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The Rutgers Turfgrass Proceedings is published yearly by the Rutgers Center for Turfgrass Science, Rutgers Cooperative Extension, and the New Jersey Agricultural Experiment Station, Cook College, Rutgers University in cooperation with the New Jersey Turfgrass Association. The purpose of this document is to provide a forum for the dissemination of information and the exchange of ideas and knowledge. The proceedings provide turfgrass managers, research scientists, extension specialists, and industry personnel with opportunities to communicate with co-workers. Through this forum, these professionals also reach a more general audience, which includes the public. Articles appearing in these proceedings are divided into two sections.

The first section includes lecture notes of papers presented at the 1998 New Jersey Turfgrass Expo. Publication of the New Jersey Turfgrass Expo Notes provides a readily available source of information covering a wide range of topics. The Expo Notes include technical and popular presentations of importance to the turfgrass industry.

The second section includes research papers containing original research findings and reviews covering selected subjects in turfgrass science. The primary objective of this section is to facilitate the timely dissemination of original turfgrass research for use by the turfgrass industry.

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Dr. Ann B. Gould, Editor
Dr. Bruce B. Clarke, Coordinator

BIOSTIMULANT PRODUCTS: WHAT RESEARCH HAS SHOWN: HOW THEY WORK

Dr. R. E. Schmidt[1]

Biostimulants, plant biochemical regulators, and plant growth regulators are terms used to describe materials other than fertilizer that when applied to plants in small quantities affect the biochemicals that influence physiological processes within plants. Examples are materials that contain high percentages of hormones. Hormones are designated organic compounds such as auxins, cytokinins, gibberellins, abscisic acid, and ethylene that influence plant function. Auxins, gibberellins, and cytokinins stimulate growth, whereas abscisic acid and ethylene inhibit growth. The use of these stimulating hormones as foliar-applied materials to manipulate plant conditioning is currently pursued in cultural aspects of turfgrass management.

Although the influence of hormones on plants was demonstrated at the turn of the 20th Century, it was not until the late 1930s that this was noted in the United States. It was documented 20 years later that auxin plus cytokinins regulated the growth and development of roots, shoots, and flowers, and that a mixture of gibberellins and cytokinins promoted leaf formation.

Biochemical regulators and hormones were topics of many plant studies initiated in the 1950s. However, it was not until the 1980s that responses to turfgrass treated with biostimulant materials were studied.

The biostimulant studies at Virginia Tech initially were attempts to enhance cool season turfgrass sod production. Results from research concluded in 1979 in our department, which showed that applications of a synthetic cytokinin at 24 g per acre significantly increased soybean seed yield, generated interest in evaluating cytokinin treatments in our on-going turfgrass sod enhancement project.

After several attempts to utilize commercial seaweed products as the source of cytokinins, positive results were realized when seaweed extracts were obtained from seaweed processes at low temperatures. Results from these seaweed extracts gave more consistent results than did the synthetic cytokinins. It was concluded that, in addition to cytokinins, seaweed supplied other compounds such as auxins and amino acids to provide responses that are more positive. More consistent results were eventually obtained when humic acid was applied with seaweed extracts, indicating that the auxin activity of the humic acid enhanced the hormone activity supplied by seaweed.

In the mid-1980s, Dr. Petrovic of Cornell University indicated that enhanced rooting of Kentucky bluegrass was observed when a triazole fungicide was applied. Our subsequent research confirmed this observation. Since then, we have documented that, in addition to treatments with seaweed, humic acid, and triazole fungicide, applications of amino acid or trinexapae ethyl have biostimulant effects. Most recently, we have detected a biostimulant effect when silicate was applied to creeping bentgrass.

Various graduate student projects over the past ten years have shown that application of seaweed and humic acid to cool season turfgrass conditioned the grass to enhance toleration of salinity, drought, nematode invasion, disease infestation, herbicide toxicity, and shade

[1] Professor, Dept. Of Crop and Soil Environmental Sciences, Virginia Tech, Blacksburg, Virginia.

