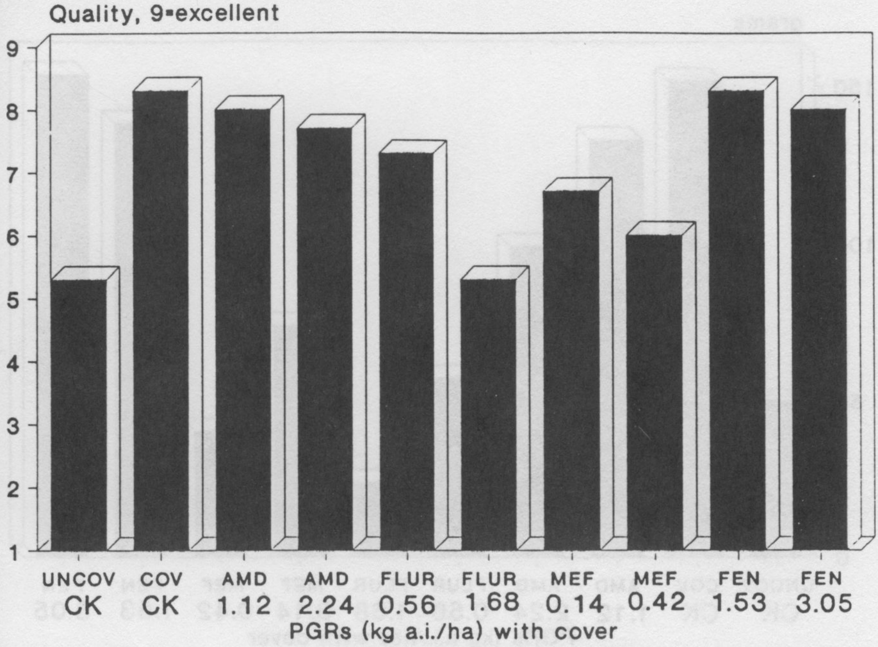


Fig. 3. Shoot dry weight 3-11-88

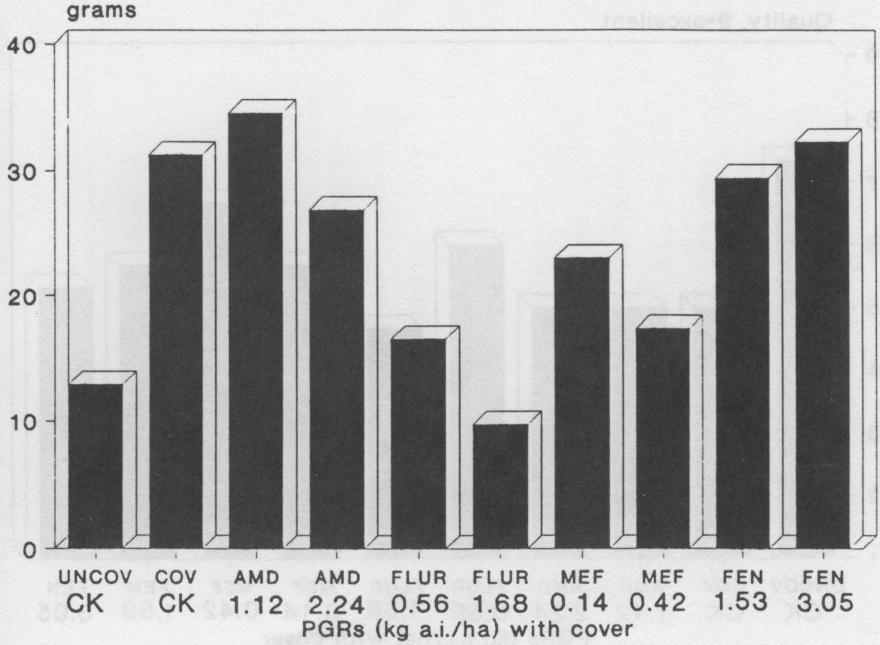


Fig. 4. Shoot dry weight 4-6-89

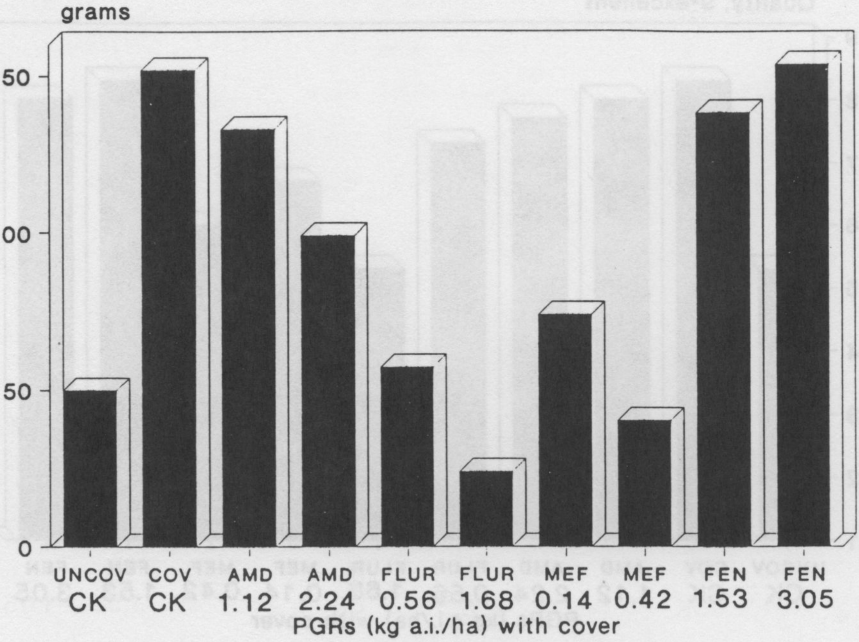


Fig. 5. Quality 4-11-88

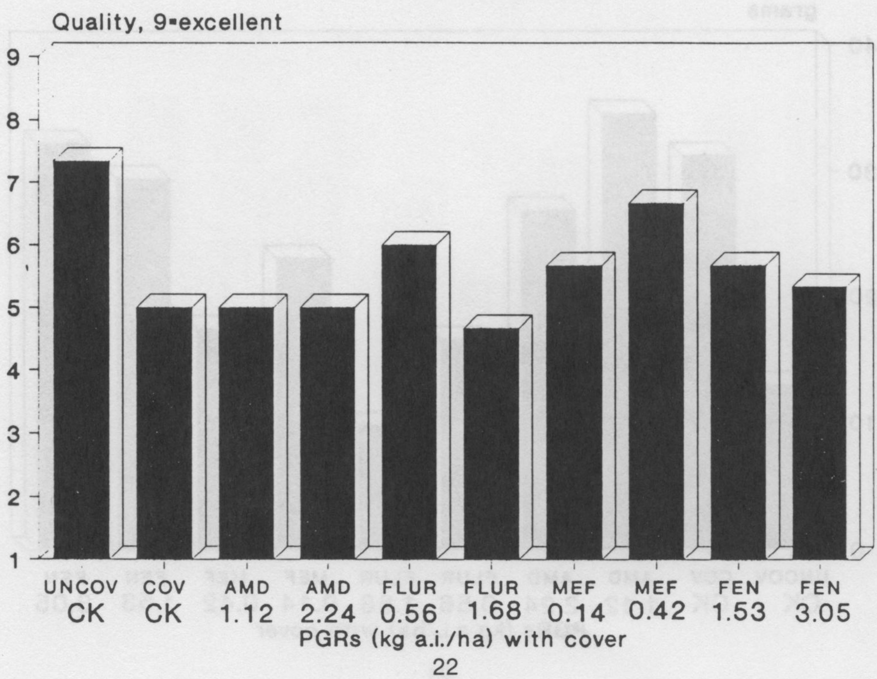


Fig. 6. Quality 4-28-89

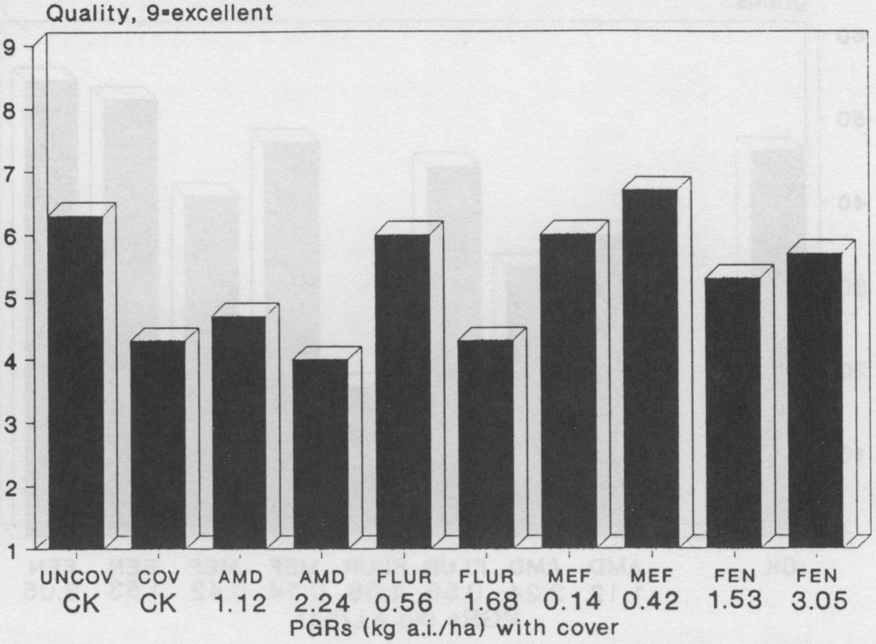


Fig. 7. Shoot dry weight 4-11-88

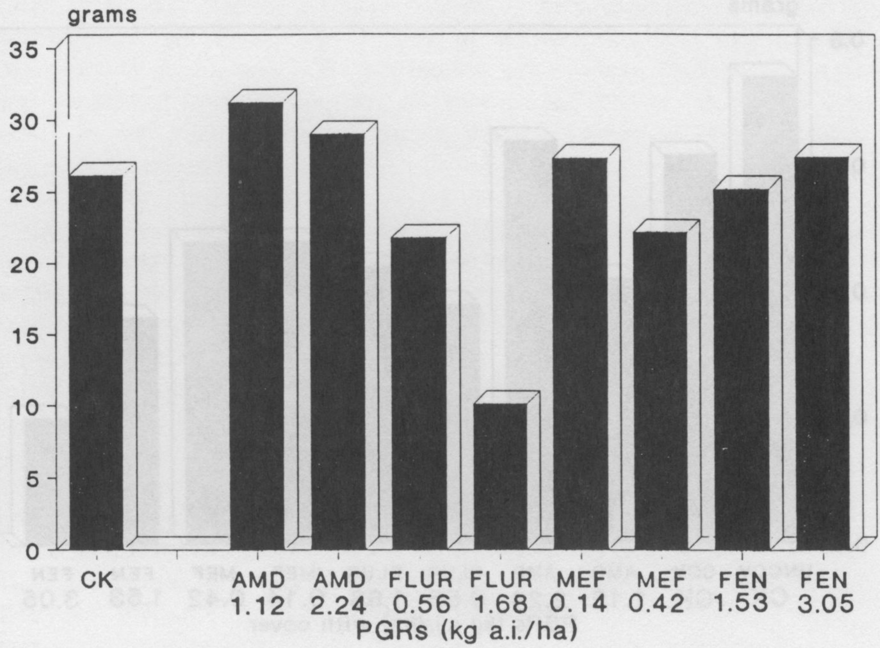


Fig. 8. Shoot dry weight 4-28-89

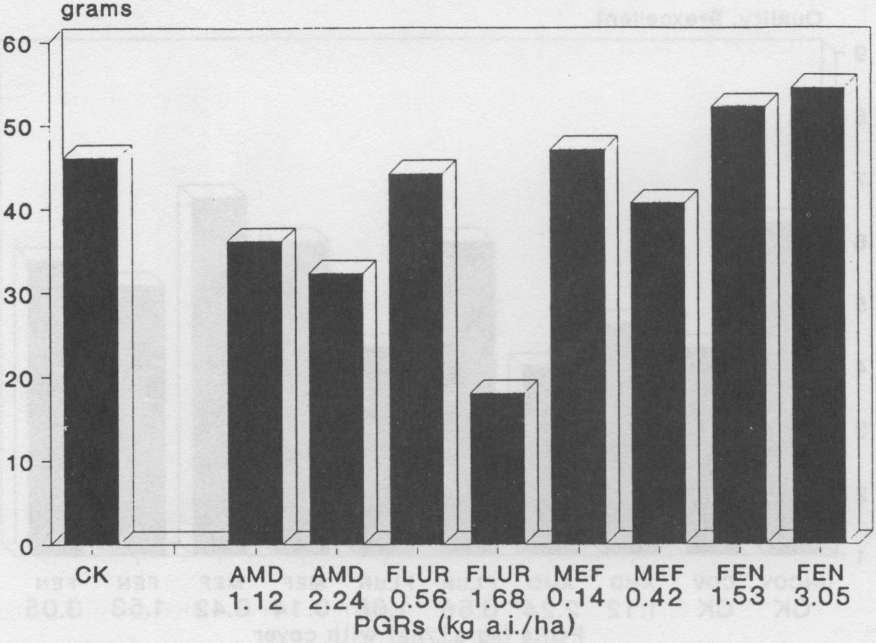
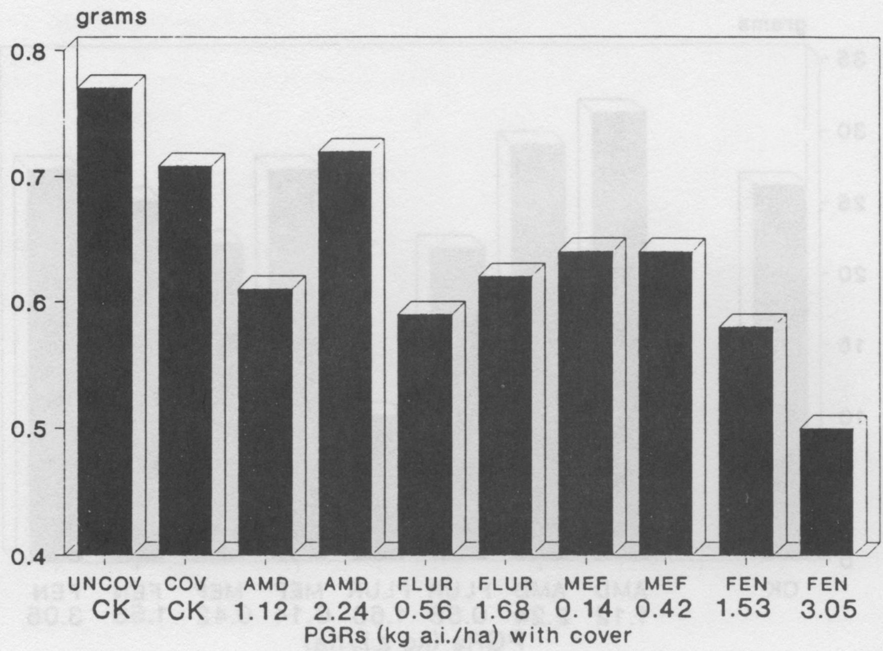


Fig. 9. Root dry weight 4-11-88



1989 NECROTIC RING SPOT FUNGICIDAL CONTROL AND KENTUCKY BLUEGRASS SUSCEPTIBILITY TEST RESULTS [1]

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Necrotic ring spot (NRS) is a serious disease problem on bluegrass turf in the Pacific Northwest. This disease is caused by the soil-borne fungus Leptosphaeria korrae, which causes patch symptoms from late spring through fall. Fungicide tests since 1983 have shown that a single application of Rubigan in early spring will provide effective control of NRS development during late summer and fall. In addition, control of necrotic ring spot has also been obtained with applications of Fungo, Banner, and Spotless. During 1989, a plot was established to test lower rates of Spotless and Banner, as well as three newly developed fungicides from Sandoz, BASF and Fermenta Plant Protection, Inc., in controlling NRS.

Another potential means of controlling NRS is through the identification and use of bluegrass cultivars with resistance to this disease. NRS-resistant cultivars would limit the importance of this disease on newly established turf, and resistant cultivars could effectively be used in overseeding programs to minimize the importance of this disease on established turf. Currently, information on the susceptibility of bluegrass cultivars is based on greenhouse and field tests primarily from Wisconsin and New York. There are some discrepancies in the relative susceptibility of individual cultivars based on these tests (for example, the cultivar Ram I had the lowest disease rating in one greenhouse test conducted in New York, but had the highest disease rating in a field test in Wisconsin). To obtain information on the susceptibility of Kentucky bluegrasses under our conditions in the Pacific Northwest, the 1985 National Kentucky Bluegrass Trials at Puyallup and Prosser were inoculated with L. korrae to determine their susceptibility to NRS.

1989 Fungicide Test

To determine the effectiveness of various fungicides in controlling necrotic ring spot, a plot was established on a mixed three-year-old turf containing Nassau, Ram I, Glade and Baron bluegrass near Rathdrum, Idaho. The plot was a randomized complete block design with five blocks and treatments were applied to 6 ft X 20 ft areas of turf in each block. The fungicides and rates tested are listed in Table 1. All fungicides were applied on May 11, 1989 in the equivalent of 4 gallons of water per 1000 ft^2 using a boom sprayer equipped with two 8004 teejet nozzles at 40 psi. At the time of application the soil temperature at 1-inch depth was 57°F, and air temperature was 50°F. The incidence of residual patch symptoms from 1988 was assessed on May 11, 1989 and averaged 6.6 patches per plot.

The effectiveness of the fungicides applied on May 11 in controlling necrotic ring spot was determined by counting the number of active patches and estimating the percent of plot with disease symptoms on September 11, 1989. Turf color and density were also rated on September 11 on a scale of 1 to 9, where 1 was very light green or thin, and 9 was very dark green or dense turf.

There were numerous small patches, 6 to 12 inches in diameter, on the turf on September 11, 1989. Single applications of Spotless and BAS48000F at the highest rates tested significantly reduced the number of patches and percentage of plot area with disease (Table 1). There were no differences in the level of disease between lower rates of these materials, the other fungicides tested and the nontreated check. In previous years, a single application of Rubigan AS during the spring had provided effective control of necrotic ring spot. The reasons for the poor control in this test are being investigated. The poor control of necrotic ring spot exhibited with applications of Banner in this test are probably due to the low rates of material tested.

