# Proceedings

Of The

# 42nd Northwest Turfgrass Conference

**September 19-22, 1988**

**Spokane-Sheraton Hotel
Spokane, Washington**

## PREFACE

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

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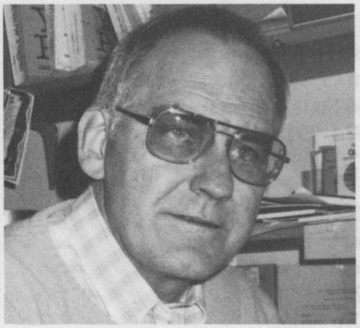
## PRESIDENT'S MESSAGE



James R. Chapman

My how the Northwest Turfgrass Association has changed just during the past year. Even so, the words of the show tune keep ringing in my head, "If You Could See Me Now."

Everyone should be so lucky to be President during a term with so many things going on and with a Board that worked as well as the one I had. We came to terms with the presence of an Executive Secretary and realized the benefits of a professional organizer. Your Board literally wrestled with the dilemma of scheduling confereces to take advantage of larger trade show facilities or more relaxing facilities with a secondary emphasis on the trade show.

Membership has expanded dramatically to include a much broader cross section of turf management. As we got a grip on running our own organization instead of relying on someone else, we became more professional. Budgets and new Bylaws evolved. The makeup of the Board changed to include Lawn Care Professionals and, our first woman member.

The next conference will be in Tacoma at the Tacoma Sheraton Hotel and Bicentennial Pavilion downtown, a beautiful facility with a very comfortable trade center and an outdoor display area so you can kick tires on equipment. I know the education sessions will be terrific and interesting. Bring your friends and let others that haven't shown up know about the best show on PNW turf.

See you then, if not before . . .

Jim Chapman
1987/88 President

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# STRATEGIES FOR TURFGRASS RENOVATION [1]

Tom Cook [2]

[1] Presented at the 42nd Northwest Turfgrass Conference, Sheraton-Spokane, Washington, September 19-22, 1988.

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If you read the trade publications or literature from equipment and chemical companies, you know all about renovation. Promotional literature makes it all seem very simple. All you have to do is spray out the existing turf with a non-selective herbicide, dethatch and/or core the area, plant the grass of your choice, fertilize and water, and Presto!, you have a stunningly beautiful lawn that is dense, green, and weed-free.

Does it really work like that? Is renovation a fool-proof method for improving or replacing turf infested with weedy grasses or damaged beyond repair by insects or diseases? Is it the easy way to convert your lawn to the latest miracle grass created by turfgrass breeders? The answer is yes or no, depending on what you do, when you do it, and how carefully you do it. Like all cultural practices, renovation requires good judgment and proper timing to give top quality results. The purpose of this paper is to guide you through some of the critical steps in renovation and to point out where mistakes are likely to occur. In addition, it will summarize the key steps necessary to achieve success with renovation.

## What is Renovation?

Renovation involves establishing new turf from seed without removing the old sod or preparing a seed bed via tilling and grading. We normally renovate turf areas in order to 1) improve the quality of existing turf and/or 2) change the grass species or cultivar to achieve a new look, improve wear tolerance, increase disease resistance, etc. To achieve these goals, there are three basic strategies you might use.

### 1) Simple overseeding

The plan here is to simply introduce seed into existing turf by whatever means you have available. The most effective planting technique is to use a slicer-seeder machine which cuts a slit in the turf and drops seed directly into the slit. Seeding can also be done by coring the turf area, broadcasting seed, and then dragging the seed into the aerifier holes and turf canopy. In heavy wear areas, seed can be broadcast on the surface, followed by sand or soil topdressing. Of the three techniques, slicer seeding is probably the most reliable. Simple broadcast seeding is sometimes very effective when used on the center of football fields once most of the turf has been destroyed through heavy use. Overseeding is generally least effective on dense turf areas, such as putting greens and home lawns.

**2) Overseeding following suppression of existing turf**

This technique is useful when you want to change the species composition of a turf that is dense and vigorous at the time you wish to renovate. The existing turf must be suppressed long enough to allow germination and early establishment of the overseeded grasses. The most common procedure here involves severe dethatching, followed by scalping to thin out the existing grass enough to allow establishment of the overseeded grass. A general rule of thumb is to get down to bare soil with the dethatcher before seeding, Because plant competition may be severe, it is important to select overseeding grasses that germinate rapidly and are competitive in the seedling phase. Perennial ryegrass is often the only suitable grass for this method, but we have had success with chewings fescue seeded into Kentucky bluegrass. The best method for planting is probably the slicer-seeder operated in two directions because it assures good contact betweeu seed and soil. It's difficult to get uniform establishment with broadcast seedings unless they are mulched with a thin layer of Sawdust or other available material to help maintain a moist surface environnent for germination. It is important to avoid heavy fertilizer applications at the time of seeding because the existing grasses will grow too much and may outcompete the seeded grasses.

Chemical suppression of existing grasses with a plant growth regulator prior to renovation is an idea that has some merit. We haven't conducted any trials to see how well this would work. If successful, this could streamline the renovation process by reducing or eliminating the need for the dethatching or scalping process. Potential negative effects of the growth regulators need to be determined.

**3) Complete renovation**

In this case, you generally will kill the existing turf via a nonselective post-emergent herbicide, dethatch to remove thatch and debris down to the soil level, fill in any potholes, plant the seed, fertilize, water, and watch for your new lawn. When all goes well, this is a very effective method of renovation, but there are several steps you need to perform properly to get the results you want.

One of the most important steps in this approach involves killing the existing grasses. There is a big difference between <u>spraying</u> and <u>killing</u> weedy grasses. In the rush to get the job done and look professional, most people simply spray the existing turf with glyphosate and a week later prepare and seed the area Often, within a year the undesirable weedy grasses have recovered and you have the same mess you started with. Obviously, you didn't kill the grasses you were trying to get rid of. What is the secret to controlling weedy grasses prior to renovation? First, you need to know what the weedy grasses are. Bentgrasses, roughstalk bluegrass, velvetgrass, tall fescue, quackgrass, bermudagrass, and, of course, annual bluegrass are our most common weedy grasses in the Pacific Northwest. Bentgrasses, quackgrass, and bermudagrass have rhizomes (underground stems) that may not be affected by foliar sprays if conditions aren't perfect. Velvetgrass has a pubescent leaf surface that may not absorb herbicides readily. Particularly when under drought stress, velvetgrass may not absorb glyphosate and thus will often survive sprays. Annual bluegrass is easy to kill, but will quickly reinvade from seed if pre-emergence herbicides are not used to prevent germination.

To get a thorough kill of weedy grasses, you need to stimulate vigorous growth with water or fertilizer, quit mowing for a few weeks, and time sprays properly. Most grasses are easy to kill in the spring when they start to flower, and in the fall when growth slows. At both times, translocation of herbicides to crowns, roots, and rhizomes occurs, which enhances herbicide activity and maximizes kill of regenerative structures. Velvetgrass (Holcus lanatus) is difficult to kill most of the time, but is susceptible in the spring when flowering occurs. I prefer to spray in the spring at flower time, wait for several weeks, and respray as needed if recovery occurs. If your goal is to get rid of unwanted grasses, you need to pay attention to the above comments. If you don't, you may find you wasted your time. Remember that the easiest grasses to kill in a lawn are often the desirable ones.

Annual bluegrass presents a special problem because it often comes back from seed after mature plants have been killed with herbicides. Until recently, there was no way to control annual bluegrass in new seedings, either chemically or culturally. With the development of ethofumesate (i,e. Prograss) we now have a chemical that can be spraycd on new seedings and renovation sites and selectively control annual bluegrass from germination up to the 3-4 leaf stage. Best results occur when new plantings of perennial ryegrass are sprayed at the 1-2 leaf stage. Ethofumesate works best on moist soils low in organic matter. We normally irrigate after application to work this herbicide into the soil. Our tests show that commercially available cultivars of perennial ryegrass are quite tolerant to ethofumesate, even at the one leaf stage of development. Limited tests indicate tall fescue is also tolerant, but other cool season grasses, particularly the fine fescues, are not tolerant to ethofumesate. Currently, it is registered for use only on seedling stands of perennial ryegrass. Testing at OSU has consistently given 100% control of annual bluegrass in new seedings and renovated sites that were broadcast seeded. On no-till renovated sites planted with a slicer-seeder, we generally get 90-100% control of annual bluegrass.

Regardless of the type of renovation you are attempting, there are several key steps that you should keep in mind to assure success. Some of them have already been discussed, but are worth reiterating here.

**1) Choose grasses suited to renovation**

Grasses that germinate rapidly and establish quickly increase your chance for success. Throughout the Pacific Northwest, perennial ryegrass has the highest success rate regardless of the actual type of renovation. Of the fine fescues, red and chewings are most competitive and will work where turf is suppressed or sprayed out prior to seeding. Hard fescue works best when existing grasses are killed prior to planting. Tall fescue is similar to red and chewings fescue. Bentgrass can work on suppressed turf or where existing turf has been killed. It is often quick to germinate, but somewhat slow to develop. We have had good success with bentgrass/ryegrass mixtures broadcast on complete renovation sites. Generally, the ryegrass dominates early and the bentgrass shows up as the turf matures. Kentucky bluegrass is difficult to establish on overseeded or suppressed turf sites because it is so slow to germinate and has a weak juvenile period. Your best chance with bluegrass is on completely renovated sites where existing grasses have been killed, eliminating competition.

**2) Insure good seed soil contact**

Establishment of renovated sites is often slow and stands are often very spotty. Many times this is due to poor germination because seed was sitting on the surface of compacted soil or hung up on top of thatch or organic debris. Planting with a slicer-seeder will generally avoid this problem, though small seeded grasses like Kentucky bluegrass may not emerge from deep slits. The slicer-seeder is perfect for perennial ryegrass. Broadcast seedings are generally much more successful when mulched with sawdust, compost, or stuaw. In fact, this is one of the most important keys to success on renovated sites. In spite of the ease of renovation, it is very difficult to produce a seed . bed as good as that achieved by tilling and grading. For this reason you need to do everything you can to enhance uniform and rapid germination.

**3) Seed relatively heavy**

Since surface conditions on renovated sites are often suboptimal, I try to compensate in any way I can. My rule of thumb is to increase seeding rates by about 50% of the normal seeding rate. In the case of perennial ryegrass, I usually increase the seeding rate from 5 lbs/l000 sq. ft. to 7-8 lbs/l00 sq. ft. A similar approach works for most other grasses.

**4) Plant at optimum times**

Spring and fall are good times for renovation. Throughout the Northwest, August 15-September 15 is hard to beat. The combination of warm days and cool nights promotes rapid germination and development. Mid-summer is a very poor time because it's hard to keep seed moist enough to germinate without increasing the chances of damping off from fungal pathogens. If you renovate in mid-summer, either use treated seed or spray fungicides for damping off shortly after planting. Remember that root initiation is poor in the heat of summer, so stand development is slow. Often, lawns renovated in July are no further along in October than lawns renovated in mid-August. April through mid-June works very well in many areas and is a great time to renovate athletic fields needed for fall sports.

## 5) Fertilize intelligently

On complete renovations where existing grasses have been killed, I encourage people to push young plantings to speed fill-in and promote dense turf. This ally means a complete fertilizer applied at planting with nitrogen rates of 1-2 lbs N/lOOO sq, ft. followed 4-5 weeks later with a second application at the same rate.

On simple overseedings and renovations on suppressed turf, fertilizer is counterproductive. Nitrogen will stimulate growth of existing grasses and help them out-compete the seeded grasses. On these sites, I try to starve the existing grasses by witholding fertilizer and removing clippings during mowing. Once the seeded grasses are up and somewhat mature, resume fertilization but don't push the stand. High rates of nitrogen may favor the existing grasses more than the seeded grasses. This is more of a problem with the fescues, bentgrasses, and bluegrasses than with perennial ryegrasses.

## 6) Water carefully

Properly planted, renovated sites require no more water than new seedings. In both cases, the goal is to keep the seed consistently moist to encourage rapid and uniform germination. Heavy irrigation on broadcast seedings may cause seed displacement, so light, frequent irrigations are the best approach. This is less of a problem when seed is planted via a slicer-seeder.

## Summary

Renovation is both easy and hard. It's easy to go through the motions and get something to grow. It's a lot harder to get rid of unwanted grasses and achieve the uniformity and quality we all have in mind at the outset. By following the suggestions I've outlined in this article, you should be able to achieve better results than you may have had in the past.

# EFFECT OF LIGHT ON TURFGRASS SEEDLING ESTABLISHMENT [1]

Thomas G. Chastain [2]

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Establishing turfgrasses in areas shaded by vegetation, buildings, and other objects can pose problems for the homeowner or the landscape professional. The light environment under a canopy of vegetation is characterized by reduced light intensity, altered light quality (wavelength or color), and is not uniformly distributed due to the presence of sunflecks. A shaded environment can adversely influence the growth and development of grass seedlings, resulting in low quality turf.

## EFFECT OF LIGHT ON TURFGRASS GERMINATION

The first and most important event during germination is the imbibition of water by the seed. Hydration of seed tissues is required for the activation of enzyme systems essential for seed germination. Development of the seed embryo into the seedling depends on the enzymatic hydrolysis of carbohydrate reserves stored in the endosperm of the seed. The development of the seedling into the adult plant after the carbohydrate reserves are exhausted depends on photosynthesis; a process that requires light.

Kentucky bluegrass (10), bentgrass (11), and tall fescue (6) seed germination is promoted by red light and inhibited by far-red light. Since green leaves absorb light in the blue and red regions of the spectrum, light that is transmitted below a tree or shrub canopy has less red light and relatively more far-red light (Table 1). A brief ( 2-minute ) exposure to red light can improve Kentucky bluegrass seed germination from 0 to 80% (10). Obviously, turfgrass seeds do germinate in shade, however, germination can sometimes be rather poor as a result of the low levels of red light present.

## EFFECT OF LIGHT ON TURFGRASS MORPHOLOGY AND ANATOMY

The possible consequences of a poor light environment at establishment include thin, weak stands having few tillers and poorly developed root systems (5). This, in turn, may cause the shaded grass to be more susceptible to drought-induced stress (4), disease (2), and to be less effective in nutrient uptake.

Few studies have examined the effect of light quality on turfgrass seedling establishment. The ratio of red to far-red light (red: far-red) is decreased when light passes through tree and shrub leaves (Table 1). This ratio determines the growth habit of the adult plant. Pines reduce the red: far-red ratio less than other trees, presumably as a consequence of their needle-shaped leaves. Shrubs do not reduce the red : far-red ratio at their bases as greatly as trees because of their short stature. Shade caused by buildings decreases the total light energy received by the turf but does not alter the red: far-red ratio.

Deregibus et al. (7) concluded that tillering in ryegrass seedlings was impaired as a result of increased exposure to far-red light as under a plant canopy. This effect was counteracted by an exposure to red light. This finding suggests that the tillering response of grasses to light may be mediated by phytochrome and that light quality, as well as quantity, may be important in determining tiller number. Other negative effects of reduced red light on ryegrass seedlings include less total dry matter ( shoots and roots ) and less leaf area (7).

Chastain and Grabe reported that shading red fescue (3) and turf- type tall fescue (4) seedlings reduced tiller numbers, dry matter production, leaf area, and caused etiolation of tillers. Reduced light intensity adversely affected Kentucky bluegrass and red fescue root growth (13).

There are differential responses among turfgrasses to shading. Kentucky bluegrass plants exhibited upright growth patterns under low light intensity, whereas red fescue maintained horizontal growth under the same conditions (16). Red fescue produced better quality turf under shade than Kentucky bluegrass. The differential response of Kentucky bluegrass and red fescue turf to shade was attributed to better disease tolerance by red fescue (2).

Barrios et al. (1) used artificial shading to simulate the effect of deciduous shade trees on turf quality of warm season grasses. They found that St. Augustinegrass had the poorest turf quality under shaded conditions, whereas centipedegrass exhibited the greatest tolerance to shade. St. Augustinegrass is generally considered to have better shade tolerance characteristics than centipedegrass (12). Shading greatly increased bermudagrass leaf blade and internode length (13). By comparison, shade caused much less change in St. Augustinegrass blade and internode length.

## EFFECT OF LIGHT ON TURFGRASS PHYSIOLOGY

Shade-induced stress can significantly alter physiological processes in turfgrass seedlings. Tall fescue leaves have more stomata in full sun than under 23% full sunlight (17). Wilkinson and Beard (15) observed that low light intensity reduced Kentucky bluegrass and red fescue stomata number . Consequently, the $C0_2$ flux into the leaf could be impaired as a result of fewer stomata under shade and is indicative of possible reductions in seedling dry matter production. Sunflecks lasting 1 minute may make significant contributions to the daily dry matter gain of plants, whereas sunflecks less than 5 seconds in duration contribute little dry matter to the shaded plant (8).

Woledge (17) found that tall fescue plants grown in full sunlight had higher photosynthetic and respiration rates than plants grown in 23% sunlight. She observed that shaded plants had 6% more chlorophyll than plants grown in full sun. Chlorophyll content of turf-type tall fescue initially increased in response to shade, but then decreased as competition for water became more severe (4). Chlorophyll content in bermudagrass and St. Augustinegrass was also increased by shading (16). The photosynthetic rates of heavily shaded perennial ryegrass leaves declined faster with age than unshaded leaves (18). Heavy shading also reduced the longevity of leaves. Wilkinson et al. (14) showed that photosynthetic and respiration rates of Kentucky bluegrass and red fescue were reduced by low light intensity.

## SUMMARY

Light is the source of energy needed in photochemical reactions that are essential for normal germination, growth, and development of turfgrasses. Special consideration must be given to the selection of trees and shrubs that minimize the damage caused by shade in areas where turf is to be established. Finally, shade-tolerant turfgrasses should be utilized in areas where a canogy of vegetation cannot be avoided in the landscape design.

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Table 1. Effect of shade on light quality incident on turfgrasses on the Washington State University campus. Light quality measurements were made on 11 August 1988.

| Source of Shade | Wavelength Red (660 nm) | Far-red (730 nm) | Ratio |
|---|---|---|---|
| | ------- micro mol $m^{-2}$ $s^{-1}$ -------- | | |
| Full Sun | 135.1 | 130.1 | 1.04 |
| Scotch Pine - Base | 2.3 | 3.0 | 0.77 |
| Scotch Pine - 3 m* | 3.4 | 4.2 | 0.81 |
| Ponderosa Pine - Base | 3.7 | 6.2 | 0.60 |
| Ponderosa Pine - 3 m | 12.6 | 14.7 | 0.86 |
| Blue Spruce - Base | 0.8 | 1.8 | 0.44 |
| Blue Spruce - 3 m | 2.6 | 4.1 | 0.63 |
| Maple - Base | 3.2 | 7.4 | 0.43 |
| Maple - 3 m | 3.7 | 5.3 | 0.70 |
| Black Locust - Base | 3.9 | 8.2 | 0.47 |
| Black Locust - 3 m | 11.5 | 16.4 | 0.70 |
| Birch - Base | 3.5 | 8.0 | 0.44 |
| Birch - 3 m | 4.7 | 6.6 | 0.71 |
| Aspen - Base | 3.3 | 9.6 | 0.34 |
| Aspen - 3 m | 4.5 | 9.2 | 0.49 |
| Horse Chestnut - Base | 1.4 | 4.1 | 0.34 |
| Horse Chestnut - 3 m | 3.3 | 5.5 | 0.60 |
| Cedar Hedge | 2.2 | 2.9 | 0.76 |
| Rose | 2.5 | 3.5 | 0.71 |
| Building | 4.7 | 4.7 | 1.00 |

*Measurement made at 3 meters from base of tree.

# THE JOY OF GRASS [1]

Gordon Witteveen [2]

[1] Presented at the 42nd Northwest Turfgrass Conference, Sheraton-Spokane, Washington, September 19-22, 1988.

[2] Golf Course Superintendent, Board of Trade of Metropolitan Toronto, Woodbridge, Ontario, Canada

The Joy, the exhilarance of touching, of feeling, of rolling, or jumping, or making cartwheels on grass is incomparable to any other experience.

Adjacent to our house in Woodbribge is a one acre bentgrass nursery maintained at putting green height. Frequently when people stroll past our house the beauty of the perfectly smooth, grassy surface will catch their eye and they will take a closer look. Sometimes they climb the low fence, then they bend down and gingerly touch the grass to see if it is real. Green grass attracts one's attention. It is like Niagara Falls; one cannot take ones eyes off it.

Grass or turf serves many functions:

1. It purifies the air and traps dust.
2. It serves as erosion control in mountain meadows, on ski hills, along stream banks, and on coastal plains.
3. A lightly knit sod causes the dissipation of heat. Turf has a cooling effect.
4. Grass provides a soft, resilient cushion on which to play and to have fun.

In Ontario grass is a $250,000,000 crop and it encompasses 385,000 acres of land. In area it is second only to grain-corn. In dollar value it is third after grain-corn and tobacco.

The joy of playing a game on qrass is directly proportional to the quality of the playing surface. In fact, if the condition of the playing field is very poor, there is no joy at all, and the players stay away. Such is ihe case not only on poorly conditioned golf courses and bowling greens but also in parks where weeds are no longer sprayed and where the turf is polluted with dog and goose droppings.

As recreation managers we must see it as our duty to provide the best possible playing environment for the greatest number of clients at peak periods. This means that our grass, whether it is bowling, golf, or park grass, must be at its best on Saturdays, Sundays, and holidays. Our watering and maintenance schedules should be such that prime conditions prevail at these peak periods. Grass does not take a holiday; it keeps on growing even when people rest.

A bowling green encompasses a small rectangular area of grass measuring about 1/3 of an acre. When used to optimum capacity, more than fifty men and women, dressed in white, can bowl at any one time.

Bowling is a game of great skill and strategy. Persons of all ages can take part in bowling but in North America it seems participation is somewhat limited to the geriatric set. This is because we have not provided conditions which make bowling appealing to the younger people. Bowling greens must be fast and flat and they can only be this way if the grass is cut at 4 mm or less with a sharp mower. Thatch is not allowed to develop. A bowling green must be firm and on the dry side. The speed or pace of a bowling green is expressed in the number of seconds it takes a bowl to travel 90 feet.

As opposed to bowling, golf reguires much more space. An average 18 hole golf course occupies 150 acres and accommodates a maximum of 300 players on a summer day. Over the length of a season 40,000 golfers will play an 18 hole course for an average of 4 to 5 hours. Perhaps this is inefficient use of green space compared to parkland and lawn bowling. Yet, there are in excess of 500 golf courses in Ontario and over 1,200 in Canada. The game has not experienced the fluctuation in participants that tennis, curling, or snowmobiling have. Golf continues to grow at a steady pace.

Many factors contribute to the popularity of golf. We like to think that the prime factor is the soothing influence of being surrounded by green grass. In other words, The Joy of Grass. Another factor, just as important, is that we have created playing conditions, which increase the enjoyment and the challenge of the game. Greens are cut short and are fast, requiring great skill. Fairways are close cropped enabling golfers to hit shots that will make the ball dance on the greens. Even the adjacent "rough" is better than most people's lawn.

Since golfers demand such a variety of conditions at all times of the season, the person in charge of the golf course, the Superintendent has become known as the turfgrass expert in the community. Through his vast knowledge and experience, no person is better qualified to give advice on grass and the maintenance of grass than the golf course Superintendent.

Grass on playing fields for soccer, football, or baseball does not require to be trimmed as closely as a golf course fairway. The turf on playing fields must be dense, uniform and strong and be able to survive the scraping and bruising of cleats and the thumping of bodies. On playing fields there is less emphasis on ball response and more of a need to provide a firm footing. Like in all sports played on grass, the esthetic value to the spectator is very important and, therefore, the grass must be green.

All turf, subject to heavy wear and compaction, must be drained properly. Therefore, sand as a growing medium has become very popular in recent years. A thick layer of sand on top of gravel and tile is now used almost exclusively as a base for greens as well as for playing fields.

In spite of the progress by turf managers to provide superior conditions, artificial turf is making inroads. We can find it in domed stadiums, on soccer fields, on golf course tees, on practice putting greens, and even on home lawns.

Yet, there have been some noticeable reverses. The Miami Dolphins are now playing on real grass after several seasons on the artificial variety. Our own soccer team, the Toronto Blizzard, were ecstatic to return to real grass at Varsity Stadium after coming from many bruising seasons at the CNE.

The future for green grass is bright. As people are stacked into apartment buildings, they will demand open space as parkland and as playing fields. To retain the quality of life we have become accustomed to, turfgrass managers have an obligation to provide green grass on which it is a joy to play, live, and love.

# SUSCEPTIBILITY OF TURFGRASSES TO NECROTIC RING SPOT [1]

Gary Chastagner [2]

[1] Presented at the 42nd Northwest Turfgrass Conference, Sheraton-Spokane, Washington, September 19-22, 1988.

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In the Pacific Northwest, symptoms of necrotic ring spot consist of donut-shaped rings or patches from several inches to 1 to 2 feet in diame ter. Active patches, which commonly develop in late spring-early summer or late summer-early fall generally have margins which are light reddish-brown in color. Most of the affected turfs in the Pacific Northwest are bluegrasses established as sod, although the disease has also been observed on seeded lawns. Initial symptoms generally appear one to three years after establishment when sod has been used.

Control of necrotic ring spot currently depends on the use of fungicides to suppress disease activity. Rubigan, which has been evaluated for a number of years in the Pacific Northwest provides acceptable control if applications are made during the spring prior to active symptom development. However, another potential method of controlling this disease is through the identification and use of turfgrasses with resistance to the fungus which causes this disease. Most of the work concerning the susceptibility of various turfgrass species and cultivars to necrotic ring spot have been done in the northeastern and midwestern portions of the United States.

In 1986, Dr. Smiley and his co-workers reported the results of a series of greenhouse tests conducted in New York to determine the susceptibility of cultivars of bentgrass, fine leaf fescues, Kentucky bluegrass, perennial ryegrass and tall fescue to Leptosphaeria korrea. In all of their tests, two isolates of L. korrae were used to infest a potting medium which was then seeded to the various cultivars tested. Replicate pots of each cultivar were then placed in a greenhouse maintained at 20°C (68F). After 59-79 days, the plants were examined and the percentage of seedlings that survived for each cultivar grown in the infested medium were compared to the survival when seedlings of the same cultivar were grown in noninfested media.

These greenhouse tests included 25 bentgrass, 53 Kentucky bluegrass, 42 fine leaf fescue, 38 perennial ryegrass and 27 tall fescue cultivars. The results of these tests indicated there was considerable variation in the susceptibility of different grasses to L. korrae and given grass species, there was considerable variation among cultivars. Also, there was considerable variability in the apparent susceptibility or resistance of specific cultivars to the two isolates of L. korrae that were used in these tests. In some instances a cultivar may have had a fairly high survival rate against one isolate, but not against the other.

To determine the relative susceptibility of each cultivar, cultivars within each grass species were ranked based on seedling survival against each isolate of L. korrae. Survival of bentgrass seedlings ranged from 3.1 to 31.1%. Emerald (30.7), Penncross (29.6) and Seaside (24.8) were the only bentgrasses ranked in the top 25% of seedlings against both isolates of L. korrae. The numbers in parentheses following the names of the cultivars are the average percentage survival in the fungus infested potting mix as compared to the non-infested controls. Survival of Kentucky bluegrass seedlings ranged from 5.7 to 53.5%. Eclipse (50.7) and Fylking (50.0) ranked in the top 15%, while Ram I (53.5), Nugget (44.0), S-21 (49.2) and Charlotte (42.0) were in the top 25% against both isolates. Survival of fine leaf fescues ranged from 13.5 to 71.3%. Jamestown (71.3) ranked in the top 10%, Flyer was in the top 15%, and FRI-Frt 83-1 (66.2), Ceres (6R.0) and HF 9-3(61.2) were in the top 25% against both isolates of L. korrae. Survival of perennial ryegrass seedlings ranged from 49 to 92.4%. Pennant (78.2), Pennfine (80.9), AllStar (87.5), and Gator (92.4) ranked in the top 25%. Survival of tall fescue seedlings ranged from 37.4 to 91.3%. Houndog (91.3) ranked in the top 10%, 5GL (90.3) was in the top 15%, and Mustang (89.8) and Olympic (85.4) were in the top 25% against both isolates.

In 1982, Dr. Gayle Worf and his co-workers at the Universit,y of Wisconsin established two large-scale cultivar susceptibility trials at two sod farms. Since that time, disease severity data have been collected on the 23 Kentucky bluegrass cultivars in these trials. Disease severity is rated on a scale of 0 (no symptoms) to 5 (75% or more of the area with patches). Disease severity data obtained in 1986 at one of the plots located at the Long Island Sod Farm ranged from 0 to 5.0 (Table 1).

In addition to the Wisconsin field evaluation tests, Dr. Smiley and his co-workers established a series of plots to examine the susceptibility of turfgrasses to necrotic ring spot under field conditions in the northeastern portion of the United States. In April, 1985, plantings containing 86 Kentucky bluegrass cultivars at Ithaca, New York, and 93 Kentucky bluegrass cultivars at Riverhead, New York (3 replications per cultivar), were incculated with a single isolate of L. korrae. The turf at both sites was 5 years old at the time of inoculation. At Ithaca, New York, patch symptoms were evident at the inoculation site in one replication of the cultivar Merit by November 1985. During May 1986, patch symptoms were present on one replicate of Cello, Argyle, and Escort and two replicates of WW Ag-480. By August 1987, a number of cultivars had patch symptoms (Table 2) the Riverhead, New York site, patch symptoms were present in one replicate of CEB-VB-3965, Classic, NJ-735, NK-70871, Birka, Bono, Cello, and MER PP43 by September 1985. One year later, the only symptoms that developed occurred in one replicate of Victa, Fylking, Bono, Ram I and MER PP43.

In addition to these trials, Smiley and his co-workers inoculated a series of sodded turf plots with a single isolate of L. korrae in April 1985. This plot is located at Farmingdale, Long Island and was established in 1979 using various sods. Seven sods consisted of single Kentucky bluegrass cultivars, 13 sods consisted of blends of Kentuckv bluegrass cultivars and six sods consisting of mixtures of Kentucky bluegrass, perennial ryegrass and fine leaf fescue. In September 1985, the percent of inoculation sites with symptoms on the single Kentucky bluegrass sods ranged from 33 to 89%, while in 1986, the percentage ranged from 33 to 100% (Table 3). The percentage of replicates of the 13 Kentucky bluegrass blends ranqed from 17 to 100% in 19B5 and 0 to 67% in 1986 (Table 4). When Kentucky bluegrass, perennial ryegrass and fine leaf fescues were components of the sod, the percentage of replicates with symptoms ranged from 0 to 100% in 1985 and 17 to 67% in 1986.

How do the results of the greenhouse evaluations compare with the evaluations under field conditions? Ram I, which had the highest percent survival under greenhouse tests, had the highest disease severity rating under field conditions in Wisconsin. If one compares the greenhouse survival rating of the Kentucky bluegrasses with the field disease severity ratings for the bluegrass cultivars that were in both the greenhouse and Wisconsin field tests, one finds that the greenhouse test was a very poor indicator of the susceptibility of these cultivars under field conditions. Charlotte, which was in the top 25% survival among the cultivars tested in the greenhouse, was the only cultivar in which all three replicates developed patch symptoms in 1987 at the Ithaca, New York field plot.

