Will Any PGRs be Safe for Ultradwarf Bermudagrass?

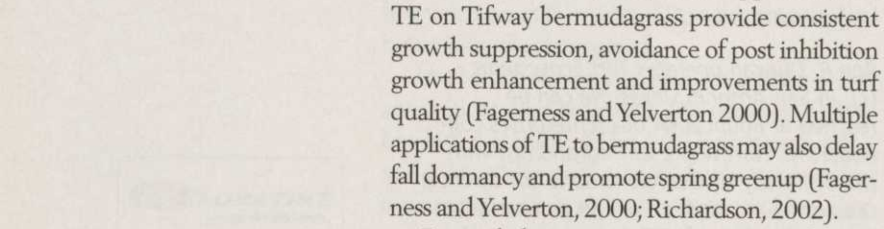
By Patrick McCullough, Haibo Liu and Bert McCarty

Successful course management is based on turfgrass quality and not total yield. Turf managers fertilize putting greens to promote color and plant health. However, luxuriant growth often disrupts surface uniformity and decreases green speeds. Inhibiting undesirable shoot growth with plant growth regulators (PGRs) provides more consistent putting surfaces and may further enhance turfgrass color and quality.

Currently, trinexapac-ethyl (TE) is the most popular PGR in the turfgrass industry. TE (Primo Maxx) represents a newer generation of gibberellic acid (GA) inhibitors that interferes with the 3b-hydroxylase conversion of GA20 to GA1, inhibiting cellular elongation in turfgrass leaves (Rademacher, 2000). Sequential applications of TE on Tifway bermudagrass provide consistent growth suppression, avoidance of post inhibition growth enhancement and improvements in turf quality (Fagerness and Yelverton 2000). Multiple applications of TE to bermudagrass may also delay fall dormancy and promote spring greenup (Fagerness and Yelverton, 2000; Richardson, 2002).

Research demonstrates TE improves turf grown under stressful conditions that would otherwise result in poor turf quality and substandard rooting. Diamond zoysiagrass (*Zoysia matrella* (L.) Merr) receiving monthly and bimonthly TE applications displayed higher root mass, higher root viability and improved photosynthesis under reduced light conditions (Qian and Engelke, 1999). Applications of TE on creeping bentgrass (*Agrostis palustris Huds.*) greens under low light intensities did not affect root mass but did increase turf cover from 6 percent to 33 percent (Goss et al., 2002). Monthly applications of TE in a two-year field study were safe on rooting of Penncross creeping bentgrass (Fagerness and Yelverton, 2001). Research is currently lacking, however, on the safety of TE applications to dwarf bermudagrass putting greens.

Recently introduced dwarf bermudagrass varieties provide Southern golf courses with a putting-green quality that is comparable to creeping bentgrass (McCarty and Miller, 2002). However, with potentially reduced photosynthetic capacity from closer mowing heights, dwarf bermudagrass turf maintained as close as one-eighth-of-an-inch may have depletion of carbohydrates available for root growth. Low cutting height and frequent mowing are directly correlated with decreases in root growth and carbohydrate reserves (Beard, 1973; Hull, 1992). Translocation of reserve carbohydrates in roots occurs after mowing for utilization in the production of new leaf tissue (Younger, 1969). Therefore, balancing photosynthate allocation away from shoot growth with TE may provide more favorable growing conditions for dwarf bermudagrass root systems. Research at Clemson University investigated effects of TE with various nitrogen (N) levels and PGR combinations on ultradwarf bermudagrass growth.



Picture 1. Untreated Champion bermudagrass vs. Champion bermudagrass treated with Primo at 1.5 ounces per acre every 10 days.

Materials and methods

Experiments were conducted at the Clemson (S.C.) University Greenhouse from September 2002 to May 2003. Experimental designs were randomized, complete blocks with four replications.

