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TURFGRASS GENETICS, BREEDING AND EVALUATION OF SPECIES/VARIETIES - SHORT COMMUNICATION

Seed mixtures of red fescue and colonial, creeping, or velvet bentgrass for pesticide-free management of Nordic golf greens

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Abstract

This research aimed to determine if creeping bentgrass (*Agrostis stolonifera* L.) can be used as an alternative to colonial bentgrass (*Agrostis capillaris* L.) in a mixture with red fescue [equal rates of Chewings fescue (*Festuca rubra* ssp. *commutata* Gaud.) and slender creeping red fescue (*Festuca rubra* ssp. *littoralis* [G. Mey.] Auquier)] on Nordic golf greens managed without pesticides. The two mixtures were compared in two experiments: Experiment 1 under the creeping bentgrass management regime (mowing height, 3 mm; fertilization, 15 g N m^{-2} yr^{-1}) and Experiment 2 under the red fescue management regime (5 mm and 10 g N m^{-2} yr^{-1}) at three sites during 2015–2018. A seed mixture of red fescue and velvet bentgrass (*Agrostis canina* L.) was included in Experiment 2 only. The results showed that red fescue plus creeping bentgrass produced greens of equal turfgrass quality and with less *Microdochium* patch than red fescue plus colonial bentgrass under both regimes. In Experiment 2, red fescue plus velvet bentgrass resulted in higher turfgrass quality than the other mixtures but was more susceptible to *Microdochium* patch than red fescue plus creeping bentgrass. Tiller counts in the mixed plots at Landvik showed that red fescue was not outcompeted by bentgrass in any of the mixtures and that it was easier to manipulate the balance between red fescue and bentgrass in the mixture with creeping bentgrass than that with colonial bentgrass. More research should be put into optimal management, especially irrigation and thatch control, of mixed red fescue–bentgrass greens.

1 | INTRODUCTION

Since 2003, the main objective of the SCANGREEN program has been to develop in-depth knowledge of turfgrass species and new cultivars for sustainable and integrated pest management of Nordic putting greens (Aamlid et al., 2012, 2015). Until 2014, the trials were limited to pure species and cultivars, but since 2015, they have included selected seed blends and mixtures to determine their suitability for use on putting greens managed without pesticides.

For almost 100 yr, researchers and plant breeders have worked to find the right seed blends and mixtures for putting greens (Dawson & Evans, 1931). In Norway and Denmark, about 30 to 40% of golf courses have greens initially seeded with creeping bentgrass (*Agrostis stolonifera* L.). Most of the remaining golf courses have greens that were initially seeded with a mixture of colonial bentgrass (*Agrostis capillaris* L.) and red fescue, which is usually a blend of Chewings fescue (*Festuca rubra* L. ssp. *commutata* Gaudin) and slender creeping red fescue [*Festuca rubra* L. ssp. *littoralis*

(G. Mey.) Auquier]. Over time, putting greens in Nordic countries seeded with this mixture often suffer from diseases and the ingression of annual bluegrass (*Poa annua* L.).

Mixtures of red fescue and creeping bentgrass as well as mixtures of red fescue, creeping bentgrass, and colonial bentgrass are commonly used for putting greens in Germany (Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau, 2020), but these mixtures have not been evaluated in trials (H. Nonn, personal communication, 2020). Influenced by British traditions, it is often argued that the ecological adaptations of red fescue and creeping bentgrass are too dissimilar to be compatible on greens (Perris & Evans, 1996).

Red fescue in a mixture with velvet bentgrass (*Agrostis canina* L.) was evaluated by Calvache et al. (2017) on putting greens maintained at two mowing heights and three fertilizer levels. Although velvet bentgrass dominated over red fescue regardless of management, a slightly better balance between the two components was achieved at the higher mowing height (5.5 mm) and the lowest fertilizer level (5 g N m^{-2} yr^{-1}).

The overall objective of this research was to evaluate turfgrass quality and disease occurrence on mixed red fescue–bentgrass greens relative to pure creeping bentgrass under a creeping bentgrass management regime and relative to pure red fescue greens under a red fescue management regime. A particular goal was to explore the potential for creeping bentgrass to replace colonial bentgrass in seed mixtures with red fescue on putting greens managed without pesticides.