In our overseeding control work, we are testing a number of bluegrass cultivatars in addition to perennial ryegrass cultivars as a means to minimize damage caused by necrotic ring spot. Symptoms developed on two cultivars of Kentucky bluegrass (Ram I and Baron) within four months of overseeding diseased bluegrass turf that had been killed with Roundup and dethatched to the soil prior to seeding. In addition, symptoms were present on two perennial ryegrass cultivars (Manhattan and Allstar). During 1988, none of the bluegrass or perennial ryegrass cultivars in our overseeding test had disease symptoms.

Variation in pathogenicity among isolates and the effect of environmental and cultural conditions on disease development may, in part, explain the differences between greenhouse data and field data. In our work with a number of isolates of L. korrae from Washington, California, Utah, Colorado, Michigan and New York, we have observed considerable variatility in the ability of specific isolates to cause disease on Scaldis hard fescue and Ram I Kentucky bluegrass during greenhouse tests. Because of this variability, the use of large numbers of isolates or mixtures of isolates might be needed to increase the chances that greenhouse data would correlate with field data.

Prior to making recommendations on the resistance of specific cultivars, additional work is needed to determine the susceptibility of bluegrass, ryegrass and fine leaf fescues to necrotic ring spot under field conditions. The National Bluegrass Trials at Prosser and Puyallup, Washington have been inoculated with three isolates of Leptosphaeria korrae in an effort to determine the susceptibility of cultivars to necrotic ring spot under our growing conditions. In addition, information needs to be obtained on the susceptibility of perennial ryegrasses and fine leaf fescues under our environmental conditions. In the meantime, turf managers should avoid using cultivars which appear to be highly susceptible under field conditions, irrespective of their susceptibility under greenhouse conditions.

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Table 1. Necrotic ring spot disease severity during 1986 at Long Island Sod Farm plots in Wisconsin. (From Worf, G. L., J. S. Stewart, and J. M. Leed, 1986.)

| | | | |
|---|---|---|---|
| I-13 (0)[1] | Midnight (1.0) | Eclipse (1.3) | Birka (3.7) |
| Vantage (0.3) | Newport (1.0) | Wabash (1.3) | Columbia (3.7) |
| H-7 (0.3) | Challenger (1.0) | Merit (1.7) | Sydsport (3.8) |
| Park (0.7) | Baron (1.0) | Merion (1.7) | Glade (4.0) |
| Adelphi (0.7) | Mystic (1.0) | Nassau (2.3) | Georgetown (4.3) |
| | | Haga (2.3) | Trampas (5.0) |
| | | | Ram I (5.0) |

[1] Numbers in parenthesis are the average disease severity rating (0=no symptoms and 5=75% or more of the turf area with patches).

Table 2. Number of replicates exhibiting necrotic ring spot symptoms on inoculated Kentucky bluegrass at Ithaca, NY during August 1987. (From Fowler, M. C., N. W. Hummel, and R. W. Smiley, 1988.)

| 1 replicate | | 2 replicates | 3 replicates |
|---|---|---|---|
| A-20 | Glade | Barblue | Charlotte |
| A-34 | MLM-18001 | Bono | |
| Baron | Mona | Cello | |
| Bristol | Monopoly | Cheri | |
| Columbia | S-21 | Kl-152 | |
| Enmundi | Shasta | Kimono | |
| Enoble | VB 4699 | Majestic | |
| Escort | Welcome | MER PP43 | |
| | 239 | Ram I | |
| | | SV-01617 | |
| | | WW Ag-480 | |

Table 3. Development of necrotic ring spot symptoms on Kentucky bluegrass sods inoculated with Leptosphaeria korrae[1]. (From Smiley, R. W. and M. C. Fowler, 1986 and Fowler, M. C., N. W. Hummel, and R. W. Smiley, 1987.)

| Cultivar | Source | Percent of inoculated sites with NRS symptoms | |
|---|---|---|---|
| | | Sept 1985 | Sept 1986 |
| Merion | 2-M-32 | 89 | 50 |
| Adelphi | 3-M-21 | 42 | 50 |
| Touchdown | 1-M-21 | 83 | 100 |
| A34 | 1-M-21 | 42 | 63 |
| A34 | 7-0-18 | 83 | 83 |
| A34 | 7-M-18 | 50 | 67 |
| A20 | 7-0-18 | 33 | 33 |

[1] Sods established July 1979 and inoculated April 1984.

Table 4. Development of necrotic ring spot symptoms on Kentucky bluegrass sods inoculated with Leptosphaeria korrae.[1] (From Smiley, R. W. and M. C. Fowler, 1986 and Fowler, M. C., N. W. Hummel, and R. W. Smiley, 1987.)

| Cultivar | % Composition | Percent of inoculated sites with NRS symptoms | |
|---|---|---|---|
| | | Sept 1985 | Sept 1986 |
| A34 + H7 | 50/50 | 17 | 0 |
| Adelphi + Merion | 60/40 | 83 | 67 |
| Adelphi + Ram I | 50/50 | 100 | 67 |
| Adelphi + Glade + Touchdown | 40/30/30 | 100 | 0 |
| Adelphi + Glade + A34 | 25/25/50 | 100 | 33 |
| Adelphi + Touchdown + A34 | 25/25/50 | 67 | 50 |
| Adelphi + Touchdown + Merion | 40/30/30 | 100 | 67 |
| Adelphi + Touchdown + Majestic | 40/35/25 | 67 | 17 |
| A34 + Glade + Parade | 50/25/25 | 67 | 83 |
| A34 + Brunswick | 50/50 | 50 | 50 |
| Baron + Merion + Pennstar | 50/30/30 | 67 | 50 |
| Adelphi + Glade + Cheri + Nugget | 25/25/25/25 | 67 | 50 |
| Adelphi + Glade + Fylking + Baron | 40/20/20/20 | 83 | 17 |

[1] Sods established July 1979 and inoculated April 1984.

Table 5. Development of necrotic ring spot symptoms on Kentucky bluegrass, perennial ryegrass, and fine leaf fescue sods inoculated with *Leptosphaeria korrae*.[1] (From Smiley, R. W. and M. C. Fowler, 1986 and Fowler, M. C., N. W. Hummel, and R. W. Smiley, 1987.)

| Cultivar | % Composition | Percent of inoculated sites with NRS symptoms Sept 1985 | Sept 1986 |
|---|---|---|---|
| Adelphi + Jamestown + Manhattan | 60/20/20 | 0 | 33 |
| Adelphi + Glade + Fortress | Unknown | 67 | 67 |
| Adelphi + Glade + A34 + Fortress | 25/25/17/33 | 83 | 33 |
| Adelphi + Glade + A34 + Pennlawn | 22/22/22/34 | 67 | 17 |
| Adelphi + Glade + A34 + Jamestown | 25/25/17/33 | 100 | 33 |
| Adelphi + Fylking + A34 + Jamestown | 30/20/20/30 | 67 | 33 |

[1] Sods established July 1979 and inoculated April 1984.

# THE SPORTS TURF SCENE "DOWN UNDER"[1]

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[1] Presented at the 42nd Northwest Turfgrass Conference, Sheraton-Spokane, Washington, September 19-22, 1988.

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Despite being a small country, New Zealand exhibits a wide climatic range. This is probably easier to understand when one considers our country's latitudinal coverage.

New Zealand is considered to have a temperate climate, due mainly to the entire country having a seaboard, with no part of the country being more than 1 1/2-2 hours from the sea. The country is approximately 1,000 miles in length, and at no point are you more than 70 miles from the sea.

The temperatures range from 10-25 °C but temperature extremes do exist at both ends. In the far south, especially in inland areas, sub-zero temperatures are encountered over winter. For the rest of the country a handful of early morning frosts are the worst that can be expected. In the far north, the climate approaches the subtropical.

Similarly, rainfall variation is also extreme, ranging from below 500mm (20'') per annum in some eastern areas, to in excess of 5000mm (200'') only 50km away on the west coast. The topographic influence from the central mountain range is the main reason for the rainfall distribution.

**Table 1.** Annual rainfall and average temperature data for selected parts of New Zealand.

| | Rainfall mm (inches) | Ave Temp °C (°F) |
|---|---|---|
| Auckland | 1180 (47) | 15 (59) |
| Greymouth | 2480 (99) | 12 (54) |
| Hastings | 810 (32) | 14 (57) |
| Invercargill | 1038 (42) | 10 (50) |
| Alexandra | 340 (14) | 11 (52) |

On average,rainfall is relatively evenly spread throughout the year, although it is still unreliable and unpredictable. Consequently, irrigation over the summer is important, as is artificial drainage over winter.

## SOILS

As with our climate, we also have a broad spectrum of soils, ranging from deep, free draining volcanic soils, to shallow, poorly drained material.

It is quite common to find a friable topsoil overlain by dense, poor draining subsoil which will require regular physical treatment.

In a country where there are just over three million people and some 60 million sheep, there are 390 golf clubs, a greater proportion per head of population than Scotland.

We have our share of top metropolitan courses using permanent staff and modern equipment. The majority of such course would employ between 4 and 6 grounds staff, including the Superintendent. These courses would be open 12 months of the year.

But a high proportion of our courses are smaller. In many small communities golf is definitely a seasonal game. The small courses (and even some of the 18 hole courses) will have two staff, while the 9 hole courses in the main areas typically have one or two. In the country areas it is all volunteer labour.

Note that of our 390 golf clubs only 4 have more than 18 greens.

Course maintenance budgets (excluding wages) vary considerably, from $20,000 US to $90,000 US. The average for an 18 hole golf course would be about $45,500 US.

Machinery is a high cost. A Triplex mower costs approximately $20,000 US. Generally, there is only one per course, but again the bigger courses have 2 or 3. The small 9 hole courses use only walk-behinds.

GRASSES

In some regions our climate allows both warm season and cool season grasses to grow alongside each other for various times of the year.

Agrostis tenuis (colonial browntop) is a native of New Zealand and thrives in all areas, especially in the South Island. The further north one goes the browntop is taken over by ryegrass. On the greens agrostis teniuse is the predominant species sown and managed. In the early 1970s creeping bentgrass (cv Penncross) was imported, and where managed properly it has proved to be very successful. However, it has a higher management input, and on some courses that didn't have adequate labour or machinery it quickly developed thatch problem.

Since then importations have been confined to colonial bentgrass, especially from Europe. Two new cultivars of colonial browntop have recently been developed from samples taken from New Zealand golf courses. These two cultivars are more aggressive than other cultivars presently available, and I can see improvements in putting Surface quality within our management resources. Turf type ryegrasses are now commonly used. Some regions have stem weevil problems, thus high endophyte cultivars only are encouraged. Further north, the use of Cynodon spp is being encouraged.

## MANAGEMENT TRENDS

### (1) Fertilizer

In New Zealand we are in the process of raising pH levels, reducing nitrogen and phosphorus, and increasing potassium applications in order to promote the browntop dominance back into the greens.

Nitrogen useage is applied according to plant density and recouperative potential. Each course is being encouraged to set its own nitrogen programme in accordance with its playing intensity, so the most suitable nitrogen rate can be achieved to avoid either too much growth and possible increased diseases, or too little, resulting in turf thinning. Nitrogen applications are also being applied as and when required, although this generally works out to be around every 4-7 weeks. On sand greens the interval is reduced. However, the aim is still minimal but sufficient. The reduced nitrogen rates are also helping to starve the poa annua. Nitrogen rates vary throughout the country, but as a guide the rates are between 1.0 - 3.0 kgs/l00sqm/yr (3-6 lbs/1000 sq ft/yr), with probably the average rate being around 1.5 kgs (3 lbs).

The main nitrogen source still used is ammonium sulphate. Other nitrogen sources are available, including slow-release nitrogen carriers, but in our conditions the cost limits the use of the slow-release formulations, (Table 2).

**Table 2.** A comparison between the cost of ammonium sulphate and IBDU on a per unit N basis

| Nitrogen Source | ammonium sulphate | IBDU |
|---|---|---|
| cost/unit N | (US 71c) | (US $4.47) |

Potassium is increasing in importance. A few years ago it was in a N:K of 3:2, but over the last couple of years and to the present day it is now closer to a 1:1.

pH levels are still low in a lot of areas. However, education in thatch degradation has helped raise the level to a more acceptable figure. At present we aim for a level of 5.0 - 6.0 for colonial bentgrass and around 6.0 - 6.5 for creeping bentgrass.

### (2) Physical Work

Due to a large fraction of our sporting areas (both golf and playing fields) being constructed from native weakly-structured, fine-textured soils, combined with the 12 month playing times, regular physical treatment on the greens is vital if acceptable putting is to be maintained. Two machines used in addition to coring are the oscillating mini-mole and the mini-mole. Both tend to shatter the soil. Several passes each autumn are common.

In regards to drainage, the use of narrow trenching is becoming popular. This has the advantage of providing drainage with minimal green disturbance.

**(3) Sand topdressing/treatment**

Sand topdressing has been underway in New Zealand for approximately 8-9 years, generally with good results. At present, some 25-30% of courses are sanding their greens. Only 3-4% of courses have greens constructed from sand with the remainder constructed from soil. Problems do develop with the underlying soil, and again physical treatment is important.

Other aspects

Dry patch is occurring more frequently, mainly due to the increased usage of sand topdressing. Effective identification of dry patch is possible over the winter, showing up as areas where there is no dew. Control is achieved using a combination of physical treatment, melting agents and organic amendments.

There is an increasing trend to contour mow the fairways and encourage more rough.

One thing that is missing in New Zealand is the use of golf carts. It would appear that other problems such as poa, and diseases are universal.

How we prepare for a tournament may make an interesting contrast. Our courses are required to be played on by ordinary club members/green-fee players right up until the tournament, as clubs only have 18 greens.

Sportsfield management

Sports ground management in New Zealand is very demanding due to the intensive usage and variety of sports played. The main winter events are rugby, soccer and hockey. Cricket is the most popular summer sport.

New Zealand has only a very few grounds where single sports are played. With economics being the over-riding factor, even the major grounds have a combination of winter and summer sports.

Demand on the grounds has increased to a level where, with the seasons having extended at both ends, it is common to see the rugby posts removed on the Saturday and the cricket stumps go in the next day.

Management of such grounds not only concerns preparing a playing surface suitable for each sports code, but more importantly recognising that the area is in use for 12 months. Thus it parallels golf course management to an extent, as any renovation has to be done while there is still play.

Preventative management programmes are implemented to preserve the playing surface. This is achieved by a combination of cultural practices and usage control.

**(a) Cultural**

**Grass species -** Although a lot of fields in the country still have native browntop, ryegrass is becoming the dominant turf cover. Where possible turf-type ryegrasses are sown. However, at a cost of $5.80/kg US it is important to get value for money. In two areas (mainly in the drier eastern region) poa pratensis is becoming established.

**Fertilizer -** Fertilizer practices are wide ranging. Some fields receive fertilizer and others are left to survive on their own. However, there is an encouraging trend toward increased fertilizer use to counter the increased wear. Good plant density is being maintained with l00kgs N/ha/year supplemented with potassium.

**Physical treatment -** Without the capacity of sand topdressing the majority of fields requre physical treatment, be it by oscillating mini-moling, or mini-moling. Such treatment is essential in order to maintain good water movement. In addition to this, extra spiking on the heavy wear areas is an efficient way of maintaining good standards. Due to time constraints it is impractical to spike the entire field every fortnight or so. However, by concentrating on the heavy wear area it is one way of maintaining these areas in good shape.

**Undersowing -** Most fields would be annually undersown until adequate density is obtained. Subsequent under drilling will only be done if the field suffers reduced density through wear. Because of a shortage of turf seed-drillers, agricultural drills are often utilized.

**(b) Usage control**

Most sportsfields in New Zealand are owned by local authorities, with sports clubs paying levies for usage. Parks overseers can find themselves the ''meat in the sandwich'' in this arrangement. On one hand, they have to deal with the costs of repairs and maintenance, while on the other they must content with providing clubs with a playing surface.

The critical period for management is the winter, when grounds can be damaged very quickly. Hence a vital ingredient in our management programmes is strict useage control through cancellations. This is important because the best field can be turned into a mud heap after one game played in the wrong conditions.

There are various levels of useage control adopted, including: no training, only one game per ground and total closure. Provision of off-site training is also worthwhile.

I hope in this short time I have been able to give an insight to turf ''down-under''. I feel that most of the problems we encounter are universally shaved. Considering the financial constraints, our turf managers do an excellent job in providing player facilities year in and year out.

# ESTABLISHMENT OF BENTGRASS PUTTING GREENS WITH COATED SEED AND HYPNUM PEAT [1]

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## INTRODUCTION

Seeding of bentgrass on a pure sand surface is sometimes not successful and often the lack of success is related to moisture stress associated with the seed or seedling environment. Thus, failure of bentgrass seed to establish on pure sand often can be related to moisture stress during the early stages of germination (prior to emergence of the radicle or coleoptile), during early emergence and growth of the root and leaf or even during the early stages of seedling growth.

The percent moisture retained in pure sands is low even at low negative water pressures and seed and seedlings are extremely sensitive and vulnerable to environmental changes which influence the water status or humidity in the sand micro environment. Spaghnum peat, straw, and various synthetic covers have Commonly been used to protect seeding surfaces from extremes of moisture stress and some sand amendments will increase the moisture level and alter the moisture retained in sand mixes under negative pressure (Figure 1). This report is a summary of three studies conducted to evaluate seeding rate, seed coating, spaghnum and hypnum[1] peat and sand/peat ratio on seedling number, seedling survival, rate of establishment, and rate of bentgrass cover on pure sand surfaces.

## THE FIRST STUDY (Renovation of Established Putting Green)

The first study compared the effects of two topdressings on overseeding and establishment of seven seed coated[2] or non-coated bentgrass cultivars on glyphosate killed annual bluegrass (Poa annua L.)/creeping bentgrass (Agrostis palustris Huds.) putting turf. The topdress material was a pure sand or 50/50 sand/hypnum peat applied at 1/4 inch depth following seeding. The seven bentgrass cultivars were Penncross, Penneagle, Pennlinks, Prominent, Emerald, ISI-HK and Putter. The seedings were made during a warm, rainless period in June, 1987. Hand watering was applied three to four times daily from 11:00 AM to 5:30 PM. Seedings were rated for daily emergence and cover.

[1] Hypnum peat, known as 'Bonaparte' peat is harvested near Bonaparte Lake in eastern Washington. Hypnum peat is marketed by Bonaparte Company, Bellevue, WA.

[2] Bentgrass seed was coated by Celpril.

In this study, topdressing the surface with sand/hypnum peat increased the total emergence, speed of emergence and increased the speed of cover attained. Sand used alone provided a very poor mulch in which to assure acceptable emergence of bentgrass seedlings even though rather good watering practices were followed during the seed germination period. Sand did not provide sufficient protection during hot days or during field days to keep sensitive seedlings from desiccation even after emergence. On the other hand, the sand/hypnum peat mulching did provide this protection and resulted in excellent establishment of bentgrass of all cultivars.

Most plots that were mulched with 100% sand failed to establish seedlings and coated seed did not provide any benefit to improve seedling establishment. In this study, seed coating was not effective in increasing total emergence and seed coating decreased speed of emergence of bentgrass. Consequently, in sand topdressed conditions at some time during the emergence period, moisture stress or heat killed nearly all of the fragile seedlings. In sand/hypnum peat topdressed conditions, the growth enhancement and development protection masked the nutrient coating benefits of seed coating. No difference existed among cultivars and no cultivar was better than another to establishment in sand alone topdressing.

THE SECOND STUDY (Establishment on Sand Surface)

Coated and non-coated Putter creeping bentgrass seed was topdressed with sand/peat ratio volume/volume (v/v) mixes of 100/0, 90/10, 80/20 and 70/30. The peat sources were hypnum and screened, fine spaghnum peat. The study was conducted on a newly constructed, unamended sand surface in early October, 1987 during dry, moderately warm weather. The seedings were hand watered as required to avoid surface moisture stress. Close-up photographs were taken daily from marked locations within each plot to develop a record of seedling emergence and seedling counts. Emergence and cover estimates were made daily beginning with first visible germination. The seeding rate of bentgrass was adjusted to seed the same numbers of seed per 1000 $ft^2$ with coated and non-coated seed.

Sixty to 70% more seedlings germinated in sand/hypnum peat at 7 and 8 days following seeding compared to germination in sand/spaghnum peat. A similar greater percentage of seedlings were established two weeks following seeding (Figure 2). In addition, seedling numbers were lower in pure sand topdressing at day 16 following seeding compared to plant seedlings in plots topdressed with 80/20 or 70/30 ratio mixes of sand/hypnum where plant numbers continued to increase (Figure 3). Even though the plot area was watered regularly, seedlings were lost in pure sand topdressed plots between day 11 and day 16 while seedlings had limited root development. This loss did not occur in sand/hypnum overseeded plots with higher peat content (20% and above). The number of seedlings from coated seed was lower than from non-coated seed 7 to 9 days following seeding; as time progressed, seedling numbers from coat treatments were the same 11 days after seeding and the number of seedlings from coated seed was about 25% higher than the number of seedlings from non-coated seed by day 15 (Figure 4). Thus, coated seed caused a delay in germination early following seeding but later the numbers of established seedlings from coated seed exceeded the numbers from non-coated seed.

Percent bentgrass cover at four and eight weeks following seeding was 20 to 30% greater with hypnum peat as the amending peat as compared to fine spaghnum peat (Table 1). Percent bentgrass cover at these same periods (four and eight weeks) increased significantly as the percentage of hypnum peat increased in the topdressing mix from 0 to 30%. However, very little increase in bentgrass cover was noted as spaghnum peat was increased in a similar manner in the topdressing mix.

THE THIRD STUDY (Establishment on Sand Surface)

The seeding rates of coated and non-coated Putter creeping bentgrass seed in establishment of bentgrass on a pure sand surface was compared. Seeding rates were 1/4 to 1.0 lb/l000 $ft^2$ and seedlings were topdressed with 1/4 inch of a 70/30 (v/v) sand/hypnum peat mix. Coated seed contained approximately 50% of the seed numbers of non-coated seed. Thus, the 1/4 lb seeding rate of non-coated seed placed approximately 2000 seed/$ft^2$ while the same rate of coated seed placed 1000 seed/$ft^2$. Close-up photographs were taken daily from marked locations within each plot to develop a record of seedling emergence and seedling counts. Emergence and cover estimates were made daily beginning with first visible germination.

In comparison to non-coated seed, seedling emergence with coated seed was over 60% less during the early days of emergence (days 7 and 8 following seeding) but established seedling numbers were approximately 20% higher at 10 to 16 days following seeding (Figure 5). The final number of seedlings that were established at day 16 following seeding was always higher with coated seed at all seeding rates (Figure 6). This difference in established seed numbers with coated seed in comparison to non-coated seed was most apparent in the cover ratings at the lower seeding rates (1/4 to 3/4 lb/l000 $ft^2$). Established seedling numbers at 2 weeks post seeding were similar and not significantly different at 3/4 lb/l000 $ft^2$ of coated and 1.0 lb/l000 $ft^2$ of non-coated seed.

The percent bentgrass cover at four and eight weeks was most associated with seeding rate. The higher the seeding rate the higher the percent cover. Although coated seed showed some advantage in development of turf cover at all rates at four weeks following seeding, this advantage was notapparent at eight weeks at 1.0 lb/l000 $ft^2$ (Table 2). Thus, seeding of coated seed had a positive influence on seed numbers established that resulted in more rapid cover at the lower rates of seed application used in this study. As the seeding rate increased toward the commonly recommended rate (1 lb/l000 $ft^2$) of non-coated seed, the advantage in cover of higher establishment numbers in coated seed disappeared as measured in cover rating.

SUMMARY

On pure sand surface:

* Sand/hypnum peat mixes were greatly superior to sand/fine spaghnum peat mixes or pure sand for topdressing over sand surfaces seeded to bentgrass. Sand/hypnum peat strongly improved the rate of cover and plant development when topdressed at a sand/peat ratio of 80/20, 70/30 or higher.
* Coated seed delayed germination and emergence of bentgrass by one to two days.
* Topdressed with 100% sand, coated seed did not establish greater numbers of bentgrass seedlings than non-coated seed.
* Bentgrass seedings topdressed with sand/hypnum mixes ranging from 10 to 30% peat, established more seedlings from coated seed than non coated seed. When bentgrass seeding rates were at the commonly recommended rate (1 lb/ 1000 $ft^2$ non-coated bentgrass) for putting green establishment in the Northwest, these higher numbers of bentgrass seedlings did not result in more rapid surface cover of bentgrass at four and eight weeks following seeding in the fall. At lower seeding rates, bentgrass cover was more rapid with coated seed when seed numbers seeded were equal. Coated seedings topdressed with sand/spaghnum peat also established more seedings than non-coated seedings but usually 10 to 50% fewer seedlings were established in sand/spaghnum topdressings as compared to hypnum peat. This higher seedling count from coated seed in sand/spaghnum topdressings resulted in slightly higher cover (at 1/4 and 1/2 lb seeding rate) from coated seed at eight weeks following seeding.
* The number of bentgrass seedlings established at two weeks following seeding and the percent cover of bentgrass at four and eight weeks following seeding with sand/hypnum peat was similar at bentgrass seeding rates of 3/4 lb coated seed/1000 $ft^2$ versus 1.0 lb non-coated seed/1000 $ft^2$. It is estimated that 15 to 25% lower seed numbers of coated bentgrass seed should result in equivalent seed numbers from non-coated seed where good seedling establishment culture is practiced. Thus, 1-1/2 to 1-3/4 lb of coated seed should replace 1 lb of non-coated seed.

Table 1. Percent cover[1] of Putter creeping bentgrass four and eight weeks after seeding on pure sand as affected by peat type and sand/peat rates (Brauen).

| Sand/peat ratio | Weeks following seeding: Four, Hypnum | Four, Spaghnum | Eight, Hypnum | Eight, Spaghnum |
|---|---|---|---|---|
| (v/v) | % Cover | | | |
| 100/0 | 38 | 34 | 55 | 53 |
| 90/10 | 62 | 40 | 67 | 55 |
| 80/20 | 70 | 30 | 75 | 43 |
| 70/30 | 77 | 41 | 84 | 57 |
| $S_{\bar{x}}$ | 5.6 | 5.6 | 9.0 | 9.0 |
| Ave. | 61 | 36 | 70 | 52 |

[1] Visual rating of percent ground cover of bentgrass.

Table 2. Percent cover of Putter creeping bentgrass four weeks and eight weeks and after seeding on pure sand as affected by seeding rate and seed coating* (Brauen).

| Seeding rate | Weeks following seeding: Four, Non-coated | Four, Coated | Eight, Non-coated | Eight, Coated |
|---|---|---|---|---|
| lb/1000 ft² | % Cover | | | |
| 1/4 | 11 | 12 | 25 | 35 |
| 1/2 | 25 | 35 | 40 | 68 |
| 3/4 | 50 | 72 | 71 | 83 |
| 1.0 | 63 | 78 | 86 | 82 |
| $S_{\bar{x}}$ | 7.1 | 7.1 | 6.8 | 6.8 |

* Seed coating applied by Celpril Industries, Inc.

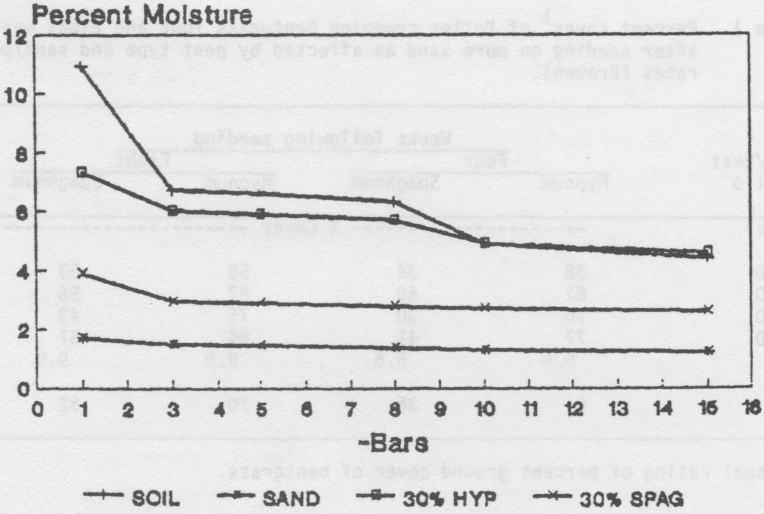


Fig. 1. Percent moisture retention of sandy loam soil, sand, sand/30% hypnum peat and sand/30% spaghnum mixes under negative pressure.

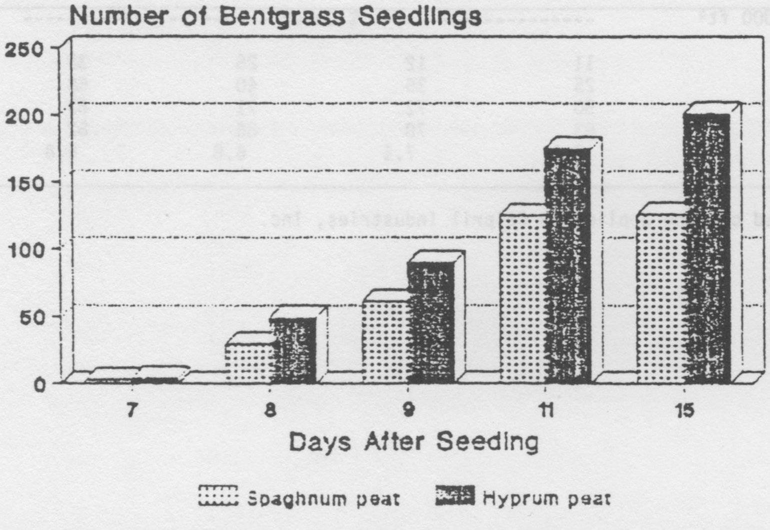


Fig. 2. Number of bentgrass seedlings emerged with topdressed hypnum or spaghnum amended sand from 7 to 15 days following seedling on a pure sand surface.

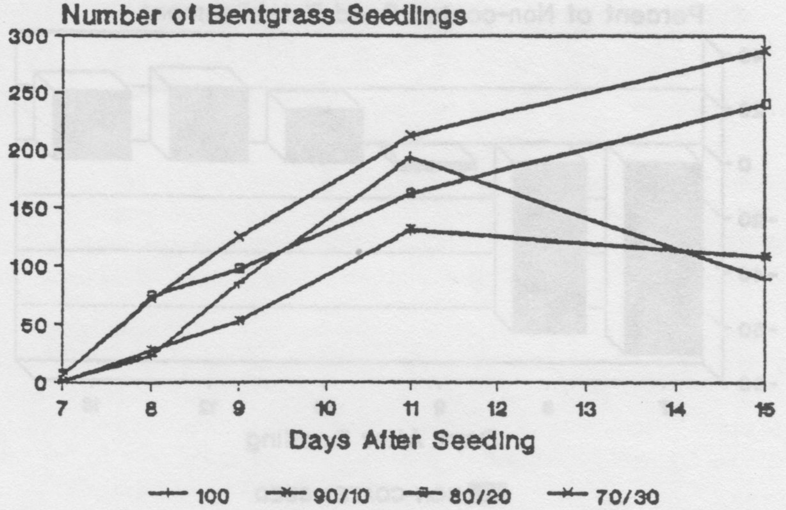


Fig. 3. Number of bentgrass seedlings emerged with sand/hypnum peat or pure sand 7 to 15 days following seedling on a pure sand surface.

