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The Use of Effluent Water for Turfgrass Irrigation

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In arid and semi-arid regions and in highly populated metropolitan areas, water is becoming a more limited natural resource. In such areas, the concept of irrigation with reclaimed water is increasingly attractive as shortages and/or costs of fresh water rise, and as more and better quality treated water becomes available for reuse.

In California, where most of the population lives close to the coastline, more than two-thirds of all reclaimed water goes directly into the ocean or estuaries where, mixed with salt water, there is no way to reclaim or reuse it. Much of the remaining one-third is returned to fresh water streams or spread on land.

Most reclaimed water not dumped into the ocean is used for groundwater recharge, industrial use, control of salt water intrusion, or agricultural use. The general public is currently unwilling to accept the return of reclaimed effluent to municipal water systems for drinking, cooking, and bathing. This is true despite the fact that technological advances in sewage reclamation make it possible to produce reclaimed water comparable to and, in some cases, better than many existing water supplies.

Agriculturally used reclaimed water is applied to: (1) Pasture; (2) Fodder, fiber, and seed crops; (3) Crops that grow well above the ground, such as fruits, nuts, and grapes; (4) Crops that are processed so that pathogenic organisms are destroyed prior to human consumption; and (5) Parks, roadsides, landscapes, golf courses, cemeteries, and athletic fields.

Although there is not much competition for use of effluent at this time, such competition is anticipated in the near future. Parks, golf courses, and other forms of nonfood agriculture will clearly be in a better position to compete for reclaimed water than for fresh water. Although the ultimate users of effluent water will be influenced greatly by state and local laws and regulations, there are several arguments favoring use of this water on golf courses, parks, cemeteries, etc., instead of for food-related agriculture: (1) Turfgrasses are generally "heavy feeders," requiring relatively large amounts of nitrogen and other nutrients. This characteristic would greatly decrease the chances of groundwater contamination by these elements in reclaimed water. (2) Reclaimed water is produced continuously, and any use of it, therefore, also needs to be continuous. A turfgrass "crop" is continuous (i.e., uninterrupted by cultivation, seeding, or harvest, all of which mean stopping irrigation for considerable periods). (3) Most expanses of irrigated turf are located adjacent to cities where the effluent water is produced; thus, transportation costs will be minimal. (4) Potential health problems related to the use of reclaimed water are lower when the water is applied to turf than when it is applied to food crops. (5) Soil-related problems that might develop due to the use of reclaimed water will have less social and economic impact if they develop where turf is cultivated than if they develop where food crops are grown.

How Water Is Reclaimed

An understanding of the procedure by which waste water is treated for reuse helps explain some of the problems that may develop due to the use of such water.

Reclaimed water may be primary, secondary, or tertiary-treated municipal or industrial waste water. Primary treatment is generally a screening or settling process that removes organic and inorganic solids from the waste water. As sewage enters the treatment plant, it may flow through screens to remove rags, sticks, and other floating objects. Screens vary from coarse to fine and are usually placed in a slanted recepticle so that debris can be scraped off and disposed of. Some treatment plants grind these objects so that they remain in the sewage flow and are removed later in a settling tank.

After the sewage has been screened or ground, it passes into a grit chamber where dense materials such as sand, cinders, and small stones settle to the bottom. The settled material is normally washed and used as landfill.

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At this point, sewage still contains undissolved suspended matter which can be removed in either a second settling tank or a primary clearifier. In either case, this material gradually settles out of the liquid and forms a mass of “raw sludge.” Raw sludge is drawn off into a digestor, which concentrates it for use as landfill.

Liquid remaining in the settling tank is called primary effluent, and, if only primary treatment is intended, it may be treated before discharge with chlorine which destroys disease-causing bacteria and reduces odor.

Secondary treatment is a biological process in which complex organic matter is broken down to less complex organic material then metabolized into simple organisms which are later removed from the waste water. Secondary treatment can remove up to 90 percent of organic matter in incoming sewage. The secondary liquid effluent may be chlorinated before release. At this time, reclaimed waters used for agricultural purposes are primarily secondary effluent water.