Plugs were collected from a TifEagle bermudagrass green located at the Turf Service Center in Clemson. Soil was washed and plugs

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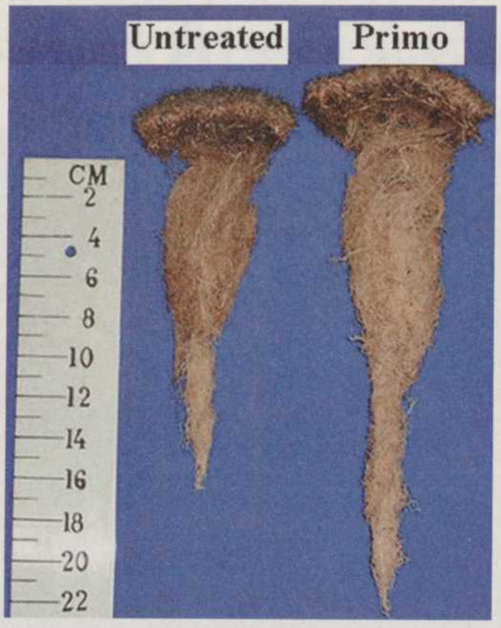

Picture 2. TifEagle bermudagrass treated weekly with 0.5 pounds of nitrogen per 1,000 square feet vs. 0.25 pounds of nitrogen per 1,000 square feet with trinexapac-ethyl every three weeks.

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placed in PVC lysimeters with 40 centimeter (cm) depths and a total surface area of 324 square centimeters built to United States Golf Association specification (USGA Green Section Staff, 1993) to help mimic field conditions. Lysimeters were irrigated to field capacity and maintained daily at five-thirtyseconds of an inch (4 millimeter [mm]) mowing height. Turf quality was measured visually on a 1 to 9 scale, where 9 equaled ideal, dark green turf and 1 equaled dead or dormant turf. For all experiments, clippings were harvested weekly and oven-dried at 100 degress Celsius for 48 hours and then weighed. Roots and verdure were harvested from entire lysimeters at the termination date, dried and weighed. Root length was determined by measuring the distance from where roots were no longer present in the soil profile to the top of the container.

Response of six cultivars

An application method commonly implemented in dwarf bermudagrass maintenance is applying TE at 1 ounce to 2 ounces per acre every seven to 10 days. Using low rates and incremental applications is a safer regimen to reduce bermudagrass injury by allowing growth adjustments to the introduced compound.

Furthermore, applying TE at low rates and frequent intervals may coincide with routine fertilizations and fungicide applications. From the success of applying TE to TifEagle bermudagrass, it is reasonable to consider that other dwarf-type bermudagrasses would benefit from its use. However, research is lacking to verify this. The objective of this experiment was to investigate growth responses of six-dwarf type bermudagrasses with and without TE applications.

Two 60-day greenhouse experiments evaluated the response of six dwarf-type bermudagrass cultivars to applications of TE at 0 ounces and 1.5 ounces per acre every 10 days.

Cultivars studied included: Champion, FloraDwarf, MiniVerde, MS Supreme, Tifdwarf and TifEagle. Turf injury was not observed from TE applications for any bermudagrass cultivar (data not shown). Trinexapac-ethyl significantly enhanced visual quality for all cultivars on every observation from 20 DAIT to 60 DAIT and effectively inhibited leaf growth (Picture 1). From four samples, TE averaged clipping yield reductions ranging 45 percent to 65 percent for all cultivars.

Root mass was enhanced approximately 25 percent for MiniVerde and FloraDwarf bermudagrass, respectively, following TE applications (results not presented). Champion, MS Supreme, Tifdwarf and TifEagle bermudagrasses treated with TE had similar root mass to the untreated respective cultivars. All bermudagrass cultivars treated with TE had similar root length to untreated turf. Overall, the TE application regime of low rates at frequent intervals appears to be effective and safe for various dwarf-type bermudagrasses.

Response to TE plus N

In this experiment, weekly nitrogen inputs were applied to TifEagle bermudagrass with an ammonium nitrate (34-0-0) solution at 0.125 (N^{6}), 0.25 (N^{12}), 0.375 (N^{18}) and 0.5 (N^{24}) pounds of N per 1,000 square feet per week. Beginning one week after the first fertilization, TE was applied at six ounces per acre (0.05 kg per hectare) every three weeks.

Trinexapac-ethyl enhanced turf visual quality 15 percent four weeks after applications compared to untreated turf (data not shown). Turf fertilized with high nitrogen rates (N^{18} and N^{24}) reached their peak quality ratings by week 8, and then declined until week 16.

