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Evaluation of *Agrostis* and *Festuca* varieties for use on Scandinavian golf greens

Results from variety testing at Landvik and Apelsvoll 2003-2006.

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Title:

Evaluation of *Agrostis* and *Festuca* varieties for use on Scandinavian golf greens. Results from variety testing at Apelsvoll and Landvik 2003-2006.

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Summary:

Based on testing of 43 varieties from 2003 through 2006, this report gives recommendations for selection of turfgrass varieties for putting greens on golf courses with various resources and in various parts of Scandinavia.

Sammendrag:

Basert på sortsprøving på Apelsvoll og Landvik gir denne rapporten anbefalinger for valg av sorter til greener på golfbaner med ulik ressurstilgang og i ulike deler av Skandinavia.

Land/county:	Norway / Grimstad
Municipality:	Grimstad
Place:	Landvik

Responsible leader

Svein Grimstad

Project leader

Trygve S. Aamlid

Contents

1.Abstract

From 2003 to 2006, three varieties of velvet bentgrass (*Agrostis canina*), thirteen varieties of creeping bentgrass, nine varieties of colonial bentgrass (*Agrostis capillaris*), four varieties of slender creeping red fescue (*Festuca rubra* var. *trichophylla*), thirteen varieties of chewings fescue (*Festuca rubra* var. *commutata*), and one variety of annual bluegrass (*Poa annua* var. *reptans*) were evaluated for establishment rate, overall turf quality (visual merit), tiller density, color, leaf fineness, per cent living plant cover, winter injury, disease resistance, spring green-up, daily height growth, and thatch accumulation in trials on USGA-spec. putting greens at the Bioforsk research stations Landvik (58°N, 12 m a.s.l.) and Apelsvoll (61°N, 250 m a.s.l.) in south-east Norway. These experimental sites are considered representative for the southern/coastal and the northern/ continental zone of Scandinavia, respectively. The trials were mowed three times per week to 3 mm for bentgrass species and annual bluegrass and to 4.5-5.0 mm for red fescues, fertilized with easily soluble, small-grain mineral fertilizer every second week, and otherwise managed as putting greens with respect to irrigation, vertical mowing, topdressing etc. The greens were not open to regular play, but artifciial wear was imposed by rolling friction-drums with golf-spikes over the trials three timers per week.

On average for varieties within each species, velvet bentgrass had the highest visual merit scores at both experimental sites. Velvet bentgrass had higher density and finer leaves than any other species in the study. Along with colonial bentgrass, it also had better winter survival than creeping bentgrass, red fescue and annual bluegrass. The main disadvantage of velvet bentgrass is the rapid formation of thatch; this problem must be resolved before a general recommendation for use of velvet bentgrass on Scandinavian putting greens can be given.

Next to velvet bentgrass, colonial bentgrass and creeping bentgrass were ranked as the most suitable species for golf courses in the northern/continental and southern/coastal zone, respectively. Red fescues should be preferred on golf courses not using fungicides and with limited maintenance budgets. While annual bluegrass 'True Putt' cannot be recommended for putting greens in any part of Scandinavia, the ranking of varieties within each species depended, for the most part, on climatic zone.

The following list of recommended varieties for putting greens has been presented to the Scandinavian Turfgrass and Environment Research Foundation:

	Climatic zone 1: **Denmark, southwestern parts of Sweden, coastal regions of Southern Norway** **Representative location:** **Landvik**	**Climatic zone 2:** **Finland, central and northern parts of Sweden, continental, and northern parts of Norway** **Representative location:** **Apelsvoll**
Golf courses with high maintenance budgets and members accepting pesticide use	***Agrostis canina*:** Greenwich, Villa ***Agrostis stolonifera:*** Independence, Nordlys, Penn G-1, Penn A-1, Penn G-2 ***F.rubra trichophylla*:** Cezanne, Barcrown ***F.rubra commutata*:** Center, Calliope, Kiruna, Blenheim ***Agrostis capillaris:*** Jorvik, Denso, Barking, Bardot	***Agrostis canina*:** Villa ***Agrostis stolonifera:*** Nordlys, Penncross, Bueno, Independence, Penn G-1 ***F.rubra trichophylla*:** Baroyal, Cezanne ***F.rubra commutata*:** Kiruna, Soberana, Bargreen, Center ***Agrostis capillaris:*** Jorvik, Leirin, Bardot, Nor
Golf courses with moderate budgets and/or members not accepting pesticide use		

2.Introduction

In December 2002, the Scandinavian Turfgrass and Environmental Research Foundation (STERF) extended a four year research grant to the Bioforsk project 'Evaluation of *Agrostis* and *Festuca* varieties for Scandinavian golf greens'. The project was partly funded also by The Norwegian Food Safety Authority (formerly The Norwegian Agricultural Inspection Service) and by entrance fees paid by breeding companies entering varieties into the trials. The objectives of the project were:

- To clarify which varieties of *Agrostis* and *Festuca* are best suited for golf greens in two contrasting climates in Scandinavia.
- To create meeting places for discussions among breeders, seed companies and greenkeepers in order to encourage cultivar awareness and continued efforts into turfgrass breeding for northern environments.

Preliminary results from the project have been presented in previous reports to STERF in December 2003, 2004 and 2005 (Aamlid et al. 2003, Aamlid & Molteberg 2004a, Aamlid et al. 2005b), at the International Turfgrass Congress in July 2005 (Aamlid et al. 2005a), as an article in the series 'Bioforsk Tema' (Molteberg & Aamlid 2006) and in numerous articles in greenkeepers' magazines in Norway and Sweden (see reference list p.13). This is the final report from the whole experimental period.

Photo 1. The experimental field at Landvik in November 2003. (Photo: Trygve S. Aamlid).

3.Methods

Plant material

A total of 43 varieties were entered into the project. The entries were distributed between species as follows:

- Velvet bentgrass (*Agrostis canina*): 3 varieties
- Creeping bentgrass (*Agrostis stolonifera*): 13 varieties
- Colonial bentgrass (*Agrostis capillaris*): 9 varieties
- Slender creeping red fescue (*Festuca rubra* var. *trichophylla*): 4 varieties
- Chewings fescue (*Festuca rubra* var. *commutata*): 13 varieties
- Annual meadowgrass (*Poa annua* var. *reptans*): 1 variety

Table 1 gives a complete list of varieties included in the project.

Table 1. List of varieties included into the green trials at Apelsvoll and Landvik 2003-2006.

Variety	Breeder / Representative	Variety	Breeder / Representative
Festuca rubra* var. *commutata		***Agrostis stoloniferea***	
Barbirdie	Barenbrug	Bueno	Svalöf Weibull
Bargreen	Barenbrug	Cato	Felleskjøpet Øst Vest
Bellaire	DLF-Trifolium	Independence	Svalöf Weibull
Calliope	DLF-Trifolium	L-93	Felleskjøpet Øst Vest
Center	Innoseeds	Nordlys	Graminor
Darwin	Innoseeds	Penn A-1	Svalöf Weibull
Blenheim (DP 77-9620)	DLF-Trifolium	Penn A-4	Felleskjøpet Øst Vest
Maritza (DP 77-9624)	DLF-Trifolium	Penncross	Felleskjøpet Øst Vest
Kiruna	DLF-Trifolium	Penn G-1	Scandinavian Seed
Soberana	Barenbrug	Penn G-2	Scandinavian Seed
SW Cygnus	Svalöf Weibull	Penn G-6	DLF-Trifolium
Rossignol	DLF-Trifolium	Providence	Svalöf Weibull
Valentina	DLF-Trifolium	SRX 1119	Svalöf Weibull
Festuca rubra* var. *trichophylla		***Agrostis capillaris***	
Barcrown	Barenbrug	Bardot	Barenbrug
Baroyal	Barenbrug	Barking	Barenbrug
Cezanne	Innoseeds	Denso	Innoseeds
Leonora	DLF-Trifolium	Jorvik	DLF-Trifolium
		Leira (KvAt 96)	Graminor
Poa annua* var. *reptans		Lance	DLF-Trifolium
True Putt	DLF-Trifolium	Leirin	Graminor
		Nor	Graminor
Agrostis canina		Pop Å.	Graminor
Avalon	Svalöf Weibull		
Villa	Innoseeds		
Greenwich	Scandinavian Seed		

Experimental sites and climatic conditions

New putting greens were constructed at Bioforsk Øst Landvik and Apelsvoll in June 2003. Landvik is located on the Norwegian south coast (58°N, 12 m a.s.l.), has a high annual rainfall (1230 mm), an average temperature April-October of 11.6°C, and an unstable winter climate typical for coastal regions of Norway, Denmark and the south-western part of Sweden. Apelsvoll is located in the inland north of Oslo (61°N, 250 m a.s.l.), has less rainfall (600 mm), and lower temperature during the growing season (April-Oct. mean is 9.6°C). It represents a continental climate typical for most of Finland and central and northern parts of Norway and Sweden. During the four year project period, the trial at Apelsvoll was under snow for about five months in 2003/04 and 2005/06, and under ice for more than three months in 2004/05. By contrast, the trial at Landvik only experienced snow cover of significant duration (almost three months) in 2005/06.

Green construction and grow-in

Two experimental greens were constructed according to USGA specifications. A mixture of finely graded sand with 20% (v/v) park & garden compost ('Green Mix') was used for the 30 cm rootzone layer at both locations. Dressings of 4 kg 100 m^{-2} of OPTI-PK™ 0-5-17 were raked into the seedbeds before sowing to ensure adequate phosphorous levels for the developing seedlings.

The trials were seeded on 27 June 2003 at Landvik and 1-2 July 2003 at Apelsvoll. Seeding rates were 2.0 kg 100 m^{-2} for *Festuca*, 0.5 kg 100 m^{-2} for *Agrostis* and 1.2 kg 100 m^{-2} for *Poa*. At both sites, the experimental design was split plot with species on main plots and varieties on subplots. Plot size was 1m x 1m, each trial having 129 plots (43 varieties x 3 blocks) plus border plots. During the first weeks after seeding, the experiments were irrigated with 3-5 mm at least twice daily. At Apelsvoll the newly seeded trial was also protected with a white and fibrous (permeable) cover to avoid dessication.

Photo 2. Seeding plots at Apelsvoll, 1 July 2003. (Photo: Mai Onsrud).