Applications of Spotless and BAS48000F tended to increase turf color, while an application of BAS48000F at the high rates caused a significant reduction in turf density (Table 1).

Susceptibility of Bluegrasses to NRS

During 1987, the cultivars in the 1985 National Kentucky Bluegrass Trials, established by Drs. Brauen and Johnston/Evans at Puyallup and Prosser, Washington, respectively, were inoculated with three isolates of L. korrae. Each trial contained replicated plantings of each of the 72 bluegrass cultivars listed in Table 1. Inoculum of each L. korrae isolate was placed at a measured location within each plot. A 1-inch core of turf was removed and inoculum, consisting of 1 gm of air-dried millet seed that had been colonized by the fungus, was deposited just below the thatch layer prior to replacing the turf plug. The three isolates of L. korrae used in these tests were selected based on greenhouse pathogenicity tests and originally were obtained from diseased turf in Kennewick, Coulee Dam and Renton, Washington.

No symptoms developed on any of the inoculated turf at Prosser during 1988. At Puyallup, patch symptoms were present at some of the inoculation sites during fall 1988. Since the establishment of the Puyallup plot, weedy grasses have invaded many of the plots, preventing us from evaluating disease development at each of the 9 inoculation sites per cultivar (Table 2). Data were collected on patch diameters at the inoculation sites during June (Puyallup) and September (Prosser) during 1989. At Puyallup, the largest patches (12 inches) occurred on Amazon, while no symptoms developed on Julia, Eclipse, Merion, Classic, Mystic and P-104. Because of the limited number of inoculation sites from which data could be obtained, there were no statistical differences between the sizes of patches on any of the cultivars in this test.

At Prosser, the largest patches (3.3 to 1.9 inches) developed on HV-97, Julia, Conni and BAR VB 534. Even though patch sizes were significantly smaller on the bluegrass cultivars at Prosser compared to Puyallup, there were significant differences in the susceptibility of the Kentucky bluegrass cultivars located at Prosser, based on patch size (Table 2). The isolates of L. korrae from Kennewick and Renton caused significantly larger patches than the isolate from Coulee Dam at both Puyallup and Prosser (Table 3).

These data indicate that there are differences in the susceptibility of Kentucky bluegrasses to Leptosphaeria korrae. Additional measurements will have to be taken over the next several years to develop reliable information on the susceptibility of cultivars over a longer period of time. In addition, because of the weedy grass invasion, the plot at Puyallup is of little value in its current state and needs to be replaced and maintained in a manner such that weedy grass invasion is minimized.

Table 1. Effect of a single fungicide treatment on May 11, 1989 on the development of necrotic ring spot and turf quality on September 11, 1989.

Fungicide	Rate oz ai/1000 ft²	Number of patches per 120 ft²	Percentage of plot area w/disease	Turf quality[1] Color	Density
Rubigan AS	1.0	22.8	14.0	7.0	9.0
SAN 619F 40WG	0.13	20.8	10.2	7.0	9.0
SAN 619F 40WG	0.07	18.8	9.4	7.0	9.0
Banner 1.1EC	0.14	18.8	6.2	7.0	9.0
Check	-	17.6	9.0	7.0	9.0
Banner 1.1EC	0.27	17.0	10.2	7.0	9.0
Spotless 25W	0.25	15.4	6.6	7.4	9.0
BAS 48000F 25W	0.1	14.8	7.2	7.4	9.0
SDS 66608	5.4	14.6	4.8	7.2	9.0
SAN 619F 40WG	0.27	13.4	5.2	7.0	9.0
Spotless 25W	0.5	3.4	1.4	7.8	9.0
BAS 48000F 25W	0.5	3.2	1.6	7.4	8.0
Spotless 25W	1.0	0.2	0.2	8.0	9.0
BAS 48000F 25W	1.0	0.0	0.0	8.6	6.8
$LSD_{(P<0.05)}$		9.5	6.7	0.6	0.5

[1] Rated on a scale of 1-9, where 1=very light green or thin; 9 = very dark green or dense.

Table 2. Invasion of weedy grasses and development of necrotic ring spot patches on cultivars of Kentucky bluegrass in the National Bluegrass trials at Puyallup and Prosser, WA.

