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TifEagle putting green management: Nitrogen and PGR applications

Using Primo on TifEagle greens may allow superintendents to reduce nitrogen fertilization.

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Ultradwarf bermudagrasses are improved cultivars that tolerate long-term mowing heights of 0.125 inch (3.2 millimeters) or less and produce putting green quality comparable to that of creeping bentgrass for transition zone golf courses. However, with ultradwarf cultivars like TifEagle, low mowing heights may increase sensitivity to environmental stresses and exacerbate root decline (8). Excessive nitrogen fertilization and routine close mowing may also shift turfgrass growth and nutrient allocation from roots to shoots. Therefore, maintaining sufficient nitrogen fertility levels without reducing root growth is a major agronomic concern for successful ultradwarf bermudagrass culture.

Ultradwarf bermudagrass putting greens generally require greater quantities of applied mineral nutrients than creeping bentgrass greens and higher-cut bermudagrass cultivars such as Tifway. Thus, improving nutrient use efficiency would be agronomically and economically beneficial for long-term putting green culture.

A gibberellic acid inhibitor, Primo (trinexapac-ethyl, 1EC), is widely used for putting green management and effectively reduces clippings of higher mowed bermudagrasses such as Tifway (2,4). Applications of Primo often enhance turfgrass color and quality from compacted leaf tissue containing greater chlorophyll per unit leaf area (1,7). Furthermore, incorporating Primo into fertilization programs may allow superintendents to reduce



Figure 1. TifEagle bermudagrass treated with and without Primo at four nitrogen rates in experiments, 2003-2004, Clemson, S.C.

nitrogen requirements by enhancing leaf color and minimizing the loss of nutrients removed through clipping collection.

Field experiments were conducted in Clemson, S.C., to investigate physiological and growth responses of TifEagle shoots, roots and rhizomes following nitrogen and Primo treatments (Figure 1).

Materials and methods

Field experiments were conducted from April to August 2003 and 2004 on a Tif-

Eagle bermudagrass putting green constructed approximately to USGA recommendations in July 2002 at the Turf Service Center, Clemson University, Clemson, S.C.

On April 17, 2003, potash was applied according to soil tests at 1 pound potassium/1,000 square feet (4.9 grams/square meter) to help correct deficiencies. Beginning the first week in May, turf was mowed daily at 0.125 inch (3.2 millimeters) with a Toro Greensmaster mower and irrigated as needed to prevent stress.

On June 21, 2003, and June 18, 2004, 0.25 pound nitrogen/1,000 square feet (1.2 grams/square meter) was applied to all plots with a greens-grade granular fertilizer containing nitrogen, phosphorus, potassium, magnesium, sulfur, iron, manganese and chloride.

Bermudagrass was aerified with hollow tines 4 inches (10 centimeters) long and 0.5 inch (1.3 centimeters) in diameter with 2-inch (5-centimeter) spacing on May 20 and July 28, 2003, and May 26 and July 28, 2004. Cores were removed, and holes were filled with sand topdressing similar to the root-zone mix. Bermudagrass aerification recovery was visually rated on a scale of 0% to 100%, where 0% = no recovery and 100% = complete aerification recovery. Crabgrass germination following aerification was rated by counting all the plants in each plot.

Treatments

The experimental design was a split-block with four replications of 5- × 7-foot (1.5- × 2-meter) plots. Four nitrogen rates were applied to whole plots (5 feet × 14 feet [1.5 × 4.3 meters]), and Primo was applied across nitrogen treatments over half of every block (5 feet × 7 feet [1.5 × 4.3 meters]). Ammonium nitrate solution was applied with a single-nozzle CO₂ spray tank at 0.125, 0.25,

0.375 or 0.5 pound nitrogen/1,000 square feet (0.6, 1.2, 1.8 or 2.4 grams/square meter) per week beginning April 24, 2003, and April 26, 2004. Nitrogen treatments were continued for 16 weeks thereafter. Primo (1EC) was applied at 0 or 6 ounces/acre (0 or 0.04 milliliters/square meter) once every three weeks with a CO₂ sprayer at 75 gallons/acre (70.2 milliliters/square meter) from May 8 to Aug. 9, 2003, and from May 4 to Aug. 11, 2004.

