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Effects of mowing and PGRs on ball roll distance

With plant growth regulators and rolling, it may be possible to reduce mowing frequency and still maintain ball roll distance.

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Managing putting greens is a challenge, and successfully maintaining turfgrasses at 0.13 inch (3.2 millimeters) or less depends heavily on sound agronomic practices. However, turf managers often have to compromise on these fundamental cultural practices to achieve both desired putting green quality and ball roll distance. Practices implemented to promote greater ball roll distance on putting greens include lowering mowing heights, double-cutting and rolling greens (5). These methods can stress turf beyond its physiological capacity and may have deleterious effects on root growth, turf vigor and the ability to recuperate from disease, traffic, heat and other environmental stresses (1).

Plant growth regulators

Incorporating plant growth regulators (PGRs) into a putting green maintenance program may provide consistent and acceptable ball roll without harming turfgrass health. Reducing turfgrass leaf growth with PGRs has become a common practice in intensive turfgrass management and may provide smoother putting surfaces by promoting lateral growth instead of undesirable top growth (6,8). Using PGRs to reduce daily growth fluctuations may provide consistent putting surfaces and may be a less stressful way to produce high-quality putting greens over the long term.

Routine mowing and PGR applications help reduce daily leaf growth, and thereby promote uniform putting green surfaces. In a recent study (2), two PGRs that are gibberellic acid inhibitors, trinexapac-ethyl and paclobutrazol, were applied monthly on Penncross creeping bentgrass (*Agrostis stolonifera*) maintained at mowing heights of 0.13, 0.16 and 0.19 inch (3.2, 4.0 and 4.8 millimeters). One month after application of



Photo courtesy of P. McCullough

Figure 1. L-93 creeping bentgrass plots were used to investigate the effects of mowing operations and PGRs on ball roll distance.

the PGRs, ball roll distance on the treated turfgrass had not increased. Reducing mowing heights to 0.13 inch did increase ball roll distance, however. In another experiment (2), treating bentgrass with PGRs increased ball roll distance on several observations throughout the same day. It was concluded that reducing mowing height produced more-consistent long-term improvements in ball roll distance than using PGRs, but PGRs may be beneficial over the course of a given day.

No research has reported the effects on ball roll distance of the PGR flurprimidol, a popular gibberellic acid inhibitor for creeping bentgrass. Another PGR commonly used on creeping bentgrass greens is ethephon. Ethephon induces ethylene, which has been shown to be effective in suppressing *Poa*

annua L. seedhead formation in creeping bentgrass putting greens (3,4). The effects of ethephon on putting green ball roll in a monostand of creeping bentgrass turf have not been reported.

Daily mowing is essential to maintain high-quality putting green surfaces and acceptable ball roll distances (5). However, other mowing operations commonly implemented to increase ball roll distance may not be necessary following PGR use.

Materials and methods

Three experiments were conducted to investigate the effects of four different PGRs and various mowing and rolling practices on ball roll distance on an L-93 creeping bentgrass green (Figure 1).

The experiments were carried out at the Turfgrass Service Center, Clemson, S.C., in 2004 on an experimental L-93 creeping bentgrass putting green established in August 2002. The experiments were conducted May 15-19, 2004 (Study 1). The experiments were repeated May 28-June 1, 2004 (Study 2), on plots located adjacent to turf used for the initial experiments.

The green was constructed approximately to USGA recommendations with a medium-fine sand root zone (7). Turf was maintained at a mowing height of 0.13 inch (3.2 millimeters) and irrigated as needed to prevent plant wilt. The green was aerified Sept. 23, 2003, and March 8, 2004, using 1/2-inch (1.3-centimeter) hollow tines. Beginning in March 2004, creeping bentgrass was fertilized weekly at 0.12 pound nitrogen/1,000 square feet (6 kilograms/hectare) with an 18-3-18 greens-grade granular fertilizer.

The experimental design was a split block with three replications of 5-foot-by-6-foot (1.5-meter by 1.8-meter) plots. Five plots were arranged per block for a total of 15 plots in

Study 1 and another 15 plots in Study 2.

