Short communication

Practical reestablishment of golf greens following winter damages – a field study.

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Core ideas:

1. Ice encasement and other abiotic stresses often result in 100 % winterkill of golf course putting greens in the Nordic countries.

2. In these trials, the reestablishment of winterkilled greens was better with spike seeding and slit seeding than with drop seeding which was similar to the unseeded control.

3. On average for trials, the development of turf coverage did not differ after seeding creeping bentgrass and rough bluegrass, but rough bluegrass was faster than creeping bentgrass if slit seeded at low soil temperature.

ABSTRACT

Dead greens in spring due to winterkill is common on Nordic golf courses. The objective of this research was to evaluate drop seeding, spike seeding and slit seeding of creeping bentgrass (*Agrostis stolonifera* L.‘007') and rough bluegrass (*Poa trivialis* L.) in comparison with an unseeded control treatment for reestablishment of annual bluegrass (*Poa annua* L.) putting greens after winterkill. Three trials were conducted on golf courses in Central Sweden (60-61°N, 15-16°E 70-170 m a.s.l.); two in 2017 with soil temperatures varying from 6 to 16 °C during the trial period, and one in 2018 (13-26 °C). On average for the three trials, turfgrass coverage four and six weeks after seeding was better with spike seeding or slit seeding than with drop seeding which was not different from the unseeded control. Creeping bentgrass and rough bluegrass coverage did not differ on average for three trials but slit seeded rough bluegrass had better coverage after four weeks than any of the other treatments on average for the two trials in 2017. Together with the evaluation of seed mixtures in the SCANGREEN program, this research shows that slit seeding of rough bluegrass can be recommended for faster recovery of winterkilled annual bluegrass greens in central and northern parts of the Nordic countries. Rough bluegrass can either be seeded alone to enable faster golf course opening, or it can be seeded in mixture with creeping bentgrass as part of a long-term strategy to replace annual bluegrass with creeping bentgrass.

Introduction

Winter damage on golf course putting greens is common in the five Nordic countries (Kvalbein, Waalen, Bjørnstad, Aamlid & Espevig, 2017). In Finland, Iceland and central and northern parts of Sweden and Norway, low temperature freezing injury, ice encasement, melting water and/or desiccation commonly result in complete winterkill, notably on greens with annual bluegrass (*Poa annua* L.) as the predominant grass species. The reestablishment

of dead greens in spring is challenging, partly because of low soil temperatures (Waalen, Aamlid & Heltoft, 2018), but also because toxic metabolites remaining in the thatch/mat layer after ice encasement can be inhibitory to germination and seedling growth (Brandsæter, Haugland, Helgheim, Gudleifsson, & Tronsmo, 2005).

The traditional method to re-establish greens in spring after winterkill is verticutting (scarification) followed by drop seeding. Since seed of green-type annual bluegrass adapted to Nordic climate is not available (e.g., Aamlid et al., 2019), the greens have usually been reseeded with creeping bentgrass (*Agrostis stolonifera* L.). However, this practice often results in slow development of new turf cover, partly because surface seeding offers limited seed/soil contact, and partly because creeping bentgrass has a high temperature requirement for germination and seedling growth (Waalen, Kvalbein, Aamlid, & Lönnberg, 2019). Heineck et al. (2019) documented improved ability of certain creeping cultivars, including '007'which is widely used in the Nordic countries, to germinate at low temperatures, but the implications of their findings remain to be validated under practical field conditions. Thus, the objectives of this project were (1) to compare alternative sowing methods and (2) to test rough bluegrass (*Poa trivialis* L.) as an alternative to creeping bentgrass '007' for faster reestablishment of winterkilled putting greens in spring.

Materials and Methods

Experimental sites, protocol, and implementation

The experiment was laid out on naturally winterkilled greens in central Sweden in 2017 and 2018. In the first year, the research took place at Surahammars Golf Course (GC) (59° 43′ 0″N,16° 13′ 00 E″ 71 m a.s.l.) and Leksands GC (60°43′53″N 14°59′56″ E, 164 m a.s.l.); in the second year at Surahammars GC only. All greens were sand-based and had an initial turf

cover of annual bluegrass. All greens were totally dead at the start of the experiment.

