James B. Beard

NORTHWEST TURFGRASS ASSOCIATION

Proceedings Of The 35th Northwest Turfgrass Conference

Sept. 22 - 24, 1981
Olympia, Washington

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PRESIDENT'S MESSAGE

DICK SCHMIDT

It has been a privilege to serve as President of the NTA and to work with the supporting officers and directors of the Turfgrass Association. A major accomplishment has been to urge and support WSU to increase our turfgrass research and extension programs. We are happy to announce that Dr. Stan Brauen will be conducting 80% turfgrass research and Dr. Roy Goss will be full time as Extension Turfgrass Specialist.

The program committee did a super job in 1981. The quality of the speakers was outstanding and of varied interest to all who were in attendance. This Proceedings is approximately 180 pages and there is a great deal of excellent reading material available for your study.

Association membership was static in 1981. I would urge all of you as NTA members to work diligently to increase the membership and take advantage of the professional association of this organization. The directors strive to produce interesting and educational conferences at a wide variety of places. For the future there is consideration being given to locations such as Whistler Village in BC and Sun Valley, ID. Please let your desires be known where the conferences should be held. In 1982 the conference will be at beautiful, sunny Yakima and I look forward to seeing all of you at this next outstanding educational event.

NORTHWEST TURF GRASS ASSOCIATION

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TABLE OF CONTENTS

APPROACHING YOUR FINANCE COMMITTEE[1]

William Campbell[2]

I. Records and Accounts

A. Operation (set up)

1. Daily
2. Monthly
3. Yearly

B. Preparation

1. Daily (employees)
2. Monthly (management)
3. Yearly (management)

C. Utilization

1. Daily
2. Weekly
3. Monthly
4. Yearly

D. Outside Data

1. National
2. Local Clubs
3. Assoc. Study

II. A. Preparation and Outline

1. Operation
2. Equipment
3. Special Projects

1/ Presented at the 35th Annual Northwest Turfgrass Conference, Olympia, WA, September 22-24, 1981.

2/ Superintendent, Sahalee Golf and Country Club, Redmond, WA.

B. Utilization of Records

1. Man Hours of Operation
2. Equipment Hours
3. Men and Equipment Hours of Projects
4. Fertilizer and Pesticide Usage
5. Aerifying and Sanding

C. Summarize

1. Facts
    a. Problems, etc.

III. Professional Staff

A. Manager and Professional

1. Utilize Finance Knowledge
2. Utilize Golf Knowledge
3. Utilize Membership Communication
    a. Objectives
    b. Goals
    c. Direction

IV. Committees

A. Greens

1. Education
2. Program
3. Facts of Needs

B. Finance

1. Program
2. Facts of Needs

C. Board of Trustees

1. Program
2. Facts of Needs
3. Membership Need

APPROACHING THE FINANCE COMMITTEE[1]

Richard A. Schwabauer[2]

The gathering of information and maintaining records are necessary before a well prepared budget can be presented to the finance committee.

The club's existing budget is an outline that can be used in preparing your budget. The line items in our budget are: Salaries; Payroll Taxes; Electricity; Course Supplies; Course Buildings; Mowers; Tractors and Trucks; Small Tools; Road, Fences, and Paths; Water and Drainage; Sand and Cinders; Travel and Dues; Seed and Shrubs; Insecticides; and Machine Rental.

The Other Course Supplies line item is divided: Hand Tools for Shop; Hand Tools for Course; Poles, Benches, and Ballwashers; Shop Supplies; Aerifying Tines, Blades, and Spray Nozzles; Bookkeeping Materials; Laundry; Club House; Pro Shop; Wetting Agent; Construction; Greenhouse; Safety Equipment; Toilets.

A ledger is used, and the information is distributed to various columns into which the line item has been divided; the date, from whom purchased, description of the item and the amount are recorded. Having this information available it is easy to go back and determine all the data concerning a particular repair or maintenance operation. The accountant at the club has the receipts. We use a triplicate purchase order form.

The Salaries budget line figure would include information gathered from work record sheets that are kept by each employee. The work record sheet has eleven main

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1/ Presented at the 35th Annual Northwest Turfgrass Conference, Olympia, Washington, September 22-24, 1981.

2/ Superintendent, Waverley Golf and Country Club, Portland, OR.

sections: Greens, Tees, Fairways, Traps, Rough, Repair, Odds and Ends, Tournaments, Clubhouse, Pro Shop, and Construction. It is important to gather additional information other than direct turf maintenance. Items as Tournaments; Clubhouse and Adjacent Areas; Pro Shop; Course Construction; Vacation and Holidays, and Sick Leave must be shown separate from direct turf maintenance.

Greens maintenance is divided: Mowing, Mowing Approaches, Mowing Aprons, Changing Cups, Aerifying and Topdressing, Fertilizing, Spraying, Irrigation, and Grooming. It is important the line item be divided to provide the particular information you need.

Salary and Wage line item information should include a list of the permanent crew, the years each has been employed, their main area or areas of responsibility and their hourly wage. This information is presented with the budget as additional information. The information from the employee work sheets can be given by the month and year to date.

Information pertaining to major equipment purchases should be supplied with the budget. A brief sentence or two giving reasons for purchase of equipment should accompany the request. We maintain a 3 x 5 card file in addition to the ledger entry on the equipment. Information on the card includes: identification number, when and where purchased, and the disposal method and date. Information for equipment repair and replacement can be compiled by the mechanic. A record of what was repaired and the time required for the repair will help replacement decisions. A list of major purchases and dates on which they were acquired is helpful. Listed on the same page should be information on the expected longevity of the equipment you use. The life expectancy information can be from your own experience, trade magazines, and the experience of fellow superintendents.

Records of fertilizer, fungicide, and herbicide application should be maintained. Information recorded would be the date, weather, temperature, chemical used, amount used, equipment and its calibration and the results.

The gathering of information from many sources is important before preparing and presenting a budget.

TOPDRESSING LARGE TURFGRASS AREAS[2]

Dennis Pagni[2]

Five years ago a question was asked of me, "Is it possible to play football on turfgrass and not in the mud?" With fields used a minimum of 24 games and an unknown number of practices, besides the constant marching of bands, I was afraid to answer that question. Today, however, athletes compete on those same fields with less than 10% mud by their final game.

The method used to successfully accomplish this is as follows:

1. To install field drainage.

2. To reconstruct the field not in clay but by adding an 8 inch layer of sand between the has marks and the full length of the field.

3. To establish an annual maintenance program of topdressing.

We are limited as to when we can begin any major maintenance on our athletic fields due to scheduled sport activities and weather conditions. The first step in our maintenance program is to thatch. If thatch is extremely heavy, repeat it in a crossing direction. Next is mandatory that the thatch substance be removed by sweeping the field. If a sweeper is not available, use a turf vacuum or a good raking will suffice. The third and most important step is to aerate. It is advisable to aerate more than once and in different directions. These three steps can usually be accomplished in one day if sufficient equipment and manpower are utilized.

1/ Presented at the 35th Annual Northwest Turfgrass Conference, Olympia, WA, September 22-24, 1981.

2/ Grounds Supervisor, North Clackamas School District #12, Milwaukie, OR.

On the following day the sand needs to be dumped upon the turfgrass area to a depth of approximately 1 to 1-1/2 inches. There are various methods of applying the sand. A lely spreader with the sand ring attachment will assure you of applying a uniform amount. Other methods that may be employed are raking with a three point landscape rake or pulling a wooden box-like drag over the field allowing the sand to drop into the low and uneven areas. A light application of water will allow the sand to wash into the turf.

The field is now ready to be seeded and fertilized. Perennial ryegrass has proven to withstand the abuse most athletic fields undergo. Seed may be applied with a broadcast spreader or even more desirable an overseeding machine which slices the area and drops seeds into the cuts. The fertilizer is then applied at the manufacturer's recommended rate. For best results, use a slow release fertilizer.

Within 6 to 8 weeks after germination the field will boast a thick and hardy turfgrass. With proper maintenance the field will now withstand the pounding of cleats, the marching of bands and our perennial rains.

DROUGHT RESISTANT TURFGRASS CULTIVARS[1]

V.G. Hickey and R.D. Ensign[2]

Water shortages have become major problems in many areas of the United States. If sufficient water quantities are available, energy costs are becoming prohibitive to utilize the resource. As cities and municipalities assign water priorities, the turfgrass industry is often considered as a low priority.

Several approaches to the water usage problem must be made. The first is to be involved in the interpretation of water priority plans. Secondly, we can select our turfgrass cultivars which are more drought resistant. Thirdly, we must utilize management practices which increase water efficiency.

Drought resistance is defined as the ability to maintain active growth or not going dormant. Drought tolerance is defined as the ability to recover from dormancy caused by moisture stress.

On many golf courses, the total area comprised of bentgrass is 2-3 acres total. In a severe water shortage, most superintendents would give priority to watering of their greens. The remainder of their golf course is comprised of Kentucky bluegrass, fine leaf fescue, perennial ryegrass, or a combination of all of these turf species. These turf species vary in the ability to withstand moisture stress (Fig. 1).

1/ Presented at the 35th Annual Northwest Turfgrass Conference, Olympia, WA, September 22-24, 1981.

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Figure 1. Drought tolerance of turfgrass species. (After Turgeon, 1980).

	high	fine leaf fescues
		Kentucky bluegrass
drought	↓	perennial ryegrass
tolerance		colonial bentgrass
	low	creeping bentgrass

Turfgrass species have different morphological characteristics which enable them to survive moisture stress. The fine leaf fescues have narrow leaves compared to other species. This presents a lower total leaf area exposed to desiccating conditions and reduces transpiration rates. Subsequently the demand is reduced for soil moisture, and the potential for drought survival is increased.

Turfgrass species vary in rooting depths. Hard fescue, one of the fine leaf fescues, is quite deeply rooted. Kentucky bluegrass is intermediate in rooting depth, and bentgrass, under intensive management has a shallow root system. Total root mass is not a good single criteria with which to compare drought resistance, as shown in Table 1.

Table 1. Drought tolerance and root mass of three Kentucky bluegrass cultivars from 1981 Parma, Idaho tests.

Cultivar	Drought resistance rating	g/l root mass
Baron	8.3	6.0
Glade	6.8	8.2
Merion	5.6	5.8

Baron Kentucky bluegrass had a higher drought resistance rating than Glade, but actually had a lower root mass. Drought resistant grasses frequently have a higher root to shoot ratio. Shoot density and drought resistance have an almost inverse relationship, as shown in Figure 2.

Figure 2. Shoot density of turfgrass species. (After Turgeon, 1980).

	high	creeping bentgrass
	↓	colonial bentgrass
shoot		fine leaf fescue
density		Kentucky bluegrass
	low	perennial ryegrass

Drought resistance varies within species as shown, and also within cultivars of one species. Seventy Kentucky bluegrass, 45 fine leaf fescue, and 45 perennial ryegrass cultivars were rated for drought resistance at Parma, Idaho in 1981.

Kentucky bluegrass cultivars which were superior in drought resistance to other Kentucky bluegrass cultivars were:

1528T	Helka
Baron	J225
Brunswick	Majestic
Cheri	Mystic
Dormie	Vanessa
Entopper	Victa
Enoble	

Fine leaf fescue cultivars which were superior in drought resistance to other fine leaf fescue cultivars were:

Dawson
Fortress
Jamestown

Perennial ryegrass cultivars which were superior in drought resistance to other perennial ryegrass cultivars were:

Citation
Pennant
Regal
Sportiva
Yorktown

The perennial ryegrasses, as a group, do not mow well because of tough vascular bundles within the leaf blade. When the mower blade tears the leaf blade, rather than cutting smoothly, drought susceptibility may be increased because of the tissue damage and potential for moisture loss.

Varieties of perennial ryegrass which mowed well with a reel mower were:

Citation
Loretta
Omega
Pennant
Regal
Yorktown

Note that several varieties which mowed well were also quite drought resistant at Parma, Idaho in 1981.

As a group, the fine leaf fescues were more drought resistant than the Kentucky bluegrasses, which as a group were more drought resistant than the perennial ryegrass.

Finally, management practices which will aid in keeping your turf drought resistant are:

1. Increase rooting depth by increasing mowing height, and periodic removal of thatch.

2. Reduce fertilizer applications. Application without adequate moisture can leave water soluble salts on leaf tissue, resulting in foliar burn, and moisture stress.

3. Irrigate thoroughly but less often. Turfgrasses which are irrigated frequently to a shallow depth will not be as drought hardy as turf which is irrigated thoroughly but less frequently. Deep irrigation results in deeper root systems, whereas frequent but light applications result in shallow root systems.

GROWING AND MAINTAINING TURF IN SHADE[1]

Jim R. Frelich[2]

Growing and maintaining turf in the shade is a problem faced by most turf managers. Because turf and trees are an aesthetically appealing combination, there are many places where turf is grown in shaded areas. It has been estimated that 20-25% of all turf grown in the United States is maintained in the shade. As most golf course superintendents have found, growing quality turf in shaded areas can be most difficult. It is important for the superintendent to be familiar with the many cultural and environmental factors which influence successful management of turf in the shade.

The Shaded Environment

Shade affects both the environment in which turf is grown as well as the turfgrass plant itself.

The most significant environmental effect is the reduction of light intensity. Heavy shade can actually screen out 98% of the light. Light quality is also changed because of the filtering effect of the leaves which reduces the photosynthetic capacity of the turf, especially beneath deciduous trees. In contrast, light quality beneath evergreens is minimally altered despite low light intensity. A moderation of diurnal and seasonal air and soil temperatures occurs along with restricted air movement. The frequency of dew is reduced in the shade, however, the duration is increased which favors disease. Tree roots also affect the environment. Shallow rooted trees such as Silver Maple and Norway Maple compete for available soil nutrients and moisture.

1/ Presented at the 35th Annual Northwest Turfgrass Conference, Olympia, WA, September 22-24, 1981.

2/ O. M. Scott and Sons, Gervais, OR.

Physiological and morphological changes occur in shaded turf. The most significant physiological changes include an increase in chlorophyll content and tissue moisture plus a reduction in respiration rate, carbohydrate level, and rate of transpiration. Morphological changes include a reduction in leaf width, stem diameter, tillering, and shoot density, as well as increase in leaf length, plant height, upright growth habit and elongation of internodes. The end result is poor quality turf with reduced tolerance to heat, cold, drought, wear and pests.

Disease incidence is a major concern due to higher relative humidity, poor air circulation and longer periods of dew that enhance fungal growth on weak, succulent turf plants which are more susceptible to infection. Powdery mildew and leafspot are the most important diseases encountered when managing turf in the shade. Powdery mildew is commonly associated with the loss of Kentucky bluegrass, as is leafspot with red fescue. Both diseases can infect either species. Use of turfgrasses tolerant to mildew and leafspot help.

Shade Management Practices

Turfgrasses vary in their ability to tolerate shaded environments. If possible, a turf manager should start with shade-tolerant species (and varieties) either by seeding or sodding. Selection of shade-tolerant varieties improves the odds of successfully growing and managing acceptable turf in shaded areas. If this is not possible, established turf in shaded areas can be improved by overseeding with improved shade-tolerant grass varieties into the existing turf.

In the northern half of the country, fine-leaved fescues have long been the preferred species for most well drained, shaded sites. It is the best adapted cool season grass in a dry shaded environment. However, long-term shade studies have shown that fine fescue varieties differ greatly in their tolerance to shade. Fine-leaved fescue varieties such as Banner, Biljart (C-26), Dawson, Fortress, Highlight, Jamestown, Koket, Pennlawn, Ruby and Scaldis perform well in the shade.

Differences in shade tolerance have also been documented with Kentucky bluegrass and perennial ryegrass varieties. Some of the shade-tolerant varieties of bluegrass have been shown to out-perform the less shade-tolerant fine fescue varieties. A few shade-tolerant Kentucky bluegrass varieties are Bristol, Nugget, A-34, Sydsport and Glade. Common types of bluegrass are susceptible to diseases and for this reason are not well suited for shade areas. Shade-tolerant fine fescue and Kentucky bluegrass varieties are frequently seeded in combination. By using a blend of both species, a better quality turf can be obtained along with increased disease resistance, broader adaptability to various environmental conditions and less contrast between turf growing in shade versus the sun. A 50% Kentucky bluegrass/50% fine fescue mixture by weight seeded at approximately 1-1/2 to 2-1/2 lb/M should be adequate under most situations. The percent fescue can be increased under dry, infertile conditions or decreased under moist fertile conditions. The best time to seed in the shade is late summer so the seeding can take full advantage of the sunlight during the fall, late winter and spring. Examples of some retail shade blends available in the Pacific Northwest are listed below:

12.6 Derby perennial ryegrass
34.4 Creeping red fescue
24.6 Chewings fescue
14.7 Kentucky bluegrass
11.9 Glade Kentucky bluegrass

34.5 Victa Kentucky bluegrass
19.7 Biljart hard fescue
19.7 Bristol Kentucky bluegrass
14.8 Banner chewings fescue
9.9 Jamestown fescue

39.7 Chewings fescue
39.5 Red fescue
9.9 Kentucky bluegrass
9.7 Highland bentgrass

29.1 Creeping red fescue
9.8 Parade Kentucky bluegrass
9.7 Rugby Kentucky bluegrass
9.7 Park Kentucky bluegrass
38.4 Pennfine perennial ryegrass

Poa trivialis (rough bluegrass) performs well where the soil remains moist most of the time. *Poa annua* is considered shade-tolerant and is able to survive and produce viable seed heads under moist, shaded conditions. K-31 tall fescue has performed well under shade conditions. A fungicide program is generally necessary if quality bentgrass turf is to be successfully maintained in shade.

Improved perennial ryegrass varieties do not perform well in shade. Since ryegrasses germinate quite rapidly there may be situations where ryegrasses can and should be used in a shade mix, such as on shady hillsides and steep banks. Perennial ryegrasses can also be treated as an annual and seeded into the shaded site each year. The more shade-tolerant ryegrasses are Derby, Loretta and Pennfine.

Turfgrasses grown in moderate to dense shade conditions are generally under more stress than turf grown in sunny areas. This means management practices are more critical in the shade. The turf manager should reduce or alleviate as many of the negative stresses as possible.

Modification of the environment can improve a shade area. Selective pruning of limbs and the crown of trees is a good idea. Turf grown under oaks and maples benefit from this practice. The lower branches of individual trees should be pruned to a height of 8-10 feet or more when possible. This allows more light to enter the shade area; especially during the morning and late afternoon when the sun is low in the sky. Removal of feeder and shallow roots is helpful.

Pruning of the underbrush and shrubs should be considered. Unnecessary trees should be removed. All of these practices improve air circulation which will help reduce humidity and therefore, lessen the incidence of diseases. New tree selections should be the deep rooted type such as oak, ash, and linden if quality turf is to be maintained beneath. Improved dwarf types of shrubs should be considered during replacements.

The mowing height of turf growing in the shade should be increased to compensate for the drop in photosynthetic rate. The cutting height of cool season grasses growing in the shade should be about 1/2 to 1 inch taller (2 to 2-1/2 inches) than turf grown in full sun. Removal of excessive clippings and leaves is important.

Tree canopies intercept and restrict the amount of precipitation which reaches the soil beneath the trees thereby resulting in frequent moisture stress. Tree roots also compete with turf for soil moisture. Deep, infrequent irrigations should be practiced during dry conditions. Light, frequent irrigations enhance shallow turf roots and encourage shallow tree feeder roots.

Water can be more important for grass grown under shade conditions than under full sun. During dry spells, turf grown in the sun will go into dormancy and later green up and recover once water is available. However, turf grown in shade may or may not go into dormancy during dry conditions, but may become elongated, weak and start to thin out and die. When moisture is supplied, the turf may not have enough stored carbohydrate reserves to fully recover.

In fall, winter and spring wet conditions commonly occur in the Northwest which may also stress turfgrasses especially fine fescue. Fine fescues cannot tolerate long periods of wet soils conditions. This makes good drainage and removal of excess water very important.

Fertilization of turf in shade should be practiced to improve color response, wear and build up food reserves. When fertilizing a shady area, a slow-release turf fertilizer should be applied. Fast release of nitrogen is not conducive to healthy turf in the shade.

Excessive and/or fast release of nitrogen should be avoided because of its potential harmful effects on turf such as (1) increased shoot over root growth, (2) reduction of carbohydrate reserves, (3) increased tissue succulence, (4) decreased wear tolerance, (5) increased disease susceptibility, and (6) loss of red fescue. In general, a complete fertilizer applied annually to provide 2-4 lb N/M should be adequate to provide the nutrient requirements of turf in shade areas.

Fertilizer applications should be applied when the most sunlight can reach the turf. This is normally when leaves are not on the trees. Spring and fall applications have been successful in maintaining turf in shade conditions. Minimal amounts of nitrogen fertilizers should be applied during the summer months. Trees and shrubs should not be surface fertilized, tree fertilizers should be placed at a depth of 12 or more inches.

If diseases become a problem, fungicides can be used to help maintain a healthy turf. However, pest control should be limited to high priority locations and used only when necessary. It is better and less expensive to use improved disease-resistant, shade-tolerant varieties.

The two most destructive diseases which attack Northwest turfgrasses in the shade include powdery mildew and leafspot.

Powdery mildew, characterized by a powdery white appearance, often occurs in the spring and fall months. Poor air circulation, overwatering, and excessive use of fertilizer will enhance the disease. Fungicides available for control of powdery mildew include benomyl, cycloheximide-thiram, and karathane.

Leafspot, favored by cool, moist weather, is most prevalent in late winter and spring months. Most common Kentucky bluegrasses and many red fescues are quite susceptible to leafspot. Some chemicals available for the control of leafspot include anilazine, chlorothalonil, iprodione, cycloheximide, PCNB and Maneb.

Remember, a minimum of 3-4 hours of sunlight are required to maintain acceptable turf quality. Any less light will require the use of shade-tolerant ground covers such as pachysandra, English ivy, myrtle, ajuga, or bark dust. This is especially effective in none-use areas. A list of a few shade-tolerant plants that will grow in shade in the Northwest are listed in Appendix Table 1. Annual reseeding with perennial ryegrass or red fescue may provide some cover for a while under dense shade.

Growing quality turf under a shaded environment is more demanding of the turf manager than growing quality turf in the full sun. Successful maintenance of quality turf in shade can be made possible by using new improved shade-tolerant varieties, slow release type fertilizers, new fungicides, and sound cultural practices.

Appendix Table 1. Shade-tolerant plants that will grow in shade in the Pacific Northwest.

Deciduous Shrubs

- Abelia grandiflora (Glossy Abelia)
- Berberis thunbergii (Barberry)
- Cercis canadensis (Redbud)
- Cornus (Dogwood)
- Hydrangea quercifolia (Oakleaf Hydrangea)

Evergreen shrubs

- Azalea
- Buxus (Boxwood)
- Camellia
- Fatsia japonica
- Ilex (Holly)
- Mahonia aquifolium (Holly Mahonia)
- Nandina domestica
- Pieris
- Rhododendron
- Skimmia

Flowering shrubs

- Begonia semperflorens (Wax Begonia)
- Coleus
- Fuchsia
- Impatiens holstii
- Lobelia ermus

TURFGRASS NUTRITION — FERTILIZER BASICS[1]

Robert C. Dixon[2]

Everyone wants a good lawn. Attractive shrubs, flowers, and ornamentals are also a source of pride and enjoyment. Good turfgrass and attractive grounds don't just happen. They are the product of knowledge, understanding and skillful management.

Ever since man began the cultivation of plants he has searched for better ways to fertilize them to increase their yields, longevity, or aesthetic beauty. This search has led down many complex and diverse pathways and there is no indication that it is to wane. The search to build the proverbial "better mousetrap" has ranged from the mechanical design and engineering of new or improved spreading equipment to the chemistry and agronomics of new products and improved use-technology. And yet, with all of our progress and accumulated experience we find that it is profitable to review those principles which are foundational to plant nutrition and fertilizer use. It is worthwhile to refresh our understanding of the mechanisms - physical, chemical, and biological - which are basic to optimum turfgrass fertility management.

SOIL - THE MOST INFLUENTIAL FACTOR

To the homemaker, soil is dirt to be vacuumed from the household carpets and washed out of the family laundry. To the builder, it is to be moved, leveled and compacted. To the farmer, it is the medium in which crops grow to feed and clothe the world. For the professional turfgrass manager, soil is probably the most influential factor in turf management. It is basic to his livelihood. Almost every facet of turfgrass

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1/ Presented at the 35th Annual Northwest Turfgrass Conference, Olympia, WA, September 22-24, 1981.

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care, from watering to aerifying to fertilizing, is influenced in some measure by the soil.

At its surface, soil is visible, easy to measure and study. However, it is in the hidden and mysterious environment below the soil's surface where significant numbers of complex and dynamic biochemical processes take place. How well a soil is able to perform its functions - support (when wet or dry), allow root development, drainage, moisture retention, aeration, nutrient retention and release - depends on its physical, chemical and biological characteristics.

Soils are of an infinite variety and pattern. Past experience is not always a reliable basis for predicting plant response, establishing management practices and, for that matter, making fertility decisions. The old adage "out of sight - out of mind" cannot be the motto for the turfgrass manager when it comes to understanding soil.

What is the best form of nitrogen to use? What happens to that nitrogen fertilizer when it disappears from the surface of the soil or turfgrass? Why do some nutrients move out of the root zone and others seem to hang on? The answers to these questions and many others can be found in an understanding of soil-plant-fertilizer relationships.

Time does not permit nor is the scope of this talk intended to deal with all of the concepts of soil fertility - soil structure, soil colloids and ions, anion retention, organic matter, soil depth, slope, microorganisms, etc. Nonetheless, let's begin with the basic components of soil and how a soil holds and releases nutrient elements.

BASIC COMPONENTS OF SOIL

Soils have four basic components: <u>minerals</u>, <u>organic material</u>, <u>air</u> and <u>water</u>. From these individual components and the close interaction of one with the other, the soil is able to perform a host of functions vital to plant growth. It is principally within the mineral and organic matter phases that some of the most important functions related to plant nutrition occur. Consideration of only these two components is in no way meant to minimize the importance of the water and air phases. However, to understand nutrient behavior in the soil and its relation to fertilizer management, we must understand the role of the clay and organic matter particles.

CLAY AND ORGANIC MATTER

Clay minerals and organic matter are broken down into extremely small particles by weathering and finally by chemical changes. The very smallest particles are called "colloids" and cannot be seen with the naked eye. These colloids are the negatively charged constituents of soils. This means that positively charged particles are attracted, held, and released by these clay and organic colloids.

Ammonium nitrogen (NH_4^+), potassium (K^+), calcium (Ca^{++}), magnesium (Mg^{++}), and hydrogen (H^+) have positive charges. These and other positively charged ions are called cations. The negatively charged colloids hold cations on their surface like a magnet holds metal filings.

CATION EXCHANGE

The process of exchanging nutrient elements between the soil's solid phase (clay and organic) and the liquid phase (soil water) is called cation exchange. Cations are also known to be exchanged in two other systems other than the solid-liquid phase. The first is directly between the soil colloids, and the second is between the surface of plant roots and the soil colloids. The capacity of a soil to hold and release nutrient elements from the surface of clay and organic matter particles is called the cation exchange capacity (CEC). The strength of a cation's positive charge varies, enabling one cation to replace another on a negatively charged soil colloid. Sand of itself has no exchange capacity -- it is inert. Therefore, modification of soils by adding a high percentage by volume of sand to a heavy soil to dilute the clay particles or the construction of the "sand green" can present special problems to the turfgrass manager. Most noted is that considerable management time must be spent supplying nutrients to the turf. The mechanism of cation exchange explains why nutrients like nitrate nitrogen (NO_3-) and sulfate sulfur (SO_4-) are free to be leached from the root zone, while the positively charged anions such as ammonium nitrogen (NH_4+) and potassium (K+) are held to resist leaching. The exchange capacity of the soil works in trading nutrient elements back and forth between clay, organic mater, and soil water to provide nutrients for growing turfgrass roots. Therefore, the mechanism of cation exchange is fundamental to the proper selection and use of fertilizers. I strongly feel that it is at the heart of fertilizer basics.

SOIL TEXTURE

Soil texture refers to the relative proportions of sand, silt and clay found in the soil. For example, a "sand" is any soil that contains 85% or more sand and not more than 10% clay. In mineral soils, the exchange capacity is related closely to the amount of clay in the soil.

CEC VALUE	Soil Textural Class
0-8	sand
8-12	loamy sand
12-20	sandy/silt loam
20-28	loam
28-40	clay loam
40+	clay and organic soil

Soil texture and its relationship to cation exchange is of practical importance to the turfgrass manager. A green built on a sandy soil obviously requires more fertilizer, as well as more water, than one built on a soil of higher clay content. The coarse textured sand simply cannot hold as much nutrients and water as a fine textured clay can.

Now if one focuses only on the CEC values, they might imply that the higher the value, that is the more clay and organic matter, the higher the nutrient holding capacity, and ultimately less fertilizer will be needed. However, as the clay content of a soil increases, there is a greater tendency for compaction. As a result, the turfgrass can suffer because the desirable soil structure is destroyed and water infiltration is reduced. Soils most appropriate for healthy root growth are those that contain a significant proportion of sand.

The following practical applications relate to soils within different CEC ranges.

A. Soils with CEC 1 - 10 Range

1. High sand content.
2. Nitrogen, potassium, and sulfur leaching more common.
3. Less lime required to correct acid pH.
4. Physical problems of a high sand soil.
5. Low water-holding capacity.

B. Soils with CEC 11 - 50 Range

1. High clay content.
2. Greater capacity to hold nutrients.
3. More lime required to correct pH.
4. Physical problems of a high clay soil.
5. High water-holding capacity.

The CEC of a specially constructed green may range from 3 to 15, depending on the amount and type of sand, soil, and organic material used. Naturally, turfgrass grown on these low CEC soils will require more frequent fertilizer applications, especially of nitrogen because of the increased leaching rate.

Thus far we have discussed the four basic components of soil and the importance of cation exchange. We have seen how the texture of a soil influences the capacity of a soil to hold nutrient elements. Next, let's consider the important characteristics of four major turfgrass nutrients - nitrogen, phosphorus, potassium and sulfur.

NITROGEN

What happens when nitrogen fertilizer is applied to turfgrass? First, the type or form of nitrogen is important. Is it ammonium (NH_4+), nitrate (NO_3-), or urea ($CO(NH_2)_2$), or a combination of these three forms.

Ammonium Form

This form carries a positive charge (cation) and is readily held by the soil colloids (clay and organic). Regardless of the source of the ammonium nitrogen it undergoes a bacterial conversion shortly after being placed into the soil or the thatch. The process of converting ammonium nitrogen to nitrate nitrogen is called nitrification and involves two distinct groups of microbacteria. The efficiency or rate of nitrification is affected by a number of soil factors. These are: (1) temperature, (2) moisture and aeration, (3) calcium level, (4) soil pH, (5) organic matter content. Although all of these factors must favorably work together for efficient nitrification, soil pH and temperature would seem to exert the more important influence. The optimum pH range is from 5.5 to 7.8 -- moderately acid to slightly alkaline. The most desirable temperature range is between 52° and 75°F.

At 75°F, nitrification may be completed in one to two weeks, at 52°F, 12 weeks or more may be required. Under optimum conditions for nitrification, as much as 95% of the applied ammonium nitrogen is converted to nitrate in 3 to 4 weeks.

Nitrate Form

By contrast, nitrogen in the nitrate form (NO_3-) carries a negative charge (anion). It is repelled from the exchange sites on the soil colloids and, as such, is a very mobile nutrient. It is free to be moved through the soil with water from either rainfall or irrigation. Although grass plants will take up ammonium nitrogen, particularly in the seedling stage of growth, the nitrate form is preferred.

