Primo Changes Plant Hormone Levels That Prompt Beneficial Side Effects For Healthy Turf

By Erik H. Ervin and Xunzhong Zhang

Primo (trinexapac-ethyl) is probably the most commonly used plant growth regulator (PGR) on fine turf surfaces throughout the world. Most of us are quite familiar with the fact that, when used at label rates and timings, Primo reduces leaf elongation at four to seven days after initial application and will usually provide a 50 percent reduction in clippings.

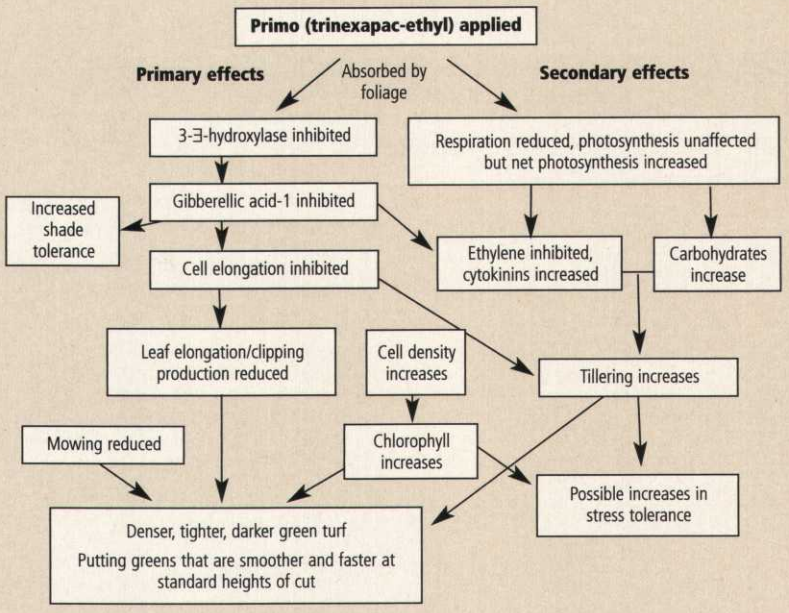
However, for many turf managers, reduced mowing frequency is often not the primary reason for continued Primo use. What they come to value most are many of the side- or secondary-effects that Primo has on turfgrass growth and development.

A recent hypothesis that we were able to test is that increased tillering and prolonged green color of Primo-treated leaves may be correlated with increased levels of cytokinins, a group of hormones responsible for cell division, new tiller initiation and delayed senescence.

However, before discussing these results, we need to spend some time trying to understand the data and observations on secondary effects that led to this hypothesis. To guide and visualize this discussion, a "Primo roadmap" has been developed presenting primary and secondary effects (Figure 1).

FIGURE 1

Proposed Roadmap of Primo (trinexapac-ethyl) Effects



Primary effects

The current formulation of trinexapac-ethyl, Primo Maxx, is absorbed by foliage one hour after application (Shepard, 2002). A radioactive tracing study reported that 24 hours after application more than 50 percent of absorbed trinexapac-ethyl remained in the foliage, while 33 percent was translocated into the crown and less than 5 percent into roots and rhizomes of Kentucky bluegrass (Fagerness and Penner, 1998).

This information indicates that the primary sites of gibberellic acid and subsequent cell elongation inhibition are shoot growing points (shoot basal and intercalary meristems).

Such inhibitions lead not only to reduced mowing requirements, but also to increased shade tolerance (Qian et al., 1998; Ervin et al., 2002; Stienke and Stier, 2003), and to smaller darker leaves with densely packed, chlorophyll-rich cells (Ervin and Koski, 2001a; Heckman et al., 2001a).

Secondary effects

The presence of dwarfed, darker green shoots has led many researchers to ask: Is photosynthetic energy conserved under regulation? If so, is conserved photosynthate being moved to

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other growing points (crown) and what is its fate? There is published evidence to support answering "yes" to all of the above.

To tell this story, we must first start with the processes of energy production and use: photosynthesis and respiration. It has been reported that Primo does not reduce photosynthesis in either cool-season (Kentucky bluegrass; Stier et al., 1997) or warm-season (zoysiagrass; Qian et al., 1998) turfgrasses and that it may even increase overall photochemical activity in creeping bentgrass (Zhang and Schmidt, 2000).