Before starting the experimental treatments, the greens were deep-aerated and verticut to 2 mm depth in two directions. Each green was then divided into two equal sections, one that was seeded with creeping bentgrass '007' and the other with rough bluegrass 'Sabrena' (Fig. 1). Each section of the green was split into four plots depending on sowing method / sowing machine: A: Unseeded control, B: One additional verticutting + drop seeding, C: Spike-seeding using SISIS Variseeder 1300 (SISIS, Kirk Langley, UK) and D: Slit-seeding using Vredo DZ Turf-Fix, 60 cm wide (Vredo DV, Dodewaard, Netherlands). The seeding rate of creeping bentgrass was 6 g m^{-2} in both years and the seeding rate of rough bluegrass was 35 and 25 g m^{-2} in 2017 and 2018, respectively. The seeding depth at spike seeding and slit seeding was 7 mm in both years.

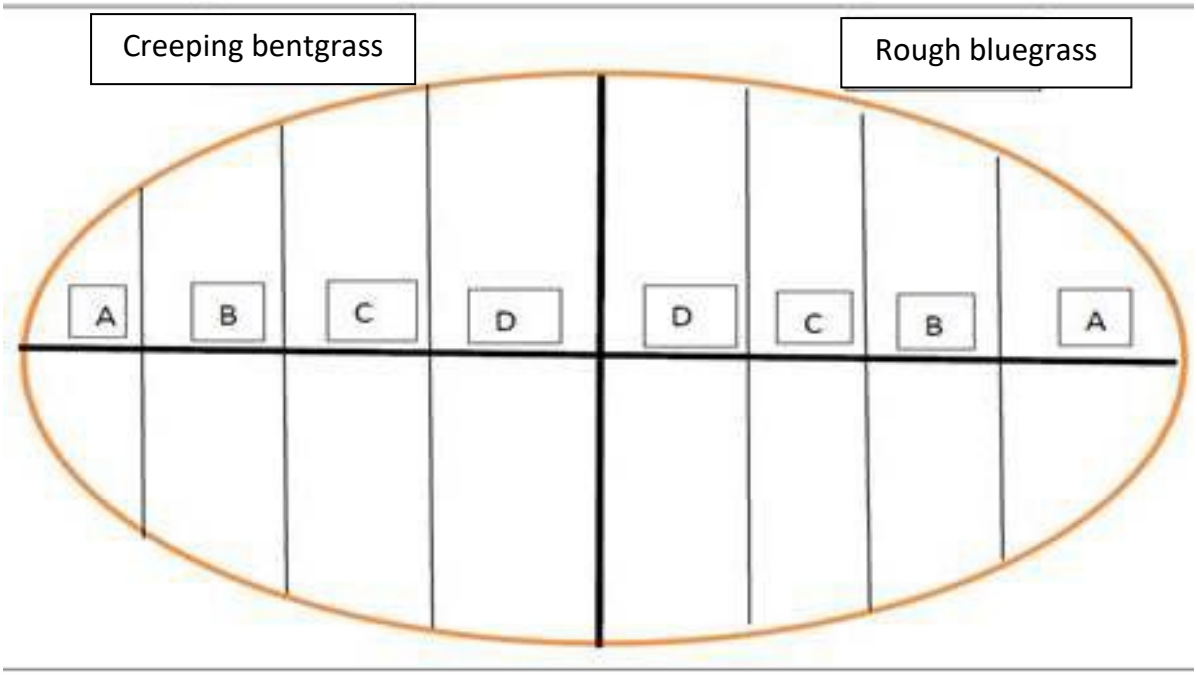

Fig. 1. Field map was in all trials. Sowing methods were as follows: A = Unseeded control, B = Verticut + drop seeding, C = Spike seeding, D = Slit seeding.

After seeding the trials were top-dressed with a sand amended with compost (10 % v/v), rolled and covered with a permeable spring tarp (Evergreen, Mississauga, ON, Canada and Lutrasil, Soft N.W., S.p.A., Cerreto, Italy) for 3 to 12 days. The tarps were removed when there was no night frost in the long-term weather forecast. Irrigation was done during the day at different intervals. The irrigation time was about 6-10 minutes per green and 3-4 repetitions was made per day. The goal was not to go below 20% volumetric soil water content.

Recordings and assessments

Soil temperature and volumetric soil water content at 0-3 cm depth were measured wo to four times at five random sites in each trial using a hand-held thermometer and a TDR sensor (Field Scout TDR 300; Spectrum Technologies, Aurora, IL, USA), respectively. The plots were assessed for turfgrass coverage after approximately four and six weeks at Surahammars GC, and after approximately four weeks at Leksands GC. Percent turfgrass coverage was assessed visually with no attempt to separate between seeded species and annual bluegrass coming from the soil seed bank. Information about seeding dates, coverage with spring tarps and assessment dates can be found in Table 1. Table 1. Dates for seeding, tarp removal on assessments in the three trials.