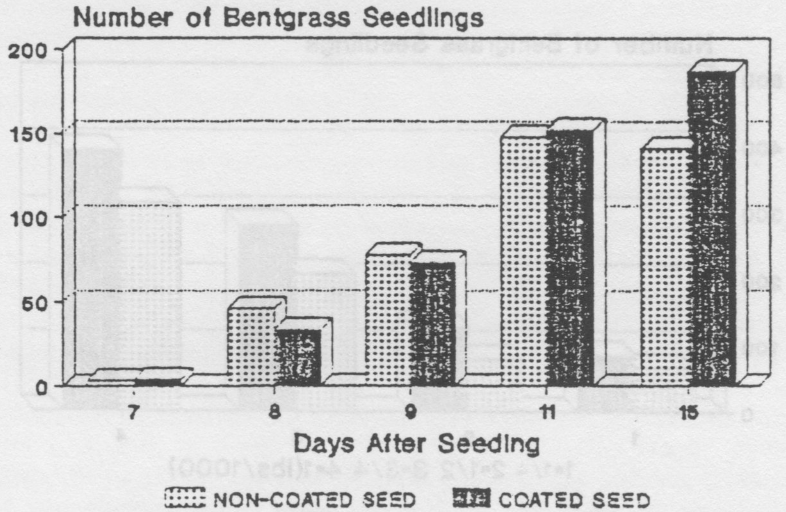


Fig. 4. Number of bentgrass seedlings emerged from coated and noncoated seed 7 to 15 days following seeding on a pure sand surface. Seed numbers of coated and noncoated were equal.

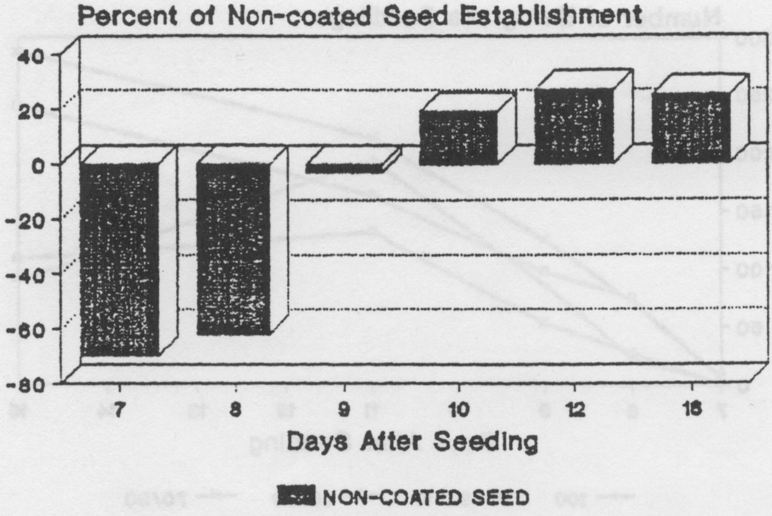


Fig. 5. Coated bentgrass seedling emergence from topdressed seedings as a percent of non-coated bentgrass seedling emergence 7 to 16 days following seeding on a pure sand surface.

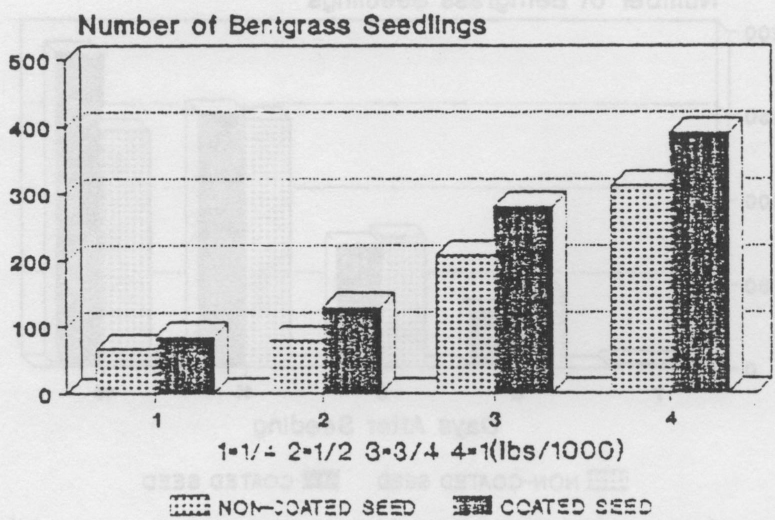


Fig. 6. Number of coated and noncoated bentgrass seedlings emerged from topdressed seedings with various seeding rates at 16 days following seeding on a pure sand surface.

# INTERACTION OF 'ACCLAIM' (FENOXAPROP-ETHYL) WITH BROADLEAF HERBICIDES [1]

William J. Johnston and Charles Golob [2]

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[1] Presented at the 42nd Northwest Turfgrass Conference, Sheraton-Spokane, Washington, September 19-22, 1988.

[2] Assistant Professor and Research Technician, respectively, Department of Agronomy and Soils, Washington State University, Pullman, Washington

Washington State University research trials during 1986-1988 have shown that 'Acclaim' (fenoxaprop-ethyl, manufactured by Hoechst-Roussel Agri-Vet) gave excellent control of crabgrass (Digitaria spp.) in eastern Washington and northern Idaho. Investigations are currently being conducted to determine if Acclaim can be tank mixed with broadleaf weed control herbicides without mitigating the crabgrass control efficacy of Acclaim.

Acclaim 1EC is a postemergence herbicide with translocation properties. It is translocated from the site of contact to meristematic tissues where it interfers with lipid biosynthesis and ultimately causes death of the target plant. Although Acclaim will translocate within the plant from the point of contact to meristematic tissue, it wi1l not translocate from one tiller to another tiller on the same plant. Therefore, in controlling crabgrass with more than one tiller, it is essential to get excellent coverage of the plant's leaf surface with the herbicide. Visual symptoms of crabgrass control are expressed as a chlorosis, 4 to 10 days after application, followed within 12 to 21 days after application of a reddening or purpling of the leaves and eventual death of plant tissue.

Acclaim was tested for crabgrass control, broadleaf weed control, and phytotoxicity to Kentucky bluegrass in 1986 at Walla Walla and Yakima, Washington; in 1987, at Walla Walla and Pullman, Washington, and at Lewiston, Idaho; and in 1988, at Clarkston, Washington. Herbicides were applied in 25 to 30 GPA at 40 psi with a $C0_2$ bicycle sprayer with 8002 tips. Crabgrass was generally between the 2-leaf and 2-tiller stage of growth during time of herbicide application in these studies.

During three years of testing, Acclaim provided excellent crabgrass control (1) (Tables 1, 2, and 3). There was some phytotoxicity observed on Kentucky bluegrass; however, this could be mitigated with nitrogen and iron applinations (1). It was observed during these tests that Acclaim was more phytotoxic on bentgrass (Agrostis spp.) than on Kentucky bluegrass. Acclaim is not recommended for use on bentgrass turf. Acclaim is also not currently registered for use west of the Cascade Mountains.

Since Acclaim has no effect on broadleaf weeds, it would be desirable to tank mix Acclaim with broadleaf herbicides. Tank-mix treatments of Acclaim and broadleaf herbicides were initiated in 1986 at Yakima to determine the effect of several herbicide combinations on crabgrass control. Acclaim alone at 0.18 lb. a.i./A gave excellent crabgrass control (Table 1). However, when tank mixed with broadleaf herbicides the efficacy was reduced. Reduced crabgrass control was only statistically true in 1986 for the Acclaim + Harmony treatment.

In 1987 (Table 2), as in 1986, there was antagonism between certain broadleaf herbicides and Acclaim. At Lewiston, Idaho, there was a general trend toward reduced crabgrass control with all broadleaf herbicides; however, Trimec was the only treatment that was statistically different from the Acclaim alone teatment.

The 1988 data from Clarkston, Washington (Table 3) showed that Acclaim at 0.18 or 0.25 lb. a.i./A gave excellent control of crabgrass (greater than 95%). HOE 46360, the single most active isomer of Acclaim, also provided excellent crabgrass control; however, it was observed to be more phytotoxic to Kentucky bluegrass than Acclaim (data not presented).

Of the broadleaf herbicides and combinations tested in 1988, only Turflon Amine statistically showed a reduction in crabgrass control when tank mixed with Acclaim (Table 3). The results with Turflon Amine are puzzling for two reasons. First, research in other areas of the country indicate that Turflon Amine is not antagonistic to Acclaim for crabgrass control (1988 personal communication with Monte Anderson, Hoechst-Roussel Agri-Vet) and second, tank-mix combinations of Turflon Amine + Break-thru or Turflon Amine + Break-thru + dicamba do not indicate any reduction in crabgrass control (Table 3). Further testing of Acclaim + Turflon Amine is certainly warranted in the Pacific Northwest.

Based on three years of study on Acclaim at Washington State University the following conclusions could be drawn:

1. Acclaim provided excellent postemergence control of crabgrass.
2. Acclaim caused slight phytotoxicity to Kentucky bluegrass, but the level of phytotoxicity could be reduced with the use of N and Fe in a tank mix with Acclaim.
3. Tank mixing Acclaim with certain broadleaf herbicides may cause a reduction in crabgrass control. Further testing of Acclaim + Turflon Amine is needed.

This research was supported in part by grants from Hoechst-Roussel Agri-Vet Company Agricultural Chemicals, the Northwest Turfgrass Association, and the Inland Empire Golf Course Superintendents' Association.

## REFERENCES

1. Johnston, W. J., and C. T. Golob. 1987. Crabgrass control with 'Acclaim' (Fenoxaprop-ethyl). Proc. 4lst. Northwest Turf. Conf. p. 111-115.

Table 1. Crabgrass control of Acclaim plus broadleaf herbicides on bluegrass at Yakima, Washington in 1986.

| Treatment | lb ai/A | 7/7/86 | 7/18/86 |
|---|---|---|---|
| | | % | % |
| CHECK | ---- | 0 | 0 |
| Acclaim | 0.18 | 73 | 95 |
| Acclaim + bromoxynil + 2,4-D | 0.18 + 0.25 + 0.25 | 70 | 87 |
| Acclaim + Turflon D | 0.18 + 0.375 | 83 | 87 |
| Acclaim + Trimec | 0.18 + 1.0 | 77 | 85 |
| Acclaim + Harmony | 0.18 + 0.012 | 73 | 52 |
| Acclaim + Matrix | 0.18 + 0.016 | 67 | 77 |
| MSMA | 2.0 | 67 | 75 |
| MSMA | 4.0 | 70 | 92 |
| LSD (0.05) | | 28 | 34 |

Applied 6/20/86.

Table 2. Crabgrass control of Acclaim plus broadleaf herbicides on bluegrass at Lewiston, Idaho in 1987.

| Treatment | lb ai/A | 7/1 | 7/15 |
|---|---|---|---|
| | | % | % |
| CHECK | ---- | 0 * | 0 |
| Acclaim | 0.18 | 97 | 95 |
| Acclaim + Turflon D | 0.18 + 0.375 | 93 | 88 |
| Acclaim + Trimec | 0.18 + 1.4 | 84 | 67 |
| Acclaim + Starane | 0.18 + 0.25 | 98 | 97 |
| Acclaim + bromoxynil | 0.18 + 1.0 | 91 | 82 |
| LSD (0.05) | | 11 | 24 |

Applied 6/17/87.

Table 3. Percent crabgrass control of Acclaim + broadleaf herbicides on a bluegrass turf at Clarkston, Washington in 1988.

| Treatment | lb ai/A | 7/21/88 | 8/4/88 | 8/18/88 |
|---|---|---|---|---|
| | | % | % | % |
| CHECK | ---- | 0.0 | 0.0 | 0.0 |
| Acclaim | 0.18 | 93.3 | 97.0 | 96.0 |
| Acclaim | 0.25 | 95.0 | 98.0 | 94.3 |
| Acclaim + Turflon | 0.18 + 1.0 | 46.7 | 68.3 | 53.3 |
| Acclaim + Turflon | 0.25 + 1.0 | 95.0 | 92.7 | 73.3 |
| Acclaim + Break-thru | 0.25 + 0.5 | 95.0 | 97.0 | 78.3 |
| Acclaim + dicamba | 0.25 + 0.1 | 95.0 | 96.0 | 94.3 |
| Acclaim + Turflon + Break-thru | 0.25 + 1.0 + 0.5 | 95.0 | 98.0 | 87.7 |
| Acclaim + Turflon + Break-thru + dicamba | 0.25 + 1.0 + 0.50 + 0.1 | 95.0 | 93.7 | 92.7 |
| HOE 46360 | 0.09 | 88.3 | 97.0 | 96.0 |
| LSD (0.05) | | 7.4 | 14.8 | 20.2 |

Treatments applied 7-7-88.
Turflon used was Turflon Amine.

CHEMICALS USED

| Name or Designator | Trade Name | Company |
|---|---|---|
| Fenoxaprop-ethyl | Acclaim | Hoechst-Roussel Agri-Vet |
| Bensulide | Prefar | Stauffer |
| DCPA | Dacthal | SDS Biotech |
| Bromoxynil | Buctril | Rhone-Poulenc |
| 2,4-D | several | several |
| 2,4-D + Triclopyr | Turflon D | Dow Chemical |
| 2,4-D + MCPP + Dicamba | Trimec | P.B.I. Gordon |
| DPX-M6316 | Harmony | E. I. DuPont de Nemours |
| DPX-R9674 | Matrix | E. I. DuPont de Nemours |
| Pendimethalin | Pre-M | Lesco |
| Triclopyr | Turflon amine | Dow Chemical |
| Chlorflurenol Methyl esters | Break-thru | The Andersons |
| Dicamba | Banvel | Sandoz |
| HOE 46360 | --- | Hoechst-Roussel Agri-Vet |

# PLANT GROWTH REGULATORS AND WINTER PROTECTIVE COVERS ON BENTGRASS PUTTING GREENS [1]

Steve Poitras, William J. Johnston, and Charles Golob [2]

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[1] Presented at the 42nd Northwest Turfgrass Conference, Sheraton-Spokane, Washington, September 19-22, 1988.

[2] Graduate Student, Assistant Professor, and Research Technician, respectively, Department of Agronomy and Soils, Washington State University, Pullman, Washington

In the Pacific Northwest winter desiccation can be a major problem for turfgrass managers, especially in inland areas that receive little moisture and have dry windy conditions during the winter months. The problems of winter desiccation can be particularly severe on elevated, exposed bentgrass (Agrostis spp.) putting greens.

Desiccation of turfgrass is the result of the loss of water in greater amounts than the root system is able to absorb. An early sign of desiccation is a wind burned appearance of the leaves. If water is not supplied at this time desiccation of the crown tissue will occur resulting in death of the plant. Bentgrass, due to its low shoot height under golf course maintenance conditions, is very susceptible to this type of injury.

In years past, turfgrass managers have tried various means to mitigate the problem of winter desiccation. Methods tried range from the use of various mulches to heavy sand topdressing. Some of these methods have been more successful than others. However, there is always the problem of removing the material in the spring. Removing sand and other materials can be hard on equipment, and/or become labor intensive and may delay the effort to bring the turf to accecptable playing condition.

In recent years the use of winter protective covers has become popular. These covers do an excellent job of preventing winter desiccation of turfgrass; however, there are some problems associated with the use of these covers. One problem is surge growth underneath the covers during warm periods that may occur during late winter and early spring. The covers create a ''greenhouse'' effect that will raise the temperature underneath them by 5 to 15 degrees (F), thus promoting early, rapid, excessive growth. Excessive growth creates a problem in establishing acceptable playing condition in the early spring. The cutting height of the mowers will have to be raised and then gradually lowered to avoid injury to the turf by removing too much foliage at any one time.

Surge growth makes timing of cover removal critical. Due to the fluctuating weather conditions of early spring in the Pacific Northwest, covers must often be removed and the excess growth mowed off. Covers may then need to be reinstalled if the weather deteriorates for a lenght of time. This can become a labor intensive and costly process.

The solution to this problem is one of trying to find a system that will reduce surged growth under the covers and still provide high quality turf earlier in the spring than uncovered turf. This should enable the turfgrass manager to leave the covers on until the time comes when they can be removed once and for all.

To try and solve the problem of surge growthd we investigated the use of plant growth regulators (PGRs) in combination with winter protective covers. This study was carried out at the Washington State University Turfgrass Research Area in Pullman, Washington.

Several PGR's were evaluated in this study (Table 1 ). A brief description of the PGR's follows.

Amidochlor ('Limit') is a root absorbed growth regulator which has shown the ability to suppress both vegetative growth and seedhead production. Amidochlor does not affect root growth and development. It possesses low to moderate phytotoxic characteristics.

Flurprimidol ('EL 500', 'Cutless') is primarily root absorbed with some shoot absorbtion. It suppresses vegetative growth by inhibiting production of gibberellic acid. Flurprimidol has low to moderate phytotoxicity.

Mefluidide ('Embark') is absorbed by foliage and translocated throughout the plant. It inhibits cell division and meristematic activity and suppresses vegetative growth and seedhead production. There is no root or rhizome inhibition with mefluidide. It has low to moderate phytotoxicity.

Fenarimol ('Rubigan') is an anti-gibberelic compound. It inhibits production of gibberellic acid and retards cell elongation, thereby, decreasing vegetative growth and seedhead formation. It has low to moderate phytotoxicity.

None of the above compounds is labelled for use on bentgrass putting greens. In fact, the fear of using them on intensively managed turf is so great that few researchers have used them on putting greens.

We feel that there may be a trade off in turfgrass quality between some PGR phytotoxicity and severe winter desiccation. There may be some level of PGR in jury that is acceptable when compared to that of winter desiccation or having excessive surge growth to contend with. Also, since bentgrass greens are naturally off color early in the spring, some slight injury from the use of PGRs may go unnoticed.

There are several winter protective covers on the market today. The cover used in this study was the 'Reemay' row cover. It is a lightweight spunbound polyester fiber that will allow 70 to 85% light transmission. It is lightweight enough that two people can easily handle enough material to cover large putting surfaces.

The experiment was conducted as a strip-plot design with three replications of each treatment. Data was collected on turgrass quality, color, shoot height, dry weight of above ground foliage, and root weight (Table 2 ). Data was collected on several dates to compare the changes over time. All data collected are not reported in this paper.

PGRs were applied on December 2, 1987. Fungicides were also applied to prevent winter diseases. The covers were put in place on December 2, 1987 and were left on until March 11, 1988 when it was deemed necessary for cover removal due to environmental and turfgrass growth conditions.

At the time of cover removal, approximately one week after the first mowing at the WSU golf course, it was evident that the qmality and color of all covered plots were superior to the uncovered plots. However, it was also evident that growth suppression from the different PGRs was variable. Dry weights ranged from a low of 9.7 grams at the high rate of flurprimidol to a high of 34.6 grams at the low rate of amidochlor (Table 3 ). The covered control plot had a dry weight of 31.2 grams.

When the plots were rated one month later (April 11, 1988) the quality of most of the treated covered plots was declining while the quality of bhe uncovered plots was increasing (Table 4 ). This is a commonly observed phenomenon. However, there was one covered treatment that had a quality rating as high as the uncovered check plot . This was the high rate of mefluidide.

The high rate of mefluidide in combination with a protective cover showed very high quality compared to the uncovered plots at the time of cover removal and remained equal to uncovened check plots once they had reached total spring greenup. In effect, this treatmemt gave earlier spring greenup than uncovered turf without the excessive surge growth and decline in quality that was experienced when covers were used alone.

In summary, most of the PGRs used in this study were found to give low quality turf some time after cover removal or did not suppress vegetative growth enough to justify their use. These preliminary results suggest that 0.375 lb. a.i./A mefluidide used with a protective turf cover can provide spring bentgrass turf quality without an unwanted surge of growth. We must emphasize that this study has only been carried out for one year and further study is needed.

This research was supported by grants from the Northwest Turfgrass Association and the Inland Empire Golf Gourse Superintendents' Association.

Table 1. PGRs and rates applied on December 2, 1987 on 'Penncross' bentgrass at Pullman, Wa.

| PGR | RATE (lb a.i./A) |
|---|---|
| amidichlor | 1.0 and 2.0 |
| flurprimidol | 0.5 and 1.5 |
| mefluidide | 0.125 and 0.375 |
| fenarimol | 1.36 and 2.72 |

Table 2. Data Collected for 1988.

| Quality | Dry wt. | Color | Shoot ht. | Root wt. |
|---|---|---|---|---|
| 2-25-88 | 3-11-88 | 2-25-88 | 3-11-88 | 3-11-88 |
| 3-11-88 | 3-28-88 | 3-11-88 | 4-27-88 | 4-11-88 |
| 3-28-88 | 4-11-88 | 5-19-88 | | |
| 4-11-88 | 4-27-88 | | | |
| 4-27-88 | | | | |
| 5-19-88 | | | | |

Table 3. Effect of winter PGRs and covers on quality and dry weight on March 11, 1988.

| PGR | RATE (lb. a.i./A) | Quality[1] Uncovered | Quality[1] Covered | Dry Weight (g) Uncovered | Dry Weight (g) Covered |
|---|---|---|---|---|---|
| CHECK | --- | 3.3 e | 8.3 a | 12.9 ef | 31.2 ab |
| amidochlor | 1.0 | 3.0 ef | 8.3 a | 11.8 ef | 34.6 a |
| amidochlor | 2.0 | 3.0 ef | 8.3 a | 11.3 ef | 26.9 bc |
| flurprimidol | 0.5 | 2.3 fg | 6.7 c | 9.4 f | 16.6 def |
| flurprimidol | 1.5 | 2.0 g | 5.3 c | 9.9 f | 9.7 f |
| mefluidide | 0.125 | 2.7 efg | 7.3 bc | 10.7 ef | 23.0 cd |
| mefluidide | 0.375 | 3.3 e | 7.3 bc | 13.7 ef | 17.4 de |
| fenarimol | 1.36 | 2.0 g | 8.0 ab | 12.0 ef | 29.4 abc |
| fenarimol | 2.72 | 2.7 e | 8.3 a | 11.1 ef | 32.3 ab |

[1]Quality rated 1-9; 9=excellent.

Table 4. Effect of winter PGRs and covers on quality and dry weight on April 11, 1988.

| PGR | RATE (lb. a.i./A) | Quality[1] Uncovered | Covered | Dry Weight (g) |
|---|---|---|---|---|
| CHECK | --- | 7.3 ab | 5.0 ef | 26.2 ab |
| amidochlor | 1.0 | 7.3 ab | 5.0 ef | 31.3 a |
| amidochlor | 2.0 | 7.0 ab | 5.0 ef | 29.0 ab |
| flurprimidol | 0.5 | 7.0 ab | 6.0 cd | 21.8 b |
| flurprimidol | 1.5 | 5.7 de | 4.7 f | 10.12 c |
| mefluidide | 0.125 | 7.0 ab | 5.7 de | 27.3 ab |
| mefluidide | 0.375 | 7.7 a | 6.7 bc | 22.1 b |
| fenarimol | 1.36 | 7.3 ab | 5.7 de | 25.2 ab |
| fenarimol | 2.72 | 6.0 cd | 5.3 def | 27.4 ab |

[1]Quality rated 1-9; 9=excellent.

# 25 YEARS OF MISTAKES [1]

Gordon Witteveen [2]

[1] Presented at the 42nd Northwest Turfgrass Conference, Sheraton-Spokane, Washington, September 19-22, 1988.

[2] Golf Course Superintendent, Board of Trade of Metropolitan Toronto, Woodbridge, Ontario, Canada

Preparing this talk was a humbling experience. It was necessary that I delve into my past and research my life for errors and for omissions. As I was doing this, it gradually began to dawn on me that I had been travelling along life's highway with a false sense of security and a false sense of my own worth.

You see, even a mule on a mountain path never stumbles on the same stone twice. But I discovered that I had been making the same mistakes time and time again. The only consolation I can find is that ''Experience'' is the name other people give to their mistakes.

I hope that you will learn from my mistakes, because I certainly did not.

I will be dealing primarily with mistakes that I made on the golf course, but I will also include some mistakes that I made as an entrepreneur. In fact, a more appropriate title for this presentation would be ''Confessions of a middle aged Greenkeeper''.

1. I started my career as a student working during the summer vacation at the Noranda Mines Golf Course in the Province of Quebec. I pushed this greensmower every morning, six days a week, (we did not cut on Sundays then). The picture was taken in the beginning of September just before going back to school. I have never been so slim since.

2. The next year I came back to the same golf course and I got promoted. Notice that I wear a shirt and tie. I'm foreman now. The equipment may have been antiquated but…

3. …the barn was no hell either.

4. My boss was very kind to me and kindled my desire to take up a career as a greenkeeper. I landed a job at the London Highland Golf Club in Ontario and I stayed there for three years.

5. I only made one serious mistake at London. I rebuilt the 12th green. Note how easy it is on this green to putt a ball into the trap. The members were quite upset about this mistake and I got the message and moved to Toronto where the big money was being made in those days.

6. I got married that year, which proved to be a mistake, and when on a brief honeymoon, my staff promptly burned two greens with ammonium nitrate.

7. I had to think of some way to redeem myself and convinced my greens chairman to let me have a go at building a new green. We did it the right way this time. USGA specs, a nice, gently rolling surface. It would hold a ball and putt well.

8. We covered it with a straw mulch and had a good catch. Soon the golfers were playing on it and complaining about it. It was only used for one Saturday. The members had an emergency meeting, and on Sunday morning play resumed on the old green.

9. At Northwood I also started to experiment with greens covers. We used a furnace filter type material, which when spread on the greens protects the grass from drying winter winds - Dessication. You will appreciate this is more than 20 years ago. This material is now back in use.

10. Just when the golfers were really anxious to be let on the course, we removed the material and …. presto - green grass. I was back in the good graces with all our members. By this time in my career I had gained a certain amount of fame and I had started travelling around the country giving talks and showing slides. One of my favourite topics was Personnel Management and Hiring and Firing. I had convinced myself that I was an expert at picking the right man for the right job.

11. I was especially good at picking out potential tractor drivers.

12. Now, mostly, you can cover up your mistakes.

13. But it becomes more difficult when it happens in an area that golfers pass daily.

14. And when there is a body involved you are liable to make headlines and you get called on the carpet to explain why you hired a jerk who could not drive a tractor in the first place.

15. I decided to go back to school and enrolled in a Turf Manager's Short Course. This was an ideal environment to learn new mistakes. After spending two months cooped up in a classroom, I could not wait until spring to test my new found knowledge.

16. The first mistake was to enlarge a tee by building a retaining wall. The golfers were petrified of falling over the edge or off the tee. We needed a sign to remind them to be careful.

17. Another mistake I learned at school was to let the rough grow in front of the tees and then to cut a path through it, so that the golfers wouldn't get wet feet. I soon learned that this was an expensive mistake that defeats the purpose.

18. Spraying used to be a very casual type of activity. Exposure to the chemical was not considered to be so hazardous as it is now. Just the same, it was a mistake and we recognize that now.

19. We have a more sophisticated approach to spraying now. The men use facemasks, rubber gloves and boots, hard hats, and disposable overalls.

20. The results of the spraying were not always perfect either. Fusarium disease is controlled only where the chemical is applied.

21. Knotweed growing as a row crop. It was not easy to make that mistake. We really had to screw up the nozzles but good to achieve this result.
    Fortunately these are the type of mistakes golfers generally don't notice. You can make quite a few before you get fired.

22. It seems to fall within the confines of this topic that I should talk about sidelines that golf course superintendents engage in. Many act as consultants at other golf courses, some do landscaping. One fellow I know manufactures flags in his basement. For me it was Christmas trees. I stock them in my backyard near the golf course.

23. At one time I operated five Christmas Tree lots in suburban Toronto. It was a good business and it fitted in well with the golf course operation. Then I made a mistake. I took in a famous hockey player as a partner. Now he operates five lots and I have one small one.

24. I decided to branch out and try something new and I became the Red Rider Distributor for Ontario.

25. Except I was a silent partner and that is even more frustrating. This sideline was not very successful either and turned out to be another mistake.

26. Therefore, I decided to start my own golf course - the dream of every superintendent. The Pleasant View Golf Club - ''Opening Soon'' the sign says.

27. Now open and now closed again. Another sideline that did not work out. It was obvious that I had too much time on my hands at Northwood and that I was making far too many mistakes at my own expense. It was necessary that I should find a place that would keep me busy making mistakes at their expense.

28. Just at that time The Board of Trade near Toronto needed a new Superintendent. I landed the job, but when I looked at this mess in their yard I was sure I had made a mistake taking the position.

29. The first major mistake we made was to install our own water system. You can see the problem was that we had nobody to blame for our mistakes. We

could not sue anyone. Our legal department was idle for that duration of the installation. Installing our own watering system was no small undertaking!

30. The second mistake was that we had to work around our old system, which had to remain operational and frequently we would hit the old lines, which was embarrassing especially since it always seemed to happen when the greens chairman came by to inspect the progress we were making.

31. The third mistake was the manner in which we used our new bridges as pipe hangers for the water line crossings.

32. We had an engineer make some beautiful drawings on how we should cross the river. The six inch pipes had four 90 degree elbows. It looked impressive but it never worked. We repaired it dozens of times until finally we eliminated the elbows.

33. You also want to make sure that you build these bridges high enough.

34. In this case we did learn from our mistakes. When we next had to cross the river, we buried the pipe deep into the river bed. It is 100 times simpler, much less costly, and has not needed repairs since installation.

35. We were one of the first courses in our area to install a fully automatic system and by so doing we were the guinea pigs and made lots of mistakes. The p.v.c. swing joint is a total fiasco.

36. The plastic nipples break under the slighest pressure.

37. And, although the arrangement permits easy levelling of the head, under our cold winter conditions frost will snap the head off the joint quite frequently.

38. We have replaced most of our swing joints and now come straight off the pipe and we use galvanized fittings exclusively.

39. It was also during my initial years at the Board that I became interested in girls … as part of the work force on the golf course.

40. Recruiting the right type of girl is often a difficult assignment.

41. Finding the right man to teach these girls to become proficient at cutting greens can sometimes be a problem and occasionally lead to a mistake. We have employed more than 40 girls over the years at the Board, but not one has ever shown any permanent interest in grass or golf course maintenance.

42. I want to discuss, for a minute, the pitfalls of recruiting new staff. Hiring a person is often a matter of impulse, which is a mistake as you will soon find

out. Bruce, the young man in the pick-up truck with unlaced boots, cigarette in his mouth and long hair and all, came to us one day, and I knew right then that it was a mistake to even interview him. But, he had a sparkle in his eye and I fell for it. Besides, he had payments to make on his truck and I sympathized with him, which is another mistake.

43. So we taught him to cut greens. Now, he is supposed to remove the pin before starting to cut but, sure enough, he caught on quickly to all the short cuts

44. and be broke his share of pins.

45. We then gave Bruce a greensmower with verticut reels and told him to do all the greens but Bruce discovered a new and different use for the verticut machine. He developed a brand new leaf mulcher. He had not struck me as a thinker when I hired him but obviously I had been mistaken. One day he was so engrossed in thought that he did not see the pond.