Mowing, fertilization and regular maintenance

Throughout the project period, both trials were mowed three times a week to a height of 3 mm for *Agrostis* / *Poa* and 4.5-5.0 mm for *Festuca*. Higher mowing heights were practised during grow-in in 2003 and at the beginning and end of each growing season. From 2004 (Landvik) and 2005 (Apelsvoll) all plots were exposed to regular compaction/ abrasive wear from a drum with golf spikes mounted on it. From 2005 vertical cutting and top-dressing was also carried out every two to three weeks on *Agrostis* and *Poa* plots and every six weeks on *Festuca* plots. No pesticides or growth regulators were used in the trials. In case of winter damage, plots were not reseeded, but left to recover naturally.

In the sowing year 2003 and the first green year 2004, all plots received the same amount of inorganic fertilizer (Yara's 'Arena' program) at biweekly intervals, in total 0.8 and 1.9 kg N/100 m^2, respectively. In 2005 and 2006, ammonium sulphate was included in the fertilizer programme in an attempt to lower pH and control take-all patch (*Gauemannomyces graminis*), and the total nitrogen amount was differentiated with 0.9 and 1.8 kg N/100 m^2 to *Festuca* and *Agrostis* / *Poa*, respectively. During dry periods, the trials were irrigated three to five times a week to replace evapotranspiration.

Results from soil analyses taken on three occasions during the project period are given in Table 2. pH values showed a decreasing tendency at Landvik, but remained stable at Apelsvoll.

Table 2. Results from soil analyses taken during the project period.

			mg / 100 g dry soil			
		pH	P-AL	K-AL	Mg-Al	Ca-AL
Both locations	June 2003. (At establishment)	7.5	6	7	9	173
Apelsvoll	April 2005	7.2	5	4	4	80
Landvik	April 2005	6.7	6	7	4	72
Apelsvoll	Oct 2006	7.1	5	5	4	95
Landvik	Nov 2006	6.4	4	4	4	60

Registrations, statistical calculations, and presentation of results

During the four growing seasons, the trials were rated visually at biweekly intervals for overall turfgrass quality (visual merit) and at monthy intervals for most other characters.

The parameters presented in the result tables are defined as follows:

- **Visual merit** = overall turfgrass quality (1-9, 9 is best): The overall score for the whole project period is a weighed mean with 1/7 on the sowing year and 2/7 on each of the three green years. Spring, summer and autumn values are mean of all ratings in the three green years during the periods 15 March – 10 June, 11 June – 10 September, and 11 September – 15 November, respectively. (Since there were more observations during summer than during spring or autumn, annual mean values are not equal to the arithmetric means of the three seasons.)

- **Tiller density** (1-9, 9 is highest density): The overall score has been weighed with 1/7 on the sowing year (assessment in late autumn) and 2/7 on each of the green years.
- **Leaf fineness** (=texture) (1-9, 9 is finest leaves): Mean values of assessments on 1 Aug. in the first, second and third green year (Leaf fineness was assessed only once per season. It was not assessed in the sowing year and not in *Festuca* spp.).
- **Colour** (1-9, 9 is darkest green): Mean values of the first, second and third green year (not determined in the sowing year).
- **Winter damage** (% of plot area): Values include both biotic and abiotic winter damages and are means of measurements in the spring of the first, second and third green year. Plant samples from *Agrostis* plots in spring usually confirmed the presence of both pink (*Microdochium nivale*) and gray (*Typhula* sp.) snow mold in the experiment at Apelsvoll. Samples taken from *Festuca* plots were generally less conclusive.
- **Date for green-up in spring** (= earliness): Recorded as day no after 31 March in all three green years at Landvik, and in the second and third green year at Apelsvoll.
- **Plant cover**: % of plot area covered with healthy, undiseased turf of the sown species. Mean value have been weighed with 1/7 on the sowing year (assessment in autumn), and 2/7 on each of the three green years.
- **In-season disease** (% of plot area): In-season diseases mostly occurred during warm and rainy periods in autumn. Major pathogens were *Pythium*, *Fusarium* and *Microdochium* at Apelsvoll and *Pythium*, *Fusarium*, *Laetisaria fuciformis* (red tread), and possibly *Sclerotina homeocarpa* (dollar spot) at Landvik. The mean values have been weighed with 1/7 on the sowing year and 2/7 on each green year.
- **Plant cover two weeks after sowing in 2003** (% of plot area): Indicates establishment rate.
- **Height increment**: Calculated from height measurements with a prism device on one Monday per month in the first and second green year (The green had been left uncut since Friday).
- **Thatch thickness**: Measured in one sample per plot at the termination of the experiments in late October 2006. While only the fresh, white thatch layer was measured at Apelsvoll, partly decomposed brown thatch (Photo 5) was also included at Landvik.

At both sites, the recordings were undertaken by the same group of experiences researchers / technicians. However, as no attempt was made to harmonize the use of scales at the two locations, direct comparison of the figures from Apelsvoll and Landvik are not valid.

The experimental data were analyzed using the SAS procedure PROC ANOVA. Analyses of variance were accomplished both separately for each trial and for the material as a whole regarding experimental site as a random variable. In both cases the following significance levels were used:

- ***: P<0.1%
- ** : 0.1%<P<1%
- * : 1%<P<5%
- ns : not significant

Whenever significant differences occurred, least significant differences (LSD) at the 5% probability level values were calculated for direct comparisons between species or varieties. In a few cases, P-values between 5% and 10% were reported as 'tendencies'.

The main results from the project are presented in Tables 3-8. In tables 4-8, varieties within each species are ranked depending on the average visual merit score for the whole experimental period. In case two or more varieties have the same scores, they are further ranked for tiller density, and, if necessary, also for winter damage.

In addition to the main tables, Figures 1-5 depict the recovery ability after winter damage for various varieties in the trial at Apelsvoll. Some photos will also be included to illustrate major finding during the project period.

4. Results and discussion

Comparison of species (Table 3)

On average for varieties, velvet bentgrass was superior to the other turfgrass species in this study. Velvet bentgrass not only had an outstanding tiller density and a fine 'velvet' texture, but during the winter 2004/05 it also survived three months of ice incasement at Apelsvoll better than any other species except colonial bentgrass (Photo 3). During the first and third winter, velvet bentgrass also developed less snow mold than creeping bentgrass. However, in cases where severe injury occurred, recovery was usually slower in velvet (and colonial) bentgrass than in creeping bentgrass (Fig. 1). In the last, and most rainy, autumn of the study, both velvet and creeping bentgrass were severely attacked by *Microdochium nivale* and possibly *Pythium* in the trial at Apelsvoll (Photo 4).

The major challenge of using velvet bentgrass on putting greens is that it accumulates more thatch than any other species (Photo 5). Over time this caused the velvet bentgrass plots to become soft and spongy, especially at Landvik. In the last year of the study, the turf in some of these plots collapsed after a relatively modest attack by *Pythium* (Photo 6). The thatch problem in velvet bentgrass can hopefully be resolved by more frequent vertical cutting / top dressing, lower pH and less fertilizer inputs than were practised in these trials. We are therefore very pleased that STERF has granted money to a new project exploring management options for velvet bentgrass putting greens.

As an overall average, creeping bentgrass was ranked before colonial bentgrass at Landvik, while it was the other way round at Apelsvoll. This was mainly because creeping bentgrass suffered more damage from ice encasement than colonial bentgrass during the second winter in the trial period. Creeping bentgrass was vulnerable to snow mold as well as ice encasement, but it had a better texture, higher density, and lower height growth than colonial bentgrass.

Within red fescue, the subspecies *trichophylla* was ranked before *commutata* at both sites. This was mostly because of a higher density, but in the grow-in year, *trichophylla* types also established more rapidly than *commutata* types, and in the green years, they started to grow earlier in spring. Moreover, the average daily height increment was significantly lower in the slender creeping than in the chewings type of red fescue. Great variation for winter hardiness existed in both subspecie, and contrary to expectation, there was no general trend for *trichophylla* types to be less winter hardy than *communtata* types.

At the bottom of Table 3, annual bluegrass ranked significantly behind the other species at both locations. The cultivar **'True Putt'** cannot be recommended on Scandinavian golf greens, especially not in inland areas experiencing a tough winter climate. Although young stands of *Poa annua* may have a remarkable ability to recover after snow mold (Fig. 2), the light green colour, low tiller density, broad leaves, vigorous formation of seed heads in spring, and severe winter damage at Apelsvoll all speak in disfavour of annual bluegrass.

Velvet bentgrass varieties (Table 4)

Differences in overall means among the three varieties of velvet bentgrass were almost significant (P=0.07) at both locations. At Apelsvoll **'Greenwich'** suffered severe damage from snow mold during the first winter and had therefore low merit in the first green year. Although it recovered and was on level with the other velvet cultivars in the third green year, the average figures speak in favour of **'Villa'** as the most promising velvet bentgrass cultivar in continental regions of Scandinavia. For coastal regions, 'Greenwich' should be the first choice before 'Villa' and 'Avalon (='SR 7200'), despite the fact that **'Avalon'** has a somewhat darker color.

Creeping bentgrass varieties (Table 5)

Within *A.stolonifera*, the Norwegian variety **'Nordlys'** advanced from a place near the bottom of the list in the sowing year to a top ranking in the second and third green year. This was primarily because 'Nordlys' suffered less winter damage than any other variety of creeping bentgrass at Apelsvoll, but the overall impression of 'Nordlys' improved with increasing green age also at Landvik. At both sites, 'Nordlys' resembled velvet bentgrass in that it had significantly higher tiller density and finer leaf texture than North-American varieties of creeping bentgrass (Photo 7). However, at Apelsvoll, it also formed more thatch than the other creeping bentgrass varieties.

Next to 'Nordlys', **'Penncross'** was the most winter-hardy variety during the two last years of the study at Apelsvoll (Figs. 2 & 4, Photo 3). At Landvik, where winter hardiness was less of an issue, 'Penncross' was ranked near the bottom of the list due to its low tiller density and coarse texture. 'Penncross' also had the most vigorous height growth of the creeping bentgrasses studied.

At both locations, the Canadian variety **'Bueno'** (='18th Green') established more slowly and had significantly darker green color than any other creeping bentgrass variety. Having acceptable winter-hardiness, but a late green-up and high vulnerability to *Pythium* and other in-season diseases, 'Bueno' seems to a variety primarily for continental regions.