Tertiary or advanced waste water treatment consists of processes that are similar to potable water treatment, such as chemical coagulation and flocculation, sedimentation, filteration, or adsorption of compounds in a bed of activated charcoal.

These proccesses can provide highly purified waters, especially if followed by chlorination for disinfection.

Suitability of Effluent Water for Turf and Landscape Irrigation

The concept of effluent water irrigation for turf and landscape is not new. Many turf and landscape managers have been using this water for the past two decades and have demonstrated that “suitability” is not a problem if the water is properly applied. Following is a discussion of the various factors that determine “suitability” of effluent water for turfgrass irrigation.

1. Health considerations

The biological composition of effluent water is of great concern because of pathogenic bacteria and viruses. Effluent waters are not generally released for irrigation without prior approval of public health authorities. Since effluent water released for turf and landscape irrigation is generally secondary effluent, it may contain some harmful chemical and biological substances. Therefore, irrigation practices should avoid direct human contact with the water and pollution of surface or groundwaters. In addition, an entirely separate delivery system must be constructed to carry the effluent; there must be. no possibility of accidental contamination of a domestic water system.

2. Seasonal and annual variation

Seasonal variation in reclaimed water quality can be significant. For example, the amount of a specific mineral contained in water discharged into a city sewage system from a processing plant operated during a specific portion of the year may vary considerably from that contained in water released during the rest of the year.

Annual variation in water quality is as important, if not more so, than seasonal variation. For example, due to greater disposal of detergent, levels of boron and/or phosphorus would be expected to increase annually in the sewage system of a city experiencing population growth.

3. Constancy of supply

After a contract has been signed, effluent water will keep coming regardless of time of year, time of day, whether or not it is raining, and whether or not it is wanted. Water supply is continuous, while turf needs are variable. Therefore, some type of water storage must be available. Because most contracts for waste water require that a specific amount be accepted each day, regardless of weather conditions, storage capability is a common feature of systems using effluent water.

4. Soil factors

Soils vary widely in the physical and chemical properties important for effluent water irrigation of turfgrasses. Cation exchange capacity, infiltration rate, percolation rate, and water holding capacity of the soil are among the more important soil factors that should be considered before applying reclaimed water.

Coarse-textured soils such as sandy loams are best for the use of reclaimed water; heavier soils are acceptable as long as changes in soil chemical properties are evaluated regularly.

The soil’s water holding capacity is also important in determining its suitability for reclaimed water irrigation. Frequent application of reclaimed water on soils with high water holding capacity, such as clay soils, will contribute significantly to their accumulation of salts and heavy metals.

Shallow soils overlaying rock, hard pan, or clay pan restrict water percolation and drainage. The resultant perched water tables will promote accumulation of soluble salts and toxic ions considerably.

In sum, although soil factors should not preclude the use of effluent water, they must be considered in any management program where reclaimed water is to be used for irrigation.

5. Irrigation system factors

Because of potential clogging of sprinkler nozzles due to algae, a good filter is suggested where the effluent water enters the sprinkler system. Also, because both harmful and beneficial substances may be applied with irrigation water, a system that distributes water uniformly is essential.

6. Disadvantages of effluent water use

A. Salinity: Salinity problems occur when the total quantity of soluble salts in the grass root zone is high enough to adversely affect the turfgrass. Most effluent waters are high in salts, and they might accumulate to levels intolerable to most turfgrasses, especially in heavy soils.

Water generally picks up approximately 300 parts per million (ppm) inorganic salts in one cycle of use. Depending on the initial salt content of the water, this level could make the water unsuitable for turfgrass irrigation. For example, if the original water contained 600 ppm salts, the effluent water would contain 900 ppm, an amount considered potentially hazardous to turf, especially on heavy clay soils.

If salinity is a potential problem in using effluent water, the following management practices should be considered:

- Irrigating more frequently to maintain a higher soil moisture content.
- Planting salt-tolerant grasses.
- Modifying cultural practices (e.g., removing clippings).
- Applying extra water to leach excess salts.
- Modifying soil profile to improve water percolation if a hard or clay pan is present.
- Installing artificial drainage if shallow water tables are a problem.
- Blending effluent water with a less salty water.