Ratings

Turf color was visually rated weekly on a 1 to 9 scale, where 1 = brown turf and 9 = dark green turf. Color ratings below 7 were considered unacceptable. Seedheads were visually rated as percent plot coverage. From May 10 to Aug. 7, 2003 and 2004, clippings were harvested with a walk-behind greensmower twice weekly, approximately 24 hours after the previous mowing. Clippings were oven-dried at 176 F (80 C) for 48 hours and then weighed. Two soil core samples (3 square inches × 12 inches [19.4 square centimeters × 30.5 centimeters) per plot were taken monthly between May 23 and Aug. 14, 2003, and between May 18 and Aug. 11, 2004. Soil samples were washed thoroughly to harvest roots and stolons/rhizomes.

After backfilling soil in sample holes,

percent lateral regrowth was measured with a sampling grid (each cell in the grid is 1 square millimeter) beginning two weeks after the first and second root samples. Total cells with plant tissue were calculated as a percentage of 3 square inches (19.3 square centimeters) until bermudagrass cover was complete.

Clippings, roots and stolon/rhizome samples were analyzed monthly for nutrient concentrations. Leaf tissue was collected for analysis on the same day as roots by collecting clippings. Soil (12-inch [30-centimeter] depth) was randomly taken from root samples and analyzed for nitrate-nitrogen concentrations. Chlorophyll concentrations (milligrams/gram of fresh clipping weight) were determined eight and 16 weeks after initial nitrogen treatments.

Results and discussion

Turf color

Throughout both growing seasons, TifEagle color improved as nitrogen rate increased. However, color declined in July and August from mower scalping and possibly from high nitrogen levels (0.375 and 0.5 pounds/1,000 square feet [1.8 or 2.4 grams/square meter] per week) that were excessive for ultradwarf bermudagrass. Fertilizing TifEagle at

PRIMO AND NITROGEN TREATMENTS

Primo (ounces/acre/3 weeks) [†]	Clipping yield [‡]	Root mass [§]	Stolon/rhizome mass [§]	Chlorophyll concentration (milligrams/gram)	Crabgrass cover (plants/square meter) [#]	Seedheads (% cover) ^{††}
	grams/square meter					
0	2.1	16.9	1,005	7.6	2	10
6	0.7	16.5	1,050	8.9	17	0.8
Nitrogen (pound/1,000 square feet/week) [†]						
0.125	0.5	18.1	1,021	10.5	6	17
0.25	1.2	17.1	1,075	7.9	18	4
0.375	1.8	16.6	1,040	7.3	6	0.5
0.5	2.0	15.0	972	7.4	8	0
Nitrogen	*	*	*	*	NS	*
Primo	*	NS	*	*	*	*

Note. An asterisk indicates a significant difference between Primo treatments or between nitrogen treatments at the 0.05 probability level. NS, no significant difference.

[†]Initial nitrogen (34-0-0) treatments were April 26, 2003, and April 24, 2004. Initial Primo treatments were May 8, 2003, and May 4, 2004.

[‡]Clippings were harvested May 10, 17, 24, 2003 and 2004; June 10, 14, 22, 24, 28, 2003 and 2004; July 2, 5, 7, 12, 14, 19, 2003 and 2004; and Aug. 7, 2003 and 2004. Clippings were oven-dried at 176 F (80 C) for 48 hours and then weighed.

[§]Roots and stolon/rhizome samples were harvested May 23, 2003; June 20, 2003; July 19, 2003; Aug. 14, 2003; May 18, 2004; June 17, 2004; July 15, 2004; and Aug. 11, 2004.

^{||}Total chlorophyll concentrations determined from samples collected June 21, 2003.

[#]Crabgrass cover was rated June 17, 2004, three weeks after aerification.

Table 1. Clipping yield, root mass, stolon/rhizome mass, chlorophyll concentration, crabgrass cover and seedhead cover of TifEagle bermudagrass treated with nitrogen and Primo in field experiments, 2003-2004, Clemson, S.C.