At Landvik, the best variety of *A.stolonifera* was **'Independence'**. Among its advantageous characteristics were fine leaves, high density, low height growth and low susceptibility to within-season diseases. At Apelsvoll it suffered severe winter damage, but it recovered faster than other varieties of creeping bent both in 2005 and 2006 (Figs. 2 & 4). To a lesser extent, this was also case for **'Penn G-1'**, which was ranked before **'Penn G-2'**, **'Penn G-6'**, **'Penn A-1'**, and **'Penn A-4'** at both locations.

On average for two sites, **'Providence'** and **'Cato'** were the creeping bentgrass varieties with the lowest visual merit scores. 'Cato' had a very poor recovery ability at Apelsvoll (Figs. 2 & 4), and its density and texture was inferior to that of 'Independence' at both locations (Photo 8). As for 'Providence', this variety tended to take more winter damage than other creeping bentgrasses even at Landvik. Both 'Cato' and 'Providence' have been widely used varieties in Norway and Sweden, but based on the present results, they should not be recommended in the future.

Another very popular creeping bentgrass variety, **'L-93'**, was ranked intermediate at both Landvik and Apelsvoll. From a rather poor start, the visual merit scores of this variety improved during the project period, but it never attained the same density and leaf texture as 'Independence' or 'Penn G-1'. This was also the case for **'SRX 1119'**, which has been used on some golf courses in Sweden.

Colonial bentgrass varieties (Table 6)

With the exception of the Danish variety **'Jorvik'** (Photo 9) different varieties of colonial bentgrass have to be recommended for northern / continental versus southern / coastal parts of Scandinavia. In addition to 'Jorvik', seed blends for continental / northern regions should include at least one of the winter-hardy Norwegian varieties **'Leirin'**, **'Leira'** or **'Nor'** (Photo 9). Among these, 'Leirin' was earlier, had a finer leaf texture and a higher tiller density, but it was also lighter green and more susceptibility to diseases than 'Nor' and 'Leira'. In seed blends for southern and coastal regions, 'Jorvik may be accompanied by **'Denso'** which is darker green, but rather susceptible to diseases. **'Barking'** and **'Bardot'** and other good alternatives for southern / coastal regions, and 'Bardot' may be included even in blends for northern and continental parts of Scandinavia. On the other hand, Scandinavian greenkeepers ought to avoid **'Pop Å'**, which is very coarse, and **'Lance'**, which in this project was inferior to other Dutch and Danish varieties of colonial bentgrass at both locations.

Slender creeping red fescue varieties (Table 7)

Differences among slender creeping red fescues at Landvik were generally small and disturbed by many of these plots were infested with bentgrasses from neighbour plots. Thus, per cent plant cover of sown species in the trial at Landvik should probably be lower than indicated in Table 7b. At Apelsvoll, **'Cezanne'** and especially **'Baroyal'** came out of the winters in a better condition than **'Barcrown'** and **'Leonora'**. 'Barcrown' is currently one of the most popular *trichophylla* types of red fescue, but Figs. 3 & 5 and Table 7 shows that it is not winter-hardy enough when seeded on putting greens in northern and continental parts of Scandinavia. On the other hand, its sister variety 'Baroyal' seems to have superior winter hardiness even in comparison with most *commutata* types (Fig. 3). When summarized over two locations, 'Cezanne' received the highest scores for tiller density, while 'Leonora' had the fastest establishment, but also the lightest green color of the slender creeping red fescue varieties.

Chewings fescue varieties (Table 8)

'Bellarie' was the least winter-hardy variety of chewings fescue at both Landvik and Apelsvoll (Photo 10). 'Bellaire' was susceptible also to in-season diseases (Photo 11) and should be avoided in both climatic zone of Scandinavia. **'Calliope'** had the highest combined score for tiller density, and was the most highly ranked chewings fescue at Landvik until, in autumn 2006, it was infected by *Pythium* (Photo 12). Thus, on average for the whole experimental period, 'Calliope' was ranked second to the old variety **'Center'** on the list of chewings fescues for southern and coastal parts of Scandinavia. While 'Center' seems to have acceptable winter hardiness also in northern and continental areas, 'Calliope's ability to recover (Figs. 3 & 5) could not compensate a rather poor winter survival at Apelsvoll.

Based on average figures for the two locations, **'Kiruna'** stands out as a chewings fescue with the best general adaptation to putting greens in Scandinavia. Since no seed is available of this variety, the best options for the northern / continental zone seem to be **'Soberana'**, **'Bargreen'**, and **'Center'**. On southern and coastal golf courses, the newly released Danish variety **'Blenheim'**, can, with its early green-up and relatively dark color, be used together with 'Center' and Calliope'. On the other hand, neither **'Barbirdie'**, **'Maritza'**, **'Rossignol'**, **'Valentina'**, nor **'SW Cygnus'** seem to have any special merit on Scandinavian golf courses. This is also the case for **'Darwin'**, which, with its very dark color, will form a strong contrast to other red fescue and colonial bentgrass varieties in the seed mixture, and also naturally invading plants of annual bluegrass.

5. Conclusions

The popularity of various turf species for use on putting greens varies among the Scandinavian countries. Based on seed usage, we can roughly distinguish between 'creeping bentgrass courses' and 'red fescue / colonial bentgrass courses'. Between the two, most superintendents will agree that 'creeping bentgrass courses' require the most resources for thatch control, disease control, irrigation, fertilization etc, and that this has to be reflected in the budget of the golf club. Provided that the thatch issue can be resolved, many of the 'creeping bentgrass courses' will perhaps become 'velvet bentgrass courses' in the future.

Based on this pesticide /economy aspect, and the simplification that Apelsvoll and Landvik represent the two main climatic zones in Scandinavia, our variety recommendations for Scandinavian putting greens can be summarized as follows:

	Climatic zone 1: **Denmark, southwestern parts of Sweden, coastal regions of Southern Norway** **Representative location: Landvik**	**Climatic zone 2:** **Finland, central and northern parts of Sweden, continental, and northern parts of Norway** **Representative location: Apelsvoll**
Golf courses with high maintenance budgets and members accepting pesticide use	***Agrostis canina*:** Villa ***Agrostis stolonifera:*** Independence, Nordlys, Penn G-1, Penn A-1, Penn G-2	***Agrostis canina*:** Greenwich, Villa ***Agrostis stolonifera:*** Nordlys, Penncross, Bueno, Independence, Penn G-1
Golf courses with moderate budgets and/or members not accepting pesticide use	***F.rubra trichophylla*:** Cezanne, Barcrown ***F.rubra commutata*:** Center, Calliope, Kiruna, Blenheim ***Agrostis capillaris:*** Jorvik, Denso, Barking, Bardot	***F.rubra trichophylla*:** Baroyal, Cezanne ***F.rubra commutata*:** Kiruna, Soberana, Bargreen, Center ***Agrostis capillaris:*** Jorvik, Leirin, Bardot, Nor

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Table 3. Comparison on species.

	Visual merit (1-9)								Tiller density (1-9)	Leaf fineness (1-9)	Color (1-9)	Winter damage %	Greenup, days after 31 Mar	Plant cover %	In-season diseases %	% cover 2 wk after sowing	Height increment mm/day	Thatch thickness, mm
	Overall mean	Sowing year	Green year 1	Green year 2	Green year 3	Spring	Summer	Autumn										
a) Apelsvoll																		
Agriostis canina	6.7	6.2	6.8	6.9	6.6	5.9	7.4	6.3	8.4	7.3	6.0	25	25	95	6	31	0.6	18
A.capillaris	5.8	5.3	5.8	5.9	6.2	5.5	6.3	5.6	6.6	5.5	6.1	20	27	96	2	23	0.9	12
A.stolonifera	5.3	7.1	6.9	4.0	4.2	4.2	5.4	5.0	6.9	6.0	5.8	59	27	86	7	24	0.6	10
F.rubra trich.	5.0	5.2	6.4	4.0	4.6	4.8	5.1	5.0	5.5	.	5.4	37	28	92	0	20	0.8	6
F.rubra comm.	4.8	5.2	6.0	3.9	4.3	4.6	4.9	4.7	5.1	.	5.3	44	28	91	0	14	0.9	5
Poa annua	2.6	5.8	1.9	2.6	1.9	2.1	2.0	2.4	3.6	4.0	3.4	59	36	82	0	23	0.8	8
Sign.	***	***	***	***	***	***	***	***	***	**	***	***	***	**	***	*	***	***
LSD 5%	0.5	0.5	0.2	0.9	0.7	0.4	0.6	0.5	0.2	0.2	0.4	9	1	6	3	8	0.1	2
b) Landvik																		
Agrostis canina	7.3	6.3	7.2	8.0	7.3	7.3	7.8	7.3	8.4	7.9	5.6	3	9	98	1	23	0.4	34
A.stolonifera	5.9	5.8	6.2	5.7	5.8	5.8	6.0	5.7	6.1	5.3	5.6	5	12	98	1	23	0.5	30
F.rubra trich.	5.4	4.7	6.0	5.3	5.2	5.8	5.4	5.3	5.3	.	5.1	6	11	97	1	18	1.1	28
A.capillaris	5.3	4.9	5.6	5.3	5.2	5.8	5.4	5.1	5.5	4.7	5.7	2	12	97	1	17	0.9	27
F.rubra comm.	5.1	4.4	5.8	4.7	4.9	5.6	5.2	4.9	4.9	.	5.0	3	14	97	1	11	1.2	22
Poa annua	4.0	4.0	3.5	3.4	5.0	3.6	3.5	5.1	4.6	3.8	4.1	8	11	96	0	19	0.6	28
Sign.	***	***	***	***	***	***	***	***	***	**	***	ns	***	8	ns	**	***	***
LSD 5%	0.3	0.3	0.3	0.3	0.4	0.3	0.3	0.3	0.2	0.2	0.4	-	1	-	-	5	0.1	4
c) Mean of two sites																		
Agrostis canina	7.0	6.2	7.0	7.4	7.0	6.6	7.6	6.8	8.4	7.6	5.8	14	17	97	3	27	0.5	26
A.capillaris	5.6	5.1	5.7	5.6	5.7	5.7	5.9	5.4	6.0	5.1	5.9	11	20	96	2	20	0.9	20
A.stolonifera	5.6	6.5	6.6	4.8	5.0	5.0	5.7	5.4	6.5	5.6	5.7	32	20	92	4	24	0.5	20
F.rubra trich.	5.2	4.9	6.2	4.6	4.9	5.3	5.3	5.1	5.4	.	5.2	22	19	95	1	19	1.0	17
F.rubra comm.	4.9	4.8	5.9	4.3	4.6	5.1	5.0	4.8	5.0	.	5.2	24	21	94	1	13	1.1	14
Poa annua	3.3	4.9	2.7	3.0	3.5	2.9	2.7	3.7	4.1	3.9	3.7	34	23	89	0	21	0.7	18
Sign.	**	ns	**	**	ns	**	**	ns	**	*	**	ns	ns	ns	ns	**	ns	**
LSD 5%	1.1	-	1.5	1.4	-	0.9	1.3	-	1.3	1.4	0.8	-	-	-	-	5		4

Table 4. Varieties of velvet bentgrass (*Agrostis canina* L.)