> **Core Ideas**
>
> - We investigated alternative seed mixtures for putting greens managed without fungicides.
> - We aimed to find the right mixture of red fescue and bentgrass with high turfgrass quality.
> - We showed that a red fescue–creeping bentgrass mixture had less *Microdochium* patch.
> - We investigated the balance between fine fescues and bentgrasses in the seed mixtures.
> - We found that the fine fescues were not outcompeted by creeping bentgrass.

2 | MATERIALS AND METHODS

2.1 | Experimental sites and treatments

Trials were seeded in June 2015 on greens established according to U.S.Golf Association specifications at Reykjavik Golf Club, Iceland (64.1°N, 21.9°W, 30 m a.s.l.); Norwegian Institute of Bioeconomy Research Apelsvoll, Norway (60.7°N, 10.9°E, 250 m a.s.l.); and Norwegian Institute of Bioeconomy Research Landvik, Norway (58.3°N, 8.5°E, 12 m a.s.l.). Weather data for the three sites are presented in Table 1. Reykjavik and Landvik have coastal climates with a high annual precipitation, whereas Apelsvoll has a continental climate with stronger seasonal temperature fluctuations and less precipitation.

Each experimental green included two experiments (Table 2): Experiment 1, with a mowing height of 3.0 mm and a fertilizer rate (after turfgrass grow-in) of 15 g N m^{-2} yr^{-1}, and Experiment 2, with a mowing height of 5.0 mm and a fertilizer rate of 10 g N m^{-2} yr^{-1}. These mowing heights and fertilizer levels are typical for creeping bentgrass greens and red fescue–colonial bentgrass greens in the Nordic countries. Each experiment had three blocks (replicates) with free randomization of the pure species and mixtures within each block.

The red fescue seed blend comprised 50% (w/w) 'Musica' Chewings fescue and 50% 'Cezanne' slender creeping red fescue. The cultivars of creeping bentgrass, colonial bentgrass and velvet bentgrass were 'Independence', 'Jorvik', and 'Villa', respectively (Table 2). These cultivars are among the most widely used in the Nordic countries and they are also long-term controls in the SCANGREEN program. The seeding rate of pure red fescue and the red fescue–bentgrass mixtures was 30 g m^{-2}, and the seeding rate of pure creeping bentgrass was 7.0 g m^{-2}. Red fescue plus velvet bentgrass was included in Experiment 2 only because earlier research showed this mixture to produce very soft and thatchy greens at higher fertilizer levels (Calvache et al., 2017).

The greens were mown three times per week and deficit-irrigated to 80% of field capacity three to four times per week in periods without sufficient natural rainfall. Fertilizer (mean N–P–K ratio, 100–22–74) was given as completely balanced compound fertilizers every second week. Wear was simulated by friction wear drums with golf spikes correponding to an average of 11,000 rounds of golf per year (Aamlid et al., 2015). There was no use of pesticides or plant growth regulators in any of the trials.

2.2 | Data collection and statistical analyses

Turfgrass quality was assessed once a month from April or May to October or November (depending on the length of the growing season) on a scale from 1 to 9, where 9 is the highest quality and 5 is the lowest acceptable quality.

Microdochium patch [*Microdochium nivale* (Fr.) Samuels & I. C. Hallet] was recorded visually as a percentage of plot area immediately after snow melt and during the monthly assessments during the growing season. Red thread [*Laetisaria fuciformis* (McAlp.) Burdsall] and take-all patch

TABLE 1 Mean monthly temperature and monthly precipitation on average for the 2015–2018 experimental period at the three experimental sites

Month	Mean monthly temperature			Monthly precipitation		
	Reykjavik, Iceland	Apelsvoll, Norway	Landvik, Norway	Reykjavik, Iceland	Apelsvoll, Norway	Landvik, Norway
	˚C			mm		
Jan.	00.4	–5.6	–0.3	71	38	145
Feb.	1.0	–4.4	–0.1	106	24	122
Mar.	2.1	–1.1	1.9	64	27	94
Apr.	4.0	3.7	6.4	99	49	78
May	7.0	12.0	13.0	89	49	66
June	9.8	14.3	15.6	57	46	92
July	11.5	16.6	17.2	42	65	82
Aug.	11.2	14.3	15.7	41	91	127
Sept.	8.6	11.5	13.5	88	84	216
Oct.	5.8	5.2	8.6	192	39	148
Nov.	2.2	00.3	4.3	138	50	189
Dec.	1.1	–2.3	3.1	131	37	134
Mean	5.4	5.4	8.2			
Whole year	–	–	–	1,118	599	1,492

