Photo: Pia Heltoft

Results from NIBIO Apelsvoll confirm superintendents' experiences:

Better winter survival with impermeable plastic covers on annual bluegrass, creeping bentgrass and red fescue putting greens

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Results from NIBIO Apelsvoll confirm superintendents' positive experiences with impermeable plastic covers during the winter on annual bluegrass, creeping bentgrass and red fescue putting greens

Photo 1. *The experimental green at Apelsvoll on 25 Nov. 2020, ready for the winter. The plots going to be covered by ice were surrounded by frames to keep the freezing water in place. The white poles extended 50 cm into the rootzone and contained tubes filled with the methylene-blue, a pigment that turns white at freezing temperatures and can be used to measure freezing depth in the soil. The black bags on wooden poles contained senders for the temperature and gas sensors than were deployed in the thatch/mat layer in treatments 1, 3 and 4. Photo: Trygve S. Aamlid*

Result from a field experiment at NIBIO Apelsvoll during the winter 2020-21 confirm greenkeepers' observations from the three last years at the Norwegian golf courses Haga, Bærum, Asker and Holtsmark: Covering the greens with plastic before winter gives better winter survival, particularly of annual bluegrass (*Poa annua*), but also of creeping bentgrass (*Agrostis stolonifera*) and red fescue (*Festuca rubra*).

In 2020 a new experimental green was constructed as part of the ICE-BREAKER project at NIBIO Apelsvoll Research Center, an inland site, 61°N, 120 km north of Oslo and 200 m a.s.l. The green had no drainage layer but was established by adding two 7.5 cm layers of USGA-spec. sand, of which the first was roto-tilled into the existing moraine soil. The green was established in June 2020 with the following grass species and cultivars:

- K: Creeping bentgrass (seed blend of 75 % 'Riptide' + 25 % 'Independence')
- R: Red fescue: Seed blend of 67 % Chewings fescue (*F. rubra* ssp. *commutata*: 27 % 'Musica', 27 % 'Barlineus', 13 % 'Linda') and slender creeping red fescue (*F. rubra* ssp. *littoralis*; 33 % 'Cezanne')
- T: Green-type annual bluegrass (established using a mixture of vegetative plant parts and seed from verticutting and core aeration of a 80 year old annual bluegrass green that had never been seeded at Borregaard GC, Sarpsborg, southeast Norway)

Figure 1 shows the field map. The experiment had three blocks, the three species being established in stripes in one direction with experimental treatments in stripes perpendicular to the species.
The experimental treatments were:

1. Control = Natural winter: No removal of snow or ice. Natural snow and ice melt in spring
2. Snow and ice removal: Snow deeper than 5 cm and all ice layers consistently removed from the green surface throughout the winter
3. Long-lasting ice cover: Establishment of a 10 cm ice layer in the first period with freezing temperatures in late November. Ice protected from melting using styrofoam mats during mild periods with no snow above the ice layer before 1 April. Natural snow and ice melt after 1 April.
4. As treatment 3, but with a transparent, impermeable, plastic sheet, thickness 115 my (SLIP AB, Söderbärke, Sweden) between the turf and the ice. No ventilation under the plastic sheets.
5. As treatment 2 (snow and ice removal) until 11 January. Then establishment of a 10 cm ice layer and as treatment 3 for the rest of the winter.
6. As treatment 3, but mechanical removal snow and ice in the first mild period after 1 March when the ice slips form the turf. Protection against night frost with a permeable spring tarp after snow and ice removal.

The field map is shown in Figure 1, while Photo 1 shows the experiment on 25 November, ready for the winter.

