Turfgrass and Environmental Research Online

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Research trials were initiated by scientists at North Carolina State University to determine if an existing 'Penncross' bentgrass fairway could be renovated with Roundup-ready creeping bentgrass (RRCB) utilizing non-destructive seedbed preparation in combination with sub-lethal Roundup (glyphosate) applications. The intent was to test whether fairway conversion to RRCB could be accomplished while play could be continued uninterupted during RRCB establishment.

Volume 5, Number 4
February 15, 2006

PURPOSE

The purpose of *USGA Turfgrass and Environmental Research Online* is to effectively communicate the results of research projects funded under USGA's Turfgrass and Environmental Research Program to all who can benefit from such knowledge. Since 1983, the USGA has funded more than 290 projects at a cost of $25 million. The private, non-profit research program provides funding opportunities to university faculty interested in working on environmental and turf management problems affecting golf courses. The outstanding playing conditions of today's golf courses are a direct result of ***using science to benefit golf***.

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Interseeding Roundup-ready Creeping Bentgrass into Established 'Penncross' Creeping Bentgrass

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SUMMARY

With the forthcoming registration of Roundup-ready creeping bentgrass (RRCB), optimum means of establishment must be determined. Research trials were initiated to determine if an existing bentgrass fairway could be transitioned to RRCB utilizing sublethal rates of Roundup and various seedbed preparation techniques. The idea to be tested was that sublethal rates of Roundup could be utilized along with seedbed preparation to allow RRCB to establish while maintaining an acceptable playing surface allowing a course to remain open for play during the transition. Sublethal Roundup rates were also staggered at various timings around seeding to determine if the initial application timing was crucial. Additionally, seedbed preparation techniques included vertical mowing in two directions, vertical mowing in two directions in combination with core aerification, and no seedbed preparation. The results included the following:

- Establishment of RRCB by interseeding into existing creeping bentgrass did not allow for a timely transition to RRCB.
- We were unable to maintain an acceptable playing surface during the transition to RRCB utilizing sublethal Roundup rates and various seedbed preparation techniques.
- Interseeding new and improved bentgrass cultivars into existing bentgrass is most likely not a successful practice, regardless of seedbed preparation.
- RRCB establishes similarly to non-transgenic bentgrass cultivars when seeded into conventionally prepared seedbed.

Roundup-ready creeping bentgrass (*Agrostis stolonifera*, RRCB) is a product of The Scotts Company and Monsanto which is similar to Roundup-ready agricultural crops which have been commercially available for several years. However, if Roundup-ready creeping bentgrass is approved and receives federal registration, it will be the first genetically modified turfgrass. Recently, much research has been initiated to investigate various applications as well as potential areas of concern associated with RRCB.

Upon the registration and approval of RRCB, golf course superintendents would have the opportunity to incorporate RRCB into new golf course construction or renovate existing playing surfaces. Once RRCB is established, superintendents would be allowed to incorporate Roundup into their weed control management plans. Roundup (active ingredient glyphosate) is a non-selective herbicide having broad spectrum postemergence activity on many annual and perennial grass and broadleaf weeds, while it possesses no significant preemergence or soil activity.

Although weed control programs in RRCB should not rely solely on Roundup, it would certainly be a valuable tool in controlling hard to control perennial and annual weeds. Specifically, control options are limited with annual bluegrass (*Poa annua*) in creeping bentgrass and typically

Seedbed preparation included verticutting in two directions and core aerifying before Roundup-ready creeping bentgrass seed was applied. After seeding, light topdressing was followed by various Roundup treatments.

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USGA Turfgrass and Environmental Research Online 5(4):1-7.
TGIF Record Number: 109661

result in annual bluegrass suppression, whereas Roundup has great activity on both annual and perennial biotypes of annual bluegrass.

