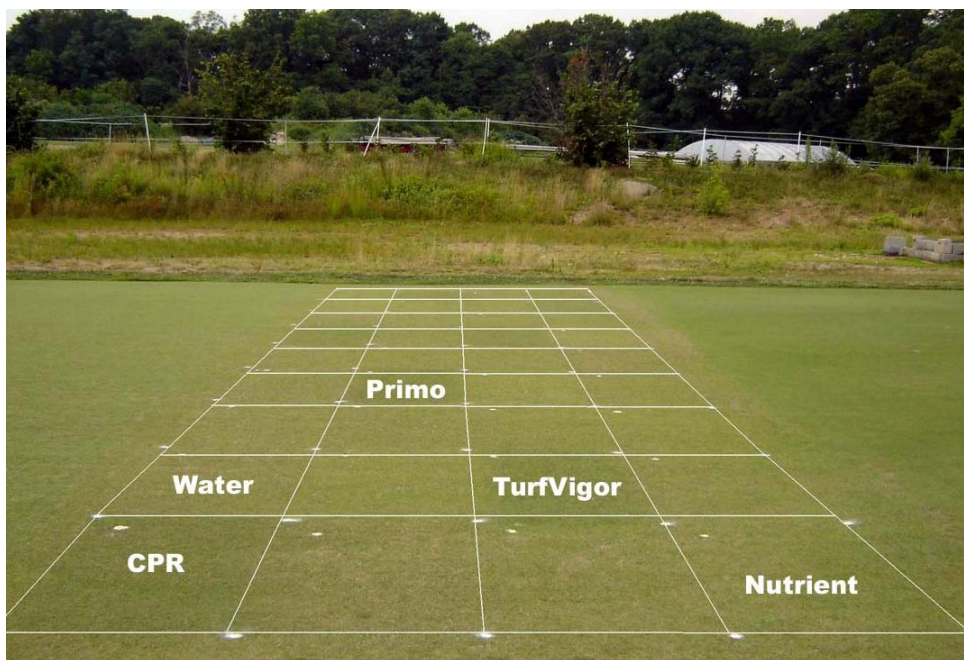


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This article reports a study that investigated whether foliar application of trinexapac-ethyl (Primo) and two biostimulants (TurfVigor and CPR) containing seaweed extracts could alleviate summer decline in creeping bentgrass (*Agrostis stolonifera* L.). The study was performed on a 'Penncross' putting green built on a sandy loam soil at Hort Farm II, North Brunswick, NJ in 2007 and 2008.

PURPOSE

The purpose of *USGA Turfgrass and Environmental Research Online* is to effectively communicate the results of research projects funded under USGA's Turfgrass and Environmental Research Program to all who can benefit from such knowledge. Since 1983, the USGA has funded more than 400 projects at a cost of \$30 million. The private, non-profit research program provides funding opportunities to university faculty interested in working on environmental and turf management problems affecting golf courses. The outstanding playing conditions of today's golf courses are a direct result of ***using science to benefit golf***.

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Promoting Better Summer Performance of Creeping Bentgrass through Application of Trinexapac-ethyl and Seaweed Extract-based Biostimulants

Bingru Huang and Yan Xu

SUMMARY

The decline in turf quality and root growth of creeping bentgrass is a major concern in managing bentgrass greens in warm climatic and transitional regions. This article reports a study that investigated whether foliar application of trinexapac-ethyl (TE) and two biostimulants (TurfVigor and CPR) containing seaweed extracts could alleviate summer decline in creeping bentgrass (*Agrostis stolonifera* L.). The study was performed on a 'Penncross' putting green built on a sandy loam soil at Hort Farm II, North Brunswick, NJ in 2007 and 2008.

- Turf was foliar sprayed with water (control), trinexapac-ethyl (0.05 kg a.i. ha⁻¹), TurfVigor (47.75 L ha⁻¹) or CPR (19.10 L ha⁻¹) from late June to early September in a two-week interval in both years.
- Foliar application of trinexapac-ethyl helped to maintain better turf quality of creeping bentgrass under summer stress by alleviating leaf senescence, but had limited effects on root growth.
- The two seaweed-based biostimulants significantly improved visual quality of creeping bentgrass in summer by promoting both shoot and root growth.
- Application of trinexapac-ethyl and selected biostimulants following their respective label rates in a two-week interval was effective to improve summer performance of creeping bentgrass.

Creeping bentgrass (*Agrostis stolonifera* L.), a widely used cool-season grass species on putting greens, grows vigorously during spring and fall, but turf quality often declines during summer months, referred as summer bentgrass decline syndrome (1). Summer bentgrass decline is a major concern of superintendents growing creeping bentgrass on putting greens across the country, especially in the southern states and the transitional zone. Heat stress is a primary factor leading

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to the decline in turf quality and physiological activities of creeping bentgrass (10). Summer bentgrass decline is characterized by thinning turf canopy, leaf senescence, and root dieback. Root dieback inhibits the production of cytokinins, a class of plant hormones that are primarily produced in roots, which, in turn, affect shoot growth and senescence.