B. **Permeability (SAR):** Permeability problems may occur if the effluent water contains high levels of sodium. Relative permeability is often expressed as SAR (Sodium Adsorption Ratio), the ratio of sodium to calcium and magnesium. A high ratio-above 9-indicates potential permeability problems.

Reduced soil permeability can also occur when the salt content of irrigation water is very low (below 0.5 m mhos/cm). Water with minimal salt content reduces permeability by dissolving calcium and other soluble salts from the soil. Removal of salts causes the final soil particles to disperse and fill the soil pore space. The result is impermeability.

Carbonate and biocarbonate content can also affect soil permeabilty and must be evaluated along with the calcium, magnesium, and sodium content of both soil and effluent water.

Typical symptoms of reduced permeability include waterlogging, slow infiltration, crusting or compaction, poor aeration, weed invasion, and disease infestation. Reclamations for correcting or preventing a permeability problem include:

- Applying soil amendments such as gypsum, sulfur, or sulfuric acid.
- Blending reclaimed water with water containing little or no sodium.
- Applying irrigation water at a slower rate over a longer period.
- Aerifying

C. Toxic elements: Effluent waters usually contain a wide variety of elements in small concentrations. Problems can occur when certain elements accumulate in the soil to levels toxic to turfgrass and other plants. Toxicities can occur due to an accumulation of boron, chloride, copper, nickel, zinc, or cadmium. Boron is added to the water through the use of soaps and detergents, and its concentration can vary from 0.5 to 1 ppm. Although this range by itself is not toxic to many plants on heavy soils, higher levels may build and present problems, especially for trees and shrubs. Turfgrasses are usually much more tolerant of boron than other plants if they are mowed and clippings are removed regularly.

Chloride is not particularly toxic to turf, but most trees and shrubs are quite sensitive to a chloride content of 10 m eq/l (355 ppm). Copper, nickel, zinc, and cadmium are heavy metals that, in some instances, build to high levels in reclaimed water. High concentrations of zinc and copper are usually beneficial to turf, nickel and cadmium are a concern only if the land will be used for other agricultural purposes (e.g., crop production). The National Academy of Sciences has recommended that effluent should contain no greater than 0.005 ppm of cadmium, 0.2 ppm of copper, 0.5 ppm of nickel, and 5.0 ppm of zinc for continuous use as irrigation water. Most secondary reclaimed waters will meet these standards, but continual monitoring is essential.

Practices that reduce the effective concentration of toxic elements include:

- Irrigating more frequently.
- Applying additional water for leaching.
- Blending reclaimed water with better quality water.
- Planting more tolerant species
- Applying lime if heavy metal toxicity is due to low pH.

7. Advantages of effluent irrigation

A. **Conservation:** Reclaimed water provides an additional water source where the supply of fresh water is short.

B. **Cost:** Reclaimed water is often much less expensive (usually one-third the cost of domestic water) and in some instances is free.

C. Nutrient content: Reclaimed water can be high in nutrients. This is usually quite beneficial in turfgrass management programs. Although quantities are low, because nutrients are applied on a frequent and regular basis, they are efficiently used by the plants. In most cases turf and trees will obtain all the phosphorus and potassium they need, and a large part of their nitrogen need will be supplied. Sufficent micronutrients are also supplied by most reclaimed water.

8. Plant factors

Depending on the quality of the water, irrigation with reclaimed water may be more desirable for some plant species than for others. In general, turfgrasses may be the best plants for effluent irrigation. They take up large amounts of the nitrogen, phosphorus, and potash found in the water. They will also accumulate large amounts of boron without showing toxicity symptoms. However, some turfgrasses are better adapted to this use than others. If salinity is expected to become a problem, salt-tolerant grasses such as “Fults” alkaligrass [*Puccinellia distans* (L.) Par].], "Adalayd" or "Excalibre" seashore paspalum *(Paspalum vaginatum Swartz.)*, hybrid bermudagrass *(Cynodon spp.)*, tall fescue *(Festuca arundinacea*, Schreb.) or St. Augustinegrass [*Stenotuphrum secundatum* (Walt.) Kuntze.] should be selected.