	Puyallup			Prosser
Cultivar	% Weedy grass invasion[1]	No. of symptomatic inoculation sites/total no. of inoculation sites[2]	Patch diameter (inch)	Patch diameter (inch)
HV 97	73.7	3/3	10.7 a[3]	3.3 a
Julia	76.7	0/1	0.0 a	2.8 ab
Conni	30.0	2/2	2.4 a	2.4 abc
BAR VB 534	60.0	4/5	7.4 a	1.9 a-d
Ba 72-441	56.7	3/3	10.0 a	1.4 b-e
Blacksburg	66.7	6/6	8.3 a	1.4 b-e
PST-CB1	76.7	1/1	7.0 a	1.3 b-e
Parade	90.0	---[4]	-	1.3 b-e
Gnome	62.6	6/6	7.0 a	1.2 b-e
Sydsport	66.7	8/8	10.5 a	1.2 b-e
Amazon	73.3	4/4	12.0 a	1.0 c-e
Dawn	63.3	3/3	7.7 a	1.0 c-e
Merit	36.7	3/3	6.3 a	1.0 c-e
Welcome	76.7	1/3	2.3 a	0.9 c-e
Kenblue	86.7	---	-	0.7 c-e
Cynthia	63.3	4/4	8.0 a	0.7 c-e
Ba 69-82	73.3	4/4	6.5 a	0.7 c-e
Midnight	46.7	3/6	3.0 a	0.7 c-e
Destiny	66.7	1/3	2.7 a	0.7 c-e
S.D. Certified	63.3	1/2	1.0 a	0.7 c-e
Compact	93.3	1/1	8.0 a	0.6 de
Rugby	76.7	3/3	9.0 a	0.6 de
Ba 72-492	63.3	4/6	6.3 a	0.6 de
Tendos	46.0	5/7	5.9 a	0.6 de
Lofts 1757	56.7	2/3	4.3 a	0.6 de
Able I	50.0	1/1	3.0 a	0.6 de
Baron	70.0	2/2	8.0 a	0.4 de
Ba 73-626	53.3	4/4	7.8 a	0.4 de
Classic	50.0	0/1	0.0 a	0.4 de
Ram I	80.0	2/2	7.5 a	0.3 de
Liberty	60.0	3/4	4.5 a	0.3 de
239	83.3	1/2	4.0 a	0.3 de
Monopoly	53.3	1/3	3.3 a	0.3 de
Eclipse	80.0	0/2	0.0 a	0.3 de
Harmony	66.7	1/2	4.0 a	0.3 de
Aquila	70.0	1/2	3.0 a	0.2 de
Huntsville	83.3	3/3	9.7 a	0.0 e
Kl-152	53.0	4/4	9.5 a	0.0 e
Ba 73-540	50.0	5/5	9.4 a	0.0 e
Glade	43.3	8/9	9.2 a	0.0 e
WWAg 495	86.7	3/3	9.0 a	0.0 e
Somerset	70.0	1/1	9.0 a	0.0 e

Table 2. (Continued)

Cultivar	Puyallup % Weedy grass invasion[1]	Puyallup No. of symptomatic inoculation sites/total no. of inoculation sites[2]	Puyallup Patch diameter (inch)	Prosser Patch diameter (inch)
Ba 70-139	50.0	6/6	9.0 a	0.0 e
Annika	63.3	6/6	8.7 a	0.0 e
F-1872	50.0	3/3	8.3 a	0.0 e
Challenger	63.3	5/6	8.2 a	0.0 e
WWAg 491	76.7	2/2	8.0 a	0.0 e
Victa	73.3	2/2	8.0 a	0.0 e
Barzan	61.1	1/1	8.0 a	0.0 e
BAR VB 57	60.0	2/2	8.0 a	0.0 e
WWAg 496	46.7	3/4	8.0 a	0.0 e
Ikone	63.3	4/5	7.6 a	0.0 e
America	86.7	3/3	7.3 a	0.0 e
Aspen	86.7	1/1	7.0 a	0.0 e
Nassau	76.7	3/3	7.0 a	0.0 e
Cheri	53.3	4/4	6.8 a	0.0 e
K3-179	80.0	1/1	6.0 a	0.0 e
Haga	73.3	2/2	6.0 a	0.0 e
A-34	46.7	3/4	6.0 a	0.0 e
Trenton	46.7	5/6	5.8 a	0.0 e
NE80-88	73.3	2/3	5.3 a	0.0 e
Wabash	83.3	1/1	5.0 a	0.0 e
Asset	26.7	4/5	5.0 a	0.0 e
Ba 72-500	60.0	3/5	4.8 a	0.0 e
Bristol	46.7	1/4	2.8 a	0.0 e
Mystic	70.0	0/1	0.0 a	0.0 e
Merion	30.0	0/1	0.0 a	0.0 e
P-104	20.0	0/5	0.0 a	0.0 e
Joy	90.0	---	-	0.0 e
WWAg 468	76.7	---	-	0.0 e
Georgetown	70.0	---	-	0.0 e
Ba 70-242	63.3	---	-	0.0 e

[1] Percentage of plot area invaded by weedy grasses on June 9, 1989. Average for three replications.

[2] Nine sites/cultivar were inoculated with Leptosphaeria korrae on July 7, 1987. The total number of inoculation sites is the number of original inoculation sites which were still readable on June 9, 1989.

[3] Numbers followed by the same letter are not significantly different, $P<0.05$, Duncan's multiple range test.

[4] --- = All inoculation sites invaded by weedy grasses.

Table 3. Differences in patch sizes caused by three isolates of *L. korrae* used to inoculate 72 Kentucky bluegrasses at Puyallup and Prosser, WA.

Isolate	Patch diameter (in)[1]	
	Puyallup	Prosser
TC-1-19	7.2 a	0.5 a
R-49	7.7 a	0.6 a
CD-18-103	4.8 b	0.2 b

[1] Average for all KBG. Data collected June 1989 and September 1989 at Puyallup and Prosser, respectively. Numbers followed by the same letter are not significantly different, $P<0.05$, Duncan's multiple range test.

TURFGRASS WATER CONSUMPTION IN THE NORTHWEST. HOW DO WE COMPARE TO OTHER REGIONS? [1]

Stan Brauen [2]

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[1] Presented at the 43rd Northwest Turfgrass Conference, Sheraton-Tacoma Hotel, Tacoma, Washington, September 18-21, 1989.

[2] Turfgrass Research & Extension Coordinator, Washington State University, Research & Extension Center, Puyallup, Washington.

Turfgrasses are accepted as an integral part of real property value and play an important part in recreational and personal comfort of people. These comforts are related to the aesthetic quality and usability of turf which, in turn, are related to the available resources contributed to turfgrass areas. The availability of water resources have a high impact upon these comforts, particularly during periods of deficit water supplies. Consequently, there is a strong need for efficient turfgrass watering practices in order to conserve water and reduce turf maintenance costs. In addition, increased efficiencies will diminish the costs associated with the development of water resources necessary to meet the conservative needs of an expanding and more centralized population.

Water consumption studies have shown that nearly half the water treated annually in the western United States for municipal use is applied to outdoor vegetation, and turfgrass is a significant part of that current water use (7,16). In response, a number of western U.S. and other universities have undertaken research quantifying the required water use rates of turfgrass and, in some studies, identifying factors altering the rate of water use in urban environments (5,10,12,17,18,19,21,23). Others have manipulated watering practices of turfgrass to develop systems most suitable to sustaining functional turf (2,3,11,15,20,22). Breeding of low water using turfgrasses (mostly warm season types or tall fescue) has been funded heavily by the USGA, especially in the central transition zone of the U.S. These grasses, some of which are drouth tolerant, are in early stages of evaluation throughout the country.

Considerable good research information has been developed at these institutions, but the majority of the research has been developed in climates of the southwest or central west, and the developments have been heavily directed toward water conservation with warm season grasses (13,15). Substantial water use work has been conducted at various locations throughout the U.S. with Kentucky bluegrass (Poa pratensis L.), a cool season grass. However, only a very limited number of presently available cultivars of this species are adapted to the marine Northwest and most do not have strong persistence characteristics here (1,4,8,9,14). Most all of the grasses seeded here are cool season grasses, such as perennial ryegrass (Lolium perenne L.), fine fescue (Festuca rubra L.), and bentgrass (Agrostis spp.) with some Kentucky bluegrass included in sodded turf. Most older lawns consist of mixes of bentgrass, fine fescue and perennial ryegrass, with heavy infestations of annual bluegrass (Poa annua L.) and some velvetgrass (Holcus spp.) or rough bluegrass (Poa trivialis L.). Little tall fescue (Festuca arundinacea Schreb.) is currently used and cultural and persistence successes in research and demonstrations have not been encouraging. The warm season species, such as Japanese lawngrass (Zoysia japonica Steud.), bermudagrass (Cynodon dactylon (L.) Pers.), buffalograss (Buchloe dactyloides (Nutt.) Engelm.), common carpetgrass (Axonopus affinis Chase), St. Augustine-grass (Stenotaphrum secundatum (Walt.) Kuntze) and Bahiagrass (Paspalum notatum Flugge) have not been persistent, functional turfs for this area.

Turfgrass growing conditions in the Northwest are uniquely different from other areas in the United States, and little of the water conservation data regarding species has been transferable to the Northwest turfgrass industry. Thus, research studies are needed to "sort out" and localize the research being reported nationally. Specifically, programs directed at identifying adapted species and cultivars with low water use requirement, with low maintenance and wear stress tolerance while maintaining functional, competitive turf under water conserving management are needed and being initiated.

The initial objectives have been to measure the water use rate of cool season grass species and cultivars in field plot lysimeters and relate these use rates to soil and surface environmental variables. The second phase is to relate turf use conditions (wear, seasonal injury, compaction, etc.), water stress and cultural management to turfgrass persistence, recovery, disease and quality in prediction models to support turfgrass water use strategies when water becomes even more limiting than present. This project was begun with funding by Rhone-Poulenc in 1986 and has been followed by funding from the Northwest Turfgrass Association Research Fund in 1987-89.

Methods

In these studies, cylindrical PVC weighing lysimeters, 24.8 x 30.5 cm in size, were used to assess field evapotranspiration (ET) of grasses during 1987, 1988 and 1989. Species water use measurements were made with annual bluegrass, Kentucky bluegrass, perennial ryegrass, creeping red fescue (Festuca rubra spp. rubra L.), tall fescue, or colonial bentgrass (Agrostis tenuis Sibth.). The lysimeters were placed in below-ground silos in a turf sod and once daily lifted from their silos and weighed within ÷ 2 g (20,000:1 sensitivity) for water loss. Measurements were made during July to September in each year.

Water Use Estimates

During the summer of 1988, the average daily turfgrass ET ranged from a low of 1.78 mm (.07 in.) to a high of 5.58 mm (.22 in.), while the average daily ET for 44 days ranged from 3.02 mm (.12 in.) for colonial bentgrass to 3.43 mm (.14 in.) for perennial ryegrass. Perennial ryegrass ET was 13.6% higher than colonial bentgrass ET. Only colonial bentgrass used significantly less water than perennial ryegrass over 44 days. Species ET declined in the order perennial ryegrass > annual bluegrass > tall fescue > creeping fescue > Kentucky bluegrass > colonial bentgrass, but no difference in average daily ET could be detected among perennial ryegrass, annual bluegrass, tall fescue or creeping fescue. These grasses were six months of age and the tall fescue (K-31) was less dense than the other species.

Grasses irrigated at 60% deficit ET used 9.3% less water, but turf quality of annual bluegrass, tall fescue and colonial bentgrass declined significantly when managed at this deficit level. The ET on 70% of the measured days ranged from 2.3 (.09 in.) to 4.6 mm (.18 in.) with about 15% of the days above and 15% of the days below this range. Averaged on a weekly basis, turfgrasses used 1.6 cm (.63 in.) to 3.2 cm (1.26 in.) of water weekly. The highest water use rate was 57% of the high expected rate in dry, southwestern climates during peak demand periods.