Management practices, such as irrigation, fertilization, mowing, pesticide use, and soil cultivation, are primarily used in managing stressed turf. In recent years, there is increasing interest in using organic compounds or natural products for promoting turfgrass health due to the increasingly stringent environmental regulations and negative public perceptions of pesticides and fertilizers. Some golf courses apply various compounds on bentgrass, hoping to improve turf growth during summer months. Incorporation of management practices such as use of natural products or plant growth regulators (PGRs) that may promote shoot and root growth may favor creeping bentgrass survival in the summer.

PGRs have been available in turfgrass management for several decades. This broad class of compounds is traditionally used in turfgrass



The decline in turf quality and root growth of creeping bentgrass is a major concern in managing bentgrass greens in warm climatic and transitional regions.

management for suppressing seedhead formation and inhibiting vertical shoot growth to reduce mowing and control weeds in low maintenance areas, such as roadsides and golf course roughs. Since the 1980s, many new chemicals have been developed that have improved efficacy and reduced phytotoxicity. In recent years, there has been increasing interest among superintendents in utilizing PGRs for multiple purposes, such as enhancing overall turf quality, promoting a smooth and uniform playing surface, and improving stress tolerance in higher maintenance areas. The use of PGRs has, therefore, become almost a standard practice in turfgrass management on golf courses.

A PGR inhibiting cell elongation, trinexapac-ethyl (Primo, Syngenta Crop Protection, Greensboro, NC), has been mainly used in for clipping reduction and improving general turf quality (7, 12, 14). Recently, trinexapac-ethyl has been found to be effective in improving turf performance under unfavorable environmental conditions, such as shade (5, 8), freezing (7), heat tolerance (16), and combined drought and heat stress (13).

Some natural products can stimulate plant growth and development are classified as plant growth promoters or collectively as biostimulants. Numerous organic products claiming to have the functions as biostimulants have emerged in recent years. The variety of ingredients in these products is remarkable (11). Biostimulants may include carbon sources, humates, microbial suspensions or powders, and hormone-containing products such as seaweed extracts. Among them, seaweed extracts are widely used in various biostimulant product formulations. Seaweed extracts contain a large number of organic compounds, such as cytokinins, auxins, amino acids, vitamins, simple and complex sugars, enzymes, and proteins, as well as inorganic nutrients, such as nitrogen, phosphorous, potassium, and iron. Seaweed extracts are particularly rich in cytokinins, and therefore, their stimulating effects on turfgrass growth have been attributed mainly to high concentrations of cytokinins, which are plant hormones regulating cell division, leaf senescence,

and stress defense.

However, not all products may be as effective as anticipated or promised. The effectiveness of growth promotion of biostimulants varies greatly with plant species, physiological condition of the plants, product formulation/composition, and application rate and timing. Many environmental factors and other cultural practices also influence the efficacy of biostimulants. Therefore, superintendents may find that the effects of biostimulants are inconsistent in many cases. Many of biostimulants promise better turf quality and stress tolerance.

In most cases, the primary ingredients in biostimulant products have proved beneficial to plant growth in controlled laboratory and/or greenhouse experiments (19). The effectiveness of PGRs and biostimulants on bentgrass summer performance under field conditions, however, is not well documented. With the increasing use of biostimulants on creeping bentgrass putting greens, the information on whether and how the biostimulants affect creeping bentgrass summer performance would help turf managers develop more efficient summer stress management practices.

This article reports results on a field study carried out in 2007 and 2008, with an aim to address the question whether foliar application of trinexapac-ethyl and two biostimulants containing seaweed extracts would alleviate decline in creeping bentgrass growth during summer months.

Research Methodology

The experiment was conducted on a putting green built to USGA recommendations established with 'Penncross' bentgrass at the Hort Farm II, North Brunswick, NJ. The green was mowed six days per week at 4 mm and clippings were removed. It was irrigated daily to replace 100% evapotranspiration water loss. A 16-4-8 (N-P₂O₅-K₂O) fertilizer was applied in April, June, and September at a rate of 122 kg ha⁻¹ of nitrogen in 2007 and 2008 to maintain adequate soil nutrient status. Fungicides (Spectro 90WDG, Daconil Ultrex, Pentathlon, and Banner Maxx) were