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0.25 pound nitrogen/1,000 square feet (1.2 grams/square meter) per week provided the most consistent turf color from April to August 2003, but in 2004, TifEagle fertilized at this rate did not produce acceptable turf color until nine weeks after initial nitrogen treatments (June 24). TifEagle in the transition zone may require higher nitrogen input (0.375 or 0.5 pound nitrogen/1,000 square feet [1.8 or 2.4 grams/square meter] per week) in spring and early summer, but these rates appear to be excessive when applied throughout the summer.

Discoloration

Primo treatments initially caused discoloration in 2003, but bermudagrass color recovered and was enhanced compared to turf not treated with Primo. In 2004 initial Primo applications did not cause discoloration, most likely because early summer tem-

peratures were warmer in 2004 than in 2003. Our research has shown that applying Primo once a week or once every two weeks at lower rates effectively reduces discoloration from early summer applications (6).

Clipping yield

Clipping yield increased with nitrogen rate (Table 1), but the clipping yield from TifEagle treated with Primo was 67% less than the yield from turf not treated with Primo.

Stolon and rhizome mass

Stolon and rhizome mass of TifEagle treated with Primo was 5% greater than that of turf not treated with Primo. Stolon and rhizome mass increased as nitrogen rate increased from May to August in both years but was 34% greater in 2004 than in 2003. Stolon and rhizome mass increased as nitrogen rate increased

from 0.125 to 0.25 pound/1,000 square feet (from 0.6 to 1.2 grams/square meter) per week but decreased with higher nitrogen rates.

Root mass

From May to August 2003, TifEagle root growth decreased as nitrogen rate increased, probably from persistent shoot growth with higher fertility rates and routine mowing at 0.125 inch (3.2 centimeters) (3,5). Applications of Primo did not affect bermudagrass root mass (Table 1).

Nutrient allocation

Monthly tissue tests showed that nutrients removed through clippings increased as nitrogen rate increased, and inhibiting bermudagrass leaf growth with Primo reduced total nutrients lost through clippings by 70% compared to turf that was not treated with Primo. Because growth suppression by Primo