	Visual merit (1-9)								Tiller density (1-9)	Leaf fineness (1-9)	Color (1-9)	Winter damage %	Greenup, days after 31 Mar	Plant cover %	In-season diseases %	% cover 2 wk after sowing	Height increment mm/day	Thatch thickness, mm
	Overall mean	Sowing year	Green year 1	Green year 2	Green year 3	Spring	Summer	Autumn										
a) Apelsvoll																		
Villa	**7.2***	6.2	7.7	7.5	7.0	6.8	8.0	6.6	8.6	7.3	5.8	16	25	97	7	33	0.6	21
Avalon	**6.8**	6.3	7.2	7.2	6.2	5.7	7.6	6.6	8.3	7.3	6.2	30	25	95	8	27	0.6	18
Greenwich	**6.1**	6.0	5.5	6.0	6.7	5.3	6.5	5.9	8.3	7.3	6.0	29	26	93	3	33	0.6	15
Sign.	0.07	ns	1.1	0.18	ns	0.10	*	ns	*	ns	***	ns	ns	ns	0.10	ns	ns	**
LSD 5%	-	-	***	-	-	-	1.0	-	0.2	-	0.1	-	-	-	-	-	-	2
b) Landvik																		
Greenwich	**7.5**	6.5	7.6	8.0	7.5	7.6	8.0	7.4	8.5	8.1	5.5	1	9	99	1	21	0.5	33
Villa	**7.3**	6.2	7.1	8.1	7.3	7.4	7.7	7.4	8.5	8.2	5.3	3	10	99	1	23	0.4	35
Avalon	**7.1**	6.1	7.0	7.8	7.0	6.9	7.6	7.0	8.1	7.5	6.0	7	9	98	2	25	0.4	34
Sign.	0.07	ns	ns	ns	ns	*	ns	ns	**	**	***	0.09	ns	ns	ns	ns	ns	ns
LSD 5%	-	-	-	-	-	0.4	-	-	0.2	0.2	0.1	-	-	-	-	-	-	-
c) Mean of two sites																		
Villa	**7.3**	6.2	7.4	7.8	7.2	7.1	7.9	7.0	8.6	7.8	5.5	10	17	98	4	28	0.5	28
Avalon	**6.9**	6.2	7.1	7.5	6.6	6.3	7.6	6.8	8.2	7.4	6.1	18	17	96	5	26	0.5	26
Greenwich	**6.8**	6.3	6.6	7	7.1	6.5	7.3	6.7	8.4	7.7	5.7	15	18	96	2	27	0.6	24
Sign.	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	0.10	ns	ns	ns	ns	ns	*	ns
LSD 5%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-

*** In this and the following tables, figures indicated in bold have been used to rank varieties within each species.**

Table 5. Varieties of creeping bentgrass (*Agrostis stolonifera* L.)

	Visual merit (1-9)								Tiller density (1-9)	Leaf fineness (1-9)	Color (1-9)	Winter damage %	Greenup days after 31 Mar	Plant cover %	In-season diseases %	% cover 2 wk after sowing	Height increment mm/day	Thatch thickness, mm
	Overall mean	Sowing year	Green year 1	Green year 2	Green year 3	Spring	Summer	Autumn										
a) Apelsvoll																		
Nordlys	**6.8**	6.3	6.5	7.1	6.9	6.0	7.5	6.3	7.8	6.7	6.3	28	29	97	2	20	0.8	19
Penncross	**5.9**	7.3	6.4	5.0	5.5	4.5	6.1	5.9	6.9	5.0	5.6	55	27	94	3	27	0.8	10
Bueno	**5.6**	6.3	7.1	4.6	4.7	4.7	6.0	5.1	6.9	5.8	6.7	51	28	89	10	10	0.5	12
Independence	**5.4**	7.1	7.0	3.9	4.6	4.3	5.6	5.1	**7.1**	6.1	5.7	**54**	27	88	6	20	0.5	10
Penn G-1	**5.4**	7.3	7.1	3.7	4.3	4.1	5.5	5.0	**7.1**	6.0	5.6	**61**	27	88	9	23	0.6	9
SRX 1119	**5.2**	7.3	6.9	3.8	4.0	4.0	5.3	4.8	**6.8**	6.0	5.7	64	27	86	8	30	0.6	8
L-93	**5.2**	7.1	6.9	3.7	4.1	4.1	5.3	5.0	**6.7**	6.0	5.8	55	27	85	8	27	0.6	9
Penn A-4	**5.1**	7.1	6.9	3.4	4.2	4.1	5.1	5.0	**6.9**	5.8	5.6	56	27	87	5	30	0.6	11
Penn G-6	**5.1**	7.1	7.0	3.6	3.6	3.8	5.1	4.8	**6.7**	6.0	5.7	57	27	85	8	27	0.6	8
Penn A-1	**5.0**	7.4	6.9	3.4	3.4	4.0	4.9	4.5	**6.9**	6.0	5.6	70	27	83	8	27	0.6	9
Penn G-2	**5.0**	7.2	6.8	3.4	3.5	3.9	4.9	4.7	**6.7**	6.2	5.6	74	27	81	6	27	0.6	11
Providence	**4.8**	7.3	6.6	3.3	3.2	3.4	4.9	4.4	6.6	6.2	5.8	75	26	79	11	27	0.6	7
Cato	**4.7**	7.4	7.0	2.8	3.0	3.5	4.6	4.4	6.6	5.8	5.8	65	28	77	11	23	0.5	6
Sign.	***	***	**	***	***	***	***	***	**	***	***	**	8	*	**	***	***	***
LSD 5%	0.6	0.3	0.3	1.5	0.9	0.7	0.9	0.7	0.5	0.4	0.2	20	-	10	4	7	0.1	4

Table 5 continued. Varieties of creeping bentgrass (*Agrostis stolonifera* L.)

	Visual merit (1-9)								Tiller density (1-9)	Leaf fineness (1-9)	Color (1-9)	Winter damage %	Greenup days after 31 Mar	Plant cover %	In-season diseases %	% cover 2 wk after sowing	Height increment mm/day	Thatch thickness, mm
	Overall mean	Sowing year	Green year 1	Green year 2	Green year 3	Spring	Summer	Autumn										
b) Landvik																		
Independence	**6.6**	6.3	6.7	6.5	6.8	6.7	6.9	6.3	6.8	6.0	5.8	0	11	99	0	23	0.4	32
Nordlys	**6.3**	5.4	6.1	6.5	6.8	5.9	6.9	6.4	**7.1**	6.7	5.7	1	13	98	1	21	0.6	32
Penn G-1	**6.3**	6.2	6.5	6.1	6.3	6.1	6.3	6.3	**6.3**	5.6	5.7	3	11	98	0	24	0.5	27
Penn A-1	**5.9**	6.1	6.2	5.7	5.7	5.8	5.8	5.8	**6.2**	5.7	5.6	4	13	98	0	23	0.5	32
Penn G-2	**5.9**	5.9	6.3	5.8	5.7	5.9	6	5.8	**6.0**	5.1	5.5	9	13	97	1	25	0.6	28
Penn G-6	**5.8**	6.2	6.5	5.5	5.2	5.8	5.8	5.5	**6.0**	5.3	5.5	10	12	97	2	24	0.5	28
L-93	**5.8**	6.0	5.9	5.7	5.9	5.9	5.8	5.9	**5.9**	5.3	5.5	**1**	12	98	1	26	0.5	26
SRX 1119	**5.8**	5.9	6.3	5.5	5.5	5.9	5.8	5.6	**5.9**	5.3	5.5	**2**	13	98	0	27	0.5	32
Penn A-4	**5.8**	6.0	6.3	5.5	5.5	5.8	5.7	5.6	**5.8**	4.6	5.4	6	13	98	1	25	0.5	31
Cato	**5.8**	5.9	6.3	5.3	5.7	5.6	5.9	5.6	**5.7**	5.3	5.6	1	12	98	0	21	0.4	31
Penncross	**5.6**	5.8	6.0	5.5	5.3	5.8	5.5	5.4	5.7	4.1	5.5	2	12	99	0	26	0.7	28
Providence	**5.5**	5.7	6.0	4.9	5.4	5.1	5.5	5.5	5.5	5.1	5.5	16	12	96	1	19	0.4	28
Bueno	**5.4**	4.9	6.1	5.3	5.2	5.5	5.9	5.1	5.9	4.9	6.2	8	13	97	2	13	0.4	29
Sign.	***	***	*	***	***	**	***	**	***	***	***	ns	0.06	ns	ns	***	***	ns
LSD 5%	0.4	0.4	0.5	0.5	0.6	0.5	0.5	0.6	0.2	0.5	0.2	-	-	-	-	4	0.1	-

Table 5 continued. Varieties of creeping bentgrass (*Agrostis stolonifera* L.)