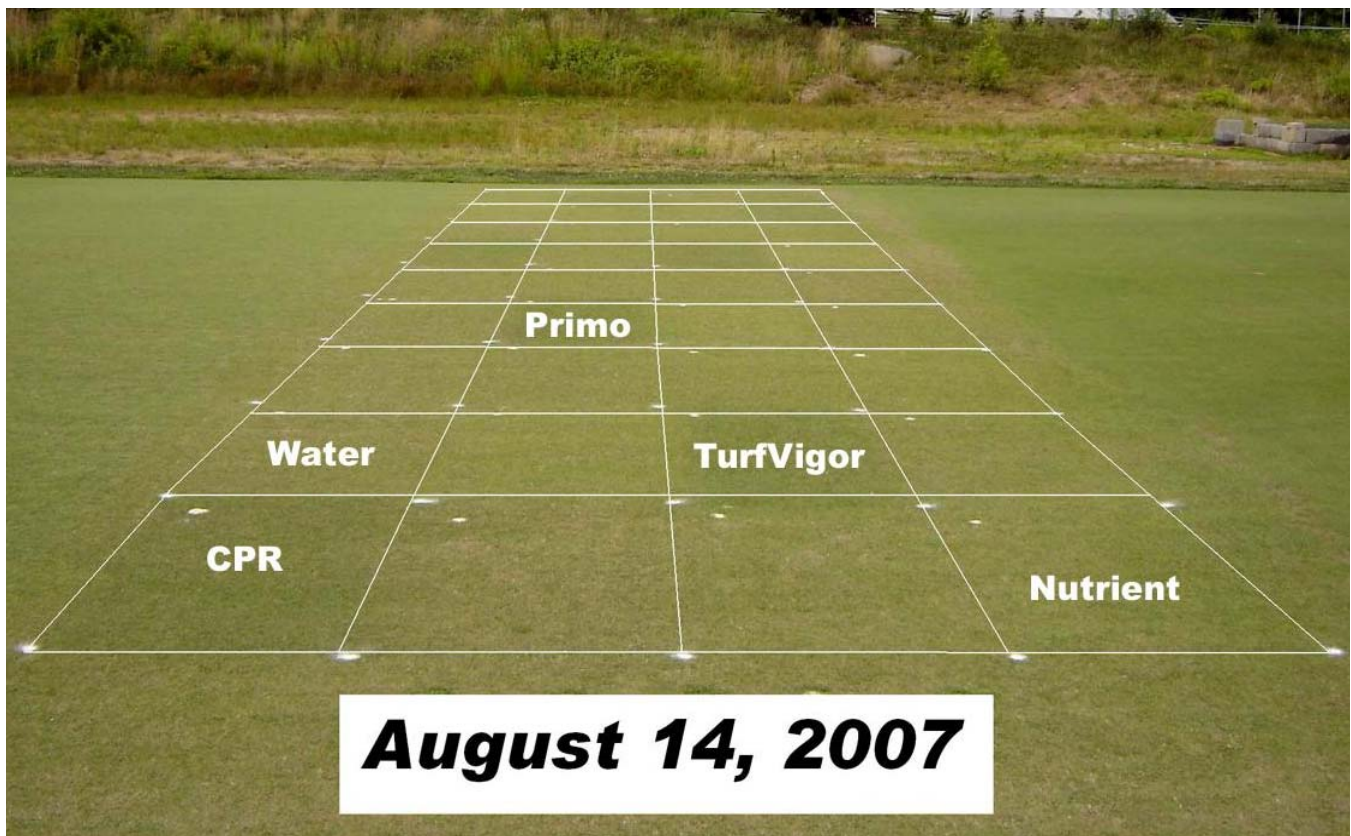


Figure 1. Effects of trinexapac-ethyl, CPR, TurfVigor and control treatments on turf quality of creeping bentgrass in August 2007.

applied on a curative basis mainly to control dollar spots and brown patch.

The two biostimulants used were CPR (Emerald Isle Solutions, Ann Arbor, MI) and TurfVigor (Novozymes Biologicals Inc., Salem, VA). CPR is a blend of natural sea plant extracts, micronutrients, and a surfactant agent. It contains 4% N, 1% K₂O, 0.53% Mg, 1% S, 2% Fe, 0.25% Mn, and 0.2% Zn. TurfVigor is a formulation containing 0.014% patented microbial strains (*Bacillus sp.* and *Paenbacillus sp.*) along with kelp extract and macro- and micro-nutrients. This product contains 9% N, 3%P₂O₅, 6% K₂O, 0.6% Fe, 0.05% Mn, and 0.05% Zn.

