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TURFGRASS TRENDS

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WEED CONTROL

99% Control Is Not Good Enough

You'll pay if bermudagrass control isn't perfect before planting

By John Boyd

Over the last few years there has been a steady stream of people interested in starting a sod farm coming to my office for advice. One of the most important things that I tell them is to make sure that their fields and the planting material that they use is free of bermudagrass. While 99% weed control is acceptable in almost every situation, is not good enough when it comes to bermudagrass.

My warning is that if bermudagrass control is not meticulous before planting, you will pay later-big time.

The Roundup + Fusilade combination outperformed either herbicide alone and tank mixes of Roundup plus the other grass specific herbicides.

A skirmish line of workers moving across a field equipped with backpack sprayers loaded with a 2% or 3% Roundup solution is a common sight on sod farms across the south. Most likely, they are spot spraying patches of bermudagrass. This is a labor-intensive, moderately effective approach to bermudagrass control.

However, once the bermudagrass population becomes dense and widely distributed, spot treatment becomes hopeless and the field will have to be abandoned or completely renovated.

Bermudagrass contamination problems are not unique to sod farms. If bermudagrass is incomplete during establishment, golf courses, sports fields and lawns will suffer the same fate over time.

Background

There is an incorrect notion among the inexperienced that one application of Roundup at 5 quarts per acre will control bermudagrass. However, this is not the case.

B.J. Johnson, while at University of Georgia, published a paper in 1988 showing that three applications of Roundup at 2 quarts per acre over the growing season (May, June and August) were needed to achieve 98 to 100% bermudagrass control at one year after treatment.

He also demonstrated that repeat applications were much more important than rate in achieving bermudagrass control. His data showed that one or two applications at 5 quarts per acre were not as effective as three applications at 2 quarts per acre.

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Griffin and Dickens, working at Auburn University in the early 1990's showed that 2 quarts per acre of Arsenal (imazapyr) will give complete control of bermudagrass. However, Arsenal is a residual (soil active) herbicide that is not labeled for use on sod farms.

Arkansas research

During 1998 and 1999, we conducted six experiments to evaluate herbicides for bermudagrass control on sod farms. Three applications (May, July, and September) of Roundup Pro at 2 quarts per acre or two applications (May and July) of Roundup Pro at 2 quarts per acre + Fusilade II at 24 fluid ounces per acre controlled 90% to 100% of 'Tifway' and 'Midlawn' hybrid bermudagrasses when evaluated one year later.

When we repeated these trials in 1999, control levels compared to 1998.

Three applications of Roundup Pro provided 85% control and two applications of Roundup Pro + Fusilade provided 76% control one year after treatment. Extremely dry weather during July, August and September 1999 is thought to be the cause for the reduced bermudagrass control.

A single application of Arsenal (not labeled for use in fine turfgrass) gave 100% control of bermudagrass at 2.0 quarts per acre. Tank mixing 2 quarts per acre Roundup Pro with the 1 quarts per acre rate of Arsenal did not improve control compared to Arsenal alone.

Recommendations

Our current recommendation, short of methyl bromide fumigation, is three applications of Roundup at 2 quarts per acre or Roundup + Fusilade at 2 quarts + 24 ounces

TABLE 1. BERMUDAGRASS CONTROL

Percent control [a] after one year of treatment

Herbicide	Product	No. of Rate/A	1998-9 Winrock Applic.	1998-9 Lonoke Tifway[c]	1998-9 Lonoke Tifway[d]	1999-0 Winrock Midlawn	Avg. Tifway[e]
Roundup Pro	2qt	3	100a	89	100a	85a	94
Roundup Pro *(+ Fusilade)*	2qt + 24fl oz	2	96ab	93	100a	76b	91
Roundup Pro	2qt	2	60cd	59	92ab	0c	53
Roundup Pro *(+ Envoy)*	2qt + 34fl oz	2	58cd	63	78b	0c	50
Roundup Pro *(+ Finale)*	2qt + 4qt	3	28e	25	85ab	0c	35
Roundup Pro *(+ Fusilade)*	2qt + 24fl oz	1	50d	0	15def	0c	16
Roundup Pro *(+ Envoy)*	2qt + 34fl oz	1	28e	0	23de	0c	13
Roundup Pro *(+ Finale)*	2qt + 4qt	2	0f	0	30d	0c	8
Roundup Pro	10qt	1	-	-	-	0c	0

a BASED ON A 0 TO 100 SCALE WHERE 0 = NO CONTROL AND 100 = COMPLETE CONTROL.
b MEANS WITHIN EACH COLUMN FOLLOWED BY THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT ACCORDING TO THE DUNCAN'S MULTIPLE RANGE TEST AT P £ 0.05.
c WINROCK APPLICATION DATES FOR 1998-1999 TRIAL: MAY 29, 1998, JULY 13, 1998, OCTOBER 2, 1998
d LONOKE APPLICATION DATES: MAY 21, 1998, JULY 10, 1998, SEPTEMBER 21,1998
e WINROCK APPLICATION DATES FOR 1999-2000 TRIAL: MAY 21, 1999, JUNE 30, 1999, SEPTEMBER 14, 1999

TABLE 2.

