Questions and answers about biostimulants

Superintendents are often in the dark about the best ways to use biostimulants and what types of results to expect.

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Several golf course superintendents have expressed some confusion about how to determine the best way to incorporate biostimulant treatments in a turfgrass nutrient program. Our conversations were reminiscent of a recent research article written by a good friend, who said that research is like a good mystery story (1). She indicated that Sherlock Holmes would have made a good research agronomist, as he would thoroughly understand the hazards of a rush to judgment.

In "A Scandal in Bohemia," Holmes tells Dr. Watson, "It is a capital mistake to theorize before one has data. Insensibly one begins to twist facts to theories, instead of the theories to suit facts." Some superintendents are much like Sherlock Holmes: A cultural practice becomes elementary only when the facts are realized.

From the 10 years of biostimulant data that we have amassed in field, greenhouse and laboratory studies, a number of facts have emerged. A biostimulant is an organic material that, when applied in small quantities, enhances plant growth and development such that the response cannot be attributed to application of traditional plant nutrients. Biostimulants also may be referred to as "positive plant growth regulators," or as James Beard, Ph.D., recently coined, "metabolic enhancers."

Our research has documented that applications of biostimulants have conditioned turfgrasses to tolerate environmental stresses and improve grass growth, particularly root development. Biostimulants have been shown to improve turfgrass photochemical activity (an estimate of photosynthetic efficiency) and overall quality when the turf is subjected to low soil moisture, dollar spot, nontarget pesticide applications, nematode infestation, high soil salinity, high UV light intensity and heat.

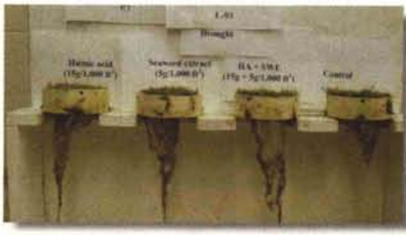

Photo courtesy of Erik Ervin

Root growth in drought-stressed L-93 creeping bentgrass treated with humic acid, seaweed extract or a combination of the two was signifcantly greater than root growth in untreated turf.

KEY points

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- **Biostimulants** are organic materials that, when applied in small quantities, enhance plant growth and development.
- **Seaweed and humic acid** are the two most commonly used ingredients in biostimulants.
- **Superintendents** should use independent research reports to verify the efficacy of a commercial biostimulant.
- **If applied before stress occurs,** biostimulants can help plants tolerate stress.

How much and how often?

How does a superintendent know how much of which material to use? How often should a biostimulant be applied? These questions are difficult to answer because biostimulants are manufactured from different materials and formulated at various concentrations. (Some that have low concentrations of biostimulating materials may seem less expensive, but they actually cost more in the long run because more material is required to realize stress-tolerance benefits. Economic comparisons should be done on the basis of cost per unit area.)

Confusion concerning biostimulants seems to arise because many materials are classified as biostimulants but have not performed as advertised. At Virginia Tech we have shown that seaweed extracts, humic acids, triazole fungicides, amino acids, potassium silicate and, most recently, low doses of salicylic acid have demonstrated biostimulant properties. However, the two most commonly used biologically active ingredients — seaweed and humic acid — have different sources, and different procedures are used to extract these materials from their sources.

Seaweeds

The chemical composition of seaweed is determined by the conditions under which it is grown. T.L. Senn, Ph.D., from Clemson University, has studied the influence of seaweed products on plants for many years. He has indicated that brown seaweed, *Ascophyllum nodosum*, prepared by alkaline hydrolysis from Norwegian waters, is a stable product when subjected to rigid quality control.

We have found that seaweed extracts obtained from a similar latitude in Nova Scotian waters provide similar biological activity (12,13). Hormones such as cytokinins and auxins have been isolated and quantified from these extracts (2) and may be the active ingredients.

Humic acids

Humic substances can be extracted from soils, peat, coal (leonardite) and lignite in an alkaline solution. These extractions are separated into humic acid and fulvic acid fractions by acidification. Humic acids are precipitated under a pH of 2 or lower. Fulvic acids, soluble at all pHs, have lower molecular weights and are the most biologically active fraction. The two main aspects of these humic fractions that influence plant growth are the auxin content and the ability to chelate certain inorganic nutrients such as iron.