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Southern Sclerotium Blight on Golf Greens in Northern California and Its Control

*Zamir K. Punja**

Southern blight, or southern Sclerotium blight, caused by the fungus *Sclerotium rolfsii*, is a disease that is not new to agricultural crops. The host range is extremely wide, and the disease occurs in numerous areas of the world (Aycock, 1966). In California, the fungus has been, and in some cases continues to be, a problem on crops such as sugarbeets, beans, and tomatoes. In the early 1930s, sugarbeet crops suffered major losses and the first significant advances in control of the disease were made in this crop (Leach and Davey, 1942).

The first report of southern blight on bentgrass golf greens was from North Carolina in 1975 (Lucas, 1976); it was also positively identified on turf in California for the first time that year, in a public park in Orange County (Ohr, et al., 1977). Since that time the incidence of the disease has apparently increased, and it now occurs on 12 golf courses throughout northern and southern California (Punja et al., 1982).

The disease has been observed on annual bluegrass, bentgrass, and ryegrass in California, on bentgrass and Kentucky bluegrass in North Carolina, and on several cool-season grasses in Maryland.

Identifying the disease

On golf greens, the disease first becomes apparent in early spring (about the first or second week in May) as yellowish crescent-shaped or circular rings with healthy-looking grass in the center.The diseased portions enlarge to produce brown, circular, dead areas with green centers (giving them a frogeye appearance). In some instances, the disease may start out as small, circular, yellowish or brown spots, which may enlarge either uniformly into dead circles or more toward one side into partial horseshoe-shaped arcs. During the summer months, the spots continue to increase in diameter, in most cases still with an inner, green, healthy area (Unruh and Punja, 1982). Some spots may achieve diameters of up to 36 inches by the end of the summer.

The presence of S. *rolfsii* can be confirmed by searching through the thatch in the diseased portions of the spots. Sclerotia fungi appear as small, round, brown mustard-seedlike structures. When conditions of free moisture or high relative humidity prevail (e.g., in the early hours of the morning), the white, delicate, cobweblike mycelium of the fungus may be seen growing on debris or on healthy grass at the advancing edge of the spot. Frequently, the mycelium may be seen growing well in advance (2 to 3 inches) of the leading edge of the spot.

Spread of the disease

The disease is undoubtedly spread by mowers, aerifiers, and other machinery, and possibly by golfers and their equipment. Diseased spots have been observed on aprons, roughs, and fairways in addition to the greens. Although the fungus has been induced to form a sexual spore state in the laboratory (Punja and Grogan, 1981b), it is presently believed that these spores do not contribute to spread of the disease. Thus, sclerotia or mycelium are the primary means by which the disease is spread,

Preliminary attempts at control

When it was first detected on the 18th green of the Del Paso Country Club in Sacramento in 1977, several approaches aimed at control of this disease were considered. These included routine applications of fungicides such as PCNB (Terraclor or FF-II), or a combination of Botran with Actidione, applied either at the onset of disease or after diseased spots became apparent, and the use of a naturally occuring antagonistic fungus *Trichoderma*, which colonizes the

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sclerotia (Punja and Grogan, 1981a). Results from these attempts were not dramatic and were inconsistent; however, they pointed out the need for information in two critical areas. First, additional fungicides needed to be tested both in the laboratory and in the field for their disease control potential; second, experimental plots were needed to determine application rates and frequency for candidate materials.

Experimental plots

Twenty-two fungicides were subsequently tested in the laboratory for their ability to prevent germination of sclerotia of S. rolfsii (Punja et al., 1982); of these, seven were tested in experimental plots set up on the practice putting green at the Del Paso Country Club in 1980 and in 1981. In addition, three nitrogen salts (ammonium sulfate, ammonium bicarbonate, and calcium nitrate) were used.