Tifway Bermudagrass Control with Arsenal One Year after Treatment

Herbicide	Product Rate/A	No. Applic.[d]	% Control[a]	
	1998-1999[c]	1999-2000[d]		
Arsenal	1 qt	1	93a[b]	53b
Arsenal	2 qt	1	100a	100a
Arsenal + Roundup Pro	1 qt + 2 qt	1	95a	57b
Arsenal + Finale	1 qt + 4 qt	1	33c	10c
Arsenal + Roundup Pro	1 pt + 2 qt	1	68b	7c
Arsenal + Roundup Pro	2 qt + 2 qt	1	98a	93a
Roundup Pro	2 qt	3	96a	92a

A=BASED ON A 0 TO 100 SCALE WHERE 0 = NO CONTROL AND 100 = COMPLETE CONTROL.
B=MEANS WITHIN EACH COLUMN FOLLOWED BY THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT ACCORDING TO THE NEW DUNCAN'S MULTIPLE RANGE TEST AT P £ 0.05.
C=APPLICATION DATES: MAY 29, 1998, JULY 13, 1998, AND OCTOBER 2, 1998
D=APPLICATION DATES: MAY 21, 1999, JULY 13, 1999, AND SEPTEMBER 14, 1999

per acre to actively growing, non-stressed bermudagrass over the entire summer.

The Roundup + Fusilade combination outperformed either herbicide alone and tank mixes of Roundup plus the other grass specific herbicides. It is essential to wait for bermudagrass regrowth before making the next Roundup or Roundup + Fusilade application.

It will take 30 to 60 days for bermudagrass regrowth so your spray schedule might be May-June-August or May-July-September. Each year and location will be different. The key is inspecting the site for regrowth before spraying.

Spraying brown bermudagrass with postemergence herbicides such as Roundup or Fusilade is of no value. Make an inspection trip the following spring (May) and spot spray any remaining bermudagrass with a 2% Roundup + 1% Fusilade solution (2.66 ounces Roundup + 1.33 ounces Fusilade per gallon of water) at least two weeks before planting.

John Boyd is a Weed Scientist at the University of Arkansas where he is involved in Extension and applied research. His areas of specialization are turfgrass, ornamental, roadside and non-cropland weed control.

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Long-term study confirms clippings sustain fertility

By Joseph R. Heckman, Ph.D.
Rutgers The State University of New Jersey

Leaving clippings on a lawn recycles plant nutrients and enhances turfgrass quality.

A recent study conducted at Rutgers concluded that when clippings are returned, an equivalent or better turf color can be achieved by using only two pounds of nitrogen per 1000 square feet per year instead of the usual rate of four pounds of nitrogen per 1000 square feet per year (Table 1). Leaving clippings was also found to reduce the population of weeds in turf.

In 1994, the first year the plots with the two different mowing practices were established, turf color improved throughout the growing season where clippings were returned when compared to where they were removed. A darker green, more luxuriant appearance was apparent within four months of initiating the practice of returning clippings.

This difference in turf color continued during the following fall, winter, and spring months. In subsequent years of returning or removing clippings, a better turf color was consistently maintained when clippings were returned. These results suggest that the improved turf color was a result of nutrients being recycled within the turfgrass system.

After six years of comparing mowing practices, soil test results confirm that higher levels of soil fertility are maintained when clippings are recycled.

When clippings are removed about 300 pounds of fresh clippings (58 pounds of dry

TABLE 1.

Turfgrass color responses to nitrogen application rate and mowing practice.

Nitrogen Rate	**Season Average Turf Color Rating**	
Pounds N per 1000 square feet per year	Clippings Returned	Clippings Removed
	------------------Color Rating[1]------------------	
0	5.2	3.2
2	6.9	5.5
4	7.7	6.4

1=A 1-10 COLOR SCALE WAS USED WITH 1 REPRESENTING BROWN TURF AND 10 REPRESENTING DARK GREEN COLOR.

TABLE 2.

Influence of six years of mowing practice (clippings returned vs. clippings removed) on soil fertility (Mehlich-3 soil test method) of a Kentucky bluegrass turf at the Rutgers Hort Farm II. Soil sampling was performed on May 10, 2000 from the 0 to 2 inch depth.

Soil Test Item	Clippings Returned	Clippings Removed	Statistics†
Soil pH	6.3	6.3	NS
Exchange Capacity (meq/100g)	8.8	8.5	**
Soil Organic Matter %	3.3	3.0	**
Nitrate, NO_3-N (ppm)	2.3	1.7	*
Ammonium, NH_4-N (ppm)	8.7	5.3	**
Soluble Sulfur (ppm)	21	21	NS
Phosphorus (ppm)	245	244	NS
Potassium (ppm)	168	125	***
Calcium (ppm)	992	978	NS
Magnesium (ppm)	244	221	***

†,*,**,*** SIGNIFICANT AT THE 0.05, 0.01, AND 0.001 LEVELS, RESPECTIVELY.
NS = NOT SIGNIFICANT.

matter) are collected per 1000 square feet of lawn in one year. Leaving these clippings on the turf would instead recycle an estimated (pounds per 1000 square feet per year) two pounds of nitrogen, 0.18 pounds of phosphorus (0.4 pounds P_2O_5) and 1.2 pounds of potassium (1.4 pounds K_2O). Thus, the recycling of clippings after a period of years may be expected to maintain soil fertility levels better than when clippings are removed.

After six years of comparing mowing practices soil test results confirm as predicted that higher levels of soil fertility are maintained when clippings are recycled

Soil nutrient supplies to turfgrass were significantly greater for nitrogen, potassium, and magnesium where clippings were returned. The soil organic matter content was also increased by the return of clippings. These findings support the recommendation that fertilizer rates should be reduced when clippings are being recycled.

