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Rapid Conversion of the Golf Course Putting Greens to Glyphosate-resistant Creeping Bentgrass

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Abstract
A genetically transformed creeping bentgrass cultivar that is resistant to the nonselective herbicide glyphosate has been developed. To date, glyphosate-resistant creeping bentgrass is not commercially available, but its use could ease weed control and improve overall quality of the putting surface. This innovation presents golf course superintendents with the opportunity to convert existing putting greens to glyphosate-resistant creeping bentgrass. To minimize disruption of golf play, methods that speed conversion of putting greens are needed. The objectives of this experiment were to evaluate how seeding date, mowing height, and nitrogen (N) fertility level affect conversion speed of established putting greens to glyphosate-resistant creeping bentgrass.

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Introduction

A genetically transformed creeping bentgrass cultivar that is resistant to the nonselective herbicide glyphosate has been developed. To date, glyphosate-resistant creeping bentgrass is not commercially available, but its use could ease weed control and improve overall quality of the putting surface. This innovation presents golf course superintendents with the opportunity to convert existing putting greens to glyphosate-resistant creeping bentgrass. To minimize disruption of golf play, methods that speed conversion of putting greens are needed. The objectives of this experiment were to evaluate how seeding date, mowing height, and nitrogen (N) fertility level affect conversion speed of established putting greens to glyphosate-resistant creeping bentgrass.

Materials and Methods

This experiment was conducted near Gilbert, IA, at the Iowa State University Horticultural Research Station on a native-soil putting green, which was established to Crenshaw creeping bentgrass one year before the start of this experiment. The experimental design was a split-split plot. Main plots that evaluated seeding dates were arranged in a randomized complete block design. Split plots that evaluated mowing regimes were randomized within each main plot. Split-split plots that evaluated N fertility levels were randomized within each split plot.

Seeding dates of August 16, September 1, September 17, and September 30, 2004, were investigated in the experiment. We applied glyphosate to main plots one day before seeding. The T.I.P. greens spiker/seeder was used to prepare the surface for seeding. The result was holes approximately the size of a pencil, which penetrated approximately 0.5 in. into the soil. Glyphosate-resistant creeping bentgrass was seeded at 1.5 lb/1,000 ft^2. The plots were topdressed with sand, which was brushed in to smooth the surface. Glyphosate was applied 21 days after germination to remove seedlings not resistant to glyphosate and any Crenshaw creeping bentgrass that had recovered.

Mowing regimes included the following: 1) The mowing was initiated at 0.25 in. when seedlings reached 0.275 in. The height of cut was reduced at a rate of 0.03 in./week. 2) The mowing began at 0.25 in. when seedlings reached 0.275 in.; the height of cut was reduced at a rate of 0.03 in./week when plots reached approximately 100% turf cover. 3) The mowing was initiated at 0.5 in. when seedlings reached 0.53 in. After plots had achieved approximately 100% turf cover, the height of cut was reduced at a rate of 0.06 in./week.

Nitrogen fertility treatments began one week after seeding and were made weekly supplying N at 0.25 or 0.5 lb/1,000 ft^2.

The percentage of glyphosate-resistant creeping bentgrass cover was estimated by visual observation of plots on October 8, 2004, and May 6 and 27, 2005. The cover of plots seeded on September 17 was not estimated on October 8 because of slow seed germination. Glyphosate-resistant creeping bentgrass cover of plots seeded on September 30 was not recorded on October 8 for the same reason. Only observations made on these two dates were included in the statistical analysis. Data were analyzed by using the mixed linear model procedure of the statistical analysis system. Seeding date, mowing regime, and N fertility level were analyzed as fixed effects with blocks random.. Mean comparisons for seeding date and mowing regime main effects, as well as for all interactions, were made by using an F-protected least significant difference test. Means for N fertility levels were separated by using the F-ratio obtained from the analysis of variance. All tests of significance were made at the $P \leq 0.05$ level.

Results and Discussion

Our results indicate that it is possible to convert a previously established putting green to glyphosate-resistant creeping bentgrass with minimal interruption to golf play. Seeding on August 16 resulted in the most rapid establishment (Table 1). When seeding occurred in late summer (August 16), glyphosate-resistant creeping bentgrass was mowed at putting green height late in the fall, and golf play could have been resumed approximately 7 to 10 weeks after seeding.

We found that when glyphosate-resistant creeping bentgrass seedlings were initially mowed to a height of 0.25 in. and the putting green was allowed to achieve almost a full cover before the height of cut was lowered by 0.03 in./week, complete turf cover was achieved rapidly and putting green quality was maintained (Table 2). However, the mowing strategy should be adjusted based on weather conditions during conversion and progress of establishment.

We did not observe any differences in establishment in response to N fertility level, but it is possible that higher N levels and shorter application intervals may hasten glyphosate-resistant creeping bentgrass establishment.

Table 1. Percentage of glyphosate-resistant creeping bentgrass cover to convert a native-soil putting green from Crenshaw creeping bentgrass to glyphosate-resistant creeping bentgrass in 2004. [3]

	Time (date of observation)		
	2004	2005	
Seeding date	Oct 8	May 6	May 27
	%		
August 16	93 a[1]	96 a	97 a
September 1	56 b	85 a	88 a
September 17	---[2]	55 b	77 a
September 30	---[2]	21 c	45 b
LSD (0.05)	20	25	28

[1]Values within a column followed by the same letter are not significantly different at P≤0.05 according to Fisher's F-protected least significant difference test.

[2]Percentage cover of glyphosate-resistant creeping bentgrass was not sufficient enough for an accurate estimation.

[3]Glyphosate was applied one day before each respective seeding date and plots were seeded at 1.5 lb/1,000 ft^2. Values are means from three replications averaged across all other factors investigated in the study.

Table 2. Percentage of glyphosate-resistant creeping bentgrass cover for each mowing regime investigated to convert a native-soil putting green from Crenshaw creeping bentgrass to glyphosate-resistant creeping bentgrass in 2004.[2]

	Time (date of observation)		
	2004	2005	
Mowing regime	Oct 8	May 6	May 27
	%		
Initial mowing at 0.25 in., reduced height of cut 0.03 in./week	64 b[1]	60 b	72 a
Initial mowing at 0.25 in., reduced height of cut 0.03 in./week after ≈ 100% turf cover was achieved	77 a	65 ab	79 a
Initial mowing at 0.5 in., reduced height of cut 0.06 in./week after ≈ 100% turf cover was achieved	82 a	68 a	80 a
LSD (0.05)	6	6	7

[1]Values within a column followed by the same letter are not significantly different at P≤0.05 according to Fisher's F-protected least significant difference test.

[2]Glyphosate was applied one day before each respective seeding date and plots were seeded at 1.5 lb/1,000 ft^{-2}. Values are means from three replications averaged across all other factors investigated in the study.