Urea Nitrogen

The urea form of nitrogen is neutral and initially moves like nitrate until it is converted to the ammonium form. This conversion process is accomplished by a natural soil enzyme, called urease. Once the nitrogen is in the ammonium form, it will be adsorbed onto the soil colloids and await conversion by nitrification.

In recent years the development of "slow release" nitrogen fertilizers such as IBDU, urea formaldehyde, and methylene urea all use urea as the principal nitrogen source. The slow release characteristic is developed by complexing the urea with organic compounds which must undergo preliminary conversion steps. In the case of IBDU the key to a constant rate of nitrogen release is the chemical process of hydrolysis or decomposing with water. With urea formaldehyde the release of the urea is tied to microbial decomposition of the formaldehyde. In all these synthetic organic fertilizers, once the urea is released it will follow known and predictable conversion steps.

NITROGEN LOSS MECHANISMS

Unfortunately, not all of the nitrogen that becomes available to plants is used by them. Normal losses might be in the range of 15 to 30%. Under severe conditions losses of nitrogen may range up to 50% or more. There are three important loss mechanisms: (1) leaching, (2) denitrification, and (3) volatilization.

Leaching

Leaching is the movement of soluble nutrients through the soil by water. If leaching is severe as it can be on sandy, coarse textured soils, nutrients like nitrate N and sulfate sulfur can be moved beyond the reach of plant roots. Leaching occurs primarily with anions because they do not enter into the cation exchange process.

Denitrification

This mechanism is the reverse of nitrification. In waterlogged soils or in soils approaching the saturation point, microorganisms will take oxygen away from the nitrate ion (NO_3). This releases the nitrogen as nitrous oxide or nitrogen gas, both of which escape into the atmosphere. Factors which affect denitrification are: (1) soil pH, (2) soil temperature, (3) soil moisture supply, (4) soil oxygen supply, (5) readily oxidizable organic material in the soil.

Volatilization

In this mechanism nitrogen in the form of ammonia is lost to the atmosphere from surface or shallow placement of the fertilizer. Although some loss occurs with any ammonium source of nitrogen, the loss from urea can be most significant.

When urea or ureaform fertilizer is applied to the soil, it is rapidly converted into ammonium carbonate by the soil enzyme, urease.

This intermediate conversion product is very unstable and the nitrogen can be lost into the atmosphere. Losses of as little as 5 to 8% or as great as 50% have been recorded. However, while losses of nitrogen to volatilization are known, definitive measurements under open turfgrass conditions are very complex and difficult.

Three factors which affect volatilization losses are: (1) depth of placement, (2) soil pH, and (3) soil temperature. Here I have shown the loss curves at various depths of placement from surface down to 1-1/2 inches. Loss curves generated by soil temperature and pH are almost identical to placement losses (Figure 1).

SULFUR

There is a dependency between sulfur and nitrate reduction within the plant. Without adequate sulfur, a plant is not able to effectively convert absorbed nitrate nitrogen into protein nitrogen.

CHEMISTRY OF NITROGEN IN THE SOIL

AMMONIA OR AMMONIUM ADSORPTION

$$4\ NH_4^+ \quad \text{PLUS} \quad {}^{-}_{-}\boxed{\text{CLAY}}{}^{-}_{-} \longrightarrow {}^{NH_4}_{NH_4}\boxed{\text{CLAY}}{}^{NH_4}_{NH_4}$$

POSITIVELY CHARGED — NEGATIVELY CHARGED — NO CHARGE

HYDROLYSIS OF UREA

$$(NH_2)_2CO \quad + \quad 2\ H_2O \xrightarrow{\text{(UREASE)}} (NH_4)_2\ CO_3$$

UREA — WATER — AMMONIUM CARBONATE

NITRIFICATION (BACTERIAL)

$$NH_4^+ \xrightarrow{\text{Bacteria}} NO_2^- \xrightarrow{\text{Bacteria}} NO_3^-$$

AMMONIUM — NITRATE — NITRATE

DENITRIFICATION (BACTERIAL)

$$NO_3^- \longrightarrow NO_2^- \longrightarrow N_2O\uparrow \longrightarrow N_2\uparrow$$

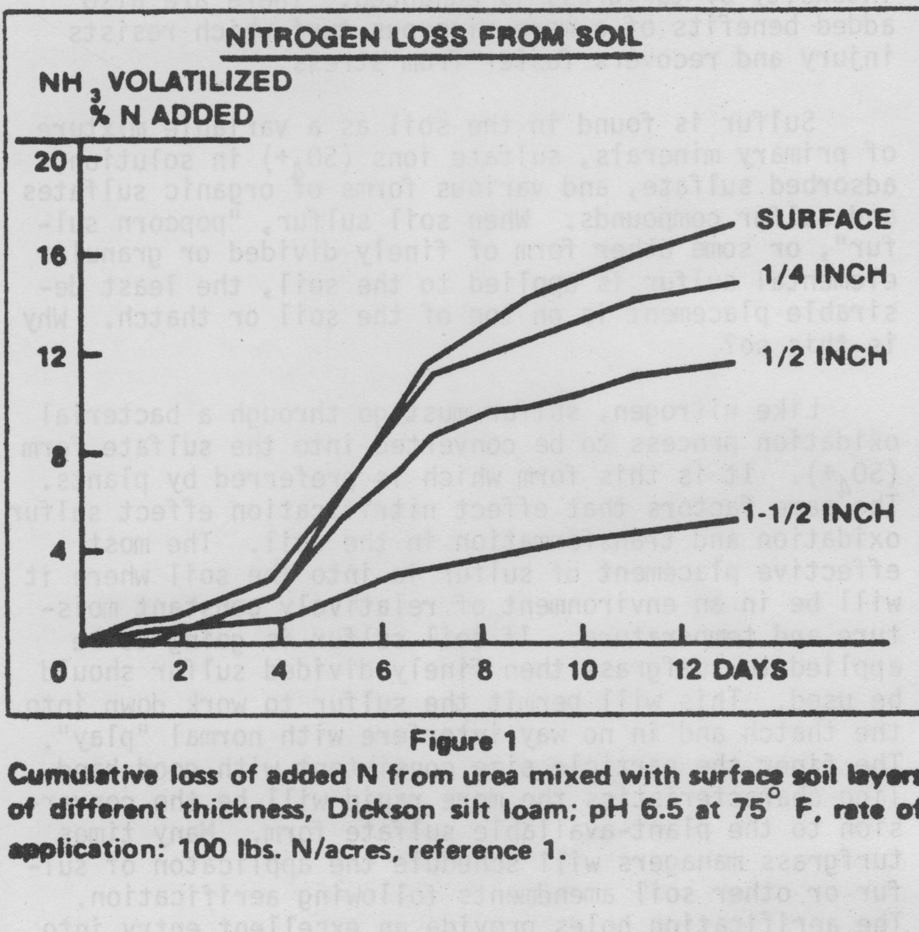

Figure 1

Cumulative loss of added N from urea mixed with surface soil layers of different thickness, Dickson silt loam; pH 6.5 at 75° F, rate of application: 100 lbs. N/acres, reference 1.

In the absence of sulfur, turfgrass exhibits a chlorosis or yellowing of the newly developed leaves. In a mild deficiency, it can be mistaken for nitrogen or even iron deficiency.

In the presence of adequate sulfur, the color and intensity of turfgrass is enhanced. There are also added benefits of a more vigorous turf which resists injury and recovers faster from stress.

Sulfur is found in the soil as a variable mixture of primary minerals, sulfate ions (SO_4+) in solution, adsorbed sulfate, and various forms of organic sulfates and sulfur compounds. When soil sulfur, "popcorn sulfur", or some other form of finely divided or granular elemental sulfur is applied to the soil, the least desirable placement is on top of the soil or thatch. Why is this so?

Like nitrogen, sulfur must go through a bacterial oxidation process to be converted into the sulfate form (SO_4+). It is this form which is preferred by plants. The same factors that effect nitrification effect sulfur oxidation and transformation in the soil. The most effective placement of sulfur is into the soil where it will be in an environment of relatively constant moisture and temperature. If soil sulfur is going to be applied to turfgrass then finely divided sulfur should be used. This will permit the sulfur to work down into the thatch and in no way interfere with normal "play". The finer the particle size consistent with good handling characteristics the more rapid will be the conversion to the plant-available sulfate form. Many times turfgrass managers will schedule the applicaton of sulfur or other soil amendments following aerification. The aerification holes provide an excellent entry into the thatch and the subsurface soil.

The sulfate level in the root zone is in constant flux. Like nitrate nitrogen, sulfate sulfur is an anion -- negatively charged ion -- and is not held by the soil colloids as part of the exchange complex. It is mobile to the extent that 80 to 90% of the sulfates may be leached from a permeable soil by 15 to 20 inches of rainfall.

To determine the optimum ratio of N:S applied in fertilizers, you must realize that the nitrate ion is absorbed by plants more readily and to a greater extent than is the sulfate ion. Therefore, while the N:S ratio in plant protein is about 15:1, the fertilizer must contain more sulfur than indicated by this ratio. Based on agronomic studies on nutrient uptake, it is estimated that a 5:1 N:S ratio in fertilizers will provide the plant with a balanced supply of these two vital nutrients.

PHOSPHORUS

Phosphorus is an anion. It is absorbed by plants as $H_2PO_4^-$, HPO_4^+, and PO_4^+, depending upon the soil pH. In light of what we already know about cation exchange, one might conclude that phosphorus, being a negatively charged ion, like nitrate and sulfate, would be quite mobile in the soil. The contrary is true. Phosphorus is tenaciously held or "fixed" by soils. Leaching water frequently contains less than 1 to 10 ppb (part per billion). Even from well fertilized irrigation cropland, the phosphorus losses by leaching are reported to be less than 1 lb per acre yearly.

Much of the soluble form added in fertilizers quickly reacts with iron, aluminum, clay, organic matter, and carbonates, and becomes unavailable to plants. For such reasons, plants seldom recover more than 15 to 25% of the applied fertilizer phosphorus. Although phosphorus readily fixes the soil, the fixation is not directly the result of the exchange capacity of the soil. The solubility of soil phosphorus is a highly complex mechanism which is influenced by numerous factors including soil pH, temperature, type of clay, and nutrient interaction. With respect to the latter factor, research has demonstrated an increased uptake of phosphorus by plants when ammonium nitrogen (NH_4^+) is added with the phosphate fertilizer. This synergistic effect does not appear to occur with the same intensity when nitrate nitrogen (NO_3^-) is used.

Phosphorus stimulates early growth and root formation. Therefore, phosphorus additions are required by most crops under these conditions: (1) growth in cold weather with soil temperatures generally below 65°F, (2) limited root growth, and (3) fast top growth.

Generally speaking, turfgrass requirements for phosphorus are only about 1/4 as much as for nitrogen. On the average, turfgrass contains about .35% phosphorus. Deficiency symptoms occur when the tissue content falls below 0.1%. Often the only symptom of a phosphorus storage is the reduction in growth. This is most noticeable with the roots. Since root growth is difficult to measure and often escapes the view of even the most experienced turfgrass manager, restricted plant growth from phosphorus deficiency need not occur if a properly balanced fertilizer is used.

POTASSIUM

Western soils may contain as much as 30 tons of potassium per acre in the form of primary minerals. However, only that small amount, 1 to 2%, which is contained in the soil solution and adsorbed on the surface of the soil colloids is readily available to plants. Potassium is taken up by plants in the form of potassium ion (K+). As a cation, it enters into the cation exchange complex of the soil. When present in the soil solution, potassium is mobile and subject to leaching. However, its concentrations in the soil solution at any one time are usually very low, thus leaching losses are slight except on sandy soils which inherently have a low exchange capacity.

Studies at major turfgrass centers have shown that well-balanced nutritional programs are of significant value in helping to suppress turfgrass diseases. Potassium increases plant resistance to disease. Troublesome turfgrass diseases such as Leaf Spot, Dollar Spot, Brown Patch, Red Thread, Fusarium, and Ophiobolus have been markedly suppressed when potassium was maintained at optimum levels on putting greens and fairways.

The potassium content of healthy bluegrass should range from 2 to 6%. Levels below 1% in the tissue will be deficient.

Drs. Goss and Gould, Western Washington Experiment Station, state that the value of the overall effects of balanced nutritional program cannot be denied. Their studies show that a balanced program made up of three parts nitrogen, 1 part phosphorus, and 2 parts potassium is giving the best results in turfgrass management programs.

CONCLUSIONS

To understand soil fertility is to understand a big key to professional turf management. The soil is a complex and dynamic physical and biochemical system. It is far from being an inactive mass providing nothing more than a home for soil-dwelling critters and an anchorage for plant roots. An ideal turfgrass soil would be one of medium texture and organic matter for optimum air and water movement; sufficient clay to provide an adequate nutrient reservoir; adequate in depth and free of subsoil restrictions to provide for maximum root extension and proper drainage. The selection and use of fertilizer is, therefore, strongly dependent upon the type of soil supporting the turf. In the words of John Madison, University of California Horticulturist, "Fertilizer is the number one management tool. It is worth all the attention you can give it."

EFFECTS OF INFLATION

(Voluntary and Involuntary)[1]

Robert L. Berger[2]

As a Landscape Architect, the comments that I make here this morning may very well depart from those that would be made by an Agronomist. I'll try to relate what WSDOT is doing as well as what we are not doing in an effort to be cost effective. I am sure that most comments that I make this morning will apply to you and your programs either directly or indirectly.

Has inflation hit turf management practices of WSDOT? My answer to this question is an emphatic yes. Our agency is currently reducing construction programs as well as our maintenance programs in an effort to survive this period of reduced income. Yet, the cost to mow an acre of turf, once, has gone from $15 per acre in 1971 to more than $28 per acre in 1981. In the early 1970's, roadside mowing involved an annual expenditure of nearly $300,000. Seventeen thousand plus employee hours were expended annually. The results of these expenditures, both dollars and employee hours, resulted in approximately 20,000 acre cuts per year. In comparing this to 1981's expenditures, we'll see that due to inflation the effort in roadside mowing has been considerably reduced. In 1981, the total expenditure for roadside mowing was about $50,000. Nearly 2,250 employee hours were expended. And the result was only 1,761 acre cuts. Inflation has hit WSDOT.

In the early 1970's when I transferred from the Design Group to the Maintenance Group, I noticed several things were happening along our highway's roadsides. The erosion control grass stands were deteriorating.

1/ Presented at the 35th Annual Northwest Turfgrass Conference, Olympia, WA, September 22-24, 1981.

2/ Landscape Architect, Washington State Department of Transportation, Olympia, WA.

The areas that were being mowed looked like bad haircuts. Fire starts were frequent adjacent to the road, and lots of time and money was being spent on mowing. My opinion at that time was that this would be a poor long-range program if perpetuated.

We began reducing mowing of the highway roadside. Our primary objective was not to save money, but rather to reestablish dense stands of grass which would resist the invasion by trees and brush and herbaceous weeds such as Tansy Ragwort. Our emphasis was primarily to establish stable roadside vegetation patterns. In the past, mowing had resulted in dramatic expansion of tree and brush stands, to the point that they had begun encroaching on the roadway itself.

Some other changes we made in the early 1970's were the disposal of reel mowers that had been used to mow the "better" turf areas. They were replaced with rotary mowers. The use of reel mowers along the roadsides was not compatible with the amount of debris that either falls from the loads of vehicles or from the vehicles themselves and subsequently ends up in the area to be mowed. With reel mowers, a single hit on one of these metal or wood objects would throw this fine piece of equipment out of adjustment; thereby necessitating a shutdown and a return to the shop for repairs. We often found that we had to cut long grasses much more frequently because the reel mowers could not handle overgrown turf areas. Also, our desirable mowing height of 2 to 4 inches could not be accomplished with most reel mowers. In a nutshell, reel mowers could not meet our objective in turf management and they incurred too high a maintenance cost to be practical.

Growth regulants were also tried in the early 1970's in an effort to control the growth of grass along Washington's highways. Products such as CF-125 plus MH30 were used. The results were marginal to poor. We found that several species in our mixed stand of roadside grasses were not controlled by these growth regulants. Other species were very susceptible to overlaps resulting from the application and severe damage or death of the grasses occurred in this overlap area. We also determined that any subsequent trimming of these grass stands treated with growth regulants resulted in a release of the grass to a normal growth pattern.

With the intended reduction in roadside mowing in the early 1970's came several problems; one of which we didn't expect. This problem involved the employee's reluctance to stop mowing. A job which many of them had performed for more than a decade. Some employees failed to respond to the verbal order to stop mowing, and we subsequently ended up taking the keys away from the operator. In one particular case, we found that the operator was hot-wiring around the ignition and still mowing. At that point, we had to physically remove the mower from access to this employee. While most of us would think that the way to address this problem would be to warn the employee and suspend them if they didn't respond to the verbal order. We found that this concerned employee was best treated by just eliminating the piece of equipment rather than involving a personnel action. The concern of the equipment operators was often mirrored by the local supervisors who are worried about the public complaints that would result from any reduced mowing operation. Fortunately, at this time two states in the midwest had completed studies which demonstrated that the public, in fact, did notice when rights of way were mowed. But they did not notice those rights of way which were not mowed. With this information, we felt confident that our intended reduction in mowing should proceed.

The last few years we have seen money and employee hours becoming less and less available to accomplish all the work required in maintaining a state highway system. And as it turns out, our earlier efforts at reducing mowing put us into a position of not having much work that we could cut out of today and tomorrow's budget. We had trimmed the "fat" out of the roadside mowing budget 10 years too early and now we were left with a "lean" program and administrators asking where cuts could be made. I believe that our past reductions in roadside mowing and our plans for continued reductions in this area into the future may provide you with some ideas in managing your own turf areas.

Basically, the highway right of way has three types of grass management programs. The first involves erosion control grasses that were planted on the general roadside at time of construction of the facility, or subsequent repair of the facility, which are not mowed except in areas where the grass would impair sight distances (such as forward side lines to regulatory or advisory signs or view lines at an intersection where traffic must cross or enter the highway facility). The second type of grass management program involves our lawns in landscaped areas, where we have severely reduced or totally deferred mowing. The last type of program that we have on Washington's highways is the one that we all enjoy participating in and that's management of good turf. Good turf now occurs only in areas which have very high priority such as rest areas and a few selected landscape areas; primarily those in which pedestrian traffic moves through or very near the irrigated turf.

Mowing of erosion control grass has been reduced. It is accomplished only where the safety requirements dictate that the sight lines be improved. During Fiscal Year 1981, ending June 30, 1981, we had accomplished only 15% of a "normal" mowing program. We had made 729 acre cuts. The cost per acre cut was $24.84. Of this, 56% was labor and 44% equipment cost. Generally, the erosion control grass that is mowed for safety sight improvement is cut the first time in late June at a height of about 4 to 6 inches and in some cases a second time 30 days later. Generally, the public has accepted this reduced mowing of the general highway right of way. As managers of this right of way, however, we've seen some problems result. The grass stands which had been weakened through many years of mowing has thinned to the point that many tree, brush and weed plants have become established between the clumps of grasses. As soon as the mowing was stopped, these plants initiated robust growth which soon overwhelmed the grass stand causing it to further decline due to poor light conditions. To respond to this new problem, we apply a selective grass tolerant herbicide program about once every 3 to 4 years at a cost of about $40 per acre for labor, equipment and materials. This program eliminated the invading tree, brush and weed species. To reestablish the integrity of the grass stand, we found it necessary in some cases to actually reseed the right of way, and in all cases we found it necessary to initiate a fertilizer program to reestablish the vigor of the grass stand. The fertilizing generally involves an expenditure of about $20 per acre for labor, equipment and materials and is done once annually for two years. We found it necessary to provide information to the public about this long-range goal of establishing a competitive grass stand that would be more or less self-maintaining for the years to come if it were vigorous enough to resist re-invasion by undesirable seedlings.

Lawn care in rest areas, the second and third types of grass care programs outlined above, are accomplished on a priority basis depending on the sensitivity of the area and the subsequent public demands for maintenance of these areas.

We find that in the highly sensitive areas, both in eastern Washington and western Washington, we must mow 24 to 30 times per year. Irrigation water must be provided as well as a fertilizer and weed control program. We did find that the edging of the lawn areas around beds and sidewalks could be deferred without citizen complaint. Some examples of this type of mowing program is 38th Street Interchange on I-5 in the Tacoma area and the lawn areas along Interstate 90 in Spokane.

Moderately sensitive areas, both east and west of the Cascades in Washington State, allow us to accomplish one or two mowings in the spring and subsequently make applications of growth regulants as well as a fertilizer, irrigation and weed control program. This provided a green lawn of a "controlled" appearance. It did not look like a fine, manicured turfgrass. Some examples of this type of program occur in the Kent Valley along Highway 167 and at Winchester Wasteway rest areas near Moses Lake.

The less significant lawn areas in western Washington are maintained with the use of growth regulants or by mowing a single swath where lawn areas abut planting beds. The reason for the single swath mowing is to prevent the lawn grasses from going to seed and dropping their seed into the planting area causing an infestation of weeds. It is recognized that the aesthetic appeal of these lawn areas is going to suffer drastically. If growth regulants are not used, then the lawn grasses will head out and subsequently brown out after the seed has set. Some examples of this type of turfgrass maintenance is the section of I-5 between 40th and Ravenna Street in the Seattle area north of the Ship Canal Bridge.

At this time I'd like to address some of the specifics on how to work these programs. During these inflationary periods. First of all it's imperative that we recognize that the quality of the end product, the turf, is going to suffer. However, our primary goal is to ensure that it survive. When funds are "tight", many of us decide on a Ford or a Chevy automobile instead of the Mercedes that we would like to purchase. Well, the financial situation within this agency and most state agencies and many private organizations is such that right now the programs that are premium are not programs that can be funded within the available resources.

The use of growth regulants has taken on a new perspective with the advent of several new products that are on the market as well as several that are currently in research and development and will likely be coming on the market within the next few years. We find that new products such as EMBARK-2S manufactured by Minnesota Mining and Manufacturing (3M) have given us good to excellent results wherever we have used the products. There is some species response variation and the apparent uniformity of the mixed grass stand can be improved by mowing at a high level approximately 3 to 5 days after application of the growth regulant. This enables us to trim off the growth of those species that were slow to respond to the growth regulant. The result is a reasonably uniform panel of grass. Current labels allow for multiple applications throughout the year enabling us to use the growth regulant for season long control. Currently we get between 8 and 12 weeks of controlled growth from each application of growth regulant. Because broadleafed control is an annual program in most turf areas, the herbicide can be combined with the growth regulant thereby saving at least one application cost in the season long maintenance program. Some limited experience by this agency shows that fall applications of growth regulant will effectively control the usual "spring flush" 3 or 4 months later. The low rates of today's new growth regulants have resulted in less problems associated with overlap. In the past, overlap of growth regulants generally had a very serious damaging or in some cases killing effect on the grasses. A 2X treatment with products such as EMBARK-2S does not give the same problem. The color of grasses treated with growth regulants sometimes diminishes soon after the treatment, but generally most species take on a deeper green color within a few weeks of application. All in all, growth regulants will become a more common tool in maintaining turfgrasses during these times of high inflation and decreased revenue.

Reduced mowing activities have had an impact on our equipment needs and equipment costs. First of all, we found that with the reduced mowing effort we did not need as much equipment as we had on hand. Therefore, surplus equipment was disposed of. In some cases, replacement equipment was acquired which would provide more flexible use of the single piece of equipment in several situations. An example of this is the use of rotary mowers in lieu of reel type mowers. With less equipment in our total fleet, we found that scheduling of the equipment had to be better than it had been in the past. Of course with more intensive use and tighter scheduling of this equipment we found that the preventative maintenance program for each piece of mowing equipment had to be followed on a timely schedule to insure proper working and good availability of that equipment to do the limited mowing.

Insect control is being accomplished differently now than it was 10 years ago. With the implementation of a remedial insect control program as opposed to a preventative program, we can find savings in our total turf management budget. Remedial spray programs will work only if insect populations are monitored in the field and when damage is likely to occur than a timely application of insecticide can be made. Preventative programs in the past have resulted in pesticide applications which impacted very small populations of insects which were in fact no threat to the turf.

Scheduling of work can often result in economies which will enable us to better perform our task within lower funding and smaller crew parameters. Within our agency, we develop an annual plan, a monthly work plan, and daily work schedules. In preparation of these management items, attention must be given to spreading out the work throughout the year to avoid peak season crew sizes. How's this accomplished? In many cases we find that a fewer number of applications of a slow or controlled release fertilizer will enable to crew to accomplish the work easier and more effectively. The use of growth regulants also will reduce the amount of mowing thereby freeing crew members for other essential tasks during the growth period. Herbicides used to control weeds within the grass areas can often be reevaluated and savings can be realized. The savings will be primarily in employee hours. In the past, 2,4-D was often used as an herbicide, and because of its lack of residual activity, it had to be applied several times during the growing season to catch the seedling weeds that germinated since the last 2,4-D application. By combining a product such as Dicamba with the 2,4-D, one or two treatments will control the weeds for the entire growing season. The Dicamba is a residual material which stays in the seed bed where the weed seed germinates and is subsequently controlled at time of germination by the residual Dicamba herbicide. On some turfgrasses, it's very possible to make applications of selective pre-emergence herbicides such as Dacthal or Ronstar G. These products are applied once and give season long control of germinating weed seeds. This work can often be accomplished in the "off season" in relation to peak season crew sizes.

Often our regular crews could be kept to a minimum the year around and contract services could be utilized during the peak season, thereby avoiding the training and hiring of seasonal crew members. Contract services can also provide specialized equipment which in the past was poorly utilized by an agency or an entity which only needed the equipment two or three times during the season. Training and licensing of employees to accomplish some specialized pesticide applications can often be avoided by utilizing the contract services people. The net effect of contract services is a reduction in the peak season crew size.

Purchase of materials used in turfgrass management often is an area where savings can be realized. Large quantity purchases that result from cooperative or group buying will bring down the net unit cost for many products. Early order discounts, for example on herbicides prior to the season of use, will often give an extra 3 to 5% price reduction. Guaranteed purchases often will result in a lower price than bids for open-end type contracts where the purchaser can buy none or up to 150% of the estimated quantities. Another area where savings are possible is in the area of purchasing by bulk containers rather than small individual packages or bags. Packaging costs today often lead to inflated unit prices of 20 to 30%. Bulk sales avoid these high packaging costs. The savings are then passed on to the customers.

In the past and in the future there are companies that are vending products which are "ready to use". These often are products that are available as concentrates but, in fact, have been diluted with water or other inert materials, thereby saving the field crew some mixing time. The mixing time experienced by the field crew would have to be extensive to offset the freight charges on a 55 gallon drum of herbicide which is 98% inert or water, shipped to western Washington from New Jersey. Purchase of concentrate materials and addition of our own water can often result in considerable savings to the buyer.

Material selection can also influence the total cost of accomplishing a specific task for the whole season. When buying materials the full season cost should be a part of the evaluation of the various products. Sometimes a single application of a very costly residual material or slow release material will result in considerable savings when compared to multiple applications of a cheaper material. The ease of application or cost of application should also be evaluated in the selection of materials to be used within a program. Some examples of this would be the use of homogenous granular fertilizer through a spinner type spreader which would cover a swath of about 30 feet on each pass, as opposed to the use of a less expensive blended fertilizer that is applied by a drop spreader covering only 8 feet or less on each pass.

Training of employees often gives a good return. The benefits of well-trained employees are many. First off, the job is done correctly the first time. We all know that it's cheaper to do something right once than to do it twice. Equipment downtime is often the case when poorly trained employees operate equipment. During this period of inflation and low budgets we find that equipment downtime is a serious problem that must be addressed through an adequate training program for the employees. Another benefit of well-trained employees is that the employee develops a sense of pride in his end product. Pride in workmanship is a element that is very difficult to measure; but at the end of a season the total cost of the well done product is noticeably lower. A well-trained employee who "has all the marbles to play with," so to speak, is the employee who can innovate and find new and better ways of doing the work which has been assigned to him or her. Often innovation by field employees will result in considerable savings in the total cost of programs.

In my opinion, and based on my experience for the past eleven years in Maintenance and Operations, I feel that the key element in surviving the effects of inflation is to work smarter, not harder. We need to assign priorities to each activity, plan each day's work, and finally, become more knowledgeable regarding the acquisition and use of new products with well-trained employees.

FLOWERS AND YOUR GOLF COURSE[1]

Wallace Staatz[2]

Flowers are not for everyone. They don't grow by themselves nor are they always easy to grow even with care. The golf course imposes still further restrictions on what may be grown. Most important if you don't like them or don't have time for them, don't even try. This talk isn't for you.

On the other hand with a little effort and attention you can add some real color and spectacular show to your course. The monotonous use of any one color becomes dull. Green is the problem on a golf course.

Before I discuss what materials may be used there are some basics that should be covered. First, flowers require care. They can't be something you do when there is nothing else to do. They must be planted on schedule, fertilized and watered regularly and weeded. A member of your staff should be either hired or assigned this responsibility who enjoys the job. If you just send the crew out to do the job - forget it. Secondly, do a first class job of soil preparation. It will pay big dividends in the results you obtain and the ease of maintenance. Get rid of the weeds and particularly quack grass first. Start the preceding fall if possible...Under no circumstances plant any perennials until the quack grass is licked. Use lots of humus, leaf mold or well rotted manure. Manure poses a weed problem, but if the manure pile is sprayed for weeds at germination and put in the flower bed, and then sprayed again before planting, you will get most of them. Round-Up is by far the best material to use. Don't use Casaron, Atrozine or similar materials as they will damage certain of the plant materials with their carry over. Also, ground fir

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1/ Presented at the 35th Annual Northwest Turfgrass Conference, Olympia, WA, September 22-24, 1981.

2/ Owner, Hi-Cedars Golf Course, Orting, WA.

bark is not an acceptable material. In some cases it has been in salt water and carries a high concentration of salt into the soil. Also the resins, tannis, etc., found in the bark seem to stunt some plants. Keep your soil mix light. A sandy loam is preferred. Heavy clay soils do not allow adequate root development for most flowers. Drainage is also important. Waterlogged flower beds don't grow good flowers. Cultivate deeply before planting. A small rototiller is great for this job.

Good watering is a must. Most flowers are shallow rooted and dry out quickly. If you can place your flowers where they are reached by your sprinkler system you will have better success. While the heavy precipitation of impact sprinklers somewhat limit the material used, they are preferable to hand watering. If possible, install a sprinkler system in your flower bed with small spray heads. If you must depend on hand watering your costs go up, it is often neglected just when it is needed most and your results are disappointing.

Fertilizer is no mystery to most golf course superintendents. You don't need some secret high priced formula. I use up my floor sweeping, broken and part sacks, or buy a little 10-20-20 cow pasture fertilizer. Mix the fertilizer into the soil at planting time and follow about mid-season with a little more worked into the soil. Fish fertilizer sprayed on will help those plants which need an extra boost.

Finally, weeding. The worst problem of all. Start clean, get the weeds when they are small, try some of the chemical weeders. There are some on the market today which can be used after planting on clean soil which will suppress weeds for six (6) weeks or more. I have tried one of these with good results.

Now we can come to materials. I have some basic criteria for materials. I will not use any material that (1) needs to be staked or pruned, (2) that needs to be sprayed for insects or disease or, (3) will not stand up to watering with impact sprinklers. The first two are obvious from a care standpoint, but the third requires some thought. The use of tall flowers or flowers with weak stems should be avoided.

Flowers can be divided in many ways. For the sake of this discussion I will talk about (1) bulbs and tubers (2) annuals and (3) perennials.

