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Refinement of the cover technology: The need for ventilation and undercovers

ICE-BREAKER Final seminar, Quality Airport Hotel, Gardermoen, Nov. 3rd, 2023

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Photo: James Bentley

Background:

- Testing of impermeable plastic covers on green was initiated by the course managers at Asker, Bærum, Haga and Holtsmark GK after severe ice and water damage during the winter 2017-2018
- Experiences during the winters 2018-19 and 2019-20 were altogether very positive: Creeping bentgrass and annual bluegrass survived 120-130 days under impermeable covers and had far better spring start than uncovered greens
  - The plastic sheets must be fastened securely using sand bags
  - Seepage of surface water and upflow of ground water under the covers must be avoided. Collars must be dug into surrounds along upper edges of the green.
  - A complete fungicide program up to coverage is important
  - Ventilation under the covers was practised in 2018-19 and 2019-20, but was difficult due heavy snow and/or ICE layers over the covers
- From the winter 2020-21, evaluation of plastic covers at the four golf clubs became part of ICE-BREAKER

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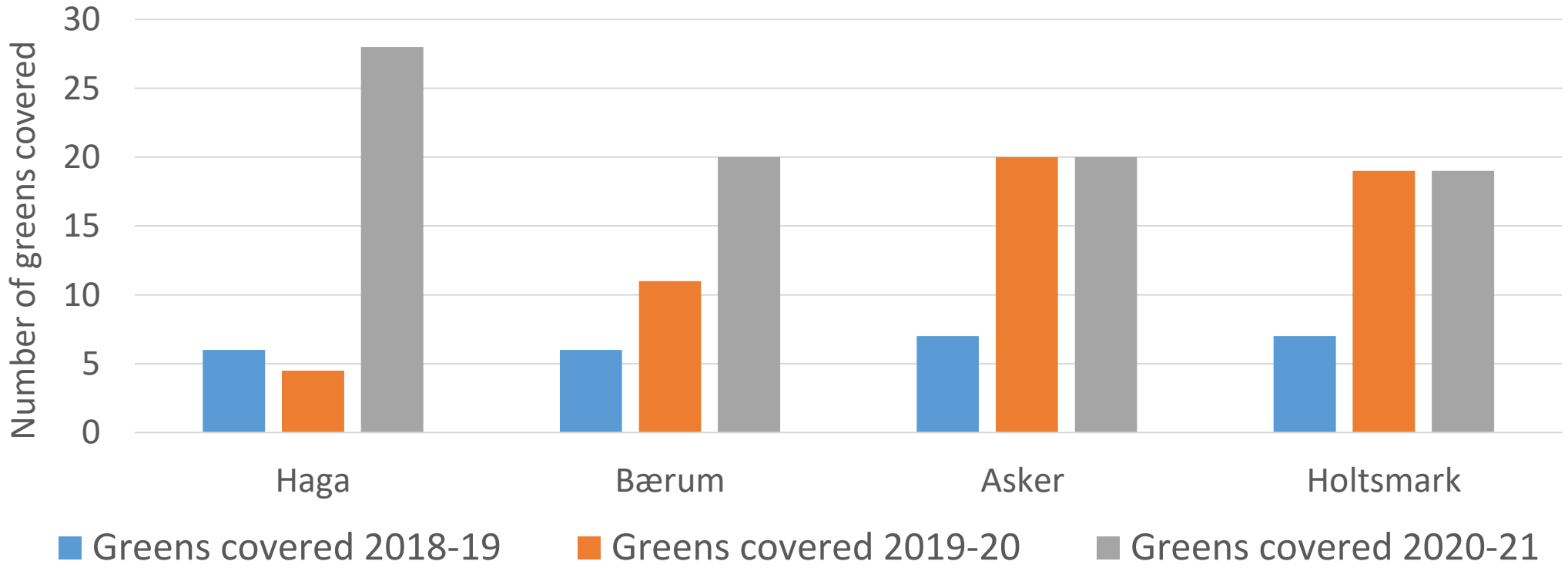
One of the most notable effects of the impermeable plastic covers was improved greenness and faster start of growth in spring

In the project description for ICE-BREAKER WP3, we suggested to compare covered and uncovered greens during the winters 2020-21, 2021-22 and 2022-23.

But the experiences from 2018-19 and 2019-20 were so convincing that the four golf courses wanted to cover all greens !



We therefore changed plans and decided to set up large field trials to refine the covering technology.