46.… No comment … We thought perhaps what he needed was a bigger machine and sent him out to cut fairways on an F-10.

47. He felt he was not cutting enough grass on the fairways. You guessed it, he ended up in the rough. I should have fired him right then, but was persuaded to give him one more chance. We reasoned that Bruce perhaps was more suited for team work.

48. And we put him on the sodding crew.

49. You guessed it. Green side up.

50. Spraying with paraquat and/or Round-up has always been one of my favourite mistakes - it is so obvious when you do something wrong.

51. … No comment…

52. We had a neighbour on the golf course who always wanted to borrow things and we gave him a little sample of Round-up.

53. Planting trees is a costly operation and frequently plagued with mistakes.

54. Looks like a healthy stand of pines, but looks are deceiving. The far one on the left is thin and off colour.

55. The reason is obvious on closer examination. Girdling. The plastic twine had not been cut on the ball when the tree was planted. We lost about 20 trees in this manner and I blamed about half on my predecessor. The others we cut down early in the morning and sodded the stumps.

56. Now we have modern methods to transplant trees. It is a lot quicker and easier,

57. but, you must make sure you cover the hole or make yet another mistake!

58. While checking on my neighbour's grass one time, my eye was caught by the sad face of a man carved in the stump of a tree. "No job" it read and a phone number.

59. On the spur of the moment I hired the wood carver and put him to work. We found a pine tree which had blown over in a storm, cut off the top and tackled the tree back up in an upright position.

60. Then our artist went to work. He chopped away and soon the figure of a man started to take shape. Our golfers watched with interest and wondered what I was up to this time.

61. When completed this Statue of a Golfer, located on a promitory of land, dominating our golf course, became a conversation piece for everyone who played our course. Members would take their guests over to view the statue. It gave much joy to all who saw it and for those of us who worked on the course, it felt good to have it there, watching us. At last - one speechless golfer who did not complain and did not say "ah shit". Then one morning, it was Friday, April 13th, the statue was gone. During the night vandals had cut it away at the base and taken it. Now only the golf shoes remain as a memory of yet another mistake.

62. I have always regretted that I did not take the administration parts of my job more seriously. You see, thinkers generally make fewer mistakes than doers. Obviously I could have avoided many of my mistakes if I had spent more time behind by desk.

63. My greens committee realized a long time ago that I acted much too impulsively, and they insisted that I deal with the municipal authorities and obtain the necessary permits before proceeding with projects.

64. Thus it came about that we manufactured our own homemade permits which were pasted on the site and looked so genuine that no one ever noticed. One of the few mistakes that I ever made and did get away with.

65. "What sort of an unusual mistake had we made this time?" we asked ourselves when this dead streak appeared on our grass one morning.

66. And then we knew. It was the hot air discharge from the air compressor which was used to blow out the watering system.

67. It certainly was a mistake on my part to buck the trend and to resist the introduction of white sand in our traps. I bucked the trend for many years but

finally yielded. Now we have the white sand in all our traps and it makes a startling contrast with the green grass and sets off the course.

68. Now to contemporary times. Our Board of Trade golf complex involves two 18 hole courses and one short 9 hole course spread over 325 acres. It is located in a suburban environment with the few remaining farm fields fast being gobbled up by developers.

69. Right smack in the middle is the Turf Care Center, comprised of a large storage building, a work shop and a residence for the Superintendent. In my highly biased opinion, this is the most important part of the Golf Club. This is where all the important decisions are made which directly affect the condition of the golf courses and thus contribute to the joy of golf. Immediately next to the Turf Care Center (a word first coined by us 15 years ago and now used at many golf courses) is our large bentgrass nursery where we train new employees how to use riding greensmowers, where we calibrate sprayers, test new products, and, yes, where we continue to make mistakes.

70. Cutting fairways with riding greensmowers, which we have been doing since 1980, was not a mistake on my part. I believe using the riders on the fairways is the most satisfying thing that I have ever experienced on the golf course. There is nothing that I have ever done that made me feel so good! But the personal satisfaction on my early morning rounds is something that money can't buy. Not only does this turf look good but it is the epitome of healthy turf and, most importantly, the golfers love to play from it.

71. Parallel cutting lines on adjacent fairways are a sight to behold. Visiting golfers simply stand in awe when they walk from the parking lot to the pro shop and look over our landscape from the top of the hill.

72. And then one day someone tries to be different and instead of going in a perfectly straight line he snakes his way down the fairway. I asked the young man to step off his machine and to walk a straight line, which he did without missing a step. Then I studied his eyeballs for signs of marijuana, but he checked out, at which point he explained how he had been cutting perfectly straight lines day after day and I never seemed to have noticed.

73. Well, I sincerely hope that you have learned from my mistakes for I certainly have not. I seem to continue to make mistakes season after season. I used to call it stupidity but now, as I am getting older, I refer to it as senility. Only this past summer … relate the story about cut worms and aerifying the fairways.

74. The North American Golf Course Superintendent is fast acquiring the image of an executive. We pride ourselves on mahogany desks, secretaries, and computers. We talk about motivation and delegation. But, I suggest to you that we should not let the modern technology go to our heads. I believe that we

should keep our feet planted solidly on the ground. We should feel the soil with our fingers and in the palms of our hands. We should gingerly touch the grass on the greens, feel for grain and thatch. I believe that we should use all our senses to keep in touch with the soil — All for the sake of better grass.

I will now briefly reiterate some of the more pertinent points that I have been trying to get across to you:

1. Try not to make the same mistakes more than three times.

2. Cover up most of your mistakes.

3. When it is absolutely unavoidable, admit to having made a mistake.

4. Remember, there is nothing more glorious than a great mistake.

# CONSERVE WATER IN THE LANDSCAPE BY CONSIDERING THE 3 M'S: METHODS, MATERIALS, AND MANAGEMENT [1]

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[1] Presented at the 42nd Northwest Turfgrass Conference, Sheraton-Spokane, Washington, September 19-22, 1988.

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Our nation's water resources are being depleted in many araas and water quality is an increasing concern. Restrictions on water use may become widespread in the future. These restrictions, which may take the form of increased costs of water or limits on the amount used, have already been applied in the state of western Washington.

Water restrictions are often first placed on landscapes of homes, businesses, and recreational areas. Traditional landscapes have been designed for humid climates and often suffer when watering restrictions are imposed. The plants become unattractive and unhealthy. To soften the efects of water reductions on plants and to help people reduce water use, various plans, such as the Denver Water Department's Xeriscape program, have been introduced.

Xeriscaping, or water-conserving landscaping, is a plan for reducing the quantity of water applied to landscape plantings. The strategies used to attain this goal can be grouped into three categories, the **3 M's:**

1. **Methods** of designing landscapes that have reduced water requirements,

2. **Materials**, including plants and hardscapes, that are appropriate for use in water-conserving designs, and

3. **Management** techniques that can be used to maintain landscapes with reduced water applications.

## METHODS:

Integral to an efective water-conserving landscape is the design of the landscape itself. Basic design methods can be used to decrease the amount of supplemental water that landscape plantings require.

A good design begins with a zoning method. Most landscapes can be divided into three zones based on their proposed use and watering needs. The primary zone is an area of high use and visibility. It usually requires high maintenance and ample water for the level of comfort and use desired. This zone should be limited to an ''oasis'' of green in the highest use area of the landscape, which for most Americans is in the back yard, where outdoor activities are concentrated. The secondary zone receives moderate use and has minor watering and maintenance requirements; front yards in water conserving landscapes are often in this zone. The minimal zone includes areas that are rarely used and not highly visible. Plants that require little maintenance and no supplemental water are used in minimal zones. This zone can be located around the periphery of the property and in difficult to reach areas. The zoning method can also be used in parks, where particular locations receive limited use.

Lawns are the largest consumers of water in the landscape and should be concentrated in primary areas. The total perimeter of the lawn is positively correlated with water use, so turf areas should be compact. Reducing the area of turf in favor of ground covers or mulched beds in areas with little foot traffic will reduce watering needs. Turf should be eliminated from, small, difficult to irrigate areas such as that between a sidewalk and street.

Another design method for reducing water needs is using areas of ''hardscape'' such as patios and decks. These can be located in primary zones and help keep water-use in these areas down.

Grading and berming can be used b control water on the site. Berms traditionally have been used to guide water off the site, but in water-conserving landscapes, berms, curbs, and gutters direct water to catchment areas, storage areas, and plant roots. Gentle slopes should be used so water will percolate into the soil, instead of running off.

Protecting plants from the environment can reduce water loss from soil and plant surfaces. Windbreaks and shading can be used to decrease evaporative losses. Low water-use plants on the fringes of the landscapes can be used to shield more sensitive plants located in the higher-use zones.

The final method of designing to reduce watering needs is the irrigation system design. Irrigation systems should be tailored to particular needs, including the area managed, the resourxes of the project, the skill and knowledge of the operator, and the plants' requirements. The key consideration is efficient use of water. Design a system with enough flexibility to deliver water only where and when it is needed. Irrigation requirements in primary zones are different from those in secondary and minimal zones, so the irrigation systems should reflect this.

MATERIALS:

When you think of plant material to use in water-conserving plantings, you might imagine cactus, or dull, gray-green leaves, or thorny, scrubby plants. You probably don't think of plants with lush, deep-green, dense foliage, yet these plants can and should be used in well-designed water-conserving landscapes. Landscapes need to be attractive and inviting, so a landscape of pure cactus is inappropriate. By reducing the area of plants that require very high amounts of supplemental irrigation, inviting landscapes that conserve waater are possible.

Any plant that requires less watering than a typical bluegrass lawn can be used in water-conserving plantings. Most plants fall into this category. Even many grasses, other than bluegrass, can be water-conserving plants. Many kinds of plants can be used in water-conserving landscapes, and the key to their use is knowing their water requirements and grouping them accordingly. Those with higher water requirements should be used in the primary zone, while those with the lowest watering requirements should be planted in the minimial zone.

The transition from a formal to a more naturalistic landscape, especially in the secondary and minimal zones, ofen reduces maintenance costs while conserving water. Low-maintenance, water-conserving open areas, for example, are often developed into naturalistic meadows, by using water-conserving grasses and wildflowers. Naturalistic plantings often use plants that are native to your local area, because these plants have adapted to growing conditions of the region and should survive with no inputs if their native habitat exists in your landscape. Adapted exotics, or water-conserving plants from other regions, can also be considered. Adapted plants often come from dry areas of the world, among them Australia, South Africa, and Asia.

## MANAGEMENT:

Irrigation. Irrigation is the most important area of management in a water-conserving landscape. The total amount of water needed in a landscape is influenced by the water-holding capacity of the soil, the timing of the watering, the quantity required, the rooting depth of the plants, and the plant requirements.

Water budgets can be developed for soil types and used for determining the quantity of water to apply. Soil types should be assessed to prevent excess applied water from percolating through the soil and out of the root zone. Automatic systems can increase infiltration and reduce runoff by applying water repeatedly for short intervals.

The timing of waterings should be carefully controlled to apply water only when needed during the season--less water needs to be applied in the spring and fall and most is required in July and August. By allowing the soil to dry on the surface between waterings, some weeds and diseases may be reduced.

Cultural Practices. Cultural practices for well-designed, water-conserving landscapes are similar to cultural practices for most well-maintained landscapes. The major difference is that less pruning may be needed in a water-conserving landscape, because there will be less excessive growth than in traditional landscapes.

The fertility of water-conserving plantings should be maintained to insure plant health, but nitrogen should not be excessive since it will lead to increased tender growth. Little fertilizer may need to be applied, because the watering regime should prevent nutrients from being leached out of the root zone. An iron supplement may enhance a plant's ability to take up water in drier soils, especially under saline conditions.

Porous mulches, such as bark chips, should be used to reduce loss of moisture from the soil surface and to increase infiltration of precipitation falling on the site. Black plastic under porous mulches is strrongly discouraged; this practice tends to cause root injury and death from high temperatures and inadequate oxygen, and the plastic often becomes unsightly over time.

Weeds, which compete for water, should be controlled. Be careful when using pre-emergent herbicides to be sure that they do not injure plant roots and interfere with water uptake during stress. Mulches can aid in weed reduction, but they should not be too thick, or roots may suffer from lack of oxygen and plant stems can rot.

Judicious mowing and pruning may be useful in reducing water use. The current recommendations are to mow turf high and frequently to conserve water. Although this causes increased transpiration from the canopy, the increased root of the turf enhances the uptake of water. Adequate coring and thatching of lawns improve water and oxygen infiltration.

Pruning can be done to decrease the total leaf area of a plant, but it should not be done excessively. Heavy pruning can disrupt that root to shoot ratio and induce weak, tender growth, such as watersprouts. Pruning may also leave openings for the entrance of pathogens which may be particularly dangerous if the plant is weakened by stress.

When watering restrictions require that less water be applied to a landscape than it was designed to receive, then the plants in the landscape will experience some level of stress. Priorities should be set as to which plants in the landscape are most valuable and should be watered, while others of less value or which could be readily replaced should be sacrificed. Many woody ornamentals are very valuable and should be maintained. Turf can go into a dormant phase if left with minimual water and can be rejuvenated when more water is available. If the watering restrictions are not short-term, then unadapted plants should gradually be removed from the landscape and be replaced by more adapted plants.

## CONCLUSION:

Water-conserving landscaping can be thought of as an improved, efficient form of landscape management. People living in well-designed, water-conserving landscapes describe them as beautiful, and are often suprised to find that the landscape requires little irrigation. When used appropriately, these landscapes can aid in conserving a vital natural resourse and may increase the knowledge and appreciation of our native landscapes.

# WILD FLOWERS OR POTENTIAL WEEDS? [1]

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[1] Presented at the 42nd Northwest Turfgrass Conference, Sheraton-Spokane, Washington, September 19-22, 1988.

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A distinction needs to be made between wildflowers that are native forbs and wildflowers that are introduced, naturalized or feral species. The dictionary says that feral means ''wild or existing in a state of nature, having reverted to the wild state, as from domestication.''

This is an extremely important concept. We have federal laws relative to feral horses, donkeys, goats, etc. as well as local laws relative to feral dogs. Why not feral plants and some basic interpretation of their potential as weeds? The Revised Code of Washington (RCW 17.10), an act (1987) relating to noxious weed control, provides the framework for just such a philosophy. ''State noxious weed list means a list of noxious weeds adopted by the state weed control board which is divided into three classes, and further: Class A shall consist of those weeds not native to the state that are of limited distribution or are unrecorded in the state and that pose a serious threat to the state.''

The State Weed Board has adopted the policy that:

> Class A weeds are those that had not been reported in the state of Washington by January 1, 1984, but which are included in one or more lists of recognized weeds and whose introduction to Washington State was not intentional or those intentional introductions which fulfill the qualifications stipulated in Section 1 of RCW 17.10 (any plant which when established is highly destructive, competitive or difficult to control by chemical or cultural practices) and for which no control is assured...

Wildflowers are featured by some seed companies. They are made very attractive to certain somewhat concerned segments of our society as the ''way to go'' on disturbed sites--and how few sites aren't or haven't been in some manner disturbed.

These wildflowers are suggested by region of the country based on their ability to naturalize--to, in other words, become a quasi-permanent part of those plant comnunities to which they are adapted (preadaption).

Baker (1974) wrote in the ''Evolution of Weeds'' that a plant is a weed ''if, in any specified geographical area, its populations grow entirely or predominantly in situations markedly disturbed by man''.

He philosophizes that:

> The evolutionary success of any organism is to be measured in terms of the number of individuals in existence, the extent of their reproductive output, the area of the world's surface that they occupy, the range of habitats that they can enter, and their potentiality for putting their descendants in a position to continue the genetic line through time.

Young and Evans (1976) in "Responses of Weed Populations to Human Manipulations of the Natural Environment" (disturbances) developed a logical scheme whereby an introduced species (downy brome or cheatgrass) could be modified by frequent or continued disturbances to the point of becoming, if not a new species, a reconstituted genotype that is superior in its adaptability and inherent competitiveness.

Thereby we may arrive at the best expression of weediness for a given set of conditions. We now return to the writing of Baker to review those characteristics considered ideal.

Table 1. Ideal weed characteristics (modified from those presented by Baker).

1. Germination requirements fulfilled in many environments-specifically, no afterripening requirements.
2. Simultaneous and continuous germination with internal and parallel environmental control systems.
3. Rapid growth through vegetative phase to flowering.
4. Continuous seed production for as long as growing conditions permit.Dispersal starts with first seed maturity.
5. Self-compatible, but not completely autogamous or apomictic.
6. When weeds are cross-pollinated, unspecialized insects or wind.
7. Dynamic seed production, very high seed production under favorable conditions, but some seed produced under most severe conditions.
8. Adaptability for short and long distance dispersal.
9. Adaptability for seeds to resist decomposition through either ruminant digestion or burning.
10. Resistance to grazing, either physical (e.g., spines) or preference (e.g., essential oils).
11. If weed is perennial, vegetative reproduction or regeneration from fragments.

12. Ability to compete interspecifically by special means (rosette, choking growth, allelochemicals).

''Weediness,'' according to Harlan and de Wet (1965), refers to an adaptive syndrome which permits a species or variety to thrive and become abundant and difficult to eradicate within areas of human disturbance.

The following ornamentals have demonstrated adaptability:

Dalmatian Toadflax

Dalmatian toadflax (*Linaria dalmatica*), a weed of the light textured soils of eastern Washington, has a long history of adaptation. Robocker (1974) reports that this native of Dalmatia (Yugoslavia) was widely cultivated in Europe during the l6th century and believed to have been introduced to North America by 1900. By 1926, it had found its niche in northeastern Washington. Roche' (1974) reported in excess of 50,000 acres in Spokane County. It continues to spread but appears to be very cyclic depending, I think, on the precipitation pattern and competition for summer moisture. Seedling mortality can be very high. And that, when combined with the relatively short life expectancy of the individual and its preference for droughty sites, significantly influences population density.

Oxeye Daisy

Oxeye daisy (*Chrysanthemum leucanthemum*) was reported by Gray (1865) as naturalized along the east coast of North America. He added that it was, even then, beginning to display its genetic plasticity as variable, but consistent, distinguishable vegetative characteristics. Its adaptability was demonstrated by the thoroughness of its introduction, early on, into the more mesic areas of the west. If it grows fir forest, it probably has oxeye. Most of Washington's 50,000 or so acres are on the west side.

Baby's Breath

Baby's breath (*Gypsophila paniculata*) is a Eurasian ornamental naturalized in Canada (Manitoba) by 1887 and collected in eastern Washington in 1929. A summarization of that available suggests that this plant is representative of the Black Sea region. It is drought tolerant, rooted to 10 feet preferably on coarse textured soils (deep sands), up to 14,000 seeds per plant provided with a tumble weed type distribution pattern and a tolerance for periodic foliar removal (Darwent, 1975).

Much of the above is similar for many range forbs whether native or alien. Their presence and especially their relative density or abundance is normally said to be inversely related to the amount and vigor of the native plant component—specifically the perennial grasses. The problem with Baby's Breath is the difficulty in deciding its relative weediness. One interpretation is needed for today and another that predicts the situation (both vegetative and economic) expected at some point in the future. This prediction mode must consider several potentials as the managerial or environmental factors vary with site, use and time.

Purple Lythrum or spike loosestrife

Purple lythrum (*Lythrum salicaria*) is noted in the Flora of the Pacific Northwest as ''colorful when growing en masse and worth a place in the damper spots of a wild garden''. This Eurasian wetland herb was first noted in 1814 as growing in the wet meadows of Canada and New England. In the 1930's it was recognized as weedy in the wetter pastures of Quebec. Balogh (1985) reports that purple lythrum occurs wild (feral not native) in 36 of the 48 contiguous states, that west of the Mississippi River it exhibits a scattered disjunct distribution and that these isolated concentrations result from garden escapees. Ours may have been isolated concentrations but it's obvious today that, in the central basin, commonplace would be more accurate than isolated.

The problem is a recommended ornamental that moves readily with water (the seeds and seedlings are bouyant) while demonstrating its competitiveness by crowding out cattails and other edge vegetation. It is also believed (observations) that the normal wildlife patterns are disrupted by the shifts in vegetation effected by purple lythrum dominance.

Knapweeds (*Centaurea* species)

Introduced knapweeds pose a major threat to western renewable resources. The problems experienced and those predicted make everything we have experienced in forage management pale by comparison. The behavior of these plants in the interior Pacific Northwest suggests that, like cheatgrass, they evolved with the ever-increasing intensity of modern resource utilization.

Sixteen species in the genus *Centaurea* have been introduced into the Pacific Northwest. The estimates of worldwide taxa within this group approach 1000 species, subspecies, varieties, hybrids, etc. They are, to say the least, prolific and still sorting out their ecologic potentials. The following is an introduction to some of the more ornamental members:

*Centaureas* (Roche' et al., 1986; Roche' and Talbott 1986)

- Bachelor buttons or cornflower (*C. cyanus*): introduced as a hardy homestead flower in 1848.

- Mountain bluet or perennial cornflower (*C. montana*): a perennial, lateral rooted, common ornamental that naturalizes easily on the more mesic sites of western Washington and northern Idaho.

- Bighead knapweed or lemon fluff (*C. macrocephala*): a common garden seed catalog speciality (based on size) that has been collected three times in Washington: all are assumed to be naturalized from abandoned gardens.

- Brown knapweed (*C. jacea*): introduced as both an ornamental and as a crop plant (bull clover). Williamette Valley in 1919; collected in San Juan county in 1923.

- Black knapweed (*C. nigra*): in Pullman as an ornamental in 1895. One of the two parents, with brown knapweed, of meadow knapweed.

- Meadow knapweed (*C. jacea x C. nigra*): may have been produced in this country, but due to the rareness of the parents it's likely that it too was introduced. Collected in western Oregon valleys as early as 1911; collected in western Washington in 1923. It is currently recognized in 16 or more of Washington's counties — and seems to be, as named, ''a meadow type''. It is palatable and has a relatively low tolerance to grazing.

Harlan and de Wet (1965) provide us with an extensive list of categorized definitions:

Definitions of Weeds

| | | | |
|---|---|---|---|
| A. | By Professional Weed Men | | |
| | Blatchley | 1912 | ''a plant out of place, or growing where it is not wanted.'' |
| | Georgia | 1916 | ''a plant that is growing where it is desired that something else shall grow.'' |
| | Robbins et al. | 1942 | ''these obnoxious plants are known as weeds.'' |
| | Fogg | 1945 | ''any plant which grows where it is not wanted,'' |
| | Muenscher | 1946 | ''those plants with harmful or objectionable habit or characteristics which grow where they are not wanted, usually in places where it is desired that something else should grow.'' |
| | Harper | 1960 | ''higher plants which are a nuisance.'' |
| | Isely | 1960 | ''any plant where it is not wanted, particularly where man is attempting to grow something else.'' |
| | Salisbury | 1961 | ''a plant growing where we do not want it.'' |

| | | | |
|---|---|---|---|
| | Klingman | 1961 | "a plant growing where it is not desired; or a plant out of place." |
| | Wodehouse | 1963 | "an unwanted plant." |
| B. | By Enthusiastic Amateurs | | |
| | Emerson (in Blatchley) | 1912 | "a plant whose virtues have not yet been discovered." |
| | Concannouer | 1950 | "--This thing of considering all weeds as bad is nonsensical!" |
| | King | 1951 | "weeds have always been condemned without a fair trial." |
| C. | By the Ecologically Minded | | |
| | Bunting | 1960 | "weeds are pioneers of secondary succession, of which the weedy arable field is a special case." |
| | Anderson | 1953 | "artifacts," "camp followers." |
| | Blatchley | 1912 | "a plant which contests with man for the possession of the soil." |
| | Dayton | 1950 | "introduced plant species which take possession of cultivated or fallow fields and pastures." |
| | Pritchard | 1960 | "opportunistic species that follow hunan disturbance of the habitat." |
| | Isely | 1960 | "the prime characteristic possessed by all important weeds is their ability to thrive in land subject to the plow." |
| | Salisbury | 1961 | "the cosmopolitan character of many weeds is perhaps a tribute both to the ubiquity of man's modification of environmental conditions and his efficiency as an agent of dispersal." |

Zohary(1962), Braun-Blanquet (1932), Tansley (1949), Weaver (1954), Clements (1928), Hanson and Churchill (1961), Ashby (1961), Godwin (1960), Hnudricourt et Hedin (1943) to cite only a few mention "weeds" in ecological contexts without either defining a weed precisely or mentioning their unwantedness. Clearly, to them, weeds are species with certain ecological characteristics.

The common thread throughout these definitions is one of "a plant being out of place". That is, according to Moore (June 1975), a relatively meaningless, anthropocentric categorical effect. If we manage our resources with even the slightest consideration for ecological interpretations, we see that a plant out of place is a poor competitor and hence not much of a weed.

I prefer to think of a weed as a part of an ecological system, even an annually disturbed one, that detracts from the optimum. To wit: A weed is a plant with a negative value within a given management system. Analysis of the system will provide a measure of the magnitude of that negative and it's only with an estimate of the negative well in hand that one can predict the value of weed control, containment, or eradication.

It has been said many times that one man's flower is another man's weed. Witness the examples given above plus numerous others familiar to the reader. In this discussion, that of ''wildflowers or noxious weeds'', suffice it to say that we need to understand the individual species sufficiently well to predict behavioral patterns in equally well understood managerial systems. It will take time, effort and conviction to develop public programs with sufficient support to regulate the movement of unproven ''weeds''. In the interim many will argue, self-servingly, that such would be excessive and oppressive.

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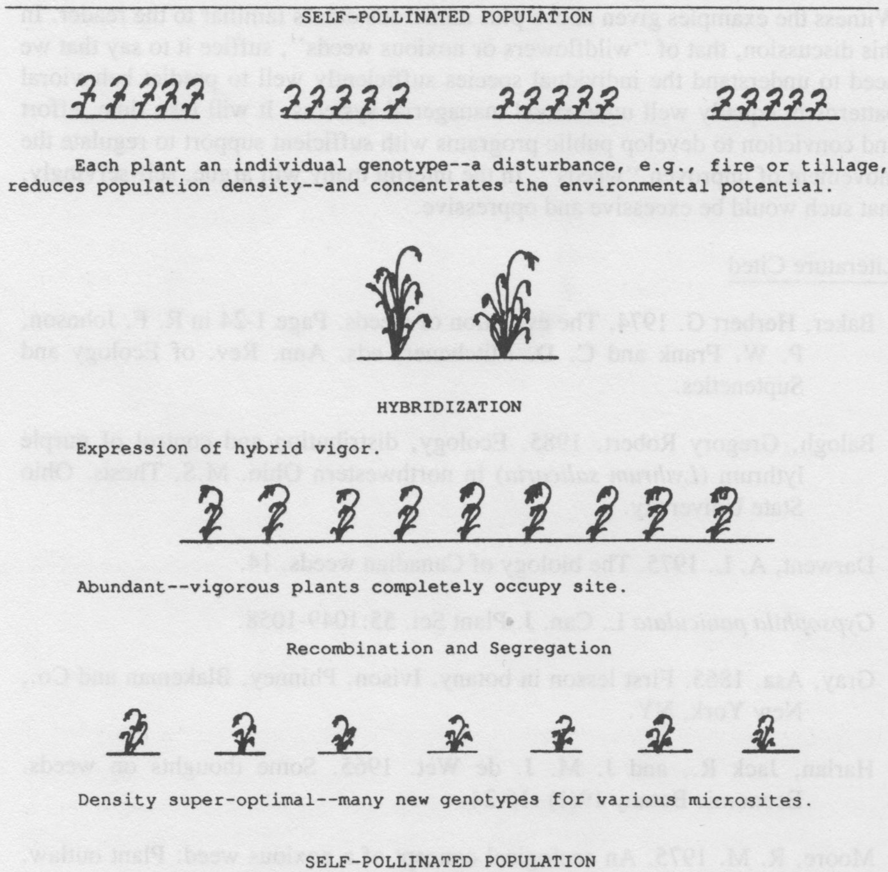


Figure 1. Model for hybridization in largely self-pollinated population of downy brome. Environmental concentration can be caused by fallow operations for weed control or by wildfires. (From: Young and Evans, Weed Science 24(2):186-190, 1976.)

# LOW MAINTENANCE TURFGRASS SPECIES [1]

A. Douglas Brede, [2]

[1] Presented at the 42nd Northwest Turfgrass Conference, Sheraton-Spokane, Washington, September 19-22, 1988.

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Kentucky bluegrass, perennial ryegrass, tall fescue, and fine fescue are the predominant turfgrass species throughout the Pacific Northwest. These species provide high quality lawn turf and good resistance to disease and stress. Progress in turfgrass breeding over the past three decades has provided advancements in the turf characteristics of these species.

The foregoing, ''traditional'' species of turfgrasses do not perform ideally under low-maintenance conditions. Tall fescue tends to do best of the four species under low maintenance, followed by hard fescue, sheep fescue, Kentucky bluegrass, perennial ryegrass, and red fescue. For the most part, current Kentucky bluegrasses were bred to perform well under medium-to-high maintenance regimes. It is rare to find a grass that will perform well under high maintenance and low maintenance both. An example of a Kentucky bluegrass bred for low maintenance is Wabash Kentucky bluegrass, which is used extensively by highway departments in the Midwest.

Under low or minimal maintenance conditions, turf managers may want to seek out species of turfgrass which can maintain adequate ground coverage under very adverse conditions. Furthermore, under extremely low maintenance conditions, or where no maintenance is provided at all, the turf manager may elect to use soil-stabilizing-type grasses to help minimize soil erosion. Under such conditions, appearance is of lesser priority than the soil stabilizing effects of the grass.

Oftentimes, when a turf manager seeks out seed of low maintenance turf species, he or she is presented with several surprises:

1. The price of low maintenance turf seed is often several times higher than that of premium high maintenance turfgrass seed.
2. The availability of seed of the low maintenance grasses is limited. This is especially true because of the high demand placed on these grasses by the Federal CRP Program.
3. Low maintenance turfgrass species will not provide the same high quality of turf that we have come to expect with the ''traditional'' turf species.

In the early 1980's, the United States Golf Association Green Section undertook an ambitious project to fund the development of low maintenance turfgrass species for use on golf courses. Their aim was to decrease the use of water and maintenance by 50 percent. To do this required a changeover from existing high-maintenance-requiring species to low maintenance species. New breeding programs were started at several United States universities to breed improved varieties of low maintenance species such as buffalograss and zoysiagrass. Jacklin Seed Company, which has long been involved with the development of low maintenance turfgrass species such as Reubens Canada bluegrass and Streaker redtop, is also at the forefront of development of improved varieties of low maintenance turfgrasses.

Through varietal improvement, it is possible to breed a desirable turfgrass which requires only minimal input of maintenance. ''Low maintenance turf and good turf are no longer being seen as two separate things,'' says Dr. C.R. Funk, Professor of Turfgrass Breeding at Rutgers University. It is possible through breeding to develop improved lines of low maintenance turf that combine the stress tolerance of their wild parents with desirable turf characteristics needed by the industry. ''Turf managers are now realizing that if you pay an extra $1 for low maintenance grass seed, you mighy get $10 or so back in lower mowing costs, water costs, or fertilizer costs. Professional turf growers get excited about that,'' says Funk.