Another scenario where RRCB would be beneficial is in creeping bentgrass putting greens with bermudagrass surrounds. Bermudagrass encroachment into these greens has been fought by golf course superintendents with barrier and edging systems and herbicides for a number of years. However, if the greens were renovated with RRCB, superintendents would have the option of selectively controlling bermudagrass without adversely affecting the bentgrass.

Possible areas of concern with the use of RRCB include outcrossing with other *Agrostis* species, movement of transgenic seed into non-transgenic areas, and treatment of irregular shaped areas which are bordered by non-transgenic turfgrass species.

Objectives

Research trials were initiated to determine if an existing 'Penncross' bentgrass fairway could be renovated with RRCB utilizing non-destructive seedbed preparation in combination with sublethal Roundup applications. The intent was to prepare a seedbed which was conducive for RRCB establishment but where play would not be disrupted and could be continued during RRCB establishment. Additionally, with sublethal rates of Roundup, it was hypothesized the growth of the existing 'Penncross' bentgrass could be regulated which would allow the RRCB to establish.

Sublethal Roundup rates were utilized in an attempt to maintain an acceptable playing surface during the transition to RRCB. The objective was to determine if the fairway could be renovated in a non-destructive manner where the playing surface would remain acceptable, hence the course remaining open for play during renovation. Additionally, this research allows some insight into the success of interseeding bentgrass into established bentgrass stands.

Methods

The research trial was initiated at the North Carolina State University Turfgrass Field Laboratory on October 10, 2001 on an established 'Penncross' bentgrass area which was maintained as a golf course fairway at 0.4-inch height of cut. The experimental design was a split-plot with a factorial arrangement of treatments including four replications. The treatment combinations included three seedbed preparation techniques and six

Treatment 1		Treatment 2		Treatment 3		Treatment 4		Treatment 5		Treatment 6	
Time of application	Rate	Time of application	Rate	Time of application	Rate	Time of application	Rate	Time of application	Rate	Time of application	Rate
0 DAP	6	5 DAP	6	10 DAP	6	14 DAP	6	14 DAP	9	------	----
1 MAP	6	1 MAP	6	1 MAP	6	1 MAP	6	1 MAP	6	------	----
2 MAP	16	2 MAP	16	2 MAP	16	2 MAP	16	2 MAP	16	------	----
3 MAP	16	3 MAP	16	3 MAP	16	3 MAP	16	3 MAP	16	------	----
4 MAP	32	4 MAP	32	4 MAP	32	4 MAP	32	4 MAP	32	------	----
5 MAP	32	5 MAP	32	5 MAP	32	5 MAP	32	5 MAP	32	------	----
6 MAP	64	6 MAP	64	6 MAP	64	6 MAP	64	6 MAP	64	------	----
8 MAP	64	8 MAP	64	8 MAP	64	8 MAP	64	8 MAP	64	------	----
11 MAP	128	11 MAP	128	11 MAP	128	11 MAP	128	11 MAP	128	11 MAP	128
Total	364		364		364		364		367		128

Table 1. Roundup application treatments used in the study. DAP = days after planting. MAP = months after planting. Application rates are given in fluid ounces of product (Roundup Pro) per acre.

After the glyphosate application had time to air dry, the RRCB was seeded with shaker jars and the trial area was lightly topdressed to increase soil to seed contact.

Roundup application regimes. Seedbed preparation techniques included: vertical mowing in two directions, vertical mowing in two directions plus core aerification with 0.5-inch hollow tines followed by topdressing, and no seedbed preparation. Following seedbed preparation, the resulting debris was removed prior to applying glyphosate.

Roundup application regimes evaluated various initial Roundup applications after RRCB seeding. Initial application timings included at planting, 5 days after planting (DAP), 10 DAP, two treatments at 14 DAP, and 11 months after planting (MAP) (Table 1). The 0, 5, and 10 DAP utilized six fluid ounces per acre (fl oz/a) of Roundup Pro while the 14 DAP utilized 6 and 9 fl oz/a. Additionally, the initial Roundup application timing of 11 MAP utilized one gallon per acre. After the glyphosate application had time to air dry, the RRCB was seeded with shaker jars and the trial area was lightly topdressed to increase soil to seed contact.