N		------15 m ------ (-- 2.5 m --)					
		Treatm. 1: Control. Natural winter conditions	Treatm. 2: Snow thicker than 5 cm and ice removed throughout winter	Treatm. 5: Snow /ice removed until 11 Jan., then establishment of 10 cm ice and as treatm. 3 for rest of winter	Treatm. 4: Green covered with plastic before establishing ice. Otherwise as treatm. 3	Treatm. 6: As treatm. 3 until 1 March. Then removal of snow and ice as soon as ice slips from grass	Treatm. 3: 10 cm ice directly over grass throughout winter
BLOCK 1	*Poa annua* (1.5 m)	101	102	103	104	105	106
	A. stolonif. (1.5 m)	107	108	109	110	111	112
	F. rubra (1.5 m)	113	114	115	116	117	118
BORDER							
		Treatm. 1	Treatm. 4	Treatm. 3	Treatm. 6	Treatm. 5	Treatm. 2
BLOCK 2	*F. rubra* (1.5 m)	201	202	203	204	305	206
	Poa annua (1.5 m)	207	208	209	210	211	212
	A. stolonif. (1.5 m)	213	214	215	216	217	218
BORDER							
		Treatm. 2	Treatm. 6	Treatm. 1	Treatm. 4	Treatm. 3	Treatm. 5
BLOCK 3	*A. stolonif.* (1.5 m)	301	302	303	304	305	306
	F. rubra (1.5 m)	307	308	309	310	311	312
	Poa annua (1.5 m)	313	314	315	316	317	318

Figure 1. *Field map of the ICE-BREAKER experiment at Apelsvoll. Each block (replicate) had stripes with creeping bentgrass, red fescue and annual bluegrass in one direction and the different treatments in the other direction. Plot number is shown in the upper left corner of each cell.*

Weather conditions and the establishment of ice cover

The fall in 2020 was very mild compared with the long-term (1991-2020) average for Apelsvoll Research Center (Figure 2). October and December 2020 also had abundant rainfall. The plastic sheets in treatment 4 were installed on 30 November after a cold spell with frost in the 1-2 cm surface layer on the green; on the same day we also tried to establish ice cover in treatments 3, 4 and 6 by repeatedly adding with small amounts of water. However, the mild weather soon returned causing the ice to become slushy and in many cases melt totally with the melting water seeping through the mostly unfrozen rootzone. New attempts to establish ice cover in December gave the same result due to the mild and rainy weather. It was not until the 'winter' finally settled just after New Year that we managed to establish a permanent ice cover in treatments 3 and 6 (photos 2 and 3). Six days later, on 11 January, ice cover was established in treatment 5 according to the experimental plan, and this ice became much more compact and dense than the one in treatments 3 and 6 because it was laid out on deeply frozen greens with no slush on the surface. Later in the winter, measurements of ice density showed an average of 1.09 g/cm^3 in treatment 5 vs. 0.97 g/cm^3 in treatments 3 and 6.