Only recently have regional test trials been started on tbe low maintenance turfgrass species. Several universities associated with the North Central Research Committee have undertaken a regional project throughout the Northern Great Plains to evaluate numerous low maintenance turfgrasses for their suitability and turfgrass qualities. A test of low maintenance grasses has been discussed for the national level, sponsored by the National Turfgrass Evaluation Program, for some time during the early 1990's. Jacklin Seed Company has been evaluating test trials of low maintenance grasses in the Pacific Northwest at their research facility in Post Falls since 1982. Some data from two trials (one established in 1982 and the other in 1987) appear at the end of this article.

Low maintenance, cool-season turfs suitable for the Northwest are Reubens Canada bluegrass, Canbar Canby bluegrass, Sherman big bluegrass, Fairway or crested wheatgrass, Streaker redtop, Climax timothy, alpine bluegrass, upland bluegrass, Prairie junegrass (Koeleria), Poa nemoralis, and Manchar, Bromar, and Regar bromegrasses. Low maintenance, warm-season turfgrasses include blue grama, little bluestem, side-oats grama, weeping lovegrass, alkaligrass, buffalograss, and seeded zoysiagrass.

Taller growing species such as the bromegrasses or timothies would be best used under ''Vista-type'' turfgrass situations, where the stand receives little traffic or maintenance. Other alternatives for Vista-type turf would include the flowers and legumes. Numerous wildflower mixtures are on the market at the present time. Other alternatives include white or Alsike clover, black medic, or Appar lewis flax.

Obtaining seed of these low maintenance turfgrass species is often difficult, since suppliers that carry the high maintenance species do not always carry the low maintenance species. A little extra looking around is often needed. In the Pacific Northwest, low maintenance turfgrasses can be obtained from the following distributors (listed alphabetically):

Cascade Seed Company, E. 121 DeSmet, Spokane, WA 99220 (contact person: Chuck Gelb)

Gibson Nursery & Landscape, S. 1401 Pines Rd., Spokane, WA 99216 (contact person: Gary Gibson)

D.F. Marks Company, 19510 114th Street, Woodinville, WA 98072 (contact person: Bill Marks)

Round Butte Seed, P.0. Box 117, Culver, OR 97734 (contact person: Bob Clark)

**Table 1. Turfgrass quality of several low maintenance turfgrass varieties, evaluated Nov. 20, 1987 at Jacklin Seed's Post Falls, Idaho, research center.**

WALLER-DUNCAN K-RATIO T TEST FOR VARIABLE: QNOV
NOTE: THIS TEST MINIMIZES THE BAYES RISK UNDER ADDITIVE LOSS AND CERTAIN OTHER ASSUMPTIONS

KRATIO=100 DF=102 MSE=1.94716 F=2.77236
CRITICAL VALUE OF T=2.22
MINIMUM SIGNIFICANT DIFFERENCE=2.5988

WARNING: CELL SIZES ARE NOT EQUAL.
HARMONIC MEAN OF CELL SIZES=2.84211

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

| WALLER GROUPING | MEAN | N | VARIETY |
|---|---|---|---|
| A | 7.000 | 3 | ARID |
| A | 7.000 | 2 | N.J.HSY |
| B A | 6.667 | 3 | ST-1679 |
| B A C | 6.333 | 3 | GREMLIN |
| B A C | 6.333 | 3 | REUBENS |
| B A C | 6.333 | 3 | ARLY |
| B D A C | 6.000 | 3 | M63-4-SH |
| B D A C | 6.000 | 3 | LEAHHSY |
| B D A C | 6.000 | 3 | TAURUS |
| B D A C | 6.000 | 3 | BARCOLTE |
| B D A C | 5.667 | 3 | DRAYLAR |
| B D A C | 5.667 | 3 | MECKLENB |
| B D A C | 5.667 | 3 | FARRAGUT |
| B D A C | 5.667 | 3 | KNR-1538 |
| E B D A C | 5.333 | 3 | BARNEMO6 |
| E B D A C | 5.333 | 3 | PASTELLE |
| E B D A C | 5.333 | 3 | DURARAND |
| E B D A C | 5.333 | 3 | COVAR |
| E B D A C | 5.333 | 3 | R.C.C.X. |
| E B D A C F | 5.000 | 3 | POAAMPLA |
| E B D A C F | 5.000 | 3 | POANEMOR |
| E B D A C F | 5.000 | 3 | SHEEPFES |
| E B D A C F | 5.000 | 3 | ST-G |
| E B D A C F | 5.000 | 3 | STREAKER |
| E B D A G C F | 4.667 | 3 | DISTANSA |
| E B D A G C F | 4.667 | 3 | SHERMAN |
| E B D A G C F | 4.667 | 3 | P-851 |
| E B D A G C F | 4.667 | 3 | BARKOEL |
| E B D A G C F | 4.667 | 3 | CANBARCA |
| E B D H G C F | 4.333 | 3 | WABASH |
| E B D H G C F | 4.333 | 3 | COLUMBIA |
| E B D H G C F | 4.333 | 3 | HERB'SID |
| E B D H G C F | 4.333 | 3 | NEMORALI |
| E B D H G C F | 4.333 | 3 | COVARAND |
| E B D H G C F | 4.333 | 3 | IAS-366 |
| E I D H G C F | 4.000 | 3 | ALPINE |
| E I D H G C F | 4.000 | 3 | SAFE |
| E I D H G J F | 3.667 | 3 | BLUEGRAM |
| E I D H G J F | 3.667 | 3 | LODORM |
| E I D H G J F | 3.667 | 3 | DESCHAMP |
| E I D H G J F | 3.667 | 3 | IAS-534 |
| E I D H G J F | 3.667 | 3 | COUNTESS |
| E I H G J F | 3.000 | 3 | IAS-533 |
| E I H G J F | 3.000 | 1 | NJHSY |
| E I H G J F | 3.000 | 3 | SHE |
| E I H G J F | 3.000 | 3 | GHE-TW |
| E I H G J F | 3.000 | 3 | SODAR |
| I H G J F | 2.667 | 3 | IAS-414 |
| I H G J F | 2.667 | 3 | P-27 |
| I H G J F | 2.667 | 3 | NEZPURSI |
| I H G J | 2.333 | 3 | IAS-253 |
| I H J | 2.000 | 3 | HIGHLIGH |
| I J | 1.500 | 2 | IAS-254 |
| J | 1.333 | 3 | TUNDRA |

Table 2. Seed sources of varieties abbreviated in Table 1.

| VARIETY | NAME | SOURCE |
|---|---|---|
| 1 | R.C.C.X. Seed Mix | JSCO |
| 2 | Distans alkaligrass | JSCO |
| 3 | Sodar streambank wheatgrass | JSCO |
| 4 | Covar sheep fescue | JSCO |
| 5 | Sheep fescue | JSCO |
| 6 | Arly | R.A.G.T. Branche Semences |
| 7 | Poa compressa Knr/538 | |
| 8 | Upland bluegrass Draylar | Plant Materials Ctr. Pullman, WA |
| 9 | Pastelle fescue | R.A.G.T. Branche Semences |
| 10 | Streaker redtop | JSCO |
| 11 | Hard fescue M 63-4-SHF-23 | JSCO |
| 12 | Farragut Amphitheater Seed Mix | JSCO |
| 13 | Reubens Canada bluegrass | JSCO |
| 14 | Blue grama W.6 | JSCO |
| 15 | Poa cambyi P851 USDA | Pullman, WA |
| 16 | ST-1679 hard fescue | NJ Ag. Exp. Stn. |
| 17 | Covar hard (3 oz.) + Reubens | JSCO |
| 18 | Leah HSY hard fescue | NJ Ag. Exp. Stn. |
| 19 | ST-G hard fescue | NJ Ag. Exp. Stn. |
| 20 (19g) | Tundra KBG | JSCO |
| 21 | Durar hard Reubens | JSCO |
| 22 | Hightlight chewings fescue | JSCO |
| 23 | GHE-TW hard fescue | - |
| 24 | SHE hard fescue | - |
| 25 (17g) | Poa glauca IAS 254 | Alaska AES |
| 26 (19g) | Poa glauca IAS 253 | Alaska AES |
| 27 | P-27 Siberian wheatgrass | JSCO |
| 28 | Barkoel hairgrass Koeleria cristeta | JSCO |
| 29 | Barcolte + HVBR perennial rye | JSCO |
| 30 (21g) | Poa nemoralis | JSCO |
| 31 (7g) | Festuca rubra red fescue IAS-414 | JSCO |
| 32 | Herb's Idaho fescue | JSCO |
| 33 | HSY hard fescue | JSCO |
| 34 | Poa alpina Alpine bluegrass | JSCO |
| 35 | Poa ampla | PMC AK Dept. of N.R. |
| 36 | Barnemo 6-34 Yield row '84 | JSCO |
| 37 | Nezpurs Idaho fescue | JSCO |
| 38 | Nemoralis 5-22 Yield row '84 | JSCO |
| 39 | Mecklenburger sheep fescue | JSCO |
| 40 | Canbar canby bluegrass | JSCO |
| 41 | Lodorm green needlegrass | JSCO |
| 42 | Sherman big bluegrass | JSCO |
| 43 (12g) | IAS-533 | Alaska AES |
| 44 (16g) | IAS-534 | Alaska AES |
| 45 | Countess chewings fescue | JSCO |
| 46 (10g) | Deschempsia caespitosa | JSCO |
| 47 (16g) | Wabash KBG | JSCO |
| 48 | IAS-366 | Alaska AES |
| 49 (88g) | Arid | JSCO |
| 50 (88g) | Safe | JSCO |
| 51 (88g) | Tarus | R. Dunham |
| 52 (88g) | Gremlin | R. Dunahm |
| 53 | Columbia KBG | Turf Seed |

Table 3. Drought tolerant grass species and their adaptation to the Pacific Northwest.

# DROUGHT TOLERANT BUNCHGRASSES

**BEARDLESS WHEATGRASS**
*Agropyron spicatum var. inerme.* An awnless subtype of bluebunch wheatgrass that is similar in adaptability and use, but slightly less drought tolerant.
Variety: Whitmar

**BIG BLUEGRASS**
*Poa ampla.* 8" min. ppt. Native bluegrass, producing excellent early spring forage. Used by upland game birds for nesting and cover.
Variety: Sherman

**BLUEBUNCH WHEATGRASS**
*Agropyron spicatum.* 6-10" min. ppt. A highly palatable native wheatgrass. Considered a valuable stabilizer, especially on dry slopes and coulees. Does not tolerate heavy grazing pressure.
Variety: Secar

**CANBY BLUEGRASS**
*Poa canbyi.* 7" min. ppt. A native understory grass related to Sandberg bluegrass. Similar to big bluegrass in producing early spring forage, and controlling invasion by winter annuals.
Variety: Canbar

**CRESTED WHEATGRASS**
*Agropyron cristatum,* Fairway type. *A.desertorum,* standard type. 5-9" min. ppt. Very drought and cold tolerant introduced species. Provide excellent forage for spring use. Fairway is "turfier" than most standard varieties, such as Nordan. Ephraim is a newly released rhizomatous crested. Ruff is a dwarf rhizomatous variety.

Note: Drought tolerance may vary with local climate, microclimate, soil type, and competition from other plants. Major factors to be considered are: mean annual precipitation and its distribution, aspect, water table level and moisture-holding capacity of the soil. Also whether or not supplemental moisture will be provided, especially during establishment.

**GREAT BASIN WILDRYE**
*Elymus cinereus.* 8" min. ppt. Large native grass, adapted to highly saline/alkaline and neutral soils. Good erosion control, wind break, and wildlife cover species, especially on deeper soils. Produces excellent standing hay crops. Vulnerable to early spring grazing. Slow to establish.
Variety: Magnar

**GREEN NEEDLEGRASS**
*Stipa viridula.* 10" min. ppt. Tall, tufted bunchgrass, performing best on medium- to heavy-textured soils. Valuable range forage grass, particularly in the spring.
Variety: Lodorm,

**HARD FESCUE**
*Festuca ovina var. duriuscula.* 12" min. ppt. Low-crowned, vigorous root producer. Somewhat slow to establish, but very competitive with weeds, once established. Primarily used for ground cover and soil protection.
Variety: Durar

**INDIAN RICEGRASS**
*Oryzopsis hymenoides.* 5-7" min. ppt. One of the most drought tolerant native grasses. Excellent stabilizer of sandy soils. Valuable forage producer, especially for early spring grazing and as a standing hay crop. Should be planted in fall to break dormancy, and fairly deeply in light-textured soils (2-5").
Variety: Nezpar, Paloma

**MOUNTAIN BROME**
*Bromus marginatus.* 16" min. ppt. Vigorous, rapidly establishing native used for forage, green manure crop, wildlife cover and erosion control. Performs well at mid-elevations up to 8,000 ft.
Variety: Bromar

**RUSSIAN WILDRYE**
*Elymus junceus.* 7" min ppt. Tall, introduced grass, drought and salt tolerant. Slow to establish. Its curing qualities make it excellent for late summer and fall grazing.
Variety: Vinall, Sawki, Bozoisky

**SIBERIAN WHEATGRASS**
*Agropyron sibericum.* 5" min. ppt. Similar to crested wheatgrass, but more drought-tolerant, later maturing and more palatable.
Variety: P-27

**SLENDER WHEATGRASS**
*Agropyron trachycaulum.* 10-13" min. ppt. A short-lived native, easily established, rapidly spreading. Used in mixtures for erosion control. Fair to excellent salt tolerance. High forage producer of moderate to high palatability.
Variety: Revenue, Primar

**SHEEP FESCUE**
*Festuca ovina var. ovina.* 8-10" min. ppt. Densely tufted, low growing perennial. A widely adapted species that prefers sandy to loamy soils. Used as ground cover for critical areas, and as an understory grass in range seedings. Fairly acid tolerant.
Variety: Covar

# DROUGHT TOLERANT SOD-FORMING GRASSES

### BERMUDA GRASS
*Cynodon dactylon.* 17" min. ppt. Heat tolerant. Important pasture grass in the South.

### CANADA BLUEGRASS
*Poa compressa.* Low growing perennial that forms an open sod. Tolerates disturbed, infertile and acid soils. Exhibits a moderate degree of drought tolerance. Used alone or in mixtures for reclamation seedings, as ground cover for horticultural crops, and for low-maintenance turf.
Variety: Reubens, Canon

### CREEPING RED FESCUE
*Festuca rubra var. rubra.* 18-20" min. ppt. Moderate shade tolerance, thrives in moist, cool conditions. Will tolerate short periods of drought. Used for turf, pasture and conservation.

### KENTUCKY BLUEGRASS
*Poa pratensis.* 18-20" min. ppt. Rapid sod-former. Troy variety is a pasture bluegrass, that greens up very early in the spring, recovering quickly after cutting and grazing. High-yielding, nutritious forage grass. Performs well on very acid and disturbed sites. Fylking is a low growing, quickly establishing turf type that has shown outstanding tolerance to air pollutants (ozone, sulfur dioxide, PAN).

### INTERMEDIATE WHEATGRASS
*Agropyron intermedium.* 12" min. ppt. Prefers moist, well-drained sites. Tolerates some salinity and alkalinity and mildly acid conditions. Produces palatable, high-yielding forage especially for late summer. Easy to establish, good seedling vigor.
Variety: Greenar, Oahe, Tegmar

### PUBESCENT WHEATGRASS
*Agropyron trichophorum.* 10-12" min. ppt. Similar to intermediate in appearance and adaptation. Slightly more drought and alkaline tolerant, earlier maturing.
Variety: Greenleaf, Luna, Mandan, Topar

Note: Drought tolerance may vary with local climate, microclimate, soil type, and competition from other plants. Major factors to be considered are: mean annual precipitation and its distribution, aspect, water table level and moisture-holding capacity of the soil. Also whether or not supplemental moisture will be provided, especially during establishment.

### SMOOTH BROME
*Bromus inermis.* 11-15" min. ppt. Tall, leafy sod-former, the southern type more aggressively so. Will tend to dominate other grasses when heavily fertilized. Good soil stabilizer and palatable forage producer. Meadow brome is a closely related species *(B. biebersteinii)* that recovers quickly after grazing.
Variety: Manchar

### STREAMBANK WHEATGRASS
*Agropyron riparium.* 9-11" min. ppt. Low growing, vigorous sod-former used extensively as ground cover, dryland lawn, and soil stabilizer. Relatively easy to establish, its name is a misnomer since it has only fair tolerance to wet soils. Not very palatable, can be used where wildlife and domestic animals are not desired (i.e., roadsides, runways).
Variety: Sodar

### THICKSPIKE WHEATGRASS
*Agropyron dasystachyum.* 6-9" min. ppt. Closely related to western wheatgrass, but more drought tolerant and found on coarser soils. Has been very successful in stabilizing critical water areas.
Variety: Critana

### WESTERN WHEATGRASS
*Agropyron smithii.* 10-14" min. ppt. Adapted to fine- to medium-textured soils, endures long periods of drought once established. Alkaline and saline tolerant, also withstands periodic flooding. Has good forage value, while actively growing.
Variety: Rosana, Barton, Arriba

### OTHER DROUGHT TOLERANT SOD-FORMERS

Alkali sacaton *Sporobolus airoides*
Beardless wildrye *Elymus triticoides* Variety: Shoshone
Buffalograss *Buchloe dactyloides*
Creeping foxtail *Alopecurus arundinaceus* Variety: Garrison
Crested wheatgrass *Agropyron cristatum* Variety: Ruff, Ephraim
Grama grasses *Bouteloua spp.*
Mammoth wildrye *Elymus giganteus* Variety: Volga
Prairie sandreed *Calamovilfa longifolia* Variety: Goshen

# WATER MOVEMENT IN SOILS [1]

Walter H.Gardner [2]

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[1] Presented at the 42nd Northwest Turfgrass Conference, Sheraton-Spokane, Washington, September 19-22, 1988.

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This invitation to talk to you today likely stems from the talk I gave at the USGA Golf Course Conference in Huston in February. The introductory story I told there fits here equally well. I am reminded of a lecture which I gave to a university class. I couldn't help noticing a young red-headed lad on the front row who industriously took down almost everything I said. I looked for him without success for several lectures. I then forgot all about him until the final examination when, there he was, right on the front row. Upon grading the papers, to my great surprise he scored 98%, and when I handed his paper back I asked how he could miss all but the first lecture and do so well on the final examination. His response was "well, teacher, if I had not come the first day and become confused I'd have had a 100."

I have little to teach you today that you don't already know, only you don't know that you already know. You encounter the principles in some way every day of your lives. In the few minutes I have I shall merely try to put your present knowledge into a new perspective. Then like, the red-headed student, you can say that you already know it all.

First, let me discuss surface tension of liquid water. You have seen rain drops or drops from a dripping tap. And, you likely have noted that these are roughly spherical--they have a positive radius of curvature. They are held in this shape by a force called surface tension which acts at the air-water interface, resembling a somewhat similar skin of a rubber balloon, opposing a positive pressure inside of the droplet. Now, much of the water you see--water from a tap, water in a lake or stream or water in the cup from which you drink--is under positive pressure. The water beneath a water table in a soil profile is under positive pressure. And, when water is added to soil at the surface by a stream or a sprinkler system it is under positive pressure. This is how most people think of water.

Now, let me discuss another class of water, water which you ordinarily think of under the term 'moisture'. You are equally familiar with this water inasmuch as it is the moisture in a dish-drying towel, in a moist baby's diaper, on the surface of damp but not wet hands before you dry them completely with a towel, in the material of your shirt when you perspire, and it is the moisture in the soil when it is not saturated. It is the water that is said to be absorbed by a porous material and it is water which exists with a negative curvature in the air-water interface as you would observe if you looked at it under a highpowered microscope. This water is under negative pressure, as contrasted to the water of the rain-drop where the air-water interface is positive and the pressure is positive.

Movement of water in these two different conditions is entirely different. Water under positive pressure moves in response to the pressure of a column of water or by gravitational forces. Water in porous materials under negative pressure must be pulled along by attractive forces that exist between water and the walls of the porous material with which it is associated and forces in a negative air-water interface which always is present.

The best example of capillary water is water that is pulled upward into a small tube by adsorptive and cohesive forccs. Gravity also acts upon this water, but, unless the material is very moist, gravity plays only a small role in moving it.

The difference in the forces which move water in the two cases, positive and negative, make huge and often dramatic differences in phenomena in which water is involved. Most phenomena involving water movement under positive pressure take place in pipes and in streams and ditches. Considerable water usually is moved in this condition. By contrast, movement in porous materials under negative pressure takes place in thin films and consequently the quantity of water moved with a similar size of moving force is a small fraction of that where a positive pressure exists.

Although we encounter water under negative pressure constantly in the tissues of the human body and almost continuously in external objects and processes, if we think about water flow we almost always associate it with the type of flow which takes place under positive pressure. The most dramatic observation of this for me took place one time when I gave a banquet lecture on water flow in porous materials to a group of engineers, including their national society eresident, an MIT hydrodynamics professor. After I had finished my lecture, in which I had shown some models of water flow like those in the film you will see in a few moments, he came up and told me that, although he had spent his entire career dealing with water flow in pipes and streams and around ship surfaces and considered himself an expert on water flow, he still would have guessed wrong about flow which he observed in my models. However, he did say that having been forced to think about it, what he observed became quite reasonable. You also, should find it so.

In turf areas, particularly around golf courses, you encounter both types of flow, saturated and unsaturated. Successful management depends upon your recognition of the type of flow with which you are dealing. In places where you have unwanted water, such as in areas with high water tables where wet spots or marshes occur, the water usually is present under positive pressure and getting rid of it depends upon opening up large channels into which water can flow and be carried away in response to gravitational forces. Here, tile drains encased in coarse sands or gravel are appropriate.

Less obvious and more difficult situations occur where Soil is too wet but not saturated--where water is present under negative pressure. Getting rid of such water involves the process of unsaturated flow where water must move along particle surfaces in very small pores. Rates of flow usually are slow under such conditions. Gravity acts upon such water but usually the particle surfaces and small pores have a greater pull on water than does gravity so that gravitation is not much help. Evaporation at the soil surface can pull water slowly from greater depths but this is a slow process. More effective than gravity is the absorption of water by living roots and its transport to leaf surfaces where it is evaported. Water can be removed from great depths by this means.

# TURFGRASS WATER CONSERVATION [1]

James B. Beard [2]

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## THE PROBLEM

Water availability and water quality are protected to be major limiting factors threatening turfgrass use in the industrialized societies in future decades. This developing problem is an even greater threat to the turfgrass and golf industries than that of the world energy shortage or plant nutrient availability. Future projections, particularly for many urban areas, indicate that less water will be available for turfgrass and landscape purposes and that the water which is available will be more saline and lower in quality than the present supplies. The increase in salinity and water quality problems will be most apparent in locations which shift to the use of effluent water. In more arid locations and during drought years, the turfgrass manager may be forced to cease irrigation of certain turf area.

Water problems are most likely to occur in the semiarid and arid plains of North America. However, many densely populated urban area in higher rainfall climatic regions with limited water reservoir capacities are subject to serious water shortages during periodic summer droughts.

## PART I
## WATER CONSERVATION STRATEGIES FOR IRRIGATED TURFS

The amount of supplemental irrigation water required for a given turf depends on (a) the specific turfgrass species and cultivar, (b) environmental and cultural factors influencing the shoot evapotranspiration rate, (c) the proper irrigation practices, (d) an efficient, effective irrigation system, and (e) the water absorption capability of the root system. The first four aspects will be discussed in this section, while the rooting aspects will be addressed in Part II.

### Turfgrass Evapotranspiration (ET) Rates

Water use rate is the total amount of water required for turfgrass growth plus the quantity transpired from the grass plant and evaporated from associated soil surfaces. It is typically measured as evapotranspiration and expressed as ET in millimeters per day (mm/d). The comparative evapotranspiration rates of turfgrass species are distinctly different from the relative drought resistances because each is a distinctly different physiological phenomenon. For example, tall fescue is one of the more drought resistant cool-season turfgruses, but it possesses a very high evapotranspiration rate. Reducing the turfgrass evapotranspiration rate is a key water conservation strategy for irrigated turfs.

Select Low ET Species

The goal is to select turfgruses that require the least possible supplemental water via irrigation. Research at Texas A&M University conducted under a United States Golf Association Green Section grant has delineated the comparative evapotranspiration rates among the major turfgrass species used throughout North America (Table 1). The differences are substantial. These evapotranspiration comparisons represent the rates that occur under non-limiting soil moisture conditions. Among the cool-season species, which grow best at soil temperatures of 60° to 75°F (15-24°C), the evapotranspiration rates range from 7.5 to 12 mm per day under high evaporative demand and non-limiting soil moisture conditions. The fine-leafed fescues rank medium in water use rate; while Kentucky bluegrass, annual bluegrass, and creeping bentgrass have exhibited very high water use rates when grown under non-limiting moisture conditions. Among the warm- season turfgrasses, which grow best at soil temperatures of 80 to 95°F (27-35°C), the evapotranspiration rates range from 8.5 to 4.5 mm per day under high evaporative demand and non-limiting soil moisture conditions. Buffalograss, bermudagrass, and centipedegrass ranked very low in terms of their evapotranspiration rates, while St. Augustinegrass and seashore paspalum were intermediate.

Mechanistic studies at Texas A&M University have revealed that certain specific types of plant morphology affect the resistance to and surface area from which evapotranspiration occurs. The major factors are a low leaf area and a high canopy resistance, whose components are as follows:

| High Canopy Resistance to ET | Low Leaf Blade Area for ET |
|---|---|
| High shoot density | Slow vertical leaf extension rate |
| High leaf number | Narrow leaf |
| More horizontal leaf orientation | |

The professional turf manager should be aware of these particular plant characteristics that contribute to a low evapotranspiration rate. These characteristics can be used as guidelines in selecting varieties or cultivars possessing a low evapotranspiration rate. This is important as there are individual varieties or cultivars for a given species that have evapotranspiration rates which are much lower than the average rates presented in Table 1. Furthermore, these same morphological traits can be used by turfgrass breeders to conduct rapid field selections of plants that are most likely to possess a low water use rate. In related studies, no relationship was found between the ET rate and the stomatal density at the interspecies level.

Environmental Influences on ET

From an environnmental standpoint, any factor that increases the external atmosphere water vapor content will suppress the transpiration rate. Environmental factors enhancing transpiration include a low atmospheric water vapor content, moderate wind Velocities, medium to high temperatures, and full sunlight; while cool, cloudy, humid days without wind movement will suppress water loss by transpiration. The former condition increases the likelihood of an internal water deficit and subsequent wilt of a turf that would necessitate irrigation. In contrast, the latter situation would greatly reduce transpiration, which is desirable from a water conservation standpoint. However, if combined with relatively high temperatures it could adversely restrict the transpirational cooling process, thus resulting in heat stress to the grass.

A high atmosspheric water vapor level surrounding the leaves is more likely to occur under conditions of poor soil water drainage and/or excessive irrigation. The water vapor level is further accentuated by positioning turfs in sites surrounded by trees, shrubs, and or hills that restrict normal air movement across the area. From this discussion one may conclude that the specific water use rate of a particular turf will vary significantly depending on the site conditions and cultural practices that affect the environment surrounding the turfgrass leaves.

The total annual water use rate increaes in proportion to the length of the growing season. Within a growing season, conditions that favor rapid shoot growth cause an increase in the evapotranspiration rate. Thus, the maximum ET rates generally occur in midsummer in most regions and decline to relatively low levels during the winter.

Environmental factors not only affect the rate at which the evapotranspiration process occurs, but also influence the basic morphology and physiology of the plant which, in turn, influence the evapotranspiration rate. For example, the percent water loss from a Penncross creeping bentgrass turf is reduced by almost 50% as the light intensity is reduced from full sunlight to a low intensity typically found under very dense tree canopies. This reduction in ET rate is highly correlated with a reduced leaf stomatal density caused by the low light conditions under which the turfgrus leaves were formed. A similar response was found when the growing temperature of Penncross creeping bentgrass was increased from 50 to 70°F (10 to 20°C). This 20°F (11°C) increase in the growing temperature caused a 25% increase in evapotranspiration and an associated increase in the leaf stomatal density. It is evident from these data that turfgrass growing under suboptimal temperatures and/or shaded conditions will have a substantially reduced evapotranspiration rate. Thus, irrigation practices need to be adjusted accordingly for optimum water conservation.

Cultural Influences on ET

The evapotranspiration rate is influenced primarily by: (a) the extent of evaporative surface or leaf area, with the evapotranspiration rate increasing as the surface leaf area increases, and (b) the degree of canopy resistance to outward diffusion of water vapor from the turf. Canopy resistance is controlled by the shoot/leaf density and degree of lateral leaf orientation. As the density increases and/or a greater portion of the leaves become horizontal, there is increased resistance to water vapor loss from the turf canopy, which decreases the evapotranspiration rate. Both aspects can be significantly influenced by the turf cultural practices selected.

## Cutting Height

The cutting height has a strong influence on the evapotranspiration rate. As the cutting height is raised, the evapotranspiration rate increases due to the increased leaf area from which evapotranspiration may occur. In an investigation with Penncross creeping bentgrass, turfs mowed at 0.25, 1 and 5 inches (0.6, 2.5, and 12.7 cm), there was twice as much water used when mowed at 5 inches (12.7 cm) as qt 0.25 inch (0.6 cm) and 56 percent more water used at a cutting height of 1 inch (2.5 cm) than when mowed at 0.25 inch (0.6 cm). Similar influences of cutting height on evapotranspiration rates have been reported for bermudagrass.

As the cutting height is lowered, the amount and depth of the root system is decreased proportionally. This decreases the portion of the soil profile from which the root system can absorb soil moisture. Although detailed research is lacking, the following scenario probably exists. In situations where adequate soil moisture can be maintained at all times through supplemental irrigation, a lower cutting height could be beneficial as a water conservation strategy. However, in turf situations where periodic water stress is anticipated, it is advisable to maintain a higher cutting height because this enhances the depth of the root zone from which the more extensive root system can absorb moisture.

## Mowing Frequency

The evapotranspiration rate also is influenced by the mowing frequency. As the mowing frequency of Penncross creeping bentgrass was increased from biweekly to weekly to 6 times per week, the evapotranspiration rate increased 41%. This response was partially the result of an increased duration when the mower wounds were exposed, thereby increasing evaporation.

## Nitrogen Nutrition

Typically, turfs receiving modest nitrogen fertilization levels will have a lower leaf extension rate and, thus, a lower evapotranspiration rate. As the nitrogen rate is increased, canopy density is maximized and the leaf extension rate is increased. Above a threshold level that varies with the individual species, the influence of increasing nitrogen levels is expressed primarily by a more rapid leaf extension rate. rhe result is a greater leaf area and an allied increase in evapotranspiration. In an investigation with Penncross creeping bentgrass, the evapotranspiration rate increased as the nitrogen rate was increased up to 2 pounds of nitrogen per 1,000 square feet (1 kg per 100 sq. meters) per growing month. The correlations between the evapotranspiration rate and both the leaf width and leaf extension rate were high. The influence of increasing nitrogen rates on the evapotranspiration rates has been found to be even greater on bermudagrasses.

