BIOSTIMULANT PRODUCTS: WHAT RESEARCH HAS SHOWN: HOW THEY WORK

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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 effect biochemicals that influence the 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 while abscisic acid and ethylene are inhibitors of 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 Twentieth Century, it was not until the late 1930's this was noted in the United States. It was documented 20 years later that the hormones 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 1950's. However, it was not until the 1980's 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 showed applications of a synthetic cytokinin at 24 gm 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 that the synthetic cytokinins. It was concluded that in addition to cytokinins, seaweed supplied other compounds such as auxins and amino acids to provide more positive responses. More

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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-1980's, 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 biostimulant effect when silicate was applied to creeping bentgrass.

Various graduate student projects over the past ten years showed 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 (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 obtain 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 plants' 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 is referred to as photosynthesis II (PSII) and by oxidation reduction process the electron (e) is transferred to PSI process where CO2 from the atmosphere is converted to carbohydrates (Figure 1). However, under stressful conditions, energy (e) transferred from PSII may be prevented from being utilized in forming carbohydrates in the PSI process. When this occurs, the energy 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, cause photosynthetic damage (Figure 2). However, if the reactive oxygen species react with antioxidants, 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, 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 that the production of antioxidant is limited during this period when antioxidants are rapidly being 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 antioxidant, superoxide dismutase (SOD), activity. The enhance 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 he biostimulant influence on turf, the better cultural tools the turfgrass manager has at his disposal.