During the summer of 1989, four varieties each of perennial ryegrass, fine fescue and tall fescue were evaluated for water use. The tall fescue varieties used about 10% more water than the average perennial ryegrass and about 7% more water than the average fine fescue. However, this was only about 40 to 50% of the water requirement for tall fescue in southwest during hot periods and 60 to 70% of the average daily water use reported from the intermountain regions (7,10,11,12).

Water use of tall fescue varieties was always high even with the fine-leaved diminutive (dwarf) selections such as Silverado or DDF compared to older types such as Kentucky 31. Little difference was observed between perennial ryegrass varieties. Scaldis hard fescue used nearly 10% less water than other creeping red, slender red or chewings fescue varieties even though density and leaf numbers were similar.

Compared to Scaldis hard fescue, the water used by perennial ryegrass was 4 to 7% higher, while creeping red, slender red and chewings fine fescues were 8 to 12% higher. Tall fescue cultivars used 14 to 17% more water than Scaldis hard fescue.

In Summary, turfgrass used 40 to 50% less water at Puyallup than could be expected of turf use in the Southwestern U.S. during peak demand periods and turf at Puyallup used 60 to 70% of the water that is commonly expected of turf in the intermountain areas on an average daily basis. On a weekly basis, this demand at Puyallup averaged about 0.75 inch but was as high as 1.25 inch during the peak demand periods with the higher water use rates experienced with tall fescue. Little difference in water use rate was observed between tall fescue varieties but highly significant differences in water use rate existed between species of fine fescue and no significant difference was observed among varieties of perennial ryegrass.

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THE EFFECTS OF pH, PHOSPHATE, ALUMINUM, AND CALCIUM ON ANNUAL BLUEGRASS AND CREEPING BENTGRASS [1]

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[1] Presented at the 43rd Northwest Turfgrass Conference, Sheraton-Tacoma Hotel, Tacoma, Washington, September 18-21, 1989.

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Most soils in the Coastal Pacific Northwest are moderately to strongly acidic. To establish and maintain a good annual bluegrass or creeping bentgrass stand, it is necessary to know how and the extent to which soil acidity can affect their growth. However, because soil acidity can also affect plant availability of soil aluminum, phosphate, and calcium, the potential effects of these elements on the growth of these turfgrasses should be studied concurrently.

Twenty-four soils were used in this investigation, which had acidity levels ranging from very strong acid (pH = 3.65) to moderate acid (pH = 5.95). Concentrations of exchangeable aluminum ranged from 12 ppm Al to 1230 ppm Al and exchangeable calcium from 5 to 1550 ppm Ca. The available phosphate by the sodium bicarbonate soil test ranged from 0.5 to 50 ppm P. The clipping yields of annual bluegrass or bentgrass grown under greenhouse conditions were not closely related to the pH levels of the soils even though a trend showing a general increase of yields with pH was observed. Low pH can inhibit radical development of annual bluegrass. However, the results of the present study gave no clear indication that annual bluegrass is less tolerant to soil acidity than the bentgrass. The pH did not account for much variability of the clipping yields for either grass. The differential tolerance to pH between the two grass species was not substantiated by the present study.

Increased exchangeable soil aluminum reduced clipping yields of both grasses. Soluble ionic aluminum is known to inhibit cell division, root growth and elongation. There was no differential growth response between the two grass species to the Al stress as anticipated. This indicates that in addition to the level of exchangeable soil Al, there was also other factors that affect the growth of the two grasses in acid soils.

Clipping yields of bentgrass and annual bluegrass responded highly to increased available soil phosphate. However, unlike bentgrass, which reached a maximum yield between 15 and 20 ppm P by sodium bicarbonate soil test, the annual bluegrass response continued to higher levels of available soil phosphate. This indicates that annual bluegrass has a greater phosphate requirement than bentgrass, a result consistent with previous findings of other researchers. Thus, proper phosphate fertilization practices are very important for the maintenance of a good annual bluegrass or bentgrass stand. Higher phosphate application rates are encouraged for annual bluegrass than for bentgrass. A routine soil test for the amount of available soil phosphate should be helpful for estimating the rates of phosphate application.

It is clear from some recent studies that Ca nutrition is vital to the ability of plants to grow under Al stress. Elevated Al accumulation can adversely affect the Ca uptake and translocation within plants. However, no specific effect of Ca on Al toxicity has been demonstrated. In the present study, an apparent function of available soil Ca for both grasses was to stimulate the plant utilization of available soil phosphate. Maximum clipping yields were reached at a lower level of available soil phosphate when the quantity of available soil calcium was increased to an adequate level.

The above results indicate that soil acidity can influence the growth of annual bluegrasses or bentgrass in a variety of ways including the regulation of the availability of soil phosphate, calcium, and aluminum. While phosphate can enhance the growth of the two grasses under Al stress, increased calcium availability can also benefit plant growth by promoting plant utilization of available soil phosphate.

PROTECTING GROUND WATER: A STRATEGY FOR MANAGING PESTICIDES AND NUTRIENTS [1]

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[1] Presented at the 43rd Northwest Turfgrass Conference, Sheraton-Tacoma Hotel, Tacoma, Washington, September 18-21, 1989.
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Good morning. I have been asked to speak to you about ground water. Ground water is a hot topic these days. Newspapers are running stories about it. Communities are developing plans to protect it. There are whole conferences about it. I'm here to try to share with you some of what all the fuss is about.

At Ecology and at other state agencies, there are a number of programs that are looking at impacts on ground water from a variety of sources: industrial discharges, stormwater, on-site sewage systems, landfills, and so on. My job is to take a look at the potential that pesticides and nutrients have to contaminate ground water, and to coordinate with other agencies in developing policy that can address that potential. I'll tell you a little more about that later.

First, let me briefly review what the concerns are. Then I'll tell about some studies being done here in Washington to try to assess impacts of agricultural chemical usage on ground water. I am talking here about chemical pesticides and also about fertilizers, especially those containing soluble nitrogen. Golf courses and other large scale turf operations are included in ''agricultural'' as I'm using the term here. Last, I'd like to talk about some of the options we have for dealing with this issue.

THE ISSUE.

If you had asked me to come and talk to you a few years ago on contamination of ground water from pesticides and nutrients, my job would have been easy. I could have spoken about nitrates and poorly sited wells, about a few problems near formulation and storage areas, and about the need to properly dispose of pesticide containers. We thought that ground water was protected, and that contamination occurred only under the most unusual circumstances. The common belief was that pesticides would degrade or volatilize fairly quickly, or would bind with or breakdowm in the soil and not migrate to groundwater.

Then in 1979 dibromochloropropane (DBCP) was found in numerous wells in California's Central Valley. That same year, Aldicarb was found in wells on Long Island, New York. The next year Aldicarb was found in Wisconsin ground water. Since then Aldicarb has been found in wells at levels of concern in eleven other states.

In California, over 50 pesticides have been found in ground water. About half can be attributed to leaks and spills. The other half are the result of normal field application.

Long Island, New York has 2000 wells contaminated with Aldicarb. Half of those had levels above the New York standard of 7 ppb. In Iowa, nine herbicides and two insecticides have been detected in ground water. Though concentrations are low, the data shows that more than a quarter of the population of Iowa are drinking water with agricultural chemicals in it.

Dinoseb has been found in New York groundwater, Simazine in California, Pennsylvania and other states, Metochlor in Iowa, Pennsylvania . . . the list goes on.

In the last ten years the potential for these chemicals to contaminate ground water has been brought forcefully to our attention. Misuse, poor storage practices, and improper mixing or disposal practices account for some of the problems that have been documented. But not all. In the case of certain chemicals, conventional usage - that is, application according to accepted practices - is also responsible for contamination of ground water.

Let's talk about ethylene dibromide for a moment. In 1982 this fungicide—EDB—was discovered in two California wells and three wells in Georgia. By the end of the following year, EDB contamination of ground water had been found in 16 different counties in four states—California, Florida, Georgia, and Hawaii.

In January 1984, EDB was found in a private well in Skagit County. The Department of Social and Health Services then did a study that found EDB in domestic wells in Skagit, Whatcom, and Thurston counties. Many of the families whose wells were contaminated had to find other sources of drinking water. Often, drilling a new well is not an option. In Whatcom County, a public supply system was extended to serve part of the contaminated area. Other families are still drinking bottled water.

GROUND WATER STUDIES

I'd like to tell you about three studies being done here in Washington State to help us try to understand what is happening to our ground water. One study is by the Environmental Protection Agency, another by the United States Geological Survey, and finally, the Pesticide Pilot Study that my department is doing.

The USGS Study is in Franklin and Benton Counties. It is focussing on testing for nitrates, and is also doing some testing for a few of the commonly used leachable pesticides.

Preliminary results from the USGS study show elevated levels of nitrates in about 18 percent of the wells tested. ''Elevated'' means above the drinking water standard of 10 ppm. Many wells are showing nitrate levels of 25 or 30 ppm. The highest level was 100 ppm. USGS also tested about 30 wells for pesticides. Five wells had low levels of pesticides: all of these were either Atrazine or a breakdown product of Aldicarb.

The Environmental Protection Agency study is a national survey looking for pesticides in ground water under a variety of land use conditions. They are testing about 1500 wells nationally, and have selected about 15 wells in this state to include in the study. The results from this study have not yet been released.

The wells for the EPA study were selected randomly, and as it happens, all the wells in Washington are in urbanizing areas. This study will give an idea of how groundwater is being affected by all land uses on a national scale.

The other study is the Pesticide Pilot Study that the Department of Ecology is doing in cooperation with the Department of Agriculture and Health. This is a Pilot study, a first step to understand if and how the use of agricultural chemicals are affecting our ground waters.

We selected a small study area in each of three counties, Whatcom, Yakima, and Franklin. These areas were selected because of the presence of typical agricultural activity, and because many of the conditions that contribute to ground water vulnerability are known to be present.

Samples were taken from 27 wells in each study area. The wells were selected at random, and included private wells, community wells, and existing monitoring wells.

In addition to testing for things like temperature, metals, nitrates, and other nutrients, we tested for about forty different agricultural chemicals. Most of the chemicals were chosen because they are in use in Washington, and because they are leachables. A few are included because they have been found in ground water in other places.

These are the results: Out of the 81 wells, 23 had indications of at least one of the pesticides sampled for. Seven of the detections were above the Proposed Maximum Contaminant Levels for drinking water. Nitrates were detected in 61 of the wells. Some of the nitrate levels were fairly low—less than 1 ppm—and may simply reflect ''background''.

But 18 of the wells had nitrates above the health standard of 10 ppm, and quite a few were in the range between background and the health standard.

There are other kinds of studies going on that provide useful information. For instance, WSU Extension has some research projects looking at how pesticides move in soils, and some conservation districts are looking at how irrigation practices affect the movement of nitrates. These kinds of studies increase our knowledge about how ground water is affected by these materials.

By law, public drinking water systems must be tested periodically. Until recently, only a few things were tested for nitrates, coliforms, and a few toxics. But now there are new requirements for larger systems to test for several dozen chemicals, many of them used as pesticides. Already, there have been some reports of wells testing positive for pesticides. Many wells are showing increasing levels of nitrates. Unfortunately, it is not always possible to know what the source of the contamination is.

We don't have a routine ground water monitoring program in this state, so right now we can't say what the picture is statewide. But based on the results from these studies and information that is coming in from other states, many of which have geological conditions similar to Washington, we have plenty of reason to be concerned.

WHY ARE WE CONCERNED?

Why are we concerned about these findings? There are two major reasons. One is our use of ground water. The other is the properties of the chemicals in question.