Based on the findings of the current study and previous research (Heckman et al., 2000) Rutgers Cooperative Extension recommendations for turf management when leaving clippings are as follows:

Use a slow release fertilizer to reduce surge growth and amount of clipping residue.

Apply less fertilizer. The nitrogen application rate should generally not exceed 2 pounds of nitrogen per 1000 square feet per year. Phosphorus and potassium application rates may also be reduced but the amounts to apply should be based on the results of regular soil sampling and testing.

Increase the frequency of mowing during periods of rapid growth.

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Biostimulants: Myths and Realities

By Ben Hamza and Amy Suggars

Over the past two decades, the turf industry has witnessed increased pressure from government agencies and environmental groups over the fate of nutrients in the environment and concern about surface and ground water. Consequently, several new products and technologies have been developed to help turf professionals deal with day-to-day management challenges; one such development is in the introduction of biostimulants. They have particularly generated both enthusiasm and serious skepticism.

The purpose of our study was to characterize perennial ryegrass seedling establishment and growth response using biostimulants alone and with nitrogen.

Understandingly, in their quest to market their products, biostimulant manufacturers put a lot of emphasis on what their products can do but did not provide evidence to support their claims (see list of common claims in table 1.).

What are biostimulants?

"Biostimulants," often used in plural form, is a broad term that literally means a group of ingredients that stimulate life. This could also be interpreted as a group of compounds that promotes favorable plant responses. Biostimulants have also been described as non-nutritional products.

Others suggested them as materials that stimulate plant growth in minute quantities (Zhang and Schmidtt, 1999). The description of biostimulants invariably becomes a discussion about their function and proposed uses in turf management. With these definitions, one could make a good argument that a light, balanced fertilizer application produces biostimulant-like responses i.e., shoot growth, increased nutrient uptake, and photosynthate translocation.

Obviously, the questions that biostimulants raised are not about definitions but rather lie in their diversified chemical composition. In a recent article, Dr. Karnok compiled about 60 different ingredients listed in 15 biostimulant labels (table 2.)

A lot of the ingredients listed are known organic and mineral substances essential to plants growth and development processes. Common commercial biostimulants contain many, if not, all of the following major ingredients:

- Plant hormones
- Humic substances
- Manure and/or sea kelp extracts

The chemistry of these basic biostimulant ingredients is extremely diverse in nature, origin, synthesis, function, and role in plant-soil ecosystem.

Plant Hormones: Research on plant hormones and their role in regulating plant growth and development processes have been extensively documented. Phytohormones are synthesized in the plant to regulate a multitude of essential cellular and tissue functions including stem elongation, root initiation, and tissue differentiation.

They are grouped in five major categories: Indoleacetic acids (IAA), commonly known as auxins, gibberellic acids, cytokinins, abscisic acids (ABA), and ethylene. Cytokinins are particularly implicated in cell division, morphogenesis (tissue differentiation), nutrient mobilization, and senescence delay.

Auxins promote root and shoot elongation (cell enlargement). Gibberellins promote shoot elongation, regulate seed germination, and seedling establishment. Biosynthesis, metabolism, and action of the different hormones are highly regulated processes. Plants maintain an intricate balance among the various hormones.

Humic Substances: These are complex, organic compounds that can generally be classified into humic acid, fulvic acid, and humin based on their solubility in water as a function of their pH (MacCarthy et al., 1985).

Many earlier studies with field crops showed positive responses to the application of humic substances. Shoot and root growth, seed germination, and seedling establishment are usually reported as direct plant responses to humic substances.

Mechanisms by which humic substances produce such responses remain unclear. However, humic substances, partly because of their complex, organic chemistry, have been demonstrated to improve soil structure, cation exchange capacity (CEC), and microbial activity.

Sea Kelp and Manure Extracts: These products contain a large number of organic and mineral compounds. They are particularly rich in phytohormones, complex organic compounds, vitamins, simple and complex sugars, enzymes, proteins, and amino acids.

Perhaps, sea kelp extracts, also known as seaweed, are best known for their high concentration of cytokinins and auxins.

Common additives to the ingredients described above include nitrogen (N), phosphorous (P), and potassium (K) and iron (Fe). Iron is added as a sulfate or in a chelated form. Potassium is mostly included as potassium sulfate.

In essence, the fact that biostimulants are manufactured and marketed as a complex mixture of ingredients is indicative of the potential functions that they may play in turf management, with plant hormones and humates are the two most important components regardless of their source or extraction process.

ExperimentA2

Rootshoot

Recent research

In a recent study conducted at North Carolina State University, humates were shown to increase root enzymatic activity but produced no effect on visual quality and clipping dry weight. Liu and Cooper (2000) reported a significant root mass increase of creeping bentgrass growing in hydroponic culture using modified Hoagland's nutrient solution treated with 400 ppm of humic acids. The authors found no similar increases in with 100 and 200-ppm concentration and that incorporating the humates at the depth of four inches produced better root responses than foliar applications.

