Response of 'Tifdwarf' Bermudagrass to Seaweed-derived Biostimulants

M.L. Elliott and M. Prevatte

Additional index words. *Cynodon*, golf courses

Summary. 'Tifdwarf' hybrid bermudagrass [*Cynodon dactylon* (L.) Pers. x *C. transvaalensis* Burtt-Davy] grown on a putting green in southern Florida was treated for 2 years with two seaweed-derived biostimulants, Kelpak and PanaSe Plus. No significant treatment differences were observed in turfgrass quality (44 observation dates) or root weights (eight collection dates). There was only 1 of 22 collection dates for clipping weights that obtained a significant difference among treatments. Although the biostimulants did not enhance plant growth or quality, neither were they harmful to the turfgrass.

The primary concerns of golf course superintendents in southern Florida are the short lengths of hybrid bermudagrass roots and periodic declines in turfgrass quality that can be observed on putting greens year-round. Most putting greens in southern Florida are maintained at a height of ≤4.7 mm. This places a stress on the plant since little leaf tissue is present to support photosynthesis (Boote, 1977). The photosynthetic rate is reduced even further by the reduction in light intensity during overcast, rainy weather typical during summer and fall. As demonstrated for common bermudagrass (*C. dactylon*), low light intensity reduces biomass allocation to rhizomes, an effect that is stronger for short plants (Dong and de Kroon, 1994) such as those on golf greens. High soil temperatures also increase the shoot : root ratio of bermudagrass (Boote, 1977). Due to the subtropical climate, the bermudagrass does not become dormant during the winter, but its growth is reduced if extended, cool temperature <16 °C occur.

Biostimulants are products that are nonnutritive promoters of growth. Growth can be promoted by stimulating nutrient uptake, chelating nutrients, providing plant growth hormones, or enhancing plant hormonal activity. Biostimulants that contain plant growth hormones can be produced synthetically or obtained from natural plant extracts. The latter are primarily obtained from the brown algae family Phaeophyceae, commonly called seaweed or kelp (Metting et al., 1990). Applying seaweed preparations have increased plant growth, including root growth (Beckett and van Staden, 1989; Blunden and Wildgoose, 1977; Crouch and van Staden, 1991; Featonby-Smith and van Staden, 1984; Finnie and van Staden, 1985; Metting et al., 1990). This plant response is often associated with the presence of plant hormones, but the seaweed extract also may act as a nutrient chelator (Metting et al., 1990).

Biostimulants that contain plant growth hormones have benefited cool-season turfgrass under drought (Schmidt, 1990) or salinity stress (Nabati et al., 1994). They also enhanced growth of creeping red fescue (*Festuca rubra* subsp. *rubra* L.) and Kentucky bluegrass (*Poa pratensis* L.) seedlings and Kentucky bluegrass sod (Button and Noyes, 1964; Goatley and Schmidt, 1990, 1991). Although these biostimulants darken bermudagrass leaf color in temperate climates in the fall (Nus, 1993), to our knowledge, no research has examined the effects of the plant-derived biostimulants on bermudagrass putting greens in a subtropical climate. Our study, conducted in southern Florida, evaluated two commercially available, seaweed-derived biostimulants, Kelpak (Environmental Supplies, Petersburg, Va.) and PanaSe Plus (Emerald Isle, Ann Arbor, Mich.), for their effect on 'Tifdwarf' bermudagrass quality, clipping weight, and root weight.

Materials and methods

A field experiment was conducted from May 1992 through Apr. 1994 at the Fort Lauderdale Research and Education Center on an established 'Tifdwarf' bermudagrass research golf green built with a root-zone mix containing 80% sand and 20% Canadian spaghnum peat moss. The area was vertically mowed and topdressed about once per month, with depth of vertical mowing depending on thatch layer thickness. Topdressing material was the same material as the root-zone mix. The turfgrass height was maintained at 4.7 mm by mowing six times weekly. The area was irrigated as needed to maintain the best possible quality.

The area was fertilized every 2 weeks using a fertilizer blend containing IBDU, potassium magnesium sulfate, iron sulfate, and manganese sulfate. For N and K, a total of 879 $kg\cdot ha^{-1}$ of each nutrient was applied per year. Phosphorus was applied twice each year at 122 $kg\cdot ha^{-1}$ per application. This is similar to the average fertility program used in southern Florida (Kuhn, 1992).

Treatments included a nontreated control, Kelpak applied at 6-week intervals, and PanaSe Plus applied at 2-week intervals and at 4-week intervals. Kelpak contains 0.3N–0.7P–0.6K and is derived from the brown alga *Ecklonia maxima* from which several indole compounds have been identified (Crouch et al., 1992). PanaSe Plus contains 0.2N–1.3P–1.7K and is derived from numerous seaweeds including *Laminaria* spp., *Chondrus crispus*, *Porphyra* spp., and *Ascophyllum nodosum* (W. Middleton, personal communication). Both products are liquids.