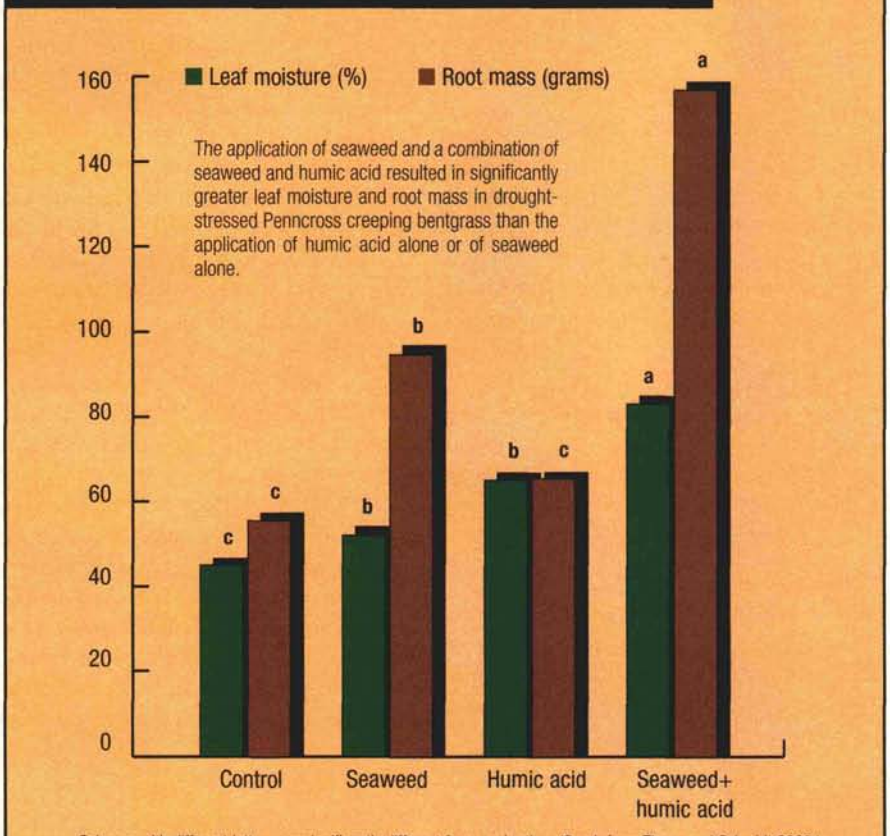
Dosage and frequency

Results from independent research reports should be used to verify the efficacy of commercial biostimulant materials and also to confirm that suppliers are providing formulations with proper dose and application frequency recommendations. Our experience is that frequent, low-dose applications are more beneficial than infrequent high-dose treatments. One should be aware that most of the biostimulants are hormonal in nature, and excess applications could be harmful to plants. For frequent applications (once a month or less), we obtained excellent results when 0.5 ounce of humic acid, 0.2 ounce of seaweed extract and 0.5 ounce of triazole fungicide were applied *in combination* per 1,000 square feet. When these materials are applied alone, the dosage may be doubled. (Because of labeling laws, triazole fungicides will not be packaged with other biostimulants. The superintendent will have to do the blending.)

The effect of a single biostimulant application can be expected to decrease gradually with time. There are some indications that better results are obtained when sequential treatments are made, and the second year is better than the first. Monthly applications before and during the stress periods (three to six applications per year) should be programmed.

Many biostimulant products list the mineral nutrient content in order to qualify in labeling. Sometimes these are listed as auxiliary to the biologically active substances (such as hormones). The "bonus" major nutrients are generally small amounts and contribute little to plant growth and development.

SEAWEED AND HUMIC ACID ON PENNCROSS



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What can reasonably be expected from biostimulant treatments?

Let us begin with an explanation of how environmental stress damages plant tissues and then discuss what we have observed and documented regarding the ability of biostimulants to diminish these damaging processes.

Environmental stress

Under favorable conditions, molecular oxygen accepts electrons during metabolic processes, producing water as a byproduct. However, under unfavorable conditions, this oxygen-accepting electron process can be overwhelmed, resulting in the production of a number of toxic oxygen species. These toxic oxygen species are often referred to as free radicals and go by names such as superoxide, singlet oxygen, hydrogen peroxide and the hydroxyl radical. These radicals, left as they are, cause pigment breakdown (bleaching) and major damage to cell walls, mitochondria and chloroplasts, which leads to a loss of photosynthetic efficiency, cell death and eventually plant death.