Hartwigsen and Evans (2000) evaluated the effects of humic acids treatment of geranium and marigold seeds and germination substrates on seedling root development. They found that humic acids treatments significantly increased root fresh weight of geranium and marigold seedlings. Root fresh weight increases were significantly

TABLE 1. COMMON BENEFITS OF BIOSTIMULANTS

Reported by manufacturers

- Stimulate plant responses and work in all weather conditions
- Increase profits, cut operating costs, lead to 50% reduction in fertilizer
- Increase natural plant toxins, repelling pests
- Increase microbial root protection from soil pathogens
- Increase soil nutrient reserve up to 3000%
- Improve root development
- Build yields
- Improve taste and shelf-life
- Improve drought tolerance
- Increases nutrient uptake
- Stimulate plants' immune system
- Produce better color
- Result in better performance
- Produce deeper roots
- Improve stress tolerance
- Accelerate establishment
- Increases Cation Exchange Capacity
- Enhances fertilization and reduces leaching
- Detoxify chemical residues and heavy metals
- Make urea a long-life nitrogen
- Improve seed germination rates
- Increase stomata opening and plant transpiration

higher that than those of nutrient controls, suggesting humic acids have affected seedling fresh weights through mechanisms other nutrient supply.

A study of post-transplant root growth and sapflow of balled and burlapped red maple trees in which three different formulations of humate-based biostimulants were applied, Kelting et al. (1998) found no statistical difference in root mass at harvest as compared to untreated controls and no visual differences in growth or caliper size, although sap flow was significantly increased. Similarly, Harris et al. (1997) found that biostimulants did not significantly benefited summer landscape tree transplants and partly attributed their findings to environmental conditions being favorable for transplant.

Several arguments were also made about biostimulants improving turf tolerance to abiotic stresses especially water stress, which is predictably a major limiting factor in highly managed turf. Water stress impacts several plant metabolic functions, including specifically photosynthesis and photosynthate transport.

Recently, at Virginia Tech, Zhang and Schmidt (2000) concluded that "hormone-containing substances" and humic acids improved shoot and root growth by increasing concentrations of α-tocopherol in tall fescue and creeping bentgrass grown under low-water regime; an antioxidant implicated in the prevention of water-stress induced damage to the photosynthetic apparatus. In their report, they indicated that exogenous applications of seaweed extracts and humic acids promoted shoot and root growth by influencing antioxidants under low moisture conditions.

These findings were consistent with a similar study on Kentucky bluegrass and with those of Smirnoff (1993) who suggested a close correlation between tissue antioxidant levels and drought tolerance. However, the drought tolerance mechanism of other species remains unclear.

In a study on wheat grown in alkaline soil, humic acids have been shown to reduce phosphorous (P) fixation and increase water soluble P to plants (Wang et al., 1995). This makes a good argument for the potential uses of humate-based biostimulants as aids to nutrient uptake by creating humate-metal-phosphate complex, thus reducing soil fixation of P.

At TruGreen ChemLawn Technical Center, we evaluated two biostimulants supplied by PBI Gordon. The experiment

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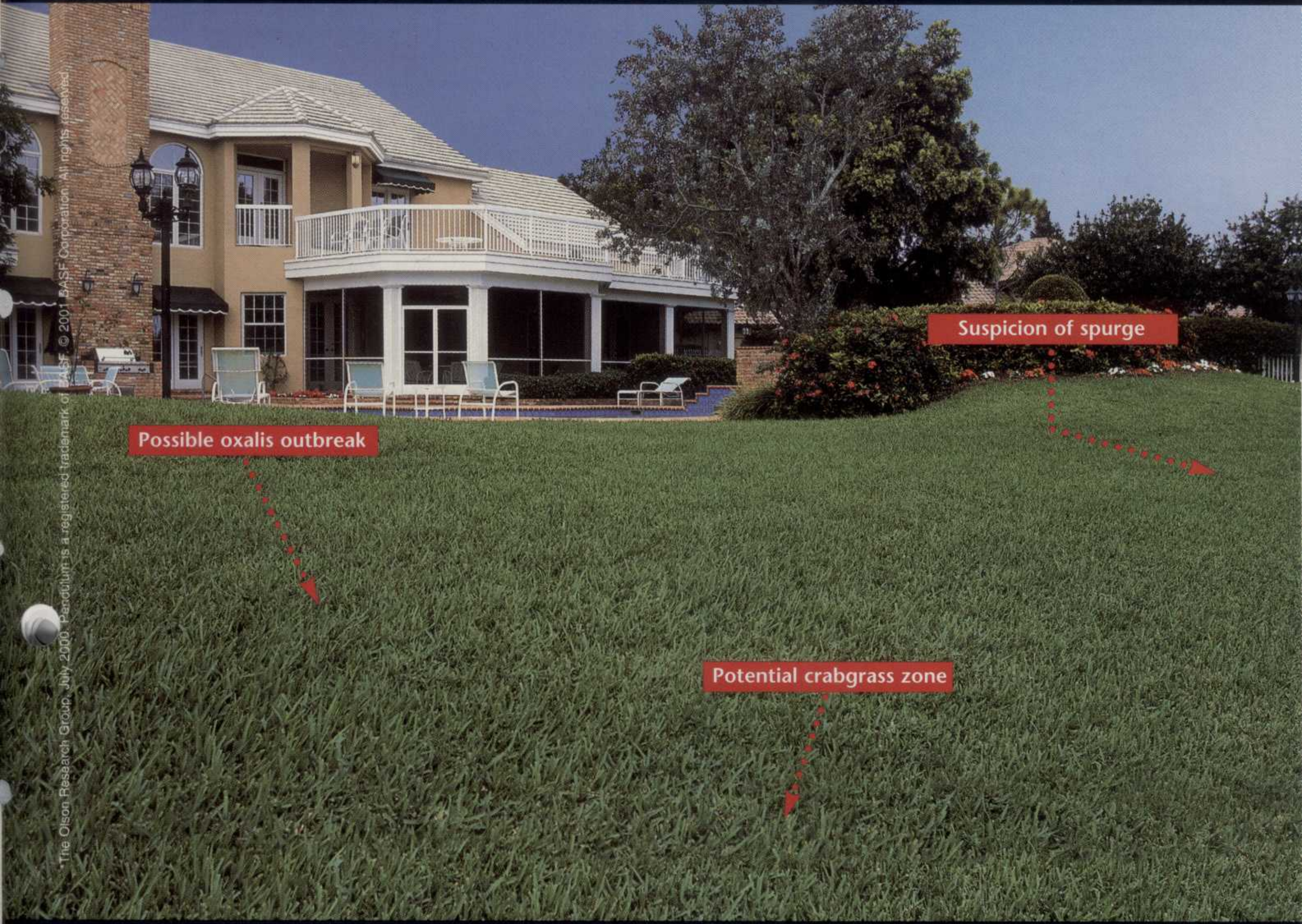

