CHEMICAL PROTECTION OF COOL-SEASON TURFGRASSES TO WATER STRESS

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Introduction

Throughout most of the cool-humid region of the United States, long dry periods during the summer present problems to the golf superintendent. Inadequacies of the irrigation system become most apparent at this time. Water has generally been available in sufficient quantity to allow for over watering of some areas for the purpose of supplying modest, badly needed amounts to other areas. Some displacement and compaction problems are occurring in over-watered areas. Additionally, quotas may be placed on the amount of water available to turfgrass irrigation. Clearly, if grasses could be maintained at reduced irrigation time and frequency, and at the same time improve the uniformity of appearance of the golf course, it would be of great value to the golf industry.

One of the most obvious ways to minimize water use is to reduce the transpiration rate of the turfgrasses. When this becomes possible, turfgrasses receiving marginal quantities of water will be able to survive and provide an acceptable playing surface.

One method of solving a high water use problem is through the application of antitranspirants. These materials work through external chemical closure of stomata, or by coating the leaves with a chemical layer impervious to water vapor. Because of mowing and traffic, these layers do not persist long (1). And while they persist, water vapor cannot escape causing leaf temperatures to rise (5), possibly to the point where damage could occur. In addition, carbon dioxide exchange appears to be inhibited, resulting in a greater reduction in photosynthesis than transpiration (6). The use of antitranspirants may tend to put the plant into a type of dormancy. This could be useful to prevent winter desiccation of a near dormant plant, but would not be as applicable for actively growing turfgrasses.

A second method is through the use of wetting agents or surfactants. However, surfactants also need to be used carefully. In water solutions, surfactants are toxic to turfgrasses, but are less so in soil solutions where absorption apparently binds the surfactant to the soil (2). It has been shown that surfactants can improve pesticide mobility into the soil (3) and that surfactants aid in the wetting of hydrophobic soils (4). Where localized dry spot problems occur, a uniform playing surface has been restored through the use of surfactants.

A third method for reducing water consumption is through systemic chemical alteration of the physiology of the turfgrass plant to make it use less water. Several systemic fungicides having a chemistry similar to kinetin, have been observed to have kinetin-like activity. Kinetins are known to reduce senescence and preserve cell integrity. The objective of this investigation was to determine the effect of four commonly used turfgrass chemicals on transpiration and photosynthesis of leaves of intact Kentucky bluegrass plants.

Materials and Methods

Mature Merion Kentucky bluegrass was obtained from the MSU Experimental Field Laboratory and acclimated in styrofoam cups in the greenhouse for two weeks. A full nutrient solution was then supplied two times per week in the check plots while treatments included the addition of 500 ppm of Aquagro, Hydrowet, Tersan 1991, or Chipco 26019. These treatments continued biweekly for three weeks. Even

though the application rate was extremely high to determine if the plants were affected by the treatment, no phytotoxicity was observed throughout the study.

For gas exchange measurements, leaves were put into a water jacketed aluminum chamber that had a window to admit light. The chamber allowed the air stream to pass over 1.19 cm^2 leaf tissue. There was a separate air stream for the upper and lower surfaces of the leaf, each with a flow rate of 50 l/hr.

The air stream was humidified, then passed through a glass condenser in a water bath kept at 18C to keep the dew point of the air constant. Also, the air was passed through two soda lime towers, after which CO_2 was added to give the desired CO_2 concentration. An infrared gas analyzer (URAS 2, Hartmann & Braun, Frankfurt A.M., W. Germany) was used to monitor the CO_2 concentration. The molar fluxes of CO_2 and H_2O for both the upper and lower leaf surfaces were measured with a fine thermocouple pressed against the non-illuminated side. Throughout all analyses the temperature and the water vapor pressure deficit of the leaf were held at 26C $\pm$ .5C and .5 ml/l respectively.

White light was provided by an Osram XBF 6000 w water cooled xenon arc lamp shining through a Corning no. 4600 infrared-absorbing glass filter. The irradiance was reduced with neutral density Plexiglas filters (no. 800 and 838, Rohm and Haas, Darmstradt, Germany). Irradiance was monitored with a silicon cell in the same plane as the leaf chambers that had been calibrated with an Eppley pyranometer. Irradiance was controlled at 130 w/m^2 throughout the investigation. Assimilation and transpiration rates, stomatal conductance, and intercellular CO_2 concentration were calculated by computer.

The figures consist of quartic prediction curves of stomatal aperature and gas exchange monitored every 2 minutes for the first 30 minutes after irradiance was initiated. Each prediction curve was based on 3 replications, and thus a total of 45 observation points. The experiment was repeated three weeks later with similar results.

Results

Maximum conductance (stomatal aperature) was found in the non-treated check 15 minutes after the light was turned on (Figure 1). Maximum conductance for Aquagro, Chipco 2601 and Hydrowet occurred within a similar time span as the check. However, maximum stomatal aperature of Tersan 1991 treated plants did not occur until 28 minutes after light treatment.