Irrigation

Another cultural factor influencing the evapotranspiration rate is the irrigation frequency. Soils which are irrigated to maintain a moist to wet condition tend to have an increased evapotranspiration rate. Studies have shown that irrigations scheduled 3 times per week versus only when the turf visually wilts resulted in a 33% increase in evapotranspiration when irrigated 3 times per week. Thus, adjustments in specific irrigation practices may have a significant impact on the evapotranspiration rate.

Growth Inhibitors

Finally, an effective growth inhibitor can be used on turfs to slow the leaf extension rate, and therefore, to significantly reduce the evapotranspiration rate. Studies at Texas A&M University have shown that certain growth regulators can reduce the evapotranspiration rate by 25 to 35% for up to 14 weeks.

## Irrigation Guidelines for Water Conservation

A key concern is that the irrigation water be applied at the proper rate and as uniformly as possible. Check to be sure the water application rate is adjusted for each distinctly different turfgrass area being maintained. Also, check to be sure that each sprinkler is applying the water uniformly. Finally, each irrigation should be scheduled so that the water is applied under low wind conditions, in order to ensure uniformity of application and the water is applied during cooler periods when evaporative losses will be minimal. These conditions are most likely to occur in the predawn nocturnal period.

Follow Proper Irrigation Practices:

* Apply irrigation water at a rate that does not exceed the soil infiltration and percolation rates.
* The total amount of water applied at any one irrigation should not result in soil water saturation and waterlogging.
* Schedule diurnal irrigations when temperatures are lowest to reduce evaporative loss: this is typically at dawn.
* Schedule diurnal irrigations when winds are lowest to achieve more uniform water distribution; this is typically at dawn.

Insure an Efficient, Effective Irrigation Systems:

* Provide for an adequate, reliable water source.

* The design must provide uniform water application via proper sprinkler head layout, spacing, and operating pressure.
* Insure the irrigation system is installed to the design specifications.
* Use zonal controls as needed for varying soils, topography, grass species, cultural systems, winds, and light levels.
* Continually inspect for and repair any leaks in pumps, distribution lines, and valves.
* Replace worn sprinkler head nozzles and parts as needed.

## PART II
## A DROUGHT SURVIVAL STRATEGY FOR NON-IRRIGATED TURFS

Drought develops as a result of an extended period without precipitation, combined with the lack of an irrigation capability and a high evapotranspiration rate. The severity of soil drought is affected by the duration without rain, the evaporative power of the air, and the water retention characteristics of the soil. The frequency with which a soil drought occurs is greater in the more arid western portion of North America. Droughts are most likely to occur during the midsummer period, although the actual timing of occurrence and frequency are not predictable.

The turfgrass manager has a number of options available to prepare a turf for drought stress. Included are:
* Selection of drought resistant species and cultivars.
* Optimize furfgrass drought tolerance.
* Maximize rainfall effectiveness.
* Maximize water absorption by roots.

### Select Drought Resistance Species and Cullivars

Turfgrass species vary greatly in their relative resistance to drought stress (Table 2). If one knows prior to establishment that the turf area will not be irrigated or that the capability to irrigate will be limited, it is usually advisable to select a drought resistant turfgrass species and cultivar. Note that species and cultivars with a low shoot evapotranspiration rate and deep, extensive root system will have good drought avoidance which is a key component of drought resistance.

There are significant differences in drought resistance among turfgrasses not only in shoot recovery but also in leaf firing. There is an opposite relationship between leaf firing and shoot recovery for each species and cultivar. This means that those turfgrasses which turn yellow or brown earlier tend to have poorer post-drought stress shoot recovery, in other words, poor drought resistance.

There also are significant differences in drought resistance among cultivars/ vari- eties within certain species. For example, Penncross is far more drought resistant than Penneagle creeping bentgrass. Host zoysiagrass and centipedegrass cultivars show good to excellent drought resistance with minor leaf firing.

Enhancing Drought Tolerance

The inherent internal physiological hardiness of turfgrasses to water stress may be affected by the cultural practices employed. Slow growing tissues possessing a small cell size and a high carbohydrate content are more drought tolerant. Thus, cultural practices that avoid excessive shoot growth stimulation will result in increased drought hardiness Factors that enhance drought hardiness include:

* Moderate to low nitrogen nutritional rate.
* Adequate potassiumum level.
* Moderate to low intensity of irrigation.
* Full sunlight conditions.

The same cultural practices also maximize turfgrasses hardiness to heat stress, which is frequently associated with summer drought stress. Note that a brown, dormant turf possessing a healthy crown and/or lateral stem system is not dead. rather, such a turf possesses the recuperative potential to initiate new growth after the occurrence of the first significant rainfall. Dormant bermudagrasses and Kentucky bluegrasses are capable of initiating of full green turf in 14 days under favorable temperatures.

Maximize Rainfall Effectiveness

Typically, some rainfall occurs during the winter and spring period prior to the onset of a drought. Thus, it is important to maximize the amount of available water that enters the soil rather than being lost by surface runoff. Turf cultivation, such as coring or slicing, may be utilized to enhance surface soil conditions that are receptive for maximum soil water infiltration and percolation. Such an approach is particularly helpful on sloping areas where water loss by runoff is greatest. Vertical french drains. 4 in. (10 cm) wide by 3.1 ft (1 m) deep, filled with pea gravel are especially effective on slopes. These techniques of water harvesting will become more important in the future.

In some cases, a limited supply of irrigation water may be available for use at the discretion of the turf manager. In such situations, there are other considerations in addition to maximizing the precipitation effectiveness.

Maximum Water Absorption by Roots

The maximum rooting depth and distribution, plus root hair development, will enable turfs to absorb moisture from a greater portion of the soil profile. Thus, selecting deep rooted species and cultivars is important. Relative interspecies rooting comparisons during the midsummer heat-drought stress period are shown in Table3. These rooting depths range from 8 feet (2.4 m) to as shallow as less than than 12 inches (30 cm). Note that bermudagrass can achieve rooting depths of up to 8 feet (2.4 cm) under mowed conditions. In contrast, zoysiagrass hw surprisingly shallow rooting. Comparable intraspecies variations in rooting also occur among the cultivars.

There are environmental and cultural factors which can be manipulated to ensure as deep a root system as possible. The potentially unfavorable rooting conditions are summarized as follows:

**Soil Environmental Factors:**

* Unfavorable Temperatures - Root growth of cool-season turfgrasses is favored by soil temperatures of 50 to 60°F (10 to 16°C). Soil temperatures above 77°F (25°C) cause the cessation of root initiation from cool-season turfgrasses, plus the loss of existing roots by increased maturation. In contrast, root growth of warm-season turfgrasses is favored by soil temperatures of 75 to 85°F (24-30°C).

* Unfavorable Soil pH - Root growth is seriously restricted and root functions limited at soil pH's below 5.6 and above 7.4. Soil tests at 1- to 3-year intervals should be utilized to monitor the soil pH.

* Soil Compaction - Compaction problems are associated with an increased soil density which results in impaired soil, air and water movement. Existing soil compaction problems can be partially alleviated by coring or slicing in multiple directions to a depth of at least 3 inches (7.6 cm).

* Soil Waterlogging - Waterlogging fills the soil pores with water which causes problems due to the elimination of adequate oxygen levels needed for root growth and general turfgrasses health. Also, anaerobic conditions formed in waterlogged soils, can produce gases and related compounds that are toxic to grass roots. One or a combination of conditions can produce a soil waterlogging problem, including: (a) improper surface drainage, (b) improper subsurface drainage, (c) excessive irrigation, (d) excessive rainfall, and/or (e) soil layering.

* Hydrophobic Soils - This problem involves an organic coating on the soil particles which causes them to repel water. It is particularly common on sandy soils and may be associated with soil fungi activity. It is best prevented or corrected by the application of an effective wetting agent, which should be watered in immediately after application.

* Saline and Sodic Soils - High soil salinity levels cause a reduction in turfgrasses rooting that is expressed through increased proneness to wilt. The development of a salinity problem is best prevented by applications of water at a rate greater than the evapotranspiration rate in order to leach the salts downward through the soil profile. Sodic soils are best corrected by the application of sodium or gypsum, preferably by soil incorporation, followed by downward leaching of the sodium after its displacement from the clay particles.

* Insect, Nematode. and Disease Injury - There are pests which feed actively on grass root systems causing serious damage. White grubs can be particularly damaging. The appropriate pesticide should be applied to correct the target pest problem when a serious problem starts to develop.

* Toxic Herbicides - Some preemergent herbicides have a degree of toxicity. to turfgrass roots. These effects may not be evident in terms of aboveground shoot growth under normal growing conditions; but can become quite striking during water stress periods when the lack of a root system restricts water absorption.

Cultural Factors:

* Close Cutting Height - As the cutting height is lowered, the depth and extent of rooting is restricted proportionally due to a decrease in leaf area available for photosynthesis.

* Excessive Nitrogen Fertility - Excessive nitrogen applications that force leaf growth cause the reserve carbohydrates to be drawn from the roots and may result in die-back of the root systems Thus, an individual nitrogen application should not exceed 1 lb N/1,000 sq. ft. (0.5 kg $are^{-1}$) as a water soluble carrier or its equivalent rate as a slow release carrier. High quality putting green turfs are maintained at a much lower rate, usually not exceeding 0.3 lb N/1,000 sq. ft. (0.15 kg $are^{-1}$ ) of a water soluble nitrogen carrier or equivalent as a slow release carrier.

* Deficiencies of Potassium or Iron - These two nutrients have a striking effect in enhancing root growth and should be maintained at high available soil levels. Soil tests conducted at 1- to 3-year intervals should be used to establish proper base levels of both nutrients. Also, additional potassium should be applied at a rate that is 50 to 75% of the nitrogen rate used.

* Excessive Thatch Accumulation - A thatch problem causes a high percentage of the roots to be concentrated in the thatch layer, thus limiting the zone from which water uptake occurs.

**Table 1. Relative ranking of evapotranspiration rates for the most commonly used major cool- and warm-season turfgrasses when grown in their respective climatic regions of adaptation and optimum culture regime.†**

| Relative Ranking | ET Rate (mm/day) | Turfgrass Species: Cool-season | | Turfgrass Species: Warm-season | |
|---|---|---|---|---|---|
| Very low | < 6 | | | Buffalograss | (*Buchloe dactyloides*) |
| Low | 6 - 7 | | | Bermudagrass hybrids | (*Cynodon* hybrids) |
| | | | | Centipedegrass | (*Eremochloa ophiuroides*) |
| | | | | Bermudagrass | (*Cynodon dactylon*) |
| | | | | Zoysiagrass | (*Zoysia* spp.) |
| Medium | 7 - 8.5 | Hard fescue | (*Festuca longifolia*) | Bahiagrass | (*Paspalum notatum*) |
| | | Chewings fescue | (*Festuca rubra* subsp. *commutata*) | Seashore paspalum | (*Paspalum vaginatum*) |
| | | Red fescue | (*Festuca rubra*) | St. Augustinegrass | (*Stenotaphrum secundatum*) |
| High | 8.5 - 10 | Perennial ryegrass | (*Lolium perenne*) | Carpetgrass | (*Axonopus* spp.) |
| | | | | Kikuyugrass | (*Pennisetum clandestinum*) |
| Very high | > 10 | Tall fescue | (*Festuca arundinacea*) | | |
| | | Creeping bentgrass | (*Agrostis stolonifera*) | | |
| | | Annual bluegrass | (*Poa annua*) | | |
| | | Kentucky bluegrass | (*Poa pratensis*) | | |
| | | Italian ryegrass | (*Lolium multiflorum*) | | |

**† Cultural or environmental factors that cause a drastic change in leaf area or shoot density of a given species may result in a significant shift in its relative ranking compared to the other species.**

Table 2. The comparative drought resistances of the major turfgrasses when grown in their respective climatic regions of adaptation and preferred cultural regime.

| Relative Ranking | Turfgrass Species Cool-season | | Warm-season | |
|---|---|---|---|---|
| Excellent | | | Zoysiagrass | (*Zoysia* spp.) |
| | | | Bermudagrass | (*Cynodon dactylon*) |
| Good | Fairway wheatgrass | (*Agropyrum cristatum*) | Centipedegrass | |
| | | | Bermudagrass hybrids | (*Cynodon* hybrid) |
| | | | Buffalograss | (*Buchloe dactyloides*) |
| | | | Seashore paspalum | (*Paspalum notatum*) |
| | | | Bahiagrass | (*Paspalum notatum*) |
| Medium | Tall fescue | (*Festuca arundinacea*) | St. Augustine-grass | (*Stenotaphrum secundatum*) |
| | | | Carpetgrass | (*Axonopus spp.*) |
| Fair | Perennial ryegrass | (*Lolium perenne*) | | |
| | Kentucky bluegrass | (*Poa pratensis*) | | |
| | Creeping bentgrass | (*Agrostis stolonifera*) | | |
| | Hard fescue | (*Festuca longifolia*) | | |
| | Chewings fescue | (*Festuca rubra* subsp. *commuata*) | | |
| | Red fescue | (*Festuca rubra*) | | |
| Poor | Colonial bentgrass | (*Agrostis tenuis*) | | |
| | Annual bluegrass | (*Poa annua*) | | |
| Very poor | Rough bluegrass | (*Poa trivialis*) | | |

Table 3. The comparative mid-summer rooting depths of the major turfgrasses when grown in their respective regions of adaptation and preferred cultural regime.

| Relative Ranking | Turfgrass Species Cool-Season | | Warm-Season | |
|---|---|---|---|---|
| Superior | | | Bermudagrass | (*Cynodon* spp.) |
| Excellent | | | St. Augustine-grass | (*Stenotaphrum secundatum*) |
| | | | Seashore paspalum | (*Paspalum vaginatum*) |
| Good | Fairway wheatgrass | (*Agropyrum cristatum*) | Bahiagrass | (*Paspalum notatum*) |
| | | | Zoysiagrass | (*Zoysia* spp.) |
| Medium | Tall fescue | (*Festuca arundinacea*) | Buffalograss | (*Buchloe dactyloides*) |
| | | | Centipedegrass | (*Eremochloa ophiuroides*) |
| Fair | Creeping bentgrass | (*Agrostis stolonifera*) | | |
| | Hard fescue | (*Festuca longifolia*) | | |
| | Perennial ryegrass | (*Lolium perenne*) | | |
| | Chewings fescue | (*Festuca rubra* subsp. *commutata*) | | |
| | Red fescue | (*Festuca rubra*) | | |
| Poor | Kentucky bluegrass | (*Poa pratensis*) | | |
| Very Poor | Rough bluegrass | (*Poa trivalis*) | | |
| | Annual bluegrass | (*Poa annua*) | | |

# GOLF COURSE HYDROSEEDING [1]

Philip D. Fortunato [2]

[1] Presented at the 42nd Northwest Turfgrass Conference, Sheraton-Spokane, Washington, September 19-22, 1988.
[2] Vice President, Briargreen, Inc., Kent, Washington

Hydroseeding has proven to be a very effective means of seeding, fertilizing and mulching large areas cost effectively and quickly. Though the most obvious application for hydroseeding has been erosion control on steep slopes, hydroseeding has also been well accepted as a means to establish turf stands of grass on a residential scale as well as park and golf course applications.

Briargreen's test plots show that hydroseeding provides a stand of grass approximately 25% faster than mechanical or hand seeding. The reason for this is simple, in the hydroseeding process the seed is bathed in a solution of fertilizer, which is held close to the seed by the wood fiber mulch. When sprayed on the ground the wood fiber mulch helps create a greenhouse effect speeding germination and providing protection for the seed.

Hydroseeding also allows for advanced pregermination techniques to be used, as well as adding soil binders and moisture retention agents, none of which could be done mechanically. Briargreen has led the industry in research and development of hydroseeding applications, as well as the use of soil binders and moisture retention agents. RAPID LAWN, the most advanced hydroseeding product on the market, brings all these things together in one package. The pregermination of the RAPID LAWN seed, together with our STAY MOIST moisture retention agent, provides a sod quality stand of grass 25% faster than conventional hydroseeding methods with about half the water requirement. A typically applied summer application of RAPID LAWN would be usable and mowable in three weeks or sooner, reaching sod quality in an additional seven to ten days.

Why hydroseed? Because you can establish a stand of grass faster, under a wider variety of conditions than any other method.

There are four basic parts to the hydroseeding mixture.
MULCH
SEED
FERTILIZER
ADDITIVES - Soil binders (liquid & powder) and Moisture retention agents.

Custom seed mixtures can easily be made with each tank load, eliminating the need for multiple seed mixtures for a given site.

When hydroseeding, seeding rates can generally be reduced to the minimums. Typical rates for 100% bentgrass greens are 1/2 to 3/4 pounds/1000 sq. ft. and 3 to 4 pounds for fairways of 30% bentgrass 70% ryegrass mix. The minimum rate of application of seed reduces seedling competition and encourages better, deeper root system development.

Pregermination can be used to speed turf establishment. This is especially important during fall seeding.

The use of standard of the shelf bulk fertilizers such as 10-20-20 or Sulfer Coated Urea are possible, avoiding the need for complete composition pelletized fertilizers, at substantial savings. As with the seed, the mixture can be changed easily for site specific conditions.

The wood fiber mulch is the medium, which makes hydroseeding work. The tacking agent bonds the fibers together, while mositure retention agents and the fertilizer solution are held in suspension close to the seed.

The long fibers in the wood fiber mulch straddle the soil particles, providing the greenhouse effect associated with hydroseeding. The papier mache like coverage of paper mulches will not give the same speed of germination of wood fiber and are not recommended.

Another advantage of hydroseeding is the use of additives which are commonly used to prevent washing and rippling, retain moisture and to shed water in severe erosion conditions.

Some of the most frequently used additives are as follows:

Powdered tacking agents are the most common in the industry. Lasting two to three months, they are relatvely inexpensive, prevent washing and rippling and provide good holding power on moderate slope conditions.

These powdered tacking agents are either added to the water before the mulch or, in the case of Silva Fiber Plus, included in the wood fiber mulch. The use of Silva Fiber Plus decreases the chances of gumballing and provides better mixing in the slurry. At a 2000 lb./acre rate you would get 60# tacking agent/acre.

The MRAs provide protection when pregerminated seed is used and reduce the need for watering.

STAY MOIST (MRA) has been used extensively by Briargreen to protect the pregerminated seed in RAPID LAWN. By keeping moisture close to the seed during germination and stress conditions, a much higher percentage of germination occurs much faster. During drought conditions watering can be reduced to every second to third day depending on soil conditions.

Used wherever matting or nettings may be required, ERO-BOND allows water to shed over the top of the hydromulched area. This product lasts up to two years and biodegrades as plant growth occurs. Do not apply in wet rainy conditions or below 50°F as procust will not cure properly. Distributed by Briargreen, Inc.

While most golf courses are still mechanically seeded, more and more superintendents are turning to hydroseeding, to bring their courses into play sooner.

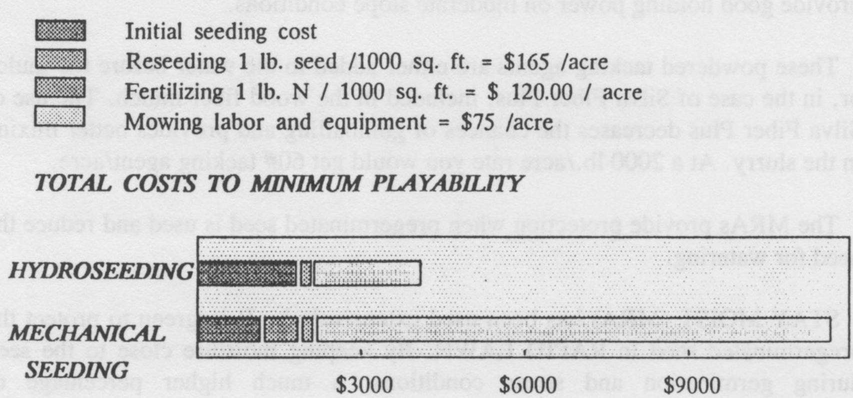
While hydroseeding is generally accepted as the best way to establish high quality stands of grass quickly and efficiently, the cost was considered prohibitive for golf couse establishment. But is it?

When comparing hydroseeding to mechanical or hand seeding, remember, with mechanical seeding no mulch is used. For a more even cost comparison a minimum hydromulch rate of 1000 # per acre, should be used. At this application rate hydroseeding would be very comparable to mechanical or hand seeding, $650/acre, but with few of the advantages of hydroseeding.

In looking past the initial seeding cost to final turf establishment and playability, hydroseeding becomes very cost effective. Following Briargreen's specification for a hydroseeding mixture, $1,700/acre, playability could occur in less than three months with one fertilization and 27 mowings. Estimates to playability for mechanically seeded fairways are much different. Initial seeding, two fertilizations, reseeding, three fertilizations, 135 mowings, until any revenues are produced.

*Playability: Point at which, if you absolutely, positively had to let golfers on a fairway for play, without cart traffic.*

Estimated costs per acre



From the beginning of seeding application to end of turf establishment, hydroseeding could save as much as 70% over the true hidden costs of mechanical seeding not counting lost revenues.

To get faster more even germination a 2000# mulch rate should be used. To prevent washing and reppling from heavy rains or over irrigation 40 to 60 lbs. tacking agen is recommended. This application along with adequate slow release fertilizer, will have your course playable in as little as three months.

If speed is essential, pregerminated seed with moisture retention agents could have your course playable, with no cart traffic, in five weeks.

Should you need more information or would like a video tape of some golf course applications please call (206) 630-5024 or (800) 635-TURF.

# SEEDING RATE: ITS EFFECT ON DISEASE AND WEED ENCROACHMENT [1]

A. Douglas Brede and Joe Dunfield [2]

[1] Presented at the 42nd Northwest Turfgrass Conference, Sheraton-Spokane, Washington, September 19-22, 1988.
[2] Research Director and Research Associate, respectively, Jacklin Seed Company

Seeding recommendations—the figures listed in most turfgrass textbooks—have been developed over the years by "seat of the pants" observation by turfgrass experts and authors. Until the late 1970's, little was known as to why these rates were best. New research from several United States universities has shown that, under certain circumstances, deviations from these recommended rates are not only allowable but oftentimes advisable. By knowing when to deviate from these rates, the educated turfgrass manager can make better decisions on a case-by-case basis of when and where to use higher or lower rates than are published.

Here're a couple of examples: A sod grower in northern Michigan has been planting Adelphi on his sod farm every year for the past 15. He has gotten nearly all of the weeds under control, and very little problem weed seed still exists in the soil. Because of this, he is able to use only a half pound of bluegrass seed per thousand square feet, where a normal lawn would require two to three pounds per thousand square feet. What's the trade off? This grower has sacrificed quick establishment for lower seeding costs. Instead of being able to mow his stand in the usual three to four weeks, it requires eight to ten weeks before he has a stand that is filling in. But since weeds aren't a problem in his case, a lower rate is tolerable.

Here's another example: A golf course superintendent in western Washington is plagued with high amounts of annual bluegrass on a fairway. He has tried to kill off the fairway in the past with glyphosate, and overseed it with an improved species, only to find another mixed stand after emergence. To help give the Kentucky bluegrass a competitive edge, he bumps the seeding rate of the Kentucky bluegrass up to four pounds of seed per thousand square feet. This provides a more desirable ratio of Kentucky bluegrass seed to annual bluegrass seed (in the soil). The higher rate of Kentucky bluegrass allows for effective competition against the annual bluegrass for several years after establishment.

I began a study in 1976 at Pennsylvania State University to scientifically investigate the effects of the seeding rate on the maturation of a turf stand and development of weeds and diseases. Specifically, we wanted to answer several questions: How long are the effects of seeding rate felt on the turfgrass stand? Is seeding rate of only a transitory nature, exerting effects on the stand during the first six months? Can higher seeding rates be used to effectively compete against annual bluegrass? Do certain cutting heights "prefer" certain seeding rates? What effect does turfgrass variety have on seeding rate? Kentucky bluegrass was chosen for this study.

I evaluated the progress of this stand for five years after planting. Effects of seeding rate were frequently seen several years after planting. On regular intervals, we sampled the shoot density of the plots. We found that even 41 months after planting (nearly four years later), we were able to detect statistically significant differences among the four seeding rates on shoot density. It wasn't until nearly five years after the trial was established that we were no longer able to detect seeding rate effects on shoot density.

Certain plots in the experiment were treated with preventive fungicides. Where we treated, we were able to preserve very high tiller densities for longer periods of time than where fungicides were not used. This was because high tiller densities predisposed turf to disease. Disease thins the turf. This thinning action tends to equalize shoot density between high seeding rate plots and low seeding rate plots.

We also found that it is desirable to use higher seeding rates with lower cutting heights. This is because lower cutting heights require more plants per square foot to maintain 100 percent ground cover than does a higher cut stand. The one pound of bluegrass seed per thousand square feet listed in many older turfgrass textbooks may have been appropriate when we were mowing Kentucky bluegrass at three inches height. Our research indicated that seeding rate should be doubled for every halving of the cutting height. For instance, while one pound might be acceptable for a three inch cut, a two pound rate might be better for an inch and a half, and a four pound rate for a three-quarter inch intended mowing height. This provides the desired shoot density of the stand without the usual "equilibration" period.

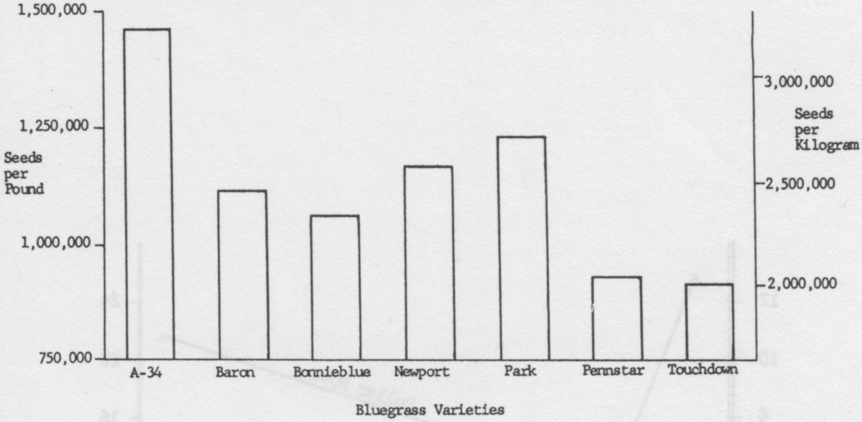
Effect on Kentucky bluegrass seeding rate on encroachment of annual bluegrass is quite profound. Using a low seeding rate or a weak cultivar will "open the door" for invasion of annual bluegrass. This invasion can occur simultaneously with emergence of the Kentucky bluegrass or may happen within the first six months or a year after planting, due to a thin stand. Any time we do not have complete ground coverage of a turf stand, annual bluegrass (being an opportunistic weed) can take over. Seeding rates of 3-4 pounds of Kentucky bluegrass per 1,000 square feet were desirable where annual bluegrass seed was prevalent in the soil. Vigorous cultivars were also more desirable for use in competing in annual bluegrass.

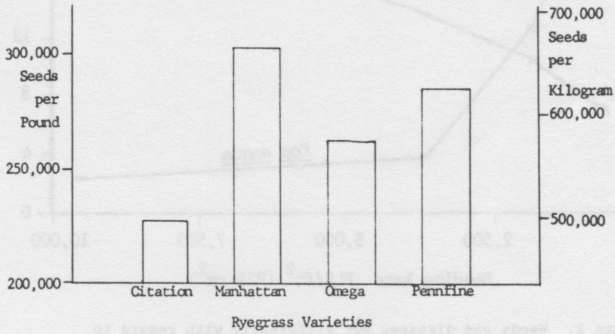
But you can get too much of a good thing. Going too far on the other extreme (seeding too heavily) may bring about added disease problems. We found that incidence of leafspot and Fusarium blight complex was directly related to seeding rate. Seeding rates above 3.5 pounds Kentucky bluegrass seed per thousand square feet greatly increased the risk of disease during the establishment phase. Once a dense stand was hit with disease, however, the shoot density was lowered by the disease, and the stand subsequently received fewer disease problems. Where we prolonged the high shoot density by means of fungicides, the stand was at a greater risk of disease damage during times when fungicides were skipped or withheld.

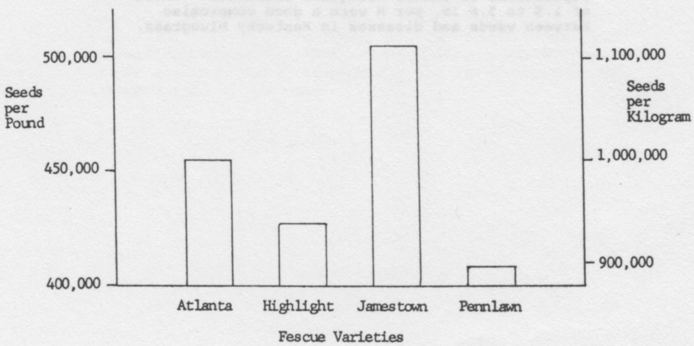
The number of seeds per pound varies considerably between Kentucky bluegrass cultivars. Bluegrasses may have from 800,000 to 2,000,000 seeds per pound -- a greater than 2x difference. Therefore, for large plantings (such as a whole golf course or sod farm), it is advisable to obtain figures on the seeds per pound and PLS (pure live seed percentage) of the variety you are using. This may save 2x in the cost of seed purchased.

Ideal rates for seeding Kentucky bluegrass are 2-3 pounds of seed per thousand square feet. One pound or less would be considered too light and greater than 5 pounds, excessive. Perennial ryegrass is best used at 4-8 pounds per thousand square feet, with 2 pounds or less being too light, and greater than 10 being excessive. Tall fescue benefits from a stouter seeding rate of 6-10 pounds of seed per thousand square feet. Skimping on tall fescue seed is undesirable since tall fescue has no runners. Seeding at less than 6 pounds per thousand square feet is considered too light, whereas seeding at greater than 15 pounds of seed per thousand square feet would be excessive.

Figure 1. Kentucky bluegrass, perennial ryegrass, and fine fescue cultivars significantly differ in number of seeds per lb. Moreover, seedlots raised under various environments may also differ in seed/lb. By knowing the seed/lb. of the variety, turf managers may plant varieties with more seed/lb. at proportionately lower seeding rates (lb./acre).



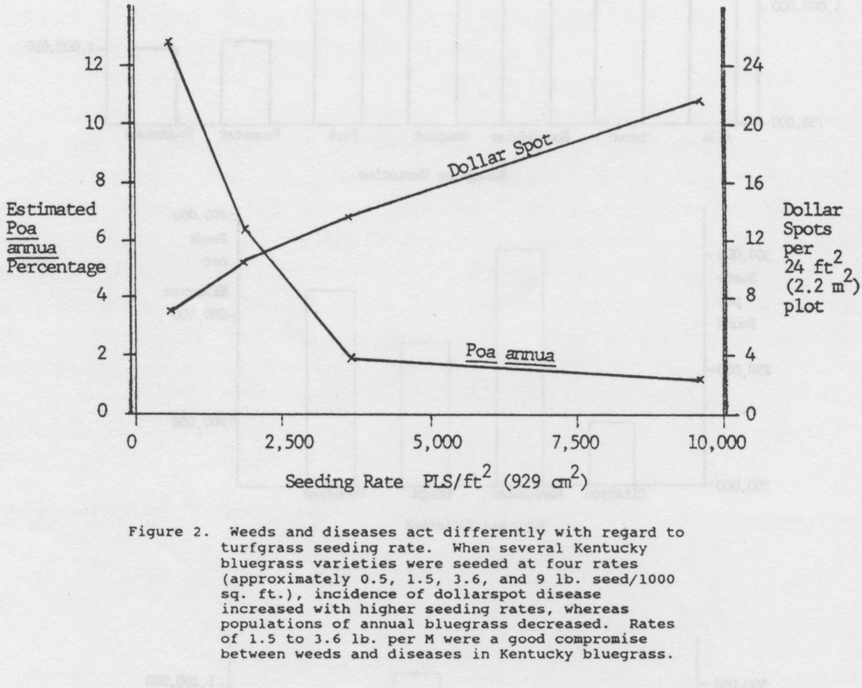



Figure 2. Weeds and diseases act differently with regard to turfgrass seeding rate. When several Kentucky bluegrass varieties were seeded at four rates (approximately 0.5, 1.5, 3.6, and 9 lb. seed/1000 sq. ft.), incidence of dollarspot disease increased with higher seeding rates, whereas populations of annual bluegrass decreased. Rates of 1.5 to 3.6 lb. per M were a good compromise between weeds and diseases in Kentucky bluegrass.