Most bulbs are relatively easy to grow. Suitable types for the golf course include daffodils, tulips, iris of all kinds, dahlias of the pon-pon or dwarf types - avoid the large flowering varieties, peonies and muscari or blue bells. Avoid the small flowering bulbs such as crocus. They tend to get lost. Gladiolus also are not satisfactory. They need staking, will not take impact watering and also are subject to insect damage. By scheduling the bulb plantings and type you can have flowers from bulbs and tubers from the end of March until frost in the fall, although the bulk of them bloom during the early spring and summer. Bulbs are the easiest of all flowers to grow. They require little care, may be left in the ground for years with the exception of tulips, which do best if dug each year, and have few disease problems. They also tolerate a wide range of soils. Their blooming period in the spring covers a time when no other flowers are in bloom. They also compliment the many flowering trees and shrubs, which may also be used on the golf course.

Annuals are plants which are started from seed each year and go through their whole life cycle in one season. They must be replanted each spring. Most of them are quite susceptible to frost. The single biggest mistake with annuals is to plant them too early in the spring. Frost either gets them or they are stunted with cold night temperatures. Don't get in a hurry to plant. Annuals can be expected to bloom from mid June to frost. Annuals are the hardiest of the three groups to grow, cost the most to bring to flower and require a great deal of care. So why grow them? They are the most colorful, coming in a wide range of colors, have a wide variety of forms and bloom over a long period of time. They make excellent material for mass plantings.

Annuals I have found that work well on a golf course are marigolds, petunias, asters, zinnias, pansies, impatiens, ageratum and snapdragons. Colendula is probably one of the easiest to grow and best. It comes in orange and yellow in several different forms. It also will reseed itself and can be started or replanted each year from the seedlings which come up. If you were to grow only one annual on your course, this is the one I would recommend.

Marigolds come in various shades of yellow, orange and mahogany. They also are found from very dwarf to very tall and from very small flowered to large. Select the semi-dwarf carnation, flowering types. The dwarf small flowered types tend not to make much of a show.

Snapdragons will winter over during a mild winter and provide early (May) flowers. Newly set plants bloom during the end of July until frost. They come in a wide range of colors.

Pansies also winter over and will provide a satisfactory show for about three years and then should be replaced. Besides a wide range of colors they bloom quite early in the spring and continue until frost.

Zinnias bloom generally from August 1st to frost and are excellent for mass plantings either mixed or in solid colors. They should be started in a cold frame or sheltered nursery area and then transplanted to their final location.

Ageratum is a showy blue border or edging plant. Impatiens is an ideal plant for shady areas.

While there are other annuals suitable for use on the golf course the ones I have discussed are easy to grow, can be started from seed in a cold frame nursery area, or under artificial light without need of a greenhouse.

If you are going to buy your annuals from a wholesale nursery your costs are going to be high and you may not get the material most suited to your needs. Part of the experience in growing annuals is the adventure with the seed catalog and watching the seedlings grow. It's a great job for a rainy early spring day. Incidentally, an old garage or shed protected from frost with a little heat using 6 foot cool white florescent lights about 18 inches above the seed flats makes an acceptable plant starting room.

Another group of plants which are easy to grow, require little care after once established, and come in many forms are the perennials. These plants once planted come up every year. They are usually propagated by dividing, although they can be started from seed, which takes longer. In this group are the primroses, which bloom early in April or May, Columbines, May and June; Lapine, June and July; Astible, July; Phlox, August; Carnations or Pinks, Shasta Daisies, Day Lilies and many others. Weeds and particularly quack grass are sometimes a problem with perennials. It is best to grow bulbs and annuals for a year or two until all grass is eradicated before planting perennials. For the beginner just starting with flowers, bulbs and perennials would be easiest way to start with resulting with the best chance of success.

Finally a word about where to use flowers. Don't place flower beds where golfers will walk through them. Also areas which come into play are not the best. Tee areas, areas you want to screen, entry ways, along paths and club house areas, are examples of places flowers can dress up an otherwise bare or uninteresting piece of ground. Flowers provide that little bit of window dressing missing in most golf courses that make the difference between just another golf course and an enjoyable experience. Golfers play for a number of reasons but the bulk of them are out to enjoy the beauty, restfulness and relaxation a golf course can provide.

Again, flowers are not for every golf course superintendent. If you are not interested or feel you don't have time, don't try. You will fail and a weedy, run down flower bed is worse than none at all.

CONTROLLED RELEASE FERTILIZERS AND EFFECTS OF NITROGEN SOURCES ON SOD ESTABLISHMENT AND ROOTING[1]

C. Robert Staib[2]

There are basically four kinds of controlled release nitrogen fertilizers used by horticulturists, home gardeners, professional turf managers, and sod producers. Though there are some similarities in their modes of release to available nitrogen over a period of time, each are unique in their own right. They are in the order of their chronological introduction in the marketplace . . .

1. Ureaform - manufactured and sold as NITROFORM (38% N) by FBC Chemicals Inc.

2. Methyleneureas - manufactured and sold as PROTURF and TURFBUILDER fertilizers by O. M. Scott and Sons Inc.

3. I.B.D.U. - iso-butylidene diurea (31% N), manufactured in Japan and sold in the U.S. exclusively by Estech General Chemicals Inc., formerly known as Swift Agricultural Chemicals Corp.

4. S.C.U. - sulfur coated urea, manufactured in Canada by Canadian Industries Ltd., aka, C.I.L., as 32% N, and in the U.S. by T.V.A. and Lakeshore Equipment and Supply Co. as 37% nitrogen. C.I.L. and Lakeshore manufacture SCU under license from T.V.A. which originally developed the technology in the early 1960's.

The characteristics of these nitrogen sources are described in reverse order, beginning with sulfur coated urea.

1/ Presented at the 35th Annual Northwwest Turfgrass Conference, Olympia, WA, September 22-24, 1981.

2/ BFG Chemicals, Inc., Kansas City, MO.

SCU

Sulfur coated urea is made by spraying molten sulfur onto granular or prilled urea. A wax sealant along with a microbiocide is the applied, completing the process. The coating material reduces the nitrogen content of the fertilizer from the original 46% to 37% or, in the case of the Canadian product, 32% N.

Nitrogen from SCU is made available by means of the urea actually diffusing through the imperfections in the coating. These imperfections consist of cracks and pin holes, and exposed urea not completely coated. The rate of diffusion is referred to as the "dissolution rate", that is . . . the amount of urea which dissolves in warm water at 100°F in seven days. Unfortunately, there is no standard test for determining the dissolution rate in soil under use conditions. However, in warm soil as encountered during summer months, T.V.A. data shows that the rate is faster than in warm water.

The dissolution rates for commercially available SCU are published as ranging from 25% to 35%. In general terms, the specifications are stating that about one-third of the urea nitrogen is released in warm water in seven days. The remaining urea dissolves at the rate of about 1% per day.

From a practical standpoint, the release rate of SCU, during the growing season, is faster than the published dissolution rate specifications. T.V.A. data shows that the dissolution rate is increased during storage 9.5% for nine months with normal stacking. Considering that it is impossile to subject sulfur coated urea to bagging, blending, transporting, and applying without damaging some of the coating, it is likely that during the growing season, as much as half the urea will diffuse through the coating in one to two weeks time.

WEATHER A FACTOR

The dissolution rate is also adversely effected by both heavy rainfall and drought. Heavy rains speed up diffusion of urea through the coating, while dry conditions, particularly in hot weather, increase degradation of the coating.

IBDU

IBDU, iso-butylidene diurea, is the resultant product from reacting urea with butyladehyde, a by-product of coal gasification. It contains 31% total nitrogen of which 29% is water-insoluble. IBDU is converted (hydrolized) to urea in the presence of moisture. The urea is then nitrified (mineralized) in the same manner as soluble urea (Figure 1). Since hydrolysis can proceed rapidly with fine particles, IBDU is manufactured in a particle size large enough to undergo dissolution over several weeks under normal conditions. Coarse size IBDU can be expected to provide available nitrogen fairly steady over six to eight weeks with controlled irrigation or intermittent light to moderate showers. If rainfall is heavy or soil moisture remains above capacity for long periods, the dissolution rate will be more rapid. Growth peaks may occur under these conditions.

Soil pH has a strong bearing on the dissolution rate of IBDU. The more acid the soil, the faster the dissolution rate. An alkaline pH will have a proportionately reverse effect; thus a neutral pH is most ideal.

IBDU NOT BIOLOGICALLY RELEASED

Because soil microorganisms are not involved in nitrogen release from IBDU, hydrolysis to urea will take place during cooler weather when microbial activity has slowed down. For this reason, IBDU will show a more noticeable response than ureaform during the cool season of the year.

METHYLENEUREAS AND UREAFORM

Methyleneureas are a series of molecules produced by reacting urea with formaldehyde in an acidic environment under exact prescribed conditions. These compounds consist of low molecular weight carbon:nitrogen linkages having varying degrees of solubility. The shortest-chained molecules (polymers), methylene diureas, are water soluble, and are fairly quickly converted to ammonia nitrogen by microorganisms. As the reaction proceeds, water-insoluble longer-chained methyleneurea polymers are formed. The reaction ceases when the acid environment is neutralized with a base. It is the longer-chained molecules, being digested more slowly by soil microorganisms, that provide residual nitrogen over the growing season, and to a degree, into the following year.

Scott's methyleneurea fertilizer differs from ureaform primarily in that the ratio of urea to formaldehyde is higher for the Scott product. The Scott process produces the same series of methyleneurea molecules as ureaform, but the end-product consists mostly of the water-soluble shortest-chained polymers. Approximately 2/3 of the nitrogen in Scott's methyleneurea is water-soluble, whereas 2/3 of the nitrogen in ureaform is water-insoluble. Because of this, Scott's methyleneurea fertilizer, including some unreacted urea, provides more immediately available nitrogen, but less residual nitrogen than ureaform. Multiple applications during the growing season are required to satisfy the needs of most turf varieties.

BFC Chemical's NITROFORM[R] is the only solid ureaform, containing 38% N, being marketed in the U.S. Much of it is sold to fertilizer manufacturers for blending or granulating with soluble nitrogen and NPK plant foods. This allows for greater economy while providing non-burning and long-lasting characteristics to turfgrass and ornamental fertilizers.

POWDER BLUE AND BLUE CHIP[(R)]

Powdered ureaform, known commercially as Powder Blue[T.M.] is mostly used by liquid lawn care applicators as a liquid suspension. Because of its greater surface area, more nitrogen becomes available over a shorter period than from granular ureaform. NITROFORM, powder or chip, is particularly useful going into hot weather because it is non-burning at typical useage rates and does not release a luxurious quantity of nitrogen. This result is particularly deleterious to cool season grasses in warm weather.

Granular (Blue or Gray Chip) NITROFORM, besides being used in fertilizer blends, is frequently used alone when a long-term residual nitrogen response is desired. For this reason, it is ideally suited for use in seedbeds or under new sod. It is within this scope that we are attempting to gain more knowledge through cooperative research with the University of Nebraska and other state universities.

Effects of Nitrogen on Sod Formation and Rooting

Casual observations of the effects of single applications of NITROFORM on germinating turfgrasses have, at times, indicated a faster uniform rate of establishment than from soluble nitrogen sources. These and other observations likewise indicated that ureaform may have a very positive effect on the development of vigorous root systems. Based on these suppositions, and on evidence from earlier research at the University of Rhode Island and Iowa State University, and turf establishment demonstrations at Washington State University's Western Washington Research Center at Puyallup, it was decided that a more complete study be undertaken on the effects of nitrogen sources on turf establishment, sod tensile strength, and on root development of transplanted sod. Because the University of Nebraska was interested in turfgrass research having application in the sod industry, our company chose to help sponsor the fertility aspects of their investigations.

In 1959, researchers at the University of Rhode Island (J. R. Kollett, A. J. Wisniewski, and J. A. DeFrance) concluded that sod could be grown to maturity 4 to 5 months sooner from single seedbed applications of ureaform (at 8 lb of nitrogen per 1000 sq ft) than from multiple applications of soluble nitrogen.

In 1978, Dr. William E. Knoop, then turfgrass research horticulturist at Iowa State University, showed that of several nitrogen sources placed under bluegrass sod discs in greenhouse studies, only ureaform at 1-lb of nitrogen per 1000 sq ft produced more roots than the no-nitrogen control. The nitrogen sources used in the test were urea, ammonium nitrate, IBDU, and NITROFORM. In this test, the materials were surface applied on 100% sand. NITROFORM produced 57% more roots than the control. Knoop's data showed that in a sandy loam soil, incorporation of the nitrogen gave the best results. Here, NITROFORM at 1-lb of nitrogen per 1000 sq ft produced 1/3 more roots than the control. IBDU produced somewhat less than this amount, but also more than the control. Urea and ammonium nitrate exhibited a negative effect on root development whether surface applied or incorporated.

Dr. Robert C. Shearman and his research team have concluded the initial phase of the nitrogen source studies at the University of Nebraska referred to previously. Preliminary data have been gathered resulting from the investigations:

1. Rate and placement effects of nitrogen sources on percent turfgrass cover of Parade Kentucky bluegrass.

2. Rate and placement effects of nitrogen sources on sod tensile strength of Park Kentucky bluegrass.

3. Rate and placement effects of nitrogen sources on root development in Park Kentucky bluegrass sod discs growing on (a) silty-clay loam, (b) washed silica sand, and (c) Turface (calcined clay).

Though it is intended that these and related studies be conducted into 1982, data gathered in the investigations thus far show that slow-release nitrogen sources exert more positive responses to sod formation, tensile strength, and sod rooting than either urea or ammonium nitrate.

FIELD STUDIES

The field study to determine the rate of sod establishment and tensile strength was initiated in September, 1979. Seeded with Parade Kentucky bluegrass at 57 lb per acre, the study was designed to evaluate effects of nitrogen carrier, rate of application (1, 2 and 3 lb of N per 1000 sq ft), and placement, i.e. surface vs incorporated from 0 to 2 inches, on establishment and growth for sod production. The treatments included urea, ammonium nitrate, SCU, IBDU, and NITROFORM (granular). Though test results indicated that soil phosphorus and potassium levels were high and very high respectively, a surface application of 2 lb of P_2O_5 per 1000 sq ft from 0-45-0 was applied immediately after seeding.

Results showing percent cover as of April 15, 1980 are indicated in Table 1a, and graphically depicted in Figure 2a. The data indicate that soil incorporation of nitrogen sources improved turfgrass establishment rate over surface application. NITROFORM and IBDU were exceptions. They performed equally well in surface or incorporated treatments. Table 1b and Figure 2b, showing the mean response of all rates, indicate clearly that only NITROFORM and IBDU did not require incorporation to produce optimum results. It should be noted that in some instances, the soluble nitrogen sources including SCU, produced less favorable results when applied at higher than the lowest rate. This may indicate the possibility of adverse effects from excessive soluble nitrogen. Such was not the case with IBDU and NITROFORM.

Sod tensile strength was measured in September, 1980, 12 months following seeding. These measurements are the averages of two sub-samples per treatment and four replications. A tensile strength of 55 lb is considered acceptable for handling sod.

In this study, increasing the rate of N from 1 to 2 to 3 lb per 1000 sq ft (Figure 3) in nearly every case from all sources produced proportionately increasing tensile strengths. The samples in the no-nitrogen check averaged only 45 lb. In no instance was 1-lb of N per 1000 sq ft from any source sufficient to meet the minimum standard of 55 lb in the 12-month period. The 3-lb rate of N from slow-release sources, including SCU, produced the best responses, showing tensile strengths in the high 70's. However, as in the establishment study, only IBDU and NITROFORM performed equally well surface applied or incorporated. The other sources had to be incorporated to obtain the best response. Table 2 shows that at the optimum rates, differences between surface application and incorporation of the soluble nitrogen sources are statistically different with only NITROFORM and IBDU being the exceptions.

The trend for SCU to exhibit lower tensile strengths than NITROFORM or IBDU, but not statistically different, shows a potential for it to "run out" before the crop reaches maturity (Table 2, surface applied).

GREENHOUSE STUDY

In a greenhouse study, a test to evaluate the performance of ureaform vs urea on sod rooting was set up similar to the one at Iowa State University. Three growing media were used, (a) Sharpsburg silty-clay loam, (b) washed silica sand, and (c) Turface (calcined clay). Comparisons were made of the effects on root growth of 1 vs 2 lb of nitrogen per 1000 sq ft and kinds of placement, i.e. over the sod vs surface applied under the sod vs soil incorporated (0-2 inches).

Though the results in this 3-week test were not as statistically clear as differences previously discussed in the field tests, the 2-lb rate of NITROFORM nitrogen clearly outperformed urea in the loam soil whether surface applied under the sod or soil incorporated. Applying nitrogen over the sod produced less favorable results than the other placement methods, though here too, the 2-lb rate of NITROFORM nitrogen produced the best results in the silty-clay loam (Table 3, Figure 4). The sod discs were watered sufficiently to avoid moisture stress.

As in the turf establishment study, the higher rate of urea frequently showed adverse effects in this test, producing fewer roots in the transplanted sod discs than the lower rate. However, in all instances, the 2-lb rate of NITROFORM nitrogen was superior to the 1-lb rate. Contrary to the data obtained at Iowa State

University, urea usually showed some improvement over the no-nitrogen control.

In summary, the slow release nitrogen sources, NITROFORM and IBDU, exhibited long-lasting benefits in turfgrass establishment and sod tensile strength in both surface and soil incorporated treatments. SCU was equal to the insoluble nitrogen sources only when soil incorporated. It appears that, by far, the best responses from urea and ammonium nitrate occur when they are soil incorporated.

From these tests it appears that the higher rates of soluble nitrogen, including sulfur coated urea, are not as effective in sod formation as lower rates of 1 or 2 lb of N/1000 sq ft in seedbed applications. Thus, more frequent applications of these sources will be required during the growing season to meet nitrogen requirements.

Table 1a. Nitrogen source, application rates, and placement effects on percent turfgrass cover (4/15/80).

Source	Rate (#N/M)	Turfgrass Cover (%) Surface	Incorporated
Urea (45-0-0)	1.0	42.5	57.5*
"	2.0	50.0	61.3*
"	3.0	42.5	58.8*
		45.0	59.2*
Nitroform (38-0-0)	1.0	52.5	52.5 n.s.
"	2.0	57.5	58.8 n.s.
"	3.0	62.5	63.8 n.s.
		57.5	58.4 n.s
NH_4NO_3 (33-0-0)	1.0	48.8	55.0*
"	2.0	48.8	57.5*
"	3.0	42.5	61.3*
		46.7	57.9*
IBDU (31-0-0)	1.0	55.0	60.0 n.s.
"	2.0	56.3	65.0*
"	3.0	63.8	63.8 n.s.
		58.4	62.9 n.s.
SCU (37-0-0)	1.0	57.5	66.3*
"	2.0	46.3	57.5*
"	3.0	48.8	56.3*
		50.9	60.0*
Check	---	38.8 n.s.	41.3 n.s.
		Mean Surface	Mean Incorporated
		50.9	58.5*

Table 1b. Mean response (Turfgrass cover) to nitrogen source and placement (4/15/80).

Source	Turfgrass Cover (%)	
	Surface	Incorporated
Urea	45.0 bx[+]	59.2 bcy
Nitroform	57.5 dx	58.4 bcx
NH_4NO_3	46.7 bcx	57.9 by
IBDU	58.4 dx	62.9 cx
SCU	50.9 cx	60.0 bcy
Check	38.8 ax	41.3 ax

[+]Values followed by the same letter are not significantly different at the 5% level Duncan's Multiple Range Test.

Table 2. Nitrogen source, application rate, and soil placement influence on sod tensil strength of 'Park' Kentucky bluegrass.+

Source	Rate (lbs N/1000 ft^2)	Sod Tensile Strength (lbs)‡ Surface	Incorporated
Urea (45-0-0)	1.0	48	49 n.s.§
"	2.0	55	62 *
"	3.0	58	67 *
NH_4NO_3 (34-0-0)	1.0	48	49 n.s.
"	2.0	53	55 n.s.
"	3.0	53	59 *
Nitroform (38-0-0)	1.0	50	49 n.s.
"	2.0	65	65 n.s.
"	3.0	75	75 n.s.
IBDU (31-0-0)	1.0	50	50 n.s.
"	2.0	68	70 n.s.
"	3.0	75	75 n.s.
SCU (36-0-0)	1.0	49	51 n.s.
"	2.0	60	68 *
"	3.0	70	78 *
Check	---	45	45 n.s.

+Nitrogen treatments were applied at time of seeding only (Sept. 1979).

+Sod tensile strength measurements made 12 months after seeding (Sept. 1980), and are averages of two subsamples per treatment and four replications. Tensile strengths of 55 lbs are considered acceptable for sod handling.

§Surface and incorporated stand for fertilizer placement. Incorporated treatments had fertilizer mixed in the upper 2.0 inches of soil. Values followed by (*) are significantly different from corresponding means between columns.

Table 3a. Nitrogen source, rate and placement effects on sod transplant rooting for Park Kentucky bluegrass sod discs growing on silty-clay loam (SCL), washed-silica sand (WSS), and Turface (T).

Source	Rate (#N/M)	Placement	Root Production (mg·dry wt/pot) SCL+	WSS	T
Urea	1.0	Turf	63 ef‡	73 cd	93 b
"	2.0	Turf	80 def	63 de	122 de
"	1.0	SS	130 bcd	170 a	140 f
"	2.0	SS	60 f	81 c	137 ef
"	1.0	SI	147 bc	170 a	106 bc
"	2.0	SI	97 cdef	63 de	127 def
U.F.	1.0	Turf	90 def	50 e	101 bc
"	2.0	Turf	153 b	75 cd	116 cd
"	1.0	SS	143 bc	83 c	117 cd
"	2.0	SS	207 a	130 b	167 g
"	1.0	SI	113 bcde	60 de	106 bc
"	2.0	SI	247 a	77 c	140 f
Check	---	---	110 cdef	60 de	65 a

+Silty-clay loam (SCL), Washed-silica sand (WSS), and Turface (T).

‡Values are rounded to nearest mg. Values in a column followed by the same letter are not significantly different at 5% level Duncan's Multiple Range Test.

Table 3b. Mean root production for transplanted Kentucky bluegrass sod according to fertilizer placement.

Placement	Root Production (mg·dry wt./pot) SCL+	WSS	T	$\bar{X}$
Turf	97 ay‡	65 ax	108 ay	90
Soil Surface	135 bx	116 bx	140 bx	130
Soil Incorporated	155 by	93 abx	119 abx	122
	129 y	91 x	122 y	

+Silty-clay loam (SCL), washed-silica sand (WSS), and Turface (T).

‡Values are rounded to nearest mg. Those followed by the same letter are not significantly different at the 5% level Duncan's Multiple Range Test.

Figure 1.

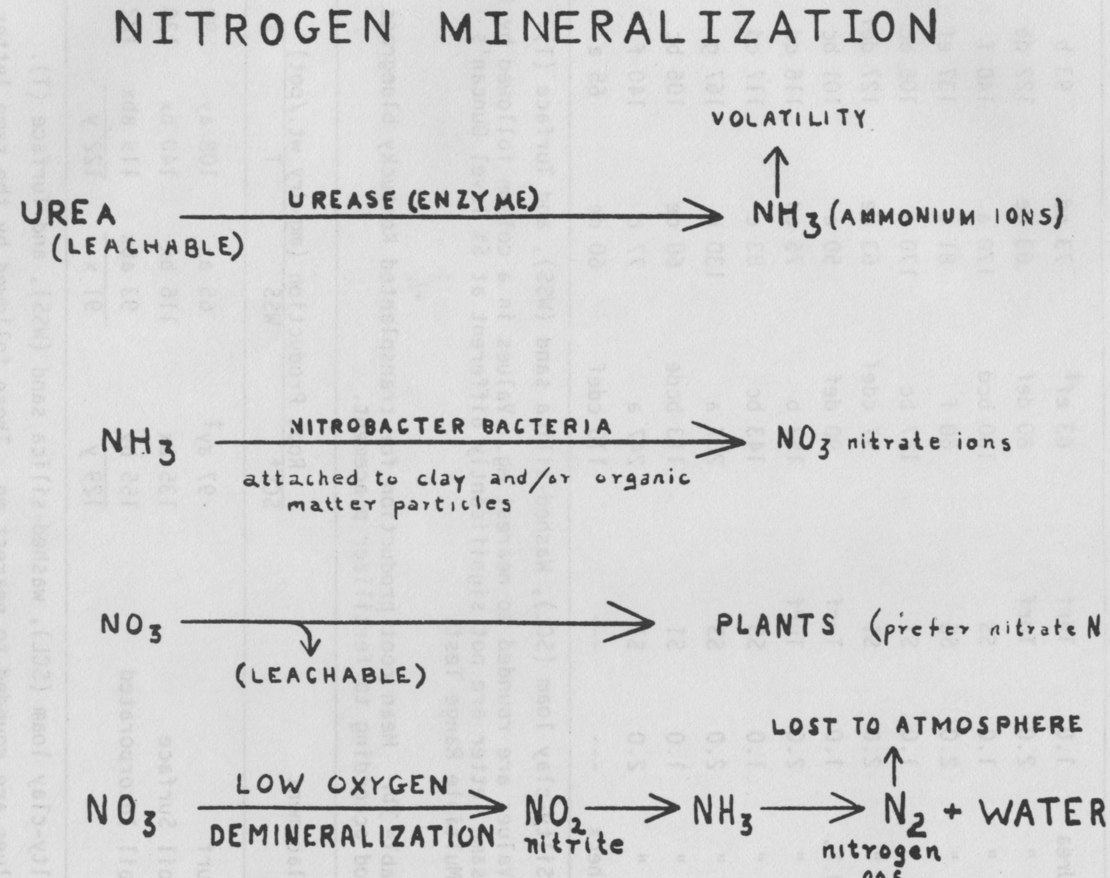
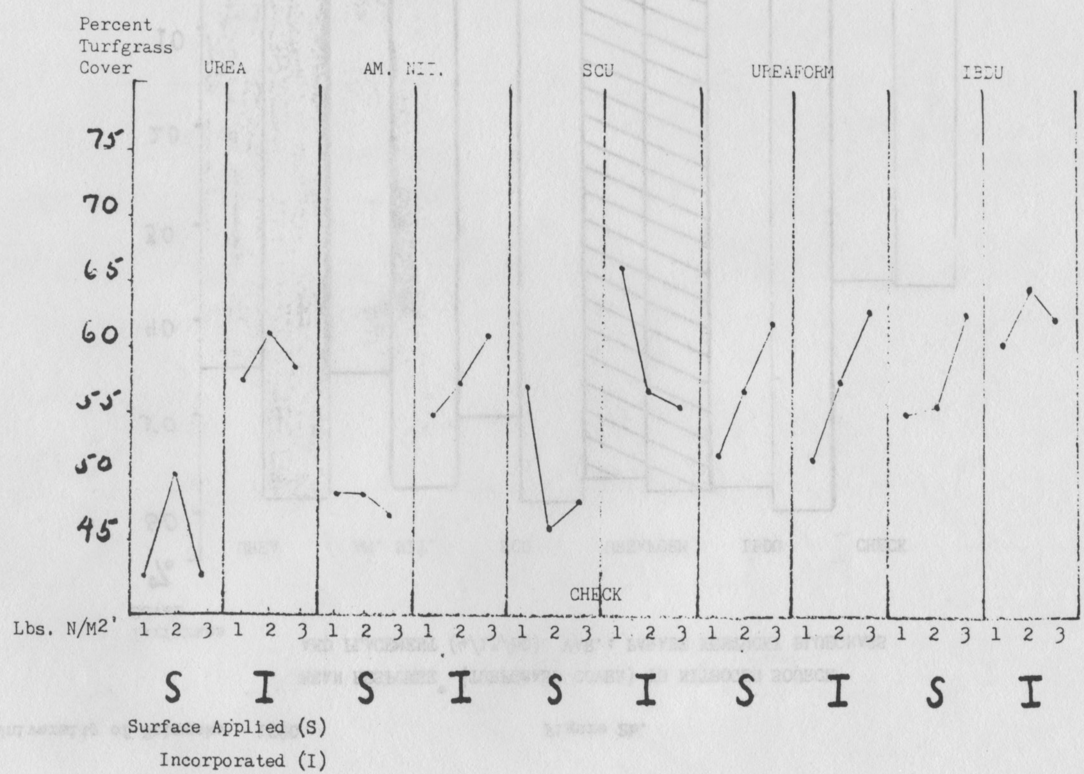

NITROGEN MINERALIZATION
VOLATILITY
UREA
(LEACHABLE)
UREASE (ENZYME)
NH3 (AMMONIUM IONS)
NH3
NITROBACTER BACTERIA
NO3 nitrate ions
attached to clay and/or organic matter particles
NO3
PLANTS (prefer nitrate N)
(LEACHABLE)
LOST TO ATMOSPHERE
NO3
LOW OXYGEN
DEMINERALIZATION
NO2
nitrite
NH3
N2 + WATER
nitrogen gas

Figure 2a.

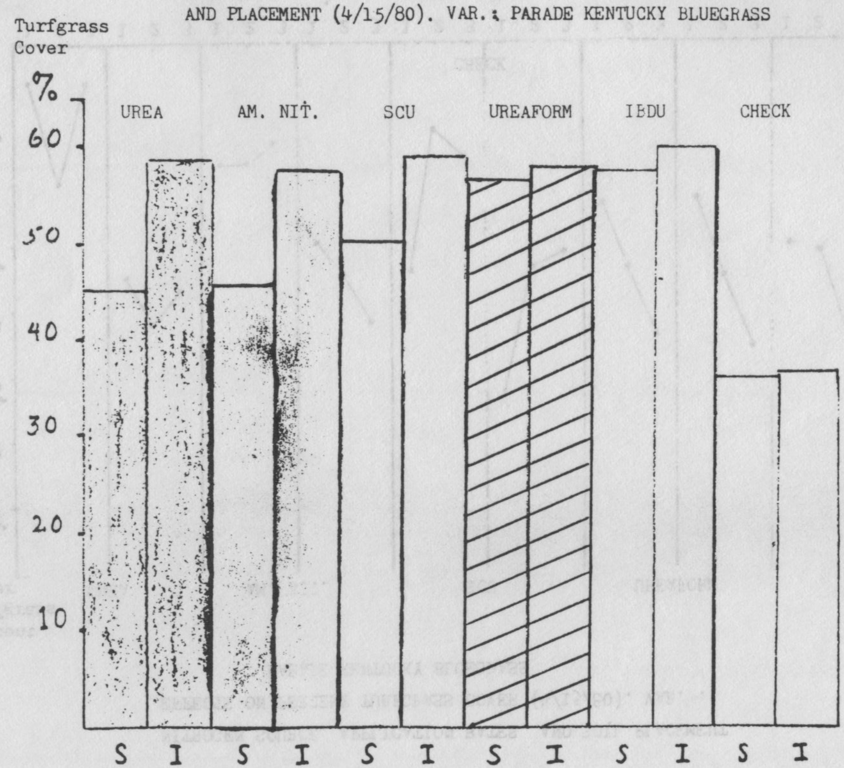
NITROGEN SOURCE, APPLICATION RATES, AND SOIL PLACEMENT EFFECTS ON PERCENT TURFGRASS COVER (4/15/80). VAR. : PARADE KENTUCKY BLUEGRASS



University of Nebraska - 1980

Figure 2b.

MEAN RESPONSE* (TURFGRASS COVER) TO NITROGEN SOURCE AND PLACEMENT (4/15/80). VAR.: PARADE KENTUCKY BLUEGRASS



SURFACE APPLIED (S)
INCORPORATED (I)

*Average of response to 1, 2, and 3 lbs. of nitrogen per 1000 sq. ft.