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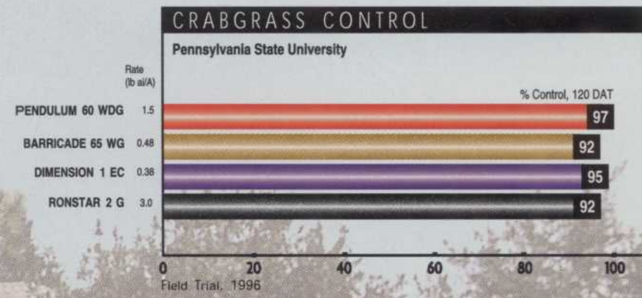

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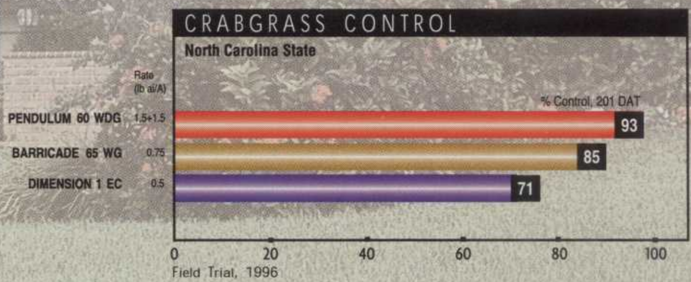

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TABLE 2. INGREDIENTS OF 15 BIOSTIMULANT LABELS

(Karnok, 2000)

- Activated nutrients
- Active Humic acids
- Amides
- Amino acids
- Antioxidants
- Bacteria
- Carbohydrates
- Carbon-rich organics
- Cellulose fiber
- Chelated micronutrients
- Chelates
- Chemical activators
- Complex sugars
- Cultured living microorganisms
- Cyanobacteria
- Cytokinin
- Disaccharides
- Enzymes
- Fermentation materials
- Fungi
- Gibberellic acids
- Growth simulators
- Humic substances
- Humic/Fulvic acids
- Hydrated organic proteins
- Intermediate metabolites
- Invert sugars
- Kelp extract
- Lignin
- Manure extract
- Metabolites
- Micronutrients
- Minerals
- Monosaccharides
- Mycorrhizae
- Natural wetting agents
- N-fixing Bacteria
- Non-inonic wetting agents
- Nutrient broth
- Organic chelates
- Peptides
- PGRs
- Plant extracts
- Plant Hormones
- Plant Nutrients
- Polysaccharides
- Proteins
- Scientifically balanced formulation (No ingredients mentioned)
- Sea kelp
- Seaweed
- Secondary nutrients
- Simple sugars
- Soil conditioners
- Sugar acid chelates
- Vitamins
- Wetting agents
- Yeast
- Yucca extract wetting agent

was set up in the greenhouse at our Technical Center outside of Delaware, OH. The purpose of our study was to characterize perennial ryegrass seedling establishment and growth response using biostimulants alone and with nitrogen. Perennial seeds were established in a sand culture. Plants were grown in plastic pots containing air-dried sand. At seeding, pots were treated with biostimulant and/or fertilizer (8-10-10) at the rate of one pound N/1000.Biostimulants were added at the recommended rates using a syringe and then the seeds were covered with a thin layer of sand. The pots were watered through capillary action. The experimental design was a randomized complete block design with four replicates.

The experiment was carried out for 28 days. Data collected included seedling height, at 7, 10, 15, 21, 28 days after treatment (DAT), color at 21 DAT and 28 DAT, and entire shoot fresh and dry weight, root weight, % root biomass at 28 DAT.

Statistical analyses showed that although biostimulants alone provided better visual seedling establishment, color ratings of pots treated with biostimulant + N, and N alone were significantly higher than those of biostimulant alone or control (see graph). Data on percentage root biomass, shoot, and root dry weights, although visually different, were not statistically significant (picture 1, and 2). This indicates that biostimulants have, at least visually produced better seedling establishment, but did not provide, on their own, better color ratings in the first 28 days after treating.

Are biostimulants needed?