During the winter 2020-21 we focused on ventilation under the plastic sheets

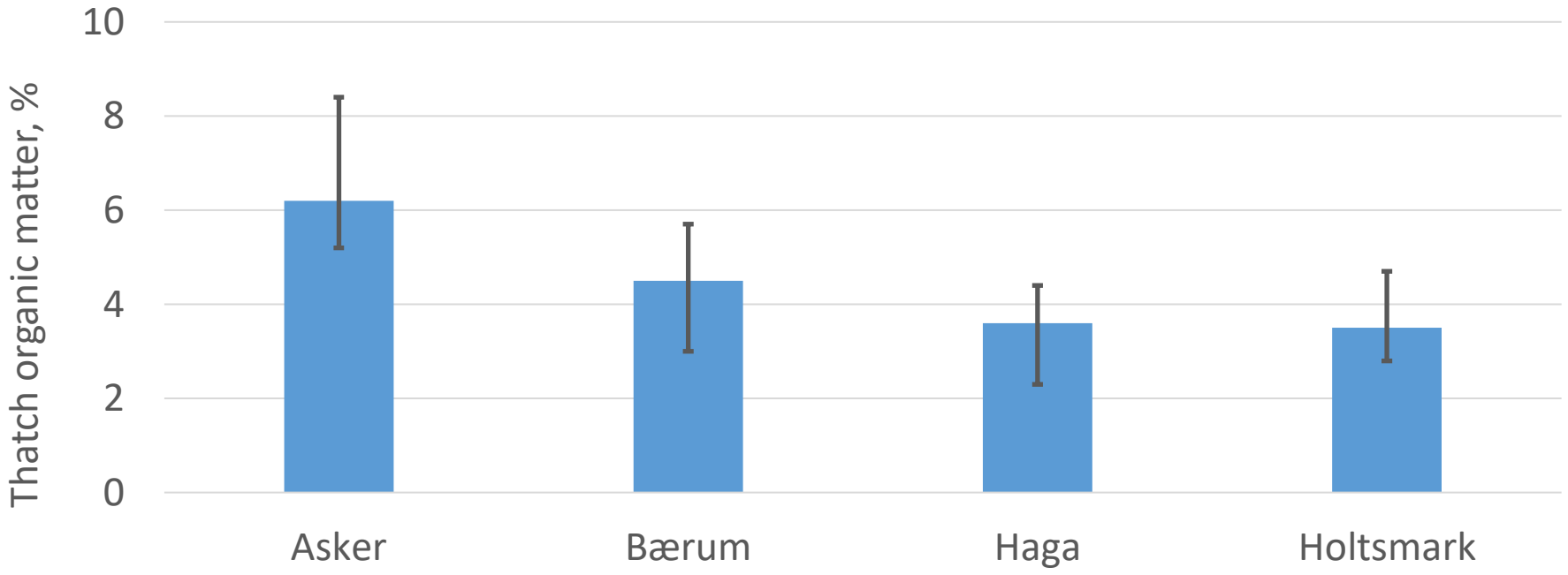
1. NO_VENT: No ventilation under the plastic covers (Control)
2. DPIPE_3WK: **Programmed** ventilation every three weeks during the winter using 5 cm wide corrugated Drainage PIPEs
3. FTUBE_3WK: **Programmed** ventilation every three weeks during the winter using 20 cm diameter Flat inflatable TUBEs
4. DPIPE_SENS: **Sensor-based** ventilation through drainage pipes (same as used in treatment 2) every time the oxygen (O_2) concentration was less than 12 % and/or the carbon dioxide (CO_2) concentration higher than 4 % (40000 ppm) at crown level.
5. FTUBE_SENS: **Sensor-based** ventilation through flat inflatable tubes (same as used in treatment 3) every time the O_2 concentration was less than 12 % and/or the CO_2 concentration higher than 4 % (40000 ppm) at crown level.

- Each treatment replicated on three greens on each golf course
- Spring tarps under the plastic in all treatments

Drainage pipes vs. flat tubes

Photos: James Bentley

At the start of the project, per cent *Poa annua* and thatch ignition loss was determined on all greens



Asker	Bærum	Haga	Holtsmark
100 % *Poa* (including *Poa trivialis*)	87 % *Poa*, 13 % creeping bentgrass	35 % *Poa* 65 % creeping bentgrass	24 % *Poa* 76 % creeping bentgrass