Plant growth regulators

Four PGRs — Proxy 2L (ethephon), Cutless 50WP (flurprimidol), Turf Enhancer (paclobutrazol) and Primo 1EC (trinexapac-ethyl) — were used in the study (Table 1). Four plots in each block were treated with a single PGR for a total of 12 PGR-treated plots and three control plots in each of the two studies. Plots in Study 1 were treated on May 15, 2004, and plots in Study 2 were treated on May 28, 2004.

PGRs were applied with a carbon dioxide sprayer calibrated to deliver 4.4 gallons/1,000 square feet (1,800 liters/hectare). Turf plots treated with Turf Enhancer 2SC and Cutless were irrigated to a depth of approximately 0.4 inch (1 centimeter) immediately after treatment.

Mowing

Three experiments were performed in Study 1 and repeated in Study 2. In each study, two mowing treatments were performed on each of the five plots in each block.

Mowing treatments were randomly assigned in each experiment to half of every block. Mowing operations were conducted by making one pass down half of each block over all five plots with a walk-behind greensmower. Turf was mowed again after each experiment to reduce influences on the next scheduled experiment. Before the studies began, mowing treatments were randomly assigned for each day.

Experiment 1: Mowing versus rolling. Half of all plots were mowed at a height of 0.13 inch (3.2 millimeters). The other half was rolled without mowing by disengaging the mower reels. All plots were mowed approximately 24 hours before the mowing experiment began.

Experiment 2: Morning versus afternoon mowing. Half a block of plots was mowed at a height of 0.13 inch (3.2 millimeters) at 8 a.m. Another half-block was mowed at 8 a.m. and then again at 12:30 p.m.

Experiment 3: Mowing once in the morning versus mowing twice in the morning. A half-block of plots was mowed once at 8 a.m., and another half-block was mowed twice at 8 a.m.

EXPERIMENTS

Experiment

1. Morning mowing vs. rolling*
2. Mowing at 8:00 a.m. vs. 8:00 a.m. +12:30 p.m.
3. Morning single mowing vs. double mowing

Plant growth regulator [†]	Application rate	
	pounds a.i./acre	kilograms a.i./hectare
Not treated		
Proxy 2L (ethephon)	3.4	3.80
Cutless 50WP (flurprimidol)	0.25	0.28
Turf Enhancer 2SC (paclobutrazol)	0.25	0.28
Primo 1EC (trinexapac-ethyl)	0.04	0.05

Note. Mowing height for all experiments was 3.2 millimeters with a walk-behind reel-type mower.

*Turf was mowed at 0.13 inch (3.2 millimeters) approximately 24 hours before experiment initiation; rolling operations were performed with the walk-behind mower without reels engaged.

[†]Plant growth regulators were applied two days before the first experiment.

Table 1. Mowing operations and plant growth regulator applications on an L-93 creeping bentgrass putting green.

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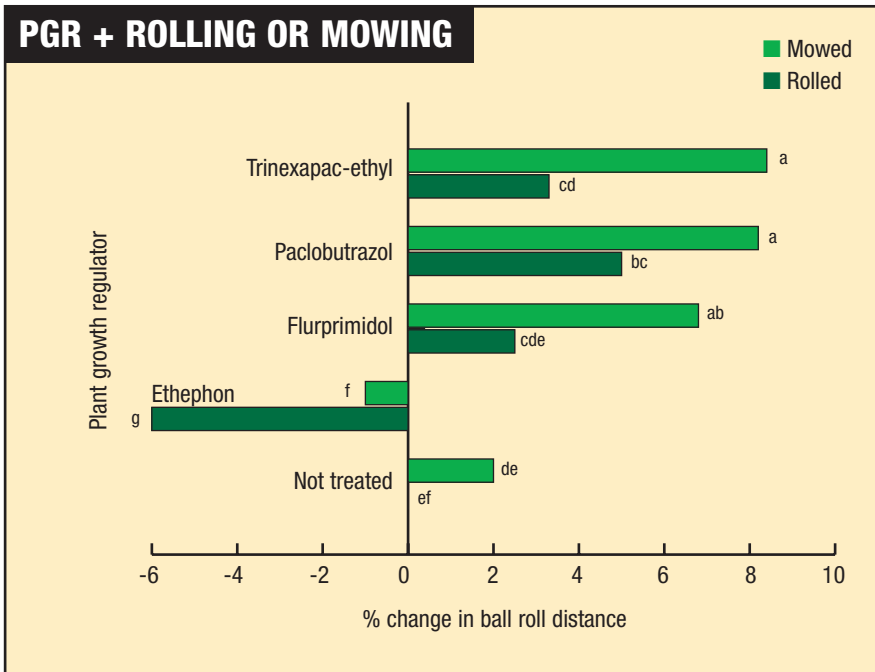