Biostimulants were applied according to the manufacturers' directions. The first Kelpak application was made as a drench with 1.4 $ml\cdot m^{-2}$ Kelpak applied in 500 $ml\cdot m^{-2}$ deionized water; all subsequent Kelpak applications were made as broadcast sprays at 0.3 $ml\cdot m^{-2}$. PanaSe Plus treatments were applied as broadcast sprays at 1.3 $ml\cdot m^{-2}$. Broadcast sprays of both biostimulant products were made in 100 $ml\cdot m^{-2}$ deionized water. Each plot was 2 × 3 m with four replicates per treatment in a randomized complete-block design.

Turfgrass quality ratings were de-

University of Florida, Fort Lauderdale Research and Education Center, 3205 College Avenue, Fort Lauderdale, FL 33314.

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termined based on observation of grass color and density using a scale of 1 to 10, with 10 representing turf with a dark-green color and a uniform dense stand. The plots were rated about every 2 weeks, 1 week after each N application.

Turfgrass clippings from plots that had not been cut for 48 h were collected once each month from a 1-m^2 area in the center of each plot. Clippings were dried at 60 °C for 72 h and then weighed. When possible, we tried to rate and collect clippings on the same day or subsequent days.

Root weights were obtained every 3 months. At each sampling date, two samples (15 cm in diameter × 10 cm deep) were obtained from each end of each plot for a total of four subsamples per plot. Root samples were not collected randomly within the plot because samples collected from the center of a plot would have resulted in voids that would have interfered with clipping weight evaluations. A 1.25-cm cap was cut from the top of the sample and then discarded to remove leaf tissue and most of the thatch layer. Samples then were processed with a commercial root washer (Gillison Hydropneumatic Elutriation System, Benzonia, Mich.) using 760-µm primary and secondary sieves. The accumulated material was dried at 80 °C for 36 to 48 h and then weighed. Weights from the four subsamples of each plot were added together to obtain the total weight per plot. Resulting "holes" from sampling were filled with topdressing material.

Data were analyzed using the analysis of variance procedure; the Waller-Duncan k ratio *t* test was used to separate means (SAS Institute, Cary, N.C.).

Results and discussion

Quality ratings were obtained on 44 dates. Except for eight dates, there were no quality differences among any plots of any treatment; the entire experimental bermudagrass area was uniform in color and density. Differences among treatments for those eight dates were not significant (data not shown). Clipping weights were collected on 22 dates, but significant treatment differences were obtained only on 27 Jan. 1993 (Table 1). However, there were no quality rating differences among any plots of any treatment on that same date. Root weights were collected on eight dates, and no significant differences were obtained among any treatment on any date (data not shown).

Although other research has demonstrated that turfgrasses respond best to hormonal biostimulants when the turf is under environmental stress (Nus, 1993), no benefits were observed in our experiment during stressful periods, such as extensive rainfall or cool temperatures. For example, 112.5 cm rain was received between 1 June 1993 and 31 Oct. 1993. The turfgrass quality gradually declined during this time period, but no quality rating differences were observed among any treatments.

Researchers who have worked with cool-season and warm-season turfgrasses have indicated that warm-season turfgrasses do not respond to hormonal biostimulants as well as cool-season turfgrasses and that the responses are highly variable (Nus, 1993). In our experiment, a consistent lack of response was observed over the 2-year study period. Although the seaweed-derived biostimulants did not enhance plant growth or quality, they were never harmful to the turfgrass. Before a golf course superintendent applies these products to all of the putting greens on the course, it would be advantageous to only treat half of two or three greens to determine if a response will be observed. This would save time and money if there is no response.

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Table 1. Effect of seaweed-derived biostimulant applications on 'Tifdwarf' bermudagrass clipping weights during the first year of the study (May 1992 through Apr. 1993).