In Figure 2, assimilation of CO_2 was greatest in the non-treated check. Maximum photosynthesis occurred within 10-15 minutes in all treatments except in Tersan 1991 treated plants which did not reach maximum until the end of the 30 minute analysis period. The Aquagro and Chipeo 26019 treatments resulted in the least reduction of photosynthesis, while Hydrowet and Tersan 1991 reduced peak photosynthesis by 50% or more compared to the check. It is interesting to note that 10 minutes of light was required before photosynthesis overcame respiration in the Tersan 1991 treated plants.

The quartic curves for transpiration in Figure 3 are nearly identical to the stomatal conductance curves in Figure 1. Since gas exchange is the basis for determining stomatal aperature, and since up to 1000 times as much water passes through stomates compared to CO_2, it is not surprising that these curves are similar.

Table 1 is a summary of the effects of the four turfgrass chemicals. The percentages are calculated on the average conductance, transpiration or assimilation of each treatment during the second half of the 30 minute analysis period. Tersan 1991 and Hydrowet exhibited the greatest reduction of gas exchange including a large reduction in photosynthesis. Chipco 26019 reduced transpiration to 58% while lowering photosynthesis to 76% of the untreated check. Aquagro

reduced transpiration by 32% while reducing photosynthesis by only 13%.

Discussion

The data in this report indicated that high rates of commonly used turfgrass chemicals reduce transpiration and photosynthesis of Kentucky bluegrass. It is recognized from the start that the rate of application is about 10 times what might be experienced in normal field conditions. To achieve field results in the order of magnitude shown by this data would be cost prohibitive. Data needs to be collected that indicates the level of effect found for normally occurring rates of these chemicals in field conditions. However, these data indicate the potential for reducing water consumption while maintaining adequate photosynthesis.

Since the plants were treated with a soil drench, root impairment, particularly for high rates of Tersan 1991, may have caused a plant water deficit and subsequent low transpiration measurements. However, the plants were periodically examined throughout the treatment period and did not exhibit the zeromorphic features typical for Kentucky bluegrass experiencing a plant water deficit. Additionally, the surfactant Aquagro, shown by Endo (2) to cause root damage in solution culture, exhibited the lowest transpiration reduction of any of the chemicals.

Thus, there is evidence to suggest that surfactants are translocated from soil solutions into turfgrass leaves where stomatal behavior is altered, and that systemic fungicides may alter host resistance to a disease by reducing water consumption and the subsequent severity of drought stress.

References

1. Beard, J. B. 1973. Turfgrass: Science and Culture. Prentice Hall, New Jersey, pp. 1-658.

2. Endo, R. M. , J. Letey, N. Valoras and J. F. Osborn. 1969. Effects of nonionic surfactants on monocots. Agron. J., Vol. 61:850-854.

3. Huggenberger, F., J. Letey and W. J. Farmer. 1973. Effect of two nonionic surfactants on absorption and mobility of selected pesticides in a soil-system. Soil Sci. Soc. Amer. Proc., Vol. 37:215-219.

4. Rieke, P. E. 1975. Soils research: N carriers, potassium studies and rewetting of a hydrophobic soil. 45th Annual Michigan Turfgrass Conference Proceedings, Vol. 4:3-5.

5. Tanner, C. B. 1963. Plant temperatures. Agron. J., Vol. 55:210-211.

6. Woolley, J. T. 1967. Relative permeabilities of plastic films to water and carbon dioxide. Plant Physiol., Vol 42(5):641-643.

Table 1. The effect of four turfgrass chemicals on transpiration, photosynthesis and stomatal conductance of Merion Kentucky bluegrass.

	(percent of untreated check)		
Chemical	conductance	transpiration	photosynthesis
Aquagro	62	68	87
Hydrowet	28	36	46
Tersan 1991	21	34	31
Chipco 26019	49	58	76
Check	100	100	100

Fig. 1 The effect of turfgrass chemicals on stomatal conductance of intact leaves of Merion Kentucky Bluegrass.