All three products were applied following their respective manufacturer recommended rates: 1) trinexapac-ethyl (120 g a.i. L⁻¹ emulsifiable concentrate): 0.05 kg a.i. ha⁻¹; 2) TurfVigor: 47.75 L ha⁻¹; 3) CPR: 19.10 L ha⁻¹. The water volume applied for control and carry volume for TurfVigor, CPR, and trinexapac-ethyl was 2 gal-

lons per 1000 ft². Water (control) treatment was also included in the experiment. Each control plot was treated with the same volume of water as the volume of trinexapac-ethyl or biostimulant solutions sprayed on treated plots. Treatments were applied using a CO₂-pressurized backpack sprayer on June 23, July 6, July 25, August 8, August 24, and September 7 in 2007, and on June 11, June 27, July 11, July 28, August 13, and August 27 in 2008.

Shoot growth and overall turf performance of creeping bentgrass were examined by measuring turf quality, turf density, leaf chlorophyll content, and canopy net photosynthetic rate. Root growth was examined by measuring total root surface area and root biomass.

Effects of Trinexapac-ethyl on Summer Performance of Creeping Bentgrass

Application of trinexapac-ethyl significantly improved turf quality of creeping bentgrass

from mid-August to mid-September in 2007 (Figure 1) and from early July to mid-September in 2008 (data not shown). The improvement in turf quality was associated with increases in green color and turf density. These positive effects of trinexapac-ethyl are most likely due to a combination of decreased leaf senescence and increased tillering capability. Trinexapac-ethyl has been shown to increase total chlorophyll content per unit leaf tissue and canopy density as measured through tiller counts or visual ratings (2, 3, 6, 15).

Ervin and Zhang (5) reported increases in cytokinin content in plants treated with trinexapac-ethyl. While cytokinins are known to promote tiller formation, the higher density in trinexapac-ethyl-treated turf may be associated with the increases in cytokinin production. We also observed trinexapac-ethyl application increased canopy net photosynthetic rates on some sampling dates, suggesting trinexapac-ethyl may increase photosynthetic capacity that could favor creeping bentgrass survival under summer stress.

The effects of trinexapac-ethyl application on root growth were not consistent between 2007 and 2008. Trinexapac-ethyl-treated plots had increased root biomass on two of the six sampling dates in 2007, but such effects were not observed in 2008. Some previous studies reported increased root growth (9) whereas others found no effects of trinexapac-ethyl on root biomass (6). In general, effects of trinexapac-ethyl on root growth are inconclusive. It appeared that the positive impact of trinexapac-ethyl application on improving summer turf performance in creeping bentgrass could be mainly due to its effects on turf canopy, by promoting greener and denser turf.

Effects of Biostimulants on Summer Performance of Creeping Bentgrass

The two biostimulants significantly improved visual quality of creeping bentgrass putting green during the summer in both years (Figure 1, data not shown). Leaf senescence during summer was alleviated, as manifested by suppression of chlorophyll loss and increased canopy density in plots treated with either product. The

maintenance of higher chlorophyll and more photosynthetically-active leaves enabled the maintenance of higher canopy photosynthesis in creeping bentgrass treated with TurfVigor or CPR during summer months in both years. There were also some positive effects of both biostimulants on root growth of creeping bentgrass, although the effects were not consistent throughout the entire summer months (July-September) in either year. Specifically, TurfVigor-treated plots exhibited larger root surface area on August 14 in 2007 and September 10 in 2008 and higher root biomass on July 17 and August 14 in 2007, and August 26 and September 10 in 2008. CPR-treated plots exhibited greater root biomass on September 10 in 2008.

The positive effects of seaweed-extract based biostimulants on shoot and root growth may be due to the function of various organic compounds present in the extract, particularly the relatively high levels of cytokinins. Cytokinins are known for their functions of suppressing leaf senescence and promoting tillering (17). Zhang and Ervin (18) recently compared the effects of seaweed-based cytokinins to a cytokinin standard (10 μ M ZR) on creeping bentgrass under heat stress (35/25 $^{\circ}$ C, day/night) and found that endogenous cytokinin contents increased to comparable levels for the two treatments. Therefore, application of seaweed-based biostimulants could affect the hormone status within plants. The microbial strains in TurfVigor may have some additional beneficial effects, but need further testing.

Concluding Remarks

If used properly, plant growth regulators provide a promising management tool in promoting turf health and improving summer stress tolerance in creeping bentgrass. The effectiveness of products may vary depending on environmental factors and how products are applied. However, one must remember that plants typically grow well without additional PGRs or biostimulants in favorable environmental conditions. When turf is subjected to stressful conditions, a plant's defensive system declines. Pre-conditioning plants with

PGRs or biostimulants in anticipation of stress may enhance stress tolerance and improve turf performance. The products may not perform as well if applied later when plants are already stressed. With continued research and further understanding the mode of actions of different products, it is likely that PGRs and biostimulants, along with proper routine cultural methods, will play an increasingly important role in maintaining high quality turfgrass.

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