Sensor units for temperature, O_2 og CO_2 were installed under the covers

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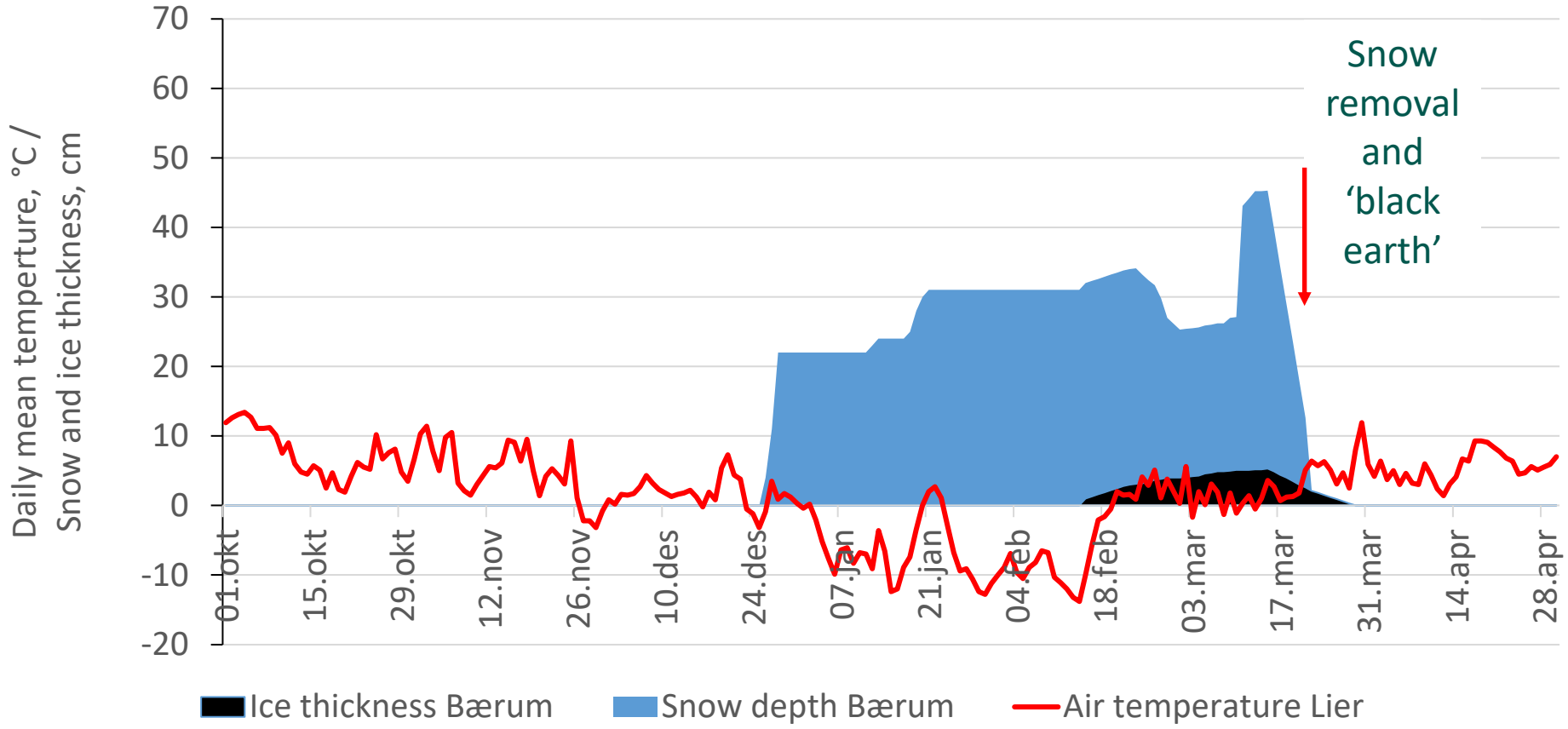
Sensor data coverage 2020-21

(Per cent of hours during cover period with successful data retrieval)

	Temperature	O2	CO2
Asker	19	35	39
Bærum	44	54	66
Haga	49	53	60
Holtsmark	35	56	42
Mean	**37**	**50**	**52**

Not good enough (and only minor improvements during the

The winter 2020-21: ‘Short but with deeply frozen greens’



Mean temperature under covers:

0.1°C

Cover period

Haga: 26 Nov. – 30 March : 123 days

Bærum: 29 Nov. – 29 March : 119 days

Asker : 30 Nov. – 29 March : 118 days

Holtsmark : 29 Nov. – 24 March : 114 days

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Number of ventilations

	Treatm. 2 & 3: Every 3 weeks	Treatm. 4: Sensor-based through drainage pipes	Treatm. 5: Sensor-based through flat tubes
Haga	**5 times** 14 Dec.- 8 Mar.	**2 or 3 times** 28 Jan. – 5 Mar.	**2 times** 22 Feb. – 9 Mar.
Bærum	**5 times** 20 Dec. – 2 Mar.	**1 to 3 times** 11 Dec. – 21 Feb.	**0-1 time** (Dec.)
Asker	**5 times** 20 Dec. - 22 Mar.	**4-5 times** 21 Dec. – 2 Mar.	**4-5 times** 21 Dec. – 3 Mar.
Holtsmark	**5 times** 18 Dec. - 9 Mar.	**0-4 times** (huge variation among greens)	**0-5 times** (huge variation among greens)

Sensors indicated little need for ventilation this winter

Did ventilation have an effect on average gas compostion ?

	Haga GC		Bærum		Asker		Holtsmark		**Mean, 4 clubs**	
	Mean	Min	Mean	Min	Mean	Min	Mean	Min	**Mean**	**Min**
1. NO_VENT	**14.7**	**7.0**	**13.0**	**6.0**	14.7	9.9	18.3	12.6	**14.5**	**8.0**
4. Drainage pipes	18.3	11.1	18.2	15.1	16.3	12.9	17.8	11.4	**17.6**	**12.6**
5. Flat-tubes	16.8	12.5	17.1	9.1	**10.0**	**4.4**	**16.5**	**10.1**	**15.1**	**9.0**
P%	>20	>20	(*)	>20	<5	<5	<1	ns		

Yes, it had an effect although we felt it was unsuccessful
But was it necessary ?

