by Dr. James B. Beard

TURFGRASS RESEARCH REVIEW

How pollution affects turfgrasses

Response of turfgrass cultivars to ozone and sulfur dioxide in the atmosphere. *E. Brennan and P.M. Halisky. 1970. Phytopathology. 60:1544-1546. (from the Department of Plant Biology, Rutgers State University, New Brunswick, N.J. 08903).*

The relative ozone (O_3) and sulfur dioxide (SO_2) sensitivity of seven species and 11 cultivars of the common turfgrasses were evaluated in this investigation. Used were mature sods of creeping bentgrass (Penncross); bermudagrass (Kansas P-16); red fescue (Pennlawn and Highlight); perennial ryegrass (Manhattan and Lamora); annual bluegrass; Kentucky bluegrass (Merion and Delta), and Japanese lawngrass (Meyer and Common). Four-inch diameter plugs were transplanted to pots in May and placed in the greenhouse where they were watered daily and maintained at a two-inch cutting height. After reaching equilibrium, four replications of each species and cultivar were exposed to controlled fumigation with 0.3ppm of ozone for six hours. The temperature in the fumigation chamber was in the range of 24 to 27 C. with a relative humidity of 30 per cent. The fumigation treatments were applied in June, and the same series was repeated in August. A visual evaluation of ozone phytotoxicity to the leaves was made after seven days. Daily observations were also made concerning ozone phytotoxicity symptoms.

In a second experiment, three bentgrass species (*A. palustris* Huds., *A. tenuis* Sibth. and *A. canina* L.) and seven cultivars (Kingston, Cohansey, Penncross, Seaside, Astoria, Highland and Holfior) were evaluated for ozone sensitivity. Five-year-old plugs of each species and cultivar were transplanted to the greenhouse in October. The experimental procedure was the same as previously described except that two levels of ozone fumigation were used: 0.23 and 0.30ppm O_3.

In the third experiment, the relative sulfur dioxide sensitivity was determined for the same seven species and 11 cultivars used in the first experiment. The procedure was the same except that the fumigation treatments involved six hours exposure to each of three levels of sulfur dioxide (0.75, 0.85 and 1.80ppm SO_2). The temperature conditions in the fumigation chamber ranged from 27 to 30 C. with a relative humidity of 50 per cent.

Results: Substantial variability in sensitivity to ozone occurred among the seven turfgrass species utilized in this experiment. The general rankings are presented in Table 1. Within

Table 1. Relative sensitivity of 8 turfgrass cultivars to controlled ozone fumigation.

High sensitivity	Intermediate sensitivity	Low sensitivity	Minimal sensitivity
Penncross creeping bentgrass Annual bluegrass	Merion Kentucky bluegrass Manhattan perennial ryegrass Pennlawn red fescue	P-16 bermudagrass Highlight chewings fescue	Meyer zoysiagrass

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species, Delta Kentucky bluegrass was less sensitive than Merion whereas no visible differences were evident between (a) Manhattan and Lamora perennial ryegrasses and (b) Meyer and common zoysiagrass.

Typical symptoms of ozone toxicity in bentgrass and bermudagrass involved necrosis and bleaching of the leaf tips. Ryegrass exhibited a glossy, dark-brown necrosis of the entire leaf. A third type of ozone toxicity symptom observed on red fescue leaves consisted of minute, dark-brown stipples. No visible injury symptoms were evident on zoysiagrass under these conditions.

All seven bentgrass cultivars utilized in the second experiment were highly sensitive to a six hour exposure with 0.30ppm O_3. However, intra- and inter-species differentials were evident among the *Agrostis* species when exposed to a lower ozone concentration. Kingston and Highland proved the least sensitive, Holfior and Penncross intermediate and Astoria, Seaside and Cohansey the most sensitive to six hour exposure to 0.23ppm O_3.

The relative tolerance of the seven turfgrass species and four cultivars to sulfur dioxide was different from that found for ozone. A summary of the relative sensitivity of these turfgrasses is given in Table 2. Within species, Manhattan perennial ryegrass was slightly less sensitive than Lamora while no visible differences were evident between (a) Delta and Merion Kentucky bluegrass and (b) Meyer and common zoysiagrass.

Sulfur dioxide injury symptoms involve immediate development of a dull, water-soaked appearance in the interveinal areas of the leaves. Subsequently this affected tissue dries and bleaches to an ivory color. Characteristically the symptoms develop at the terminal portions of the leaf blades.

Comments: Turfgrass injury from atmospheric pollutants is of increasing concern to professional turfmen and turfgrass users. Three basic types of pollutants occur: (a) toxic gases, (b) minute solid particles and (c) aerosols of small water droplets containing high concentrations of acids or salts. The injurious effects of atmospheric pollutants on plants may be through direct toxicity or indirectly through the screening of incoming solar radiation. Turfgrasses which are injured or weakened by atmospheric pollutants are more prone to serious damage by wear, diseases, insects and nematodes.