	Visual merit (1-9)								Tiller density (1-9)	Leaf fineness (1-9)	Color (1-9)	Winter damage %	Greenup days after 31 Mar	Plant cover %	In-season diseases %	% cover 2 wk after sowing	Height increment mm/day	Thatch thickness, mm
	Overall mean	Sowing year	Green year 1	Green year 2	Green year 3	Spring	Summer	Autumn										
c) Mean of two sites																		
Nordlys	**6.5**	5.8	6.3	6.8	6.9	6.0	7.2	6.4	7.4	6.7	6.0	15	21	97	1	21	0.7	25
Independence	**6.0**	6.7	6.9	5.2	5.7	5.5	6.2	5.7	6.9	6.1	5.8	27	19	94	3	22	0.4	21
Penn G-1	**5.8**	6.8	6.8	4.9	5.3	5.1	5.9	5.7	6.7	5.8	5.7	32	19	93	4	24	0.6	18
Penncross	**5.7**	6.6	6.2	5.2	5.4	5.1	5.8	5.7	6.3	4.6	5.6	29	19	96	2	26	0.7	19
Bueno	**5.5**	5.6	6.6	5.0	5.0	5.1	6.0	5.1	**6.4**	5.3	6.5	**30**	21	93	6	12	0.5	21
Penn A-4	**5.5**	6.6	6.6	4.4	4.8	4.9	5.4	5.3	**6.4**	5.2	5.5	**31**	20	92	3	28	0.6	21
SRX 1119	**5.5**	6.6	6.6	4.6	4.8	5.0	5.6	5.2	**6.4**	5.6	5.6	**33**	20	92	4	29	0.5	20
L-93	**5.5**	6.6	6.4	4.7	5.0	5.0	5.5	5.4	**6.3**	5.6	5.6	28	19	91	4	26	0.5	17
Penn A-1	**5.4**	6.7	6.6	4.6	4.5	4.9	5.4	5.2	6.5	5.9	5.6	37	20	90	4	25	0.5	21
Penn G-2	**5.4**	6.5	6.6	4.6	4.6	4.9	5.4	5.2	6.3	5.7	5.5	42	20	89	3	26	0.6	19
Penn G-6	**5.4**	6.7	6.8	4.5	4.4	4.8	5.4	5.2	6.4	5.6	5.6	33	20	91	5	26	0.5	18
Cato	**5.2**	6.6	6.6	4.1	4.4	4.5	5.3	5.0	6.1	5.6	5.7	33	20	87	5	22	0.4	19
Providence	**5.1**	6.5	6.3	4.1	4.3	4.2	5.2	4.9	6.1	5.7	5.6	45	19	87	6	23	0.5	18
Sign.	ns	***	**	***	0.09	ns	*	ns	***	**	**	ns	ns	ns	ns	***	***	ns
LSD 5%	-	0.3	0.3	1.5	-	-	0.9	-	0.4	0.6	0.3	-	-	-	-	5	0.1	-

Table 6. Varieties of colonial bentgrass (*Agrostis capillaris* L.)

	Visual merit (1-9)								Tiller density (1-9)	Leaf fineness (1-9)	Color (1-9)	Winter damage %	Greenup days after 31 Mar	Plant cover %	In-season diseases %	% cover 2 wk after sowing	Height increment mm/day	Thatch thickness, mm
	Overall mean	Sowing year	Green year 1	Green year 2	Green year 3	Spring	Summer	Autumn										
a) Apelsvoll																		
Jorvik	**6.2**	5.4	6.2	6.0	6.8	5.6	6.8	6.1	7.1	6.2	6.1	19	27	95	3	17	0.8	12
Leirin	**6.1**	5.1	5.9	6.6	6.4	6.1	6.6	5.7	6.5	5.9	5.8	15	27	96	4	23	1.0	12
Bardot	**5.9**	5.3	6.2	5.7	6.2	5.5	6.3	6.0	**7.1**	5.6	6.0	26	28	96	2	15	0.9	12
Nor	**5.9**	5.6	5.9	6.1	5.9	6.0	6.2	5.3	**6.1**	5.1	6.4	**11**	29	98	1	20	1.0	13
Leira	**5.9**	5.9	5.7	6.0	6.0	5.7	6.1	5.5	**6.1**	5.0	6.3	**14**	29	98	1	27	1.0	12
Barking	**5.8**	5.3	5.6	5.4	6.6	4.9	6.2	6.0	6.9	5.8	5.7	24	27	93	3	30	0.9	11
Denso	**5.7**	5.0	6.1	5.2	6.2	5.1	6.3	5.4	6.9	5.9	6.1	29	28	94	4	27	0.9	12
Lance	**5.6**	5.1	5.1	5.8	6.3	4.8	6.2	5.8	6.8	5.6	5.8	36	26	93	2	20	0.9	10
Pop Å	**5.4**	5.1	5.2	5.9	5.4	5.4	5.7	5.0	5.8	4.9	6.3	10	27	97	1	27	1.0	11
Sign.	*	ns	***	ns	***	***	*	***	***	**	**	**	ns	***	***	ns	*	ns
LSD 5%	0.4	-	0.4	-	0.4	0.7	0.5	0.4	0.2	0.7	0.4	13	-	2	1	-	0.1	-
b) Landvik																		
Jorvik	**6.3**	5.0	6.5	6.5	6.5	6.9	6.5	6.3	**6.8**	5.9	5.8	1	9	99	0	14	0.8	30
Denso	**6.3**	5.2	6.2	6.4	6.8	6.6	6.7	6.1	**6.6**	5.7	6.0	5	11	96	3	15	0.7	28
Barking	**6.1**	5.4	6.2	6.6	5.9	6.7	6.2	6.0	6.5	5.8	5.5	1	9	98	1	23	1.0	30
Bardot	**6.0**	5.1	6.3	6.0	6.2	6.6	6.3	5.9	6.0	5.3	5.7	4	12	99	0	11	0.9	26
Lance	**5.6**	4.9	5.7	5.8	5.7	6.2	5.6	5.7	5.9	5.0	5.5	4	10	98	0	14	0.8	26
Leirin	**5.1**	4.8	5.6	4.9	4.7	5.5	5.2	4.6	5.1	4.1	5.3	0	13	94	3	22	0.9	27
Nor	**4.6**	4.6	5.4	4.3	4.0	5.1	4.7	4.1	4.3	3.7	5.8	0	15	97	0	20	0.9	30
Leira	**4.3**	5.1	4.8	4.0	3.7	4.8	4.1	3.8	4.4	3.9	5.7	1	14	94	2	18	0.9	26
Pop Å	**3.7**	4.2	4.0	3.3	3.5	4.2	3.6	3.4	3.9	3.2	5.9	2	15	95	1	14	0.9	25
Sign.	***	ns	***	***	***	***	***	***	***	***	***	0.07	***	ns	**	**	ns	ns
LSD 5%	0.4	-	0.6	0.3	0.9	0.5	0.6	0.8	0.5	0.3	0.2	-	1	-	2	6	-	-

Table 6 continued. Varieties of colonial bentgrass (*Agrostis capillaris* L.)

	Visual merit (1-9)								Tiller density (1-9)	Leaf fineness (1-9)	Color (1-9)	Winter damage %	Greenup days after 31 Mar	Plant cover %	In-season diseases %	% cover 2 wk after sowing	Height increment mm/day	Thatch thickness, mm
	Overall mean	Sowing year	Green year 1	Green year 2	Green year 3	Spring	Summer	Autumn										
c) Mean of two sites																		
Jorvik	**6.2**	5.2	6.4	6.3	6.7	6.2	6.7	6.2	6.9	6.1	6.0	10	18	97	2	16	0.8	21
Denso	**6.0**	5.1	6.1	5.8	6.5	5.9	6.5	5.8	**6.7**	5.8	6.0	17	19	95	4	21	0.8	20
Bardot	**6.0**	5.2	6.3	5.9	6.2	6.0	6.3	5.9	**6.6**	5.5	5.9	15	20	98	1	13	0.9	19
Barking	**5.9**	5.4	5.9	6.0	6.2	5.8	6.2	6.0	6.7	5.8	5.6	13	18	95	2	27	0.9	21
Lance	**5.6**	5.0	5.4	5.8	6.0	5.5	5.9	5.7	**6.4**	5.3	5.7	20	18	95	1	17	0.9	18
Leirin	**5.6**	4.9	5.8	5.8	5.5	5.8	5.9	5.2	**5.8**	5.0	5.5	8	20	95	3	23	1.0	19
Nor	**5.3**	5.1	5.7	5.2	4.9	5.6	5.5	4.7	5.2	4.4	6.1	5	22	98	1	20	1.0	22
Leira	**5.1**	5.5	5.2	5.0	4.9	5.3	5.1	4.7	5.3	4.4	6.0	7	21	96	2	22	0.9	19
PopÅ	**4.6**	4.7	4.6	4.6	4.5	4.8	4.7	4.2	4.8	4.0	6.1	6	21	96	1	21	0.9	18
Sign.	ns	ns	ns	ns	0.10	ns	ns	0.10	*	*	*	ns	0.10	ns	0.09	*	*	0.14
LSD 5%	-	-	-	-	-	-	-	-	1.1	1.1	0.3	-	-	-	-	7	0.1	-

Table 7. Varieties of slender creeping red fescue (*Festuca rubra* var. *trichophylla*)