Figure 3.

NITROGEN SOURCE, APPLICATION RATE, AND SOIL PLACEMENT
ON SOD TENSIL STRENGTH OF PARK KENTUCKY BLUEGRASS
(Nitrogen treatments were applied at time of seeding only, 9/79)

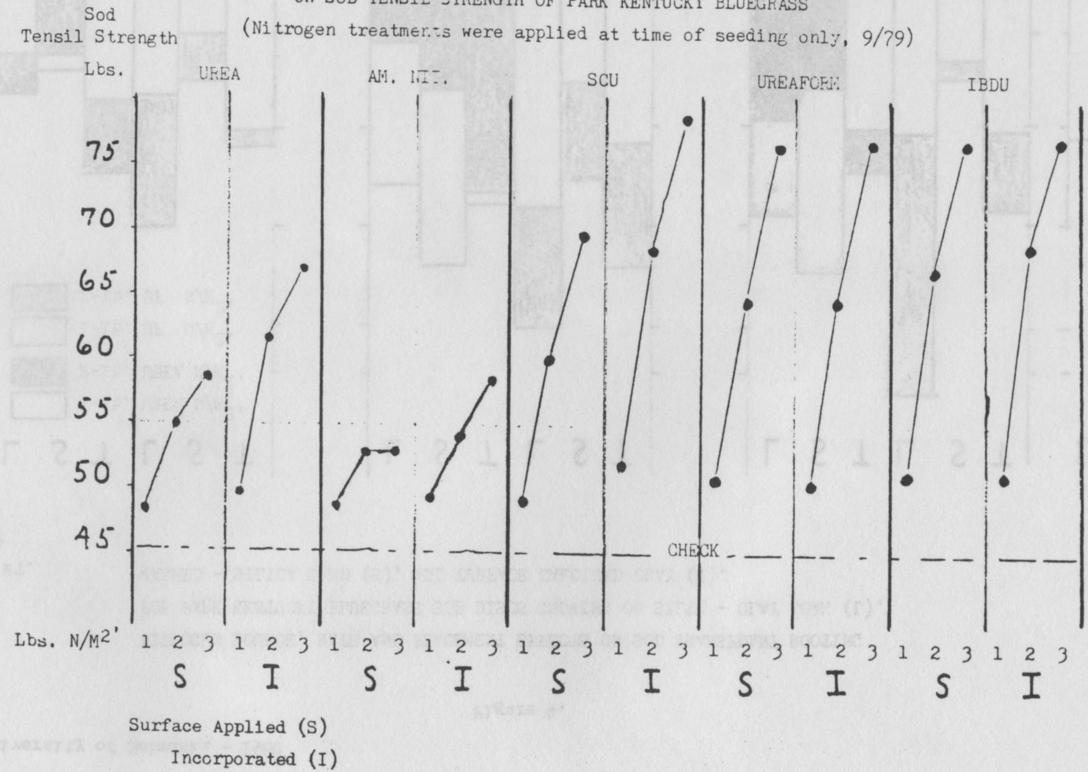


Figure 4.

NITROGEN SOURCE, RATE AND PLACEMENT EFFECTS ON SOD TRANSPLANT ROOTING FOR PARK KENTUCKY BLUEGRASS SOD DISCS GROWING ON SILTY - CLAY LOAM (L), WASHED - SILICA SAND (S), AND TURFACE CALCINED CLAY (T).

FUNGICIDE RESISTANCE IS A REALITY[1]

or

Some Came to Bury Systemics, Not Praise Them

Joseph I. Niedbalski[2]

"*Double, double toil and trouble...fire burn and caldron bubble*", so wrote William Shakespeare in MacBeth...

I know what he (Shakespeare) had in mind! Way back then! It's nothing new..we all can (at least some of us) recall the reports of cadmium, mercury and dyrene dollar-spot resistance. *Double...toil...and trouble...*

During the past 15-20 years, disease specialists have been busy trying to discover (*fire...burn...and calcron bubble*) an effective systemic fungicide, believing it would solve all our problems.

Yes, we now have a basket full of systemic fungicides, and a caldron full of bubbles and...TROUBLES. What can we expect from solely using the systemics?

Wait, let's back up a minute. Golf Course Superintendents and researchers all too often, in the past, immediately attributed poor or erratic results from a fungicide to either: (1) poor application techniques, (2) unfavorable weather, (3) faulty formulation, (4) miscalculation of dosage, and (5) any number of other excuses. Many times their speculations were correct; however, in the last 15 years or so, just as systemic was the buzz word... <u>resistance</u> is its counterpart TODAY.

1/ Presented at the 35th Annual Northwest Turfgrass Conference, Olympia, Washington, September 22-24, 1981.

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Resistance still stirs debate within phytopathological circles; however, why should fungicides be excluded? Resistance to human and veterinary bacterial pathogens has been recognized for three decades or more. Resistance to penicillin and streptomycin was detected very soon after the antibiotics were introduced.

Entomologists have faced similar problems, such as the dramatic resistance developed by the housefly due to repeated use of (excuse me) DDT. Now spectacular occurences of fungal resistance to fungicides have developed through the use of "new" systemics in turfgrass. Indeed, the *calcron bubbles* with *troubles* and that rhymes, and that's in our...River City...the turf market.

Disease resistance, particularly in the turfgrass industry, is no longer a curiosity...but a bonafide reality. Plant breeders (geneticists) attempt to use natural resistance to disease in their breeding programs by incorporating desirable characteristics. Many types of resistance involve biochemical interactions between host tissue and the invading pathogen. But, at this point, it is important to have a common definition of what we mean by RESISTANCE. Resistance: The power of an organism to overcome, completely or in some degree, the effect of a pathogen or other damaging factor (substance or chemical) or...The inherent capacity of a fungus to prevent or restrict the entry or subsequent activities of a fungicidal agent when the fungus is exposed to the chemical under environmental conditions normally suitable for fungitoxicity.

About 23 years ago (1958) Parry and Wood studied the adaptation of various plant pathogens to higher levels of captan, thiram, ferbam, nabam, zineb, copper and mercury materials. They employed a repeated transfer process whereby agar disk inocula were transferred to increasing concentrations of the test chemicals. Adaptation to ferbam, captan, copper sulfate and phenylmercuric acetate was obtained with *Botrytis cinerea* (Gray mold) but not with *Venturia inequalis* (Apple scab) for any compounds treated.

Some 10 years later (1968) Cole, Massie and Duich reported "resistant" *Sclerotinia homoecarpa* isolates from turfgrass sites showing poor control of Sclerotinia dollarspot by certain fungicides. In agar plate studies these isolates were shown to be more resistant to the fungicide in question than isolates from turf areas where the fungicide provided good control. We could occupy the balance of our time addressing the history and the problem of resistance. We do not have the luxury of time. I do, however, recommend an article that appeared in the July issue of Plant Disease, (Vol. 64, No. 7) authored by Dr. Charles J. Delp of E. I. duPont de Nemours, titled, "Coping with Resistance to Plant Disease Control Agents"; it is an excellent presentation and it should be required reading for all of us.

Resistance is here and will remain a threat! An understanding of the mechanisms of resistance is, indeed, helpful for a rational approach to the problem. To deal with the pathogen in its natural environment, laboratory phenomenon must be related to field situations to be meaningful.

To do this, we must consider fungal evaluation, survival and the concept of populations.

A population is a group of organisms similar, but not identical in every characteristic. (Sex appeal vs. Sexuality). <u>Fungicide resistance</u>, like any other characteristic, may differ between members of a population.

Some degree of resistance is proven if members of a population vary in this quality. In any event, one must search for resistance <u>within</u> a population. To compare the reaction of one species to another, as is commonly done, does not speak to the variability of a population. It is the ability of a variable population to respond to a chemical through selection that renders a fungicide ineffective.

Two general types of fungicide resistance exist; the first is <u>non-heritable</u> and the second is <u>heritable</u>. We refer to <u>non-heritable</u> fungicide resistance as "training". Over a period of time and by gradually increasing the concentration of the toxicant, we can successfully train an isolate to tolerate higher concentrations of the toxicant that it originally could. When the "trained" isolate is cultured in the absence of the toxicant for one or more transfers, this type of resistance is no longer demonstrable. This loss of resistance is characteristic of the non-heritable type of resistance. Several reports of this type of resistance with cycloheximide with yeast, bacteria and a few non-pathogenic fungi have been reported. Therefore, cycloheximide is an example of a non-heritable resistance which is reversible in the laboratory.

Heritable fungicide resistance is characterized by passage through either a sexual or parasexual cycle to its progeny. The trait of resistance can be conditioned by either nuclear (e.g. genes) or extraneuclear (e.g. non-chromosomal) factors. Single gene fungicide resistance to a variety of toxicants has been discovered in a number of organisms. Benomyl is an example of heritable resistance which is not reversible in the lab or the field!

Two general mechanisms may render an organism resistant to a fungicide. The first is by limiting entry of the toxicant, for example, by altered permeability of the cell membrane. The second is by altering the toxicity of the chemical through inactivation of the toxic compounds or by altered physiology of the organisms so that it is no longer sensitive to the compound.

When fungicides are used continuously on crops that are not rotated (i.e. turf) the same host pathogen population interaction exists and it becomes a matter of survival of the fittest within the members of the pathogen population. If the sensitive members are more fit to survive and reproduce from year to year than the resistant members, their frequency will increase.

In the above case, the sensitive members predominate and increase in the absence of any spraying or during intervals between sprayings. A continual application of one toxicant which is highly effective against these sensitive members will tip the population balance towards the resistant members who continue to increase in number and gradually (in some cases, rapidly) become the dominant or exclusive portion of the population... when this occurs, the superintendent starts reporting poor results and ineffectiveness with his fungicide. A case for rotating systemic and contact-type fungicides.

The introduction of systemic fungicides in the last few years has introduced toxicants with narrow activities involving a few or single metabolic pathway. Their specific metabolic blocks have already been easily bypassed by certain pathogenic fungi with the net result we call fungicide resistance.

I'll come back to this point of pathways a bit later.

A few examples of current Fungicide Resistance in the Turf area would include benomyl and iprodione. You may be interested in a brief chronology:

<u>Benomyl</u>

1968-69 Schroeder and Provvidenti reported benomyl (Tersan 1991) resistance with powdery mildew on cucurbits. 1971, Shanmugasudaram et. al. reported similar findings. 1971, Vargas reported Tersan 1991 resistance with powdery mildew on turf (bluegrass) at the Michigan Turf Conference and again in 1972 at the annual American Phytopathological meetings in Mexico City.

1972, superintendents at golf courses in Ohio, Illinois, Pennsylvania, and New Jersey all reported loss of dollarspot control following various periods of Tersan 1991 use. Cole and Vargas, both confirmed resistance to Tersan 1991 at these locations. Cole further reported his findings at the Pennsylvania State Turf Days.

Bartels-Schooley (1971) reported development of vigorous colonies of *Fusarium oxysporium* following exposure to the selected pressure of Tersan 1991. Brown rot (*Monolinia fructicola*) resistance to Benlate was highlighted in their product literature as early as 1976.

Irpodione

Fungi controlled include: *Alternaria*, *Botrytis*, *Fusarium*, *Helminthosporium*, *Rhizoctonia*, and *Sclerotinia*.

In 1977, a French paper by P. Lerous, R. Fritz, and M. Gredt reported resistance to *Botrytis cinerea*. In 1978, a German paper by P. Schuepp and M. Kung also reported resistance to *Botrytis cinerea*. Also in 1978 Sztegnberg and A. L. Jones revealed tolerance to *M. fructicola*, while again the French in 1978, P. Leroux, M. Gredt, and R. Fritz cited resistance to some phytopathogenic fungi. And finally, your own G. A Chastagner, and W. E. Vassey, in 1979, published on resistance to *Botrytis tulipae*.

What about turf in all of this? Well, G. A Chastagner and W. Vassey in 1980, in a summary (Hand out at Washington State University Turf Field Day), cited resistance to *Fusarium nivale*. The *Fusarium nivale* tolerance is of particular interest, since iprodione was registered in 1979 for the use on *Fusarium* patch. It was considered to be one of the most effective fungicides tested against the disease. Application of iprodione in September and October of 1979 failed to control *Fusarium* on two greens on a course near Seattle. These greens had been utilized in the development program for iprodione in 1977-78/1978-79. Both greens were on exclusive iprodione programs until late 78-79 when PMAS was required to control the disease. Laboratory tests confirmed the strain to be tolerant at levels of 1,000 ppm while non-tolerant strains were controlled at 10 ppm.

Why are systemics more prone to resistance? Remember earlier, I spoke about the effectiveness of a fungicide in controlling a disease depends on a number of factors other than its fungistatic effect on a pathogen. Some of the synthetic and catabolic processes fungicides interfere with to inhibit fungal growth are:

Cell Wall Formation
Cell Membrane
Respiration
Energy Transfer
Nucleic Acids (benomyl)
Protein Synthesis (cycloheximide)

Protein synthesis is an extremely complex process which is essential for growth and metabolic activity of all cells. The chair of events leading to the formation of protein may be conveniently divided into 5 steps.

1. Activation of amino acids with ATP in the presence of specific activation enzymes forms the aminoacyl-AMP-enzyme complex.

2. In the presence of the same enzyme (aminoacyl-SRNA synthetase) the amino acid is transferred to form the aminoacyl-SRNA, releasing the AMP.

3. The aminoacyl-SRNA, the mRNA, and the ribosome form a complex.

4. The aminoacyl-SRNA is then transferred to the ribosome in a sequence that is dictated by the code in the mRNA.

5. Growth of the chain is terminated and the protein is released.

Cycloheximide blocks all five sites in protein synthesis. Cycloheximide can also; disrupt cellular metabolism by interferring with energy transfer; inhibit enzymes essential in glycolysis; inhibit enzyme essential in nitrate assimilation. It is interesting to compare a contact fungicide such as cycloheximide with a systemic, benomyl.

A Super Abstract of this comparison could reveal:

<u>benomyl</u>	<u>cycloheximide</u>
Hits 2 spots	Hits 8+ spots
Develops 2 alternate	Develops 2 alternate
Pathways = Resistance	Pathways = Control

Or Expand the Abstract:

	cycloheximide	benomyl
Fungitoxicity	Fungistatic	Fungistatic
Resistance Mechanism	Non-heritable Laboratory reversible	Heritable not reversible
Site of Attack:	Multiple: nucleotide level ribosome level energy transfer carbohydrate breakdown nitrate assimilation	Singular: nucleotide level
	Resistance- UNLIKELY	RESISTANCE

Two points not discussed as yet, must also be kept in mind. The realities of Cross tolerance and predisposition. Cross tolerance has been demonstrated within the benzimidazole types (Tersan 1991, TBZ, Topsin) by many researchers (Cole, Vargas, and others) with powdery mildew and dollarspot. A paper presented at the 1980 APS Meetings by D. F. Ritchie of N.C.S.U., has shown laboratory tolerance to resistant strains of *Monolinia fructicola* within the dichloro nitroaniline class of compounds that includes iprodione.

Predisposition has been reported in the literature with benomyl. Gold berg et. al. and Jackson reported benomyl use on turf to increase incidence of *Helminthosporium* sp. Thompson in Georgia, Harrison in Texas have reported increased rust on peanuts following benomyl use to control leafspot. There are numerous reports from North and South Carolina of increased rust associated with benomyl use on peanuts. Observations in Massachusetts and the midwestern states (Michigan, Indiana, and Illinois) of increased fairy ring on golf greens following benomyl use.

Oh, the systemics do not have a corner on predisposition. You may or may not be aware that papers have been published linking chlorothalonil (Bravo or Daconil) applications in peanuts for leafspot control with an increased incidence of *Sclerotinia*.

Where does all this leave us, you ask?

In Reasonable Shape! You, as a golf course superintendent, or one who advises golf course superintendents relative to turf disease control programs, have a number of options. Dr. C. J. Delp, in his article, I feel, puts it very succinctly. "Resistance can be mitigated or presented by early use of spray programs designed to preclude long-term exposure of the pathogen to a single disease control agent. Once resistance is a significant part of a pathogen population, the only choice is to use disease control agents to which there is no cross-resistance, if such agents are available and registered for use (There are indeed...options that are registered) on Turf. When a chemical with a propensity for resistance is being used, the program must be planned from the beginning to prevent resistance."

Further, whenever possible, turfgrass managers must attempt to utilize the most economical long-range maintenance programs, and recognize the consequences associated with the use of fungicides that have known resistance, cross resistance, are acidifying, or thatch-inducing. I don't want to leave you with the impression that systemic is synonymous with resistance. As the song from Porgy and Bess goes..."It ain't necessarily so!" However, you have a choice, exercise all of the available options.

Remember...Fungicide Resistance is a Reality...and.. Some Came To Bury Systemics, Not Praise Them.

EFFECTIVE SPEAKING[1]

Larry R. Christensen[2]

I appreciate this opportunity to speak before such a distinguished and large group. It is my aim today to quit talking before you quit listening. I accept that aim because I feel that I have something to share with you this morning that will truly help each of us.

Public speaking is not easy. If it were easy, everyone would be doing it. And as we all know, everyone is not doing it. Unlike the artist who can throw away a painting he doesn't like before anyone sees it, a speaker is on the firing line, and doesn't have the luxury of taking it back if it isn't to his liking. So why take a chance? Well obviously, many people don't. But if you look around you now, or think for a moment of your business associates and friends, you will likely see that there is a correlation between success and the ability to verbally express yourself in front of a group. And I don't mean just standing up and talking. I'm referring to a person who appears confident, who organizes his thoughts and presents them in an understandable way, and a person who puts me, the audience, at ease and makes me feel good. That is my goal this morning.

We are going to talk about three basic areas of speaking. First, speech organization and preparation. Second, how to overcome nervousness and, for some, sheer terror. And third, what I call the magic of speech.

The written text of a speech can look about as interesting as a bucket of dead smelt. But a speaker who can add his personality to that speech and bring it to life will accomplish something that will bring satisfaction to himself and pleasure to an audience.

1/ Presented at the 35th Annual Northwest Turfgrass Conference, Olympia, WA, September 22-24, 1981.

2/ Toastmasters International, Federal Way, WA.

Emerson said, "Speech is power". I could add to that, speech is privilege, and speech is responsibility. To demonstrate that point, it would take me two to three hundred hours to convey my message to you one at a time. So it is not inconceivable that the preparation for my talk this morning is two to three hundred times more important than it would be if presented to only one of you. So along with the power goes privilege and responsibility. Whether we speak to five people or five hundred people.

A speaker is nearly always limited as to the amount of time he will be given on a program. Someone asked Woodrow Wilson how long he would prepare for a ten minute speech. He said, "two weeks". "How long for an hour speech?" "One week." "How long for a two hour speech?" "I am ready now." He apparently felt that he could say everything he had to say in two hours. We seldom have the luxury of speaking that long. And if we did, we'd have to find some people who would sit still that long. So as our allotted time to speak is limited, we must first limit the scope of our subject. And second, we must choose our words carefully.

When choosing a subject, there's a natural tendency to cover as much ground as possible. But if you will take a moment to remember the last speech you heard before this conference, you will probably find that you remember only one or two points from that speech, if that many. So although it might seem like a mediocre goal, if you can leave an audience with one or two points that they actually remember, take home with them and use, you've done a magnificent job.

Your time would be better spent reinforcing a few points, rather than presenting many new ideas. So instead of talking about lawn mowers, we might talk about one particular mower, or how this particular mower works in certain areas, or in certain weather conditions, durability, maintenance. You have several good examples on your own program. One is 'Effects of Nitrogen on Sod Rooting'. Another is 'Topdress Large Turf Areas'. Draw your subject into a smaller and smaller circle so you will have the time to do it justice, and not have to talk in generalities in order to cover the ground you have chosen.

When we have determined what our subject is going to be, there are four areas of our speech that must be worked out. They are the Introduction, the Opening, the Body, and the Close. They should first be outlined, and then written out in full text. If you are being introduced by someone, you must never depend on that person for a proper introduction. A program chairman does not have the time to research your background. And he can't be expected to have sufficient understanding of your speech to properly introduce it. So if you'll follow this formula for speech introductions, you'll create favorable interest in your speech before you even open your mouth. You'll create a receptive mood, and you'll help a very deserving program chairman look even better. A good introduction covers five main points.

1. Create interest or desire for your subject.
   A. Wouldn't it be nice . . .
   B. I'm sure we've all wondered . . .
   C. Imagine having access to . . .

2. Offer a solution.
   A. Today we have . . .
   B. It's our good fortune . . .

3. Qualifications of speaker to speak <u>on that subject</u>.
   A. Education
   B. Experience
   C. Position

4. Speech title.

5. Speaker's name.

When I wrote my own introduction, I intended to use it as an example of these five points. See if you can pick them out.

"I'm sure that each of you have experienced problems when speaking in public. From finance committees and greens committees to conducting employee meetings, we have all experienced the problems of expressing our thoughts clearly, and avoiding the pitfalls of sweaty palms and dry throats. Our next speaker has experienced similar problems. He has agreed to share some ideas with us today about how we may attain a greater degree of success thru speech. He has been a member of Toastmasters International for eight years. He has professionally spoken and provided educational speeches around the Northwest for businesses and has participated in educational seminars for Toastmasters. He has a degree in Business and has been a successful salesman for 11 years with a publishing company, Commerce Clearing House. His speech title: Effective Speaking or Could I Go To The Dentist Instead". Help me welcome Larry Christensen."

If you are not introduced, you must handle that responsibility yourself. What people want to know is your name and your subject or title. You then must create interest, offer a solution and cover your own qualifications. Obviously when covering your own qualifications, you must tread lighter than a chairman would because of the possibility of sounding self-serving.

The two parts of a speech most difficult to prepare are the opening and the close. Both must be relatively short, about 10% of the speech for each one. But they have a definite purpose. First, an opening must set the tone or mood of a speech. It seems obvious, but it's surprising how often someone gets up to give a serious speech and thinks he has to tell a joke first. Second, an opening must give the listener a good idea of what the speech is about.

The body is the substance of a speech. Our introduction has created interest in a subject. Our opening has briefly outlined the subject matter to be covered. The purpose of the body is to give three to five examples of our main point and back these points up with facts and figures. The listener must hear something definite to carry home with him. Generalities will not do. I could now say, "Many speakers do not adequately prepare their speeches." Or I could say, "Out of ten speakers, seven are almost certain to fail to make a serious effort to get worthwhile facts for an audience, two will do a fair job, and one will make a comprehensive study of his subject." Even a little effort will leave him just one real competitor out of ten speakers on the average two-day convention program.

So in preparing your speech, you must:

1. Know your subject.

2. Use facts, figures and illustrations.

3. If the audience is to be convinced of some proposition, begin with subject matter with which there is agreement.

4. Do not argue, but explain.

5. State briefly and clearly either at the beginning of the speech the three, four, or five main points to be discussed.

The conclusion outlines the major points you have made in the body of the speech. As I mentioned earlier, a listener is going to remember one or two points, and this gives you one more chance to reinforce the points that are important to you. When writing the conclusion, reread the opening and try to use words or phrases from it in the conclusion. This adds continuity, and tends to tie the speech together. A conclusion adds the finishing touch to a speech like gift wrapping and ribbon add the final touch to a present.

Let me give you a short example of an opening, body and conclusion:

"Today we are told, and I'm sure you will agree with me that most people seek success and yet to many of us, success is always a little elusive. And yet, it is within our grasp always, because we can achieve it by developing a success attitude. A point of view that opens us up to the opportunities rather than the road blocks. For example, some 2,000 years ago, a nine foot giant, 400 pounds of Phillistine champion stood on the plains and challenged the Israelites. His name was Goliath, and he said, "I am going to beat you. Send out your champion and I will destroy him." The Israelites said, "Wow, that's a giant. He's too big. He's bigger than ten of us. We don't have a champion strong enough and big enough to beat him. He's too big for us to meet in battle." Seventeen year old David came by and he looked at this 9 foot giant, 400 pounds, great big wide shoulders and said, "My God, what a target. I can't miss." He said, "I'll challenge him." And David's brothers took him aside and said, "Look, he'll destroy you, he's too big." And David said, "No, he's too big to miss." And the story is history. That with the proper attitude, we can achieve success.

There it is: Opening, body, and conclusion.

I am often asked how one overcomes the fear of public speaking. Nervousness, sweaty palms, dryness of the mouth, and tipsy stomach. How many of you have experienced some of these at one time or another? I read in the Mike Mailway column recently, and I quote: "Fear of speaking before groups is listed as the number one phobia. It's said to outrank the fears of heights, insects, financial problems, deep water, sickness, death, flying, loneliness, dogs, riding in cars, darkness, elevators, and escalators." So obviously, the fear of public speaking cannot be taken lightly. And overcoming it is a major obstacle. There are ways to overcome the fear of speaking. They fall into three categories:

1. Diligent preparation. Know your subject! As we discussed earlier, few people are prepared to give a speech. Many people have a great deal of knowledge on a subject, but have not taken the time to write it out in a logical sequence so an audience can follow and understand it. What a waste of knowledge! Too many people believe that knowledge of a subject <u>is</u> preparation. <u>It</u> <u>is</u> <u>not</u>.

2. Practice. How many of you are golfers? How many of you consider yourselves good golfers? I've golfed a little. We all know what practice is, and like in any endeavor, it is reinforcing the new

habits and eliminating the old. While speaking, everytime we get on our feet, even on the spur of the moment, we must remember these principles. And if we have time to prepare, we must use that time to prepare an interesting, logical, understandable speech. And we must do it <u>every time</u>.

3. Attitude. Oh how I live to talk about attitude. How often do we mentally watch ourselves fail? We Just know we won't do a good job when we give that speech. Using myself as an example, I know I'm going to do a good job today. I know my subject, I've practiced it well, and I've watched myself give this speech in front of you. Now that may sound egotistical, but when you stand up to that golf tee, do you picture the ball going into the woods, or do you see it going straight down the fairway 250 yards? Chances are, where you picture that ball going is usually where it goes. There is nothing you can do that will give you a better chance of improving your attitude about speaking than to sit back, close your eyes, and picture yourself giving a great speech and having it warmly received.

I'm going to get right back to attitude, but first let me sum up this point by reemphasizing that the best way to overcome the jitters is thru (1) preparation, (2) practice, and (3) attitude. Whenever I think of attitude, I'm often reminded of something one of my friends once said. He told of a fellow who lived in the city and decided to relocate in a beautiful farmland. He's driving along the road and sees a farmer in the field and he says,"I could find out what's in this little village up ahead; find out if that would be a suitable place to relocate." He pulls the car over, steps out and says to the farmer, "What are the people like in this village up ahead?" And the farmer saunters over and says, "Well, what were the people like in the city you came from?" "Oh my God, they were miserable people. They were thieves, I couldn't find any that I agreed with. They were always trying to do me in." The farmer looked at him and said,"Hey, the people in that little village are just the same." So the fellow drove on and passed that little village. It wasn't fifteen minutes later when another fellow with the same ideas, from the same city drove by, stopped the car, and called the farmer over and asked him the same question. "What are the people like in this little farm village up ahead?" And the farmer in his wisdom asked the same question. "Well what were the people like in the city you came from?" He said, "They were great! The people were helpful. They were kind, and whenever I needed assistance, they were always there to show the way. And they were a fair lot." And the farmer looked at him and said, "That's just like that group of people who live in that little village up ahead. You'd enjoy these people." That family found a new home that day. When you come to an audience, be that second traveler. Look at this audience as a group of spiritual beings filled with love, and love them back.

The choice of individual words and the arrangement of these words is a very important part of public speaking. Clearness of expression is the first imperative. Everything else yields to clarity. The effort that speakers make to obtain style and clarity of expression is illustrated by the comment of Phyllis Moirs writing of Winston Churchill in "I was Winston Churchills Private Secretary". She wrote: "I can see him now, pacing slowly up and down the room, his hands clasped behind his back, his shoulders hunched, his head sunk forward in deep thought, slowly and haltingly dictating the beginning of a speech or article. I wait, my pencil poised in midair as he whispers phrases to himself, carefully weighing each word and striving to make his thoughts balance. Nothing may be put down until it has been tested aloud and found satisfactory. A happy choice bring a glint of triumph to his eyes; a poor one is discarded. He will continue the search until every detail of sound, rhythm and harmony is all to his liking. Sometimes there are long halts, during which he patiently sounds out a phrase a dozen times, this way and that, making the cigar in his hand serve as a baton to punctuate the rhyme of his words."

From this statement it is evident that Winston Churchill's eloquence did not just happen. It was not an accident. It was a most carefully studied effort of a great mind that had struggled word by word and phrase by phrase for the brilliant expression of ideas that would move nations.

Clearness of expression is most easily achieved thru simplicity of word choice, and sentence structure. Spoken language must be understood immediately. A listener does not have the luxury of looking up words he doesn't understand, or rereading sentences or phrases that he does not understand. If we use words people do not understand, we also take the chance of alienating an audience because a person can get the feeling you're talking down to him. It makes him feel uncomfortable, and worst of all, he'll quit listening. The one thing he won't be is impressed.

One of the most moving speeches I've ever heard demonstrates this simplicity of style and clarity, while sacrificing absolutely nothing. It is the eulogy given at Bobby Kennedy's funeral by his brother Ted. Listen to the beauty of its simplicity.

"Like it or not, we live in times of danger and uncertainty. That is how he lived, and that is what he leaves us. My brother need not be idealized or enlarged in death beyond what he was in life. But to be remembered simply as a good and decent man, who saw a wrong and tried to right it, saw suffering and tried to heal it, who saw a war and tried to stop it. Those of us who loved him, and who take him to his rest today, pray that what he was to us, and what he wished for others, will someday come to pass for all the world. As he said many times in many parts of this nation, to those he touched and to those who touched him. "Some men see things as they are, and say why, I dream things that never were and say why not?"

This speech beams with simplicity. The longest word is "uncertainty", and the most difficult word is "idealized", and the average length of every word is 3.5 letters.

We have talked about how we build ourselves up.

The key ingredients in any presentation are:

1. Speak our thoughts in a confident way.

2. Articulate our words so anyone can understand them.

3. Put our thoughts in their natural progression of order.

4. Present these thoughts in such a way that we could persuade our audience that what we are presenting has value to them, and may even change their life.

But as Houdini wrote in his great book on magic. He said, "The trick of pulling the rabbit out of the hat was really the trick of putting the rabbit into the hat in the first place." The trick is being able to find confidence, to articulate, to be able to present our ideas in their logical order. We must find these within ourselves first, then begin to express them in our daily lives.

I was asked about two years ago to give a speech that would explain a phenomenon that I decided to call the "Magic of Speech". I set about trying to find what it was that came over us in certain listening situations. Rarely, but sometimes when we're listening to a speaker, we become totally unaware of the physical world. We might be sitting on a chair that's too hard, but we don't notice that it's uncomfortable. We might have something else on our mind, but we are drawn away from it as we're pulled further into this experience. It might be described as a level of hypnotism. It could be described as an out of body experience. You may or may not believe that there are other channels of communication other than listening, speaking and sight. If you've ever had the opportunity to hear a speaker who was not polished, he or she knew nothing of the technique of talking, and wasn't dressed well, but somehow when that person talked, everybody listened, because the person was talking from the heart. And I'm sure you've heard other speakers. They were the polished pros. They did everything right.

And for some reason you sat back and said, "I don't know. I don't know if I trust that person." There are other avenues of communication that I don't pretend to understand. I think it was Will Rogers who when asked if he believed in God said, "I don't really know, but just in case there is, I'm going to cover all the bases." And that's what we must do in public speaking. We must feel within and touch all the bases. We must feel within ourselves for love, kindness, self assurance, and a belief that what we have to present is worthwhile.