Couple this with a reported Primo-induced decrease in maintenance respiration (Heckman et al., 2001b), and it can be concluded that increased net photosynthesis may occur on Primo-treated turf.

To state it more plainly, Primo-regulated turf should contain increased free (or nonstructural) carbohydrates. This conclusion is supported by Han et al. (1998), who reported that Primo significantly increased the total nonstructural carbohydrate content of creeping bentgrass verdure (crowns + tillers) at two weeks after application, with enhancement diminishing at four weeks as inhibition subsided.

These results are also consistent with the postinhibition shoot growth flush that is often noted on PGR-treated turf that does not receive sequential applications (Bingaman and Christians, 1997).

For sequentially treated turf, the question of how these conserved carbohydrates are used remains. They could be used to increase rooting, lateral growth or tillering. Recall the general rule that shoots generally take precedence over roots for carbohydrate use during periods of optimum growing temperatures.

In fact, overapplication of nitrogen during periods of vigorous cool-season shoot growth (midspring through early summer), have been shown to favor shoot growth at the expense of root growth.

Such facts allow us to reason that increased carbohydrates caused by Primo may not be immediately used by the plant for root growth.

Additionally, since the process of leaf elongation is not functioning as a normal energy sink in Primo-regulated shoots, the next energy sink in line would appear to be the crown.

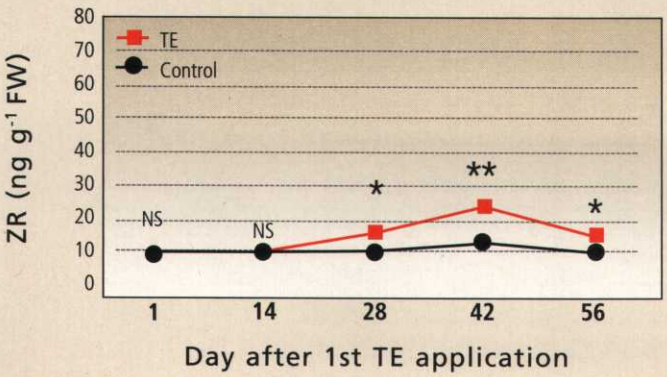
If greater carbohydrates are partitioned to the crown, more energy may be available for intravaginal and extravaginal branching. While greater tiller density of turf that has been sequentially treated with Primo has often been reported (Ervin and Koski, 1998, 2001b; Fagerness et al., 2001), no effects (positive or negative) on lateral growth (Stienke and Stier, 2003; Richardson, 2002; Fagerness and Yelverton, 2001) or gross root mass (Ervin and Koski, 1998, 2001b; Fagerness and Yelverton, 2001) have been noted

In summary, greater available energy to the crown appears to result in greater tillering, but not rooting or lateral spread of Primo-regulated turf.

Is this the whole story? No — plant devel-

FIGURE 2

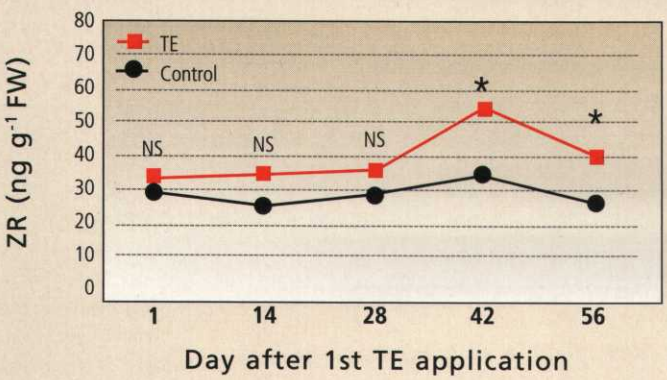
Leaf zeatin riboside (ZR) content as influenced by trinexapac ethyl in creeping bentgrass



'*' '**', significant cultivar differences on LSD=.05 and LSD=.01, respectively; NS, not significant

FIGURE 3

Leaf zeatin riboside (ZR) content as influenced by trinexapac ethyl in Kentucky bentgrass



'*' '**', significant cultivar differences on LSD=.05, LSD=.01, respectively; NS, not significant

opment is not merely controlled by how much energy is available and where; changes in the developmental pattern of growth are usually determined by certain chemical signals, that is, changes in hormone concentrations and ratios.