Plants deal with these damaging byproducts of metabolism by producing chemical compounds that are appropriately called *antioxidants*. These compounds react with oxygen radicals to produce nontoxic end products such as water and molecular oxygen. Generally, under nonstress conditions, enough antioxidants are produced to quench or detoxify these ever-present free radicals.

Any type of environmental stress can greatly increase the generation of free radicals, overwhelming the ability of the antioxidant system to stop their damaging effects. If this happens and the stress continues, the plant goes into a survival mode that can culminate in semidormancy or plant death. During this high-stress phase, the plant produces greater levels of the hormone ethylene, which signals the beginning of leaf senescence and conservation of energy reserves in plant growing points (turfgrass crowns). Photosynthesis halts, and respiration is greatly reduced, continuing only to a minor extent in the crowns and roots. Higher levels of ethylene almost always coincide with reductions in the growth hormones cytokinins and auxin.

Treatment with biostimulants

We postulate that pretreatment with the biostimulant active ingredients — seaweed extract and humic acid — may change the hormonal balance to favor cytokinins and auxin over ethylene enough so that antioxidant production can continue when stress occurs. In effect, the turf may be "triggered" into continuing to grow and protect itself during periods of stress when it normally would begin to shut down.

According to our research, the paramount impact that biostimulants have on turfgrass stressed by drought (12,13,14), salinity (4,11), heat (14), cold (5), dollar spot (14), high UV light intensity (7), herbicides (6,15) and nematodes (9) is associated with the stimulation of endogenous antioxidant development that protects the plant during the formation of excess free radicals.

For example, many warm- and cool-season turf areas now are being irrigated with brackish water. As water is lost through evapotranspiration, salt accumulates in the soil and plant free radicals increase because of salinity stress. The antioxidants stimulated by biostimulant treatments will help offset the toxic influence of the free radicals (10). In addition, we have some evidence that uptake of sodium and chloride is reduced in grass treated with biostimulants (11).

Possibly, the tolerance of low soil moisture could be the most evident and beneficial aspect associated with biostimulant treatments of turfgrasses (12). Biostimulant-treated plants retain more moisture than nontreated grasses under dry soil conditions. Turf treated with biostimulants may tolerate longer periods between irrigations and require less afternoon syringing to prevent wilting. This practice could help alleviate the formation of algae and moss so prevalent on some overwatered greens.

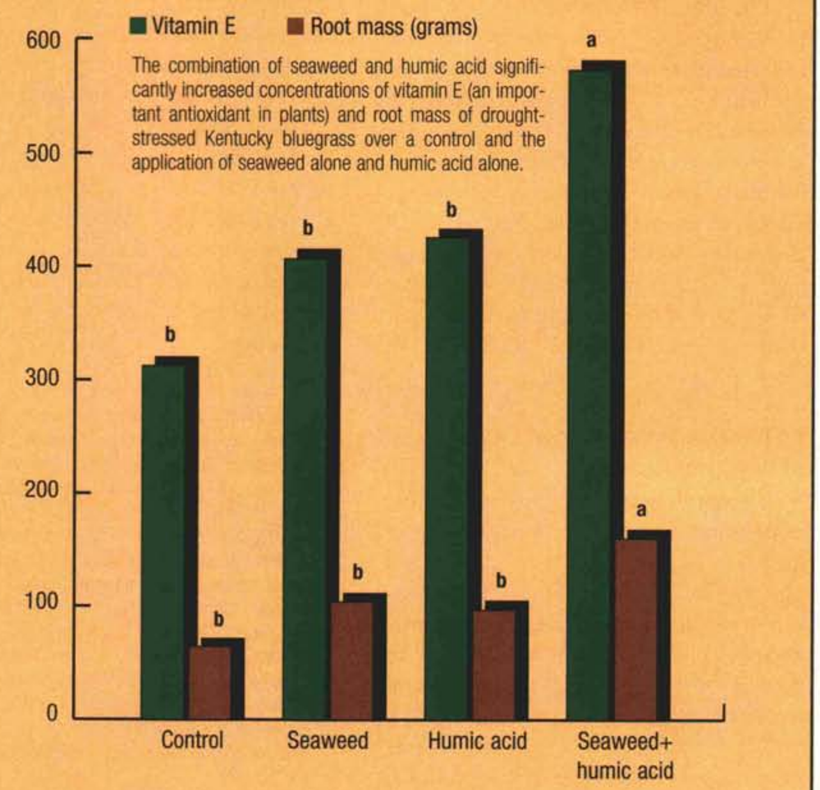
At Virginia Tech, we have shown that, in addition to treatments with seaweed extracts, humic acid, triazole fungicides or amino acids, applications of potassium silicate (8) and low doses of salicylic acid (7) have demonstrated biostimulant properties. However, there are different sources of seaweed and humic acid, and different procedures for extraction of these sources. Commercial products also differ in their concentrations of amino acids and silicates. Our research indicates that the correct dosage of salicylic acid is important for obtaining positive results.