The great worth of you will surface thru effective communication. An author is usually no greater than the book he writes. And certainly, I think you'll all agree that an artist is no greater than his painting. But having written a book the author can write a better book. And having painted, the painter now with that experience can go on to greater things. And so with each of you, your first speech is or was no greater than you, or me. But the second one will be greater, and the third will be greater yet, and the fourth and fifth and so on throughout the natural progression of our own lives. We will build a life quality with a degree of freedom that only a few percent of the American people have today, and that is the freedom to confidently and lovingly stand before people and speak.

POA ANNUA CONTROL IN TURF WITH NORTRON[1]

Tom Cook & Carol Maggard[2]

In recent years Nortron (ethofumesate) has been used successfully for *Poa annua* control in seed fields. Research has also been conducted in the south on overseeded putting greens with promising results. We have been testing this chemical for the past two years to determine if it can be used successfully in the Willamette Valley on turf.

There appears to be considerable confusion as to whether this chemical is primarily a pre-emergent herbicide, a post-emergent herbicide, or both. Obviously, until these properties are determined, Nortron will be of little value in turf culture.

PRELIMINARY OBSERVATIONS

Our initial tests were conducted on mature turf of perennial ryegrass, colonial bentgrass, and Kentucky bluegrass. Each of these grasses were treated with 3 formulations, and 3 or 4 different rates of Nortron. In addition, each species was treated in fall, spring, and summer to determine seasonal tolerance. After two years we have observed no post-emergence control of *Poa annua* at any rate or formulation regardless of timing. Turfgrass tolerance has been excellent at all times except for slight injury to Highland bentgrass from fall treatments. Kentucky bluegrass also showed slight discoloration from fall treatments but without lasting effects. We are now looking at repeat treatments to determine if they will affect the mature *Poa annua*.

Greenhouse tests have been designed to determine pre- and post-emergence activity of Nortron on *Poa annua*

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and selected turf species. At rates of Nortron between 1 - 2 kg ai/ha, pre-emergence activity against *Poa annua* has been excellent. Applied at the 1 to 3 leaf stage, Nortron has also been effective in controlling *Poa annua*. After tillering Nortron retards the *Poa annua* but does not kill it. These observations are consistent with those of Dr. Orvid Lee who has tested Nortron extensively for use in grass seed fields.

Additional greenhouse tests have indicated that Nortron may have selective pre-emergence properties. For example, when Nortron was applied at 1.5 kg ai/ha to flats seeded with several cool season turf species, perennial ryegrass and red fescue were able to germinate and establish, while Kentucky bluegrass and bentgrass were not. In our initial tests there were delayed germination and retarded growth in both the perennial ryegrass and the red fescue. We are now doing more work to determine the best rates and timing to insure selective development of these grasses.

CONCLUSIONS

Our work thus far indicates that Nortron has limited value as a post-emergence control for mature *Poa annua*. However, it does show promise as a pre-emergence herbicide with slight post-emergence activity. Further, it has potential for use in selective pre-emergence control of *Poa annua* in new plantings of perennial ryegrass and fine fescue. Additional work will be oriented toward the last direction.

GROWTH REGULATOR RESEARCH ON TURF[1]

Tom Cook[2]

I. Effects of Embark and MBR 18337 on predominantly *Poa annua* turf.

METHODS AND MATERIALS

The treatment area was a one-year-old mixed stand of *Poa annua* and *Poa trivialis* and contained an assortment of broadleaf weeds including clover, false dandelion, and black medic. At the time of treatment the area contained approximately 60 percent *Poa annua*. Turf was mowed regularly during the experiment. Rainfall was plentiful and no supplemental irrigation was applied during the test. Plots were not fertilized during the course of the experiment.

Chemical treatments were initiated March 27, 1981 with repeat applications made April 20 and May 4. Treatments were made to 1.5 x 1.5 m plots using a compressed CO_2 sprayer with a fixed boom. Spray volume was 711 ℓ/ha (= 75 gal/acre). After treatment, plots were rated for color, flower intensity, and turf quality.

1/ Presented at the 35th Annual Northwest Turfgrass Conference, Olympia, WA, September 22-24, 1981.

2/ Assistant Professor, Department of Horticulture, Corvallis, OR.

RESULTS AND DISCUSSION

Table 1. Effects of single applications of Embark and MBR 18337 on plot color of *Poa annua* turf.

Treatment	Rate kg ai/ha	$\bar{X}$ plot color*
Check	0	6.0 a**
MBR 18337	0.2	3.7 b
Embark	0.2	3.0 bc
Embark	0.4	3.0 bc
MBR 18337	0.4	3.0 bc
MBR 18337	0.8	2.7 bc
Embark	0.8	2.3 c

* Rated on scale of 1-9 1 = brown 9 = dark green

** Means followed by different letters are statistically different at the 0.5 level using Duncan's multiple range test. (Duncan's significant range = 1.13)

Treatments in Table 1 were made 3/27/81 and ratings were made on 4/16/81. At that time all treated areas had received one application. Relative discoloration generally was not statistically greater with increasing application rates but there did appear to be a trend towards more injury at higher rates. Poor color ratings for treated plots reflects injury to the *Poa annua*. In this test *Poa trivialis* was injured less than the *Poa annua*. Broadleaf weeds showed no effects from treatments except for chickweed which appeared stunted.

Table 2. Effects of repeat applications on Embark and MBR 18337 on plot color of *Poa annua* turf.

Treatment	Rate kg ai/ha	No of appl.	$\bar{X}$ plot color*
Embark	0.8	1	7.0 a**
Embark	0.4	2	6.3 ab
MBR 18337	0.8	1	5.7 bc
MBR 18337	0.4	2	5.3 cd
Check	0	0	4.7 de
MBR 18337	0.2	3	4.0 ef
Embark	0.2	3	3.7 f

* Rated on scale 1-9 1 = brown 9 = dark green

** Means followed by different letters are statistically different at the 0.5 level using Duncan's multiple range test (Duncan's significant range = 1.81)

Plots receiving one application were treated on 3/27/81. Plots receiving two applications were treated 3/27/81 and 4/20/81. Plots receiving three applications were treated 3/27, 4/20, and 5/4/81. Ratings reported in Table 2 were made on 5/19/81. The data indicate that Embark treatments at .8 and .4 kg ai/ha were recovering from initial discoloration and were beginning to show the color enhancement often observed with Embark. MBR 18337 at .8 and .4 kg ai/ha showed similar trends but had not regained as much color as the similar Embark treatments. The poor color rating for the check plot reflects the fact that no fertilizer had been applied to the test plots during the course of the experiment. MBR 18337 and Embark applied 3 times at .2 kg ai/ha were still active and resulted in color ratings generally lower than the check plots. Most discoloration in these plots was due to injured or dead *Poa annua*.

Table 3. Effects of repeat application of Embark and MBR 18337 on intensity of flowering in *Poa annua* turf

Treatment	Rate kg ai/ha	No. of applications	$\overline{X}$ flower intensity*
Check	0	0	7.7 a**
Embark	0.8	1	5.7 b
Embark	0.4	2	3.0 c
MBR 18337	0.8	1	2.3 cd
MBR 18337	0.4	2	1.7 cd
Embark	0.2	3	1.0 d
MBR 18337	0.2	3	1.0 d

* Rated on scale of 1-9 1 = no flowers 9 = heavy flowering

** Means followed by different letters are statistically different at the .05 level using Duncan's multiple range test (Duncan's significant range = .96)

Ratings for flower intensity were made on 5/19 which was approximately 2 weeks after the last repeat applications and 7 weeks after initial treatments. Flower intensity was greatest in check plots followed by the single Embark treatment at 0.8 kg ai/ha. Both of these treatments showed statistically greater flowering than any of the other treatments. At a given rate MBR 18337 appeared to be more effective than Embark in suppressing flowering. In general flower suppression appeared to be excellent for all treatments as long as the chemical was active. Once activity diminished, flowering proceeded almost as if no treatment had been made. Since the flowering period for *Poa annua* is relatively long in our area, it is doubtful that a single treatment with Embark would give season long control of flowering regardless of rate.

Table 4. Effects of repeat applications of Embark and MBR 18337 on turf quality of *Poa annua* turf.

Treatment	Rate kg ai/ha	No. of applications	$\overline{X}$ plot quality*
Embark	0.8	1	7.0 a**
MBR 18337	0.8	1	6.7 ab
Embark	0.4	2	6.0 abc
MBR 18337	0.4	2	5.7 bc
Check	0	0	5.0 c
Embark	0.2	3	3.3 d
MBR 18337	0.2	3	2.7 d

* Rated on a scale of 1-9 1 = dead turf 9 = dense, lush green

** Means followed by different letters are statistically different at the .05 level using Duncan's multiple range test (Duncan's significant range = 1.23)

On 6/15/81, eleven weeks after initial treatments, turf quality was inversely related to the number of chemical treatments that plot had received. Embark applied once at 0.8 kg ai/ha gave highest turf quality although statistically it was no better than MBR 18337 at 0.8 kg ai/ha or Embark applied twice at 0.4 kg ai/ha. Both Embark and MBR 18337 applied once at 0.8 kg ai/ha were statistically better than the check plot. This again reflects the color enhancement often observed with Embark and the fact that the check plot received no fertilizer during the test. The poor quality in the 0.2 kg ai/ha plots was due largely to thin turf caused by dead *Poa annua*. Surviving turf in these plots was primarily *Poa trivialis*.

CONCLUSIONS

In this test Embark and MBR 18337 were very similar in their effects. Typical activity included initial discoloration, 4-6 week growth suppression, flower inhibition, and a greening response after growth suppression had ended. In general MBR 18337 was more active as indicated by greater discoloration, longer suppression of growth and flowering, and generally greater injury to the *Poa annua*. Post activity color enhancement was greater with Embark.

Repeat applications with either material resulted in prolonged growth and flower suppression, greater discoloration, and generally lower turf quality. Single applications did not yield full season suppression of flowering.

II. Effects of Embark and MBR 18337 on *Lolium perenne* turf.

MATERIALS AND METHODS

The treatment area was a two-year-old stand of perennial ryegrass (50% Diplomat, 50% Regal) maintained at a mowing height of 1 inch. At the time of treatment the entire area contained less than 5% *Poa annua* and was relatively weed free. The turf was mowed regularly during the experiment. Rainfall was plentiful and no supplemental irrigation was applied. No fertilizer was applied during the experiment.

Chemical treatments were initiated 3/27/81 with repeat applications made 4/20 and 5/4. Treatments were made to 1.5 x 1.5 m plots using a compressed CO_2 sprayer with a fixed boom. Spray volume was 711 ℓ/ha (=75 gal/acre). After treatment, plots were rated for color and flower intensity.

RESULTS AND DISCUSSION

Table 1. Effects of single applications of Embark and MBR 18337 on plot color of perennial ryegrass turf.

Treatment	Rate kg ai/ha	$\bar{X}$ plot color*
Check	0	7.3 a**
Embark	0.2	6.3 b
Embark	0.4	6.0 bc
MBR 18337	0.2	6.0 bc
MBR 18337	0.4	5.3 cd
Embark	0.8	4.7 d
MBR 18337	0.8	4.7 d

* Rated on scale of 1-9 1 = brown 9 = dark green

** Means followed by different letters are statistically different at the 0.5 level using Duncan's multiple range test. (Duncan's significant range = .96)

Color ratings in Table 1 were made 3 weeks after initial treatments which were applied on 3/27/81. At the 0.2 and 0.4 kg ai/ha rates the turf tolerated Embark well. The 0.2 kg ai/ha rate of MBR 18337 was similar to the Embark treatments. At 0.4 kg ai/ha the MBR 18337 material appeared to be slightly more severe than the Embark treatment. At 0.8 kg ai/ha both materials caused severe discoloration. There were no obvious effects on the broadleaf weeds in the plots regardless of herbicide application rate.

Table 2. Effects of repeat applications of Embark and MBR 18337 on plot color of perennial ryegrass turf.

Treatment	Rate kg ai/ha	No. of appl.	$\overline{X}$ plot color*
Embark	0.8	1	8.0 a**
MBR 18337	0.8	1	7.7 ab
Embark	0.4	2	7.3 ab
Check	0	0	7.0 bc
MBR 18337	0.4	2	6.3 cd
Embark	0.2	3	5.7 de
MBR 18337	0.2	3	5.0 e

* Rated on scale of 1-9 1 = brown 9 = dark green

** Means followed by different letters are statistically different at the 0.5 level using Duncan's multiple range test (Duncan's significant range = .89)

Ratings in Table 2 were made on 5/19, approximately 2 weeks after the last repeat applications. At this time the single treatments of Embark and MBR 18337 generally rated highest followed by Embark at 0.4 kg ai/ha and the check plot. Embark at 0.8 kg ai/ha was statistically better than the check. These high color ratings reflect the color enhancement that typically results after the initial effects of Embark have diminished. Embark at 0.4 kg ai/ha was statistically better than MBR 18337 at the same rate. This follows a general trend and it appears that MBR 18337 is slightly more active than Embark. Three applications of either material at 0.2 kg ai/ha resulted in continued discoloration of treated plots and rated lowest of all treatments.

Table 3. Effects of repeat applications of Embark and MBR 18337 on intensity of flowering in perennial ryegrass turf.

Treatment	Rate kg ai/ha	No. of applications	$\overline{X}$ flower intensity*
Check	0	0	6.0 a**

Table 3 (continued)

Treatment	Rate kg ai/ha	No. of applications	$\overline{X}$ flower intensity*
Embark	0.4	2	2.3 b
Embark	0.8	1	1.7 b
MBR 18337	0.4	2	1.7 b
MBR 18337	0.8	1	1.3 b
Embark	0.2	3	1.0 b
MBR 18337	0.2	3	1.0 b

* Rated on a scale of 1-9 1 = no flowers 9 = heavy flowering

** Means followed by different letters are statistically different at the .05 level using Duncan's multiple range test (Duncan's significant range = 1.48)

Even though the test plots were mostly perennial ryegrass there were enough contaminants such as *Poa annua*, *Poa trivialis*, and *Holcus lanatus* to see apparent differences in flowering among plots. As the data indicate there were significantly more flowers in the check plots than in treated plots. Differences between other treatments were not significant.

CONCLUSIONS

As in the *Poa annua* plots Embark and MBR 18337 showed very similar activity including growth suppression, discoloration, flower inhibition, and color enhancement after growth suppression subsides. MBR 18337 appeared to be somewhat more active than Embark.

In general perennial ryegrass tolerated the treatments well although multiple applications showed a tendency towards excess discoloration and some thinning. In comparing the *Poa annua* plots with the ryegrass both Embark and MBR 18337 appeared to be more active on *Poa annua* than on perennial ryegrass.

MISCELLANEOUS OBSERVATIONS

Embark was applied on 3/20/81 at a rate of .25 lb/acre to a large turf area that had been established with 5 different species of turf the previous fall. Slow germinating grasses such as Kentucky bluegrass and in this case colonial bentgrass were heavily invaded by *Poa annua* and mouseear chickweed. Plots containing *Poa annua* and chickweed showed extreme yellowing while others showed minimal discoloration. Growth suppression was good for about 5 weeks. Eventually the injured *Poa annua* recovered and proceeded to flower prolifically.

UNDERSTANDING THE MECHANISM FOR THE CULTURAL CONTROL OF ANNUAL BLUEGRASS *(Poa Annua)* WITH LOW SOIL pH AND LOW PHOSPHORUS FERTILITY[1]

John T. Law Jr.[2]

Roy Goss and others have shown that by reducing soil pH through sulfur applications and by minimizing phosphorus fertility, annual bluegrass invasion of bentgrass turf can be reduced. This fertility management is a cultural practice so the reduction of annual bluegrass is not nearly as quick or dramatic as with selective herbicides, but nevertheless is clearly there. However, this cultural control of annual bluegrass is not as consistent or predictable as we would like. One problem is we don't know how the low soil pH and phosphorus fertility reduces annual bluegrass competitiveness relative to bentgrass. If we understood the mechanism we could probably better understand the observed inconsistencies and better integrate this cultural approach with selective herbicides. For example, if we knew when the cultural program had minimal effectiveness, we could use a selective herbicide like Endothall and maintain control. This form of pest management is called integrated pest management (IPM).

To determine how low pH and low phosphorus reduce annual bluegrass growth is a complicated problem. When pH is lowered aluminum concentration (or activity) is increased, and aluminum is toxic to most plants. Bentgrass is relatively tolerant to toxic heavy metals and may also be tolerant to aluminum, also a toxic metal. Therefore, aluminum could be a factor in reducing annual bluegrass growth. Aluminum also complexes with phosphorus, effectively reducing the amount of phosphorus

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1/ Presented at the 35th Annual Northwest Turfgrass Conference, Olympia, WA, September 22-24, 1981.

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available to the turfgrasses. To further complicate matters, aluminum concentration strongly influences pH. Calcium also interacts with pH and phosphorus and could easily be another aspect of the problem, but is one we are not focusing on.

What we have is a situation in which at least three factors important to plant growth which change with each other, i.e. aluminum concentration, pH, and phosphorus concentration. Therefore, the traditional agronomic approach of varying one factor and holding the others constant cannot be straightforwardly used.

Fortunately, the variation between aluminum, pH and phosphorus concentration is not strictly proportional. In other words, aluminum concentration can be changed a certain amount and soil pH will not change the exact same amount, or soil pH can be lowered without reducing soil phosphorus levels to the same degree. To determine how the cultural control program for annual bluegrass works we will have to experimentally exploit these small differences.

We assume that the primary action of the cultural control is on roots and that the observed differences in turf stand composition result from these differences in root growth. We make this assumption because soil pH, phosphorus and especially aluminum, strongly affect root growth. Measuring root growth is difficult because roots are not directly observable and are difficult to separate from the soil. Another problem is variability in root distribution. This means that many samples have to be taken to be sure of getting a true measurement of root growth.

This past summer we developed a method to quantify root growth and have taken some preliminary data. What we have learned is that there is yet another complicating interaction with pH. Breakdown of roots is suppressed at low pH's so root masses may be higher at a low pH even if the actual amount of functioning roots is lower. This winter we hope to refine our methods so we can actually determine the amount of functioning roots present. Even if we continue to have trouble with root determination, we can still estimate the amount of annual bluegrass in a stand of bentgrass and use that measurement as we have in the past. To understand how pH, phosphorus and aluminum affect annual bluegrass we have to be able to measure these factors. There are many soil phosphorus analyses available, and this past winter we worked out an aluminum analysis method. Soil pH is easily measured with a pH meter. Therefore, we can measure the three main factors which we assume limit annual bluegrass growth. However, measuring these factors and interpreting what they mean are two entirely different problems. Phosphorus tests are difficult to interpret even though many soil scientists and agronomists have put decades of research into this problem with traditional crop plants. Turfgrasses are even worse because they can utilize phosphorus that is considered unavailable for most crop plants. An extremely low phosphorus level for traditional crops, as indicated by a soil test, may be more than adequate for turfgrasses. In fact, several common phosphorus tests will indicate no available phosphorus in a soil that supports vigorous, healthy bentgrass. Much less research has been done with aluminum, but the problems of relating how a chemical analyses "sees" an easily complexed soil element and how a plant "sees" the element are similar.

Fortunately soil pH values are easier to interpret and as mentioned above are also easy to measure with a pH meter. As I mentioned above, Roy Goss has already shown that annual bluegrass is generally reduced by lowering pH or phosphorus levels, and he has set up long-term fertility plots and has observed them for many years. If we measure soil pH and the amount of annual bluegrass present for several years on various fertility treatment plots, we will have an indication of how consistently annual bluegrass growth is influenced by pH. The next step is to look for turf plots where there are consistent differences in amount of annual bluegrass but little difference in soil pH. When these areas are found, it would then be worthwhile to put the time and effort into phosphorus and aluminum measurements to see what their levels are. We will be trying to determine whether phosphorus is consistently low or aluminum is consistently high. If this is done enough times we should be able to tell if it is the phosphorus or aluminum that is causing the difference in annual bluegrass growth. Remember that soil phosphorus and aluminum concentrations generally vary with each other with small exceptions, and this is why phosphorus and aluminum determinations will have to be done many times; to pick out these small differences.

THE NEW WWREC MICROCOMPUTER SYSTEM AND ITS USE IN THE TURFGRASS RESEARCH PROGRAM[1]

John T. Law Jr.[2]

The turf research program at the Western Washington Research and Extension Center in Puyallup has made use of the computer at Washington State University in Pullman for data analysis for years. We came to the conclusion last year that we could make our research program more efficient, as well as provide more information for turfgrass managers, by having our own computer in Puyallup. The continuing price reductions and performance increases in small (micro) computer systems in recent years had made this possible. This past winter I spent part of my time implementing a microcomputer system and writing computer programs to meet our turf research needs.

Therefore, part of my discussion of our ongoing turf research will focus on how the new computer system is presently being used to support the turf research program. In addition, I will discuss some potential uses of the computer which will strengthen the turf research program in coming years.

First, I would like to discuss the evaluation of new agricultural chemicals. There are several experimental root-absorbed growth regulators, and we see a lot of potential for these products. These new growth regulators show no or very little phytotoxicity, and depending on the compound, suppress or enhance seedhead production. Money and energy spent on mowing can be saved by the use of these growth regulators. There are also several promising selective post-emergence grass herbicides. These post-emergent grass herbicides show

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1/ Presented at the 35th Annual Northwest Turfgrass Conference, Olympia, WA, September 22-24, 1981.

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promise in reducing the serious problem of invasion of one grass species by another. The outstanding problems are *Poa annua* invasion of bentgrass and bentgrass invasion of bluegrass, red fescue and ryegrass.

Our computer system facilitates this work by making product evaluations faster and more efficient as well as improving the presentation of results. A great deal of data are generated, all of which must be statistically analyzed and summarized for interpretation. For better appreciation of what is involved with testing agricultural chemicals I would like to discuss some numbers involved with collection of data. Say we decide to test ten chemical products or mixtures of chemical products out of the 50 or so that we feel have potential for use by turfgrass growers. As one part of this test we want to know how the turf responds to different application rates. For example, for a product to be practical for the turfgrass industry, it must not have too narrow a range between the minimum effective rate and the maximum rate at which no toxicity is evident (the working range). Therefore, we must usually test a number of rates. If the product has not been tested much before, we might have to try five rates to be sure of getting both a minimum effective rate, and a rate where toxicity is evident. If the product has been tested several times before, we may know the proper rate. For the purposes of this discussion, let's say we use two rates. That gives us 10 products X 2 rates, or 20 turfgrass plots.

We routinely work with 6 turfgrass species; creeping bentgrass, colonial bentgrass, red fescue, perennial ryegrass, Kentucky bluegrass, and tall fescue. Say we test 10 chemical products on only 3 species. That gives us 10 products X two rates X three species or 60 turfgrass plots.

Most of these chemicals are sensitive to application timing since all plants go through a yearly life cycle, and also respond to other weather changes. So apply the product on 3 dates. That gives us 10 products X 2 rates X three species X three application times or 180 turfgrass plots.

As I mentioned above, the information from these chemical trials has to be statistically analyzed so we can identify differences attributable to the chemical products when there are also differences from other causes. For this determination we need replications of treatments. Three replications are usually the minimum one can get by with. Generally, between four and eight replications are required for field work. Sometimes, especially when analyzing root growth, more are needed. For this example we will expect such a dramatic response from our product that other changes are overwhelmed and use only three replications. Now we have 10 products X two rates X three species X three application times X three replications or 540 turfgrass plots.

All these plots have to be evaluated for various responses to the product. We have to decide how well the product works. For example, did this particular herbicide kill the particular weedy grass we thought it would. Often we have to evaluate the herbicide effectiveness on several weed species. For example, in a red fescue turf we might want to make separate evaluations for effectiveness against bentgrass, annual bluegrass and maybe velvetgrass. For broadleaf herbicides an evaluation of action against even more species is required. There are at least 7 broadleaf weeds we consider a problem.

Besides evaluating the experimental plots for how well a product works, we have to evaluate how the desirable turfgrass species was affected by the product. Important phytotoxic effects can be relatively subtle. If the product slightly inhibits tiller formation or speeds up the natural senescence of old or weak tillers the turf will look essentially the same, but density will have been decreased. This phytotoxic effect has to be considered when evaluating the product. Another common phytotoxic effect is the yellowing of the turf called chlorosis. Therefore, at the very least, turf in a chemical evaluation trial has to be evaluated for density and color.

Let's consider our numbers again. We have 540 turfgrass plots and each one is evaluated for density, color, and product efficacy. We will assume that there are only two measurements involved with product efficacy. That will give us 540 plots X 4 evaluations (eg. effect on weed 1, effect on weed 2, density, and color), or 2,160 pieces of data.

We are still not at the end. Most of these measurements have to be taken at several different times. A product might work faster or slower depending on the nature of the product, the weather and how well the turf was growing when the product was applied. For example, an herbicide might decrease density because the dead weeds left empty spaces. How much of a problem this is depends on how quickly the turf fills in. Maybe the herbicide slows turf growth for a while. Therefore, density has to be evaluated several times. Color is similar. Slight chlorosis for 3 days might be okay, but not for 3 weeks. Some weeds take longer to die than others, so herbicide efficacy also has to be evaluated several times. Say we evaluate our plots 3 times. We now have 540 plots X 4 different evaluations X 3 evaluation times or 6,480 pieces of data from the plots. We will also have environmental data such as soil temperature, air temperature and rainfall. Environmental data is essential for integrating cultural and chemical management.

After collecting this data it has to be analyzed. The first part of data analysis is data entry. Data entry is simply typing the numbers from the field data sheet into a calculator or computer. This may seem like a simple task, and it is, but many errors are made because of the tedium. One advantage the computer has over the calculator is the data only has to be entered once, even if you later decide to do a different statistical analysis, add some data, or put the data into a graph or chart.

There are other ways our computer system enhances data entry. The computer has several centers of intelligence (microprocessors) and one of them monitors the keyboard. Therefore we have an intelligent person typing numbers into an intelligent keyboard that transfers them to the central processing unit. With this arrangement we can set the computer screen up like the original data sheet. The person typing numbers just has to make the computer screen appear like the data sheet and then you know the numbers have been entered correctly. Rather than dealing with numbers one line at a time you can move all around the screen entering and correcting numbers just like on a sheet of paper. Because the process is more natural it is more accurate and requires less training. Since the keyboard is intelligent, it can even enter the repetitive parts of the data itself; such as the application dates, replications, different species, etc., that we discussed previously.

I hope it is clear that we have a lot of numbers to analyze, even for routine agricultural chemical product evaluations. The researcher himself usually has to put a lot of time into this data analysis. Time spent in this way takes away from other activities, of course, but also it is time for which we get little professional recognition. Our computer system helps remedy this situation somewhat by reducing the time it takes to do data analysis, thereby freeing the research staff for recognized academic activities like writing manuscripts. The computer gives us an additional benefit. It can be used to quickly and easily organize the data into tables or charts or graphs thereby making interpretation of the data easier, especially for someone not familiar with the data.

So far we have just considered the data (numbers) that come from our experimental plots. Now let's consider the plots themselves. In the example I just went through we came up with 540 experimental plots. These are 540 little turf areas scattered all over our experimental farm and elsewhere. We need to keep track of these areas and that is no easy matter. Remember, these are turf plots that have to be mowed, so we can't just pound stakes in the ground as is done with field crops like wheat or cabbage. Even marking the plots with grass killer interferes with mowing because the dead grass creates a depression causing the mower to bounce and give an uneven cut. Permanent lines also interfere with re-using the turf.

Another aspect of managing field plots is keeping track of where they were after a particular product evaluation is over. Since many of these chemical products are new, we don't know what the long term effects are, and yet the same area has to be used over again for several studies or we would quickly run out of turf. If something odd appears in a patch of turf we have to be able to determine what the history of that patch was. Sometimes we know the turf has been changed by a particular treatment. This turf can be used for further product evaluation by taking this difference into account when designing a new evaluation trial. For example, say a grass herbicide is not effective against bentgrass in a red fescue turf. Therefore, after the evaluation we will have some red fescue turf infested with bentgrass and some red fescue turf with no bentgrass. The turf in these plots will no longer be equal. However, by the statistical procedure of blocking, we can correct for these differences and use the turf in a new evaluation trial. But we must be able to keep track of the plots with these known differences or the differences will appear as error.

Our computer system is a powerful tool for keeping track of both where the turf plots are and what has been done to them. The computer can also draw accurate plot diagrams with its attached plotter. This last capability is particularly nice since few workers like the tedious job of drawing plot diagrams.

II

In the future we hope to have the computer system provide useful information for some of the decisions turf managers have to make. One of these decisions is whether to spray fungicide for a particular disease. This decision is based on how likely it is that the disease will cause damage to the turf. Some people apply fungicides if there is any chance at all of getting a disease. Such an approach will sometimes result in the unnecessary use of fungicides. This will waste money, and even worse, might contribute to the development of fungicide-tolerant fungi. Another approach is to apply a fungicide only after the disease symptoms appear. Unfortunately, a fast moving disease will kill a lot of turf before the fungicide takes effect. The proper approach is somewhere in between, apply the fungicide only when a disease outbreak is likely.

How does one decide if a disease is likely to occur? This is one of the problems our turf pathologist, Dr. Gary Chastagner, is working on. He is looking into the factors that cause diseases to occur. Climate is an important determinate of disease, and a complex one. The general approach is to measure climatic variables like temperature, sunlight, humidity, and wind, and then correlate these measurements with disease outbreaks. This task is highly dependent upon the computer system both to analyze the data and also to obtain it. I mentioned above how the computer can draw plot diagrams with a plotter. It can also read the charts that weather instruments record their data on with another attached instrument called a digitizer. Without the computer system most data recorded by the charts cannot be used due to the time it takes to hand transcribe the charts.

Once this climatic data is in the computer, it can be reduced to an interpretable and managable form. After reduction and simplification the climatic data is combined with pathogen life cycle patterns and other information into a mathematical model which is fed into the computer. This model then predicts the probability of a disease outbreak, given a set of initial conditions. The prediction would be similar to a weather report, eg. there will be a 40% probability of a *Fusarium* outbreak. This has already been done with certain diseases on other crops. With enough time and effort we can develop predictive models for turf diseases.

III

Another future goal is to have the computer improve the use of visual turf ratings. Visual ratings are the primary method of evaluating turfgrass responses to experimental treatments. The eye is very sensitive and the mind can be trained to distinguish small changes in turfgrass growth patterns. Visual ratings by an experienced person can be accurate (what is seen is actually there), and if one person does the ratings, visual ratings can be precise (repeatable). However, there is a strong element of subjectivity involved, i.e. a person's convictions will influence what is seen. Subjectivity in ratings is most apparent when comparing data from different people. For example, one of the new growth regulators was tested by turf groups around the country. The data showed differences in phytotoxicity and density between the groups. Some of these differences were real, but after discussion and examining slides, it was realized most came from subjectivity in the rating process. Problems with subjectivity are a serious impediment to conducting cooperative research between regions.

This is unfortunate because similar treatments done in different parts of the country can yield information on climatic influences. Furthermore, chemical companies want comparable data from many regions when testing their products so they can gauge the potential market. If we can help identify a larger market for turf herbicides and growth regulators, more of these compounds will probably be developed for the specialized turf market.

Another problem is the time it takes to do the visual ratings, especially when travel time is also involved. Already this is a limiting factor when conducting trials in outlying areas. We would like to do more chemical and fertilizer testing on turf other than our own at the research station. This is the only way to know how well a product or treatment works under actual grower management, soil, and micro-climate conditions. For example, our putting green turf is not mown as often or as short as many golf greens. We simply don't have the manpower. Also our turf is grown on an excellent valley soil and receives very little traffic. Unfortunately, there is hardly enough time to properly evaluate ongoing work right at our own field plots, let alone the time it takes to travel somewhere else and rate treatments. Even if someone did want to take the time, there is not enough travel money now and even that inadequate amount is declining fast.