Figure 2. Percent change in averaged ball roll distance for L-93 creeping bentgrass rolled and mowed with and without plant growth regulator applications in combined field studies. Bars with different letters indicate that values are significantly different from each other. Ball roll distances are relative to those for turf that has not been treated with a PGR and has been rolled (without mowing) in the morning (0 on the axis).

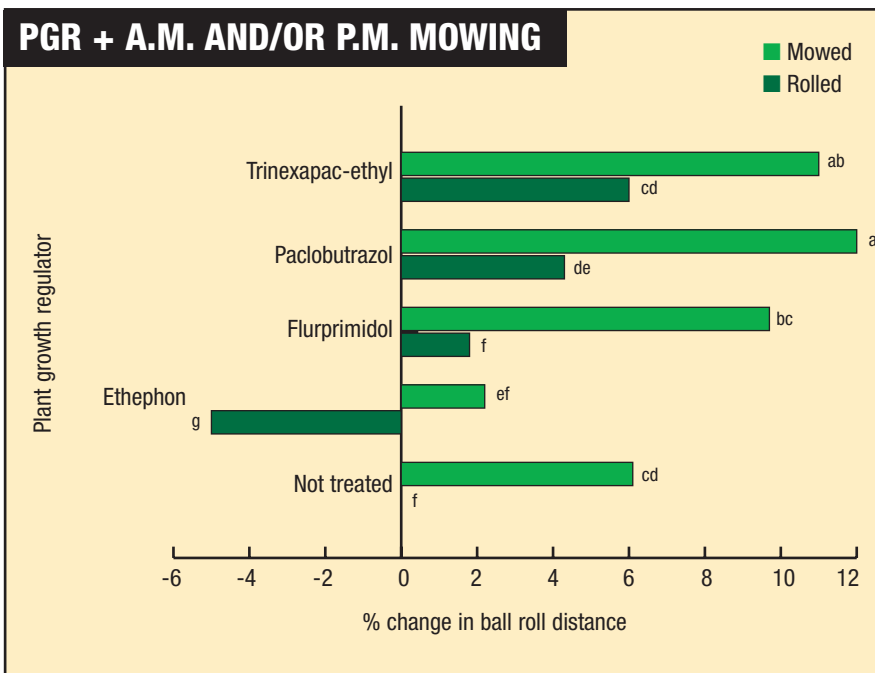


Figure 3. Percent change in averaged ball roll distance for L-93 creeping bentgrass treated with four plant growth regulators and mowed at 8 a.m., with and without a second mowing at 12:30 p.m., in combined field studies. Bars with different letters indicate that values are significantly different from each other. Ball roll distances are relative to those for turf that has not been treated with a PGR and has been mowed at 8 a.m. only (0 on the axis).

Visual quality

Turfgrass visual quality was rated on a 1 to 9 scale, where 1 = dead turf and 9 = ideal, dark green turf. Ratings below 7 were considered unacceptable.

Ball roll

Because of the length of the experimental plots, a 36-centimeter (approximately 14 inches) modified Stimpmeter was used to measure ball roll distances. Six ball roll measurements (three rolls in opposite directions) were made with the Stimpmeter on May 17, 18 and 19, 2004, for the first round of experiments (Study 1) and again on May 30, 31 and June 1, 2004, for the second round of experiments (Study 2). One end of the Stimpmeter was raised off the ground until gravity caused the golf ball to roll off the cleft on the opposite end of the Stimpmeter. Tape measures were laid parallel to the plots to measure ball roll distances.