In all of these studies, plants were subjected to controlled nutrient regimes, i.e., all essential nutrients were available to the plants under controlled conditions. The studies do no show the mechanisms involved or what would have been the response, should one or several nutrients were made limited.

For example, Harris et al. (1997) concluded that biostimulants are ostensibly not useful if proper transplant practices are followed with balled and burlapped landscape trees. This is consistent with the principle that under normal growing conditions, plants are self-sufficient and do not respond to exogenous supply of hormones because they are self-sufficient.

University research on biostimulants and their uses in turfgrass management does not fully agree with the claims often made by biostimulant manufacturers especially with regards to reducing fertilizer and pesticide uses. However, there are positive reports that biostimulants show potential uses in turf under stress conditions and promote favorable nutrient mobilization, although the responses to biostimulants may vary depending upon the biostimulant formulation and/or composition and among species.

Future research needs

Biostimulant uses in the turf industry will have to be better defined in order to gain a wide acceptance among turf professionals.

Future research should focus on questions pertaining to their role in seed establishment, turf stand quality, nutrient use and efficiency, abiotic stress tolerance under field conditions.

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Just What Constitutes True Foliar Feeding?

The "real thing" should lower nutrient inputs, boost stress tolerance

By William D. Middleton

In the past 25 years I've visited more than 4,000 golf courses throughout North America, in every state except Alaska and every Canadian province except Newfoundland and Prince Edward Island. Over that time, maintenance standards have ratcheted steadily upward to keep pace with escalating player demands for "tournament type" playing conditions. At the same time, pressures from environmental advocates, legislators and regulators to implement lower input turfgrass management practices have also increased.

This article is intended to help today's professional turf manager better understand the current state-of-the-art in the rapidly evolving technologies that meet these demands and to discuss how they can overcome some of the shortcomings associated with conventional soil nutrition and root feeding.

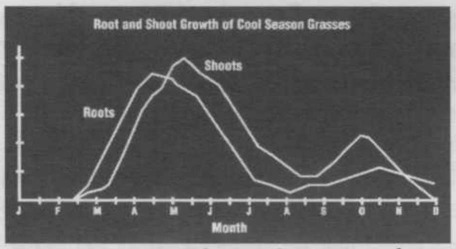

Figure 1. Seasonal growth patterns for root and shoot development in cool season turfgrass.

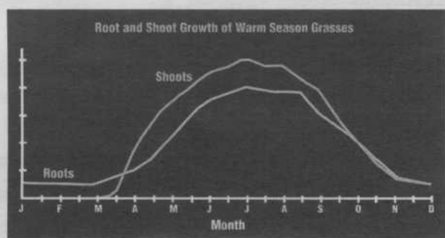

Figure 2. Seasonal growth patterns for root and shoot development in warm season turfgrass.

Better turf, less inputs

In my conversations with golf course superintendents, I frequently ask these two questions:

1. Do you think golf course conditioning demands will continue to rise for the foreseeable future or will they level off or perhaps even decline?

2. Do you think pressures from regulators, legislators and activists for lower input turfgrass management will increase, decrease, or stay about the same?

Many are concerned that they will have to produce ever better turf but with fewer chemical and nutrient inputs. In other words, they will be asked to do more with less.

In fact, their concerns are well-founded. Until recently, most of the efforts to lower inputs focused on lowering pesticide inputs.

Now, however, the attention of legislators and regulators is broadening to include lowering nutrient inputs. Both nitrogen and phosphorus are coming under much more intense environmental scrutiny because of their detrimental effects on water quality.

In Missouri, for example, HB-914 recently introduced in the Missouri House of Representatives would limit the use of fertilizers containing more than three percent phosphorus on managed turf. The bill does not discriminate between homeowners and professional applicators. It would require commercial fertilizer applicators to be certified by the state.

Similar bills are being introduced throughout the U.S., including Florida, New York and Michigan. A bill in St. Johns County, Florida, for example, would impose a ban on quick-release fertilizers for lawn care. Clearly, the pressures on golf course superintendents and other professional turf managers to target their environmental stewardship efforts on lowering nutrient inputs are going to increase dramatically.

As Professor Nick Christians, Ph.D., of Iowa State puts it: "Turf Managers must be just as careful with fertilizers as with pesticides." (Golf Course Management, February 1996.)

At the same time, the pressures to produce top quality turf under conditions of lower mowing heights and higher stress conditions will also continue to mount. So, the prospect of having to do more with less will become a high priority issue with turf professionals. That is why there is so much more interest in true foliar fertilization.

True foliar fertilization offers the realistic potential to produce higher quality, more stress resistant turf with lower nutrient inputs.

True foliar fertilization

Most modern day golf course superintendents have three main components in their fertility programs:

■ A synthetic fertilizer component, including granular and liquid controlled release materials applied for root uptake

■ An organic fertilizer component targeted at stimulating soil microbial activity as a well as providing plant nutrients for root uptake and

■ A sprayable fertilizer component designed to supplement the first two and intended for foliar absorption rather than root uptake.

In addition, many superintendents include "inorganic" components, some of which are natural, such as muriate of potash.

In general, most turf professionals and, in fact, most turf researchers are far better informed about the first two components. In recent years significant advances have been made in fluid nutrition and foliar formulation chemistry that help overcome the shortcomings associated with conventional soil nutrition and root feeding.