One way to reduce these problems is to use the computer to assist in visual ratings. By attaching an optical scanner to our computer, photographs of turf can be evaluated for color, density and other factors. Once a photograph of a given type of turf under a limited set of conditions is read by the computer and interpreted by the investigator, then any more of the same type can be quickly read by the computer. Ratings done this way would be quicker and more objective. Also, photographs can be mailed, so the investigator would not have to travel as much to conduct research in distant areas.

Image processing and analysis is a specialized field, but this is not a serious impediment. One capability of our computer system I haven't discussed yet is its communications ability. Our computer can communicate with the main computer at Washington State University in Pullman by telephone. Therefore, we can make use of the very extensive and sophisticated computer resources in Pullman. One of these resources is state-of-the-art image processing expertise and computer software (programs). Therefore, this specialized area of image processing is available to us here at the Western Washington Research and Extension Center since we are part of Washington State University. Also, the plant pathology group here at WWREC is interested in computer-aided image analysis, so we in turf won't be alone in developing procedures. We are already working on acquiring an optical scanner for our computer system.

MANAGING TURFGRASS GROWTH AND STRESS WITH NITROGEN FERTILITY[1]

John T. Law Jr.[2]

Growing quality turf requires a significant quantity of fertilizer, especially nitrogen to replace that lost in clippings, immobilized in thatch and mat formation, and immobilized in soil organic matter, leached past the root zone, and lost through volatilization. Nitrogen also has more potential for causing management problems than any other fertilizer element. Therefore, proper use of nitrogen fertilizer requires more thought and consideration of harmful side effects than any other aspect of fertility management. An understanding of how turfgrass plants respond to increasing amounts of fertilizer makes proper fertility management easier.

Top growth, root growth and disease tolerance all increase when fertilizer is applied to extremely deficient turf. If only a small amount of fertilizer is added, the turf may still show deficiency symptoms even though growth rate will have increased. As more fertilizer is added the growth rate increases further and deficiency signs are no longer evident. Eventually a point is reached at which the addition of more fertilizer does not increase growth. If fertilizer additions are continued anyway, a point will be reached at which the fertilizer will be toxic (usually a salt effect), and growth will be reduced. This response of going from increased growth to decreased growth with increasing amounts of fertilizer is called a subsidy-stress gradient (3). As fertilizer rates are increased, growth is subsidized by the fertilizer. When too much is added the turf is stressed. Different fertilizer elements

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1/ Presented at the 35th Annual Northwest Turfgrass Conference, Olympia, WA, September 22-24, 1981.

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will require different amounts of fertilizer to go from subsidizing the turf to stressing it, i.e., there are differing safety margins.

For example, potassium applied at approximately 3 lb per 1000 ft^2 supports maximum top growth, root growth and disease tolerance. Applying twice that much or 6 lb per 1000 ft^2 gives no more response than 3 lb per 1000 ft^2, and also causes no stress (Figure 1). Applying more than about 10 lb per 1000 ft^2 will decrease top growth, root growth, and disease tolerance because of too much soluble salt. Therefore, potassium fertility is relatively easy to manage. As long as at least 3-4 lb per 1000 ft^2 and not more than 8-10 lb per 1000 ft^2 of potassium are applied, optimum top growth, root growth and disease tolerance is supported (assuming no other fertilizer elements are deficient). The other essential plant nutrients, with the exception of nitrogen, are similar to potassium in their effect on root growth, top growth, and disease tolerance.

Nitrogen response is more complicated because root growth, top growth, and disease tolerance respond differently to a given nitrogen fertilizer rate (Figure 2). Optimum root growth is obtained at a very low nitrogen rate. In fact, the rate is so low, it is just about physically impossible to apply the optimum rate without using slow release nitrogen sources. Achieving optimum root growth would be impractical anyway because top growth would be so slow that the turf would be very thin.

Optimum tolerance to diseases like *Fusarium* patch and blight and *Helminthosporium* leaf spot and blight is obtained at low to moderate nitrogen levels. Disease tolerance does not drop rapidly like root growth at moderate nitrogen levels. Therefore, a somewhat low but acceptable rate of top growth can be obtained at a nitrogen rate that is not too far from that required for optimum disease tolerance.

It must be pointed out that looking at diseases as a function of nitrogen fertility greatly oversimplifies the real situation. The severity of the disease and whether the disease will actually occur is also strongly determined by weather, microclimate, amount and virulence of the inoculum, and age and cultivar composition of the turf stand. Certain diseases also show a different response to nitrogen fertility than the above mentioned diseases. Both red thread and rust are worse at low nitrogen levels than moderate to high nitrogen levels. At low nitrogen levels the rate of top growth is not sufficient to replace damaged tissue. At higher nitrogen levels growth of new leaf blades and tillers occurs faster than these diseases progress, so disease damaged tissue is masked.

To grow quality, close cut, intensively used turf requires high rates of nitrogen fertility relative to that required for utility turf or for most other plants. If the leaf blades and tillers of a turf stand are not vigorously growing, the stand will not be capable of self-repair (recuperative potential) when damaged by wear or insect pests. If open spaces in turf are not rapidly filled in by new growth, weeds and weedy grasses will invade, the soil will be more vulnerable to compaction, and aesthetic quality will be reduced. It must be remembered that in achieving the goal of quality turf a certain amount of stress is inevitable because both root growth and disease tolerance are reduced, neither of which are directly seen. This inevitable stress is manageable however.

Since roots are not visible it is the indirect effects of insufficient root growth that are usually apparent to turf growers. For example, if an area of turf has a crane fly or Japanese beetle infestation, roots will be eaten by the larvae. Visible turf damage results when so many roots are eaten that not enough are left to provide minerals and root produced hormones to support the above-ground part of the turfgrass plant. If the amount of roots is also excessively reduced by high nitrogen fertility, then the crane fly damage will be worse, occur sooner, and with a smaller population of crane flies. Another example is summer stress of cool season turf. Heat stress is the result of insufficient roots and is, therefore, also compounded by high nitrogen rates (2). A third example is water stress. If the turfgrass plant has more roots, it will usually be more resistant to water stress. If excess nitrogen rates reduce root growth, then drought tolerance will also be reduced. Reduced root growth also means that greater than normal diligence is required to keep enough of the fertilizer elements besides nitrogen in the root zone. On sand playing fields and greens the combination of a small root zone and high leaching rates makes it particularly important to keep general fertility adequate.

The tendency of high nitrogen rates to reduce disease tolerance is also easily overlooked. As one example, *Helminthosporium* leaf spots on Kentucky bluegrass are larger, look worse, and cause more damage to turf fertilized with high nitrogen rates. Another example is *Fusarium* patch in bentgrass. The patches are larger, spread faster, and do more damage when nitrogen fertilizer rates are high. In both cases, high nitrogen causes shortages of the compounds (phenolics) necessary to wall off infections before they cause extensive damage. What this means for the manager of close cut turf is that fungicide use must be scheduled at times of the year when disease outbreaks are likely.

When performing turf management tasks, the growth regulating effects of nitrogen fertilizers should be considered. When using herbicides the rate and timing of nitrogen applications should be almost as important as the rate and timing of the herbicide itself. One example is controlling annual bluegrass (*Poa annua*). Annual bluegrass often invades bentgrass greens. One of the best ways to kill annual bluegrass is with the herbicide Endothall. Endothall works to some extent by causing desiccation. Bentgrass is more tolerant of desiccation than annual bluegrass, so the annual bluegrass is selectively killed. Endothall also causes some damage to bentgrass and the overall turf stand is thinned by killing the annual bluegrass portion. It is the fear of harming the bentgrass that causes many people to put up with damage-prone annual bluegrass infested turf. The proper use of nitrogen fertilizer can minimize the adverse effects on bentgrass (1). In the months before applying Endothall, the nitrogen fertilizer rate should not be excessive so that bentgrass will have a vigorous root system and be even more tolerant to the desiccating effects of Endothall. A month or so before applying Endothall sufficient nitrogen should be applied so that the top growth of the annual bluegrass is lush. Annual bluegrass with lush, vigorous top growth is much more susceptible to Endothall, while bentgrass (or bluegrass or ryegrass) is more tolerant to Endothall when vigorously growing. After applying Endothall, nitrogen should again be applied so the bentgrass will quickly fill in the area formerly occupied by annual bluegrass. Otherwise, annual bluegrass will again invade. If the nitrogen rate was high in the months before Endothall application, the nitrogen application just before and after Endothall application might cause enough stress to harm the bentgrass. Applying Endothall during moderate temperatures will also minimize damage to the bentgrass.

Broadleaf herbicides also leave spaces in a turf stand when the weeds are killed. If nitrogen fertilizer is reduced to favor root growth before applying the herbicide, then it can be more safely increased after application. This will stimulate top growth and fill in the gaps in the turf cover.

Because of the important effects of nitrogen on turfgrass growth, the rate and timing should always be carefully considered. Remember that the high nitrogen levels required for the successful culture of fine, close cut turf have potential for harm that is not always obvious. Also remember that different cultivars of the same species require different amounts of nitrogen fertilizer for the same performance. Always question whether your nitrogen rates can be reduced, even slightly. When planning to use herbicides, consider the timing of your nitrogen application. Herbicide effectiveness can usually be increased by altering turfgrass growth with nitrogen. Nitrogen is not just one of the numbers on a fertilizer bag, it is a powerful turf management tool.

LITERATURE CITED

1. Cook, Tom. 1978. Turf in the Pacific Northwest using Endothall. 32nd NW Turf Conf., Richland, WA.

2. Law, John T., Jr. 1980. Supraoptimal temperature stress and nitrogen nutrition in Kentucky bluegrass (Poa pratensis L.). Ph.D. Thesis. Univ. of Rhode Island. 158 pp.

3. Odum, Eugene P., John T. Finn, and Eldon H. Franz. 1979. Perturbation theory and the subsidy-stress gradient. BioScience 29(6):349-352.

Fig. 1 Hypothetical response of turfgrass top growth, root growth, and disease tolerance to Potassium fertilizer.

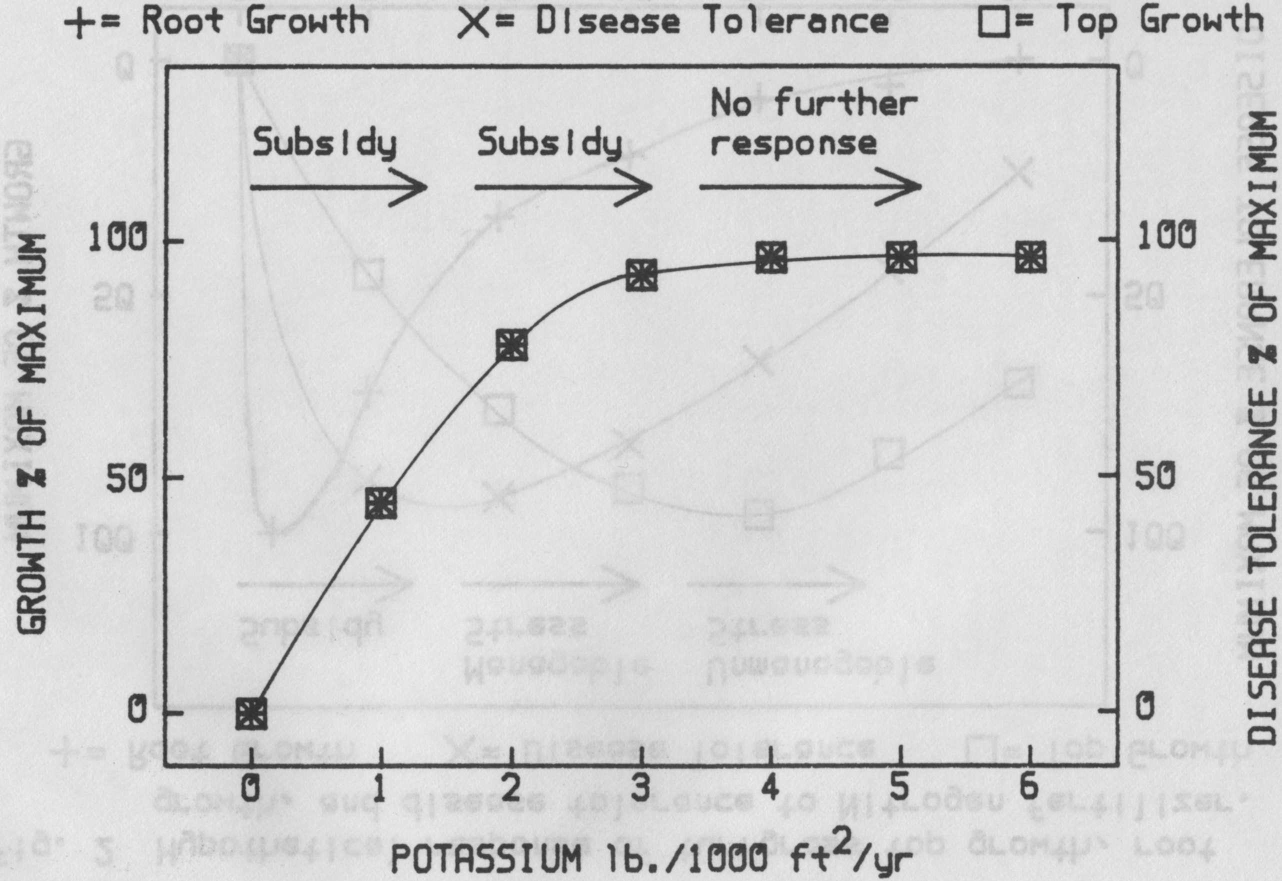
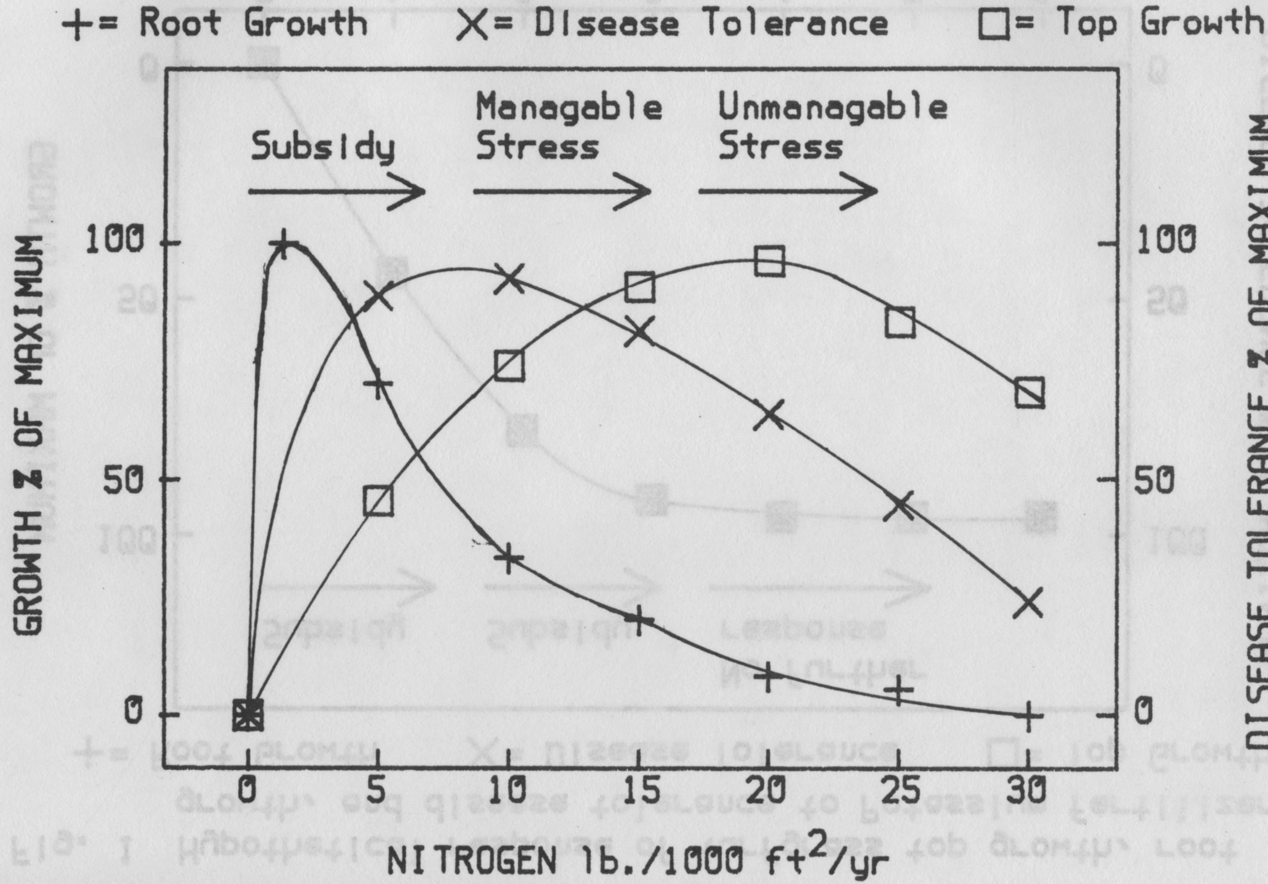


Fig. 2 Hypothetical response of turfgrass top growth, root growth, and disease tolerance to Nitrogen fertilizer.



UPDATE ON DISEASE RESEARCH IN WASHINGTON[1]

G.A. Chastagner[2], W.E. Vassey[3], and Fred McElroy[4]

Control of *Fusarium* patch (pink snowmold) is a consistent problem for growers of fine quality turf in the Pacific Northwest. Extensive work has shown the influence various management practices, particularly the choice of fertilizers, have on the occurrence of this disease. The selection and use of fungicides are also important parts of disease management practices.

During 1980 and 1981 we evaluated several fungicides for their ability to control this disease. The purpose of this evaluation was to (1) compare the relative effectiveness of registered and nonregistered fungicides in controlling *Fusarium* patch, (2) compare the relative effectiveness of different formulations of the same active ingredient, and (3) determine if applications of elemental sulfur during the fall and winter reduce the incidence of *Fusarium* patch.

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MATERIALS TESTED

Acti-dione RZ (WP, Tuco*) 1.3% cycloheximide plus 75% PCNB

Acti-dione TGF (WP, Tuco) 2.1% cycloheximide

Acti-dione Thiram (WP, Tuco) 0.75% cycloheximide plus 75% thiram

Bayleton (WP, Mobay) 25% triadimefon

Chipco 26019 (WP, Thone-Poulenc) 50% iprodione

Daconil 2787 (F, Diamond Shamrock) 40.4% chlorothalonil

MF647 (WP, Mallinckrodt*) 50% vinclozolin

Proturf FFII fertilizer and fungicide (G, Scott's*) 15.4% PCNB

Proturf FFII fertilizer base (G, Scott's) 14-3-3

Proturf Fungicide VI (G, Scott's) 1.3% iprodione

Sulfur (WP) 90% sulfur

Terraclor (WP, Olin) 75% PCNB

* Financial assistance provided in addition to product

Fungicide applications (nongranular) were made with a sprayer equipped with a boom and 8004 tee-jet nozzles. Applications were made at 40 psi pressure. Each application was made in the equivalent of 5 gallons of water per 1000 ft^2. Applications of granular materials were hand broadcast over the turf. This trial was conducted on 'Penncross' bentgrass maintained at 1/4 inch height.

Applications of Chipco 26019 at 6 oz a.i., Scott's FFII, Scott's FFII Fertilizer Base, and Terraclor 75W at 8 oz a.i. per 1000 ft^2 were applied on November 14, 1980 and January 16, 1981. Six applications of the remaining materials were made at 3 week intervals starting

November 14, 1980.

Individual plots measured 1.1 (1 m) x 1.6 (1.5 m) feet and each treatment was replicated six times in a randomized completely blocked design. One to 5.7% of the turf had *Fusarium* patch when the initial application was made. Disease ratings, based on the number of spots per 16.1 ft^2 (1.5 m^2) were made on December 5, 1980, January 7, 15, February 6 and 25, 1981. These data were subjected to analysis of variance and compared using Duncan's multiple range test. The results are presented in Table 1.

COMMENTS

Six applications of Chipco 26019 at 1 oz or 2 oz a.i. per 1000 ft^2, Daconil 2787 F, Actidione RZ, Actidione TGF, Terraclor 75W at 4.5 oz a.i. per 1000 ft^2 and MF 647 every 21 days provided excellent control of *Fusarium* patch. Excellent control was also obtained when applications of Chipco 26019 at 6 oz a.i. per 1000 ft^2, Scott's FFII (PCNB) and Terraclor 75W (PCNB) at 8 oz a.i. per 1000 ft^2 were applied at the start of the test and again 62 days later.

Although Scott's FFVI contains the same active ingredient as Chipco 26019, applications of this material by hand provided slightly less control than did applications of Chipco 26019. Applications of Bayleton at 5 oz a.i. per 1000 ft^2 were not effective in controlling disease development. Previous testing has shown that higher rates of Bayleton were effective in controlling *Fusarium* patch.

The experimental compound MF 647, which is to be sold under the trade name Ornalin, provided good control of disease development throughout this test. This compound is chemically similar to Chipco 26019 and isolates of *F. nivale* tolerant to Chipco 26019 will also be tolerant to Ornalin.

Applications of sulfur during this test did not result in a significant reduction in the incidence of *Fusarium* patch indicating that foliar applications of sulfur do not act as a contact fungicide.

PLANT PARASITIC NEMATODES

Samples collected during April 1981 from our nematode control plots at Ballinger Park Municipal Golf Course revealed that plots which had received fall and/or spring applications of either Nemacur 15G or Dasanit 15G during 1979-80 had significantly fewer ring *Criconemoides* and spiral *Helicotylenchus* nematodes compared to the nontreated areas (Table 2). These results would indicate that use of these nematicides to control nematodes on turf should suppress nematode activity for at least one year.

Microplots have been established at Farm 5 near Puyallup to determine if three of the nematodes which were most commonly found during our 1979 and 1980 surveys are able to cause damage to 'Penncross' bentgrass and *Poa annua*. Changes in nematode populations and damage to these turfgrasses will be determined during the next three years.

TABLE 1. Relative effectiveness of various fungicides in controlling Fusarium patch on 'Penncross' bentgrass.[1]

Treatment	oz a.i./1000 ft^2	% area w/disease 11/17/80	Average number of spots per 16.1 ft^2 (1.5 m^2) 12/5/80	12/24/80	1/7/81	1/15/81	2/6/81	2/25/81
None	-	1.0 x	20.8 x	4.5 x	30.8 w	36.0 v	33.2 x	28.7 v
Chipco 26019 50W	1.0	1.2 x	9.7 x	1.5 x	2.3 yz	3.7 yz	4.0 z	1.3 z
Chipco 26019 50W	2.0	1.0 x	7.7 x	2.3 x	0.7 z	0.8 z	1.0 z	0.7 z
Chipco 26019 50W	6.0	1.3 x	15.2 x	2.3 x	5.5 yz	6.8 yz	4.2 z	0.3 z
Daconil 2787 F	4.4	1.3 x	14.2 x	2.0 x	1.8 z	1.8 yz	2.3 z	0.7 z
Scott's FVI	1.0	5.7 x	18.2 x	7.2 x	15.3 xyz	15.8 wxy	10.8 yz	5.5 xyz
Bayleton 25W	0.5	1.2 x	15.7 x	2.7 x	17.3 wxy	21.7 wx	22.0 xy	21.5 vw
Acti-dione Thiram	0.05 + 4.5	1.2 x	4.7 x	1.0 x	6.8 yz	9.3 xyz	11.3 yz	8.3 xyz
Acti-dione RZ	0.08 + 4.5	5.0 x	9.0 x	1.7 x	3.0 yz	0.2 z	3.5 z	2.0 z
Acti-dione TGF	0.13	1.0 x	3.5 x	1.5 x	4.3 yz	5.5 yz	6.8 z	4.7 yz
Terraclor 75W	4.5	2.2 x	16.3 x	1.7 x	4.8 yz	3.0 yz	5.7 z	0.8 z
Scott's FFII	8.0	2.0 x	18.8 x	2.5 x	5.0 yz	6.0 yz	5.8 z	2.0 z
FFII fertilizer base	43.9	4.2 x	21.8 x	7.8 x	24.7 wx	25.7 vw	28.3 x	21.3 vw
Terraclor 75W	8.0	4.2 x	15.3 x	5.8 x	2.5 yz	1.2 z	4.5 z	1.3 z
Sulfur 90W	8.0	5.0 x	27.2 x	7.3 x	23.0 wx	24.0 vw	25.3 x	17.0 vwx
Sulfur 90W	16.0	3.3 x	15.8 x	5.2 x	10.8 xyz	23.7 vw	26.5 x	15.8 wxy
MF647 50W (Ornalin)	1.0	3.3 x	23.3 x	4.2 x	6.7 yz	6.5 yz	10.2 yz	4.2 yz
MF647 50W (Ornalin)	2.0	5.0 x	19.8 x	5.0 x	7.2 yz	2.0 yz	7.2 z	3.7 yz

[1] Application dates are presented in the text. Numbers in vertical columns followed by the same letter are not significantly different, P = 0.01, Duncan's multiple range test.

Table 2. Effectiveness of nematicide applications during 1979-80 in reducing populations of Helicotylenchus (spiral) and Criconemoides (ring) nematodes in Poa annua putting turf through April 24, 1981.

Treatment	Application[a]	No. nematodes/pint of soil[b] Spiral	Ring
None	-	1775.0 x	1243.8 x
Nemacure 15 G	F & S	0.0 y	6.3 y
Nemacure 15 G	S	12.5 y	12.5 y
Dasanit 15 G	F & S	83.3 y	0.0 y
Dasanit 15 G	S	262.5 y	75.0 y

[a] Applications were made using a drop spreader set to apply 3 lb product/1000 ft^2 on November 20, 1979 (F) and March 11, 1980 (S).

[b] Numbers in vertical columns followed by the same letter are not significantly different, P = 0.05, Duncan's multiple range test.

PERFORMANCE OF PERENNIAL RYEGRASS CULTIVARS AND SELECTIONS IN TURF TRIALS AT PUYALLUP, WA[1]

S.E. Brauen, R.L. Goss, J.T. Law, M. Abraham, and S.P. Orton[2]

Many new fine-leaved perennial ryegrass cultivars have been developed in the past few years. Many of these cultivars are far superior to common cultivars of the past. The newer grasses have improved color, finer leaves, improved mowing quality, lower growing characteristics, and improved density. For areas that have colder winter temperatures, some of these grasses have improved winter hardiness as compared to common types. There appears to be improvement in heat tolerance and wear which is somewhat related to their improved leafiness and density. As with most ryegrasses of the past, they are easy to establish and are adapted to a wide range of soil types. Some are more resistant to rust than others. Rust can cause some cultivars to lose color and quality during mid and late summer.

Perennial ryegrasses have become popular among many turf managers as a result of the above improvements. This popularity has stimulated seed companies to develop more improved cultivars. As a result, more information is needed by users on the strengths and weaknesses of the many new cultivars available to them. Moreover, cultivar developers themselves need to be aware of the performance of their cultivars in different regions. Here at Puyallup one perennial ryegrass evaluation was conducted from 1973 to 1977 to assist in determining cultivar performance characteristics. Two other studies were begun in 1978 to assist in evaluation of the most recently released cultivars and some experimental cultivars.

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EXPERIMENTAL METHODS

Two perennial ryegrass studies were established on a Puyallup fine sandy loam soil with a pH of 5.8 in late summer of 1978. The plot size was 6.5 x 6.5 ft (2 m x 2 m) with three replications in each test. Broadleaf weeds were controlled with a 2,4-D and Dicamba combination once annually. The mowing height was 1.25 inches. The supplemental test which consists of mostly experimental cultivars was mowed with a reel mower with clippings retained on the turf area while the Regional evaluation was mowed with both mulching and bagging type rotary mowers.

The plots receive 4 lb of nitrogen per 1000 ft^2 annually. This fertilizer was applied in 4 equal applications of 1 lb of nitrogen in May, September, December, and March. The plots received adequate irrigation through the dry periods of June through September. Phosphorus and potassium was applied once annually.

SUMMARY OF TURF PERFORMANCE

The average turf quality performance of the named perennial ryegrasses in the Regional evaluation are recorded in Table 1. Cultivars Diplomat, Score, Blazer, Ensporta, Omega, Arno, Bellatrix and Hunter led the list in overall average turf quality. Good general performance occurred from commonly available cultivars such as Pennfine, Derby, Acclaim, Yorktown II, and Manhattan.

As was indicated earlier, all cultivars in the regional study are cut with a mulching rotary mower and a bagging rotary mower in a split-plot layout. In the past, these mowing practices have significantly affected disease development. In 1980, red thread (*Corticium fuciforme*) was significantly more severe where clippings were mulched. Red thread susceptibility differences between cultivars was not clear.

During 1981, rust developed beginning in mid-July and continued to develop through September. Where clippings were bagged, usually the most susceptible cultivars developed rust symptoms early while others developed more slowly. Eventually, all cultivars developed rust symptoms but Diplomat, Blazer, Ensporta, Loretta, Aristocrat, Goalie, and Compas were least affected. Omega, Hunter, Derby, Yorktown, Fiesta, Manhattan, MOM LP 20, Regal, Caravelle, and Servo were highly susceptible.

Where the grasses were mulched, rust did not develop on mnay cultivars. Only a few of the most susceptible cultivars such as Bellatrix, Derby, Yorktown, Manhattan, MOM LP 20, Regal, and Servo developed rust symptoms which significantly altered turf quality. These turf cultivar trials received only 4 lb of nitrogen per 1000 ft^2 annually. Since the nitrogen nutrition level may have been higher in the plots where the grass clippings were mulched into the turf, the difference in disease development experienced in these trials may not occur under higher levels of nitrogen nutrition. Thus, the influence of mowing practices on rust and red thread disease development may be most important under low maintenance conditions.

In the second trial three cultivars have average performance scores higher than the standard cultivars of Manhattan, Citation, and Derby. These varieties are Barry, Premier, and Dasher. All three of these cultivars have received very high mowing quality scores.

On the basis of our current knowledge of rust and red thread resistance, turf quality, density, and mowing quality performance the best all around performance should be expected from the cultivars listed in Table 2.

Table 1. Turf quality performance of perennial ryegrass cultivars and selections and averaged over mulch and bagged cutting management at Puyallup, WA.