The materials were applied either separately or in combination every two weeks starting in the first week of May. The rates used are indicated in Table 1. Disease severity was estimated in August by counting the number of spots that developed in each plot and calculating the percent of diseased area.

Precautions

In order to prevent phytotoxicity by some of the materials used in experimental plots, applications were made only when temperatures were below 80°F, and they were followed by heavy watering to remove fungicides or salts from the foliage and to place them in the areas of the crown and thatch where sclerotia are most abundant.

The results summarized below and in Table 1 are from experimental trials. They do not imply that the rates or frequency of application indicated are necessarily suitable for all needs or that materials are registered for use on turf. These and other possible materials need to be tested further to determine whether lower rates or fewer applications would provide effective control and whether label registration for their use against S. *rolfsii* is feasible.

Summary of results

Southern Sclerotium blight was effectively controlled by applications of PCNB (either Terraclor or FF-II), Vitavax, Captan, OAG 3890, or mixtures of Botran plus Actidione Vitavax plus Captan, and Vitavax plus ammonium bicarbonate. All fungicides were applied as a preventative prior to the onset of disease. Though applications of materials containing nitrogen also reduced the incidence of disease, this approach in itself may not be a practical means of control; however, if used in combination with selected fungicides, satisfactory control may be obtained.

Table 1. Results from Experimental Chemical Control Trials against *Sclerotium rolfsii* Blight on Golf Greens in Northern California*

Rate	Rate (ounces active material 1,000 sq. ft.)	Number of diseased spots in each plot*	Percent of area diseased’
Captan	24.0	6	1.6
Dithane M-45	31.0	14	8.7
OAG 3890	2.0	3	0.6
PCNB	6.0	0	0
Vitavax	5.5	1	0.05
Botran+Actidione	4.9+ 1.4	0	0
Vitavax+Captan	3.5+12.0	0	0
Vitavax+ammonium bicarbonate	3.5+3.0	0	0
Ammonium bicarbonate	6.4	2	0.8
Ammonium sulfate	8.1	2	2.3
Calcium nitrate	5.0	14	12.8
Check	0	15	15.4

Data are a composite of results obtained in I980 and 198 I.
‘Average of four replications.

Acknowledgments

1 wish to thank T. Unruh, Superintendent, Del Paso Country Club, for assistance with the experimental plots; Dr. R.G. Grogan, Professor, University of California, Davis, for valuable suggestions; Dr. H.D. Ohr, Extension Plant Pathologist, University of California, Riverside, for samples and information on experimental fungicide OAG 3890; and the Northern California Turfgrass Council and the Golf Course Superintendents Association for financial support.

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Sclerotium Blight of Cool-season Turfgrasses in Southern California and Its Control

R.M. Endo, H.D. Ohr, and W.D. Wilbur[1]

Sclerotium blight of cool-season turfgrass is a new disease caused by the soil-borne fungus *Sclerotium rolfsii*. Its recent appearance on turfgrass is surprising because even though the fungus has been known for nearly 90 years, it has not been reported previously as attacking turfgrass.

Since the fungus occurs commonly in the southeastern United States, it is usually called southern blight or southern Sclerotium blight on turfgrass; however, we prefer the name Sclerotium blight.

Though the fungus attacks more than 500 species of plants, its occurrence in California on hosts other than sugarbeets and beans has been very rare and sporadic. In the late 1950s and early 1960s, for example, S. *rolfii* attacked and caused extensive damage to dichondra in southern California. Then, as mysteriously as it appeared, the fungus and disease on dichondra disappeared. The reasons for this sudden flare-up and disappearance are unknown. Whether or not Sclerotium blight of turfgrass in California will also eventually diminish in intensity and frequency of occurrence is equally unknown. We suspect that it will not, because the disease attacks dead as well as living turfgrass tissue, because environmental conditions in California such as temperature and moisture favor its occurrence, and because the disease is capable of attacking all cool-season turfgrasses.