The six rolls were averaged for each treatment (PGR and mowing combination) (Table 1). Ball roll distances were measured at several times throughout a given day; however, to simplify our results, the treatments were pooled per day and presented as overall means in figures. The effects of mowing and PGRs were not different for Study 1 and Study 2; therefore, the results of the two studies were combined and presented as overall results for ball roll distances.

Results and discussion

Experiment 1: Mowing versus rolling.

Mowing alone and the use of PGRs alone had highly significant effects on overall ball roll, but synergistic interactions did not occur. Ball roll distances decreased 6% between noon and 6 p.m. (results not shown). Although dew was removed at 8 a.m., an hour before mowing, soil and creeping bentgrass leaves likely had higher moisture at 9 a.m. and noon relative to 3 p.m. and 6 p.m. because afternoon sunlight had dried the leaf tissue and provided a better surface for ball roll.

Over the course of the day, ball roll distance was 5% greater for turf mowed in the morning compared to turf that was rolled but not mowed (Figure 2). Averaged over both rolled and mowed turf, Cutless, Turf Enhancer 2SC and Primo 1EC increased ball roll distances 3%, 5% and 4%, respectively, compared to turf that was not treated with a PGR, whereas Proxy reduced ball roll dis-

tances 5%.

Turfgrass that was treated with Cutless, Turf Enhancer 2SC, or Primo 1EC but not mowed in the morning had ball roll distances comparable to or greater than turfgrass that was mowed in the morning but not treated with one of these PGRs. Reducing mowing frequency may be beneficial to creeping bentgrass putting greens, especially during summer stress. These results suggest ball roll distances can still be maintained by rolling the turf in the morning instead of mowing if the turf has been treated with PGRs approximately 48 hours before rolling. Ethephon appears to reduce ball roll distances on creeping bentgrass putting greens that are completely free of *Poa annua*.

Experiment 2: Morning mowing versus morning and afternoon mowing. Daily leaf growth caused a linear decrease in ball roll distances between 12:30 p.m. and 6:30 p.m. Mowing and PGR use did not mask the influence of daily leaf growth on ball roll distances; however, both practices significantly affected overall ball roll distance (Figure 3). For turf mowed at 8 a.m. and again at 12:30 p.m., ball roll distance was 6% greater between 12:30 p.m. and 6:30 p.m. than it was on turf mowed only at 8 a.m.

For plots mowed only at 8 a.m., ball roll distance increased 5% on plots treated with Turf Enhancer 2SC and 6% on plots with Primo 1EC when compared to ball roll distance on plots not treated with PGRs and also mowed only at 8 a.m. (Figure 3). On Proxy-treated plots mowed at 8 a.m., ball roll distance was reduced 5%.

Compared to creeping bentgrass plots that were not treated with PGRs and mowed at 8 a.m. and again at 12:30 p.m., turf mowed only at 8 a.m. and treated with Primo 1EC had similar ball roll distances at 12:30 p.m. and 3:30 p.m. and 2% greater ball roll distances at 6:30 p.m. (results not shown). Creeping bentgrass leaf growth suppression following Primo 1EC and Turf Enhancer 2SC applications may promote increases in ball roll distance comparable to those for turf that was not treated with PGRs and received afternoon mowing. For plots mowed at 8 a.m. and 12:30 p.m. and treated with flurprimidol, Turf Enhancer 2SC or Primo 1EC, average ball roll distances were 9%, 12% and 11% longer, respectively, than ball roll distances for plots that were not treated with PGRs and mowed only at 8 a.m. Ball roll distance for