	Overall mean	Visual merit (1-9) Sowing year	Green year 1	Green year 2	Green year 3	Spring	Summer	Autumn	Tiller density (1-9)	Leaf fineness (1-9)	Color (1-9)	Winter damage %	Greenup days after 31 Mar	Plant cover %	In-season diseases %	% cover 2 wk after sowing	Height increment mm/day	Thatch thickness, mm
a) Apelsvoll																		
Baroyal	**5.5**	5.3	6.4	5.3	4.8	5.6	5.7	5.0	5.6	.	5.6	32	27	97	0	13	0.9	6
Cezanne	**5.4**	5.2	6.7	4.4	5.0	5.3	5.4	5.5	5.8	.	5.4	37	28	95	0	13	0.8	6
Leonora	**4.8**	4.9	5.8	4.0	4.5	4.5	4.9	4.8	5.3	.	5.1	36	28	92	0	27	0.9	6
Barcrown	**4.5**	5.4	6.5	2.4	4.1	3.9	4.5	4.6	5.4	.	5.5	44	28	84	0	27	0.7	7
Sign.	**	*	***	**	*	***	**	*	0.11	-	**	ns	ns	***	ns	**	ns	ns
LSD 5%	0.3	0.4	0.2	1.0	0.4	0.7	0.4	0.5	-	-	0.2	-	-	4	-	7	-	-
b) Landvik																		
Cezanne	**5.5**	5	6.1	5.4	5.3	5.9	5.6	5.4	5.4	.	5.2	6	12	97	1	14	1.0	28
Barcrown	**5.3**	4.9	5.9	5.1	5.2	5.8	5.3	5.3	**5.5**	.	5.0	10	10	97	2	16	1.1	26
Baroyal	**5.3**	4.3	6.0	5.4	5.2	6.0	5.5	5.3	**5.2**	.	5.3	**3**	12	97	0	15	1.2	29
Leonora	**5.3**	4.5	6.0	5.2	5.1	5.8	5.3	5.2	**5.2**	.	4.9	**5**	10	97	1	27	1.1	27
Sign.	ns	*	ns	ns	ns	ns	ns	ns	ns		**	ns	ns	ns	0.14	*	ns	ns
LSD 5%	-	0.4	-	-	-	-	-	-	-		0.2	-	-	-	-	8	-	-
c) Mean of two sites																		
Cezanne	**5.4**	5.1	6.4	4.9	5.2	5.6	5.5	5.4	**5.6**	.	5.3	21	50	96	1	14	0.9	17
Baroyal	**5.4**	4.8	6.2	5.4	5.0	5.8	5.6	5.2	**5.4**	.	5.4	17	50	97	0	14	1	18
Leonora	**5.0**	4.7	5.9	4.6	4.8	5.1	5.1	5.0	5.2	.	5.0	21	49	95	1	27	1	17
Barcrown	**4.9**	5.2	6.2	3.7	4.7	4.9	4.9	4.9	5.4	.	5.2	27	49	90	1	21	0.9	16
Sign.	ns	ns	ns	ns	ns	ns	ns	ns	ns		*	*	ns	ns	ns	ns	ns	ns
LSD 5%	-	-	-	-	-	-	-	-	-		0.2	5	-	-	-	-	-	-

Table 8. Varieties of chewings fescue (*Festuca rubra* var. *commutata*)

	Visual merit (1-9)																	
	Overall mean	Sowing year	Green year 1	Green year 2	Green year 3	Spring	Summer	Autumn	Tiller density (1-9)	Leaf fineness (1-9)	Color (1-9)	Winter damage %	Greenup days after 31 Mar	Plant cover %	In-season diseases %	% cover 2 wk after sowing	Height increment mm/day	Thatch thickness, mm
a) Apelsvoll																		
Kiruna	**5.4**	5.1	6.2	4.9	5.4	5.4	5.6	5.4	5.3	.	5.1	28	29	97	0	30	0.9	5
Soberana	**5.2**	4.4	6.1	5.0	4.8	5.2	5.4	5.2	**5.2**	.	5.4	**25**	27	96	0	18	0.9	5
Bargreen	**5.2**	5.3	6.1	4.6	4.8	5.1	5.2	5.1	**5.2**	.	4.8	**34**	29	96	0	12	1.0	5
Center	**5.1**	5.6	6.1	4.1	4.7	4.9	5.1	4.8	5.2	.	5.3	42	28	94	0	10	0.9	6
Darwin	**5.0**	5.2	6.6	4.0	4.3	5.0	5.1	4.7	**5.2**	.	6.4	45	29	91	0	17	0.9	5
Barbirdie	**5.0**	5.6	5.9	4.3	4.4	4.7	5.0	4.8	**5.0**	.	5.1	48	27	94	0	13	1.0	4
Blenheim	**4.8**	4.8	6.0	3.8	4.8	4.5	5.0	4.8	**5.3**	.	5.6	41	28	92	0	13	0.9	7
Maritza	**4.8**	5.5	6.1	3.7	4.3	4.5	4.8	4.7	**5.2**	.	5.3	49	28	92	0	8	0.9	5
Calliope	**4.6**	5.7	6.0	3.2	4.1	4.4	4.5	4.4	5.2	.	4.8	49	29	90	0	11	0.9	5
Rossignol	**4.5**	5.4	6.0	3.1	3.8	4.2	4.5	4.1	**5.0**	.	5.1	49	29	87	0	11	1.0	5
SW Cygnus	**4.5**	4.3	5.6	4.0	4.1	4.5	4.7	4.6	**4.8**	.	5.1	37	27	91	0	4	1.0	4
Valentina	**4.4**	4.6	5.8	3.4	4.1	4.3	4.5	4.4	4.8	.	5.2	52	27	90	0	7	0.9	5
Bellaire	**4.2**	5.7	6.0	2.6	3.0	3.6	4.1	3.8	5.1	.	6.0	78	29	76	1	23	0.8	5
Sign.	*	***	***	**	**	***	**	*	ns	-	***	***	**	*	**	**	ns	0.06
LSD 5%	0.6	0.6	0.3	1.1	0.9	0.7	0.7	0.8	-	-	0.3	11	1	4	1	10	-	-

Table 7 continued. Varieties of chewings fescue (*Festuca rubra* var. *commutata*)

	Visual merit (1-9)																	
	Overall mean	Sowing year	Green year 1	Green year 2	Green year 3	Spring	Summer	Autumn	Tiller density (1-9)	Leaf fineness (1-9)	Color (1-9)	Winter damage %	Greenup days after 31 Mar	Plant cover %	In-season diseases %	% cover 2 wk after sowing	Height increment mm/day	Thatch thickness, mm
b) Landvik																		
Center	**5.4**	4.9	6.2	4.9	5.2	6.0	5.3	5.2	5.1	.	4.9	2	15	98	1	13	1.3	22
Calliope	**5.3**	5.2	6.4	5.0	4.5	6.2	5.4	4.6	**5.4**	.	4.6	3	14	97	3	9	1.3	27
Kiruna	**5.3**	4.9	6.0	4.8	5.2	5.9	5.5	4.8	**5.1**	.	4.7	0	15	98	0	17	1.2	23
Blenheim	**5.3**	4.2	5.9	5.1	5.3	5.8	5.4	5.3	**5.0**	.	5.1	1	12	97	0	12	1.1	20
Barbirdie	**5.2**	4.8	5.9	4.9	5.1	5.8	5.3	5.1	**5.0**	.	4.8	2	12	97	1	20	1.2	21
Maritza	**5.2**	4.3	5.8	4.8	5.3	5.6	5.4	5.1	**4.9**	.	4.9	1	14	97	1	10	1.1	23
Rossignol	**5.1**	4.6	6.1	4.7	4.7	5.7	5.3	4.7	**4.9**	.	4.6	2	14	97	2	11	1.3	22
Bellaire	**5.1**	5.1	6.1	4.4	4.7	5.2	5.2	4.8	**4.8**	.	5.5	18	14	95	3	10	1.1	23
Bargreen	**5.0**	4.7	5.9	4.8	4.6	5.7	5.1	4.6	4.9	.	4.6	2	13	97	2	13	1.3	22
Darwin	**4.9**	4.0	5.8	4.6	4.9	5.6	5.0	4.8	4.8	.	6.1	2	15	97	0	8	1.3	20
Valentina	**4.8**	3.5	5.1	4.7	5.1	5.2	4.8	5.0	**4.7**	.	5.1	1	14	95	1	9	1.2	21
Soberana	**4.8**	3.8	5.3	4.5	5.0	5.4	4.8	4.7	**4.6**	.	5.1	1	13	96	1	12	1.1	21
SW Cygnus	**4.5**	3.3	5.2	4.3	4.6	5.0	4.7	4.5	4.2	.	4.9	2	13	95	1	5	1.2	22
Sign.	****	***	***	*	**	***	***	**	***	-	***	***	**	***	**	**	ns	ns
LSD 5%	0.3	0.6	0.3	0.5	0.4	0.4	0.3	0.4	0.3	-	0.3	4	1	1	1	6	-	-

Table 7 continued. Varieties of chewings fescue (*Festuca rubra* var. *commutata*)

	Visual merit (1-9)																	
	Overall mean	Sowing year	Green year 1	Green year 2	Green year 3	Spring	Summer	Autumn	Tiller density (1-9)	Leaf fineness (1-9)	Color (1-9)	Winter damage %	Greenup days after 31 Mar	Plant cover %	In-season diseases %	% cover 2 wk after sowing	Height increment mm/day	Thatch thickness, mm
c) Mean of two sites																		
Kiruna	**5.4**	5.0	6.1	4.8	5.3	5.7	5.5	5.1	5.2	.	4.9	14	22	97	0	23	1.1	14
Center	**5.2**	5.3	6.1	4.5	5.0	5.4	5.2	5.0	5.1	.	5.1	22	21	96	0	12	1.1	14
Blenheim	**5.1**	4.5	6.0	4.4	5.0	5.1	5.2	5.1	**5.2**	.	5.3	21	20	95	0	13	1.0	14
Bargreen	**5.1**	5.0	6.0	4.7	4.7	5.4	5.2	4.8	**5.1**	.	4.7	18	21	96	1	13	1.1	14
Barbirdie	**5.1**	5.2	5.9	4.6	4.8	5.2	5.2	4.9	**5.0**	.	4.9	25	20	96	1	17	1.1	13
Calliope	**5.0**	5.5	6.2	4.1	4.3	5.3	5.0	4.5	**5.3**	.	4.7	26	22	94	1	10	1.1	16
Darwin	**5.0**	4.6	6.2	4.3	4.6	5.3	5.0	4.7	**5.0**	.	6.3	**24**	22	94	0	12	1.1	13
Maritza	**5.0**	4.9	6.0	4.3	4.8	5.0	5.1	4.9	**5.0**	.	5.1	**25**	21	95	0	9	1.0	14
Soberana	**5.0**	4.1	5.7	4.8	4.9	5.3	5.1	5.0	**4.9**	.	5.3	13	20	96	0	15	1.0	13
Rossignol	**4.8**	5.0	6.1	3.9	4.2	4.9	4.9	4.4	5.0	.	4.9	25	22	92	1	11	1.1	13
Bellaire	**4.6**	5.4	6.1	3.5	3.8	4.4	4.7	4.3	5.0	.	5.7	48	21	86	2	17	0.9	14
Valentina	**4.6**	4.1	5.5	4.0	4.6	4.8	4.7	4.7	4.7	.	5.1	27	20	92	1	8	1.1	13
SW Cygnus	**4.5**	3.8	5.4	4.2	4.3	4.7	4.7	4.6	4.5	.	5.0	20	20	93	0	5	1.1	13
Sign.	ns	***	ns	ns	0.07	0.10	ns	ns	*		***	*	*	ns	ns	ns	*	ns
LSD 5%	-	0.5	-	-	-	-	-	-	0.3		0.2	15	1	-	-	-	0.1	