NO !

- There was virtually no ice damage, just some snow molds

	Snow molds, % of plot area				
	Haga	Bærum	Asker	Holtsmark	Mean
1. No ventilation	3	2	4	12	5
2. Vent. through drainage pipes every 3 wk	3	9	4	16	8
3. Vent. through flat-tubes every 3 wk	2	1	3	17	6
4. Sensor-based vent. through drainage pipes	4	1	5	12	6
5. Sensor-based vent. through flat-pipes	3	3	3	10	5

Trend to more snow mold with the most intensive ventilation treatment (2)

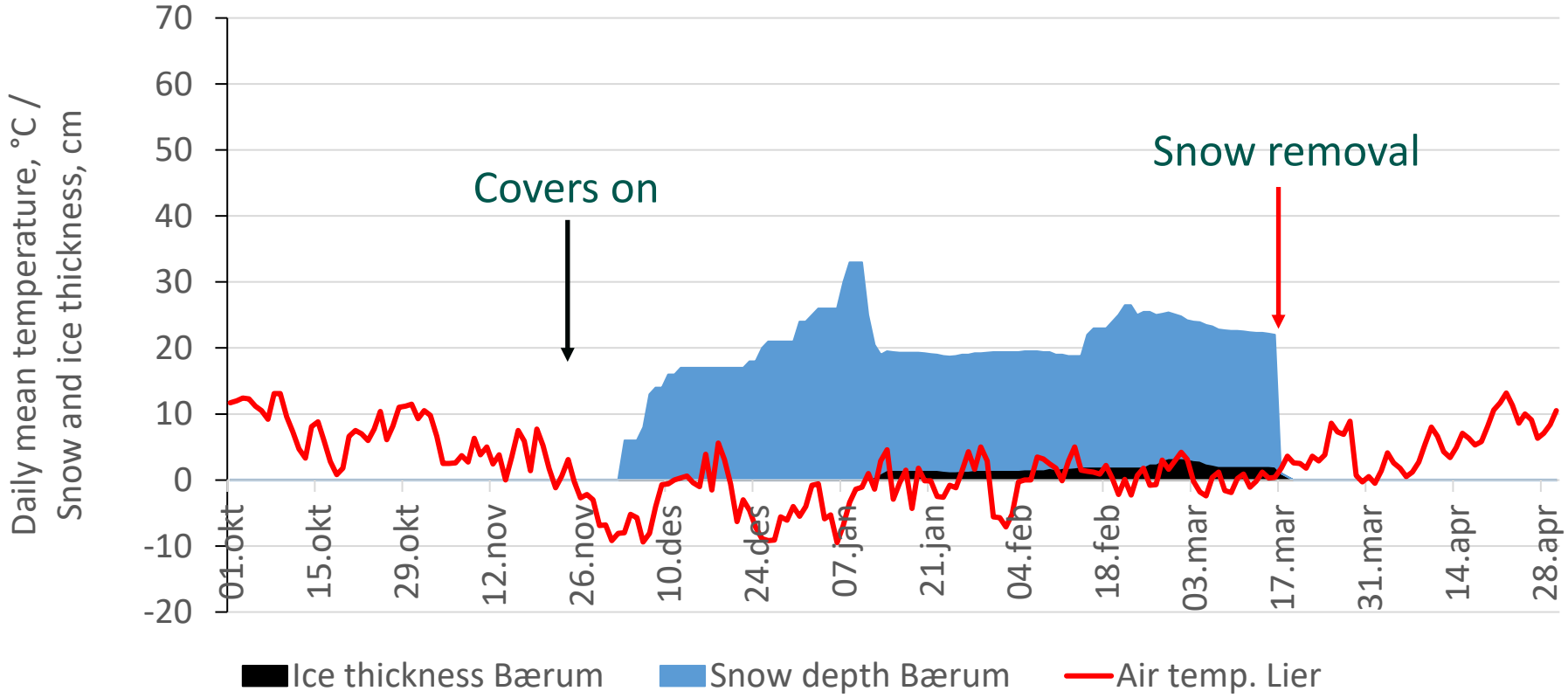
Experimental treatments 2021-22:

Focus on the need for undercovers

1. Plast sheets **with a undercover of NORGRO spring tarp. No ventilation.**
2. Plastic sheets with a undercover of NORGRO spring tarp. Ventilation through drainage pipes **every 3 weeks**
3. Plastic sheets with an undercover of NORGRO spring tarp. **Sensor-based** ventilation through drainage pipes. Criteria: $O_2 < 12$ % or $CO_2 > 4$ %.