Year	Golf course	Seeding date	Spring tarp removal, date	First assessment of turf coverage, date	Second assessment of turf coverage, date
2017	Surahammars	11 Apr.	2 May	8 May	23 May
2017	Leksands	27 Apr.	15 May	10 May	24 May
2018	Surahammars	20 Apr.	28 Apr	18 May	31 May

Statistical analyses

Analyses of variance (ANOVA) were performed to study the effect of sowing method, seeded species and their interaction on turfgrass coverage. Each trial was considered a replicate (random variable) since there was no replication of treatments within each trial. Fishers protected Least Significant Difference (LSD) at $P \leq 0.05$ was used to separate mean values for turfgrass species, sowing methods and combinations.

RESULTS

Soil temperature and soil water content

Soil temperatures at seeding and during the subsequent weeks were 7-10°C higher in 2018 than in 2017 (Fig. 2). The volumetric soil water content at 3 cm depth was similar in the two years: 19.3% on average for six measurements at Surahammars and Leksands GC in 2017 and 21.0 % on average for four measurements at Surahammars GC in 2018.

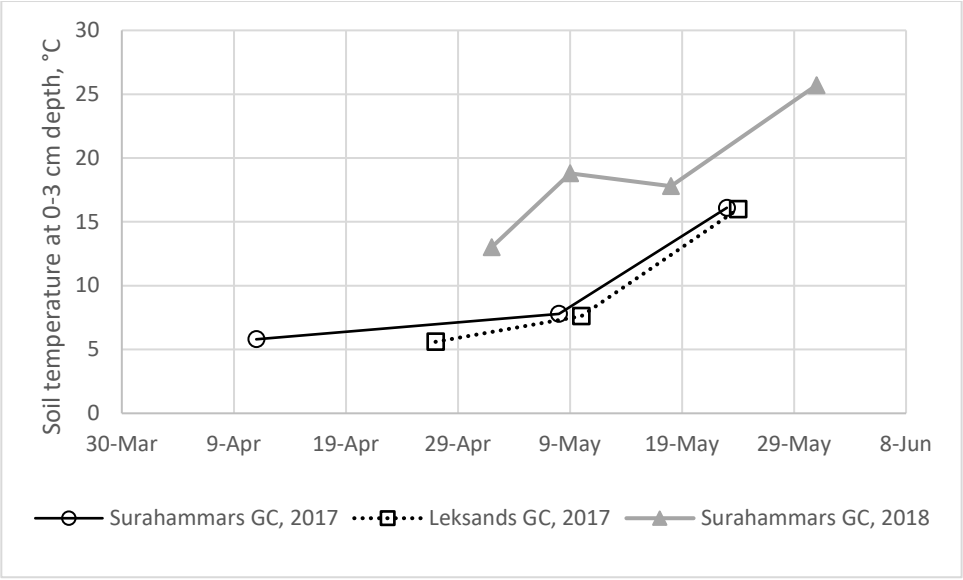

Fig. 2. Soil temperature at 0-3 cm depth measured with a hand-held thermometer during the first 4-6 weeks after seeding in three trials. Each data point is the mean of 5 measurements.

Turfgrass coverage

On average for treatments, turfgrass coverage four weeks after seeding was approximately 30 % in all trials. From four to six weeks after seeding, the coverage at Surahammars GC developed much faster in 2018 than in 2017 (Fig. 2).

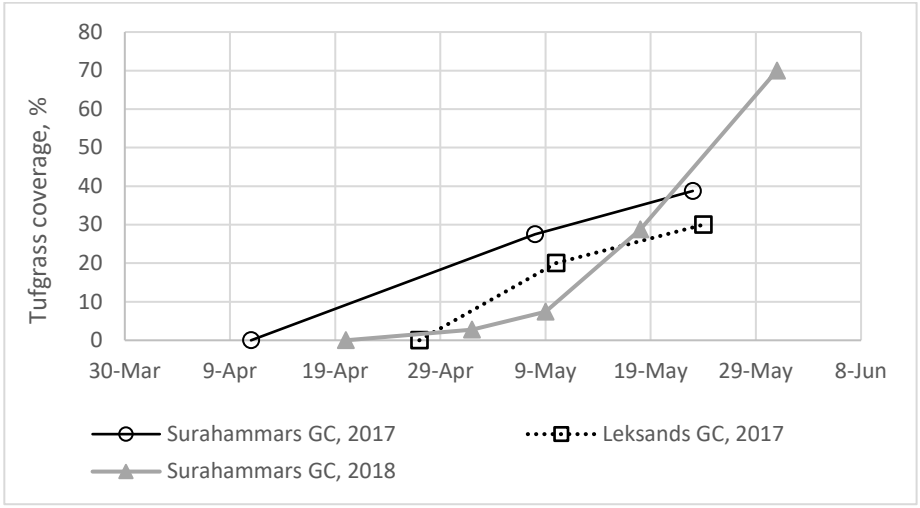

Fig. 3. Development of turfgrass coverage in three trials. Mean of sowing methods and grass species.