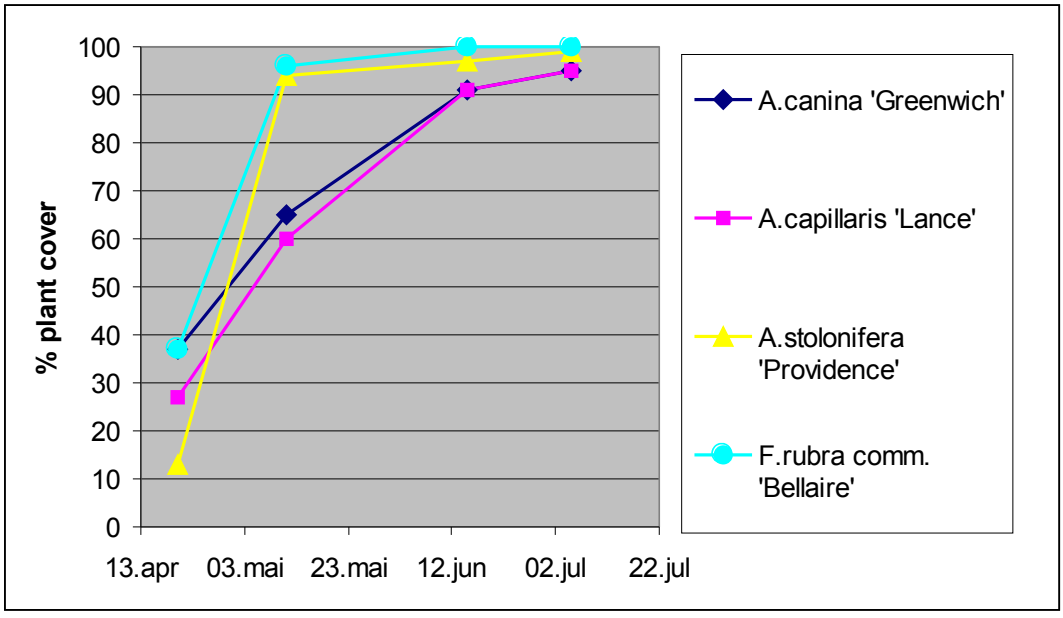

Fig. 1. Recovery of the varieties of velvet bentgrass, colonial bentgrass, creeping bentgrass and red fescue suffering most damage (mostly from snow mold) during the first winter (2003/04) at Apelsvoll.

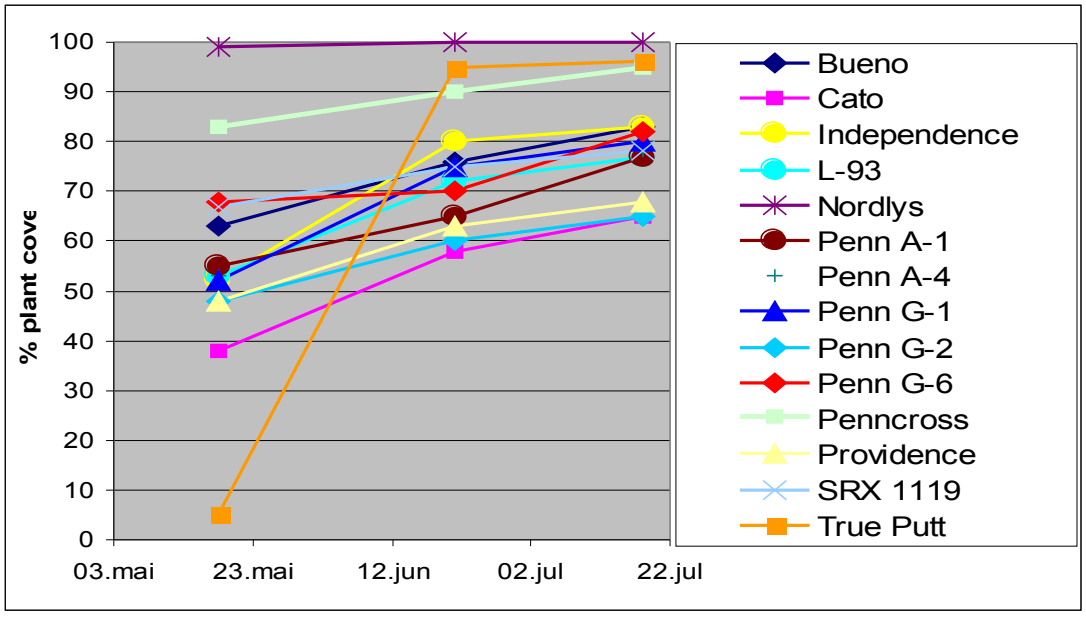

Fig. 2. Recovery of thirteen creeping bentgrass varieties and one annual bluegrass variety (True Putt) after damage (mostly from ice encasement) during the second winter (2004/05) at Apelsvoll.

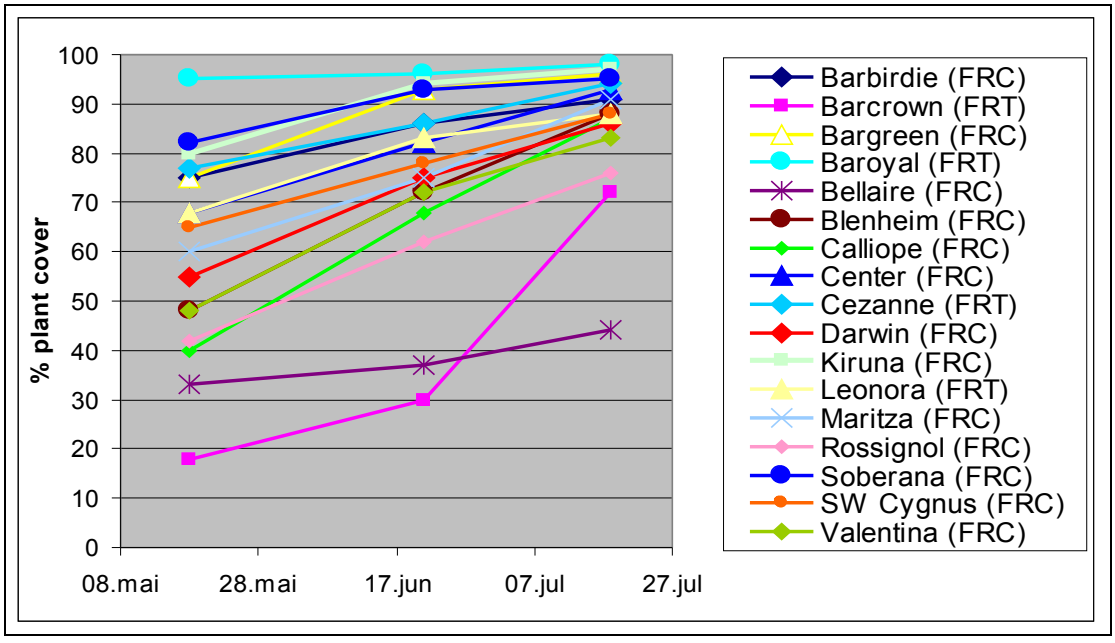

Fig. 3. Recovery of seventeen red fescue varieties after damage (mostly from ice encasement) during the second winter (2004/05) at Apelsvoll. (FRC = *commutata*, FRT = *trichophylla*)

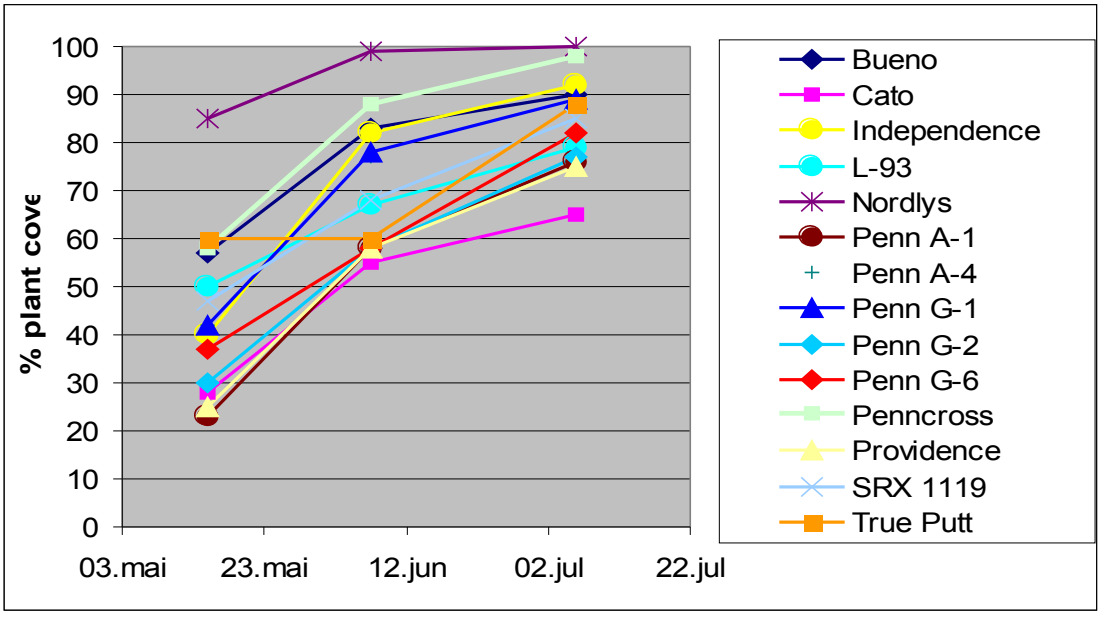

Fig. 4. Recovery of thirteen creeping bentgrass varieties and one annual bluegrass variety (True Putt) after damage (mostly from snow mold) during the third winter (2005/06) at Apelsvoll.