From week 10 to 16, TE treatments resulted in roughly 25 percent higher visual quality from untreated turf, apparently masking quality decline of high N fertility. Visual quality enhancements are consistent with higher total chlorophyll concentrations in TE treated turf after eight weeks.

Increased N rate resulted in linear increases in clipping yield but applications of TE reduced clippings 52 to 65 percent (data not shown). Total clipping yield from all 16 sampling dates for turf treated with N^{12}, N^{18} and N^{24} with TE were similar to turf fertilized with the lowest N rate, N^{6}. After 16 weeks, TE enhanced root mass 43 percent and root length 22 percent (Picture 2 and Figure 1).

Increased N levels resulted in reduced root mass and root length, especially for N^{18} and N^{24} treated turf. However, root masses for turf treated with higher N rates with TE were similar rooting to turf treated with lower nitrogen rates without TE. The absence of a significant N x TE interaction for root mass suggests TE applications masked the influence of high N fertility on root decline.

Ethephon plus TE

A popular PGR combination in golf course management is TE plus ethephon (Primo plus Proxy). Inhibiting seedheads of the most problematic winter annual weed on bermudagrass golf courses, *Poa annua L.* (McCarty and Miller, 2002), may be achieved by combining GA inhibitors with ethephon (Proxy), a compound that decomposes to release ethylene (Gelertner and Stowell, 2001).

Synergistic growth suppression of the desired turf may occur from simultaneous GA inhibition, such as from TE and the induction of ethylene within the plant from ethephon. Turf discoloration from ethylene applications is common in both warm- and cool-season grasses. In contrast, mixing ethephon with TE has shown to reduce discoloration and prevents thinning of creeping bentgrass (Kane and Miller, 2003). This nine-week greenhouse experiment was conducted to analyze the effects of ethephon combined with trinexapac-ethyl on visual quality, rooting and clipping yield of TifEagle bermudagrass. Applications were made every three weeks with ethephon (2 liters [L]) at 0 ounces, 5 ounces and 10 ounces per 1,000 square feet with and without TE at 5 ounces per acre.

TE-treated bermudagrass had enhanced turf color from the untreated after one month. Turf treated with ethephon had up to 36 percent quality decline with initial and repeated applications.

An initial combination with TE increased phytotoxicity with ethephon treatments. However, visual quality recovered and was similar to the untreated. TE enhanced chlorophyll concentrations in both studies while ethephon treatments reduced chlorophyll concentrations 14 percent.

Ethephon reduced total clipping yield from non-PGR treated turf by 10 percent and 22 percent at 5 ounces and 10 ounces per 1,000 square feet every three weeks (Figure 2a).

In the presence of TE, bermudagrass clipping yield was reduced from non-PGR treated turf by 57 percent, 70 percent and 72 percent when ethephon was applied at 0 ounces, 5 ounces and 10 ounces per 1,000 square feet every three weeks, respectively. After nine weeks ethephon reduced root mass from non-PGR treated turf and bermudagrass treated with ethephon at 10 ounces per 1,000 square feet without TE had 33 percent less root mass (Figure 2b).

TifEagle bermudagrass treated with TE without ethephon averaged 38 percent more root mass than the untreated. Ethephon at 5 ounces and 10 ounces per 1,000 square feet every three weeks reduced TifEagle bermudagrass root length by approximately 15 percent, compared to non-PGR treated turf (Figure 2c).