After seeding, the plots were maintained to encourage the establishment of RRCB and were evaluated to determine the success of interseeding RRCB into an existing 'Penncross' bentgrass fairway. After the initial Roundup application, all treated plots (excluding the 11 MAP) received monthly Roundup applications through six months after planting to determine if the existing 'Penncross' could be transitioned to RRCB while maintaining an acceptable playing surface. Monthly Roundup application rates beginning at one month after planting across treated plots were 6, 16, 16, 32, 32, 64 fl oz/a, respectively through six months after planting.

Additionally, at eight months after planting, all treated plots received 64 fl oz/a Roundup Pro while at eleven months after planting all plots (including previously nontreated) received 128 fl oz/a Roundup Pro (Table 1). The eleven month treatment of Roundup Pro (128 fl oz/a) was included to ensure the tolerance of RRCB to higher application rates of Roundup Pro as well as to determine how much RRCB was present in the plots that were previously nontreated, or plots that had received seedbed preparation and were seed-

ed but had not previously been treated with Roundup. Additionally, this will offer some insight into the effectiveness of interseeding other bentgrass cultivars into existing 'Penncross' bentgrass with seedbed preparation procedures.

The research trial was monitored and data were collected for one year. Specifically, turfgrass quality (1 - 9 scale where 1 equals dead turf and 9 equals supreme quality) and percent bentgrass cover (0 - 100% scale) were visually estimated and data were analyzed accordingly.

Results

Data were analyzed and sorted according to Fisher's Protected LSD (P=0.05) and are presented as average treatment means for seedbed preparation or Roundup application treatments (Figures 1-4). Averaged across seedbed preparation techniques at 12 and 16 WAP, all treatments were providing unacceptable turfgrass quality and RRCB cover (Figures 1 and 2). At 12 WAP, all treated plots exhibited severe phytotoxicity and non-uniform playing surface with turf quality ranging from 1.8 to 2 on a scale of 1 to 9 where 1 was completely dead and 7 was reflective of non-treated plots. At 16 WAP, turf quality increased compared to 12 WAP, but remained unacceptable ranging from 3.4 to 4.5 while RRCB cover ranged from 25 - 45% (Figures 1 and 2).

It was not until 24 WAP that RRCB turf quality and cover reached acceptable levels (Figures 1 and 2). At 24 WAP, averaged across seedbed preparation, RRCB cover exceeded 90% in all plots and no significant differences in cover were present among Roundup treatments (Figure 2). Additionally, turf quality ranged from 6.7 - 6.8 in Roundup-treated plots which was below 7 of the nontreated plots. This slight reduction in overall turf quality was evident because RRCB was not as uniform as the nontreated plots giving the RRCB plots a clumpy appearance.

Averaged across Roundup application regimes at 24 weeks after planting, turf quality was greatest in the plots where vertical mowing was completed in two directions (6.9) followed by no seedbed preparation (6.8) followed by vertical mowing in two directions in combination with core aerification (6.7) (Figure 3). These differences were statistically significantly different, but each treatment provided an acceptable playing surface. Similarly, all seedbed preparation techniques provided greater than 90% bentgrass cover