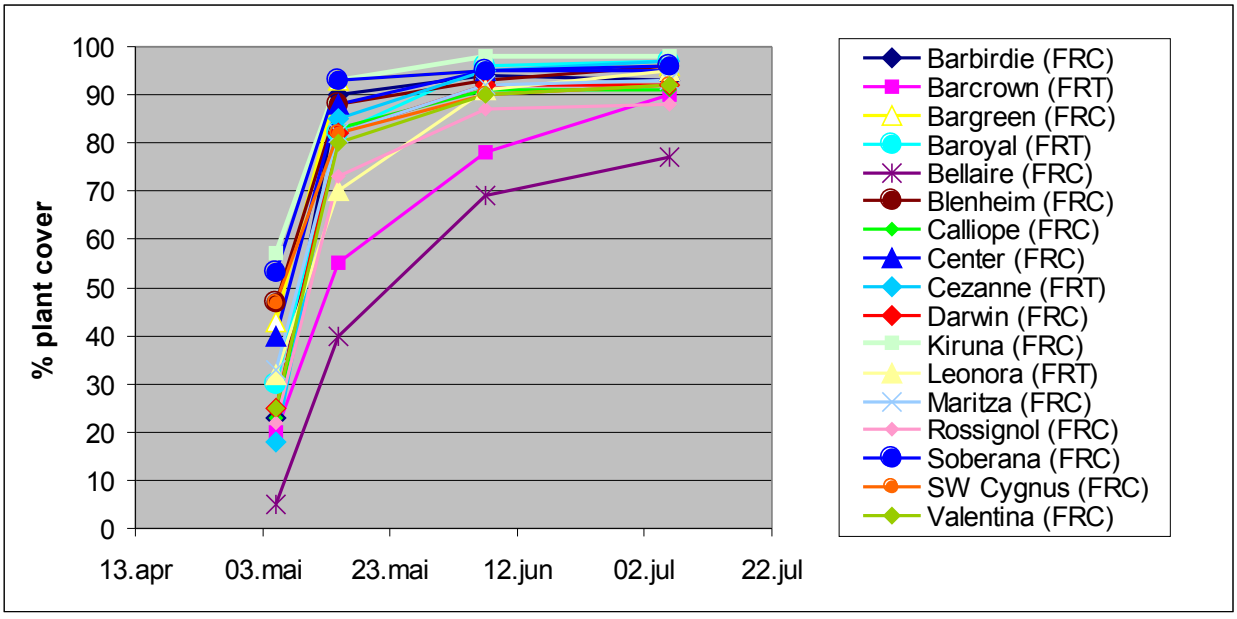

Fig. 5. Recovery of seventeen red fescue varieties after damage (mostly from snow mold) during the third winter (2005/06) at Apelsvoll. (FRC = *commutata*, FRT = *trichophylla*)

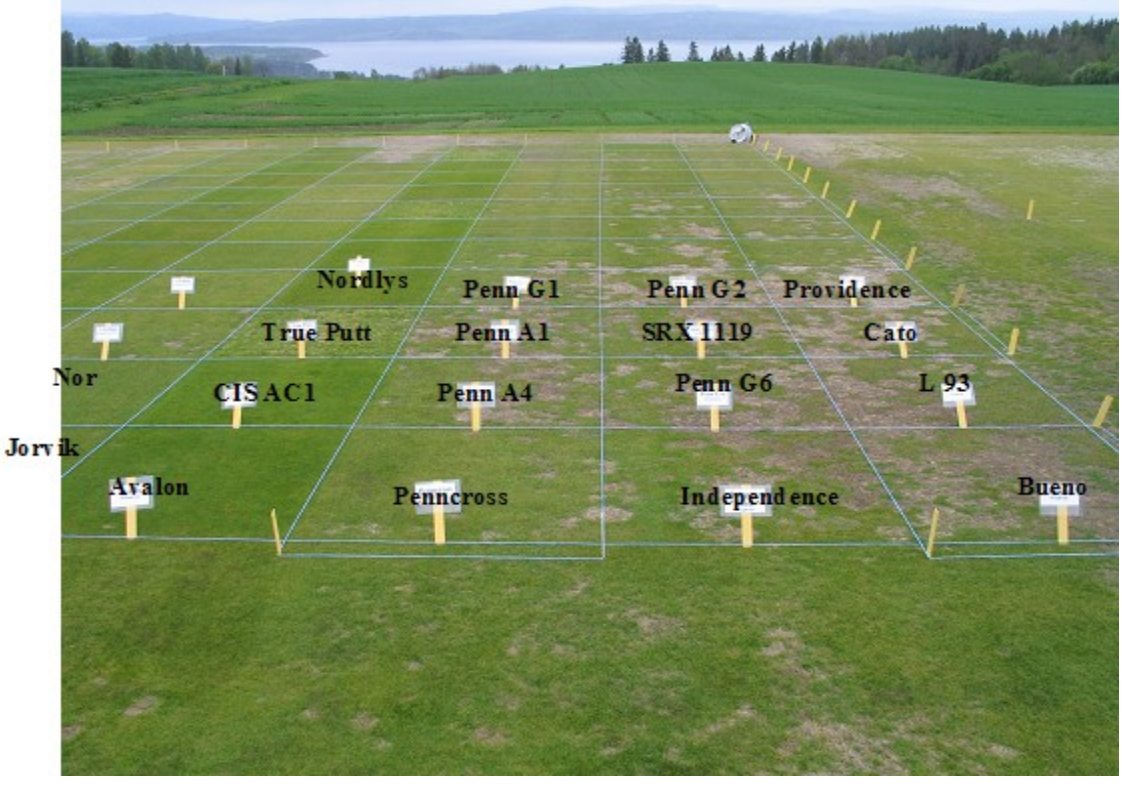

Photo 3. Varieties of velvet bentgrass and creeping bentgrass at Apelsvoll in May 2005, after three months of ice encasement. (Photo: Bjørn Molteberg)

Photo 4. *Microdochium and Pythium* in velvet bengrass 'Avalon', Apelsvoll 24 Oct 2006. (Photo: Trygve S. Aamlid).

Photo 5. Thatch accumulation of chewings rescue 'Bargreen', slender creeping red fescue 'Cezanne', annual bluegrass 'True Putt' colonial bentgrass 'Jorvik', creeping betgrass 'Independence' and velvet bentgrass 'Greenwich' at the end of the project period at Landvik. (Photo: Trygve S. Aamlid).

Photo 6. Sunken spots with collapsed turf, velvet bentgrass 'Greenwich', Landvik 7 June 2006. Samples diagnosed at the Bioforsk Plant Health Clinic revealed no other diseases than *Pythium*. (Photo: Trygve S. Aamlid).

Photo 7. The Norwegian creeping bentgrass variety 'Nordlys' had finer texture and higher tiller density than the Penn As and Gs. Photo taken at Landvik in August 2006. (Photo: Trygve S. Aamlid).

Photo 8. Tiller density and leaf texture in the creeping bentgrass varieties 'Cato' and 'Independence'. Photo taken at Landvik in August 2006. (Photo: Trygve S. Aamlid).

Photo 9. Tiller density and leaf texture in colonial bentgrass 'Nor' and 'Jorvik'. Photo taken at Landvik in August 2006. (Photo: Trygve S. Aamlid).

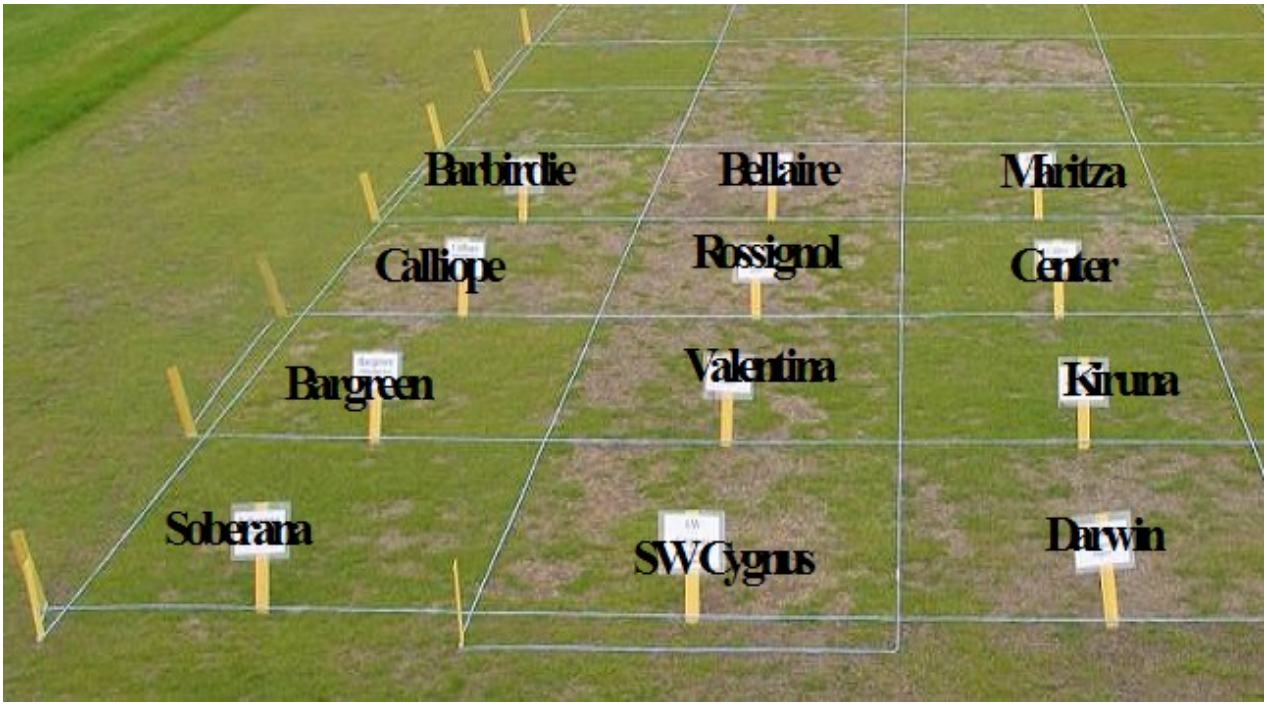

Photo 10. Survival of chewings fescues at Apeslvoll in May 2005, after three months of ice cover. (Photo: Bjørn Molteberg).

Photo 11. 'Bellaire' was the chewings fescue variety most susceptible both to winter damage and diseases during the growing season. This photo shows *Pythium* in 'Bellaire' at Landvik in October 2006. (Photo: Trygve S. Aamlid).

Photo 12. *Pythium* in chewings fescue 'Bargreen' (behind string) and 'Calliope' (front of string). Photo taken at Landvik in November 2006. (Photo: Trygve S. Aamlid).