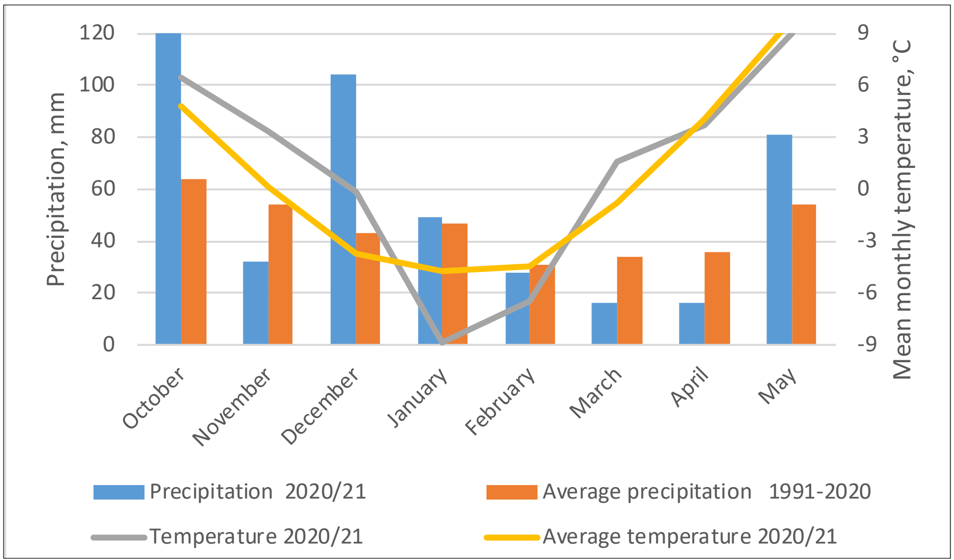

Figure 2. *Temperature and precipitation at Apelsvoll, October 2020 – May 2021 compared with 30-year mean values, 1991-2020*

Photo 2. *Research technician Jan Tangsveen establishing ice cover in treatment 3 on 5 January 2021. Attempts to establish ice were made for the first time on 30 November and repeated several times in December, but the mild weather resulted in the formation of slush and no compact ice. On 5 January the winter had finally settled, but the ice layers in treatments 3, 4 and 6 became rather porous because of the slush that was already present on the plots. Photo: Marte Skattebu.*