4. **Plastic sheet directly on the grass. No undercover, no ventilation**.
5. **Plastic sheet directly on the grass. No undercover, Sensor-based ventilation through drainage pipes.** Criteria: $O_2 < 12$ % or $CO_2 > 4$ %.

2021-22: Unstable winter with early formation of ice under a thin snow layer



Mean temperature under covers:

-0.7°C

Cover period

Haga: 22 Nov. – 10 Apr.: 138 days (No snow removal)

Asker: 25 Nov. – 19 Mar.: 113 days

Bærum: 23 Nov. – 22 Mar.: 118 days

Holtsmark: 25 Nov. – 18 Mar.: 112 days

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Oxygen concentrations

	Haga GC		Bærum		Asker		Holtsmark		**Mean, 4 clubs**	
	Mean	Min	Mean	Min	Mean	Min	Mean	Min	**Mean**	**Min**
1. With undercover, no ventilation	17.0	11.9	14.1	**7.4**	14.1	8.4	16.9	13.0	**15.5**	**10.2**
3. With undercover, sensorbased ventilation	17.7	13.8	19.1	16.9	16.6	11.4	17.3	14.7	**17.7**	**14.2**
5. No undercover, sensorbased ventilation	16.0	9.8	17.4	13.1	**14.9**	**8.9**	**17.8**	**14.2**	**16.5**	**11.5**
P%	>20	>20	>20	>20	13	>20	>20	>20		

Higher oxygen concentrations with ventilation, but again:
Was it necessary ?

NO, there was no damage except in the treatments without undercover

			Ice and water damage, % of green area				
			Haga	Holtsmark	Asker	Bærum	**Mean**
1	With undercover, no ventilation		0	0	0	1	**0**
2	With undercover, vent. every 3 wk		0	0	0	0	**0**
3	With undercover, sensor-based ventilation		0	0	0	0	**0**
4	No undercover, no ventilation		1	13	5	1	**5**
5	No undercover, sensor-based ventilation		0	0	3	0	**1**

Under the plastic:

- Condensation of humidity on greens without undercover
- Plastic freezes to the grass
- More risk for winter damage

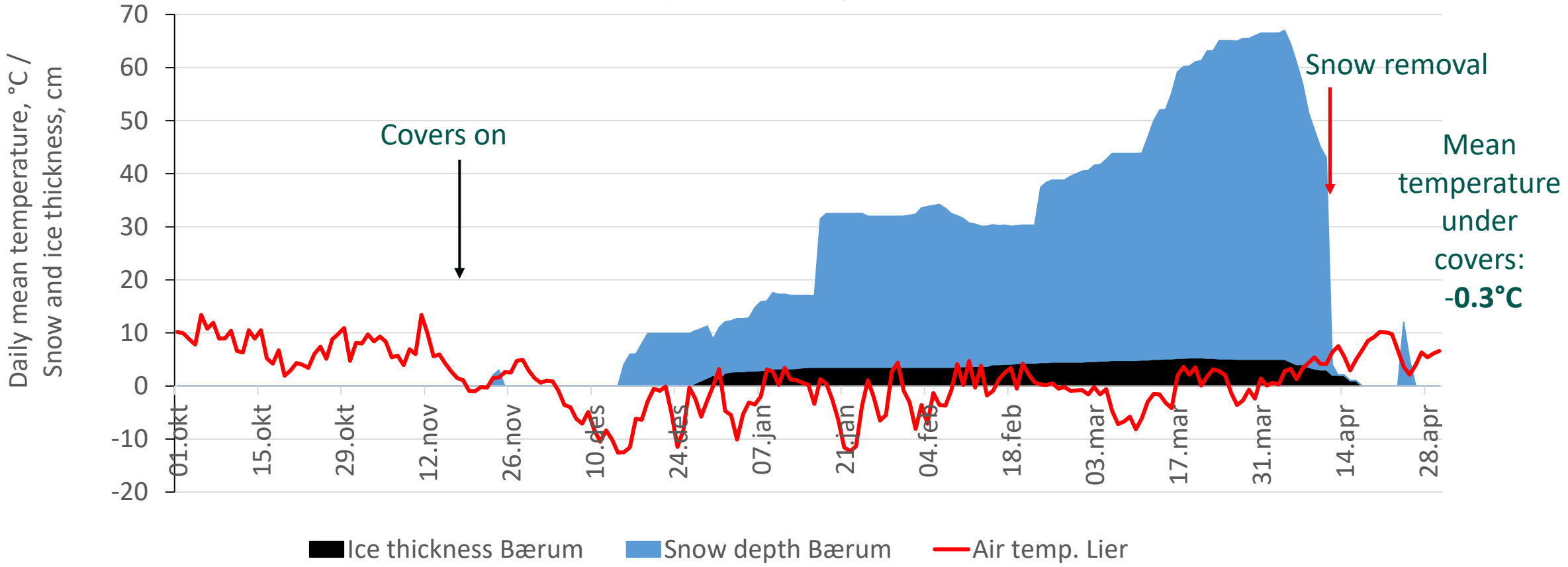
Experimental treatments 2022-23

Retesting previous treatments + new focus on duration of coverage in spring

1. Plastic sheets **with undercover. No ventilation.**
2. Plastic sheets **with undercover.**
   Programmed ventilation through drainage pipes **every 3 weeks.**
3. Plastic sheets with undercover
   Sensor-based ventilation through drainage pipes.
   Criteria: $O_2 < 12$ % or $CO_2 > 4$ %.
4. Plastic sheet directly on the grass.
   No undercover, no ventilation.
5. Plastic sheet **with undercover.**
   No ventilation. No snow clearance - longer cover period