TABLE 2 Seed mixtures (weight ratios) and pure species included in Experiments 1 and 2

Treatment code	Turfgrass	Proportion
		%
Experiment 1		
FR + AS	Red fescue seed blend	90
	Creeping bentgrass	10
FR + ACAP	Red fescue seed blend	90
	Colonial bentgrass	10
AS	Creeping bentgrass	100
Experiment 2		
FR + AS	Red fescue seed blend	90
	Creeping bentgrass	10
FR + ACAP	Red fescue seed blend	90
	Colonial bentgrass	10
FR + ACAN	Red fescue seed blend	90
	Velvet bentgrass	10
FR	Red fescue seed blend	100

Note. Experiment 1 was managed with 3.0 mm mowing height and 15 g N m^{-2} yr^{-1} fertilization. Experiment 2 was managed with a mowing height of 5.0 mm and 10 g N m^{-2} yr^{-1} fertilization.

[*Gaeumannomyces graminis* Sacc. Arx & Oliver var. *avenae* (Turner) Dennis] were recorded visually during the growing season as a percentage of plot area.

The species composition in all plots seeded with red fescue–bentgrass mixtures was determined at Landvik in October 2015, 2016, and 2017. Five random samples were taken as small cylinders (2.8 cm^2) from each plot and the number of tillers of each species was counted under a magnifying lens. Both chewings fescue and slender creeping red fescue were counted as 'total red fescue tillers' as it is very difficult to distinguish between the two subspecies. The collection of data was discontinued in the last evaluation year (2018), as the experiment at Landvik suffered from severe ice damage during the winter of 2017–2018.

Each experiment was analyzed via PROC ANOVA (SAS Institute, 2002). Observations of turfgrass quality and diseases were averaged over the 4-yr trial period before analyses. Turfgrass quality and disease data were analyzed both separately for each site and across sites according to a model in which site was considered a fixed variable and the effects of species or mixtures and the interaction of species or mixture × site were tested against their pooled interaction with 'block within site'. The effects of mixtures on fescue and bentgrass tiller numbers in Experiments 1 and 2 at Landvik were analyzed year by year using PROC ANOVA. In all analyses, Fisher's protected LSD ($P < .05$) was calculated for comparing the treatments. In this article, differences with a probability level in the range of $.05 < P \leq .10$ will be referred to as 'tendencies'.

3 | RESULTS AND DISCUSSION

3.1 | Turfgrass quality

3.1.1 | Experiment 1

The overall analysis of Experiment 1 showed a significant ($P = .01$) interaction between species or mixture and experimental site (Table 3). At Landvik, plots seeded with creeping bentgrass and red fescue had significantly ($P < .05$) higher quality than pure creeping bentgrass plots in 2015, 2016, and 2017, and higher quality than colonial bentgrass and red fescue in 2017 (yearly values not shown), thus showing a strong tendency ($P = .06$) in favor of the creeping bentgrass–red fescue mixture on average for the whole experimental period (Table 3). The mean values for Apelsvoll also suggested a leading edge for creeping bentgrass and red fescue, which had significantly higher quality than colonial bentgrass and red fescue in 2016 and the same tendency in 2017. In contrast, colonial bentgrass and red fescue performed significantly better than creeping bentgrass and red fescue in 2015 and 2017, and showed similar trends in 2016 and 2018 at Reykjavik. This difference between the Icelandic site and the two sites in southern Norway may reflect that creeping bentgrass is better adapted to moderate to high summer temperatures, whereas colonial bentgrass has an advantage in coastal, subarctic regions with cool summer temperatures (Rummele, 2003).