Four weeks after seeding, turfgrass coverage was better with spike seeding and slit seeding than with drop seeding and without seeding in all trials (Table 2). Numerically, the difference was most conspicuous at high soil temperatures in 2018, although this effect could not be verified statistically because there was only one trial in that year. Drop seeding did not produce better coverage than on unseeded control plots which were revegetated by annual bluegrass from the soil seed bank.

The main effect of species was not significant in any of the trials (Table 2). While rough bluegrass tended to have a leading edge over creeping bentgrass at the low soil temperatures in 2017, the opposite tendency was observed in 2018. In 2017, there was, however, a significant interaction between sowing method and grass species as slit-seeded rough bluegrass produced better coverage than any of the other treatments (Fig. 4).

Table 2. Effect of sowing method and species seeded on turfgrass coverage after four and six weeks in various trials.

	Turfgrass coverage four weeks after seeding			Turfgrass coverage six weeks after seeding
	2017 (mean of trials at Surahammars and Leksands GC	2018 (Sura-hammars GC)	Mean of three trials	Mean of two trials at Surahammars GC (2017 and 2018)
	----------% of plot area----------			
Sowing method				
Unseeded control	15	9	13	36
Drop seeding	20	4	15	40
Spike seeding	33	50	38	66
Slit seeding	48	53	49	75
P-value[1]	**	-	**	*
$LSD_{0.05}$	30	-	18	21
Species seeded				
Creeping bentgrass	26	34	29	51
Rough bluegrass	31	24	29	58
P-value[1]	ns	-	ns	ns
P-value, interaction[1]	*	-	ns	ns

[1] The following symbols are used: **: $P \leq 0.01$, *: $0.01 < P \leq 0.05$, ns: $P > 0.05$

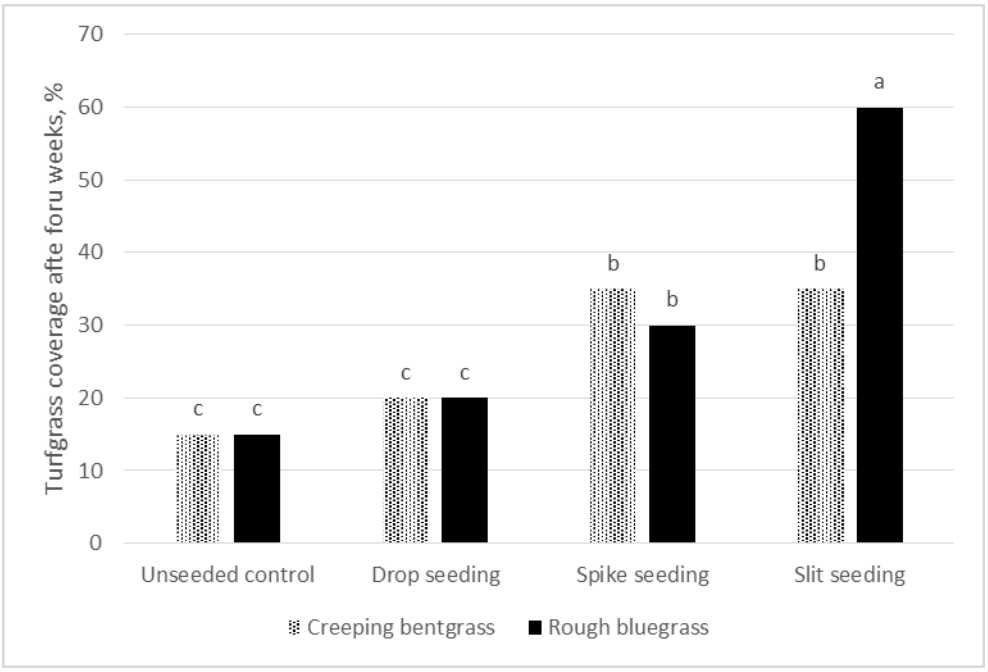

Fig 3. Turfgrass coverage four weeks after seeding as affected by sowing method and grass species. Means of trials at Surahammars and Leksands GC in 2017. Different letters above bars indicate significant difference at $P \leq 0.05$.