Pre-emergence herbicides

Safer use of pre-emergence herbicides may be obtained with biostimulant treatments (6). Our recent research has shown that applications of biostimulants applied separately or in tank-mixes with post-emergence herbicides increased the efficacy of the herbicide (15). This indicated that lower dosages of these herbicides could be employed. We postulate that the biostimulant increased translocation of the herbicide. In addition, we obtained reduced phytotoxicity to nontarget plants when a biostimulant was applied in conjunction with certain pre-emergence or post-emegence herbicides. The injury reduction apparently was related to the increased antioxidant activity associated with the biostimulant treatment.

Basically, biostimulants enhance plant

SEAWEED AND HUMIC ACID ON KENTUCKY BLUEGRASS



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metabolic activity to condition the plant to tolerate stresses. Therefore, biostimulants have a greater impact when they are applied before the turf is subjected to an anticipated stress.

What about mixing the different types of materials that have biostimulant properties?

Triazole fungicide

Our research has shown mixing different biostimulating materials to be a good practice in some cases. For example, the combination of a triazole fungicide, humic acid and seaweed extract has provided excellent results (12). Dosages of each of the materials when blended may be lowered and yet retain the efficacy of the biostimulant effect and disease control. This combination reduces the need for high rates of triazole fungicide to control certain diseases. Higher triazole rates may be detrimental to turfgrasses under certain conditions. The combination of seaweed and humic acid generally has better biostimulant properties than either material alone.

Trinexapac-ethyl

The use of trinexapac-ethyl (Primo) to suppress turfgrass top growth has increased in popularity. We have shown that applications of trinexapac-ethyl have increased endogenous antioxidants, but not root growth as other biostimulant materials have. The addition of seaweed extract with trinexapac-ethyl may encourage the development of roots under stress periods. Our current research has shown that the incorporation of salicylic acid with seaweed and humic acid enhances biostimulant properties.

Do biostimulants affect turfgrass fertilization programs?

Biostimulants, even those containing some mineral fertilizers, do not supply all the essential nutrients in the quantities a plant needs. Their main function is to condition the grass to tolerate environmental stresses. Therefore, biostimulants should be used in conjunction with proper mineral fertilization.

We believe that biostimulants enhance the effectiveness of conventional fertilizers. Research indicates that less mineral fertilizer is required when biostimulants are used (3). This has both a practical and environmental impact. An example of the practical aspect is that, in our experience, applying less nitrogen than the conventional rates to the newer creeping bentgrasses results in reduced thatch development and possible subsequent deterioration of the turf associated with heavy nitrogen fertilization.

Biostimulant treatments should be beneficial when used in conjunction with the spoon-feeding technique of fertilizing creeping bentgrass putting greens. This is espcially true when summer application of nitrogen is scheduled. Reducing applications of mineral nutrients reduces the potential of soil-water contamination, resulting in good environmental practices.

Conclusions

Research on biostimulants permits advances in turfgrass nutrition. Understanding the organic metabolism impact as well as mineral functions within a grass will enable enhancement of nutrition of turfgrass subjected to stresses. Organic aspects of a grass are as important as mineral aspects in proper plant nutrition. The difference in mineral content between plants of the same cultivar with different growth responses is relatively small. Mineral nutrition is poorly correlated with tolerance to stresses. However, knowing the impact that biologically active materials have on turfgrass metabolism allows superintendents to condition turfgrasses better to tolerate environmental stress. Using this knowledge provides an additional tool for producing high-quality turf under adverse environments.

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