Ground water is a major resource in Washington. Half of our population (and more in most rural areas) rely on ground water for drinking water. I live in Thurston County and get my drinking water from a well. Many of you in this room also get your water from a well.

Ground water recharges lakes, streams, and wetlands. It is used for irrigation, aquaculture and other purposes.

Once contaminated, ground water can remain contaminated for hundreds of years. Ground water tends to move very slowly, inches and sometimes feet per year. And, by its very nature of being underground, ground water is very difficult and extremely costly to clean up. For these reasons, it is important to do what we can to protect ground water before damage is done.

WHAT ARE THE RISKS?

What are our risks from these substances? After all, the concentrations of pesticides being detected in ground water are often in the range of parts per billion. But even at these low levels, the concern for health is legitimate.

With pesticides there is a concern about long-term or chronic exposure from low concentrations. Our knowledge of chronic health effects for humans is often incomplete, but lab studies with animals and various studies looking at human exposure to pesticides suggest that cancers and other tumors, birth defects or other chronic illness may be related to exposure to certain chemicals. Fish and other animals may be even more sensitive.

Until we have better information, we need to err on the conservative side.

The concerns with nitrates have generally centered around drinking water for infants and the problem of methemoglobinemia. While the problem is relatively well understood, there are no accurate statistics on its occurrence, and, tragically, acute cases still occur.

As nitrates have risen in water supplies, the potential for further problems has also increased. In addition, recent research shows that older children and adults also may suffer health effects from long term exposure to nitrates.

WHAT NEXT?

So the question now might be "What next?"

We need to make some decisions about further study in the state as a whole, and we need to look at our options for protecting ground water.

We are just beginning to get a handle on how much of a problem we have, and we are in the early stages of working on some solutions. But the important thing is not to wait until there is a problem. We want to act to preserve water quality. Let me tell you about where we are right now, and what some of the tools we have to work with.

Two years ago Ecology asked a Citizen's Advisory Group to help us develop a Strategy for Ground Water Quality Protection.

This is the goal of that strategy:

"To maintain high quality for all water of the state, allowing no reduction in water quality, except in overriding consideration of public interest. No reduction would be allowed to adversely affect the ability to use that water for its intended beneficial use." The Ground Water Quality Strategy outlined a series of tasks. Developing Ground Water Quality Standards was one of those tasks.

Ecology is in the process of developing standards for ground water quality. The State of Washington has had standards for surface water quality for some time now. These standards are used to guide permit writers and others making decisions that can affect surface water quality. Ground Water standards would be used in much the same way as surface water standards, and also can be used to help guide us in making decisions on how to manage nonpoint source pollution.

The standards will include numerical criteria for contaminants, and would also set ''Early Warning Values.'' For some materials, these values will be a percentage of the standard. If a contaminant were to reach this value, then we would have time to act before the beneficial use of the ground water is affected.

Something else we hope to do is to identify and map those areas most vulnerable to contamination. This kind of mapping will help us determine where we need to take extra precaution to ensure that water quality is preserved.

Once these standards are implemented, they'll serve as a guide to evaluate how well ground waters are being protected. Hopefully, we'll be able to assess ahead of time - before irreparable damage has occurred - how our activities are affecting ground water.

If we're paying attention, we'll be able to modify what we do and how we do it in order to protect this very important resource.

MANAGING PESTICIDES AND FERTILIZERS

Another task in the Ground Water Quality Strategy is to look at how to manage pesticides and fertilizers to protect ground water. The State Nonpoint Source Management Plan that was developed last year also identified this as a priority, along with stormwater runoff, on-site sewage systems, and leaking underground storage tanks. Ecology is developing programs to address all of these. My job is to coordinate the development of a Ground Water Pesticide and Nutrient Management Strategy.

Let me give you some background:

Three agencies in this state have important regulatory functions in relation to ground water. Ecology has responsibility for protecting ground water as a resource. The Department of Agriculture regulates the use of agricultural chemicals. The Department of Health - until recently part of DSHS - is responsible for setting standards for drinking water. These three agencies have a Memorandum of Understanding to support the Ground Water Quality Strategy.

A number of other agencies are also involved: the Extension Service, the Soil Conservation Service, the Conservation Commission, the Department of Natural Resources, among others. All of these have programs or activities that relate to pesticides and ground water, either directly or indirectly. For instance, the SCS is developing a Water Quality Technical Guide to help Conservation District field technicians select appropriate Best Management Practices to protect both surface and ground water. The Washington State University Extension Service is beginning to evaluate Best Management Practices for a reference manual.

But right now there is no coordination of all these activities. That is what the Ground Water Pesticide and Nutrient Strategy will do: it will provide the framework. It will identify what is being done, what needs to be done, and what resources are available. It will set priorities, and most of all, it will set goals so that we know where we are going.

Not only agencies will be involved in developing this plan: a Citizen's Advisory Committee will have an important role in putting it together. And we will be holding public workshops to encourage input from people like you.

How does all this affect you?

You work and live in the environment I am talking about. Ground water is part of our lives: it contributes to the water we drink, swim, fish, enjoy as part of the beautiful Pacific Northwest. We - you, and I, and our neighbors - are responsible for seeing that what we do and how we do it retains the quality of the environment we live and work in, not just for now, but for tomorrow.

There is a chance that some of the chemicals you are accustomed to using may have restrictions placed on them. Regulating chemicals is certainly part of what I'm talking about. But let's look beyond that. One of the most important factors in protecting ground water is the choices that individuals make. An important part of this is providing the kind of information that you need in order to make responsible decisions about pest management. The agencies I am working with are also looking for ways to develop this information and make it available to you.

There are techniques - Best Management Practices is one name for them - that can help protect ground water. Some of these may involve choosing a chemical for specific soil conditions, timing the application by the weather, or choosing an appropriate method of application for some kinds of chemicals. There may be options you can use and recommend to your clients that don't involve chemicals. Pest management may include making decisions about plant varieties, or about cultural practices that can build pest resistance or interrupt the pest cycle.

Because you make these kinds of decisions, you are an important link in ground water protection. In fact, a critical link. That's why I'm here talking to you today.

Everything that my agency does, everything that WSDA does, everything that the SCS or the Extension Service does depends, finally, on the choices that people like you make in going about your business.

We have a challenge ahead of us - all of us - regulators, producers, distributors, and users of chemicals. I invite you to join us in meeting that challenge.

THE EXTREMES OF TURFGRASS MAINTENANCE [1]

Ronald W. Fream [2]

[1] Presented at the 43rd Northwest Turfgrass Conference, Sheraton-Tacoma Hotel, Tacoma, Washington, September 18-21, 1989.

[2] Architect, Golfplan Design Group, Inc., Santa Rosa, California.

- Midnight Sun Center, Finland, 65 degrees north;
- Pirita Golf, Tallinn, Estonia, USSR;
- Sentosa Golf Club, Singapore, the equator;
- Mariyui Country Club Resort, Mar del Plata, Argentina, 37.5 degrees south;
- Golf El Kantaoui, Tunisia, 8 to 10 inches natulal rainfall and sewage treated saline irrigation water;
- Royal Brunei Golf Club, Borneo, rainfall in excess of 200 inches per year, average humidity over 85 percent;
- Happy Valley Golf Club, Hokkaido lsland, Japan, sub-artic;
- Palm Hills Golf Resort, Okinawa, Japan, five hours flying time south of Hokkaido, tropical climate, typhoon potential;
- Panya lndra Golf Resort, Bangkok, 400 table top flat, clay, rice paddy acres;
- Asiana Golf Resort, near Seoul, Korea, 450 feet of vertical terrain change and over 6,000,000 cubic yards of earth to move for 36 holes.

The above name dropping demonstrates the diversity of environments where golf courses designed by my office are currently being created and maintained. The world-wide expanse of this work presents challenges and opportunities not encountered in only one or two local sites, to say the least.

lt is a considerable task to try and stay ahead of the specific demand of these various sites. Each country - even more so each location - has its own particular requirements, methods and problems. Spanning the world north to south, seasons change in only a few hours of airline travel. Bangkok, a year-round steam bath, and sub arctic, rockstrewn Finland, can be visited consecutively to review construction works and turfgrass establishment.

What is frequently taken for granted here in the United States cannot be taken for granted elsewhere. Only the British have any formal established turfgrass maintenance educational program, and even that is not of university level. ln

France, some recent efforts to establish turfgrass maintenance programs have begun, but in a very basic way. lt will be some years before skilled golf course superintendents are available.

In all too many locations, mowing and watering are the only objectives of the turfgrass manager.

With the increase in the number of golf players skyrocketing, golf construction cannot keep pace with the demand for new courses. Providing experienced golf course superintendents is even more of a problem in many of the countries where golf is only now becoming a popular sport or tourist attraction. Many newly emerging golfing locations had few or no courses at all only a few years ago. There were few courses available even to train maintenance personnel, let alone schools to teach modern turfgrass maintenance. Those greens keepers who did exist had minimum of modern technical knowledge.

To deal with a near total absence of skilled superintendents and trained, knowledgeable, maintenance personnel, the golf course architect must try to resolve and prevent future possible problems. Anticipating future problem areas and resolving those problems on paper as the design and working drawings are prepared can save many headaches later. Having an awareness of local customs, procedures and manpower capabilities can certainly assist in formulating design solutions and written technical specifications which are adapted to the specific conditions of the site and location.

Detailed, illustrative drawings, while initially frequently confusing to the inexperienced, can help to implement the conversion of design ideas to realization in the field. Bulldozers and hand labor can each achieve the same result, it just takes different time schedules.

Attention to environmental specifics, climatic specifics, ecological considerations, social and cultural factors becomes not quite automatic, but certainly an important part of the design process.

ln some exotic locations around the world, sites totally unlike anything known in America are presented as proposed golf courses. Solutions to design objectives, construction methods and turfgrass maintenance may have few comparable in America. Budgets for construction and maintenance can be far less, or at times far greater, than what would be considered typical in America.

ln many locations around the world, it is not practical to introduce American construction personnel or American golf course superintendents. Local social, political and/or economic factors make the use of local people a necessity. Many of these local people are not well educated. ln some cases only the person who is to be the golf maintenance superintendent can read and/or speak English.

Members of the crew may not be literate in their own native language. As most current technical information is published in English, a problem of getting sufficient information and direction to the person responsible for the day to day turfgrass maintenance can be a problem.

With turf maintenance managers who are limited in education, and maintenance crews of modest education or limited knowledge, achieving desired standards of maintenance can be difficult. Grass may be mowed, but not necessarily by technically correct methods. More elaborate maintenance practices may or may not occur, on arbitrary schedules or automatic schedules which were learned elsewhere, and with no concern or adaptation to present site conditions. Adjustments in maintenance practice for increases in play, weather changes or fertilizer availability can become demanding concepts not fully understood or appreciated.

Even with knowledgeable supervision, local economic and/or bureaucratic factors can make acquisition of needed chemicals, fertilizers, spare parts or new equipment difficult or impossible. Short notice deliveries are frequently impossible. Importation is always a source of delay. Repair may be delayed or impossible because of the lack of ability of the mechanic. Work ethics and motivation differs greatly from country to country. Military-like mechanized precision and mass movement in one country can be balanced against poorly motivated manual labor in another.

Climatic conditions, heat, rainfall, and humidity can influence productivity. Even today in some parts of the world, daily wages of two to three dollars are not uncommon. Wages of three or foul hundred dollars a month are also encountered. This may be a good wage locally, but motivation, initiative and ambition do not always follow. Education does not automatically come with those wages, either.