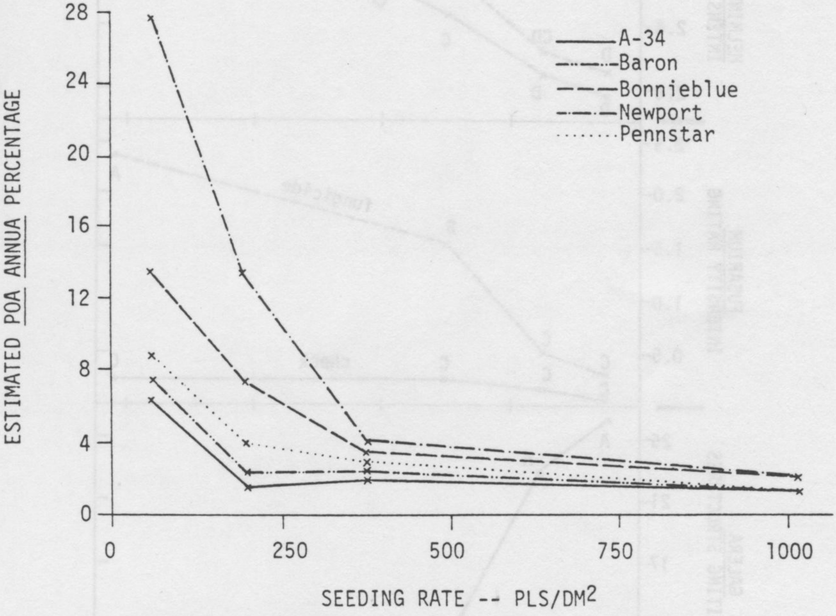



Figure 3. Where *Poa annua* seed exists in the soil, seeding rates of 3 to 4 lbs. per M helped the Kentucky bluegrass compete. There was no benefit in competitive ability from exceeding 4 lbs. At seeding rates below 3 lbs., the vigor of the cultivar became paramount in the encroachment of annual bluegrass. Weak varieties, such as Newport, allow considerable encroachment of *Poa annua* at lower seeding rates.

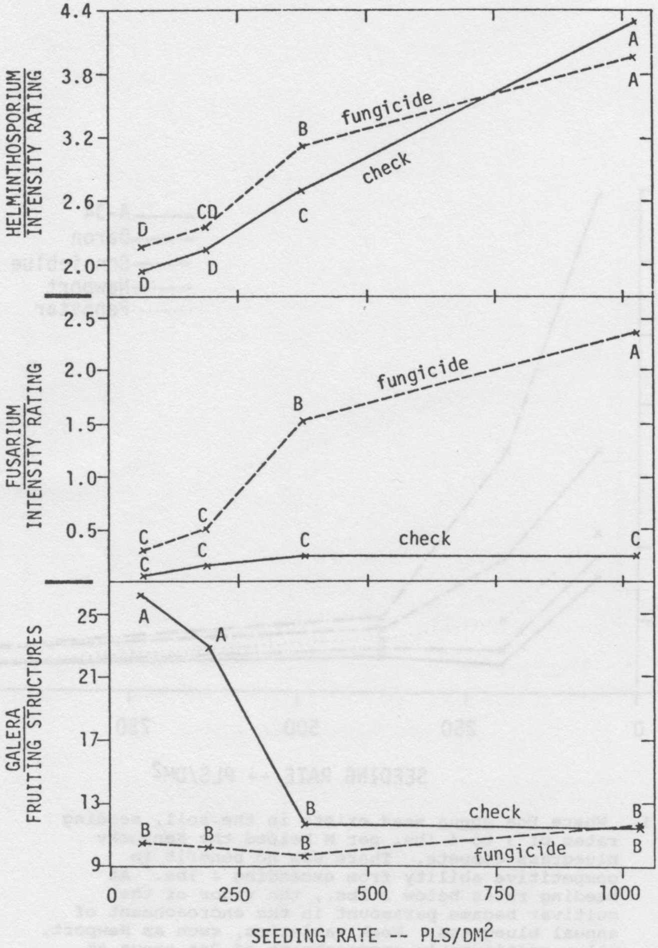



**Figure 4.** **Effect of seeding rate on diseases becomes complicated when the question of fungicide application arises. In general, higher seeding rates induce higher amounts of disease. When fungicides are skipped or withheld, diseases can occur in greater severity than if no fungicides had ever been applied in the first place. This is because fungicides tend to "shelter" small, dense plants from the natural thinning effect of disease. Even non-target organisms such as Pixie Cap mushrooms (Galera spp.) are affected by seeding rates and fungicide.**

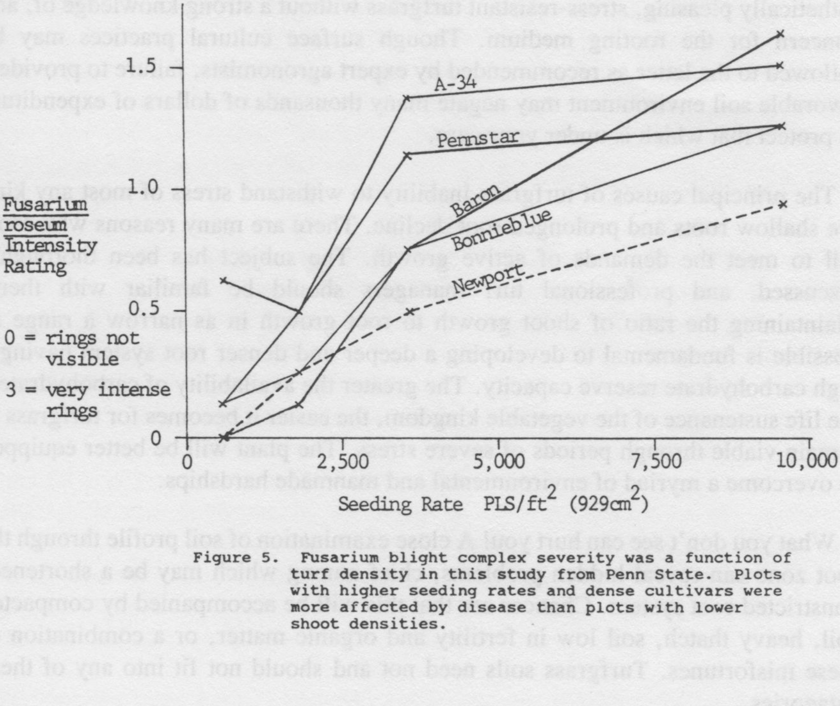



**Figure 5. Fusarium blight complex severity was a function of turf density in this study from Penn State. Plots with higher seeding rates and dense cultivars were more affected by disease than plots with lower shoot densities.**

# TURFGRASS NUTRITION FROM A SOIL PERSPECTIVE [1]

C. Robert Staib [2]

[1] Presented at the 42nd Northwest Turfgrass Conference, Sheraton-Spokane, Washington, September 19-22, 1988.

[2] Senior Sales Representative, NOR-AM Chemical Company, Des Moines, Iowa

The objective of good turf culture should be to encourage maximum root development to meet the needs of the plant during seasons of growth and to instill and sustain hardiness during periods of dormancy. It is impossible to maintain an esthetically pleasing, stress-resistant turfgrass without a strong knowledge of, and concern for the rooting medium. Though surface cultural practices may be followed to the letter as recommended by expert agronomists, failure to provide a favorable soil environment may negate many thousands of dollars of expenditure to protect that which is under your care.

The principal causes of turfgrass inability to withstand stress of most any kind are shallow roots and prolonged root decline. There are many reasons why roots fail to meet the demands of active growth. The subject has been thoroughly discussed, and professional turf managers should be familiar with them. Maintaining the ratio of shoot growth to root growth in as narrow a range as possible is fundamental to developing a deeper and denser root system having a high carbohydrate reserve capacity. The greater the availability of carbohydrates, the life sustenance of the vegetable kingdom, the easier it becomes for turfgrass to remain viable through periods of severe stress. The plant will be better equipped to overcome a myriad of environmental and manmade hardships.

What you don't see can hurt you! A close examination of soil profile through the root zone can reveal hidden problems, chief among which may be a shortened, constricted root system. Chances are that this will be accompanied by compacted soil, heavy thatch, soil low in fertility and organic matter, or a combination of these misfortunes. Turfgrass soils need not and should not fit into any of these catagories.

Now that you have identified a problem of insufficient root development, what will you do about it? There are several mechanical cultural practices that are well recommended to improve root response, e.g. more frequent mowing, raising cutting heights, more cultivation, etc. Adjusting your fertilizer program to provide more uniform, but less than maximum growth may be the best long-term solution. Some turf experts have suggested that limiting growth to @ 70% of maximum should be standard procedure to promote deep roots and sustained vitality. The flow of inorganic or urea nitrogen from soil to the plant via ammonification to free ammonia and ammonium ($NH4+$) ions, and thence by mineralization to nitrate ($NO_3^-$) nitrogen is typically quite rapid. In soil temperatures above 50° F, urea can be completely converted to nitrate N in 48 to 72 hours. Luxurious consumption of nitrate, frequently accompanied by some loss of ammonia through volatilization, and /or loss of nitrate N from leaching, sets up a pattern of feast and famine which is a major cause of root decline and heavy thatch formation. Slow release nitrogen (SRN) does much more than just save labor on fertilizer applications. By itself or in combination with soluble nitrogen, SRN helps the plant maintain color and vigor with fewer growth peaks. The more uniform the rate of growth, the greater the root response. Slow release fertilizer containing water-insoluble nitrogen greatly resists leaching even in porous soil, and research has shown that volatility loss of ammonia ($NH_3$) is negligible.

Perhaps the greatest consequence of the feast and famine syndrome is heavy thatch, the accumulation of dead root, stem, and crown tissue that is produced faster than soil microorganisms can decompose it. The problems associated with heavy thatch are well known in this industry. So universal is the correlation between thatch and root decline that measures taken to correct one will frequently correct the other. To reduce thatch or prevent it from becoming a problem in the first place, think back about the role of soil microorganisms in decomposing dead plant residue.

Thatch is a phenomenon resulting from two happenstances working against each other...too rapid plant growth, too few microorganisms: Some interesting research conducted on newly established Kentucky bluegrass turf at the University of Illinois in the early 1980's showed startling differences in thatch formation from vazious N sources following two years of applying 4 lbs. of N per 1,000 sq.ft. per year. Fast release nitrogen produced significantly greater quantities of thatch than slow release sources. It was also speculated that the increased acid reaction in the soil from soluble fertilizer like ammonium sulfate created a hostile environment for bacteria, thus compounding the problem. NITROFORM (R) ureaform on the other hand, produced less thatch than the control. Nitrogen release and growth response were more uniform, and the organic polymers supplied both nitrogen (food) and carbon (energy) for utilization by the soil bactelia in a less acidic environment.

Perhaps we have about come full circle and are returning to "grass roots" agriculture, realizing that grandpa was right all along. Modern agriculture is trending towards conservation farming such as "no-till", and once again is enriching the land with green manure and crop residue. The most productive soils on earth are those that are high in organic matter. This truth is as fundamental in the world of turf as in heartland, row-crop America. You can grow turf and other crops in sand, as professional turf managers frequently do - at a cost. It is far easier (in the long run) to grow turfgrass in a healthy *living* soil, even in a predominently sand medium. With just a bit of encouragement, beneficial microorganisms will multiply and do for your turf practically everything you could do except mow. Now that is a broad statement, and some explanation is in order. The terms "organic matter" and "soil microorganisms" are integrally linked together when you consider their relationship to each other and the benefits they both provide to the root medium. The quantities of soil microorganisms reach into the googol numbers, e.g. as many as 500,000,000 bacteria may inhabit a single gram of agricultural soil. Other species of fewer number include actinomycetes, fungi, yeasts, protozoa, algae, and nematodes. Each serves their own unique role in the process of decay, but very important for turf managers, they compete vigorously against pathenogenic organisms and assiist in making insoluble major and minor nutrients available to plants. Certain bacteria and some blue-green algae fix nitrogen through the action of the enzyme, *nitrogenase*, converting atmospherlc free nitrogen ($N_2$) to ammonium nitrogen. Certain fungi release nitrogen as ammonia during decomposition of organic residue. A good example is the release of nitrogen by the action of the fairy ring fungus. Some strains of soil bacteria contribute to phosphorus availability by dissolving insoluble phosphate. Organic acids synthesized during decay dissolve insoluble metal complexes and bind with the metal ions. These *chelated* metal nutrients then become available for plant uptake.

Of equally great importance, and at times perhaps most important, is the suppression of disease organisms by the concept of the "survival of the fittest". The living soil, though friend to man, is in reality a fierce battleground. When left alone, the good guys usually win. When man steps into the picture, the good guys sometimes lose and would just as soon fight their own battles...as when too much acid-reacting fertilizer is used on turf and compacted soils are void of oxygen. Beneficial microorganisms provide many other services, known and unknown to man, we are learning that mycorrhizal fungus can dramatically improve nutrient responses in plants. The mycelia serve as a direct pipeline to soil elements which would normally be in too short supply.

The foundation of the living soil is the organic matter. Comprised primarily of humus and intermediate fractions of decay, organic matter is the storehouse of nearly everything plants need to sustain optimum, stress-resistant physiologic growth. Humus, the last stage of bacterial decomposition, is one of nature's most abundant gifts to mankind. When you examine the list of benefits, the miracle of humus becomes readily apparent. How many of these events do we take for granted that would not occur without it? The world would become a desert without the water holding capacity of humus. Soils would have only limited means of holding and releasing nutrients without the cation exchange capacity of humus. Neither would they have structure. Humus and polysaccharide intermediates are the binding forces of nature to produce stable soil aggregates.

The composition of organic residue is complex, Included are carbohydrates, lignins, fats, waxes, fatty acids, and proteins. The carbohydrates are the first to decompose, and provide much of the energy (carbon) for the decay organisms. The lignins are the most resistant components, Thatch is largely composed of this fraction, and high levels of certain soil bacteria and perhaps certain strains of actinomycetes are required to reduce it to humus.

The decay process frequently begins with the macroorganisms, sometimes referred to as soil animals. Examples include centipedes and earthworms as well as many other soil-inhabiting insects. The casts brought near the surface by earthworms are extremely rich in plant nutrients including available phosphorus. Certain fungi begin the decomposition of grass clippings while soil bacteria multiply profusely in the vicinity of dead root material if nitrogen is available and the pH is favorable. Bacteria favor neutral to slightly alkaline pH in contast to fungi which prefer an acidic environment. The end result of decomposition is nutrient-rich humus, the ultimate objective.

Ureaform may be just one way to provide a source of both food and energy to soil bacteria. Through metabolism, they gradually releasc ammonium N back to the soil. The effects of conventional fast and slow-release inorganic nitrogen sources are pzimary to the plant. Ureaform and natural organic nitrogen however, are in effect, more primary to the soil microorganisms. They and plants both benefit. Where turf is under prolonged stress, particularly if there is heavy thatch or a constricted root structure, core cultivation (aerification) will help significantly to activate the soil microbial population. When the soil is open and exposed is an excellent time to apply ureaform or natural o = ganic fertilizer. They'll be readily accessible to soil bacteria and visa versa. This also is a good time to ''incorporate'' phosphorus and potassium if the need arises since these elements move only slowly in the soil. This is particularly true for phosphorus. When seeding or sodding, enriching the soil with onganic nitrogen just prior to planting will assure an active microbialenvironment for the duration of the establishment period and often beyond. It has been observed that incidences of fusarium patch, common in some Kentucky bluegrass lawns and usually appearing 2 to 3 years following sodding were fewer when sodbeds were pre-fertilized with NITRO-FORM, Research is on-going and it is hoped that we'll have documentation in the near future,

Maybe it's time for you, too, to return to ''grass roots'' agriculture. Examine carefully your own grass roots, and see if there is room for improvement using the new old fashion way. You'll gain your customers' respect and rest easy knowing you've got lots of helpers underfoot keeping turf and ornamentals lush *all* season long.

# SYSTEMIC APHID CONTROL FOR SHADE TREES [1]

Cindy Maitland Deffe' [2]

[1] Presented at the 42nd Northwest Turfgrass Conference, Sheraton-Spokane, Washington, September 19-22, 1988.

[2] Tree/Weed Department Manager, Senske Lawn and Tree Care, Spokane, Washington

Aphids are serious pests that attack many of our food crops and ornamentals. Control of these pests is important to keep plants healthy, to prevent the spread of disease, and to eliminate the sticky honeydew that they excrete. When ornamental shade trees are infested with aphids one of the biggest public concerns is the honeydew that drips onto cars and people below. There is a very effective method of controlling aphids on shade trees which many people are unaware of. Soil injections of systemic insecticides are very effective and are often the most desirable method of aphid control. We have been injecting trees for twenty years or so now and feel that injections are an option worth considering.

Aphids are small, soft bodied, sucking insects. There are hundreds of aphid species that attack a multitude of plants. Aphids are commonly found in large numbers on plant stems and leaves. All stages of development may be found together at any time as most species have many overlapping generations. There are some characteristic differences between species, but most aphids are pear shaped and have a pair of tubular apendages (cornicles) on the rear end of the abdomen.

The life cycle of most aphids is complex and quite unusual. Many of the aphids that attack our ornamental trees overwinter as eggs on tree branches. These eggs hatch in early spring as the new growth unfurls. Since most species are parthenogenic, the female can give birth without mating, and most bear live young. These characteristics, as well as short generation time allow most aphid species to build up very rapidly.

There are several reasons why we need to control the aphids that attack our ornamentals. Aphids feed on plant juices thus reducing the vigor of the host. Their feeding can also cause leaf malformation and tissue distortion. If they are not controlled before this injury occurs plants appear twisted and devitalized for the season. Premature leaf drop is another common symptom of aphid feeding.

Many aphid species vector serious plant diseases. As the aphids move from one plant to another to feed they carry disease particles on their proboscis. The disease enters the new host as the aphid pierces the plant to feed. Aphids are the number one vector of many virus diseases.

As aphids feed they excrete a sticky substance called honeydew. Honeydew consists mostly of excess plant sap, sugars and other waste material from the insect's feeding. Honeydew, though harmless, is the main reason why most people want to control aphids. The honeydew drips onto plant leaves, cars, decks and people below the infested plants. This is especially annoying when cars are parked undcr aphid infested shade trees. A black fungus called sooty mold often grows in the honeydew, covering tree trunks and branches. This fungus is not damaging, but it causes the plants to look unsightly.

Predators such as lady beetles and green lacewings help control aphids, but their populations are usually not early enough or heavy enough to provide much control. Insecticidal soaps work very well when sprayed directly on the aphids. The soaps dessicate and smother the soft aphid bodies, These products only control the insects that are sprayed however, so there is no residual activity.

Most insecticides are labeled for aphid control, but contact sprays only last for a short time. Aphids breed very rapidly and thus they build up again soon after a spray. Several sprays are necessary for season long control.

We have found that systemic insecticides provide much longer control of aphids. They are more effective because they are absorbed by the plants and are present in plant juices throughout the tree. As the aphid feeds it also injests the systemic insecticide. Since the insecticide is inside the plant it does not break down as quickly as contact sprays. We have found that the most effective method of getting the systemic into the tree is by soil injection. We often will get season long aphid control from one soil injection done in the spring. There are many other reasons why soil injections are often the chosen method of aphid control. As trees get bigger they become difficult, if not impossible to spray. These large trees can be injected with excellent resultS.

In park and golf course plantings spraying may be undesirable due to the constant presence of people in the area. Tree injections are a viable alternative in these situations. Injections will not disrupt beneficial insects or wildlife present in the tree either. There is also no problem with spray drift from this type of application.

Tree injections allow you to be very flexible. They can be done during any type of weather and at any time of day. Since aphids often become a problem in the spring when weather is so variable this is a real plus.

The best time to inject shade trees is in the spring as the new buds are breaking. Sap flow is very rapid at this time and plant juices are strongly moving upward to feed the new growth. The insecticide is picked up and translocated to the leaves the fastest at this time of the year. Injections can be done at any time there are green leaves on tree (through mid-late Aug.).

Most shade trees that are commonly attacked by aphids can be injected. Birch trees, maples, aspens, elms, oaks, hawthorns and many others are commonly injected. Some shrubs such as snowball bushes and spireas can also be injected for season long aphid control.

There are two systemic insecticides commonly used for soil injection. Dimethoate 267, a Wilbur Ellis product, is the prefered product in this area. Mobay's Metasystox-R2 is the product of choice West of the Cascades. We have no data to substantiate why this is so, but we feel that we get better season long control with the Dimethoate 267. Soil injection recommendations are not on the Dimethoate label as it is a SLN registration. Be sure to get a copy of the correct SLN for your area if you use this product.

It is important to fully read the label of the selected insecticide to determine the injection rate for that product. The rate for the Dimethoate 267 is based on the trunk circumference of the tree at chest height. The rate for Metasystox-R2 is based on the diameter of the tree trunk at chest height. The number of injections per tree also varies by the product used so please refer to the appropriate label.

Tree injections need to be placed into the root zone of the plant for proper absorption and translocation. Tree roots grow at least as fast as the tree branches, and often 2-3 times faster. We generally recommend starting the injection around the dripline of the desired tree, making coincentric rings from a couple feet inside the dripline to a few feet outside as needed. Often one injection row around the dripline is adequate to apply the appropriate rate.

There are a number of ways to inject the insecticide into the soil either in a concentrated or a dilute form. We have found the Kioritz injector to be most suitable for our operation. This injector holds up to 3 quarts of concentrate insecticide and can be calibrated to deliver from 0-1/6 oz per stroke. The calibration ring is right under the pump handle on the top of the injector and it is very simple to adjust. The best way to calibrate this type of an injector is to set the stroke at the appropriate setting, fill the injector with water and bucket-test the injector. Pump the injector 100 times into a bucket and measure the output. Divide the total quantity by 100 pumps to see if each pump is giving you the desired amount. If your rate is off adjust the calibation ring as needed and re-test. The injector should be re-calibrated periodically to make sure your rate is correct.

As I mentioned earlier, the insecticide needs to be injected into the root zone of the desired plants. Sometimes this is not as easy as it sounds. If the plant you are to inject is bordered by a street or other barrier then you will need to adjust where the injections can be made. If 1/3 to 1/2 of the root zone area is injectible then adequate aphid control can be obtained. Any less than 1/3 is questionable. If 1/2 of the root system is covered by concrete or is somehow uninjectible then the full amount of insecticide must be placed around the tree where the other 1/2 of the roots will pick it up. It is important not to place injections too close together in this situation or some foliar burn may occur. Injections should always be placed a foot or more apart.

When injecting around other ornamentals try to avoid getting close to arborvitae, spruce and other evergreens as they are a little more sensitive than deciduous plants. It is best to stay away from annual and perennial bedding plants as well.

Since these insecticides are systemic it is important to keep crops. It is not recommended to inject Black Walnut trees if they are bearing nuts either.

Aphids are common insects that attack many of our desirable plants. They are relatively easy to kill with a number of insecticides, but systemics provide the longest and best control. When aphids attack our shade trees spraying is often not a feasable or desirable method of control. We have found that soil injections of systemic insectides provide the most effective aphid control with the least exposure to people, other plants or the environment. Soil injections are not necessarily the best in all situations, but they are a very important tool in a good pest management plan.

# EVALUATION OF NEW BROADLEAF WEED CONTROL HERBICIDES [1]

Stanton E. Brauen [2]

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[1] Presented at the 42nd Northwest Turfgrass Conference, Sheraton-Spokane, Washington, September 19-22, 1988.

[2] Turf Science Associate, Washington State University, Puyallup Research and Extension Center, Puyallup, Washington

INTRODUCTION:

As the public becomes more demanding concerning the application of herbicides in the environment, alternative weed control solutions are explored. Some of the research efforts are directed at biological control; others are directed toward the selection and development of safer and more environmentally safe products. Examples of products currently being evaluated in place of 2,4-D for control of broadleaf weeds in turf are triclopyr, clopyralid, chlorimuron ethyl, metsulfuron methyl, DPX-M6316, fluroxypyr, and chlorflurenol. Many of these compounds have been evaluated alone and in various combinations and in comparison to several commonly available registered products. These registered products have included Weedone DCP, Weedestroy, Trimec amine, Trimec ester, Turflon D (amine), and Turflon II (ester).

Many broadleaf weeds in turf may be selectively controlled with postemergence herbicides. Commonly, these postemergence herbicides are absorbed through the leaf and stem or root system and are transported throughout the plant. Typical herbicide products that provide good broad spectrum weed control are listed in Table 1. Good control of many broadleaf weeds can be achieved with this group of herbicides if good spray coverage is attained, good growth conditions prevail, and good conditions for herbicide uptake follow the application.

Often dry conditions or stress conditions following application can minimize the effectiveness of postemergence applications. Some postemergence herbicides may remain soil active for a sufficient period of time to prevent early reseeding or renovation of a turfgrass site. In addition, herbicides such as dicamba can cause injury to ornamental shrubs and trees, but this rarely happens when applied according to directions supplied with the label. 2,4-D may injure flowers, tomatoes, grapes and occasional ornamentals through misapplications or by off-target drift.

It should also be remembered that two applications of a broadleaf herbicide are often required either in one month intervals between each other or as spring and fall treatments in order to pyovide a high level control of hard-to-kill broadleaves, such as false dandelion and English daisy. Other broadleaf weeds, such as creeping speedwell or creeping buttercup, are not well controlled even with two applications.

Table 2 lists the general control that has been observed from single applications of the herbicides listed and the rate range of application. However, combinations of many of these compounds will enhance the control obtained so that greater acceptability is accepted. In addition, higher rates of some compounds, such as the upper ranges of metsulfuron methyl, can be very toxic to the turfgrass.

Most of the successful broadleaf weed control has been present with combinations of triclopyr and clopyralid. Table 3 lists the broadleaf weed control associated with triclopyr-clopyralid combinations that were applied at active ingredient rates equivalent to 2, 3 and 4 pint/acre with and without a surfactant. In these mid-summer applications, surfactant was extremely effective in improving the broadleaf weed control of the 2 pint/acre rate. In addition, we have found clopyralid combinations with triclopyr to be much more effective in fall applications than in spring applications. Figure 1 suggests clopyralid may be highly effective in providing nearly complete control of some broadleaves when applied at relatively low rates in a late fall application. By contrast, summer applications of clopyralid were considerably less effective at low rates. Thus, if current studies and experiences now being tested in 1988 and 1989 are as successful as preliminary and intermediate results suggest, a nonphenoxy alternative to 2,4-D may be available for *some weed combinations.* The major weeds in the studies reported here were white clover (Trifolium repens L.), common dandelion (Taraxacum officinale Weber.), mouse-ear chickweed ( Cerastium vulgatum L.), broadleaf plantain (Plantago major L.) and false dandelion (Hypochaeris radicata L.).

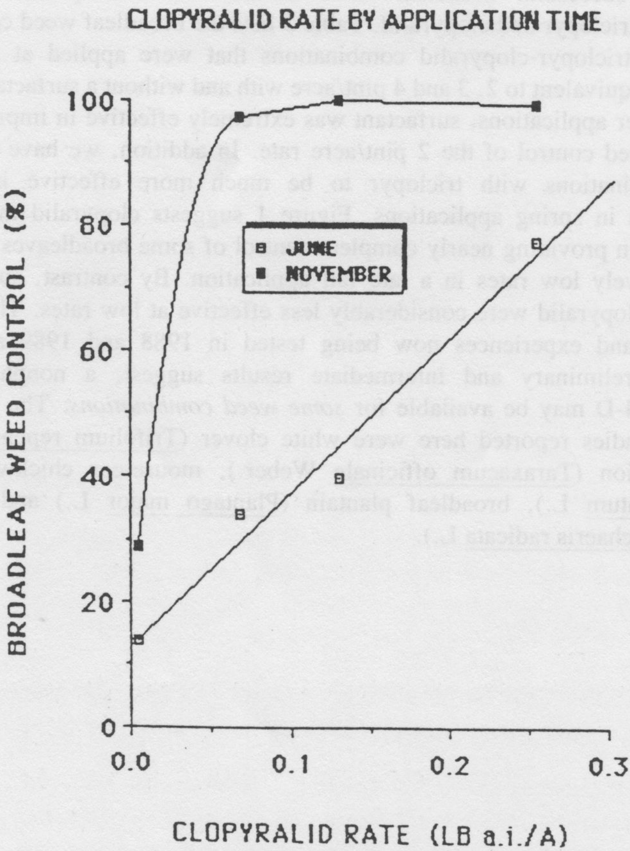


Fig. 1. Postemergence broadleaf weed control with clopyralid when applied in early summer or late fall to actively growing turfgrass.

Table 1. Broadleaf Weed* Control in Turfgrass with Commonly Available Herbicide Products.

| Herbicide | Rate (pt/A) | Control (%) |
|---|---|---|
| Weedone DCP | 2.0-6.0 | 45-80 |
| Weedestroy | 3.0 | 55-73 |
| Trimec (Amine) | 3.0-4.0 | 63-74 |
| Trimec (Ester) | 2.0-3.0 | 63-87 |
| Turflon D (Amine) | 2.5-4.0 | 56-81 |
| Turflon II (Ester) | 2.5-4.0 | 81-93 |

* Intense pressure from White clover (Trifolium repens L.), Common dandelion (Taraxacum officinale Weber.), Mouse-ear chickweed (Cerastium vulgatum L.), Broadleaf plantain (Plantago major L.), and False dandelion (Hypochaeris radicata L.).

Table 2. Broadleaf Weed* Control in Turfgrass with New Herbicides.

| Herbicide | Rate | Control |
| --- | --- | --- |
| | (lb/A) | (%) |
| Triclopyr | 0.5-0.75 | 35-58 |
| Clopyralid | 0.1-0.5 | 15-68 |
| Fluroxypyr | 0.1-0.4 | 43-90 |
| Chlorimuron ethyl | 0.125 | 0-20 |
| Metsulfuron methyl | .002-.004 | 33-47 |
| M6316-26 | .0125-.025 | 20-43 |

* Intense pressure from White clover (Trifolium repens L.), Common dandelion (Taraxacum officinale Weber.), Mouse-ear chickweed (Cerastium vulgatum L.), Broadleaf plantain (Plantago major L.), and False dandelion (Hypochaeris radicata L.).