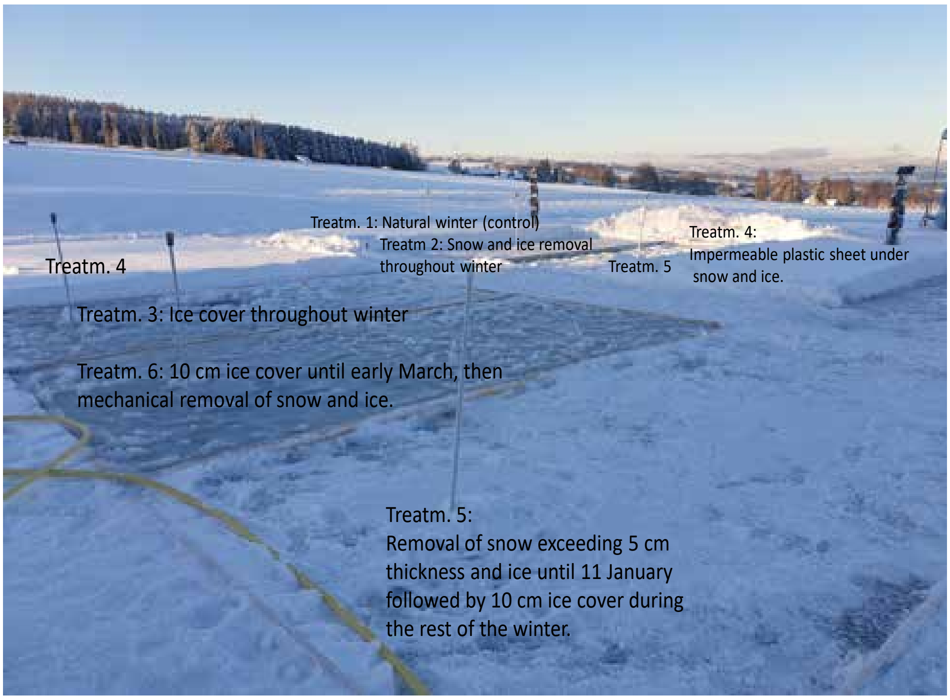

Photo 3. *Overview of experiment on 5 January. Photo: Marte Skattebu.*

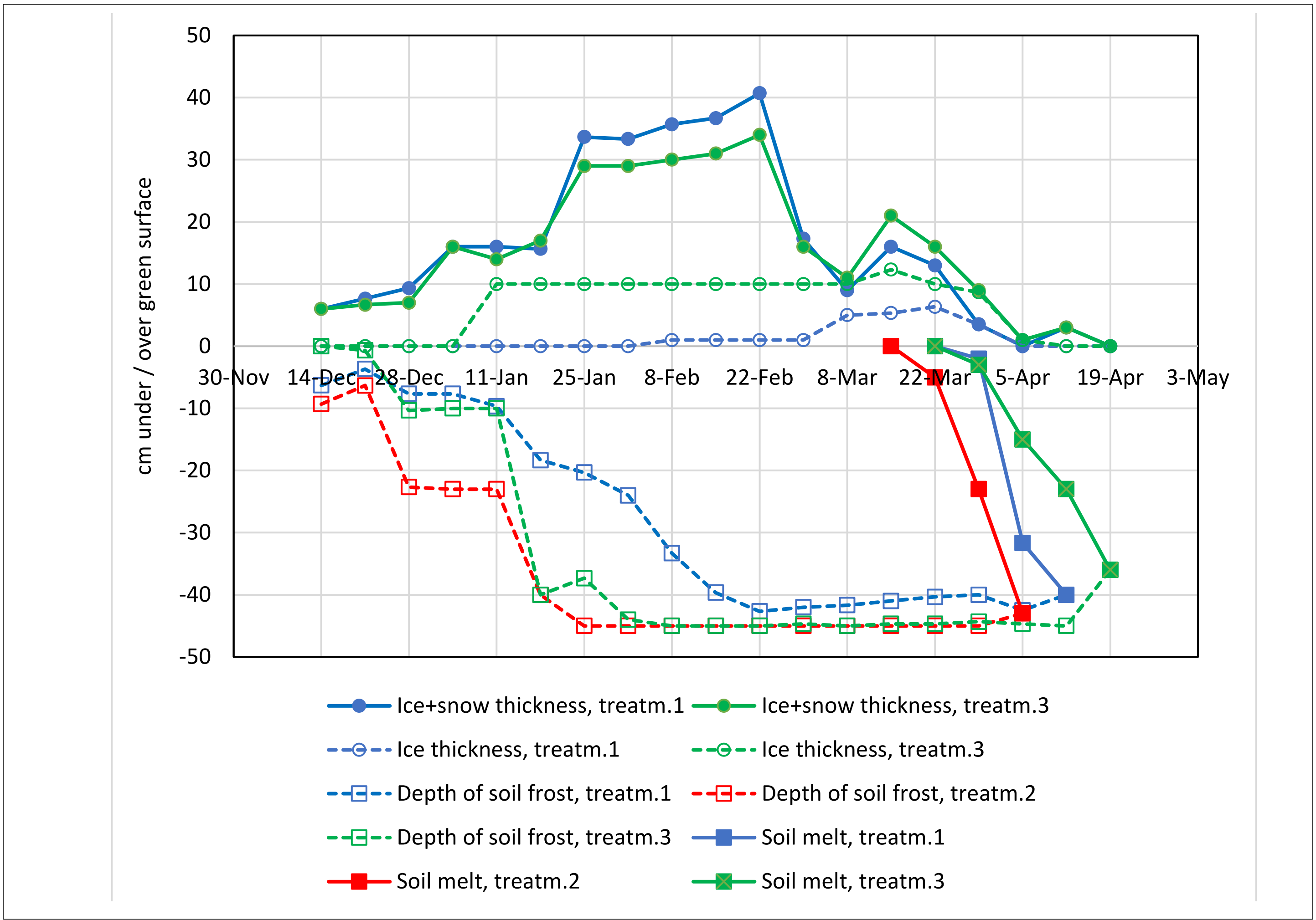

Figure 3. *Snow and ice thickness, depth of soil frost and melting from the surface in March/April in treatment 1 (natural snow and ice cover), 2 (snow and ice removed throughout winter) and 3 (man-made ice cover, 10 cm thick). Snow thickness in treatment 2 is not shown as the snow was always removed as soon as it exceeded 5 cm. Data from treatments 5 and 6 are also not shown in order not to overload the figure. Tubes for measurement of soil frost (Photo 1) were not installed in treatment 4 in order to perforate the plastic.*