To determine the host range of the fungus on turfgrass, inoculations were carried out in the greenhouse at the University of California, Riverside. Warm-season turfgrasses (bermudagrass, zoysiagrass, and St. Augustinegrass) were found to be resistant, whereas cool-season turfgrasses (Poa annua , perennial ryegrass, annual ryegrass, fescues, and Kentucky bluegrass) were found to be susceptible.

On golf courses, the fungus first becomes active on fairways, aprons, roughs, and greens in spring when air temperatures reach 70°F but is most active and destructive in summer and early fall when air temperatures range between 75° and 95°F. In the accompanying article on southern Sclerotium blight, Dr. Z.K. Punja describes the symptoms of the disease and methods of spread of the fungus, including spread by sclerotia and by mycelial threads. We suspect that infected grass clippings might also spread the fungus from area to area.

Control

Cultural: Many golf course superintendents have tried to eliminate both the fungus and the disease by digging up the areas of diseased turf and replacing them with healthy sod. They have obtained mostly negative results, even when an area of apparently healthy turf six inches outside the diseased area was also removed. The reason for the lack of success is probably due to the fact that *Sclerotium rolfsii* colonizes dead plant tissue that occurs below healthy appearing turf in advance of the diseased area, though this saprophytic activity is not apparent to the observer.

Chemical: Fungicidal control experiments were carried out in both 1980 and 1981 on golf greens located in Los Angeles County. Since the results were similar for both years, only the results of the 1981 trials are reported here. These trials were conducted with the excellent cooperation of golf course superintendent Mike Heacock on two golf greens located at the Lakeside Country Club in Hollywood. The plots consisted of plants of Seaside bentgrass and Poa annua . The plots were 5 x 5 feet in size, completely randomized, and replicated four times.

The fungicides were first applied in May after the initial appearance of the disease. Except for the experimental fungicide OAG 3890, the fungicides were applied at 14-day intervals, and all were watered-in immediately after application because the sclerotia were found to be located on the lower leaves of diseased plants and in and on the thatch. (The maximum depth of sclerotia on the aerified greens was found to be 1/8 inch.) The results of the fungicide trial are shown in Table 1.

Table 1. Fungicidal Control of Sclerotium Blight on Bentgrass Golf Greens, Lakeside Country Club, 1981

Treatment	Rate (ounces active material 1,000 sq. ft.)	Av. sq. ft. diseased	Days between application
Control	0	3.30	14
OAG 3890	4	0.85	28
PCNB	4	0.53	14
Botran + Actidione	2+2	0.43	14
Vitavax	4	0.13	14
Difoltan	4	0.05	14

All fungicides gave effective control of the disease, but Vitavax and Difoltan were slightly more effective than PCNB, OAG 3890, and a mixutrc of Botran plus Actidione. Only PCNB and Botran plus Actidione are registered for turf but not as yet for control of Sclerotium blight. These fungicidal control results agree well with those reported by Punja in the accompanying article.

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UC TURF CORNER

UC Turf Comer contains summaries of recently reported research results, abstracts of certain conference presentations, and announcements of new turf management publications. The source of each summary is given for the purpose of further reference.

Error Noted

Drs. M. Ali Harivandi and J.D. Butler authored the article "Factors Associated with Iron Chlorosis" in California Turfgrass Culture Vol. 32 Nos. 1 and 2, Winter and Spring, 1982, pages 1 and 2. It should be noted that the following *Results and Discussion* section should replace that presented in the original text.

Results and Discussion

Neither soil pH nor available iron of the individual plots were significantly different. The pH was 7.4± 0.1 for each plot, and the available soil iron ranged from 9.1 to 17.9 ppm.

Available iron was sufficient to satisfy the iron needs of certain cultivars and produced turf that did not display chlorosis. A significant difference among cultivars and blends occurred in total content of iron (see table). Thus, some cultivars are more efficient in absorbing iron from the soil than others.

Visually-determined color ratings were compared with cholorophyll content of the turfgrass. Chlorophyll contents lower than 2.17 mg/g were associated with the light-green color. The table shows that cholorophyll content appears to be at least one factor that influences color difference among Kentucky bluegrass cultivars and blends.