(Table 1). One doctoral student obtained data showing that bermudagrass was affected less by chilling temperatures when treated with cytokinin and iron.

The measurements of turfgrass growth provided strong evidence that, indeed, plant growth regulators did condition turfgrass to better tolerate stressful environments. The question "Why did we obtained these results?" needed to be addressed.

In JiYu Yan's doctoral dissertation, evidence was provided that application of hormone-containing materials or a triazole fungicide can acclimate turfgrasses to stressful environments. She showed that the application of these materials to perennial ryegrass increased the plant's cell membrane fluidity, which was correlated to saline and drought tolerance of this grass.

The "snake oil" connotation that the use of seaweed or humic acid to condition turfgrass to enhance tolerance to environmental stress was completely dispelled after X. Zhang's dissertation was completed. His studies showed that drought tolerance was associated with the antioxidant content of grass. Application of seaweed and humic acid significantly increased the concentration of the antioxidants Vitamins C and E, as well as enzymatic antioxidant superoxide dismutase (SOD) to cool season grasses.

A brief review of plant biochemistry will illustrate why the data generated are pertinent to turfgrass management (Figure 1). Energy from the sun captured by chlorophyll generates electrons (e^-) by splitting water, referred to as photosynthesis II (PSII). By oxidation reduction process, the e^- is transferred to the PSI process where CO_2 from the atmosphere is converted to carbohydrates (Figure 1). However, under stressful conditions, the e- transferred from PSII may be prevented from being utilized to form carbohydrates in the PSI process. When this occurs, the e- is donated to form reactive oxygen species such as superoxidized oxygen or a free radical. The occurrence of reactive oxygen species, which are strong oxidizing agents that destroy biological molecules, causes photosynthetic damage (Figure 2). If the reactive oxygen species react with antioxidants, however, water and oxygen are formed and photosynthetic damage, or senescence, is negated (Figure 2). In other words, the higher the antioxidant content of the grass, the less free radicals, and the better the grass will tolerate stress.

In the past two years, we measured the antioxidant content of tall fescue and creeping bentgrass from early spring to late fall. The lowest concentration of the antioxidant content occurred during late June through late July (Figure 3). It is hypothesized that because non-structural carbohydrates are utilized excessively and respiration is high during this period, the production of antioxidant is limited during this period when antioxidants are being rapidly utilized.

The antioxidant content of turfgrasses can be stimulated with applications of biostimulants. In Figure 3, it can be shown that the application of humic acid (HA) plus seaweed extract (SE) to creeping bentgrass will significantly enhance the activity of the antioxidant superoxide dismutase (SOD). The enhanced vigor of bentgrass associated with antioxidant content can be demonstrated in Figure 4. Infection of dollarspot disease is decreased with the increase of antioxidant content of the bentgrass leaves.

Results of our studies strongly suggest that the benefits derived from applications of biostimulant materials to turfgrass results from the stimulation of antioxidant produced in the grass. Biostimulants enhance gene expression under different environmental stresses. As more is learned about the biostimulant influence on turf, the better the cultural tools the turfgrass manager has at his disposal.

Table 1. Data have been obtained in our turfgrass research that have shown positive results when biostimulants are applied to turf treated prior to stress.

		Physiological condition		Environmental stress			
Biostimulant	Grass type[1]	Root development	Photosynthetic capacity	Enhanced salinity	Drought tolerance	Nematode tolerance	Disease reduction
Seaweed	C-3	X	X	X	X	X	X
	C-4	X	X	X			
Humic acid	C-3	X	X	X	X		X
	C-4	X	X	X			
Triazole	C-3	X	X	X	X		X
Amino acid	C-3	X	X				X
Si	C-3	X	X				X
Primo	C-3	X	X		X		X

[1]C-3 = cool season, C-4 = bermudagrass

Figure 1. Formation of superoxide (O_2^-) by ferredoxin (Fd) reduction in the photosynthesis I (PS I) reaction center where under plant stress electrons are donated to oxygen. Damage to the plant metabolism results. Plants containing high levels of antioxidants, such as the enzyme superoxide dismutase (SOD), defend against oxidative stress.