Japan has a very intense level of maintenance, highly motivated and huge by United States standards. Maintenance crews of 40 persons on 18 holes are not uncommon. But golf in Japan is like nowhere else in the magnitude of the construction, the level of hand manicured maintenance, and the size of membership fees and greens fees.

The objective must remain constant - provide first class playing surfaces in a distinctive, challenging and memorable way. Patience and perseverance are necessary. Not always can the results equal the general expectation accepted here in the United States. Lower standards can be adequate or ample in many locations. As long as the player enjoys the round and feels satisfied enough to return and play the course again one day, the objectives will have been met.

THE WORLD OF GOLF COURSES [1]

Ronald W. Fream [2]

[1] Presented at the 43rd Northwest Turfgrass Conference, Sheraton-Tacoma Hotel, Tacoma, Washington, September 18-21, 1989.

[2] Architect, Golfplan Design Group, Inc., Santa Rosa, California

The game of golf is experiencing a period of growth never before seen. In the United States the rate of increase in play has reached over seven percent per year, up from a five percent average of many years. While even seven percent growth may not seem large, it becomes one million six hundred thousand new players a year!

Beyond the shores of the United States golf play is exploding. France only recently discovered golf, yet growth in number of players exceeds twenty percent per year. Germany, a country of harsh winters, limited and expensive land, is showing an annual growth rate of over fifteen percent. Countries as diverse as Finland, Taiwan, Korea and Thailand are presently seeing a doubling, or more, of existing golf courses. In Japan, where land is at a true premium, the demand for new courses is unquenchable, even at ten to fifteen million dollars per course. This demand is pushed by over 13,000,000 players trying to get onto less than 2000 courses (and 5,000 driving ranges), all in an area with less land than California.

It has been projected that by the year 2000 there will be over fifty million golfers world-wide; in my opinion that figure is conservative.

Designing golf courses in foreign countries is, in many fundamental ways, no different than designing golf courses in the United States. However, when you consider ever changing political, environmental, cultural, social, religious, financial, climatic, and topographic features, vast technical differences arise.

My office presently has clients in about twelve countries, with conditions ranging from near arctic in Finland, to the tropical jungles of Borneo, where we have built a championship course for the Sultan of Brunei. We have designed courses in equitorial, capitalistic, Singapore, and Soviet Estonia's capital of Tallinn; the sea-side resort of St. Tropez, to the north African deserts of Tunisia. Concurrently we must deal with salinity and waste water treatment stations in the desert, and typhoon rainfall that can put several feet of rain on a site overnight. Every site is different and must be treated as unique, even though the basics of the design process remain constant.

Each course must be designed to meet the objectives of the client, the conditions of the specific site, and to some budget level. Each should be designed to be individual, distinctive, creative, innovative, memorable, challenging, and relatively easy to maintain in the long term.

Construction can be a problem in locations where no one has even seen a golf course before. It is difficult to describe desired objectives to labor crews who are comprised of illiterate persons. Contractors unfamiliar with contouring and sculptured earthmoving constantly try to grade everything flat. Hand labor may be the only equipment. When there is equipment, it is not always new or operating properly. Spare parts may be only nonexistent, or only slowly attainable. Materials may not be available or not in the form or condition suitable for use. P.V.C. pipe may only come from the factory when the factory feels like making the pipe. Importation can become a bureaucratic nightmare. Working with educated or intelligent personnel is not always a certainty. Some project sites overwhelm with dozens of bulldozers, while others cannot keep two bulldozers moving correctly.

Construction working drawings must be comprehensive, detailed and thorough. Frequently, the drawings must be prepared in the local language. Irrigation engineering must be comprehensive, though not always computer controlled. Agronomic objectives of correct seedbed, preplant fertilizers, and selected mixtures of turfgrass varieties, must be carefully done.

Adapting to the individual site can present interesting challenges, especially when the site may be a mass of boulders left from a long receded glacier, or alkaline sands, or a tropical swamp presently home to various snakes and numerous mosquitoes. In certain instances the site presents challenges such as frequent heavy rain, 400 or 500 feet of sidehill vertical terrain changes, and five million or six million cubic yards of earthmoving - all on the same site!

Design and construction must give careful consideration to long term turfgrass maintenance. This is particularly crucial in light of the fact that in many countries there are only grass cutters, no professional golf course superintendents, and perhaps not even an in-country representative of the irrigation equipment or turfgrass maintenance equipment manufacturer.

It is frustrating to have a dramatic site, perhaps a one-of-a-kind site, and know that what will be, will be only part of what could have been - if only given what we usually take for granted when designing and building a golf course in the United States. Accomplishing seventy or eighty percent under such conditions is not all bad. The satisfaction of even achieving seventy or eighty percent in a location where others said it could not be done, or said it shouldn't be done, is a form of reward not attainable on a nice, simple, site in Washington or California.

International golf has been the majority of our business for over seventeen years now. There are times when the simple and easy local job looks very tempting. Then, from the fax or telex pops a request to come to some presently obscure location to assist in pulling a championship golf course from an inhospitable site. Out comes the passport, and off we go. The challenge remains the main attraction.

MODE OF ACTION OF TRICLOPYR HERBICIDE FOR TURF [1]

Stott W. Howard [2]

[1] Presented at the 43rd Northwest Turfgrass Conference, Sheraton-Tacoma Hotel, Tacoma, Washington, September 18-21, 1989.
[2] Extension Specialist, Washington State University, Cooperative Extension Experimental Station, Mount Vernon, Washington.

Turf has many hard-to-control weed pests that cause the meticulous turf care specialists much grief. Herbicides that will help provide relief from these most odious and noisome life-forms are beheld with delight by users. A relative newcomer to the turf herbicide arsenal is triclopyr, a product manufactured by Dow Chemical. Triclopyr turf products are sold under the trade names of TURFLON Amine, TURFLON Ester, TURFLON II Amine, and TURFLON D. The latter two, TURFLON II Amine and TURFLON D, are prepackaged mixtures of triclopyr plus 2,4-D intended to broaden the spectrum of weed control. These products have become welcome additions to turf care specialists as they have made possible the control of some of the more difficult to control turf weeds.

One of the most important aspects of using triclopyr, or any herbicide, is understanding its mode of action. This will enable users to maximize efficacy, while reducing or eliminating potential problems of phytotoxicity. A herbicide's 'mode of action' is a series of events that occur from the time the herbicide is sprayed out of the nozzle until it exacts a phytotoxic toll upon the target plant. This is inclusive, therefore, of absorption by the plant, translocation of the herbicide to the site of activity, the resultant phytotoxic affects, and any herbicide metabolism that may occur during the process.

The spray volume for triclopyr is quite important for triclopyr efficacy. Research has demonstrated that spray volume does not affect triclopyr absorption, but it is necessary to use higher spray volumes to achieve adequate coverage and penetration of the target plant canopy. Different formulations can influence triclopyr absorption rate, at least initially. Certain plants will absorb the ester formulation faster than the amine, however, there is no detectable difference in subsequent total absorption.

Once triclopyr is absorbed, it is translocated in the phloem to the carbohydrate 'sinks' (meristematic tissue, storage organs, etc.) in the plant. Then triclopyr influences activities normally governed by the natural plant hormone auxin. Processes such as regulation of cell wall softening and protein synthesis are affected resulting in gross anatomical aberrations such as epinasty, stem thickening, chlorosis and necrosis. Triclopyr's mode of action is susceptible to interruption and delay from fluctuating environmental conditions. The efficacy of triclopyr is maximized by conditions that favor normal growth and development. Conversely environmental conditions that stress plant growth (drought, temperature extremes, excessive moisture, etc.) will reduce triclopyr efficacy.

Triclopyr will control many tough perennials that infest turf. It appears as though the prepackaged combinations of triclopyr plus 2,4-D are preferred in many situations because of the broadened spectrum of weed control. While there are reports of variable success in control of some of the weeds on the herbicide's label, more often than not triclopyr is an efficacious herbicide for use in turf. Care should be taken to carefully follow all label directions in order to most benefit from its use.

LIVING MULCHES [1]

Stott W. Howard and Craig B. McConnell [2]

[1] Presented at the 43rd Northwest Turfgrass Conference, Sheraton-Tacoma Hotel, Tacoma, Washington, September 18-21, 1989.
[2] Extension Specialists, Washington State University, Cooperative Extension, Experimental Station, Mount Vernon, Washington.

In Whatcom County, public concern regarding the use of roadside vegetation management strategies that rely predominantly upon the use of herbicides, has necessitated the evaluation of alternative management strategies. The use of 'living mulches' that suppress the growth of tall-growing undesirable vegetation is one of the alternatives being investigated. In 1985 and 1986, four locations were selected that varied in ballast composition, topographical features, local pesticide political concerns, and predominant climatological conditions. At each location the site preparation included an application of glyphosate to suppress emerged perennial weeds (one location, the Nulle Road, was not sprayed because it was within a sensitive watershed area) and soil scarification to prepare a fine seedbed. Treatments were broadcast and hydroseed plantings of Companion grass, Manhattan perennial ryegrass, Penngift crownvetch, and Polo playground mix. Also included at each location was the standard management practice for the area (spraying or frequent mowing) and an untreated check. The ability of the living mulches to suppress the growth of undesirable weeds was evaluated by determining the type and number of weeds present within the plots. The data presented in the tables are from evaluations taken in the fall of 1988.

Each location varied in weed pressure (Fig. 1). Nulle Road had a significantly greater number of weeds than the other three locations. This was due to the lack of a site preparation herbicide spray. Perennial weeds that were present prior to plot initiation quickly regrew and reduced the ability of the mulches to become established.

Method of planting had an affect on weed populations (Fig. 2). When all four locations are summarized, broadcast plantings of the mulches were more effective than hydroseeding in decreasing the occurrence of undesirable vegetation.

The ability of the different Plant materials to suppress the growth of undesirable vegetation is depicted in Fig. 3. Manhattan perennial ryegrass was the most effective and Penngift crownvetch was least effective.

Overall, Manhattan perennial ryegrass, whether broadcast planted or hydro-seeded, was most effective in suppressing the regrowth of undesirable vegetation at all locations (Fig. 4). Companion grass mix ranked second in suppression capability.

While some of these plant materials demonstrated the capability to suppress undesirable roadside vegetation, the ultimate determining factor is economics. Establishment of vegetation along the roadside is expensive and this may be prohibitive on a grand scale.