Plant growth and development is controlled by five classes of major plant hormones and can be broken into the "growth" hormones — cytokinins, auxins, and gibberellins — and the "stress" hormones abscisic acid and ethylene. Changes in the relative ratios of these hormones will signal certain processes to occur.

For example, a higher ratio of auxins to cytokinins will promote adventitious rooting, while a higher ratio of cytokinins to auxins will promote tiller initiation and development. Further, higher levels of ethylene relative to cytokinins will allow chlorophyll degradation and leaf senescence, while the opposite ratio will protect chlorophyll function and retard senescence.

During the early commercial development of trinexapac-ethyl and compounds with closely related chemical structures, it was shown that such compounds reduced ethylene production in addition to gibberellic acid inhibition (Grossman, 1991).

Cytokinins not only promote tillering, they also function as antioxidants, thereby helping to preserve chlorophyll integrity.

This data, along with observations of enhanced green color retention, lent credence to the hypothesis that cytokinin levels may also be enhanced in Primo-treated shoots.

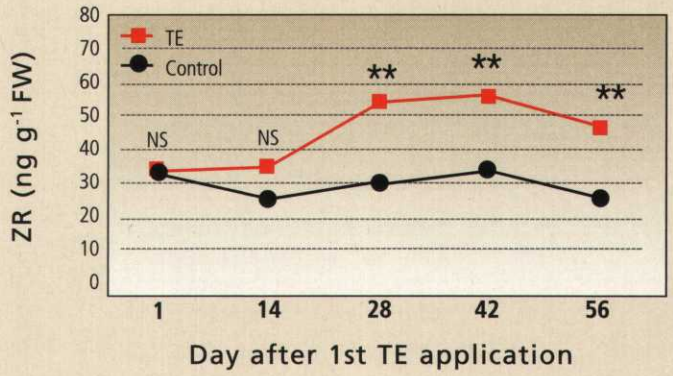
Further support for this hypothesis occurred when numerous reports of increases in tiller density because of repeated Primo applications were published because a higher ratio of cytokinins are needed to promote tillering.

Last year, our lab tested this hypothesis for the first time in L-93 creeping bentgrass, Midnight Kentucky bluegrass and Tifway hybrid bermudagrass (Ervin and Zhang, 2003).

Primo was applied every 14 days at labeled rates (3 ounces per acre (oz./A) for bentgrass, 6 oz./A for bermuda and 13 oz./A for bluegrass), and leaf tissue samples were taken every 14 days for determination of zeatin riboside levels. Zeatin riboside is one of the most prevalent and bioactive of the cytokinins present in turfgrasses.

FIGURE 4

Leaf zeatin riboside (ZR) content as influenced by trinexapac ethyl in bermudagrass



'*' '**', significant cultivar differences on LSD=.05 and LSD=.01, respectively; NS, not significant

A total of four Primo applications were made, and zeatin riboside levels were determined at five sample dates and compared to untreated controls. It was found that zeatin riboside levels increased following the second application and remained higher than the untreated control through the fourth application (Figures 2, 3, 4).

At 14 days following the last application (day 56), it appeared that zeatin riboside levels were returning to untreated levels as the inhibitory effects of trinexapac-ethyl subsided.

What are the possible implications of this new secondary-effect finding of Primo? Recently, turfgrass researchers have reported increased creeping bentgrass drought (Zhang and Ervin, 2004) and heat tolerance (Liu and Huang, 2002) because of artificially induced increases in tissue cytokinin levels.

Cytokinins not only serve to promote tillering. They also function as antioxidants to help preserve chlorophyll integrity and photosynthetic function during stress.

These results serve to support periodic research (Jiang and Fry, 1998; Zhang and Schmidt, 2000; Heckman et al., 2001c) and anecdotal (Shepard, 2002) reports indicating that.

Primo may precondition turf for improved stress resistance. As with any product, Primo

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and PGRs with similar modes of action should never be regarded as substitutes for adherence to sound cultural management programs.

However, research and practical experience continue to reveal various products that informed turfgrass managers might employ to modify plant hormone levels to encourage optimized turfgrass performance.

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