Photo: Guttorm Tuxen

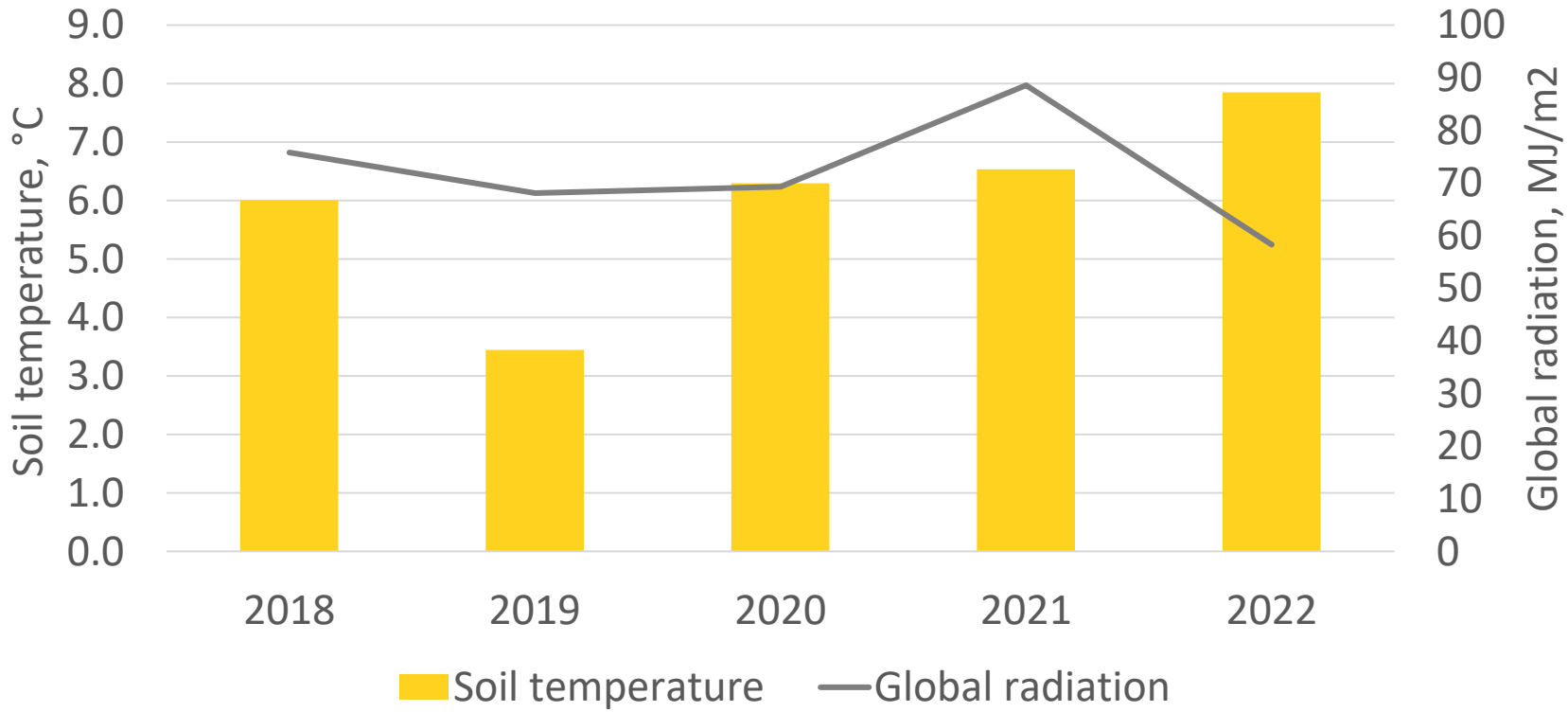
2022-23: A looong winter with early ice formation under snow



Cover period: Haga: 16 Nov. – 26 Apr.: **160 days** (166 days in treatm. 5) Bærum: 18 Nov. – 18 Apr. **150 days** (156 days in treatm. 5)
Asker: 18 Nov. - 14 Apr.: **146 days** (up to 153 days in treatm. 5) Holtsmark: 19 Nov. – 14 April: **145** days

What was special about the winter 2022-23 ?