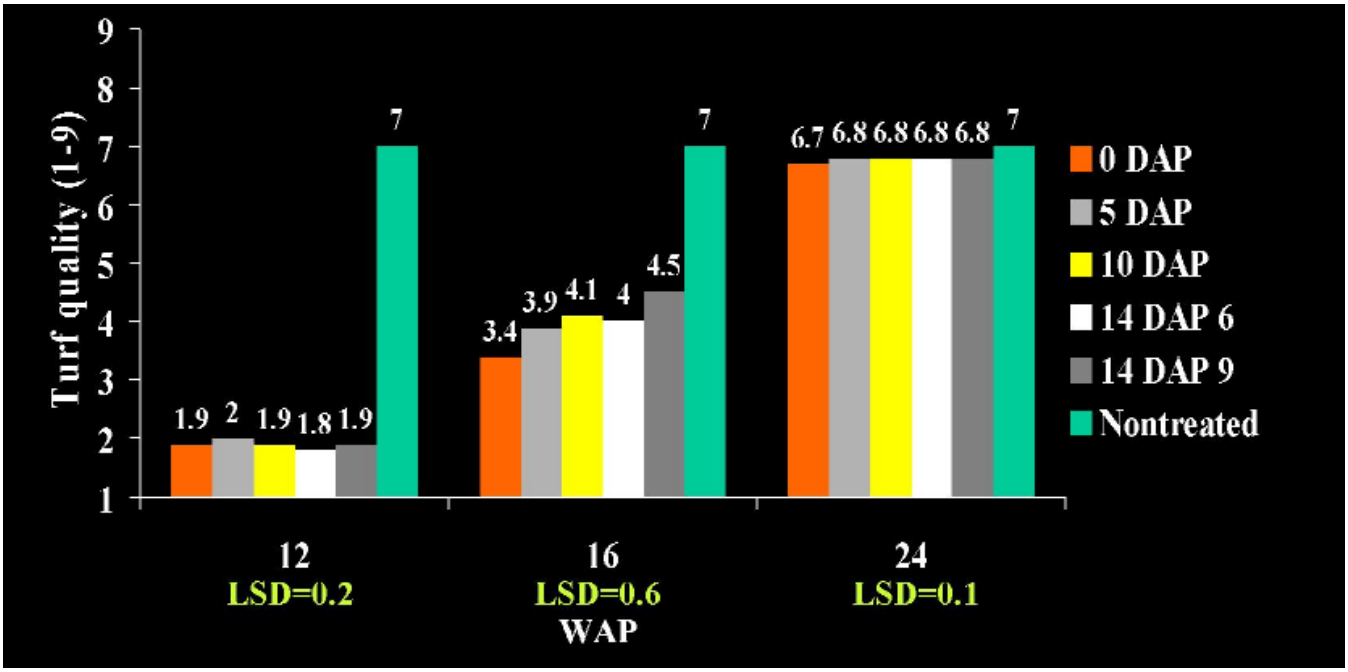

Figure 1. Turf quality of fairway creeping bentgrass plots 12, 16, and 24 weeks after planting (WAP) with Roundup-ready creeping bentgrass as affected by various postemergence applications of Roundup Pro (as shown in Table 1). Results indicate turf quality did not return to nontreated levels (indicating full transition to RRCB) until 24 weeks after planting (WAP).