FIG. 1. NUMBER OF WEEDS/LOCATION

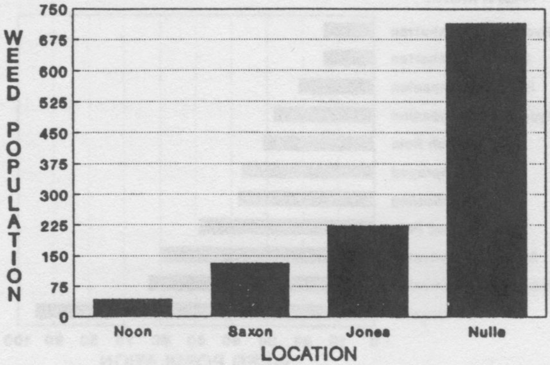


FIG. 2. TREATMENT METHOD

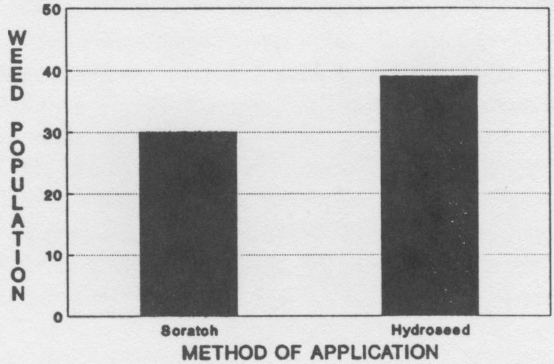


FIG. 3. PLANT MATERIAL

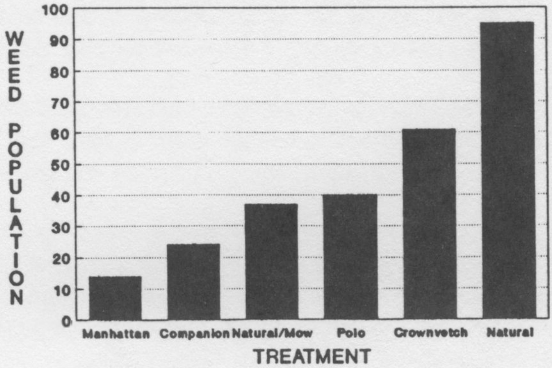
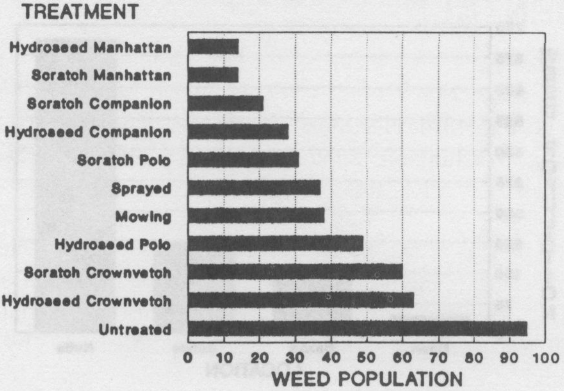


FIG. 4. OVERALL TREATMENT RANKING



SLOW RELEASE FERTILIZATION OF ORNAMENTALS [1]

Gary W. Furze [2]

[1] Presented at the 43rd Northwest Turfgrass Conference, Sheraton-Tacoma Hotel, Tacoma, Washington, September 18-21, 1989.
[2] Territory Manager, VIGORO Industries, Eugene, Oregon.

This slide talk will focus on the use of Woodace Slow-Release Fertilizers in ornamental plantings. The nitrogen source in all the formulations discussed here today is IBDU. IBDU is the registered trade mark for isobutylidene diurea, a controlled-release nitrogen source. It is manufactured by combining isobutylidene and urea to yield the most effective source of water-insoluble nitrogen. IBDU is formulated into these Woodace Nursery Fertilizer Granules, which come in 50 lb plastic bags, and 7- and 17-gram briquettes, which are sold in 33 lb boxes.

There are two different briquette analyses—the 14-3-3 with micronutrients, and the new 9-9-4 with micronutrients. The 17- gram 14-3-3 briquettes used at planting time in landscape situations provide uniform, safe, long-lasting (in this area two years or more) fertilization. On the right is a briquette which has been in the soil for more than one year. You can see how it is dissolving from the surface and will at the end of the second year be completely dissolved and utilized. The 14-3-3 briquette with the higher nitrogen content is recommended for use on trees and shrubs where high quality vegetative growth is desired. I'm using these burford hollies to illustrate the quality of vegetative growth that was obtained from using two briquettes in these one gallon nursery containers.

These Mugo pines received one 14-3-3 Woodace briquettes on the left and two on the right. Fred Zeitoun of Agricare, a nursery consultant, is inspecting the early root system developing beneath the 14-3-3 briquette placed in the pot about 3 months earlier. In this case, for a slower-growing conifer, one 17-gram briquette is adequate. When planting container nursery stock into the landscape we recommend one or two briquettes per gallon size of the nursery container, using the higher rate for the more vigorous growers.

When using briquettes on newly-planted shade trees use two or three per foot of height. These trees recently planted at Riverside Golf Clubs in Portland were all planted using the 14-3-3 17-gram briquettes.

In eastern washington and northern Idaho, Bob Lee, our distributor representative in that area, has worked with Christmas tree growers and Don White, extension specialist for northern Idaho, to develop a technique for planting new seedling Christmas trees using Woodace briquettes. A 16-inch hole is dug, one briquette dropped in the bottom and the seedling planted. The deep placement of a 2-year-long slow-release fertilizer source aids in early deep strong root development. This is critical for these young seedlings to survive the first hot dry summer when no supplemental watering is done.

These young true fir Christmas trees show a comparison of the early root development that has been achieved using the Woodace briquettes. When planting nursery stock that is either bareroot or balled and burlapped, a large percentage of the root system is often removed when they are dug. Placing the briquettes around the base of the ball or in the root zone of the tree as it is planted provides an immediate, very safe, continuous supply of fertilizer to quickly establish it in its new setting. This cedar was planted without briquettes and this one was planted with them.

Well, what makes these Woodace briquettes so different from other slow-release nitrogen sources? The IBDU in the briquettes is slowly and evenly hydrolyzed (dissolved) to a soluble nitrogen that is continuously utilized by the plant. No other slow-release fertilizer available today will release simply by hydrolysis. Others depend on adequate temperature and bacterial activity, adequate coating thickness, application technique, and/or diffusion of soluble nitrogen through a porous membrane.

The newest Woodace briquette (9-9-4) was introduced two years ago in Hawaii for use on lei orchids. These plants are grown for their flowers, so the orchid grower doesn't want excessive vegetative growth. It also rains heavily in Hawaii and orchids are grown in volcanic cinders or crushed blue rock—these 9-9-4 briquettes placed on the surface of these rocks dissolve slowly, and uniformly provide the nutrition needed to grow orchids in Hawaii.

Here in the Pacific Northwest we have been working with briquettes on several varieties of flowering ornamentals. Dr. Zeitoun is looking at azalea liners which received one 7-gram 9-9-4 briquette several months earlier. This acid-tolerant plant's only fertilizer source was the briquette. Azaleas and rhododendrons are very sensitive to fertilizer salt burn and because they are sold in bloom, the grower wants a fertilizer that doesn't push excessive vegetative growth at the expense of flowering.

This group of rhododendron liners received a 17-gram 9-9-4 briquette when planted into peat moss. You can see the difference in root development and vegetative top growth where the briquette was used.

These 9-9-4 briquettes in both 7- and 17-grams sizes are ideal for use when planting new landscaping projects. This is especially true of annuals for color. One or two 7-gram briquettes at planting time will provide N, P, K, and micronutrients uniformly to each plant for 7-9 months. Each plant gets the same amount of fertilizer, resulting in uniform growth and bloom for all plants.

Planters and beds like these are difficult to fertilize or to remember to fertilizer once they are planted. A briquette or two at planting time is enough fertilizer for the entire growing and blooming season.

Enough about the briquettes. Once the ornamentals are planted and established the granular topdress type fertilizers are more convenient to use. Woodace 18-5-10 Top Dress Special is a unique slow-release fertilizer for ornamentals. Woodace 18-5-10 has most of its nitrogen in the form of granular IBDU, and also has micronutrients.

Once a crop of seedling maples is planted on beds like this one, rainfall through the winter and spring is the only source of moisture. Much of the time the fields are too wet for heavy equipment. 18-5-10 with IBDU can be very safely top dressed at rates of nitrogen of up to 2 lb/1000 sq ft and feed these young seedlings through the wet germination period, getting them off to a strong start.

This granular product will release nitrogen from IBDU for 3-4 months. Even when spilled at very high rates the seedlings emerge through the IBDU without injury and growth is extremely uniform and vigorous. These seedlings must achieve a certain size in the first growing season to be saleable. Woodace 18-5-10 helped get them off to a very strong start, safely!

Here's a chart showing the salt indexes of several commonly-used fertilizers. The nitrogen sources with a high salt index show a correspondingly high rate of plant injury. Note that IBDU surpasses all other nitrogen sources in safety due to its low salt index.

On conifers and other evergreens we are achieving excellent growth and color responses in the spring from fall and early winter applications of 18-5-10. The IBDU nitrogen applied at this time of year is slowly taken up by the plant's roots and stored as carbohydrate for the following spring growth flush. This is much like the late fall/early winter fertilizations we make with IBDU on turf.

This field of seedling Colorado Blue Spruce had been receiving repeated applications of ammonium sulfate until the pH had gotten so low as to cause growth to all but stop. An application of lime to the entire field and 18-5-10 topdressed at 2 lb nitrogen per 1000 sq ft resulted in this growth difference and this color difference in the early spring. The basic difference is the use of a slow-release nitrogen in the fall. IBDU feeds longer because it is 90% slow-release water-insoluble nitrogen, which is 1000 times less soluble than urea. There is minimal loss by leaching or volatilizing from IBDU.

These two charts show the comparative differences in leaching and volatility of urea vs. IBDU. To further expand on the use of Slow-Release Woodace 18-5-10 as a fall application, several nursery growers of in-ground/field-grown stock have been using it and achieving the same results, plus you can see here the intense blue color of these Colorado Spruce continuously supplied with a adequate level of nitrogen around the drip line of the tree. The rates are 1-2 oz of product per year of growth. We have experience of up to three years of repeated fall applications on the same trees as viewed here at Woodburn Ornamentals in Oregon.

A first-year growth response is seen here, and these side shoots and leaders show the result of the overwinter storage of carbohydrate and very strong spring growth. Note the excellent heavy bud set for the next spring season growth cycle.

Bristlecone Pines are very slow-growing and one of the oldest living trees. One application of 18-5-10 in the previous fall resulted in this kind of growth flush the following spring.

IBDU is not dependent on soil temperature and microbial activity, therefore it will feed your landscape species with a more predictable release, especially in the cool late fall and early winter, than any other fertilizer product. It also won't leach away with the first few heavy rains.

These charts show the nitrogen release of IBDU based on particle size, from 0.3 mm to 4.0 mm. The 3.0-4.0 mm size releases only 25% of the nitrogen in 8 weeks while the 0.1-0.3 mm size releases 100% during that same period. We will be using a larger IBDU granule size in our 18-5-10 than you are familiar with in our parex turf grades.

Please note the difference various moisture levels have on the release of IBDU. The higher the moisture levels, the faster the release, based on a 0.7-2.0 mm particle size.

This gives you a better picture of the influence of several factors including moisture and temperature.

And now some shots of where Woodace 18-5-10 can be used as a top dress on colorful annuals, especially if you forget to put the 9-9-4 briquettes with them as they are planted. Here is the Riverside Golf and Country Club in Portland where Woodace Slow-Release Fertilizers were used on their annuals and shrubs. Remember 18-5-10 with IBDU can be broadcast without fear of foliar burn due to its slow release and low salt index features.

IBDU, 31% nitrogen, is 100% available to your plants. This, plus the very high nitrogen use efficiency, makes it the most economical fertilizer available.

Remember, Woodace with Slow-Release IBDU makes the growing of ornamentals greener and more colorful! Thank You!

GOLF COURSE REGULATORY COMPLIANCE — AUDITING YOUR SITUATION [1]

Steven R. Wharton and Patrick Jones [2]

[1] Presented at the 43rd Northwest Turfgrass Conference, Sheraton-Tacoma Hotel, Tacoma, Washington, September 18-21, 1989.

[2] Author and Presenter, respectively, Director of Communications, Golf Course Superintendents Association of America, Lawrence, Kansas

Key Points

There are several key points that I would like to cover in this presentation. First, I would like to provide an overview of just what is an environmental audit. Second, I will offer some comments on why you, as golf course superintendents, have a vested interest in environmental auditing. Third, I will explain how the Hall-Kimbrell/GCSAA Compliance Assistance Program was developed specifically for the golf course industry. Fourth, I will explain how the program works. And finally, I will review the benefits that you can expect to receive from going through the self-audit process.