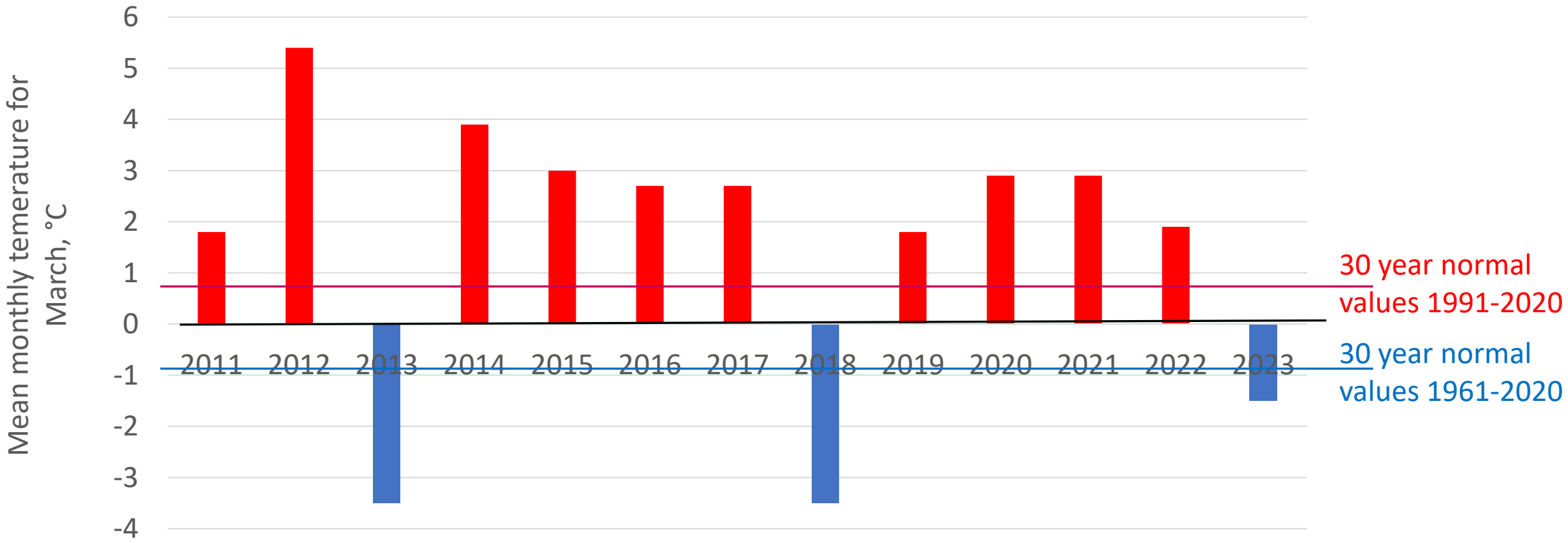
1. Poor hardening conditions 15 Oct. – 15 Nov.
   A ‘heat magazine’ in the soil at coverage



Data from NIBIO’s weather station Lier

What was special about the winter 2022-23 ?

2. A cold March (with plenty of new snow)



Data from NIBIO's weather station Lier

Number of ventilations

	Treatment 2 Ventilation every 3 wk.	Treatment 3: Sensor-based ventilation
Asker	**5 times:** 9 Dec. – 28 Mar. **3 times OK until 11 Jan.**	**6 times** 5 Dec.- 18 Jan. **5 times OK until 11 Jan.** No detectable effect after 11 Jan
Bærum	**6 times** (5 Dec. – 20 Mar.) **3 times OK until 16 Jan.** .	**16 times (**25 Nov. **–** 20 Mar.) on Green 1 **9 times** (25 Jan – 20 Mar.) on Green 5 **6 times** (13 Feb – 20 Mar.) on Green 6
Haga	**4 times** (12 Dec. – 12 Feb.) **2 times OK until 2 Jan.** Ventilations after 10 Jan. useless ?	**6 times** (10 Jan. – 13 Feb. on 2 greens **3 times** (23 Jan.- 6 Feb. on 1 green) Ventilations after 10 Jan. useless ?
Holtsmark	**5 times** (5 Dec. – 27 Feb..) Good effect of ventilation	**5 times** (16 Jan - 20 Feb.) on two greens **3 times** (6-20 Feb.) on one green Good effect of ventilation

Oxygen concentrations 2022-23

	Haga GC		Bærum		Asker		Holtsmark		**Mean, 4 clubs**	
	Mean	Min	Mean	Min	Mean	Min	Mean	Min	**Mean**	**Min**
1. With undercover, no ventilation	11.1	0.0	9.2	0	5.9	0.4	12.3	2.2	**9.0**	**0.7**
3. With undercover, sensorbased ventilation	11.7	5.9	16.6	10.3	16.5	10.7	13.7	7.1	**14.6**	**8.5**
4. No undercover, no ventilation	12.3	1.8	14.4	3.8	8.1	3.0	9.0	0.4	**11.0**	**2.3**
P%										**<1**

Higher oxygen concentrations, and especially higher minimum values, with sensor-based ventilation

Was ventilation necessary ?