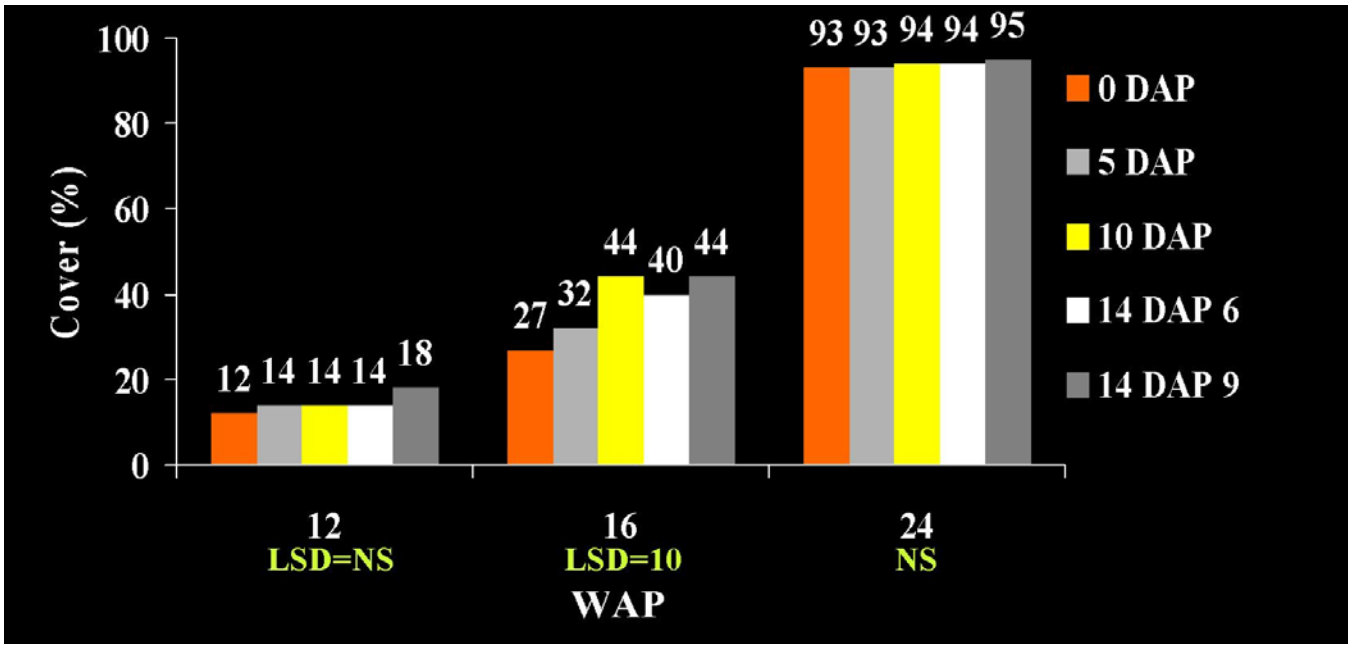

Figure 2. Turf cover (expressed as a percentage of the plot area) of fairway creeping bentgrass plots 12, 16, and 24 weeks after planting (WAP) with Roundup-ready creeping bentgrass as affected by various postemergence applications of Roundup Pro (as shown in Table 1). Results indicate turf quality did not return to nontreated levels (indicating full transition to RRCB) until 24 weeks after planting (WAP).

at 24 WAP although vertical mowing in two directions (96%) or vertical mowing in two directions in combination with core aerification (95%) provided slightly higher RRCB cover compared to that of the nontreated (91%) (Figure 4).

These data indicate interseeding RRCB into an existing 'Penncross' creeping bentgrass fairway does not provide a timely transition