Snow depth, ice thickness and soil frost during winter

Figure 3 shows results from weekly measurements of snow depth, ice thickness and soil frost in treatments 1, 2 and 3. Because of the mild temperatures, only the top 5 cm of the rootzone was frozen until 21 December. After that soil frost penetrated to approximately 20 cm depth in treatment 2 where the snow was removed but only to 8-10 cm in treatment 1 that was covered with 10-15 cm snow. After successfully establishing ice on 5 January, the frost rapidly penetrated deeper in treatment 3 but needed longer time to penetrate to the same depth on the plots which were covered by snow. The take-home message from this is that an ice layer, unlike a snow layer, does not provide any insulation against low freezing temperatures. However, during this particular winter, long periods with minimum air temperatures below -15°C in January and February caused frost to penetrate deeper and deeper into the green despite snow depth eventually reaching a maximal thickness of 40 cm. At the most, the soil was frozen to 40-45 cm depth, i.e. well into the indigenous moraine soil under the green.

On 22 February the weather turned mild for about one week (Figure 3). There was no precipitation, but the snow started to collapse because of air temperatures above zero, even during night. During this period, a porous ice layer accumulated to a thickness of about 7 cm in the control treatment with natural winter (treatment 1).

The protocol for treatment 6 prescribed mechanical snow and ice removal during the first mild period in March, ‘as soon as the ice slips from the grass’. This had perhaps been possible in the last week of February, but on 2 March, cold weather returned with night temperatures down to -5°C and day temperatures barely above zero. The snow was removed in treatment 6 on 12 March, but we did not start chopping ice until 18 March as the grass were still tightly encapsulated in ice. Not until Easter week (30 March) were the plots in treatment 6 sufficiently bare from ice and melting water that the spring cover, a performated white tarp from the Norwegian company Norgro, could be laid out. The plots in treatment 2 were covered on the same date while the plots in the other treatments had to wait for one more week for all snow and ice to disappear. The plastic in treatment 4 was removed on 6 April, and the spring tarps in treatments 1, 3, 4 and 5 installed three days later. In treatment 3 and 5 that had been covered by a compact ice layer since 11 January, the soil at 30 to 40 cm depth remained frozen until 19 April (Figure 3).

The green always melted from the surface, with virtually no melting from the bottom of the profile.

Results

The experiment produced huge amounts of data, many of which still remain to be analyzed. This is particularly the case with the data from the temperature, oxygen and CO_2 loggers that were deployed in the thatch/mat layer in treatments 1, 3 and 4 in all species. We also have not yet analyzed the data for freezing tolerance and regrowth of samples taken to the greenhouse during the trial. These data will be helpful for the interpretation of winter survival in the various treatments. The experiment will also be repeated one more winter to create a stronger basis for scientific and practical conclusions.

Photo 4. *The experiment in Easter week, Monday 29 March; figures indicate treatment number. The plots in treatments 2 and 6 (no snow or ice) were covered with the spring tarp on 30 March. In the other treatments, the spring tarps had to wait until 9 April, after natural ice and snow melt. Yellow styrofoam mats that were used to prevent ice melt before 1 April in treatments 3, 4 and 5 can be seen to the right. Photo: Marte Skattebu.*