Environmental Audits

Environmental auditing is a systematic, documented, periodic and objective review by regulated entities (golf courses) of facility operations and practices related to meeting environmental requirements.

This description (taken from the 1986 EPA policy statement on environmental auditing) describes an operational audit. There is another type of environmental audit, the property transfer audit, that is designed to assess the impact and risk of current and historical activities on future uses of the property in question. This type of audit is vitally important when considering the transfer or development of real property.

Audits can be designed to accomplish any or all of the following 1) verify compliance with environmental requirements, 2) evaluate the effectiveness of environmental management systems already in place, 3) assess risks from regulated and unregulated materials and practices in the workplace.

The Compliance Assistance Program is designed to address each of the considerations listed above.

The Role of the Superintendent

In the operation of today's golf courses, the superintendent plays a more significant role than any other member of the golfing community in helping to safeguard the quality of our environment and assuring safe and healthful surroundings for players and workers alike.

Superintendents, as stewards of their course grounds, have been fulfilling the roles of environmental managers for many years. In recent years, interested citizens have expressed their concerns about chemical usage and other activities that are commnonplace in today's golf course operations. These concerns have been translated through legislative bodies at all levels of government into an ever growing maze of laws and regulations. Striking a compromise with concerned groups is not always an easy task, but showing involvement in a comprehensive environmental, health and saftey program can definitely lessen the adversarial nature of these interactions.

It is important to note that while conmpletion of an environmental and health and saftey audit is not mandated by existing regulations, performance of such an audit represents a pro-active approach on the part of the superintendent in dealing with regulatory concerns. Regulatory agencies not only recommend performing self audits as an aid to ensuring compliance, but take into consideration participation in such programs when scheduling their inspections. Comprehensive liability insurance costs may also be reduced through implementation of this type of program.

The superintendent, like any business professional, needs help in dealing with a situation of this comlplexity. Completion of a self-audit and implementation of a comprehensive environmental management plan can help to bring about a desirable outcome to interactions with each of these organizations or agencies.

Development of the Compliance Assistance Program

During 1988 the GCSAA's Board of Directors and Government Relations Commnittee worked in conjunction with Hall-Kimbrell Environmental Services to define a program that would benefit superintendents in meeting their environmental responsibilities. The program was developed not only to help the superintendents improve compliance at their facilities, but also to help them become better environmental managers in the process. This underlying educational theme is an integral part of all GCSAA programs.

A series of 22 site visits was arranged across the country so that the best possible assessment of compliance responsibilities at all types of golf facilities could be made. This included visits to facilities in each of the nine maintenance regions identified in the 1987 Biennial Maintenance Report, all of the major turfgrass adaptation zones and included courses of all sizes and types of ownership and operation. This was the first coordinated and comprehensive environmental risk assessment of the industry in the United States.

The superintendents at each of these facilities offered suggestions and guidance as to their regulatory compliance needs and responsibilities. The self-audit materials were developed from this information and an in-depth analysis of the applicable regulations.

How The Program Works

The Compliance Assistance Program begins with the completion of the self-audit for superintendents. The audit package contains an informational videotape that should be viewed prior to completing the audit questionnaires. It describes each of the areas of regulatory concern covered by the program. The video may also be used to provide the superintendent with a managment tool for use in communicating to upper management the importance of regulatory compliance and risk minimization. It is important to keep in mind that the quality of the resulting management report will be influenced by the accuracy and honesty with which the questions are answered. The audit is not a test that can be passed or failed so tendencies to answer questions in a manner that seems desirable must be avoided. The purpose of the audit is to determine facts not find fault.

Once the audit questionnaires have been completed and submitted to our staff at Hall-Kimbrell, a detailed environmental management report is produced and sent to the superintendent. The report will help identify which areas of the operation need revision and what management practices should be instituted to ensure compliance. The advisories will also point out the management practices that could be applied to go beyond current regulatory requirements and ensure a pro-active and environmentally responsible approach to course management.

Benefits of the Program

The cost of the program becomes insignificant when one compares that cost to the benefits that are derived from participation in the program. Improving the compliance status of the course lessens the possibility of fines or penalties being levied against the course owners or the superintendent. Since most environmental statutes contain provisions for both criminal as well as civil penalties, this can be an important matter to all individuals who may be held personally liable for violations. The participatory nature of the program yields several benefits. The increased knowledge gained by working through the audit places the superintendent in a better position relative to maintaining ongoing or future compliance responsibilities. This aspect of professional development also enhances the individual's value as a knowledgeable and environentally responsible manager.

Improved cost containment will result from the program; initially from the superintendent's participation in the audit process and secondarily from increased operational efficiencies. Improved worker protection and awareness will result in fewer accidents and less lost time. Having an organized and consolidated procedure for compliance activities and related documentation will innprove efficiency as well. Decreased overall risk will lead to improved insurance claims performance and reduced premium expense for the entire operation.

Demonstration of increased concern for environmental protection will improve relationships with potentially concerned organizations and individuals and lessen the likelihood of an adversarial interaction with these groups.

THOUGHTFUL TREE PLANTING[1]

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To the novice golfer, or average club official planting a tree on a golf course seems fairly straight forward. After all, it only takes a short trip to the nursery and ten minutes to dig a hole. Well not exactly, because an improperly placed tree of the wrong species can seriously interfere with the original intent of the course architect, or even worse completely destroy a putting green.

In the following pages I wish to present ten guidelines that one should ponder before attempting to plant a tree. Hopefully these guidelines will help insure that a new tree becomes an asset to the entire club, rather than a thorn in the Superintendent's side. Before reviewing these guidelines, please realize that each may not always apply strictly in all situations. For example, a large tree planted 25 yards away from a putting green on the south side will cause greater problems than a tree planted the same distance on the north side, due to heavy shading. Without further delay let us ponder.

Guideline Number 1. Make sure to select a planting location so that the mature canopy of the tree will not protrude on the line-of-flight between a tee and fairway. Trees with protruding limbs dramatically reduce the usable size of a tee. For example, a tree planted too close to the front right hand side of a tee will promote concentrated use on the left hand side of the tee. The result of such concentrated divoting on one side of the tee usually promotes discussion about the Superintendent's abilities. The solution to large overhanging limbs is usually sympathetic pruning that leaves the tree permanently disfigured. Actually complete removal of the tree could be the best solution.

Guideline Number 2. Resist the temptation to plant dense groves of trees around greens, tees and fairways that will block sunlight and vital air movement. Poor air circulation, especially in areas where greens are located, produces soaring temperatures and humidity during the summer that in turn promotes harmful disease development. Furthermore, poor air circulation and dense shade during the winter produces cooler soil temperatures that severely retards the growth rate, leaving greens helpless against foot traffic. In situations where poor air circulation and restricted sunlight penetration cause unacceptable turf loss, tree removal should be without question.

Guideline Number 3. Never try to completely fill in rough areas between adjacent fairways with trees for the sake of safety. No matter how many trees you plant to protect neighboring players, the odds are the first high handicapper will find a way through. Once they do, LOOK OUT! The player automatically feels qualified to join the PGA tour and aims directly into the oncoming players hoping to hit a high fade back over the trees. If your intent is to protect golfers in adjacent fairways, a more appropriate strategy of tree planting would be groups of trees strategically near the tee. This will prevent errant shots from even having a chance to stray. Then leave several openings between adjacent fairways near the landing area, so that if someone does stray they have the opportunity to return to their fairway uninhibited.

Guideline Number 4. Never plant large trees closer than 75 feet from a green, or tee because they will become serious competitors for available water and nutrients. Most individuals are under the mistaken impression that tree roots cannot extend outward from the trunk further than the drip line of the tree. In reality, tree roots can extend outward from the trunk approximately 1 to 1.5 times the total height of the tree. For example, if a tree is 100 feet tall its roots can extend as far as 100-150 feet. Once tree roots have invaded underneath a green or tee, they sap water and nutrients away due to their overwhelming size. In situations where tree roots are a problem, sever them with a trencher and install a permanent barrier.

Guideline Number 5. Without question flowering trees add unmistakable beauty to any course. However, due to their tender bark and dwarf stature they are extremely sensitive to mower damage. This extreme sensitivity makes most flowering trees a poor candidate for use on golf courses unless they can be Carefully protected. Augusta National is a good example. The beautiful flowering dogwoods and azaleas have been planted underneath large pine trees where there is never an occasion to operate heavy mowing equipment.

Guideline Number 6. Try to avoid screening out scenic vistas. Scenic vistas include the clubhouse, ocean or mountain views, lakes or other open areas of the course. Once a scenic vista has been lost it is usually forgotten, and consequently may be lost forever.

Guideline Number 7. It is often best to avoid using a standardized tree planting as yardage indicators. Problems arise in the future when one of the planting is lost or damaged. For example, if palm trees are used on each hole to indicate a distance of 150 yards, it will be impossible to replace a dying palm with one of matching size. In addition, a tree planted to the edge of the fairway can severely penalize a golfer. A better means of indicating yardage may be to mark large, landmark trees already present throughout the course with a small wooden or metal plaque. The advantages of marking landmark trees is that they blend in with the course surroundings, they are already present throughout the course, and because of their size they can be seen by golfers that stray into adjacent fairways.

Guideline Number 8. When selecting a tree, choose species that match the existing vegetation and have favorable characteristics. Cottonwoods and large fruit bearing trees are not good candidates for golf courses because they are either strong surface rooters, or require continuous maintenance. In addition, try to limit the number of different species as much as possible. A continuous vegetation scheme is often the trademark of many of America's highest ranked courses. For example, the site of this year's U.S. Open is Oak Hill Country Club in Rochester, New York. This particular course has a continuous theme of oak trees from the first tee through the eighteenth green. Courses that tend to plant a potpourri of tree species are usually unflatteringly referred to as tree zoos, or specimen parks.

Guideline Number 9. Try to naturalize the appearance of large tree plantings by randomizing the distance between each tree. A good way to develop a randomized tree planting would be to hit several dozen golfballs into a rough area from a distance of 200 yards. Then place a small flag where each ball has landed and selectively remove one flag at a time until there are an appropriate number left.

Guideline Number 10. To prevent unnecessary neglect of newly planted trees, never plant more than the maintenance staff can adequately maintain. During the first year of establishment, small trees require extra attention and frequent hand watering during the summer. If you must purchase trees in large numbers due to cost, it might be best to establish a tree nursery near the maintenance facility where they can be easily cared for. Then over the next several years slowly spread them over the course.

In summary, remember that a good tree planting program on any course starts with a long range plan. What makes a golf course different from a park, or your own front yard is the presence of sensitive putting greens and the integrity of the Game. The agronomic impact of misplaced trees is commonly seen in the form of shade, root competition, and poor air circulation. Thoughtful tree planting should not only improve the appearance and playability of your course, but more importantly remove the thorn from your Superintendent's side.

EDITOR'S NOTE:

The following Proceeding papers that were presented at the conference were not submitted for publication:

New Fine-Leaf Fescue Cultivars	Bill Meyer Turf-Seed, Inc.
Turfgrass Response to Wear and Traffic	Bill Meyer Wear and Traffic
Athletic Field Maintenance	John Monson Seattle Seahawks, Inc.
Microbiological Management of Turfgrass	Bruce Tainio Tainio Technical Techniques
Progress in Developing Improved Annual Bluegrass	Don White University of Minnesota
Athletic Field Construction With Sand	Don White University of Minnesota

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