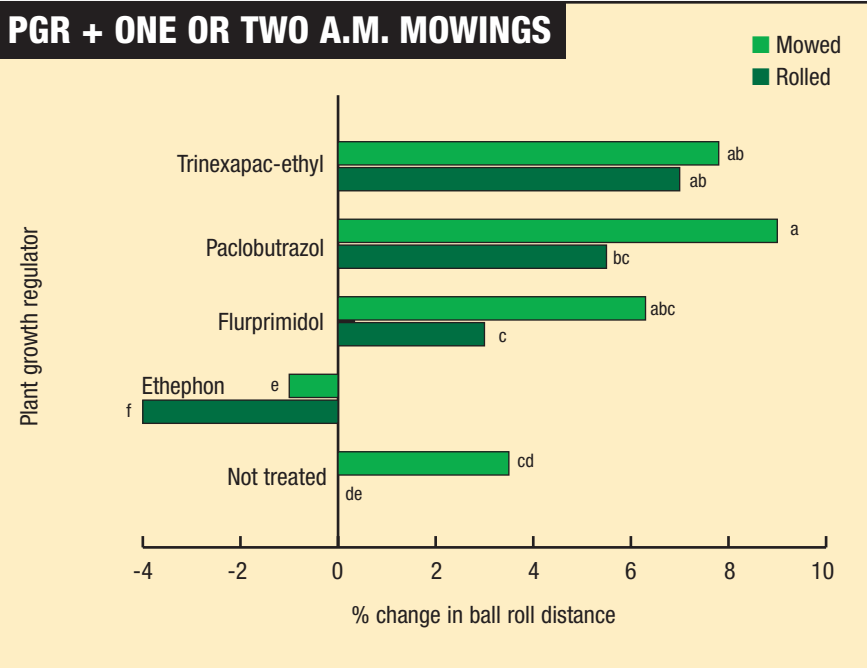


Figure 4. Percent change in averaged ball roll distance for L-93 creeping bentgrass treated with four plant growth regulators and mowed once or twice at 8 a.m. in combined field studies. Bars with different letters indicate that values are significantly different from each other. Ball roll distances are relative to those for turf that has not been treated with a PGR and has been mowed once at 8 a.m. (0 on the axis).

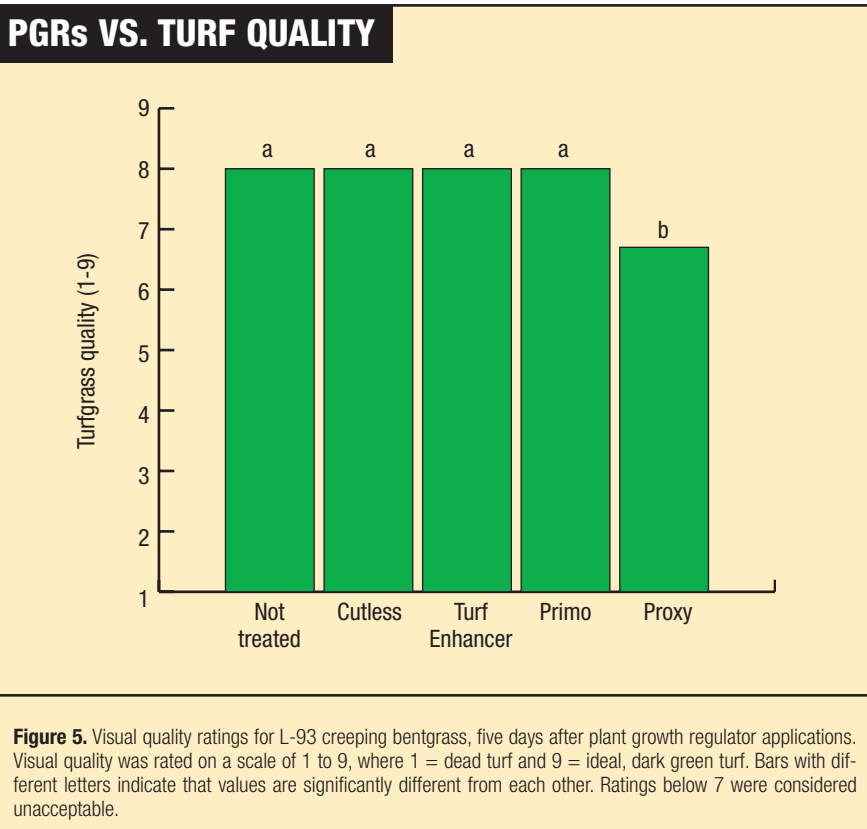


Figure 5. Visual quality ratings for L-93 creeping bentgrass, five days after plant growth regulator applications. Visual quality was rated on a scale of 1 to 9, where 1 = dead turf and 9 = ideal, dark green turf. Bars with different letters indicate that values are significantly different from each other. Ratings below 7 were considered unacceptable.