	Application	Clipping wt (g)[z]									
	intercal	1992						1993			
Treatment[y]	(weeks)	29 July	27 Aug.	23 Sept.	28 Oct.	27 Nov.	30 Dec.	27 Jan.	24 Feb.	7 Apr.	21 Apr.
PanaSea Plus	2	7.47	5.20	5.07	1.84	4.10	4.25	2.71 a	3.18	6.42	4.65
	4	8.09	5.45	5.00	1.71	4.22	3.47	2.74 a	3.17	6.05	4.08
Kelpak	6	7.59	6.18	5.79	1.63	4.00	3.78	2.28 b	2.84	6.27	4.30
Control	---	7.28	5.47	5.23	1.59	4.19	3.96	2.65 ab	3.28	6.62	4.58
Pr > F		0.89	0.43	0.51	0.47	0.96	0.23	0.05	0.84	0.88	0.84

[z]*Values are means of four replicate plots. F values were too small to conduct mean separation test on all dates except 27 Jan. 1993. Mean separation for that date by Waller–Duncan k ratio* t *test (*P *= 0.05).*
[y]*PanaSe Plus application rate was 1.3 ml·m^{-2}; Kelpak application rate was 0.3 ml·m^{-2}.*

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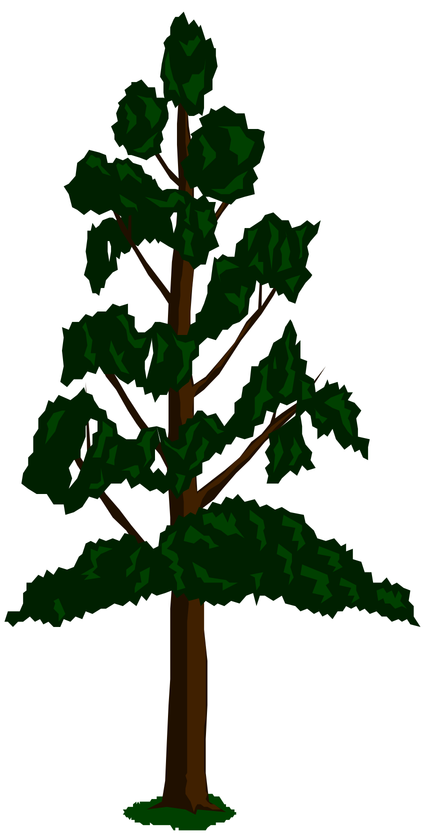

Scientific Home Pages on the World Wide Web

Gary W. Lightner[1]

Additional index words. World Wide Web, horticulture, home page

Summary. As the World Wide Web increases in popularity, it has become easier to create and maintain home pages on the network. How this is accomplished is as varied as those using the web. The possibilities for scientific sites create questions for the research page editor. This paper provides a nontechnical discussion of why and how to create a scientific home page. Universal Resource Locators are given for home pages that may benefit the reader.

As the World Wide Web increases in popularity, it has become easier to create and maintain home pages on the network. How this is accomplished is as varied as those using the web. The possibilities for scientific sites create questions for the research page editor.

Why? The first question to be asked is, "Why create a home page?" Communication among colleagues is better handled with direct e-mail. Data can be transferred with e-mail or FTP exchanges. Many scientific interest groups have established electronic mailing lists to communicate effectively with most or all researchers in specific research areas. Home pages are designed for public access by a world audience (Burger et al., 1995). A home page publisher must have a reason or desire to share the information with all that might pause at that location while scanning the web. The effort and costs associated with the creation and maintenance of the page should be offset by the perceived benefits of presenting the information to the public.

Has a home page already been created for this purpose? The web has become very popular and increased use has resulted in declining performance. If a similar or related page already exits, check with the author to see if your information can be provided for inclusion at the existing site or to establish a link to your new page.

How? The first requirement is to obtain a link to the Internet. Faculty members should contact their campus computer center. Universities often will provide access for nonprofit or government researchers at little or no cost. Assistance will vary with the work load and abilities of the computer center staff. Students and other users also can be good sources of information and aid to the novice. Local network providers are usually the lowest priced and will provide the software to get started. Once up and running, however, the ability to educate the user on how to use the software provided may be lacking. If a web site becomes accessed heavily, the author may have to pay increased server fees for the popularity. Although the disk space used remains the same, a popular web site means that a large number of users will be using the telecommunication abilities of the host site for access. With either of these options, the user must learn to use some file transfer method to place the finished document in a location on the provider's system. The method and directory information will be supplied by the Internet provider.

National providers, such as America Online or CompuServe, provide free software and generally are easier to use but more expensive than local or area providers. Creating home pages through these companies may be the easiest means, with ample online help available.

As the use of the web increases, so does the amount of software available to create and view home pages. Any ASCII text editor can be used to create a home page using hypertext markup language (HTML), but software designed for the job such as FrontPage (http://www.vermeer.com) or HotDog (http://www.sausage.com) make the task easier (Fig. 1). Most companies provide free software downloads of either their actual products or trial versions of their software. When assistance is required to create the home page, the software preference of those providing the technical assistance

[1]*USDA, Agricultural Research Service, Appalachian Fruit Research Station, 45 Wiltshire Road, Kearneysville, WV 25430.*

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