3.1.2 | Experiment 2

The overall analysis showed no interaction between species or mixture and experimental site in Experiment 2. Red fescue and velvet bentgrass produced the highest turfgrass quality at all sites (Table 3). This is in agreement with Calvache et al. (2017), who found this mixture to produce higher quality than pure red fescue, despite softer greens with more accumulation of organic matter in the mat layer. The difference between the red fescue plus creeping bentgrass plots and the red fescue plus colonial bentgrass plots were not significant at any site, but these mixtures also ranked higher than pure red fescue in the overall analysis across sites.

3.2 | Diseases

3.2.1 | Experiment 1

Differences in take-all patch and red thread were not significant in Experiment 1 (data not shown). For *Microdochium* patch, the analysis showed a highly significant ($P < .001$) interaction between species or mixture and site, as pure creeping bentgrass was more susceptible to *Microdochium* patch than red fescue plus creeping bentgrass and red fescue plus colonial bentgrass in the coastal climate at Reykjavik, although only red fescue plus creeping bentgrass had less disease than pure creeping bentgrass in the continental climate at Apelsvoll. The lowest disease infection across sites was found on plots seeded with red fescue plus creeping bentgrass (Table 3).

3.2.2 | Experiment 2

As in Experiment 1, there was no difference in take-all patch among species or mixtures. The higher susceptibility of red fescue plus colonial bentgrass than of red fescue plus creeping bentgrass to *Microdochium* patch was confirmed in Experiment 2 at Apelsvoll and on average for all three sites (Table 3). The high susceptibility to *Microdochium* patch of red fescue plus velvet bentgrass, which was statistically not different from that of red fescue plus colonial bentgrass, was also observed at all sites. These observations are in general agreement with earlier comparisons of pure species in the Nordic countries (Aamlid et al., 2012, 2015) and in Germany (Nonn, 2005). The finding that pure red fescue was more susceptible to *Microdochium* patch than red fescue–bentgrass mixtures at Reykjavik was surprising, but could perhaps indicate that slender creeping red fescue dominated over Chewings fescue in this coastal climate. Unlike the general opinion in North America (Braun et al., 2020), slender creeping red fescue is usually considered to be more susceptible than

TABLE 3 Mean values for turfgrass quality and percentage of plot area infected by *Microdochium* patch for different species and mixtures in Experiments 1 and 2 at each site and on average for three sites

	Turfgrass quality[a], 1–9 (9 is highest quality)				*Microdochium* patch			
	Reykjavik, Iceland (17)[b]	Apelsvoll, Norway (19)	Landvik, Norway (24)	Mean of 3 sites	Reykjavik, Iceland (6)	Apelsvoll, Norway (19)	Landvik, Norway (23)	Mean of 3 sites
					% of plot area			
Experiment 1: Creeping bentgrass management regime								
FR + AS	5.2	6.5	6.8	6.2	00.9	00.9	00.3	00.7
FR + ACAP	5.6	6.1	6.4	6.0	00.9	3.3	00.8	1.7
AS	5.5	6.1	5.8	5.8	1.7	2.6	00.9	1.7
P-value	ns	ns	†	†	*	**Significant at	ns	***Significant at
$LSD_{0.05}$	–	–	–	–	00.5	00.9	–	00.3
Site × species mixture interaction	**Significant at				***Significant at			
Experiment 2: Red fescue management regime								
FR + AS	5.1	6.6	6.1	5.9	1.4	1.4	00.3	1.0
FR + ACAP	5.0	6.6	6.3	5.9	1.7	3.1	00.2	1.7
FR + ACAN	5.2	6.8	6.7	6.2	1.9	3.5	00.4	2.0
FR	4.8	5.9	6.1	5.6	3.3	1.7	00.1	1.7
P-value	ns	†	**Significant at	**Significant at	**Significant at	**Significant at	ns	***Significant at
$LSD_{0.05}$	–	–	00.3	00.3	00.9	1.1	–	00.4
Site × species mixture interaction	ns				***Significant at			

Note. Turfgrass treatment abbreviations are explained in Table 2.

[a]Turfgrass quality was scored on a 1 to 9 scale, where 9 indicates the highest quality.

[b]The number of observations during the experimental period 2015–2018 is shown in parentheses.

*Significant at .01 < $P \le .05$. **Significant at .001 < $P \le .01$. ***Significant at $P \le .001$. †Significant at .05 < $P \le .10$ (‘tendency’). ns, $P > .10$.