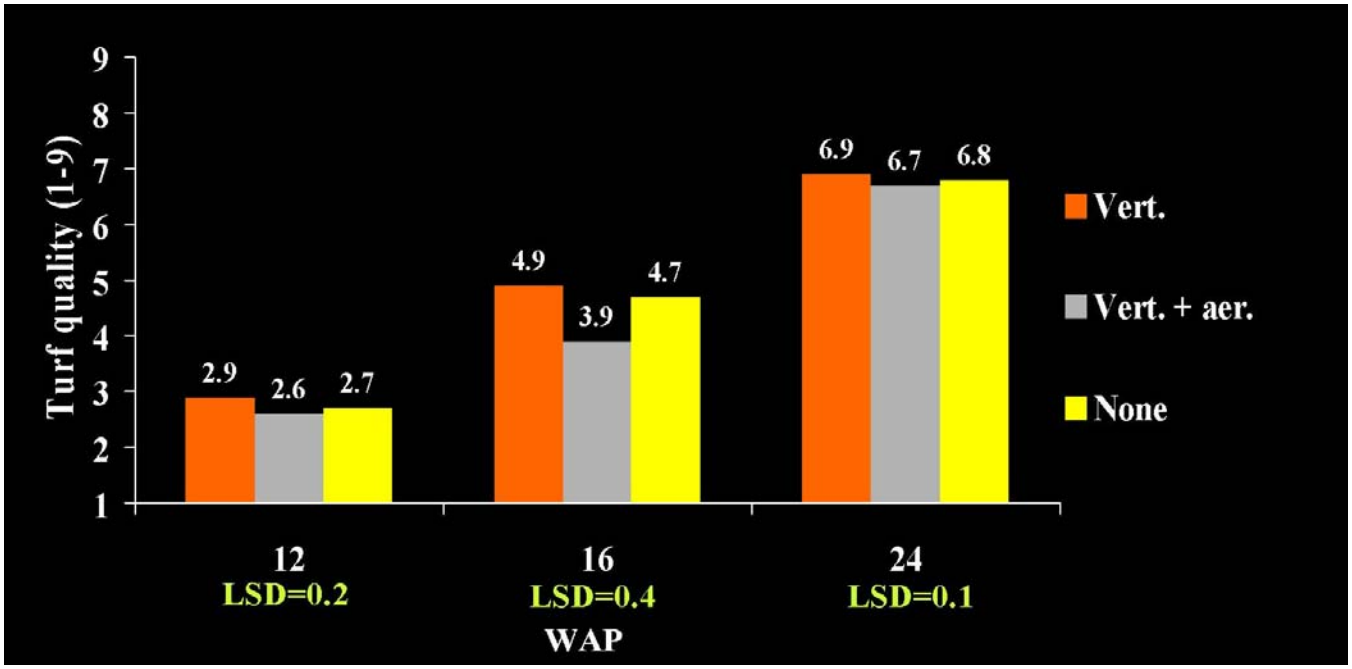

Figure 3. Mean turf quality (1-9 ratings) of fairway creeping bentgrass plots 12, 16, and 24 weeks after planting (WAP) with Roundup-ready creeping bentgrass as affected by seedbed preparation. (Vert. refers to verticutting in two directions; vert. + aer. refers to verticutting in two diretions and aerifying plots with half-inch hollow tines followed by topdressing; and none refers to plots that were seeded with no seedbed preparation prior to Roundup applications.) Results indicate turf quality did not reach acceptable levels until 24 weeks after planting regardless of if the plots received seedbed preparation or not, as long as Roundup treatments eliminated the existing 'Penncross' creeping bentgrass as the RRCB became established.