To be sure, impressive advances have been made in soil nutrition and root feeding technologies over the past several years with products like IBDU, Polyon, Agrotain and others. However, when you look closely at the root systems of intensively maintained turfgrasses and the negative impacts that higher maintenance standards and lower mowing heights have on them, it becomes abundantly clear that more and better nutritional strategies are essential.

Consider, for instance, how fundamentally different the seasonal growth patterns are for root and shoot development in cool season and warm season turfgrasses as shown in figures 1 and 2.

With cool season turfgrasses, both root and shoot development peak in late spring and then decline abruptly. Both hit bottom in summer—just in time for the dog days. This pattern represents the single biggest shortcoming of conventional soil nutrition and root feeding with respect to cool season turfgrasses.

At the very time of the year when the turfgrass plant needs nutrition most critically for stress tolerance and survival, the plant's root system is least able to provide it. This pattern is the driving force behind the development of true foliar nutritional alternatives to conventional soil fertilizers and micronutrients.

It's as simple as this: a conventional root uptake turf fertilization program can be no better than the root system itself. Its effectiveness is limited by the root uptake capacity. Root uptake capacity is limited by seasonal growth patterns and further reduced by both high temperature and low mowing heights. So while significant improvements in conventional root uptake fertilization technology have been made, they cannot overcome the seasonal limitations inherent in the root systems of intensively-maintained turfgrasses; nor can they ameliorate the effects of environmental and cultural stresses.

Perhaps it would be helpful to clarify a couple of things at this point. First of all, let's define what we mean by a true foliar nutritional alternative. A true foliar is designed to overcome the numerous obstacles to foliar uptake of traditional plant nutrients, thus allowing for efficient utilization of all its beneficial components. Secondly, all true foliars are liquids...but not all liquids are true foliars.

To qualify as a true foliar, all of the beneficial components of the product must have the potential to penetrate the leaf surface and translocate within the plant; overcoming molecular size exclusion and electrochemical gradient barriers, as well as other obstacles.

Historically, the entryway into the foliage was through the stomates. However, as we will see, there are inherent limitations with stomatal openings.

In recent years, advances in formulation chemistry have made it possible to maximize the use of transcuticular pores as the points of foliar entry. These submicroscopic spaces are several orders of magnitude smaller and vastly more numerous than stomatal openings.

If you picture a piece of turfgrass about the size of your thumbnail (1 sq. cm.), it would have about 20,000 stomates. In that same space there would be 10 billion transcuticular pores.

Looked at in the other extreme, you could imagine a gargantuan blade of turfgrass about 200 miles long and 20 miles wide. Each of the stomates in that space would be the size of three football fields joined end-to-end. Each of the transcuticular pores would be about the size of a golf ball.

Size exclusion, then, is the first barrier a true foliar must overcome.

The transcuticular pore spaces on the surface of the leaf blade are the openings through which true foliar nutrient molecules must pass to penetrate into the turfgrass plant. Unlike stomatal openings, which are closed more often than they are open the transcuticular pore spaces are open all the time. These pore spaces are much more numerous but also much smaller than stomatal openings.

So, the first step in designing true foliar fertilizers, micronutrients and trace elements is to make sure the molecular structures are small enough to pass through the transcuticular pores.

Another obstacle to be overcome is the electrochemical gradient within the turfgrass plant itself. Two primary forces regulate the movement of nutrient ions in solution; one is chemical and the other is electrical. Ions move down the chemical gradient from a higher to a lower concentration in order to reach equilibrium. Ions also tend to be transported most easily against an electrical gradient when their electronegative potential is low.

The cell walls of living plants carry a negative charge. Since opposite charges attract and like charges repel, for a negatively charged ion such as nitrate (NO_3) to cross the cell wall and move into plant cells where nitrate concentrations are higher, additional energy must be expended by the plant to overcome the electrochemical gradient. It is as if the nitrate ion is swimming against the current and so the plant must expend more energy. This is referred to as active transport.

Positively charged species such as Ammonium ions (NH_4^+) are generally taken up by passive transport which requires no additional energy expenditure by the plant. [There are some notable exceptions to the active/passive transport rules. Potassium (K+), for example, is taken up by active transport at low K+ concentrations and only transported passively at high K+ concentrations.]

The best designed true foliars sidestep the obstacles of chemical and electrical gradients by packing a powerful nutrient punch into a formulation made up of neutral or only partially charged species. These special nutrient forms are then secured in a non-traditional matrix that protects the nutrient species, minimizes the potential for leaching and volatilization, and enhances uptake and utilization of the beneficial components of the formula.

Two basic questions

There are two fundamental questions that professional turf managers ask and want answered about true foliar nutrition. Compared to conventional soil nutrition and root feeding, can fluid nutrition and foliar feeding:

1. produce comparable or superior results with more control and less risk of diseases associated with higher fertility levels?

2. produce comparable or superior results with greater efficiency and lower nutrient inputs?

To address those questions, lets look as some recent efficacy data and nutrient input data.

In the year 2000 at the University of Nebraska, Dr. Roch Gaussoin conducted a study that where conventional treatments were designed by a panel of experienced Nebraska golf course superintendents. The study showed the effects of two fluid nutrition and foliar feeding programs on the establishment and maturity of USGA type Providence creeping bentgrass putting greens compared to two conventional programs. The details of Dr. Gaussoin's research on "Grow-In Protocol 2000" are available through the author of this article.