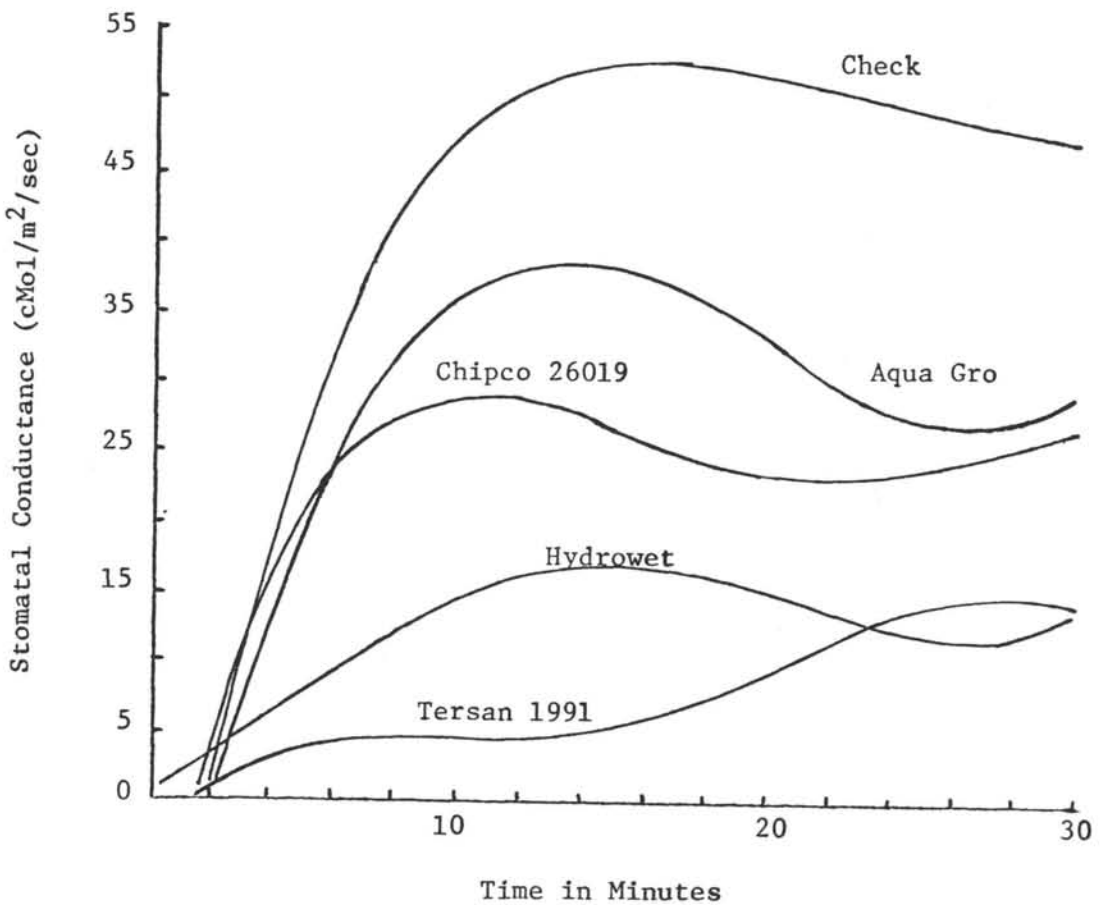

Fig. 2 The effect of turfgrass chemicals on assimilation of intact leaves of Merion Kentucky Bluegrass.

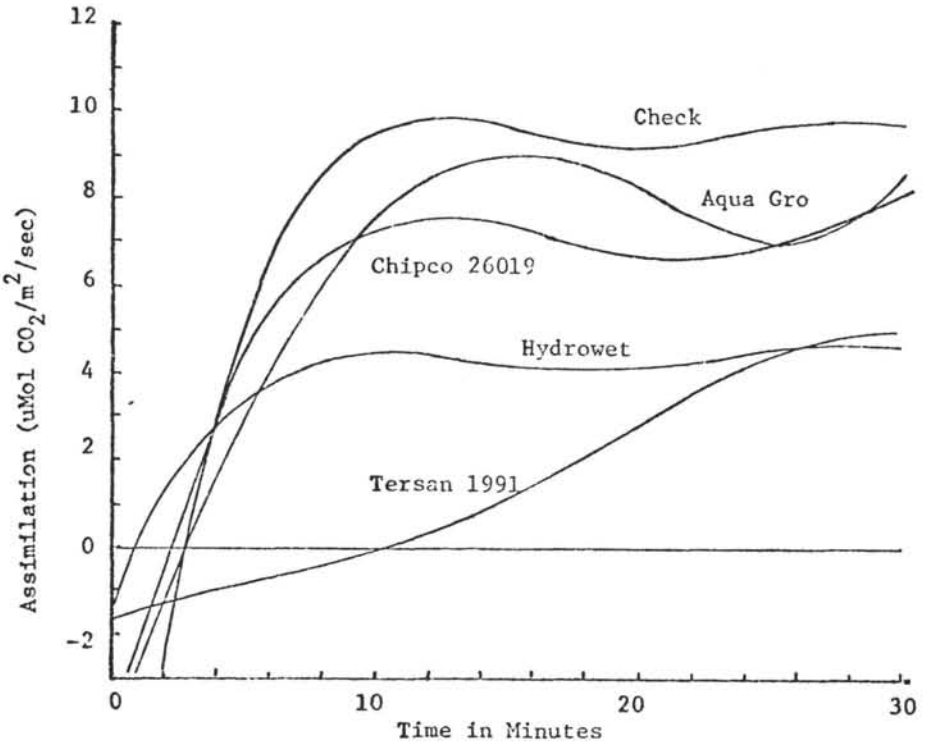

Fig. 3 The effect of turfgrass chemicals on transpiration of intact leaves of Merion Kentucky Bluegrass.