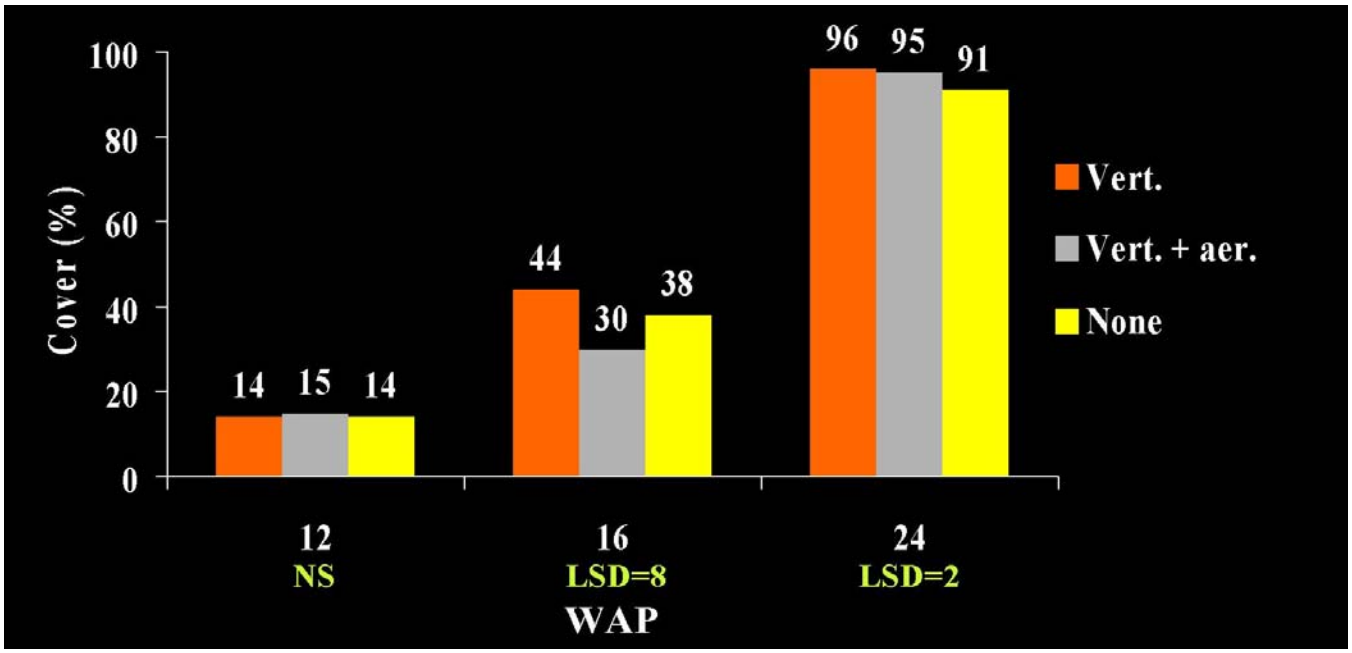

Figure 4. Turf cover (expressed as a percentage of the plot area) of fairway creeping bentgrass plots 12, 16, and 24 weeks after planting (WAP) with Roundup-ready creeping bentgrass as affected by seedbed preparation. (Vert. refers to verticutting in two directions; vert. + aer. refers to verticutting in two diretions and aerifying plots with half-inch hollow tines followed by top-dressing; and none refers to plots that were seeded with no seedbed preparation prior to Roundup applications.) Results indicate turf cover did not reach acceptable levels until 24 weeks after planting regardless whether the plots received seedbed preparation or not, as long as Roundup treatments eliminated the existing 'Penncross' creeping bentgrass as the RRCB became established.

regardless of seedbed preparation technique or Roundup application regime (1). In this trial, 24 weeks were required to obtain an acceptable playing surface which is not a timely option for renovation. Once an acceptable playing surface was achieved at 24 WAP, subtle, if any, differences were present with respect to seedbed preparation techniques or Roundup application treatments. Additionally, vertical mowing in two directions, vertical mowing in two directions in combination with core aerification, as well as no seedbed preparation resulted in an acceptable playing surface at 24 WAP indicating the seedbed preparation may not be required as it did not hasten RRCB establishment and transition.

At one year after treatment, which was one month after the 128 fl oz/a Roundup application, plots previously treated with Roundup exhibited no phytotoxicity. However, the previously non-treated plots (treatment 6 in Table 1), which received seedbed preparation and were seeded but received no Roundup until 11 MAP was completely killed, indicating no establishment of RRCB in these plots regardless of seedbed preparation technique. Interseeding new and improved cultivars into existing bentgrass may be an unsuccessful practice without the use of Roundup or other means to limit the existing bentgrass and allow the new cultivar to become established.

In additional trials, RRCB was seeded into a conventionally prepared seedbed to compare the establishment and maintenance of RRCB compared to several non-transgenic creeping bentgrass cultivars including 'Crenshaw', 'Penncross', 'Penneagle', 'Providence', 'Backspin', 'A-4', and 'L-93.' Data from these trials indicate RRCB responds similarly to conventional non-transgenic bentgrass cultivars grown under fairway conditions with the added exception of tolerance to Roundup. Additionally, RRCB established from seed grew-in similarly to non-transgenic bentgrass cultivars indicating seeding is a viable option for RRCB establishment.

Acknowledgements

The authors would like to thank Hennen Cummings, Jason Hinton, Scott McElroy, Walt Pierce, Leon Warren, and Bill Whaley for their efforts initiating the research trials. The authors would also like to thank United States Golf Association and The Scotts Company for funding of this research.

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