DISCUSSION

The difference between 2017 and 2018 in turfgrass coverage after six weeks at Surahammars GC confirmed that soil temperature has a profound influence on turfgrass establishment from seed. Slow germination and seedling growth of creeping bentgrass at daily temperatures below 10°C is in agreement with earlier Scandinavian results (Waalen, Kvalbein Aamlid & Lönnberg, 2018), although '007' should be among the better cultivars of creeping bentgrass when it comes to germination at low temperatures (Heineck et al., 2019). Because of the slow establishment of creeping bentgrass at low soil temperatures, we have, in Northern Sweden over the past decade, seen increasing use of rough bluegrass as an alternative species for reseeding of winterkilled greens in spring. The lack of significant differences between creeping bentgrass and rough bluegrass in 2017 is nonetheless in agreement with British studies into wild rough bluegrass populations showing strongly delayed germination at soil temperatures below 10°C (Budd, 1970). To some extent, this may also be a question of rough bluegrass cultivar or seed lot (Liu, Camberato, Martin & Turner, 2001). The significant interaction between sowing method and grass species in 2017 further suggests that placement of the seed at a certain depth, i.e., in darkness, or at least in good contact with the soil, is equally if not more important for rough bluegrass at low than at high soil temperature. Reseeding of winterkilled greens in central and northern Scandinavia usually occurs at long photoperiods which may well be inhibitory to germination of rough bluegrass at low soil temperature, as earlier demonstrated with Kentucky bluegrass (*Poa pratensis* L.) in northern Norway (Aamlid & Arntsen, 1998; see also Toole & Borthwick, 1971).

One disadvantage of seeding rough bluegrass on greens in Northern Scandinavia is that the species has limited winter hardiness (Aamlid et al., 2019). Hence, the recommendation would normally be to seed a mixture of rough bluegrass and creeping bentgrass, in which case rough

bluegrass would take the role as a nurse grass. Alternatively, slit seeding of pure rough bluegrass may be used to speed up recovery of greens otherwise relying on the annual bluegrass seed bank, as shown by the comparison with the unseeded control treatment. One negative implication of using rough bluegrass could be reduced playability, but this can mostly be handled by management. The usual method is to verticut or brush after the rough bluegrass has established and the turf cover is homogeneous. Heltoft et al. (2021) recently documented higher turf quality on mixed rough bluegrass / creeping bentgrass greens than on pure creeping bentgrass greens, not only in the seeding year but also in the year after.

Our result showed better reestablishment with spike seeding and especially slit seeding than with drop seeding. Apart from the possible inhibition of rough bluegrass germination by almost continuous light, the predominant reason for this was probably better seed-soil contact in these treatments than with drop seeding. Fry, Taylor, Wolf, Stuntz, and Zuk (2007) found that slit seeding was more efficient than verticutting + drop seeding when introducing new plant material into existing turf, and they also argued that this method would potentially reduce the required seeding rate when compared with drop seeding.

Stier (2005) and Kvalbein (2009) argued that winterkill should be regarded as an opportunity to replace annual bluegrass with more durable species on golf course putting greens. While the botanical composition was not part of our study, Inguagiato, Henderson and Miele (2015) found verticutting to result in more annual bluegrass germination from the seed bank than core cultivation or no cultivation prior to seeding. Without any cultivation of the seedbed before seeding, creeping bentgrass germination was better with slit seeding than with drop seeding or spike seeding (Inguagiato et al., 2015). Company representatives selling turfgrass slit seeders on the Nordic turfgrass market usually advise against verticutting before seeding

in order not to stimulate annual bluegrass germination (Ø. Nøkland, Global Turf Solutions, pers. comm., Nov. 2020).

CONCLUSION

In conclusion, this research showed that spike seeding and especially slit seeding that create good seed-soil contact and seed placement at 0.5-1.0 cm depth were better than drop seeding for reestablishment of winterkilled greens in spring. The establishment rate of creeping bentgrass and rough bluegrass was mostly similar, but rough bluegrass had an advantage at low soil temperatures when slit seeded. For both species, there is a need for more research into the impact of cultivars, seed lots and seeding rates at low soil temperature and under adverse seedbed conditions.

ACKNOWLEDGEMENTS

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