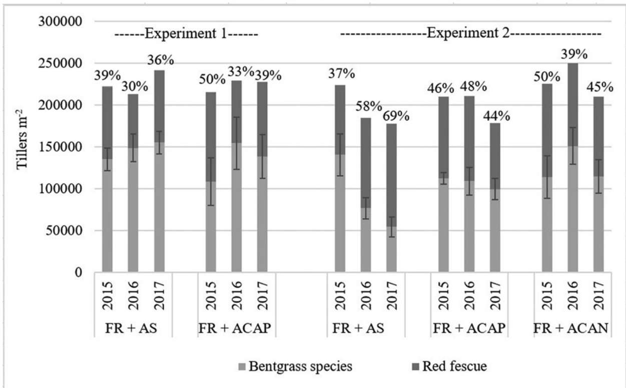

FIGURE 1 Tiller numbers of bentgrass species and red fescue in October 2015, 2016, and 2017 in plots seeded in June 2015 with the following mixtures: red fescue plus creeping bentgrass (FR + AS), red fescue plus colonial bentgrass (FR + ACAP), and red fescue plus velvet bentgrass (FR + ACAN) subjected to the creeping bentgrass management regime (Experiment 1) or the red fescue management regime (Experiment 2) at Landvik. Bars indicate ± 1 SE for the number of bentgrass tillers. Figures above the bars indicate the percentage of red fescue tillers

Chewings fescue to *Microdochium* patch in Nordic countries (Kvalbein et al., 2016).

3.3 | Species composition

All mixtures produced an acceptable balance between red fescue and bentgrasses in the trial at Landvik (Figure 1). On average for mixtures and management regimes over the three evaluation years, the red fescue/bentgrass tiller ratio was 44:56, and there was no tendency for red fescue to be outcompeted in any of the treatments. These results are in contrast to those of Calvache et al. (2017), who found that velvet bentgrass dominated over red fescue even at a fertilizer rate of only 5 g N m^{-2} yr^{-1}. Their research was conducted from 2010 to 2012 with a seed blend of red fescue that, in addition to 'Musica' Chewings fescue (20%) and 'Cezanne' slender creeping red fescue (40%), also included the old cultivars of Chewings fescue 'Bargreen' (20%) and 'Calliope' (20%). Research into the competitiveness of red fescue against annual bluegrass in Denmark showed the importance of using new and competitive cultivars of red fescue in mixtures for putting greens (Nielsen, 2008, 2010). The fact that the present trial received deficit irrigation to 80% of field capacity may also have improved the competitiveness of red fescue vs. bentgrasses relative to the trial by Calvache et al. (2017), which was irrigated to field capacity.

The differences in bentgrass and fescue tiller numbers among the various mixtures were mostly not significant. An interesting exception was the decrease in bentgrass tillers from 2015 to 2017 in red fescue plus creeping bentgrass plots in Experiment 2 (Figure 1). In contrast, the balance between red fescue and creeping bentgrass remained stable over the 3 yr in plots in Experiment 1. These results indicate that species composition may be influenced by the nitrogen rate and mowing height even within the short timeframe of 2 to 3 yr after seeding (Calvache et al., 2017).

4 | CONCLUSION

With the possible exception of subarctic regions with low summer temperatures, these results suggest that a seed mixture of red fescue and creeping bentgrass can produce putting greens of the same high quality and with less *Microdochium* patch than the more commonly used mixture of red fescue and colonial bentgrass. Recordings of the species composition on the mixed greens at Landvik showed a balanced tiller ratio of red fescue and bentgrass species under the creeping bentgrass management regime and under the red fescue management regime. None of the bentgrasses outcompeted red fescue, and the balance between red fescue and bentgrass was more easily controlled by mowing height and fertilizer rate when red fescue was seeded with creeping bentgrass rather than with colonial bentgrass. It is nonetheless important to keep in mind that the species composition was recorded only at one site and 2 yr after seeding. More research is therefore needed to determine the impact of both climatic conditions and management (notably irrigation and thatch control, as well as fertilization, mowing heights etc.) on mixed red fescue–bentgrass greens.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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