NITROGEN AND PRIMO

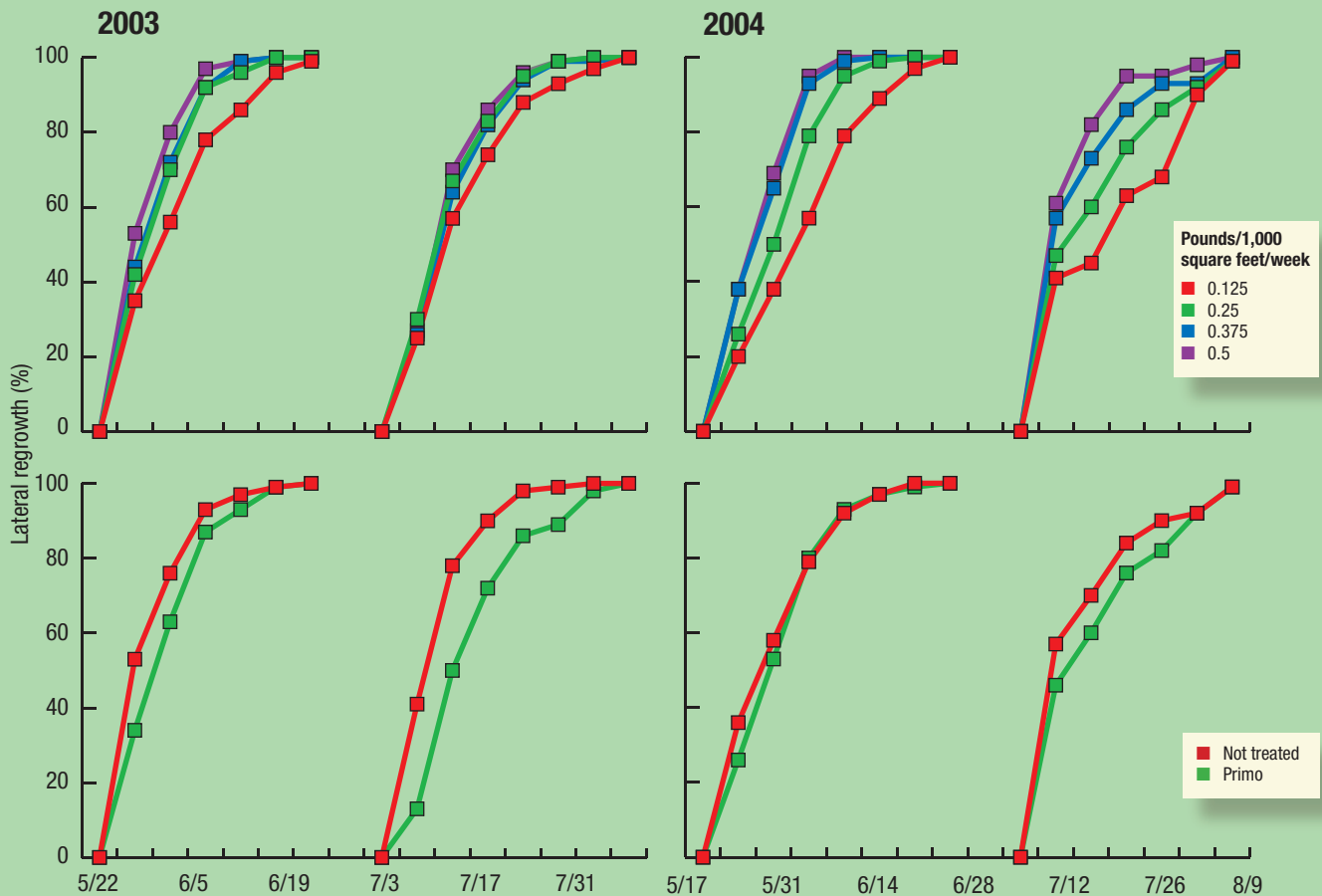


Figure 2. Percent lateral regrowth from two separate 20-square-centimeter samples of TifEagle bermudagrass treated with nitrogen (34-0-0) and Primo (0 or 6 ounces/acre once very three weeks) in field experiments in Clemson, S.C.

decreased nutrient removal through clippings, greater amounts of nutrients were retained in belowground plant tissues relative to turf that was not treated with Primo. TifEagle bermudagrass treated with Primo had about 10% to 30% higher nitrogen, phosphorus, potassium, calcium, magnesium, sulfur manganese and iron retention in rhizomes in June and August 2003, and higher nitrogen and phosphorus retention in rhizomes in July 2004. Root nutrient levels were similar to those in turf that was not treated with Primo on all sampling dates in both years.

Lateral regrowth and aerification recovery

As nitrogen rate increased, lateral regrowth increased in 2003 and early in 2004 (Figure 2). Later in 2004, lateral regrowth from higher nitrogen rates declined to the same level as regrowth from lower nitrogen rates.

Primo reduced lateral regrowth in TifEagle 4% to 34% from samples taken May 23 and 3% to 67% from samples taken June 20, 2003, compared to turf not treated with Primo. In 2003, the most significant reductions in lateral regrowth occurred one week after sod plugs were removed. In 2004, from samples taken May 18, Primo reduced lateral regrowth only 13% after two weeks. However, Primo reduced lateral regrowth 19% to 32% for up to four weeks from samples taken on June 17.

Bermudagrass recovery after aerification on May 20, 2003, increased as nitrogen rates increased one and two weeks after aerification (data not shown), but by three weeks after aerification, nitrogen rate did not affect recovery. At one week after aerification, Primo had reduced bermudagrass recovery 13% in comparison to turf not treated with Primo; however, recovery was similar for treated and nontreated turf on other dates. In 2004, at one to three weeks after aerification, Primo had reduced aerification recovery 13% to 38% in comparison to turf that was not treated.

In 2004, reduced aerification recovery caused by Primo allowed crabgrass to germinate in aerification holes by June 17, and resulted in eight and a half times more crabgrass plants per square meter than in plots that were not treated with Primo. Nitrogen fertilization rate had no effect on crabgrass germination.