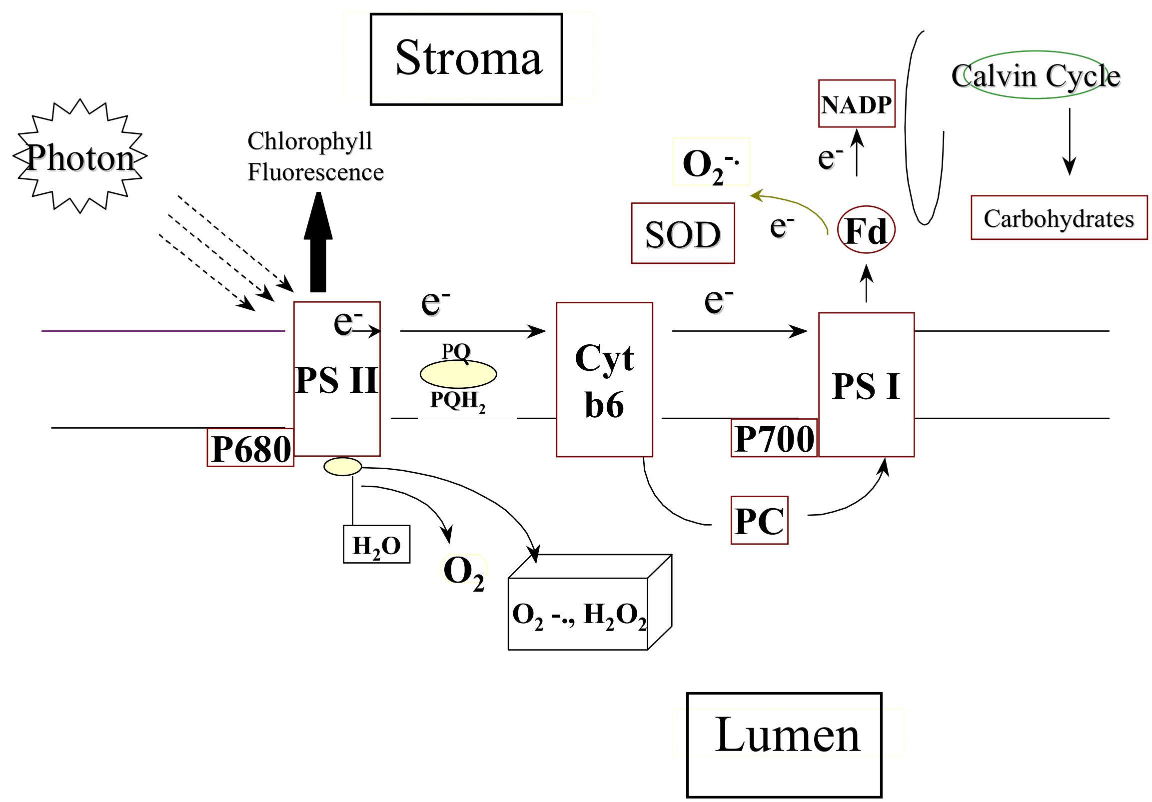

Figure 2. Plant stress causes the formation of free radicals (O_2^-) resulting in photosynthetic damage. Plants pre-conditioned to develop high concentrations of antioxidants defend against the oxidative injury.