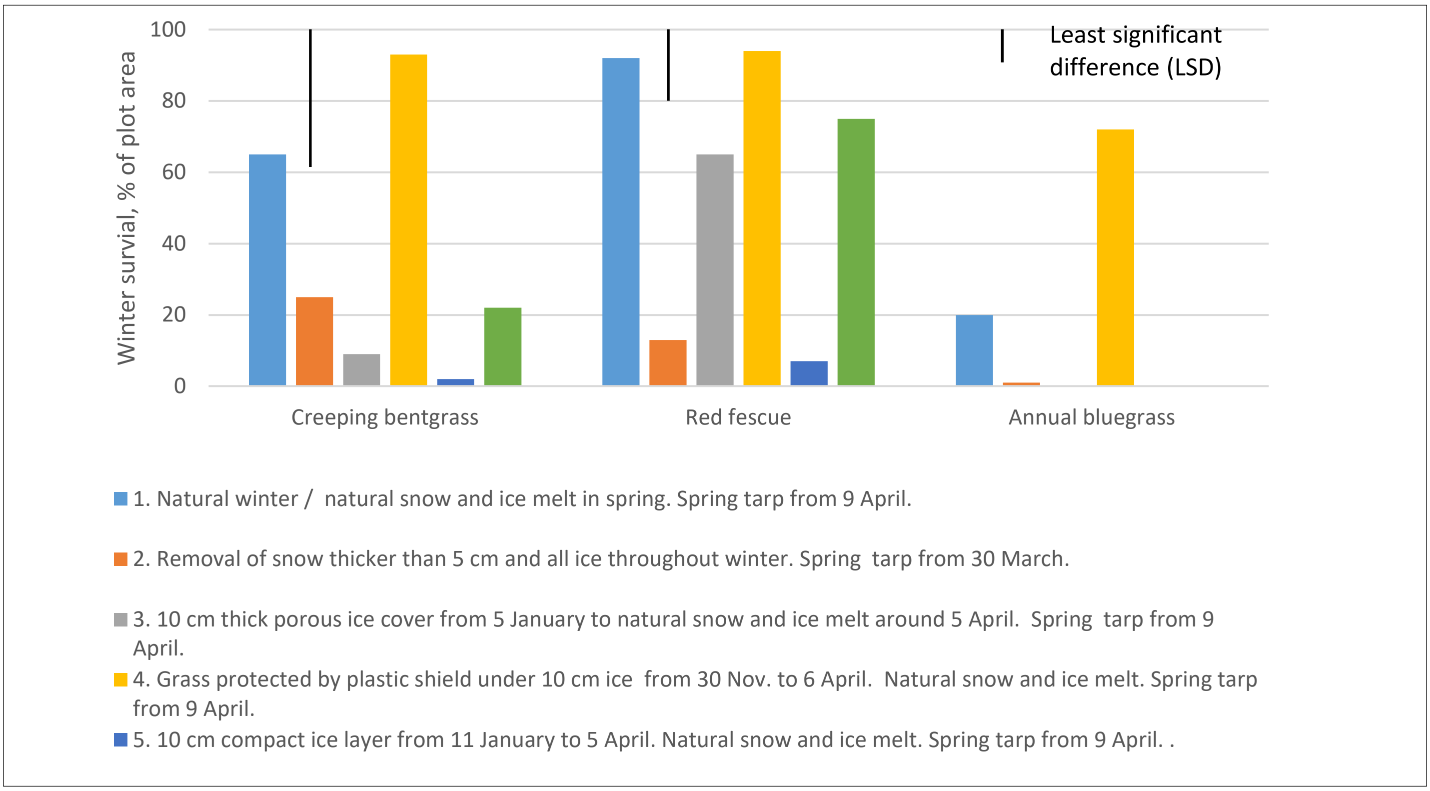

Figure 4. *Winter survival of creeping bentgrass, red fescue and annual bluegrass in treatments 1-6. Results from assessments on 5 May 2021.*

Significantly better winter survival under plastic sheets

Despite these reservations, there is no doubt that the plastic covers in treatment 4 produced the best winter survival of all grass species (Figure 4, Photos 5 and 6). Figure 4 shows that the difference between treatment 4 and treatment 3, which had the same ice cover but no plastic between the turf and the ice, was highly significant in creeping bentgrass, red fescue and annual bluegrass, whilst the difference between the control treatment (treatment 1: natural winter) and treatment 4 was significant in annual bluegrass and showed a similar tendency in creeping bentgrass.