**Table 3. Broadleaf Weed* Control in Turfgrass with Triclopyr and Clopyralid Combinations.****

| Herbicide | Rate (lb/A) | Control (%) |
|---|---|---|
| **Without Surfactant** | | |
| Triclopyr + Clopyralid | 0.75 | 67 |
| Triclopyr + Clopyralid | 1.125 | 91 |
| Triclopyr + Clopyralid | 1.50 | 95 |
| **With Surfactant** | | |
| Triclopyr + Clopyralid | 0.25 | 94 |
| Triclopyr + Clopyralid | 1.125 | 99 |
| Triclopyr + Clopyralid | 1.50 | 99 |

* Intense pressure from White clover (Trifolium repens L.), Common dandelion (Taraxacum officinale Weber.), Mouse-ear chickweed (Cerastium vulgatum L.), Broadleaf plantain (Plantago major L.), and False dandelion (Hypochaeris radicata L.).

** 2.25 lb/gal triclopyr plus 0.75 lb/gal clopyralid.

# GOLF CART PATH CONSTRUCTION [1]

Jon Heselwood [2]

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[1] Presented at the 42nd Northwest Turfgrass Conference, Sheraton-Spokane, Washington, September 19-22, 1988.
[2] Project Superintendent, Eagle Bend Golf Course, Bigfork, Montana

The reasons why we need golf cart paths may seem obvious. The dramatic increase in rounds played every year has placed a great burden on our turfgrasses, and it seems additional cart paths are always needed. Agronomic impacts of golf cart traffic on turf include reduced water infiltration, reduced soil aeration, soil structure degradation, weed encroachment, and anaerobic conditions.

We must also consider the safety of our golfers. Properly constructed cart paths enable our golfers to safely negotiate courses even under adverse weather conditions. In this day and age, we must always do our best to limit our exposure to litigation. It is recommended that you confirm you are covered by professional liability insurance as an employee of your club, and in the event of an accident, have a policy to direct your employees on the procedure you wish to have followed, such as photographs and **immediate** mechanical inspection of the golf car by your mechanic. Whenever possible you should consult with professional engineers when constructing cart paths in hazardous situations. One final thought on minimizing your exposure would be to ask the manufacturer of your golf cars to submit to your club a letter stating that their golf cars can safely negotiate your facility without additional equipment (e.g. front brakes).

Several path construction materials are listed below with estimates for complete installation.

| | |
|---|---|
| Gravel 1 - 8 inches thick | $.10 to.50 per square foot |
| Asphalt 1 - 2 inches thick | $.50 to 2.00 per square foot |
| Concrete usually 4 inches thick | $3.00 to 4.00 per square foot |
| ''Geo Blocks'' | $1.20 to 2.00 per square foot |

We found that after our asphalt cart paths were installed, we had several drainage problems as well as a problem when it came to crossing a path with a ''French'' drain. We discovered a company out of Seattle, Washington called National Deversified Sales that handles various drain inverts. One of their products called SPEE-D drain worked very nicely for crossing an asphalt path. Installation included using an asphalt cut-off saw to make a clean cut, French drain installation under the path, installation of the SPEE-D drain, and caulking the seams. They work great and look very professional when completed.

Another item that may have to be dealt with regarding path constrution is that of installing a bridge. I highly recommend that you hire an engineering firm to oversee the ordering of the bridge, design and staking of the bridge foundations, and coordination and inspection of the work performed by the contractors. Let the professionals handle this one because if you order a $15,000 bridge and it is one foot too short, you may find yourself in big trouble! When budgeting for a bridge, do not forget the installation costs. Cranes can easily run $100 per hour, so installation costs can reach several thousand dollars. Also, consider your local crane service. Do they have big enough cranes to handle your job, or are you going to have to import a crane from hundreds of miles away at $ XXX per hour travel time!

In conclusion, I would recommend that we all try our best to install properly built paths that will stand up for many years to come. I feel it is better to do one cart path a year properly than three by the ''lowest bidder''. I would like to thank Dr. Bill Johnston and the Northwest Turfgrass Association for this opportunity and honor of presenting to our associates.

# CONTROLLING POA ANNUA WITH PROGRASS® IN COOL-SEASON TURF [1]

C. Robert Staib [2]

[1] Presented at the 42nd Northwest Turfgrass Conference, Sheraton-Spokane, Washington, September 19-22, 1988.
[2] Senior Sales Representative, NOR-AM Chemical Company, Des Moines, Iowa

*Poa annua*, well known as annual bluegrass, historically has been a major obstacle to managing and maintaining fine golf turfs. Because *Poa annua* is so abundant and prolific throughout much of the country, golf course superintendents too frequently succumb to the proverbial resignation, "you can't live with it; you can't live without it." Recent deveopments in the chemical industry however, are making it much easier to live without it.

A herbicide, ethofumesate, brand name... PROGRASS® from NOR-AM Chemical Co., is selectively active against *Poa annua* in cool-season golf turfs and in dormant bermudagrass. It is labeled for use in perennial ryegrass, Kentucky bluegrass, and fairway-maintained bentgrass. PROGRASS is unique among industly introductions to control or suppress *Poa annua*. It is a true herbicide and not a plant growth regulator. It exhibits both pre and post-emergence activity. Existing *Poa annua* plants die slowly following root and foliar absorption, mainly from the latter. Depending on conditions, herbicidal action may be observed within a week or two following application. In some cases control may not be evident until the following spring. As *Poa annua* seeds germinate, residual PROGRASS in the soil is absorbed by tissues prior to emergence, effectively preventing establishment. In most soils, PROGRASS will remaln active for up to 6 weeks following the last application.

TIMING:

Experience has shown that late summer and fall is the best time to apply PROGRASS to gain maximum effectiveness for pre and postemergence control of *Poa annua*. Annual bluegrass is a winter annual with its primary establishment period extending from mid August into November, or even later when temperatures are moderate. This is also the period when older plants, having survived the summer, are most susceptible to post-emergence control. You'll get the optimum return on your investment by planning PROGRASS applications within this time frame. From a practical standpoint, this is also the desireable time for cool-season turf renovation programs, and affords the opportunity to take advantage of treating when there is less play on the golf course.

OVERSEEDING:

It is important to realize that as *Poa annua* is eliminated in the treated anea, bare spots may appear unless vegetation is reestablished in an overseeding program.

Fortunately, perennial ryegrass can be overseeded just prior to treatment without phytotoxic effects. Eliminating competition from the *Poa annua* helps the ryegrass become more quickly and uniformly established.

Kentucky bluegrass seedlings are sensitive to PROGRASS, and thus should not be incorporated in an overseeding program within 8 weeks before or after treatment. PROGRASS does not inhibit rhizome development. If it is important to increase the Kentucky bluegrass stand faster than through normal rhizome propagatlon, dormant seeding (at least 8 weeks following the last PROGRASS treatment) or spring seeding the the following season would be valid options. If the extent of *Poa annua* infestation in Kentucky bluegrass fairways is severe enough that obvious bare spots would result fnom PROGRASS treatments, overseeding with perennial ryegrass should be undertaken. Incorporating perennial ryegrass into Kentucky bluegrass fairways should not detract from the esthetics you are trying to maintain, and may, in the long run, form a turf more adaptable to the shorter cutting heights preferred by golfers.

Superintendents planning to apply PROGRASS in fairway-maintained bentgrass must likewise be prepared for the possibility of bare spots resulting from *Poa annua* elimination. These areas should be overseeded with bentgrass prior to treatment, but delay applying PROGRASS until 30 to 45 days after emergence. Applying a slow-release nitrogen fertilizer will encourage more rapid establishment of the new seedlings. There may be some [9]efinements in bentgras[9] seeding interval recommendations when additional data becomes available. Do not disregard overseeding perennial ryegrass into bentgrass as a temporary measure to make certain there is green cover in areas previously occupied by *Poa annua* plants. Eventually, bentgrass will dominate since close mowing will encourage it over the ryegrass.

RATES:

When planning a *Poa annua* control program with PROGRASS, be sure to read the label for specific recommendations pertaining to turf species and soil type. There are allowable ranges depending on soil type and the extent of the annual bluegrass infestation. In general, the following treatments have pnoven successful:

I. Perennial ryegrass...

Apply 1 gallon (1 1/2 lbs. active ingredient) per acre. Repeat at this rate in 30 days. When overseeding with perennial ryegrass, apply the first treatment when the seedlings are approximately 1-inch high, (one to two weeks after seeding).

II. Established Kentucky bluegrass (mowed 3/4'' higher)...

Apply 1/2 gallon (.75 lbs. active ingredient) per acre. Repeat at this rate in 21 days, and repeat a third time 42 days following the initial treatment. If overseeding is necessary during the control period, use only perennial ryegrass.

III. Fairway-maintained bentgrass...

Apply 1/2 gallon (.75 lbs active ingredient) per acre. Repeat at the same rate in 21 days. Repeat a third time 42 days following the initial treatment. Delay treating with PROGRASS until 30 to 45 days following bentgrass seedling emergence, (approximately 6 weeks after seeding).

CONCLUSION:

Experience has demonstrated that longer lasting results are achieved if identical treatments with PROGRASS are undertaken for two successive years. It is the nature of *Poa annua* to reestablish itself, given any opportunity. The more severe the infestation, the more important it becomes to adhere to this protocol. Likewise, it is important to follow the program of multiple applications as suggested to efficiently cover the time span when Poa annua is susceptable to both pre and post-emergence control.

In turf areas having a low population of annual bluegrass and in aeeas which have undergone two years of multiple applications of PROGRASS, the number of treatments can be reduced, and the chemical can be applied on an as-needed basis.

There are several other weeds common in golf turfs which are controlled by PROGRASS. Common chickweed, for example, is effectively controlled post emergence. Some other annual grasses and broadleaf weeds are controlled preemergence. Refer to the label for weed species controlled by PROGRASS.

PROGRASS resists leaching and does not readily move in soil. Normal irrigation and rainfall does not effect its performance.

Controlling *Poa annua* has long been the dream of golf course superintendents and turf scientists alike, and in recent years, there has been a flurry of activity to accomplish this objective. One means of control may not be the final answer. It would be adviseable for turf managers to consider all approaches, and be thoroughly familiar with all product labels. One thing is certain; *Poa annua* has shown an amazing ability to genetically adapt to changing environments.

# TREE WOUNDS AND TREE PRUNING [1]

Dr. Ray Maleike [2]

[1] Presented at the 42nd Northwest Turfgrass Conference, Sheraton-Spokane, Washington, September 19-22, 1988.

[2] Extension Horticulturist, Washington State University, Puyallup Research and Extension Center, Puyallup, Washington

The pruning of trees is both an art and a science. Prior planning should dictate that the plant reach its maximum size at the height and/or width needed or at least the tree can be maintained to the size that is needed. Pruning procedures may vary with the large number of different species and cultivars available; however, there are certain "typical" procedures to be followed and certain "typical" responses to pruning cuts. Plants may be formally or informally "styled".

Pruning of trees serves many purposes which include:

1. Size management—pruning to keep trees within bounds or contained within a given volume.
2. General health of the plant—maintenance of vigor.
3. Maintain shape and habit as dictated by a particular situation in the landscape.
4. Train main scaffold branches early.
5. Size reduction for trees which have gotten out of bounds.
6. Specialized pruning such as trellis, topiary, espalier, and/or bonsai.

Woody plants react to pruning cuts and other wounds inflicted upon them. Trees have the ability to seal off a wounded area (to varying degrees) and then generate new live tissue to close over the wound. This is called compartmentalization or compartmentalization of decay in trees (CODIT). The boundaries set by the tree are four walls, each of which will hinder the spread of decay. These boundaries are chemical in nature. Wall 1 limits decay upward and downward, wall 2 in an inward direction, wall 3 in a lateral direction, and wall 4 is the boundary formed by the new live tissue growing over the outside of the wound. Wall 1 is the weakest and wall 4 is the strongest.

Trees vary in their ability to compartmentalize a wound. This ability varies with different species and also varies within cultivars of the same species. General health and vigor also may play an important role as to the degree of compartmentalization. If walls 1, 2, and 3 break down or are weakly formed, the decay can spread to the center portion of the tree and cause rot. A hollow tree is a dangerous tree. Heart rot may be caused by poor pruning cuts (flush cuts), stub cutting, and other mechanical damage to the trunk or branches. It is imperative that the pruner realize where the branch collar is and not to damage it.

The general rules for pruning are simple, and if pruning cuts are made properly the tree can be maintained in a healthy or even healthier state. The first rule of pruning trees is — if the tree does not need pruning, do not prune it. If the tree does need pruning, then pruning should be limited to these targets in the following order:

1. Prune out any diseased, dead and damaged wood to maintain health. When working with diseased wood, pruning tools should be sterilized (disinfected) with alcohol between cuts to limit spread of disease.

2. Cut out any rubbing, interfering, and wrongly placed branches or branches which potentially may become rubbing. Narrow "V" crotches should be eliminated also.

3. Prune the plant to the shape desired. Early training may avoid problems later, that is, it is easier to prune a young branch with a pruning shears than with a chain saw ten years later.

4. Pruning at transplant time should be limited to the above. Recent research has shown that it is not necessary, in fact it may be harmful, to prune one-quarter to one-half of the branches when transplanting a tree, <u>unless</u> a deciduous tree is in <u>full</u> <u>leaf</u> when dug.

5. The final step should be to prune the plant to the shape desired.

There are two basic types of pruning cuts called heading or thinning. A heading cut is cutting a branch off to a bud. This causes the lateral buds beneath the cut to grow. Sometimes these newly formed branches will form a narrow angle which can cause problems later. They may be weakly attached and are more susceptible to breakage. Stub cutting or cutting a large branch off but not to a point of attachment (another branch or the main trunk) is to be avoided as this can cause a myriad of problems, such as heart rot, which may eventuallv make the tree unsafe or kill it outright. The effect of a heading cut is localized to a point of the pruning cut, usually causing a proliferation of new shoots below the cut.

A thinning cut is the removal of a branch back to a point of attachment, that is, removing a branch back to another branch or the main trunk, or removing the main trunk back to a branch. Resultant growth from a thinning cut will be directed to those branches remaining on the tree. Size reduction of trees should be by a series of thinning cuts and not heading cuts.

Branch structure consists of a cone of branch wood inserted into the trunk. The branch wood, cone, and trunk wood are distinct and different. Around the branch where it is attached to the trunk is a collar which is trunk wood. Any pruning cut made for branch removal should do as little damage to the tree as possible. The pruning cut should be such that only branch wood is cut, and this means the cut should be made on the outside of the branch collar. Cutting into the collar means the tree not only has to wound close over a larger area but stem (trunk tissue may be killed above, below, and inward from the cut. This can lead to all sorts of problems including very large stem wounds above and below the cut and the possibility of decay getting into the center of the tree.

Stem wounds occur in many different ways on trees, while most of these are usually from mechanical sources, wounds may be physiological in nature from poor pruning practices and sometimes misused herbicides.

Stem wounds to the base of the plant may be inflicted by lawn mowers and string weeders. Either piece of equipment may completely girdle the plant which will kill the phloem and cambium in that area. Since the phloem is the direct link to the roots from the leaves (food source), the roots may die, which in turn, can kill the top of the plant. Basal bruising by equipment may also lead to the introduction of plant pathogens into the wound causing basal cankers and may also kill the plant.

Flush pruning cuts can injure and kill large areas of stem tissue above and below the cut. The tree has to compartmentalize this area and there will be live tissue growing over dead tissue. Since the live and dead tissue do not expand and contract at the same rate, stem (frost) cracks can develop under repeated freezing and thawing conditions. Many of the so called frost cracks develop because of stem wounds or poor pruning cuts.

Bark scald on the southwest side of the trunk is usually stress related. Recently transplanted trees are very susceptible. On sunny, cold days in the winter, the setting sun can heat up the bark to temperatures well above the ambient air temperature. When the sun sets, the bark temperature rapidly approaches the air temperature. Under subfreezing conditions the live tissue may not be able to adjust to this temperature change and may be killed. Wrapping the trunk with a light-colored material may prevent bark scald.

Herbicides such as dicamba (Banvel) or dicamba-phenoxy type herbicide mixes may also cause death of large sections of trunk tissue. This very often happens because of an overdose of herbicide to the root zone of trees planted in turf areas.

If a tree trunk or stem is wounded, the loose and damaged bark should be removed (with a sharp knife) back to live, undamaged tissue. The wound should be made as small as possible and care should be taken to make the bottom and top of the wound rounded. Older references suggest tracing out a narrow ellipse with the bottom and top of the wound pointed. It has been shown that this actually hinders the wound closing process.

The use of tree wound compounds is optional. Recent research has shown that these compounds do not seal the wound, do not keep out insects and pathogens, and may hinder the wound closing process. If this material is to be applied, it should be for cosmetic purposes only and then only a very light coat should be applied. The spray materials work well for this purpose.

Useful Pruning References


1. Brickell, C. Pruning. Simon and Schuster, N.Y.,N.Y. 99 p.
   - A very useful reference on a systematic and practical approach to pruning of landscape trees, shrubs, and vines. Does not include any of the newer information of CODIT.

2. Deaton, C. and M. MacCaskey. 1978. All About Pruning. Ortho Books, San Francisco. 96 p.
   - Good for homemakers, good pictures, no CODIT.

3. Feucht, J.R. and J.D. Butler. 1988. Landscape Management. Van Nostrand, Rheinhold Co., N.Y. 179 p.
   - An up to date, very good reference book of every phase of landscape plants and turf grass management, good explanation of CODIT.

4. Harris, R. (ED). 1973. The Complete Book of Pruning. McMillan, N.Y., N.Y. 157 p.
   - Useful, practical, but mainly deals with shrub pruning. Excellent reference on rose pruning. Nothing on CODIT.

5. Harris, R. 1983. Arboriculture: Care of Trees, Shrubs, and Vines in the Landscape. Prentice-Hall, Englewood Cliffs, N.J. 688 p.
   - This book in a short period of time has become the ''bible'' of all phases of landscape plant management. Excellent reference book, good explanation of CODIT.

6. Shigo, A.L. 1986. A New Tree Biology. Shigo & Trees Associates, Durham, N,Y. 595 p.
   - A very unusual, worthwhile book, primarily on CODIT, pruning cuts and tree wounds. Pictures are excellent.

7. Stebbins, R. and M. MacCaskey. 1983. Pruning: How-To Guide for Gardeners. H.P. Books, Tucson, AZ. 160 p.
   - As with number 2 above—excellent photography.

8. Williamson, J.F. 1972. Sunset Pruning Book. (Paperback) Lane, Menlo Park, CA.
   - As with number 2 and 7 above—excellent photography.

# ORNAMENTAL INSECT PESTS - THE TEN LEAST WANTED [1]

Tonie Fitzgerald [2]

[1] Presented at the 42nd Northwest Turfgrass Conference, Sheraton-Spokane, Washington, September 19-22, 1988.

[2] Horticulture Extension Agent, Washington State University, Spokane County Cooperative Extension, Spokane, Washington

My talk is about pests of ornamentals - insect pests in particular. I've chosen ten or eleven insect pests that are fairly common and occur on both sides of the Cascade Mountains. The two regions have very different climates and therefore different pest and disease problems, but some insect pests are the same and these are the ones I've selected for discussion.

| | |
|---|---|
| Tent Caterpillar | 3 Adelgids: Cooley Spruce Gall |
| Fall Webworm | Balsam Wooley |
| Tussock Moth | Pine Bark |
| European Pine Shoot Moth | Pine Bark Beetle |
| Honeylocust Pod Gall Midge | Bronze Birch Borer |

## Tent Caterpillar:

Western tent caterpillar is an orange and black caterpillar about 1-1/2 to 2 inches in length. It feeds on many different deciduous tree hosts.

Tent caterpillars have their name because they make silken tents or nests around branches. There may be enough caterpillars in one tent to cause 20% defoliation of a tree. Several tents in one tree may mean severe defoliation. Although a single attack will rarely kill a tree, defoliation always weakens a tree and makes it more susceptible to other stresses such as drought, diseases or winter kill.

The tents are most characteristic of this insect pest, but another clue to their presence is the egg cluster. Adult moths lay eggs in a frothy band - like brown styrofoam around twigs and branches and sometimes on tree trunks or other structures.

Eggs hatch in April or May and the larvae or caterpillars feed for several weeks and then form cocoons. Adults emerge in late June, mate and lay 200 to 300 eggs which will overwinter on the twigs.

It is possible to reduce the amount of damage done by tent caterpillars by removing the branches with tents on them or by cutting off egg clusters.

Tent caterpillars also have a few natural enemies including a fly which parasitizes the caterpillar. Caterpillars are also subject to a virus disease and attacked by some birds. However, severe infestations will not be controlled naturally.

When tent caterpillar pressure is severe, chemical control may be necessary. Dipel or B. T. is effective when sprayed after feeding damage is apparent, but before caterpillars are mature and begin to wander off in search of protective places to pupate. They don't feed at this time and B.T. becomes ineffective.

The product Dipel is only effective on larvae that ingest it. Dipel is a solution of a kind of bacterium, Bacillus thuringiensis that parasitizes caterpillars. (The initials B. T. is another product name.) It does not effect bees, sucking insects, mammals or caterpillars that aren't actively feeding. Thorough leaf coverage is very important.

Other effective insecticide sprays include: malathion, diazinon, Orthene and Sevin.

Fall Webworm:

Fall webworms also attack several different deciduous host trees. They form tents at the ends of branches which enlarge as the caterpillars move. Fall webworms, unlike tent caterpillars, always stay within the tents. They skeletonize leaves under the tent, and are protected from predators.

Fall webworms are 1 1/2 inch yellow or brown caterpillars covered with white hairs. They finish feeding by fall and overwinter as cocoons.

As with tent caterpillars, the population of fall webworms can be greatly reduced by removing the branches that are enclosed by webbing.

Dipel spray is effective if you get it on before much of the webbing surrounds the branch. Other effective insecticides include diazinon, Orthenet Dursban and Pestroy.

An interesting fact about Fall webworm - it is native to North America and is one of the very few pests that spread from the United States to Europe. Almost all other pests of ornamentals have travelled in the other direction.

Tussock Moth:

The larval or caterpillar stage of the tussock moth is very destructive to both deciduous and conifer trees. Tussock moths can defoliate entire trees in a matter of days. Damage is usually from the top down. Several trees in an area may be damaged at once.

There are several species of tussock moths, but the two most common in the PNW are the Rusty Tussock Moth and the Douglas Fir Tussock moth.

The caterpillars of both kinds are unusual looking. They are hairy or furry looking with tufts of hair protruding from the front and back ends and four dense colors of hair sticking up from their backs. Hairs of various colors seem to stick out all over their bodies. These hairs are somewhat poisonous to humans, causing skin rashes.

Tussock moths have natural enemies including birds and parasitic insects, but populations can go beyond these natural controls.

Dipel is quite effective. Orthene and Sevin sprays also control tussock moths.

European Pine Shoot Moth:

European Pine Shoot moths are serious pests of most ornamental pines in landscapes, nurseries and Christmas tree plantations. The insect bores into the buds and shoots of pines, stunting and deforming tip growth.

The most evident stage is in the spring when large pitch globules are seen in the buds where the larvae have spent the winter.

The larvae leave this bud in the spring and bore into a new bud or shoot which bends over and dies. The insect pupates here and emerges only two weeks later in June or July as adult moths.

Moths lay eggs in needles, larvae hatch, feed on needles and later bore into bud to overwinter.

You can break off infested shoots in May but this is not a practical method of control.

Insecticides are necessary for bad infestations. Cygon, Imidan and Guthion are recommended starting in June and repeated three more times at two week intervals.

Honeylocust Pod Gall Midge:

Honeylocust Pod Gall Midge rarely causes serious damage to honeylocust trees, but repeated damage can deform and kill individual branches and the tree loses its ornamental value.

Almost all stages of this insect pest are difficult to see. The adults only measure three millimeters long. They appear with the first growth on tree and lay eggs on the leaflets.

The feeding of the hatching larvae causes the leaflets to curl inward and form a gall around the insect as it pupates.

New generations occur every 15-30 days. Therefore, if insecticides are used for control, you need to apply them every two weeks. Malathion, Orthene, Meta systox R and Sevin are all registered, but chemical control is rarely necessary unless repeated leaf deforming occurs.

Aphids or Adelgids: There are a few tree pests commonly known as aphids, but are actually adelgids. The distinction is unimportant. Adelgids are just small gnat-like insects, also called plant lice. Three of the most common adelgids are: Cooley Spruce Gall Adelgid, Pine Bark Adelgid and Balsam Wooley Adelgid.

The cooley Spruce Gall Adelgids are common on several spruces and on Douglas fir trees. Feeding of this pest on spruces causes the tips to form brown, dry galls which are often mistaken for cones. The Cooley Spruce Gall Adelgid has a very complicated life cycle. There are five forms - three on spruce and two on fir. It takes two years to go through all five stages and both spruce and fir are required for all five forms to develop. The spruce and fir trees are called alternate hosts. The life cycle is described in EB 966.

Females overwinter on spruces in a white, wooly substance and produce eggs in spring. These hatch and begin feeding which causes a gall to form around them. Galls are first green swellings of branch tip with needles still intact. Galls later dry and turn brown. Spraying is ineffective once these galls begin forming.

Later the pest migrates to Douglas fir. No galls are formed, but white tufts appear all over the needles. At bud break, tiny black dots can be seen. This is a susceptible stage for spraying. At this stage in development, the adelgid on the Douglas fir can reproduce indefinitely without mating.

Removal of galls from spruces is an impractical form of control on any but small trees. Thiodan is the most effective insecticidal spray for Cooley Spruce Gall adelgids.

Trees must be sprayed in spring prior to bud break to get susceptible stages of this pest. Spruces can be sprayed again in the fall when galls open, but before the first killing frost.

Balsam Wooly Adelgid is another gall forming insect, although in this cause, the gall does not form around the insect to protect it.

The Balsam Wooly Adelgid attacks all true firs, but not the Douglas fir. They are tiny, less than 1 millimeter long. They are wingless and remain attached to the tree their entire life cycle. Apparently the wind moves these tiny insects from tree to tree.

They stay on the bark of the tree and insert a long tube-like mouthpart - many times longer than the insect itself. They extract sap from the tree and as they feed, a white, waxy substance is secreted from their bodies which makes the tree or branches appear white.

The swellings at the ends of branches are not enclosing the insects. They are apparently caused by a hormone injected into the tree which stops its growth.

Lindane or Thiodan sprayed in spring at bud break controls this insect. Thorough coverage is important.

Pine Bark Beetle:

A similar looking pest on pines is the Pine Bark Adelgid which attacks White pine, Scots pine and Austrian pine. Light infestations cause little problem, but heavier and persistent problems can cause reduced growth and death of trees.

It has a complicated life cycle with five distinct forms, but no alternate hosts. Trunks may appear whitewashed and small white tufts on pine needles may be apparent.

As with Balsam Wooly Adelgid, spray with Lindane or Thiodan to thoroughly cover trunk and branches in spring.

Pine Bark Beetle:

Pine bark beetles are different pests, not to be confused with the pine bark aphids or adelgids. Pine bark beetles are the most destructive pests of pines in eastern Washington. They occur rarely on the west side of the Cascades, but they are so common and destructive on the east side that I've included them in this discussion.

Pine bark beetles are surprisingly small for the amount of damage they do. People coming into our plant clinics expect to see giant beetles which are responsible for killing their trees or infesting wooded lots, but actually bark beetles are tiny - they are merely 1/8 to 1/4 inch in length. They can kill whole trees, top portions of trees and large areas of trees.

Pitch tubes are identifying signs of beetle infestation. Pitch tubes are formed when adult beetles bore into tree trunks. Healthy trees will try to expel or pitch out the invading beetle. Beetles actually drown in the pitch or sap.

The problem is that most pines, unless watered frequently, are not always healthy enough to withstand attack. We are in the third or fourth year of drought conditions and some trees have lost the ability to pitch out beetles. In these cases, sawdust is the only sign that beetles have entered trees. This sawdust will appear on the bark or on the ground below trees. As with any pest, weakened or stressed trees are much more susceptible to attack than others.

Under the bark of dying trees are other signs of invasion. Patterns made by their tunneling under the bark are called galleries. These galleries destroy the water conducting tissue in the tree and kill it.

One type of bark beetle - the Mountain Pine Bark Beetle - carries a fungus disease with it into the tree. The fungus, called the blue stain fungus, also destroys the phloem tissue and the tree dehydrates.

There are two main types of pine bark beetles. Mount Pine Beetles are 1/4 inch long, dark and attack mature, large trees in July and August. They overwinter as larvae in the tree, pupate under bark in spring and emerge in June, or July.

The IPS beetle is the second kind. Ips beetles attack immature trees and tops of older trees. The adult is 1/8 inch long and attacks trees in June. They come from overwintering sites in the ground or plant debris.

There is little to do once beetle attack has occurred. You'll hear of spray measures, but these are expensive and of little to no value.

Prevention of attack is your major defense. Keep trees from suffering too much moisture stress if possible. Avoid root or trunk damage. Keep trees thinned. Cut out dead trees.

Bronze Birch Borer:

This is another pest which is rare on the West side of the mountains, but is a serious pest of birches in eastern Washinston. Most birches are susceptible, although a few resistant cultivars are listed in WSU's publication, ER 1380.

Diagnostic signs are small, yellow leaves, sparseness in upper branches and if you can locate the beetle in the branches or trunk, the bark will be lumpy and you'll find half circle shaped holes where beetles have come out.

In July and August, adult beetles which are 1/2 inch long and slender, lay eggs under the bark. Larvae hatch and start tunneling around as they feed. The galleries fill up with sawdust and frass material. This tunneling cuts off water and nutrients to portions of the tree or branch above their feeding.

Larvae overwinter under the bark in tunnels, pupate in the spring and bore out of the trees in June, July, making the half-circle shaped exit holes.

Woodpeckers and parasitic wasps are natural enemies. Weakened, stressed trees are of course more subject to attack. Control aphids which reduce tree vigor and avoid herbicide or other damage.

Prune out branches and tops of trees where beetle tunneling or holes are found.

Lindane and Cygon are registered sprays, but must be carefully timed to hit emerging beetles in June and July. Three applications are recommended two to three weeks apart to cover the extended emergence period. Thorough coverage is important. Do not spray Cygon when temperatures exceed 80 degrees F. Spraying is really only effective if all birches in the area are sprayed.

The WSU bulletin EB 1380 lists these resistant birch varieties: Betula papyrifera - paper birch B. maximowicziana - Monarch birch C. platyphylla japon ica - Whitespire

In conclusion, I'm sure you recognized the common thread running through discussions of each of these insect pests - stressed trees are more susceptible to attack than healthy ones. Spraying of large trees is expensive, and in some cases, too impractical to offer control.

Planting trees correctly in the first place and then avoiding mechanical or herbicide damage and moisture stress are so important.

## EDITOR'S NOTE:

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

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| WSU Turfgrass Program—<br>An Overview of the Future | Dwane G. Miller |
| Turfgrass Management<br>in the Year 2000 | James Beard |
| Strategic Aphid Control<br>in Shade Trees | Joe Much |
| The Good, Bad and the Ugly<br>in Golf Course Maintenance | Larry Gilhuly |

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