Cultivar	2 yr Mean	Turf quality score 9 = best						Rust[1]		Red thread	
		Feb	Apr	Jun	Aug	Oct	Dec	Mulch	Bag	Mulch	Bag
								(%)			
Diplomat	6.9	6.5	7.3	8.0	7.3	7.8	5.8	3	35	18	38
Score	6.8	7.2	7.7	7.2	6.5	7.3	6.0	11	62	20	29
Blazer	6.7	6.2	6.0	7.9	8.0	7.4	5.8	2	35	28	27
Ensporta	6.7	6.5	6.5	7.6	6.8	7.5	6.3	7	34	19	37
Omega	6.5	6.8	6.2	6.9	7.3	7.4	6.3	11	85	17	38
Arno	6.5	6.0	7.2	7.1	6.6	7.3	6.3	3	45	31	35
Bellatrix	6.5	6.0	6.8	7.5	7.2	6.6	5.3	24	55	28	36
Hunter	6.5	6.0	7.1	7.3	7.3	7.0	5.5	8	78	23	28
Pennfine	6.4	5.5	6.2	7.5	7.7	7.3	6.2	3	60	25	12
Player	6.4	5.1	6.5	7.7	7.5	6.8	6.0	3	45	16	34
Derby	6.4	6.0	6.0	7.3	7.0	6.9	6.2	22	87	20	16
Acclaim	6.4	5.3	6.2	7.5	7.8	7.3	5.7	2	45	27	10
Yorktown II	6.4	5.3	5.8	7.6	7.8	7.1	5.6	10	45	8	30
Yorktown	6.4	6.0	6.3	6.9	7.5	7.1	6.3	62	95	23	19
Pennant	6.3	6.0	6.5	6.8	7.0	7.2	5.7	4	43	18	20
Fiesta	6.3	5.6	6.3	7.0	7.3	7.1	5.8	8	72	20	26
Manhattan	6.3	5.8	6.3	7.0	7.0	7.4	6.0	18	67	29	35
Loretta	6.2	6.1	6.2	7.0	7.0	7.5	6.5	3	27	9	21
Sprinter	6.2	6.3	6.3	6.8	6.7	6.6	6.0	4	45	32	39
MOM LP 20	6.2	6.1	5.7	7.1	7.3	6.6	5.6	24	85	26	22
Citation	6.2	5.0	5.5	7.2	7.3	6.5	5.6	12	58	18	10
Elka	6.2	5.2	5.6	6.9	7.3	7.3	6.0	6	47	24	21
Birdie	6.1	5.6	6.0	6.5	7.0	6.5	5.3	15	52	19	80
Pippin	6.1	6.2	5.5	7.0	6.8	6.4	5.5	7	58	21	32
Regal	6.1	5.1	6.2	6.6	6.8	7.2	5.5	27	73	28	19
Aristocrat	5.9	5.0	5.3	6.7	7.1	6.4	5.3	2	35	19	21
Runner	5.9	5.3	6.1	6.5	6.8	6.2	5.3	4	65	23	30
Goalie	5.8	4.8	6.3	6.6	7.6	6.3	5.5	2	37	10	26
Venlona	5.8	5.5	5.2	6.7	6.3	6.0	5.5	5	62	20	31
Sportiva	5.8	5.0	5.3	6.3	6.5	6.3	5.3	6	67	35	33
Caravelle	5.5	5.3	5.8	5.6	5.7	6.0	5.0	6	80	33	28
Compas	5.4	5.2	5.2	6.0	5.8	6.1	5.0	4	32	18	40
Servo	4.8	4.5	4.3	6.3	5.6	5.6	4.2	68	95	42	53

[1] Percent of leaves showing rust symptoms on 9/27/81.

Table 2. Cultivars with the best overall turf quality performance combined with the lowest disease susceptibility after three years at Puyallup, WA.

BEST	
Diplomat	Acclaim
Blazer	Yorktown II
Ensporta	Pennant
Arno	Loretta
Player	Barry
Premier	Dasher
GOOD	
Score	Bellatrix
Derby	Hunter
Omega	Pennfine
Fiesta	Manhattan
Yorktown	Citation
Elka	Sprinter

TURFGRASS PERFORMANCE AND RUST DISEASE REACTION OF KENTUCKY BLUEGRASS CULTIVARS AND SELECTIONS AT PUYALLUP, WA[1]

S.E. Brauen, R.L. Goss, J.T. Law, M. Abraham, and S.P. Orton[2]

Many new cultivars of Kentucky bluegrass (*Poa pratensis* L.) have been developed by turfgrass breeders in recent years. Although many Kentucky bluegrass cultivars are not well adapted for longterm turf west of the Cascade Mountains, many of these cultivars are becoming available to seed dealers and as a result they are available to turfgrass growers. To help us make better choices in the selection of bluegrass cultivars to be used in mixes or blends of turf seed, we are continuing to evaluate 55 named cultivars for turf quality, density, susceptibility to disease, mowing management, persistence and weed invasion. These evaluations were begun in 1978 and are a part of a larger regional program to evaluate these cultivars throughout the western area. Since many Kentucky bluegrass cultivars are not persistent in the Northwest Pacific Coast area, this test becomes more valuable as it increases in age.

EXPERIMENTS AND PROCEDURE

The Kentucky bluegrass studies were established on a Puyallup fine sandy loam soil in the late summer of 1978. The plot size was 6.5 x 6.5 ft. (2 m x 2 m) with 3 replications in each test.

1/ Presented at the 35th Annual Northwest Turfgrass Conference, Olympia, WA, September 22-24, 1981.

2/ Associate Agronomist, Extension Agronomist, Turfgrass Research Associate, Ag. Res. Tech. II, and Ag. Res. Tech. II, Western Washington Research and Extension Center, (WSU), Puyallup, WA.

The plots received 4 lb of nitrogen per 1000 ft^2 annually applied in 4 equal applications of 1 lb of nitrogen in May, September, December, and March. The plots received adequate irrigation through the dry periods of June through September. Phosphorus and potassium were applied once annually. The plots were sprayed for broadleaf weed control with a combination of 2,4-D and Dicamba during the spring of 1981.

The plots were cut twice weekly at a cutting height of 1-1/4 inches with rotary mowers. Each variety plot was split into two mowing treatments. One-half was mowed with a rotary mulching mower while the second half of each plot was mowed with a rotary rear bagging mower. A summary of turf quality performance scores and rust infection scores is presented in Table 1. Many bluegrass cultivars were highly susceptible to rust when mowed with a rear bagger rotary mower. Cultivars that were highly susceptible to rust when the clippings were bagged tended to be the same cultivars that were most susceptible when the clippings were mulched. The cultivars Touchdown and Obelisk were the most susceptible. However, cultivars such as A-34, Enaldo, Bonnieblue, Merion, Celo, Aquila, Enoble, Entensa, Pion, Adelphi, Vanessa, Kimono, Plush, Mosa, Harmony, Dormie, Scenic, and Bluebell were moderately rust susceptible. The most rust tolerant cultivars were AG 480, Bristol, Parade, Orna, Majestic, Columbia, and Haga. The remainder of the cultivars were intermediate in reaction.

If high rust susceptibility of the cultivar is taken into consideration, the cultivars with the highest performance scores were AG 480, Cheri, Sydsport, Bristol, Parade, RAM I, Orna, America, and Majestic. All cultivars had unsatisfactory turf quality scores during January and most cultivars had unacceptable turf quality scores during November and March. Table 2 lists the best performing bluegrasses in these evaluations at the present time.

Table 1. Turf quality performance of Kentucky bluegrass cultivars and selections averaged over mulched and bagged cutting management at Puyallup, WA.

Cultivar	2 yr Mean	Turf quality score 9 = best Jan	Mar	May	Jul	Sep	Nov	Rust[1] Mulch	Bagged
								(%)	
Touchdown	6.6	4.8	6.7	8.3	7.4	7.6	6.1	17	92
AG 480	6.4	4.9	5.7	7.6	7.7	7.5	5.7	1	23
Cheri	6.4	4.4	5.8	7.0	7.8	7.7	5.6	4	55
Obelisk	6.4	4.7	6.2	8.7	7.7	6.8	5.8	92	94
Sydsport	6.4	3.9	5.8	6.9	7.6	7.9	5.5	1	28
A-34	6.3	3.8	5.7	8.0	7.7	7.2	4.9	17	88
Enaldo	6.3	4.6	6.0	6.7	7.4	7.4	6.2	12	90
Bonnieblue	6.2	3.8	4.6	6.2	6.7	7.7	5.5	22	90
A 20-6	6.1	4.6	5.1	7.1	7.4	7.4	5.3	11	65
Trenton	6.1	4.2	5.7	7.1	6.9	7.6	5.6	7	48
Bristol	6.1	4.9	5.1	6.2	7.3	7.9	5.9	2	37
Birka	6.1	4.4	5.3	7.5	7.2	7.2	5.5	9	47
Holiday	6.1	4.5	5.6	7.0	6.7	7.3	5.8	12	55
H-7	6.0	4.5	5.5	7.0	7.0	6.6	5.8	14	73
Princeton	5.9	3.6	4.9	7.2	7.4	7.2	5.3	11	40
Glade	5.9	4.2	4.7	7.2	7.7	7.3	5.3	11	47
Brunswick	5.9	3.8	4.7	6.2	6.9	7.8	5.4	17	63
Merit	5.9	4.1	5.2	6.7	7.4	7.0	5.3	7	83
BFB-35	5.9	4.1	5.1	6.3	6.9	7.3	5.5	9	47
Merion	5.8	3.4	5.3	7.2	7.7	6.7	4.7	21	95
Parade	5.8	4.3	5.2	5.9	6.7	7.7	5.5	4	25
Baron	5.8	3.9	4.7	7.0	7.2	7.4	5.6	4	70
RAM 1	5.8	3.9	4.4	5.8	7.2	8.3	5.7	1	21
Cello	5.8	3.1	5.6	7.2	7.0	6.8	4.7	37	87
Enmundi	5.8	4.1	4.5	7.2	7.2	7.2	5.3	9	68
Orna	5.8	3.8	4.8	7.1	7.8	7.4	5.2	0	7
America	5.8	3.8	4.7	5.9	7.2	7.5	5.9	6	38
Majestic	5.7	4.1	4.7	5.8	7.0	7.6	5.1	8	31
Aquila	5.7	4.1	3.9	6.2	7.6	7.1	5.3	21	78
Charlotte	5.7	3.1	4.3	6.5	7.4	8.2	5.2	4	62
Enoble	5.7	4.2	4.8	7.1	6.5	6.9	5.4	13	77
Rugby	5.7	3.8	4.8	6.1	6.8	7.7	4.9	5	47
Victa	5.7	3.2	4.6	7.0	7.1	7.4	5.3	6	82

Table 1. (Continued)

Cultivar	2 yr Mean	Turf quality score 9 = Best						Rust[1]	
		Jan	Mar	May	Jul	Sep	Nov	Mulch	Bagged
								(%)	
Entensa	5.6	5.0	4.9	5.9	6.1	6.8	5.6	20	70
ISI-28	5.6	4.7	4.5	5.4	6.4	7.2	6.0	2	43
Pion	5.6	5.3	4.6	5.8	5.5	7.3	6.2	14	78
Adelphi	5.6	3.7	4.7	6.0	6.9	7.0	5.3	14	72
Columbia	5.6	3.7	5.1	5.3	6.3	7.6	5.3	1	22
Geronimo	5.6	3.9	4.7	6.6	5.8	7.4	5.5	3	30
Fylking	5.5	2.9	4.6	6.5	7.3	7.7	4.2	10	54
Entopper	5.5	4.0	4.7	7.5	6.8	7.0	5.1	4	75
Vanessa	5.5	3.5	4.8	6.6	7.2	7.2	4.5	17	87
Kimono	5.5	3.4	4.5	6.2	7.2	7.2	4.4	14	96
Plush	5.5	3.8	4.2	5.3	6.8	7.3	5.2	13	85
Mosa	5.5	3.6	4.7	6.7	7.0	7.3	4.4	10	77
Harmony	5.4	4.2	4.3	5.6	7.0	7.2	5.2	43	96
Haga	5.3	3.8	4.9	4.9	6.0	7.5	5.3	3	22
Cleopatra	5.3	3.9	4.3	6.1	6.9	7.6	5.1	2	60
Welcome	5.0	2.7	3.7	5.4	7.2	7.2	4.6	11	71
Dormie	4.9	2.3	2.9	5.8	7.3	6.9	3.8	37	91
Sving	4.9	3.4	3.8	5.7	6.7	6.8	4.2	7	83
Scenic	4.7	3.8	3.8	4.7	5.3	6.5	4.9	35	96
Bluebell	4.7	2.9	3.8	5.0	6.7	6.9	4.3	22	90
Hekla	4.6	2.7	3.3	5.2	6.2	7.4	4.7	7	52
Sherpa	4.6	2.6	3.2	6.1	6.3	7.1	3.8	4	48

[1] Percent of leaves showing rust symptoms on 9/27/81.

TURFGRASS PERFORMANCE OF FINE FESCUE CULTIVARS AND SELECTIONS AT PUYALLUP, WA[1]

S.E. Brauen, R.L. Goss, J.T. Law, M. Abraham, and S.P. Orton[2]

Generally the fine fescues are tolerant of acid soils, moderate shade, low fertility and drouthy areas. Improved cultivars of fine fescues make these grasses desirable components for areas of low maintenance. Potential shortage of water, increasing prices of fertilizer and costs of mowing will undoubtedly increase the use of this species for lawn areas.

EXPERIMENTAL PROCEDURE

The fine fescue cultivar study was established at Puyallup in the summer of 1978. The study included a collection of chewings fescues (*Festuca rubra* subsp. *commutata*), slender creeping red fescue (*Festuca rubra* subsp. *trichophylla*), strong creeping or spreading red fescue (*Festuca rubra* subsp. *rubra*), and hard fescue (*Festuca longifolia*). These cultivars were evaluated in replicated 6.5 x 6.5 ft (2 m x 2 m) plots. The plots were fertilized with 4 lb of nitrogen per 1000 ft^2 annually, and the plots were mowed with rotary mowers. One-half of each plot was mowed with a rotary mulching mower and the other half was mowed with a rotary bagging mower. The mowing height was 1-1/4 inches.

EXPERIMENTAL RESULTS

The overall turf quality of the cultivars is recorded in Table 1. Many of the chewings fescues have

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1/ Presented at the 35th Annual Northwest Turfgrass Conference, Olympia, WA, September 22-24, 1981.

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performed well in this study. Usually the turf quality scores are approximately 1 point higher for the chewings fescue cultivars and the slender fescue cultivars as compared to the spreading or strongly creeping cultivars. Dawson has shown excellent performance in these and earlier evaluations and appears to be highly competitive with other grasses. Many of these fescue cultivars are particularly attractive during the early spring and late fall periods. Weed invasion into these grasses has been non-existent if they were established in a clean condition. Pernille and Ensylva spreading red fescue cultivars have generally performed the best of the spreading fescues in these studies.

No clear separation has occurred to this point in the performance of chewings cultivars. Those with the highest average turf quality scores are listed first in Table 1, while those with the lower average turf quality scores are listed last. No good differences have been observed in red thread susceptibility or resistance in these cultivars at the present time.

Table 1. Turf quality performance scores of fescue cultivars at Puyallup, WA.

Cultivar	2 yr mean	Turf quality score 9 = best					
		Jan	Mar	May	Jul	Sep	Nov
CHEWINGS							
Grelo	7.0	5.3	7.0	7.7	8.1	7.8	6.3
Ilona	6.9	5.4	7.3	7.5	8.3	7.4	6.6
Menuet	6.8	5.1	6.8	7.5	8.0	7.8	6.7
Frida	6.8	5.9	7.1	7.5	7.3	7.7	6.8
Wilton	6.6	5.1	6.3	6.5	7.3	7.5	6.8
Parita	6.5	5.4	6.5	7.3	7.6	7.1	6.5
Checker	6.5	5.7	6.8	5.7	7.7	7.0	6.3
Wintergreen	6.5	5.5	6.1	7.2	7.8	7.3	6.3
Corona	6.5	4.9	6.8	6.5	7.6	7.0	6.8
Bingo	6.5	5.3	5.5	6.8	8.2	7.2	6.0
Koket	6.5	5.3	6.3	7.2	7.0	7.3	6.3
Luster	6.4	4.8	6.0	7.7	7.8	7.3	5.5
Atlanta	6.3	4.6	6.5	6.8	7.3	7.1	5.8
Banner	6.3	5.3	6.5	7.0	7.3	7.1	5.8
Agram	6.2	5.1	6.5	6.8	7.6	6.8	5.7
Adonis	6.2	5.0	6.3	7.7	7.7	6.8	5.8
Tamara	6.2	4.7	6.3	6.7	7.4	6.6	6.0
Tatjana	6.2	5.7	5.7	6.0	6.9	7.1	6.1
Waldorf	6.1	4.7	6.7	7.0	7.4	6.2	5.6
Rolax	6.1	5.3	5.5	7.2	6.9	6.9	5.8
Syn W	6.1	5.3	6.0	6.3	7.8	6.8	5.9
Satin	6.1	3.8	6.7	6.0	7.8	6.8	6.3
Highlight	6.1	5.3	6.3	7.0	6.-	7.0	5.9
Jamestown	5.8	4.5	5.8	6.2	7.8	6.3	4.9
Jade	5.7	3.8	5.3	6.5	6.8	5.9	5.7
SLENDER							
Dawson	6.7	5.8	6.2	7.2	7.8	7.2	7.0
Polar	6.7	4.9	6.8	6.3	8.3	7.0	6.8
Sonnet	6.3	5.0	6.3	6.7	7.4	6.7	6.7

Table 1. (Continued)

Cultivar	2 yr mean	Turf quality score 9 = best					
		Jan	Mar	May	Jul	Sep	Nov
SLENDER							
Oase	5.7	4.3	5.5	7.0	6.5	5.9	5.5
Starlight	5.6	4.3	4.8	7.2	6.9	6.3	5.4
SPREADING							
Pernille	6.1	4.8	5.2	7.0	7.2	6.7	6.3
Ensylva	6.0	4.5	5.0	6.5	7.0	6.6	5.8
Envira	5.5	4.2	4.7	6.5	6.5	6.2	5.0
Moncorde	5.4	3.6	5.2	6.7	7.3	5.9	4.9
Enzet	5.2	4.2	4.5	6.0	6.9	6.0	5.4
Fortress	5.1	3.3	4.7	6.5	6.5	5.7	4.9
Engina	4.7	3.7	4.2	7.2	6.1	5.3	4.8
HARD							
Silvana	5.7	4.4	4.8	8.0	7.0	6.3	5.5
Tournament	5.7	4.5	4.8	6.7	7.2	6.7	5.3
Waldina	5.5	4.0	4.2	6.7	6.9	6.2	5.0
Scaldis	5.5	4.0	5.0	7.3	6.3	6.0	5.4
Biljart	5.3	3.8	5.2	5.8	6.6	6.3	5.4
Balmoral	5.3	3.8	4.3	6.8	6.2	6.4	5.0

BROADLEAF WEED CONTROL WITH TRICLOPYR AND DOWCO 290[1]

S.E. Brauen, R.L. Goss, and J.T. Law[2]

Garlon 3A (triclopyr), Dowco 290 (3,6-dichloropicolinic acid) and Lontrel 205 (Dowco 290 + 2,4-D) were evaluated for broadleaf weed control on bentgrass lawn turf and on a mixed bluegrass, ryegrass, and bentgrass lawn turf. These chemicals offer some hope in the control of some broadleaf weeds that are difficult to control with phenoxy-type herbicides and may offer a potential substitute for these herbicides on turf or in urban areas if their use is selectively restricted.

EXPERIMENTAL METHODS

Garlon 3A, Dowco 290 and Lontrel 205 were applied at rates recorded in Table 1. Each material was applied in 5 gal of water per 1000 ft^2. Each location was applied at approximately 70-75°F. A light shower followed the application of the bentgrass turf applied on May 27, 1981. The applications to the mixed bluegrass, ryegrass and bentgrass turf was made on July 2, 1981 and was fertilized with 1/2 lb of nitrogen from a complete 21-7-14 ratio fertilizer and irrigated with 1 inch of water 48 hr after herbicide application. The turf at the time of application was growing well with low nitrogen maintenance and the turf was not moisture stressed at the time of application. The treatment plots were 2 m x 2 m, replicated 3 times in a randomized complete block design and herbicides were applied in 5 gal of water per 1000 ft^2.

1/ Presented at the 35th Annual Northwest Turfgrass Conference, Olympia, WA, September 22-24, 1981.

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EXPERIMENTAL RESULTS

Results of the July application are summarized here. All treatments with the exception of Trimec caused significant reduction in color scores within 4 days following application (Table 2). Phytotoxic effects were apparent on grass at the highest treatment levels of Garlon alone and Dowco 290 + Garlon for 8 weeks following application. Phytotoxic effects were acceptable for Garlon alone and Dowco 290 + Garlon treatments at the lowest levels of application and may be acceptable on a temporary basis for Garlon alone at the intermediate level.

The highest levels of application of Garlon, Lontrel 205 and Dowco 290 + Garlon caused mostly unacceptable turf for 4 to 8 weeks following application and turf density was reduced significantly. A broad spectrum of good to excellent broadleaf weed control was obtained with all materials at the highest level (Table 3). Good to fair control was obtained with Garlon alone at the intermediate application and fair control of clover, Veronica and common plantain was obtained at the lower level of Garlon application. The addition of a low level of Dowco 290 at the lower level of Garlon application improved the control of these weeds and provided good to excellent control of creeping buttercup and dandelion. The intermediate rates of Garlon and Dowco 290 were required to provide good to excellent control of all weeds present but grass phytotoxicity and reduction of turfgrass density may be of concern.

Garlon alone and Garlon + Dowco 290 appeared to provide selective control of some grass species (Table 4). Bentgrass levels were reduced with the highest level of these products and velvetgrass was significantly reduced in comparison to the lower levels of application. The percentage of perennial ryegrass in turf was increased after grass recovery.

In summary, Garlon and Dowco 290 will provide control of many broadleaf weed species. At the application rates necessary for high levels of control of a broad spectrum of broadleaf weeds, phytotoxic effects on the lawn turf were encountered. These were evident for 6-8 weeks. Some grass species were eliminated or set back at these levels and the turfgrass species mix was altered permanently at the highest levels. This study would indicate that the combination of Garlon 3A + Dowco 290 or Garlon 3A alone may be useful in the elimination of coarse velvetgrass from some combinations of lawn turf. Further work needs to be conducted.

Table 1. Garlon 3A, Dowco 290 and Lontrel 205 rates of application on turfgrass.

Product	Active ingredient	Application rate: Product per 1000 ft^2	Product per acre	a.e. per acre
		(TBSP)	(qt)	(lb)
Garlon 3A	Triclopyr (3,5,6-trichloro-2-	1	0.66	0.5
Garlon 3A	pyridimyloxyacetic acid, 3 lb a.e./gal)	2	1.33	1.0
Garlon 3A	"	4	2.64	2.0
Lontrel 205	Dowco 290 plus (2,4-D; 2 lb a.e./gal)	1.5	1.00	0.125 + 0.5
Lontrel 205	"	3.0	2.00	0.25 + 1.0
Lontrel 205	"	6.0	4.00	0.5 + 2.0
Garlon 3A + Dowco 290	triclopyr + (3,6-dichloropicolinic acid;	1 + 1	0.66 + 0.66	0.5 + 0.5
Garlon 3A + Dowco 290	3 lb a.e./gal)	2 + 2	1.33 + 1.33	1.0 + 1.0
Garlon 3A + Dowco 290	"	4 + 4	2.64 + 2.64	2.0 + 2.0
Trimec	2,4-D; .64 lb a.e./gal + Mecoprop; 0.3 lb a.e./gal + Dicamba; 0.52 lb a.e./gal	3	2.00	0.32 + 0.15 + 0.26

Table 2. Effects[1] of Garlon 3A, Dowco 290 and Lontrel 205 on turfgrass color, density and recovery. (9 = best)[2].

	TBSP per 1000 ft^2	Color					Density	Recovery
		July 6	July 22	Aug. 21	Sept. 13	Nov. 2	Sept 13	July 22
Garlon 3A	1	6.7 dc	6.7 b	7.7 ab	7.3 bc	7.7 ab	8.0	6.3 c
Garlon 3A	2	5.3 ef	5.3 bc	8.3 a	7.7 abc	8.0 ab	7.7	6.7 bc
Garlon 3A	4	2.3 g	1.7 e	5.7 c	8.7 a	8.3 ab	6.7	3.3 e
Lontrel 205	1.5	6.3 cde	8.3 a	8.7 a	6.7 c	7.7 ab	7.7	8.7 a
Lontrel 205	3	6.7 cd	6.7 b	8.0 a	7.0 bc	7.7 ab	7.7	7.3 b
Lontrel 205	6	4.7 f	3.7 d	7.3 abc	8.0 ab	8.0 ab	8.0	5.3 d
Garlon 3A + Dowco 290	1 + 1	7.0 bc	6.7 b	7.3 abc	7.7 abc	7.7 ab	7.7	7.0 bc
Garlon 3A + Dowco 290	2 + 2	5.7 def	4.0 cd	6.0 bc	8.7 a	8.3 ab	6.3	5.3 d
Garlon 3A + Dowco 290	4 + 4	2.7 g	1.7 e	6.0 bc	8.7 a	8.7 a	5.7	2.3 f
Trimec	3	8.0 ab	8.7 a	8.7 a	8.0 ab	7.7 ab	7.7	8.3 a
No treatment	-	8.6 a	9.0 a	8.7 a	7.3 bc	7.3 b	3.3	9.0 a

[1] Chemicals applied July 2, 1981 on mixed bluegrass, ryegrass, bentgrass lawn turf.

[2] Means followed by the same letter in vertical lines are not different significantly by Duncan's multiple range test at the .05 level of confidence.

Table 3. Lawn broadleaf weed control with Garlon 3A[1], Lontrel 205 and Dowco 290[2].

	TBSP per[3] 1000 ft^2	Buttercup	Clover	Catsear	Dandelion	Veronica	Plantain	Moss	Brdlf
Garlon 3A	1	F	P	F	F	P	P	P(?)	F
Garlon 3A	2	G	F	G	G	F	F	P-F	G
Garlon 3A	3	E	F	E	E	G	G	G	E
Lontrel 205	1.5	F-G	P	E	E	P	P-F	P	G
Lontrel 205	3	G	F	E	E	G	F	F	E
Lontrel 205	6	E	G	E	E	E	G	G-E	E
Garlon 3A + Dowco 290	1 + 1	G-E	F	F	E	F	F	P(?)	G
Garlon 3A + Dowco 290	2 + 2	E	G	G	E	G-E	G	G-E	E
Garlon 3A + Dowco 290	4 + 4	E	E	E	E	E	G	G-E	E
Trimec	3	F	F-G	G	G	F	G	F	G

1 Garlon 3A contains 3 lb/gal a.e. triclopyr; Dowco 290 formulated at 3 lb/gal a.e. 3,6-dichloropicolinic acid; Lontrel 205 contains 2 lb 2,4-D a.e. and 0.5 lb Dowco 290 (3,6-dichloropicolinic acid) a.e./gal.

2 P = poor, F = fair, G = good, E = excellent control of species eight weeks after herbicide application.

3 Tablespoons of product/1000 ft^2.

Table 4. Selective control of lawn grasses with Garlon 3A, Lontrel 205 and Dowco 290.

	TBSP per 1000 ft^2	Velvetgrass (%)	Ryegrass (%)	Bentgrass (%)
Garlon 3A	1	22	27	73
Garlon 3A	2	16	30	70
Garlon 3A	3	5	77	23
Lontrel 205	1.5	25	27	73
Lontrel 205	3	22	28	72
Lontrel 205	6	21	48	52
Garlon 3A + Dowco 290	1 + 1	21	37	63
Garlon 3A + Dowco 290	2 + 2	3	77	23
Garlon 3A + Dowco 290	4 + 4	0	90	10
Trimec	3	14	30	70
No treatment	-	20	26	80

CHEMICAL GROWTH REGULATION AND SELECTIVE CONTROL OF TURFGRASS SPECIES[1]

S.E. Brauen, R.L. Goss, and J.T. Law[2]

There is a strong need for effective chemicals to control grass growth and to selectively control grass species. Numerous experimental growth retardants are under study nationwide, some of which have widely different effects on plant phytotoxicity, broadleaf weed control, selective grass control and length of growth control and morphological development. Also, cultivars or grass species within a genus may be affected differently and their survival altered. In addition, plant root growth patterns may be changed and the plant's ability to deal with disease, temperature, nutrition, or moisture stress may be altered. Consequently, the type of turf and the turf use patterns will need to be considered prior to the use of growth regulant chemicals.

A number of growth regulant chemicals have been surveyed at Puyallup since 1977. Some of these have shown good possibilities for development.

This past summer several new root-absorbed growth regulators were tested and compared to the older foliar-absorbed chemicals (Table 1). These new chemicals are still experimental but look very promising. The new products are MBR 18337, EL 500, and PP 333. EL 500 and PP 333 caused essentially no phytotoxicity and EL 500 actually improved color in some cases. PP333 caused a lessening of the color rating a small amount. Neither of these chemicals suppressed seedhead formation. MBR 18337 did cause a slight amount of phytotoxicity but was

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very effective at seedhead suppression. All three are very effective growth regulators. When using these chemicals to suppress spring growth, red thread must be controlled with fungicides and broadleaf weeds must be controlled with an appropriate herbicide. Severe red thread infection confounded some of the data presented in Table 1 and lowered color ratings in some cases. We have tested tank mixes of trimec and the growth regulators and found no incompatibility. Initial studies seem to indicate that several bentgrass types or cultivars are differentially affected by Embark.

Several selective grass control chemicals were studied this year in preliminary tests. Fine fescue continues to show a high level of tolerance to glyphosate. Phytotoxicity of the fescue occurs immediately after application and persists for 4 to 5 weeks. Nearly complete recovery is attained at an application rate of .25 lb a.i. per acre of glyphosate. At higher levels of glyphosate (.375 and .5 lb a.i. per acre) phytotoxicity is more severe initially and persists for a longer period. Density of the turf is also reduced.

Fine fescue and *Poa annua* also appear to be tolerant to RO 13-8895 while bentgrass and bluegrass seem highly susceptible. Ryegrass appears to be intermediate in tolerance. Almost no phytotoxicity occurred on fescue turf after the application of .036, .072 and .144 lb a.i. per acre of RO 13-8895. Ryegrass appears to be somewhat tolerant at .036 and .072 lb a.i. per acre while bluegrass and bentgrass appear to be highly susceptible at .072 lb a.i. per acre. These two chemicals (RO 13-8895 and glyphosate) and triclophyr appear to offer developmental possibilities for selective grass control in some turfgrass combinations.

Table 1. Effect of growth regulators on blade height (cm), weight (g/m^2), and color (1-9) of four unmown turfgrasses.

	Colonial bentgrass		Kentucky bluegrass + annual bluegrass			Red fescue			Perennial ryegrass		
	height	color	height	weight	color	height	weight	color	height	weight	color
Check	19.4	7.7	27.3	47.1	7.8	19.7	20.1	7.0	25.9	36.3	
EL 500	14.6	5.6	17.0	28.1	8.0	16.0	-	7.3	26.0	29.3	
PP 333	16.0	4.6	16.0	27.3	5.3	13.0	12.0	5.0	16.0	-	
Maintain	24.0	7.0	21.0	23.5	2.7	17.0	11.6	5.3	21.0	28.5	
Embark	18.0	2.6	19.3	20.4	4.0	17.3	10.4	1.6	19.3	26.4	
Embark + EL 500	15.3	2.0	17.0	26.3	1.7	12.0	9.3	2.0	17.0	-	
MBR 18337	17.8	5.0	22.3	30.1	5.1	15.3	17.0	5.4	16.4	24.8	

INTEGRATION OF CHEMICAL AND CULTURAL METHODS FOR *POA ANNUA* L. CONTROL[1]

John T. Law Jr.[2]

Poa annua (Poa) is one of our major turfgrass species as well as the No. 1 turfgrass weed. As a major turfgrass species, it forms a fine textured, dense vigorous turf that putts true, and does well under low cutting heights. Poa produces abundant seed that germinates quickly and will rapidly fill in injured turf areas when growing conditions are good. Poa also grows very adequately on compacted soil and in shady locations. In the cooler parts of the regions where cool season grasses grow well, Poa becomes a major component of close cut, well maintained turf, especially golf course fairways. Most of these areas were originally seeded to Kentucky bluegrass and/or red fescue and/or perennial ryegrass, but these cool season grasses do not normally persist under low cutting heights (less than 1 inch) desired on golf courses and soccer fields. Modern irrigation systems also provide good germination conditions for Poa seeds and prevent water stress to which Poa is very susceptible.