These results confirm three years' positive experiences with impermeable plastic covers at Haga, Bærum, Asker and Holtsmark GC, all situated in the greater Oslo area. What is perhaps most surprising is that the plastic-covered greens survived so well despite oxygen-sensors showing concentrations down to 2-5 % in the absence of a ventilation system under the covers. There was no bad smell when the plastic was removed after 97 days' coverage.

Photo 5. *Good winter survival of red fescue (upper subplot), annual bluegrass (central subplot) and creeping bentgrass (nearest subplot) on a plot that had been protected with an impermeable plastic barrier between the turf and the 10 cm ice layer. The main plot to the left of the frame was treatment 1 (natural winter conditions) and the main plot to the right was treatment 3 (ice cover in direct contact with the turf. Photo taken on 7 April 2021, the day after removal of the plastic sheets. Photo: Marte Skattebu.*

Damage from diseases

The only visible damage at the removal of the plastic in treatment 4 was microdocium patch (Microdochoum nivale) in creeping bentgrass and to a lesser extent in annual bluegrass (Photo 5).

The patches had developed under the covers despite the fact that the green had been sprayed with Delaro SC 325 (prothioconazole + trifloxystrobin, 175 + 150 g a.i./ha) around 1 October and Medallion TL (fludioxonil, 375 g a.i./ha) after mowing had been discontinued in late October. These observations may also be interpreted in the light of observations at Haga, Bærum, Asker and Holtsmark golf courses showing more microdochium patch on covered creeping bentgrass greens with than without ventilation pipes installed under the plastic sheets. The results suggest that the oxygen level under the plastic had not been not been low enough to inhibit disease development, and a question for further research is therefore if there is possible to target an oxygen concentration or O_2/CO_2 ratio that inhibits microdochium development without being harmful to the grass.

Another reason why no oxygen deficiency occurred in this trial may also have been that the experiment was laid out on a young green with little thatch and therefore little microbial activity that may otherwise compete with the grass for oxygen and contribute to the accumulation of CO_2 or other toxic gases.

Ice or plastic?

The far better winter survival in treatment 4 than in treatments 3, 5 and 6 (which did not have plastic between the ice and the green surface) brings up the question if other causes than oxygen deprivation or the accumulation of toxic gases are critical for turfgrass survival under ice vs. plastic covers.

One likely explanation is that coverage with plastic from 30 Nov. resulted in a lower water content in green profile, and particularly in the thatch/may layer, at the onset of low freezing temperatures in January.

Another noteworthy observation is the importance of ice compactness / density for turfgrass survival: Figure 4 shows that, especially in red fescue, the porous ice created by adding water to an existing slush layer on 5 January (treatment 3) was far less harmful than the more compact ice created by repeated applications of small amounts of water on a deeply frozen green on 11 January.