Artificial pollutants are the most frequent cause of direct toxic injury to turfgrasses. The most common types are (a) sulfur dioxide gas, (b) fluoride containing gases and (c) toxic gases associated with smog.

Sulfur dioxide

Sulfur dioxide has been a major pollutant for a long time. It evolves from the burning of coal and oil having a high sulfur content as well as from the smelting of sulfide ores. Sulfur dioxide is most commonly a problem in Europe and certain industrialized urban regions of the United States. Sulfur dioxide injury to plants is characterized by the des-

Table 2. Relative sensitivity of 8 turfgrass cultivars to controlled sulfur dioxide fumigation.

High sensitivity	Intermediate sensitivity	Low sensitivity
Highlight chewings fescue	Annual bluegrass	P-16 bermudagrass
Pennlawn red fescue	Merion Kentucky bluegrass	Meyer zoysiagrass
Penncross creeping bentgrass	Manhattan perennial ryegrass	

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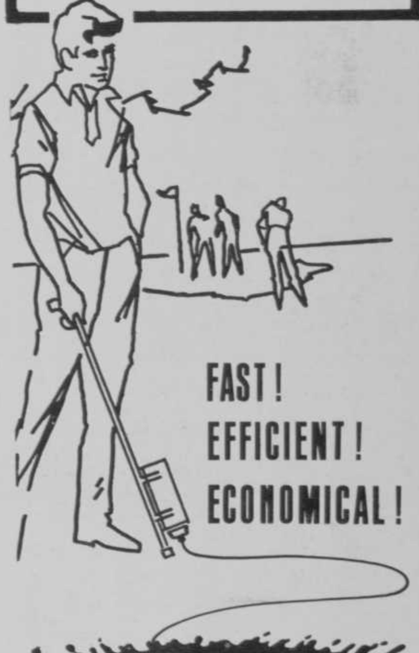

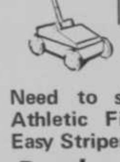

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truction of chlorophyll, which inhibits photosynthesis and restricts growth. Injury is usually more severe at high light intensities, temperatures above 40°F. and high atmospheric relative humidities.

Fluorides

Toxic fluoride containing gases, such as hydrogen fluoride and silicon tetrafluoride, can be serious problems in the vicinity of certain types of industry. Extremely low concentrations of fluorine can cause serious plant injury. Typical symptoms are a gray-green, water soaked appearance at the leaf tips. Lesions form which turn light tan to reddish brown and gradually extend downward to the leaf base. Succulent, young leaves are most sensitive to fluoride injury. Annual bluegrass, perennial ryegrass and red fescue are quite sensitive to hydrogen fluoride whereas Kentucky bluegrass is intermediate in sensitivity.

Smog

Smog is a more complex type of air pollutant involving a unique blending of solid and liquid aerosols in fine particles with numerous inorganic and organic gases. The more significant toxic constituents of smog are not the direct products of industrial-urban activities but are formed by slow photochemical reactions which occur in the atmosphere between certain non-toxic substances, such as the unsaturated hydrocarbons admitted from the internal combustion engine, and small concentrations of certain nitrogen oxides. The resulting toxic oxidants include ozone, ozonides, peroxynitrates and peroxyacids.

The prerequisites for a serious smog problem are (a) sources of nitrogen oxide and unsaturate hydrocarbons, (b) atmospheric conditions involving a low wind velocity and a large scale semipermanent, nondiurnal temperature inversion which prevents transport of atmospheric pollutants from the area and (c) solar radiation for driving the photochemical reactions which produce ozone and peroxyacetylnitrate (PAN). Ozone is the primary phytotoxic atmospheric pollutant along the Eastern, industrial-urban coast line of the United States, whereas PAN is most serious along the industrial-urban complex of the United States Pacific coastline.

The turfgrass ozone phytotoxicity comparisons given in this study vary somewhat from the California studies. Evidently the smog studies of California involve a greater response to PAN phytotoxicity and associated symptoms whereas this study has concentrated on the direct effects of ozone alone.

Symptoms of smog (PAN) injury involve tan spotting and/or transverse banding of the grass leaf blades. Elongating leaf tissues are the most sensitive to smog injury, particularly if the stomata are open. Smog injury results in a reduced chlorophyll content, an impairment of photosynthesis and an increased respiration rate. The relative rankings of turfgrass species in terms of smog (PAN) sensitivity are fairly comparable to the ozone sensitivity comparisons given here.

It is quite evident from this discussion that one should specify the particular phytotoxic agent involved to avoid confusion when discussing turfgrass injury from atmospheric pollutants. The specific injury symptoms and relative phytotoxicity among turfgrass species and cultivars vary substantially depending on the particular atmospheric pollutant which occurs in a given area. ☐