In western Washington and Oregon bentgrass fairways are common and bentgrass can persist under a low cutting height. Because bentgrass does as well as Poa at low cutting heights Poa does not achieve the overwhelming dominance it does elsewhere in northern regions. Even so, many putting greens in western Washington and Oregon will be dominated by Poa after 8 to 10 years (10).

In spite of the good turf qualities and widespread use as turf, Poa is most often considered a weed because it becomes an unwanted and often large component of turf

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stands. The Poa is unwanted because it is a prolific seedhead former, it is more susceptible to heat, cold and drought stress, and turf diseases, and is not as tolerant to wear and abrasion as most other turf species (2).

The production of light colored seedheads seriously detracts from the aesthetic value of turf for most people. This is especially true when the seedheads are produced profusely in late spring and early summer. On putting greens the seedheads also disrupt an otherwise even putting surface. However, only a person who putts consistently well will usually be significantly affected by the characteristically soft turf formed by Poa on fairways, because it does not support the ball as well. This soft Poa turf also suffers from a lack of wear tolerance which is a serious problem for heavily trafficked turf such as playing fields and areas on many golf courses. Bentgrass and especially perennial ryegrass, bluegrass and red fescue will tolerate more use than Poa without forming bare spots. Bare spots are unattractive of course, but also detract from playability of sports turf. When soil is exposed, its structure is often destroyed by compaction and puddling making re-establishment of any turf more difficult. One positive aspect of Poa is that it can fill in large bare or thin areas by seed germination if adequate water is supplied and temperatures are moderate.

The most serious problem with Poa is the lack of stress and disease tolerance. Extremes of cold and heat that cause Kentucky bluegrass, red fescue and bentgrass to stop growing will kill Poa. Poa also takes considerable more water to maintain a turf cover than do most other cool season grasses. Poa is a very high maintenance species and maintaining a healthy Poa fairway requires more fungicide than for Kentucky bluegrass or bentgrass (12). A consideration of the biology of Poa makes it clear why this lack of stress and disease tolerance is present. Poa is adapted to setting seeds which will re-establish the population when good growing conditions return. It does not matter if the plants that produce the seeds die. The other cool season grasses are adapted more to vegetative reproduction.

Therefore, they must tolerate stress and disease as living plants capable of tiller and/or rhizome and/or stolon production when good growing conditions return.

A considerable amount of research has been done to understand and control Poa. This research has led to the development of programs which can greatly reduce the amount of Poa in highly maintained close-cut turf. Tom Cook developed a chemical control program for bentgrass based on the post-emergent herbicide Endothall (4). Endothall was selective for Poa when applied to vigorously growing bentgrass turf that is not suffering from heat, cold, or drought stress. Endothall does stress bentgrass, but not seriously. Usually only a slight yellowing is observed. If the Poa infestation is greater than 10% (a common occurrence) the endothall control must be supported by a pre-emergence herbicide such as bensulide. Otherwise Poa seed will germinate and re-establish itself. Since bentgrass will not fill in the areas where Poa is killed unless the patches are small, John Roberts and Roy Goss (10) developed overseeding methods to re-establish bentgrass after the endothall-bensulide treatments.

No control programs have been developed which completely eliminate Poa so it tends to re-establish itself. This is especially true on putting green turf where repeat endothall applications within one season run the risk of stressing the grass too much. Annual use of the endothall program is often required to keep the Poa in check. If the Poa continually builds up patches that must be overseeded as part of the chemical control program, a considerable amount of time and money will be consumed. How quickly and to what extent Poa will reinvade bentgrass depends on the relative vigor of the two grasses. This vigor is strongly influenced by cultural practices, especially those related to soil structure and fertility.

The choice of particular cultural practices can either favor Poa, favor bentgrass, or favor both. One of the reasons Poa is such a serious problem on golf courses is that Poa responds very well to the close cutting and high maintenance required to grow quality bentgrass turf. Poa gains a competitive edge and will dominate the bentgrass if heavy turf use causes soil compaction since Poa tolerates compacted soils much better than bentgrass. Therefore, soil structure should be kept in good shape with topdressing and aerifying as necessary. Poa also has a competitive edge in filling in bare or thin areas through seed germination. For example, if *Fusarium* patch disease is allowed to thin and kill areas of bentgrass, Poa will germinate in these areas sooner than the bentgrass can grow into the areas through vegetative growth (7). Therefore, by controlling diseases and maintaining soil structure one can avoid giving Poa a competitive edge. However, to really keep Poa out, turfgrass managers have to give the bentgrass a competitive edge.

One of the best ways to favor bentgrass over Poa is to keep the soil pH low. Bentgrass (and red fescue) can grow remarkably well at a low pH, while Poa is not nearly as tolerant to low pH. The pH of the soil surface layer is particularly important. This is clearly seen in studies using a variety of nitrogen sources and lime. Bentgrass putting green turf fertilized with ammonium sulfate had the lowest amount of Poa while plots receiving lime had the highest (Table 1). Ammonium sulfate lowers the pH of the surface layers (1) while lime raises the pH of the surface layers. The pH of the surface layer is probably important because that is where the Poa seed germinates; also most turfgrass roots are in the surface layers. If it is not desirable to use ammonium sulfate as a nitrogen source, then pH can be lowered through sulfur applications. High sulfur rates tend to suppress Poa. It has been shown in a growth chamber study that high rates of neutral sulfate sulfur do no harm to Poa, so Poa suppression by sulfur is assumed to be a pH effect (14).

Use of sulfur actually has two benefits. One is the lowering of soil pH, the other is to insure an adequate supply of sulfur to the bentgrass. Bentgrass has a high sulfur requirement, particularly when fertilized heavily with nitrogen as required to maintain quality turf (3,6). The sulfur requirement is even higher in the Pacific Northwest where the soil sulfur levels are very low. Sand greens are also prone to sulfur deficiency because sulfate sulfur (the form used by plants) is easily leached out of the root zone.

Another cultural practice which can reduce Poa agressiveness is to keep phosphate fertility low (5). Poa has a higher phosphate requirement than other cool season grasses, especially bentgrass. A good root system is required for phosphate absorption since phosphate is not mobil in the soil. Seedlings have a particularly high phosphate requirement because of their small root systems. Therefore, Poa coming from seed is particularly vulnerable to low phosphate availability. The reason Milorganite favors Poa is probably because it supplies phosphorus to the Poa. Phosphate availability is strongly influenced by pH. The reason low pH inhibits Poa and lime favors Poa may be because low pH causes phosphate to be tied up while lime releases it. Low soil pH also increases the availability of metals like aluminum and manganese which may be toxic to Poa. Bentgrass is generally more tolerant to potentially toxic metals than other grasses.

Irrigation is another management practice that can be used to discourage Poa. Bentgrass, perennial ryegrass, bluegrass, and especially red fescue, are much more tolerant of water stress than Poa. If water can be withheld until the bentgrass, perennial ryegrass, bluegrass, or red fescue components of the turf are close to wilting, any Poa will be killed. Enough water should be applied to completely rewet the root zone. The turf should then be allowed to use almost all of this water before again rewetting the entire root zone. Each time water is applied some Poa seed will probably germinate, but these plants will be killed each time the soil dries.

As an aside, it should be noted that it is seed from the prostrate perennial type of Poa (*Poa annua* ssp. *Reptans*) that tends to germinate when irrigation or rainfall provides surface moisture during the summer. Seed from this subspecies can germinate with no ripening period any time of the year. Seed from the upright annual type of Poa (*Poa annua* ssp. *Annua*) has a ripening period and germinates best with spring and fall temperatures (9).

The use of water stress as a part of the Poa control program is not as straightforward as it sounds. If the turf is suffering from other stresses, then the additional stress from withholding water may be too risky. For example, *Fusarium* blight symptoms become worse in drought stressed turf (13). This is probably due to a stunted root system. If roots are stunted for other reasons such as high nitrogen fertility, short mowing heights, high temperature stress (8), or a large population of root feeding insect larvae, then water stress may very well kill the desirable turf along with the Poa.

Another problem with using irrigation management for Poa control is being able to rewet the entire root zone in a reasonable time. To do this one must have an irrigation system with sufficient capacity to apply the water, and a turf-soil system with sufficient infiltration capacity to absorb the water without excessive runoff. An adequate irrigation system is only a technical (and financial) problem of enough water pressure and proper irrigation head placement.

Maintaining a sufficient infiltration rate is a more difficult problem, especially on intensively used turf. Traffic will compact soil, greatly reducing infiltration rate and root growth. Not only does this make it difficult to use water stress for Poa control, but as discussed above, actually selects for Poa because of Poa's tolerance to compacted soil. Infiltration rate of compacted soils can sometimes be increased by aerification using hollow tines or spoons to penetrate the compacted layer. Usually this is only successful on turf areas with moderate traffic. If traffic is heavy or turf is used at times when the surface layer is wet, the best solution is to reconstruct the area using a mixture containing at least 87% sand by weight (11). The next best method is to combine aerification with a good topdressing program.

Another reason infiltration rates drop is thatch buildup. This is especially true on high maintenance turf where growth rates are kept high. High growth rates cause organic matter to build up faster than soil organisms can break it down. Highly maintained turf also often requires fungicide treatment which sometimes further slows organic matter breakdown by inhibiting some of the soil organisms. Low pH also inhibits soil organisms, so the low pH management program sometimes causes thatch buildup. This organic matter becomes hydrophobic (water repelling) because microorganisms prefer to breakdown and metabolize the hydrophylic (water attracting) plant debris letting the hydrophobic portion build up. Some of the hydrophobic material was originally made by the plants to specifically protect against infection by microorganisms, so is very resistant to decay. The only effective cure for thatch buildup is a good topdressing program.

If you consider Poa a problem on your turf, it can be controlled. This may not be easy, but it certainly is possible by combining good general turf management with the cultural controls of low pH, low phosphate, and perhaps water stress along with chemical controls.

REFERENCES

1. Baker, A. S. and S. Kuo. 1979. The influence of ammonium sulfate and urea on the distribution of available N in the soil surface. Proc. 33rd Ann. Northwest Turf. Conf., Port Ludlow, WA.

2. Beard, James B. 1970. An ecological study of annual bluegrass. U.S.G.A. Green Section Record. March 1970:13-18.

3. Brauen, S. E., R. L. Goss, C. J. Gould, and S. P. Orton. 1975. The effects of sulphur in combinations with nitrogen, phosphorus and potassium on colour and Fusarium patch disease of Agrostis putting green turf. J. Sports Turf Res. Inst. 51:83-91.

4. Cook, Tom. 1978. Control of *Poa annua* in lawn and putting turf in the Pacific Northwest using endothall. Proc. 32nd Ann. Northwest Turf. Conf. Richland, WA.

5. Goss, R. L. 1974. Effects of variable rates of sulfur on the quality of putting green bentgrass. Proc. 2nd International Turf. Res. Conf. pp. 172-175.

6. Goss, R. L., Stanton E. Brauen, and S. P. Orton. 1979. Uptake of sulfur by bentgrass putting green turf. Agron. J. 71(6):909-913.

7. Goss, R. L., T. W. Cook, S. E. Brauen, and S. P. Orton. 1980. Effects of repeated applications of bensulide and tricalcium arsenate on the control of annual bluegrass and on quality of Highland colonial bentgrass putting green turf. Proc. 3rd International Turf. Res. Conf. pp. 247-255.

8. Law, J. T., Jr. 1980. Supraoptimal temperature stress and nitrogen nutrition in Kentucky bluegrass (*Poa pratensis* L.). Ph.D. Thesis. Univ. Rhode Island. 158 p.p.

9. Madison, John H. 1971. Practical turfgrass management. Van Nostrand Reinhold Co., NY. 466 pp.

10. Roberts, John M. and Roy L. Goss. 1979. Overseeding methods following endothall or endothall/bensulide treatments. J. Sports Turf Res. Inst. 55:99-106.

11. Taylor, D. H. and G. R. Blake. 1979. Sand content of sand-soil-peat mixtures for turfgrass. Soil Sci. Soc. Am. J. 43:394-398.

12. Vargas, J. M., Jr. 1979. H.A.S. decline of annual bluegrass. Proc. 33rd Northwest Turf. Conf. 41-45.

13. Vargas, J. M., Jr. 1979. There ain't no free lunch. Proc. 33rd Northwest Turf. Conf. 81-88.

14. Westhafer, M. A., J. T. Law, Jr., and D. T. Duff. 1980. Physiological responses of annual bluegrass (*Poa annua* L.) to sulfur nutrition. Agron. Absts. 1980.

TABLE 1. The influence of nitrogen source and lime on *Poa annua* infestation of putting green turf.

Nitrogen source	Poa annua seedheads/1.5 decimeter^2	
	No lime	50 lb/M lime
Ammonium sulfate	0.5	10.5
Urea	8.5	22.0
Milorganite	6.0	15.0

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Estech Gen. Chem. Corp.
c/o Paul Kram
30 North LaSalle St.
Chicago, IL 60602

Eugene Country Club
255 Country Club Rd
Eugene, OR 97401

Everett Golf & CC
Box 1105
Everett, WA 98201

Everett Muni. Golf
145 N. Alverson Blvd.
Everett, WA 98201

Evergreen Services Corp.
12010 SE 32nd
Bellevue, WA 98005

Evergreen Turf Supply
10932 NE 33rd Place
Bellevue, WA 98009

Walter Hall Golf Course
1226 Casino Road
Everett, WA 98201

Fairway Irrigation
252 Taylor St.
Eugene, OR 97402

Fairwood Golf & CC
17070 - 140th SE
Renton, WA 98055

Stoneridge Country Club
Box 487
Blanchard, ID 83804

Fiddlers Green
Kim Wenger
91292 Hwy 99N
Eugene, OR 97402

Fircrest Golf Club
6520 Regents Blvd
Tacoma, WA 98466

Forest Hills Golf Club
Rt. 2, Box 220
Cornelius, OR 97113

Forest Lawn Cemetery
6701 - 30th SW
Seattle, WA 98126

H. D. Fowler & Co.
P. O. Box 160
Bellevue, WA 98009

Fran-Cher Chem., Inc.
P. O. Box 1399
1152 - 3rd Ave., Ste A
Longview, WA 98632

Gallery Golf Club
NAS-Whidbey Island
Oak Harbor, WA 98277

Ernie George
Seymour Golf & CC
3723 Mt. Seymour Pkwy
N. Vancouver, BC,
CANADA V1G 1C1

Tex Gifford
4727 - 15th Ave NE
Olympia, WA 98506

John Alexander
Glen Acres Golf Club
1000 S. 112th St.
Seattle, WA 98168

Glendale Country Club
13440 Main St.
Bellevue, WA 98005

Grants Pass Country Club
230 Espey Road
Grants Pass, OR 97566

Great Western Seed Co.
Box 387
Albany, OR 97321

Green Acres Golf Course
1375 Irving Rd
Eugene, OR 97404

Green Master Prod. Ltd
201-525 Seymour Street
Vancouver, BC, CANADA
V6B 3HF

Green Meadows CC
7703 NE 72nd Ave
Vancouver, WA 98662

George Haas
2037 - 34th Ave S
Seattle, WA 98144

Haines Tree Service
4700 E. Oregon St.
Bellingham, WA 98225

Dean Hanson
Linden Golf Club
12603 State Hwy 5
Puyallup, WA 98371

Thomas Hawley
36650 Yocum Loop
Sandy, OR 97055

Hayden Lake Golf Club
1800 E. Bozanta Drive
Hayden Lake, ID 83835

Hemphill Bros.
5427 Ohio Ave S
Seattle, WA 98134

Hi-Cedars Golf Club
Box 660
Sumner, WA 98360

Gregg Higgs
Meadow Springs CC
Richland, WA 99352

Don Hogan
1703 N. Dexter Ave.
Seattle, WA 98109

Don Hoos
USGA Green Section
Western Director
222 Fashion Lane, Ste 107
Tustin, CA 92680

Keith Hopkins
Hobbs & Hopkins, Ltd.
3964 SE Anking
Portland, OR 97214

James Howes
747 N. Lake Samish Dr.
Bellingham, WA 98225

Chas Hoydar & Assoc.
4612 Union Bay Pl. NE
Seattle, WA 98105

Ronald E. Hudson
19329 NE 112th St.
Brush Prairie, WA 98606

Gary Stormo
Inglewood Country Club
Box 70
Kenmore, WA 98028

International Seed Co.
Box 168
Halsey, OR 97348

J-B Sod and Seed
5289 Bluegrass Lane NE
Silverton, OR 97381

Jacklin Seed Co.
Rt. 2, Box 402
Post Falls, ID 83854

Monty Jantzer
Ceder Links Golf Course
3155 Ceder Links Dr.
Medford, OR 97501

Burl Cox
Jenks-White Seed Co.
Box 267
Salem, OR 97308

Tom Jeffords
Baker Golf Club
Baker, OR 97814

Mike Jones
Grow It Green
4045 Palisades Pl W
Tacoma, WA 98466

Jeffrey Jones
412 Logan St.
Port Townsend, WA 98368

Josephine Co. Parks
Jack Sim
101 NW "A"
Grants Pass, OR 97526

Kah-Nee-Tah Resort
Box 548
Warm Springs, OR 97761

Kaiser Estates
Sy Byle
Box K
Deer Harbor, WA 98243

Kellogg Country Club
Box 908
Pinehurst, ID 83850

Kent School Dist #415
12033 SE 256th
Kent, WA 98031

Randall King
12810 SE Lincoln
Portland, OR 97233

City of Kirkland
215 Central
Kirkland, WA 98033

Gerhard von Kohlbeck
Rt. 2, Box 1480
Corbett, OR 97019

Carl H. Kuhn
Box 493
Mercer Island, WA 98040

E. G. LaFleur
P. O. Box 467
Terrebonne, OR 97760

City of Lacey
P. O. Box B
Lacey, WA 98503

City of LaGrande
808 Adams Avenue
LaGrande, OR 97850

Richard Goodrick
LaGrande Country Club
Box 836
LaGrande, OR 97850

Lake Limerick Golf Club
E. 790 St. Andrews Drive
Shelton, WA 98584

Lake Oswego Parks Dept.
P. O. Box 369
Lake Oswego, OR 97034

Lake Tapps Develop. Co.
1414 Dexter Ave. N. #326
Seattle, WA 98109

Lakeland Village
c/o Howard Sisson
P. O. Box 108
Allyn, WA 98524

Lakeside Schools
Charles Forsman
14050 - 1st Ave. NE
Seattle, WA 98125

Jim McClure
Lake Wilderness Golf
P. O. Box 317
Maple Valley, WA 98038

Lawn-A-Mat of Seattle
14040 NE Lake City Way
Seattle, WA 98108

Leavenworth Golf Club
Rt. 1, Box 165 A
Leavenworth, WA 98826

Ray Lekberg
20203 SE Bornstedt Rd
Sandy, OR 97055

Lil Augusta Golf Club
9571 Avondale Rd
Redmond, WA 98052

Arthur Dome
Chas. H. Lilly & Co.
5200 Denver Ave. S.
Seattle, WA 98108

Thayne Loendorf
3014 NE 135th Ave.
Vancouver, WA 98662

Ronald L. Long
1737 SW Madison #A
Portland, OR 97205

Longview Country Club
Box 1075
Longview, WA 98632

L. Ben Malikowski
W. 1807 Northridge Ct #1
Spokane, WA 99208

Tom Wolff
Manito Golf & CC
Box 8025, Manito Sta.
Spokane, WA 99203

Marine Drive Golf Club
7425 Yew Street
Vancouver, BC, CANADA
V6P 6H1

Marysville Parks Dept.
6810 - 84th Place NE
Marysville, WA 98270

Meridian Valley CC
24830 - 136th Ave SE
Kent, WA 98031

Brad Merritt
Star Valley Ranch CC
Box 127
Thayne, WY 83127

Messmer's Landscape Co.
24664 SE 156th
Kent, WA 98031

Missoula Country Club
Box 3057
Missoula, MT 59806

Mist'er Rain
8411 Pacific Hwy E
Tacoma, WA 98424

Mohoric's Garden Service
3227 NE 167th St.
Seattle, WA 98155

Richard M. Morrow
112 W. 10th Ave.
Ellensburg, WA 98926

Moses Lake Country Club
Box 329
Moses Lake, WA 98837

Mount Si Golf Club
Box BB
Snoqualmie, WA 98065

Mukilteo School Dist #6
9401 Sharon Drive
Everett, WA 98204

Al Mundle
Eugene Country Club
255 Country Club Rd
Eugene, OR 97401

Clayton R. Nelson
2300 SE Harvester Dr.
Milwaukie, OR 97222

Duane Nelson
Nelson Landscape Serv.
11001 Newport Highway
Spokane, WA 99218

Nile Country Club
229 Third Ave. N.
Seattle, WA 98109

N. American Plant Brdrs
8177 Saghalie Dr. S.
Salem, OR 97302

Northshore Golf Club
1611 Browns Point Blvd
Tacoma, WA 98422

Don Glitschka
North Thurston School
6202 Pacific Ave. SE
Lacey, WA 98503

Northwest Mowers
926 N. 165th
Seattle, WA 98133

Nulife Fertilizer Co.
P. O. Box 883
Tacoma, WA 98401

Art Mehas
Olympic Landscape
1220 Goodpasture Isld Rd
Eugene, OR 97401

Oakbrook Country Club
8102 Zircon Dr SW
Tacoma, WA 98498

Olympia Country & GC
3636 Country Club Dr NW
Olympia, WA 98502

Olympic Landscape
941 N. 182
Seattle, WA 98133

Oregon Toro
9525 Commerce Circle
Wilsonville, OR 97070

Oregon Hort. Supply
5050 SE Stark
Portland, OR 97215

Oregon Turf Farms
Rt. 1, Box 437
Hubbard, OR 97032

G. Duane Orullian
3456 Crestwood Lane
Idaho Falls, ID 83401

Oswego Lake Country Club
Box 508
Lake Oswego, OR 97034

Sam Zook
Overlake Golf & CC
Box 97
Medina, WA 98039

Pacific Agro Co.
Box 326
Renton, WA 98055

Pacific Lutheran Univ.
Weldon Moore, Phys. Plant
Tacoma, WA 98447

Dennis Pagni
13222 Roseberg Ave.
Oregon City, OR 97041

PBI-Gordon Corporation
21971 S. Farm Pond
Oregon City, OR 97045

Peninsula Golf Club
Box 105
Port Angeles, WA 98362

Pickseed West Inc.
Box 888
Tangent, OR 97389

Jim Pitman
Turfgo Northwest
P. O. Box 77047
Seattle, WA 98133

Point Grey Country Club
3350 SW Marine Dr.
Vancouver, BC, CANADA
V6N 3Y9

Port Angeles Park Dept
140 W. Front St.
Port Angeles, WA 98362

Port Ludlow Golf Club
Rt. 1, Box 75
Port Ludlow, WA 98365

Portland Golf Club
5900 SW Scholls Ferry Rd
Portland, OR 97225

Joe Pottenger
215 N. 56th Ave., Unit 6
Yakima, WA 98908

David W. Powers
1921 SW Mapleleaf Road
Lake Oswego, OR 97034

Puget Sound Seed Co.
1120 Ewing St.
Seattle, WA 98119

Rainier Golf & CC
1856 S. 112th St.
Seattle, WA 98168

Redeturf
Rt. 3, Box 630
Aurora, OR 97002

Redmond Lawn & Tractor
18014 Fall City-Red. Rd.
Redmond, WA 98052

Redmond Parks Dept
15670 NE 85th
Redmond, WA 98052

J. R. Rivers
P. O. Box 196
Nanaimo, BC, CANADA

Riverside Golf Club
1451 NW Airport Way
Chehalis, WA 98532

Richard Malpass
Riverside Golf & CC
8105 NE 33rd Drive
Portland, OR 97211

Riviera Country Club
Anderson Isld, WA 98303

Jack Robertson
Rt. 2, Box 261
Monroe, WA 98272

Rock Creek Golf Club
5100 NW Neakahnie
Portland, OR 97229

Vern Rollin
West Seattle Golf
4470 - 35th SW
Seattle, WA 98126

Rolling Hills Golf Club
1695 McWilliams Rd
Bremerton, WA 98310

Royal Oaks Country Club
8917 NE 4th Plain Rd
Vancouver, WA 98662

Mike Russell
1046 S. Vissault #6
Tacoma, WA 98465

Sahalee Country Club
21200 NE 28th Place
Redmond, WA 98052

Salishan Golf Resort
Box 147
Gleneden Beach, OR 97388

Clip Collard
San Juan Golf & CC
2261 Golf Course Road
Friday Harbor, WA 98250

Sand Point Country Club
8333 - 55th Ave NE
Seattle, WA 98115

Richard Scholes
P. O. Box 277
Tualatin, OR 97062

O. M. Scotts & Sons
7644 Keene Rd
Gervais, OR 97026

Seattle Golf Club
Milt Bauman
210 NW 145th St.
Seattle, WA 98177

Seattle School Dist #1
Maintenance Office
810 Dexter N.
Seattle, WA 98109

Senior Estates Golf Club
1776 Country Club Rd
Woodburn, OR 97071

Senske Weed & Pest Cont.
P. O. Box 3024 T.A.
Spokane, WA 99220

Leo Moen
Golf Course Supt
Shadow Hills Country Club
204 Cartage Avenue
Eugene, OR 97404

Sham-Na-Pum
72 Geo. Washington Way
Richland, WA 98352

Shaughnessy Golf & CC
4300 SW Marine Drive
Vancouver, BC, CANADA
V6M 4A6

Shelton-Bayshore Golf
Box 89
Shelton, WA 98584

Nick Sherstobitoff
Site 19, Comp. 12
SS #2
Castlegar, BC, CANADA

Shoreline Schools #412
NE 158th & 20th NE
Seattle, WA 98155

Randal Shults
Summerfield Golf & CC
10650 SW Summerfield Dr.
Tigard, OR 97223

Similk Beach Golf Club
575 Satterlee Road
Anacortes, WA 98221

Skagit Golf & CC
1493 Country Club Dr.
Burlington, WA 98233

James Skahan
Wm. Grieve Robinson Golf
4304 E. Oregon
Bellingham, WA 98226

Snohomish County
Kayak Point Golf Club
15711 Marine Dr.
Stanwood, WA 98201

Snohomish Golf Club
7806 - 147th SE
Snohomish, WA 98290

Steve Nord
S. Seattle Com. Col.
12043 Standring Ct. SW
Seattle, WA 98146

Spokane Country Club
Box 7750
Spokane, WA 99208

Spokane Co. Parks Dept
Sam Angove
Courthouse Annex
Spokane, WA 98201

Spokane Parks Dept
504 City Hall
Spokane, WA 99201

John R. Steidel
Golf Course Architect
4204 S. Tacoma Place
Kennewick, WA 99386

Sunland Golf Club
137 Fairway Drive
Sequim, WA 98382

Charles D. Harger
Sunriver Properties
Golf Maint. Bldg. #1
Sunriver, OR 97701

Sunriver Golf Course #2
Sunriver Properties
Sunriver, OR 97701

Sunset Northwest
1919 - 120th NE
Bellevue, WA 98009

Suntides Golf Club
2215 Pence Rd
Yakima, WA 98902

Tacoma Golf & CC
Gravelly Lake Dr SW
Tacoma, WA 98498

Tam O'Shanter Golf Club
Andrew Soden
16505 SE 30th St
Bellevue, WA 98008

Mac Taylor
Box 10219
Bainbridge Isld, WA 98110

Shane Taylor
Star Valley Ranch CC
Box 127
Thayne, WY 83127

Ron G. Taylor
425 Cheyenne
Pocatello, ID 83201

Ronald Fream & Assoc.
3820 Sebastopol Road
P. O. Box 1823
Santa Rosa, CA 95402

John Tillman
City of Golden Valley
Golden Valley, MN 55427

Herb Tinker
16229 - 21st SW
Seattle, WA 98166

Tri City Country Club
Box 6758
Kennewick, WA 99336

Tumwater Valley Golf Club
Box 769
Olympia, WA 98507

Turf-Seed Inc.
Box 250
Hubbard, OR 97032

Turf & Toro Supply
20224 - 80th Ave. S.
Kent, WA 98031

Twin Falls City Parks
Box 1907
Twin Falls, ID 83301

Twin Lakes Golf & CC
3583 SW 320th
Federal Way, WA 98002

Turfgo Northwest
P. O. Box 77047
Seattle, WA 98133

Twin Lakes Village
Rt. 1
Rathdrum, ID 83858

Ken S. Tyson
Madrona Links Golf
3604 - 22nd Ave. NW
Gig Harbor, WA 98335

United Pipe & Supply
Box 17068
Portland, OR 97217

VA Domiciliary
Veterans Administration
White City, OR 97501

Vancouver Golf Club
Box 1174
Coquitlan, BC, CANADA
V3J 7A2

Vancouver Isld Golf Club
P. O. Box 196
Nanaimo, BC, CANADA
V9R 5K9

Vashon Golf Club
Box 370
Vashon, WA 98070

Velsicol Chemical Corp
341 E. Ohio St.
Chicago, IL 60611

Veterans Memorial Golf
Box 478
Walla Walla, WA 99362

Victoria Golf Club
1110 Beach Dr.
Oak Bay, Victoria, BC
CANADA V8S 2M9

Wagner's Nursery
504 Clay St.
Walla Walla, WA 99362

Walla Walla Country Club
Box 1236
Walla Walla, WA 99362

Walla Walla Com. Col.
500 Tausick Way
Walla Walla, WA 98362

Wandermere Golf Club
Rt. 11
Spokane, WA 99208

Warden Golf Club
204 W. Lake Samamish SE
Bellevue, WA 98008

Washington Tree Service
20057 Ballinger Rd NE
Seattle, WA 98155

Waverley Country Club
1100 SE Waverley Dr.
Portland, OR 97222

Wayne Golf Club
16721 - 96th NE
Bothell, WA 98011

Kathryn Welch
1906 Hoover Avenue
Oakland, CA 94602

Wellington Hills Golf
7026 Wellington Hts Dr
Woodinville, WA 98072

Wenatchee Golf & CC
Box 1479
Wenatchee, WA 98801

West Delta Golf Course
John Zoller
3500 N. Victory Blvd
Portland, OR 97201

Whidbey Golf & CC
1411 W. Fairway Land
Oak Harbor, WA 98277

Whistler Vil. Land Co.
Mr. Bob Wick
P. O. Box 35
Whistler, BC, CANADA
VON 1BO

Whitefish Lake CC
Box 666
Whitefish, MT 59937

Norm Whitworth Ltd
1275 High St.
Gladstone, OR 97027

David L. Wienecke
2094 Firth Avenue
Springfield, OR 97477

Willamette Valley CC
2396 NE Country Club Dr.
Canby, OR 97013

Zane Williams
New Village Greens Golf
2298 Fircrest Drive SE
Port Orchard, WA 98366

Charles W. Woosley
540 NE Colorado Lake Rd
Corvallis, OR 97330

Albert J. Worthington
North Idaho College
1000 W. Garden Ave.
Coeur d'Alene, ID 83814

WSU Golf Course
Wilson Compton Union
P. O. Box 2100 C.S.
Pullman, WA 99163

Yakima City Parks
Wayne Dean
129 N. 2nd St.
Yakima, WA 98901

Yakima Country Club
Box 1403
Yakima, WA 98907

Yakima Co. Parks & Rec.
Ronald K. McQuerry
1000 Ahtanum Road
Yakima, WA 98903

Zintel Canyon
121 S. Ely
Kennewick, WA 99336

David Zimmerman
10002 SW Conestoga Dr.
Beaverton, OR 97005

John Zoller
3104 Forest Lake Road
Pebble Beach, CA 93953

Wilbur Ellis Company
P. O. Box 8838
Portland, OR 97208

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