The major conclusions are these:

- In terms of efficacy, the fluid nutrition and foliar feeding programs were comparable in terms of overall quality (color and density) to the conventional programs.
- With regard to lowering nutrient inputs thereby reducing the potential risks for negative environmental impacts, as well as certain diseases, the fluid nutrition and foliar feeding programs were far superior; producing comparable results with 25 to 80% less Nitrogen, 5 to 90% less Phosphorus, 55 to 85% less Potassium.

One of the goals of the research was to demonstrate the theoretical potential efficiency of foliar feeding of turf as an exclusive source of post-plant nutrition. Toward that end, it was necessary to conduct the trial on new, never fertilized plots, to be certain there was no residual fertility in the root zone that could skew the results.

During the subsequent weeks throughout the summer, the plots fertilized solely with the foliar products from Emerald Isle compared favorably with the conventionally fertilized plots in terms of quality.

In addition, in July though there was significant pythium in the high input conventionally fertilized plots, there was none in the foliar-treated plots. By July, the treated plots were also denser than the conventionally fertilized plots, and by September, they had statistically better color.

Until recently, efforts to lower inputs focused on lowering pesticides. Now legislators and regulators include lowering nutrient input.

It bears repeating that these benefits were achieved with significantly lower fertilizer inputs to the foliar plots than the conventional plots. The foliar plots received about 25 to 80 percent less Nitrogen, 75 to 90 percent less Phosphorus, and 55 to 85 percent less Potassium than the conventionally fertilized plots.

Interestingly, comparison of the microbial levels in the root zones yielded significantly higher levels of both bacteria and fungi in the foliar treated plots. It is theorized that the higher microbial levels and the lower N inputs may have been responsible for avoiding the pythium earlier in the season.

Perhaps most remarkably, at the end of the season, the foliar fed treatments yielded rootzone nutrient levels that in all comparisons, were equal to or higher than the levels found in the conventionally fertilized root zones. These data would suggest that during the course of the four-month growing/fertilizing season, significant N, P, and K supplied to the conventionally fertilized plots was neither utilized by the turf nor remained in the rootzone.

These data would further suggest that the foliar treated plots also lost fewer nutrients to leaching and/or volatilization than the conventionally fertilized plots. The foliar products included in this trial were Emerald Isle NutriRational nitrogen (19-1-6), Emerald Isle NutriRational phosphorus (6-12-6), and CPR (4-0-1 with 3% Iron).

Based on these results, we will continue this research in order to determine how much further we can reduce (and seasonally tailor) our application rates, and still grow superior turf with efficiency, control, and reduced likelihood of disease.

It is not an overstatement to say that true foliar fertilization offers the realistic potential to produce better quality, more stress tolerant turf with lower nutritional inputs. This is not to suggest that foliars can or should replace conventional granular, liquid or water-soluble controlled release fertilizers. However, it does suggest that new generation true foliars can be used strategically to get more of the genetic growth and survival potential out of intensively-maintained turfgrasses than can be achieved with conventional root uptake fertilizers alone.

Not your father's foliars

True foliars produce plant responses at surprisingly low dosages and those responses often last longer than those produced by traditional liquids and water solubles. The new generation foliars take some getting used to…not unlike getting familiar with a new set of golf clubs.

The best advice is to simply start using them based on soil and/or tissue testing results and your own experience with your own turf. The beauty of these materials is that the responses are typically rapid so the feedback is almost immediate.

After that, your experience and judgment will dictate how you can use true foliars most effectively to achieve your turf management goals.

William D. Middleton is founder and president of Emerald Isle Ltd. since its incorporation 24 years ago. He is also President and founder of Ocean Organics, Inc., and is a Director of the O.J. Noer Research Foundation. With a degree in International Business, Bill previously held numerous positions with AT&T, Johnson and Johnson and Warner Lambert.

Regulations open doors for solid research

By Curt Harler/Managing Editor

Curt Harler Managing Editor

This month's issue has two articles linked by the simple fact they both explore technologies and techniques that hardly existed when most of our readers were in college a decade or two ago.

In both articles, the authors cite the pressures of legislation and regulation as keys to the interest in the technologies.

William D. Middleton looks at foliar feeding, more formally termed fluid nutrition and foliar formulation chemistry. He says root uptake capacity is limited by seasonal growth patterns and further reduced by both high temperature and low mowing heights. So while significant improvements in conventional root uptake fertilization technology have been made, they cannot overcome the seasonal limitations inherent in the root systems of intensively-maintained turfgrasses.

Middleton maintains that one way to overcome that hurdle is with foliar feeding. He says true foliars produce plant responses at surprisingly low dosages and those responses often last longer than those produced by traditional liquids and water solubles.

Ben Hamza and Amy Suggars look at the introduction of biostimulants. Biostimulants have received a jaundiced eye from some researchers but have generated solid enthusiasm from others, especially in the user community. As Hamza and Suggars note, biostimulant manufacturers put a lot of emphasis on what their products can do to make life easy for turf managers.

Face it: those manufacturers are in business to market a product, not to write journal articles. Many researchers felt the industry did not provide empirical evidence to support its claims, but industry spokespeople simply pointed to their happy customers to back their claims.

The jury is still out, Hamaz and Suggars say. Their article is a good look at exactly where the biostimulant market sits today.

For those readers looking for fertile ground for research – either in-house or towards an advanced degree – either of these subject areas merit exploration. Serious research into either practice all but guarantees a budding scientist a respectable and fruitful career.

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