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turf not treated with PGRs and mowed at 8 a.m. and again at 12:30 p.m. was 6% greater than ball roll distance for turf not treated with PGRs and mowed only at 8 a.m.

Experiment 3: Single versus double-mowing. Turfgrass daily leaf growth decreased ball roll distances from 8 a.m. to 4 p.m. (results not shown). Mowing twice in the morning increased ball roll distance 3% compared to mowing once. Ball roll distances of creeping bentgrass mowed once in the morning and treated with Cutless, Turf Enhancer 2SC and Primo 1EC were increased approximately 3%, 5% and 6%, respectively, but treatment with Proxy reduced ball roll distances 4% compared to the ball roll distance of turf that was not treated with a PGR and mowed once in the morning (Figure 4). Compared to turf not treated with a PGR and mowed twice in the morning, creeping bentgrass mowed once and treated with Turf Enhancer 2SC or Primo 1EC had 6% longer ball roll distances at 8 a.m. (results not shown). At noon and 4 p.m., turf treated with Primo 1EC or Turf Enhancer 2SC and mowed once in the morning had ball roll distances greater than or equal to those for turf not treated with PGRs and mowed twice in the morning. Compared to turf not treated with PGRs and mowed only once at 8 a.m., ball roll distances for creeping bentgrass mowed twice at 8 a.m. were 6% greater when treated with Cutless, 9% greater when treated with Turf Enhancer 2SC and 7% greater when treated with Primo 1EC. Ethephon-treated turf mowed twice in the morning averaged ball roll distances equivalent to creeping bentgrass not treated with a PGR and mowed once in the morning.

Visual quality. Ethephon-treated turf had unacceptable visual quality (ratings below 7) five days after treatments (Figure 5). Although Proxy is an effective PGR for *Poa annua* seedhead suppression on creeping bentgrass putting greens, it appears to have deleterious effects on visual quality and ball roll distances on a monostand of creeping bentgrass maintained under putting green conditions. The visual quality of turf treated with Cutless, Turf Enhancer 2SC or Primo 1EC was similar to that of turf that had not been treated with a PGR.

Summary

In conclusion, routine mowing and PGR applications help minimize the impact of daily leaf growth, thus, promoting uniform

THE RESEARCH | says . . .

- **Incorporating plant growth** regulators (PGRs) into a putting green maintenance program may provide an approach to consistent and acceptable ball roll that is less stressful to turfgrass health.
- **Mowing and rolling** can also improve ball roll distance.
- **In all cases**, the PGR Proxy reduced ball roll distance, and the PGRs (gibberellic acid inhibitors) Cutless, Primo 1EC and Turf Enhancer 2SC increased ball roll distance.
- **The combination of** gibberellic acid inhibitors and supplemental mowing provided the greatest increases in ball roll distance when compared to routine daily mowing of untreated turf.
- **In combination with** PGRs and mowing, some management practices such as nitrogen fertility and irrigation may also affect ball roll distance.

surfaces for ball roll. Inhibiting turfgrass leaf growth with PGRs may not arrest daily leaf growth fluctuations; however, ball roll distances are significantly increased relative to turf that is not treated with a PGR.

Putting green ball roll distance enhancements following flurprimidol, Turf Enhancer 2SC and Primo 1EC applications may be comparable to supplemental mowing operations commonly employed to promote green speeds. Ethephon, however, does not appear to be a suitable PGR for promoting ball roll on a monostand creeping bentgrass putting green. Applying gibberellic acid inhibitors may allow superintendents to reduce mowing frequency without compromising ball roll distances. Furthermore, the combination of gibberellic acid inhibitors and supplemental mowing provided the greatest ball roll distance increases relative to routine daily mowing of untreated turf. Ball roll distance results following PGR use may vary with management practices such as nitrogen fertility and irrigation. Testing mowing operations and PGRs on a nursery green before taking them to the course may help in determining whether mowing practices can be compromised when using PGRs in a particular maintenance program.

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