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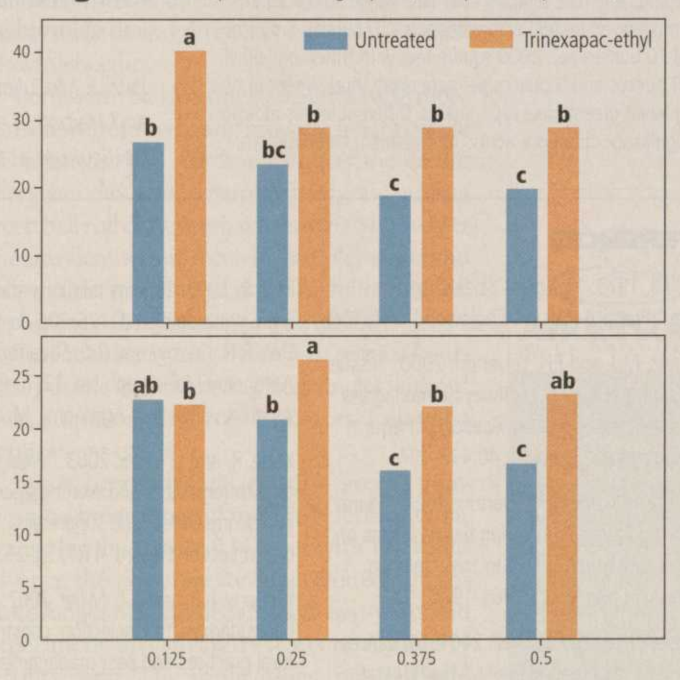
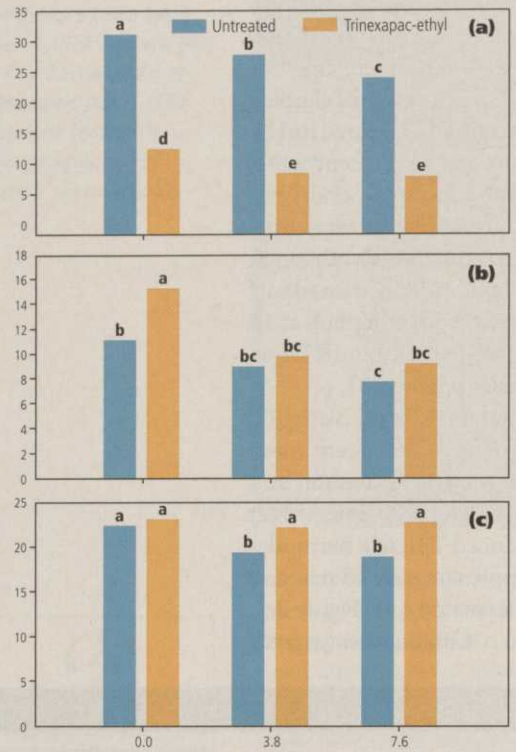
FIGURE 1



Dry root mass and root length after 16 weeks for TifEagle bermudagrass treated with weekly nitrogen inputs and trinexapac-ethyl at 6 ounces per acre every three weeks with trinexapac-ethyl at 0 ounces and 5 ounces per acre every three weeks in two combined greenhouse experiments. Different letters indicate a significant difference across all treatment combinations.

FIGURE 2

Ethephon Rate (kilograms of actual material per hectare every three weeks)



Clippings and root samples after nine weeks for TifEagle bermudagrass treated with ethephon at 0 ounces, 5 ounces and 10 ounces per 1,000 square feet with trinexapac-ethyl at 0 ounces and 5 ounces per acre every three weeks in two combined greenhouse experiments. Different letters indicate a significant difference across all treatment combinations.

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Bermudagrass treated with ethephon at 5 ounces and 10 ounces per 1,000 square feet plus TE had 12 percent and 20 percent higher root length compared to respective ethephon rates without TE after nine weeks.

This study demonstrates potential reductions in rooting and turf quality from ethephon may be counteracted by tank mixing TE on TifEagle bermudagrass. However, ethephon will probably not be a suitable PGR for regular dwarf bermudagrass management due to high phytotoxicity and turf thinning with and without TE applied.

PGR field studies at Clemson

Field studies are currently underway on dwarf bermudagrass research greens.

The first experiment is investigating four N rates with TE, similar to the greenhouse study mentioned. Another is investigating a spoon-feeding PGR approach. Despite minimal to no phytotoxicity with TE in the controlled greenhouse environment, early summer applications may result in undesirable discoloration.

Turf injury, however, could be minimized by rationing TE treatments in low rates at more frequent intervals. For example, applying 6 ounces per acre every three weeks of TE is likely to cause discoloration from initial applications. On the other hand, applications of 1 ounce to 2 ounces per acre every week could minimize phytotoxicity. This study is examining TE at 2 ounces per acre every seven days, 4 ounces per acre every 14 days and 6 ounces per acre every 21 days. Physiological responses including shoot growth, root growth and chlorophyll content will be evaluated.

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