Reduced lateral growth of TifEagle treated with Primo delayed aerification recovery. This may be of concern because dwarf

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says . . .

- **Applying Primo in May** to TifEagle initially caused discoloration, but turf recovered with color enhanced 10% to 25% from the untreated turf.
- **Primo reduced clippings** approximately 70% from untreated turf without restricting root growth, but Primo inhibited lateral growth, which reduced recovery from aerification.
- **TifEagle required higher** nitrogen rates from May to June (0.375 to 0.5 pound nitrogen/1,000 square feet/week), but lower nitrogen rates were sufficient to maintain acceptable turf quality in July and August (0.25 pound nitrogen/1,000 square feet/week).
- **Clipping reductions from** Primo applications reduced nutrients removed through clipping collection by approximately 70% while increasing nutrient retention in stolons and rhizomes.

bermudagrass requires routine aerification, topdressing and vertical mowing to manage prolific thatch accumulation (8). Withholding Primo treatments before aerification or enhancing nitrogen levels will probably promote quicker recovery.

Increasing nitrogen to 0.5 pound nitrogen/1,000 square feet (2.4 grams/square meter) per week caused substantial discoloration following aerification in both years, but bermudagrass color generally recovered to acceptable levels within seven days.

Seedheads

Bermudagrass seedheads were present in June of both years. TifEagle seedhead coverage was reduced as nitrogen rates increased (Table 1). Bermudagrass that was not treated with Primo averaged 10% seedhead coverage in June, but turf treated with Primo had less than 1% coverage.

Conclusions

Our results suggest that superintendents in the transition zone who consistently use Primo to manage shoot growth in ultradwarf bermudagrass may be able to reduce yearly nitrogen applications. Reducing leaf growth of ultradwarf bermudagrass greens reduces nutrient removal through clippings and favors nutrient storage in rhizomes. Primo applications do not appear to adversely affect rooting of TifEagle. However, the greater stolon/rhizome mass and reduced lateral growth may increase thatch production, which must be controlled with frequent aerification. Aerification recovery, in turn, may also be slowed by Primo through inhibited lateral growth.

Superintendents should be cautious with initial Primo treatments on bermudagrass greens in early summer because the turf is

more sensitive to plant growth regulators in cooler weather. Only actively growing and healthy bermudagrass greens should be treated with Primo, but reduced rates and sufficient nitrogen fertility in early summer will help mitigate initial discoloration.

Funding

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Literature cited

1. Ervin, E.H., and A.J. Koski. 2001. Trinexapac-ethyl increases Kentucky bluegrass leaf cell density and chlorophyll concentration. *HortScience* 36:787-789.
2. Fagerness, M.J., and F.H. Yelverton. 2000. Tissue production and quality of Tifway bermudagrass as affected by seasonal application patterns of trinexapac-ethyl. *Crop Science* 40:493-497.
3. Fagerness, M.J., and F.H. Yelverton. 2001. Plant growth regulator and mowing height effects on seasonal root growth of 'Pennncross' creeping bentgrass. *Crop Science* 41:1901-1905.
4. Johnson, B.J. 1994. Influence of plant growth regulators on two bermudagrasses. *Agronomy Journal* 86(5):805-810.
5. Liu, X., and B. Huang. 2002. Mowing effects on root production, growth, and mortality of creeping bentgrass. *Crop Science* 42:1241-1251.
6. McCullough, P., H. Liu and B. McCarty. 2006. PGR programs for bermudagrass greens. *Golf Course Management* 74(7):84-88.
7. Qian, Y.L., and M.C. Engelke. 1999. Influence of trinexapac-ethyl on 'Diamond' zoysiagrass in a shade environment. *Crop Science* 39:202-208.
8. White, R.H., T.C. Hale, D.R. Chalmers, M.H. Hall, J.C. Thomas and W.G. Menn. 2004. Cultural management of selected ultradwarf bermudagrass cultivars. Online. *Crop Management* doi: 10.1094/CM-2004-0514-01-RS.

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