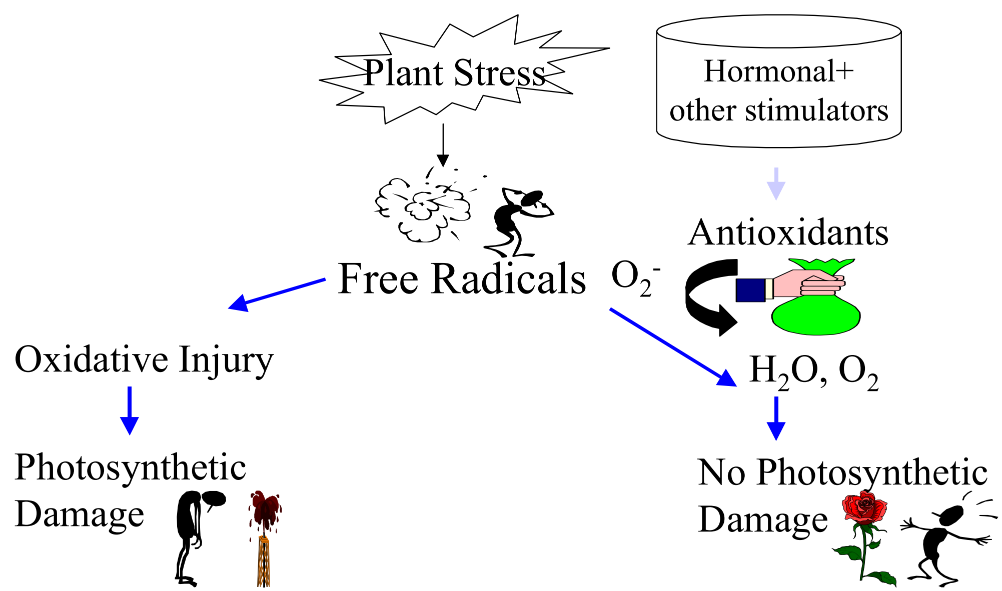

Figure 3. Superoxide dismutase activity of bentgrass as influenced by humic acid plus seaweed extract.

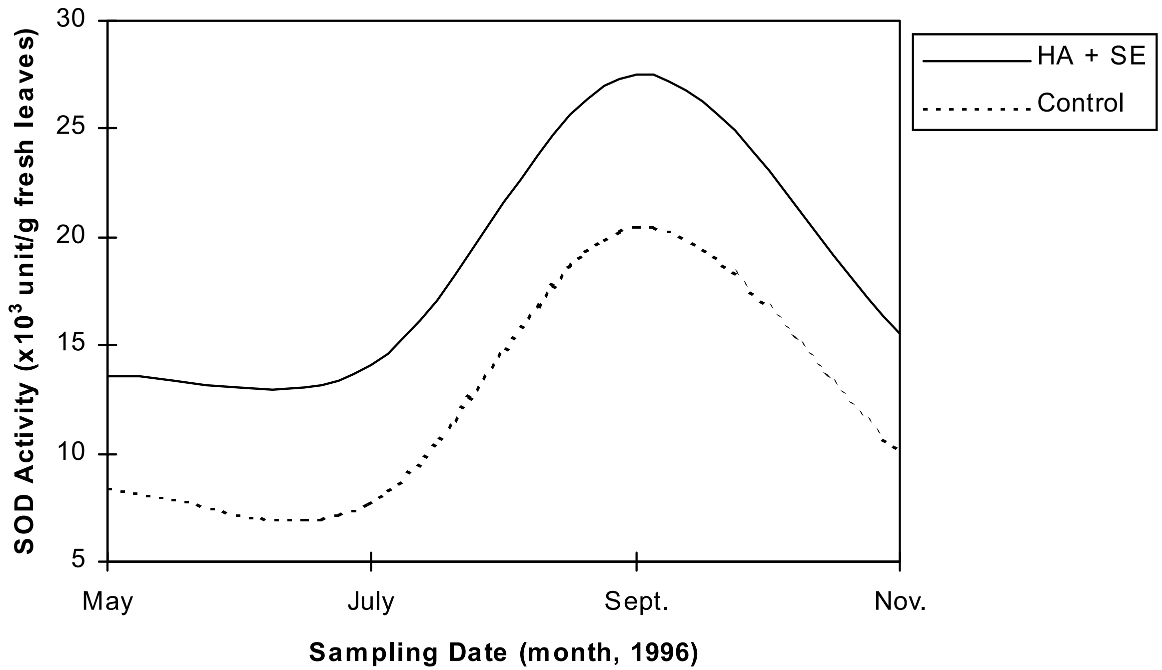

Figure 4. Relationship between superoxide dismutase (SOD) activity and dollarspot disease incidence of creeping bentgrass grown under two fertilizer regimes (1997).