'Adelphi,' III. 38-17, 'Sodco,' 'Sydsport,' 'Windsor,' and blends of 'Common' + 'Kenblue' and 'Windsor' + 'Merion' were rated dark-green. 'Warren's A-20' and 'A-34,' 'Park,' 'Arboretum,' 'Nugget' and blends of 'Fylking' + 'Pennstar' + 'Nugget' and 'Park' + 'Delta' + 'Newport' showed severe chlorosis.

Kentucky Bluegrass Cultivars Differ in Billbug Infestation Response

Kentucky bluegrass cultivars showed differences to an infestation of bluegrass billbug in a field trial at the University of Nebraska-North Platte Station.

Cultivars were rated for visual injury following a severe, natural, billbug infestation of the trial using a scale of 1 (no injury) to 9 (all plants injured). Billbug larval density was determined by counting larvae from a sod sample taken from the center of each plot.

All cultivars showed some visual injury. Ratings averaged from a high of 8.2 for Rugby to a low of 1.2 for Artista. Park was chosen as the standard cultivar for statistical comparisons due to its low mean billbug larval number per sample in an earlier (1974) study.

Larvae varied from a high of 62 in Sydsport to a low of 6 in South Dakota Certified and Delta. The general agreement in cultivar response from this trial and the earlier one, the Nebraska researchers note, suggests a genetic basis for the differential response to the insect. Those cultivars with low injury ratings and either low or high billbug larval density offer a potential for breeding or selecting resistant or tolerant cultivars.

(See "Kentucky Bluegrass Cultivar Response to Bluegrass Billbug, *Sphenophorus parvulus* Gyllenhal," by D.T. Lindgren, R.C. Shearman, A.H. Bruneau, and D.M. Schaaf, *HortScience,* Vol. 16(3), June 1981).

Effects of Glyphosate and Paraquat on Germination and Growth of Grasses and Legumes

Oregon State University scientists recently measured the effects of glyphosate and paraquat on the germination and growth of six grasses and two legumes in greenhouse experiments.

The two herbicides were applied to exposed seeds of Baron Kentucky bluegrass, Manhattan perennial ryegrass, Penncross creeping bentgrass, Fawn tall fescue, Banner Red red fescue, Napier orchardgrass, Vernal alfalfa, and Kenstar red clover.

Paraquat was toxic only to the grasses. Glyphosate reduced germination of Manhattan perennial ryegrass, Fawn tall fescue, Banner Red red fescue, and the two legumes and reduced seedling growth of all species.

Glyphosate mainly affected germination and growth of legumes when applied directly to their seeds, according to the Oregon scientists who conducted the experiments. Reductions also were measured, however, when untreated legume seeds were transferred to glyphosate-treated soil.

(See "Germination and Growth of Grasses and Legumes from Seeds Treated With Glyphosate and Paraquat," by L.C. Salazar and A.P. Appleby, *Weed Science,* Vol. 30, No. 3, May 1982.)

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WARNING ON THE USE OF CHEMICALS

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in their original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Recommendations are based on the best information currently available, and treatments based on them should not leave residues exceeding the tolerance established for any particular chemical. Confine chemicals to the area being treated. THE GROWER IS LEGALLY RESPONSIBLE for residues on his crops as well as for problems caused by drift from his property to other properties or crops.

Consult your County Agricultural Commissioner for correct methods of disposing of leftover spray material and empty containers. Never burn pesticide containers.

PHYTOTOXICITY: Certain chemicals may cause plant injury if used at the wrong stage of plant development or when temperatures are too high. Injury may also result from excessive amounts or the wrong formulation or from mixing incompatible materials. Inert ingredients. such as wetters, spreaders, emulsifiers, diluents, and solvents, can cause plant injury. Since formulations are often changed by manufacturers, it is possible that plant injury may occur, even though no injury was noted in previous seasons.

NOTE: Progress reports give experimental data that should not be considered as recommendations for use. Until the products and the uses given appear on a registered pesticide label or other legal, supplementary direction for use, it is illegal to use the chemicals as described.

CALIFORNIA TURFGRASS CULTURE EDITORIAL COMMITTEE

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