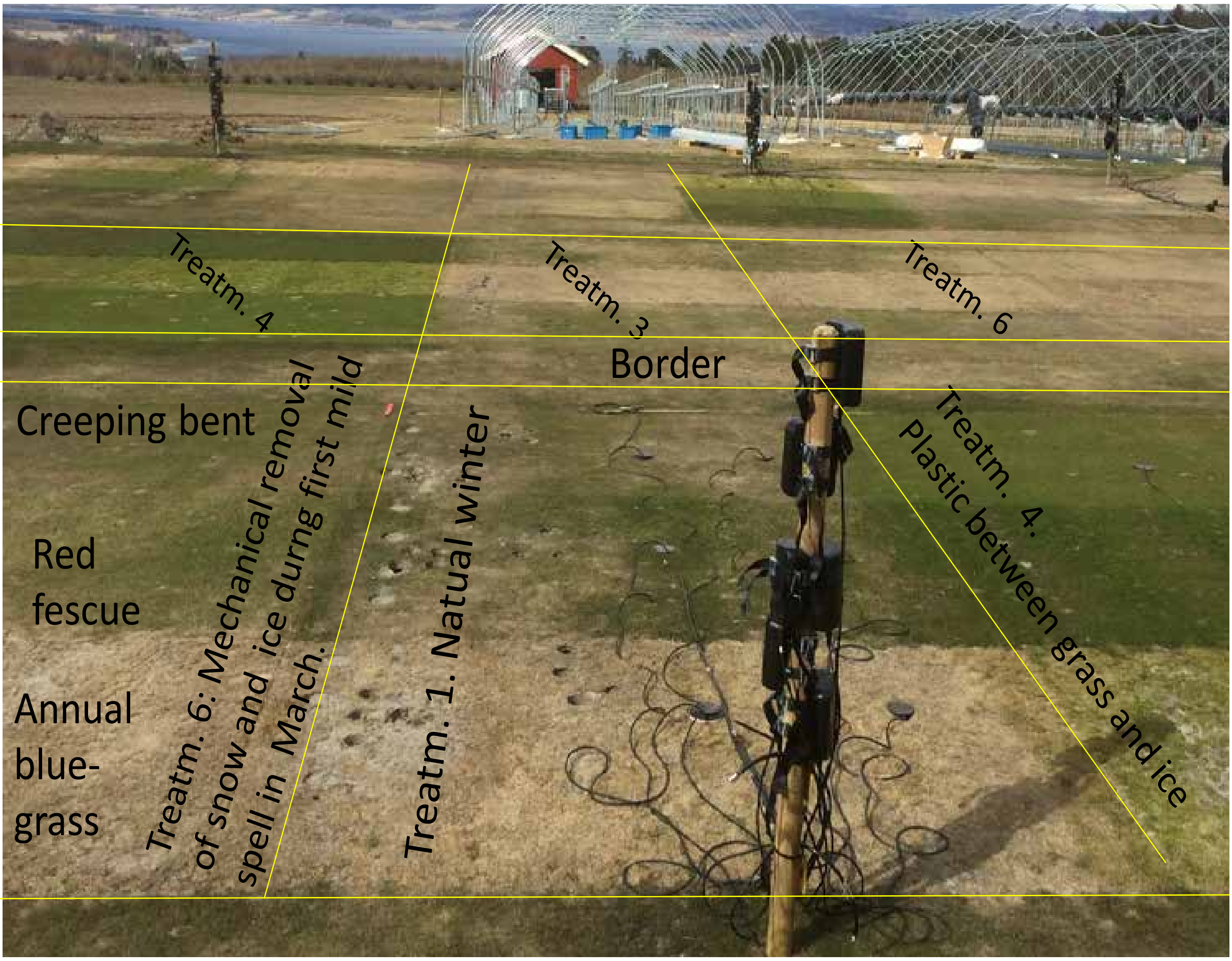

***Photo 6**. From the experiment at Apelsvoll on 23 April.*

Red fescue: Better winter survival than creeping bentgrass

Finally, the average survival of the three species across treatments, 36, 58 og 16 % in creeping bentgrass, red fescue and annual bluegrass, respectively, deserves a reflection. At least in Norway, it is a common opinion among greenkeepers that red fescue is less winter-hardy than creeping bentgrass, but this experiment as well as former results from SCANGREEN variety trials at Apelsvoll shows opposite. Admittedly, the slightly better survival of creeping bentgrass than of red fescue in treatment 2 (removal of ice and snow throughout winter) may well be taken as an indication the that the freezing tolerance, i.e. ability to withstand low temperatures in the absence of an insulting snow cover, was better in creeping bentgrass than in red fescue, but on the other hand, the tolerance to ice cover and resistance to microdochium patch were clearly better in red fescue.

Perhaps there are other issues , e.g. a slower recovery after ice damage, that speaks in the disfavor or red fescue and has caused its reputation as less winter-hardy species? This is an aspect that we will return to in coming articles from the ICE-BREAKER-project.