YES, this year we had less ice and water damage on the greens that had been ventilated the most

(although not statistically significant)

		Ice and water damage, % of green area				
		Asker	Bærum	Haga	Holtsmark	Mean
1	With undercover, no ventilation	17	55	1	2	**19**
2	With undercover, programmed ventilation every 3 wk.	18	50	10	17	**24**
3	With undercover, sensor-based ventilation	3	30	4	0	**9**
4	No undercover, no ventilation	50	22	6	31	**27**
5	As 1 but no snow removal / longer coverage period	43	60	22	0	**31**
		ns	ns	ns	ns	**ns**
	Mean	**26**	**43**	**9**	**10**	**22**

Haga: Little damage after sensor-based ventilation (treatment 3)

Faster green-up close to ventilation pipes

Photos: James Bentley

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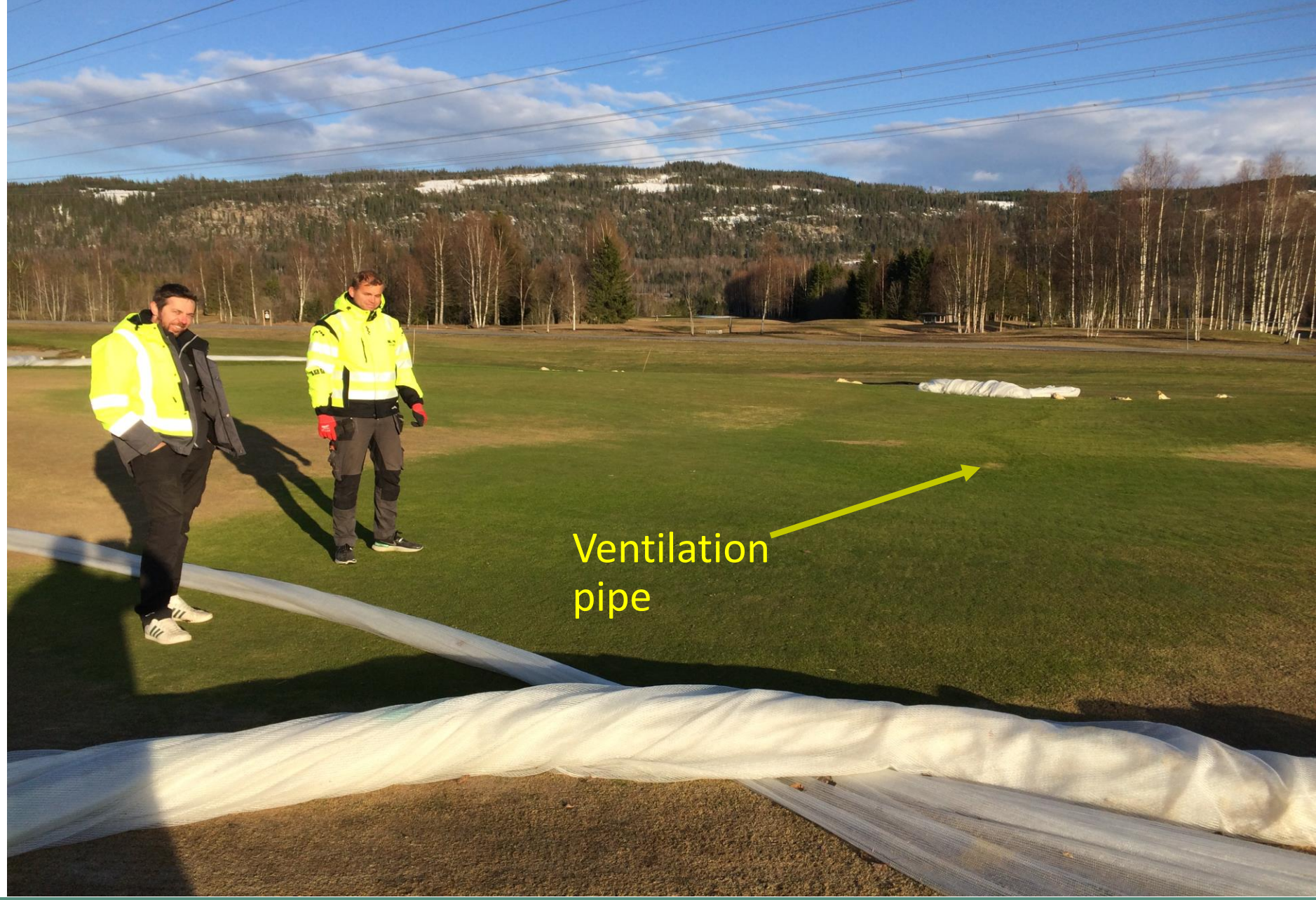
Holtsmark, Putting green,

Treatment 2:

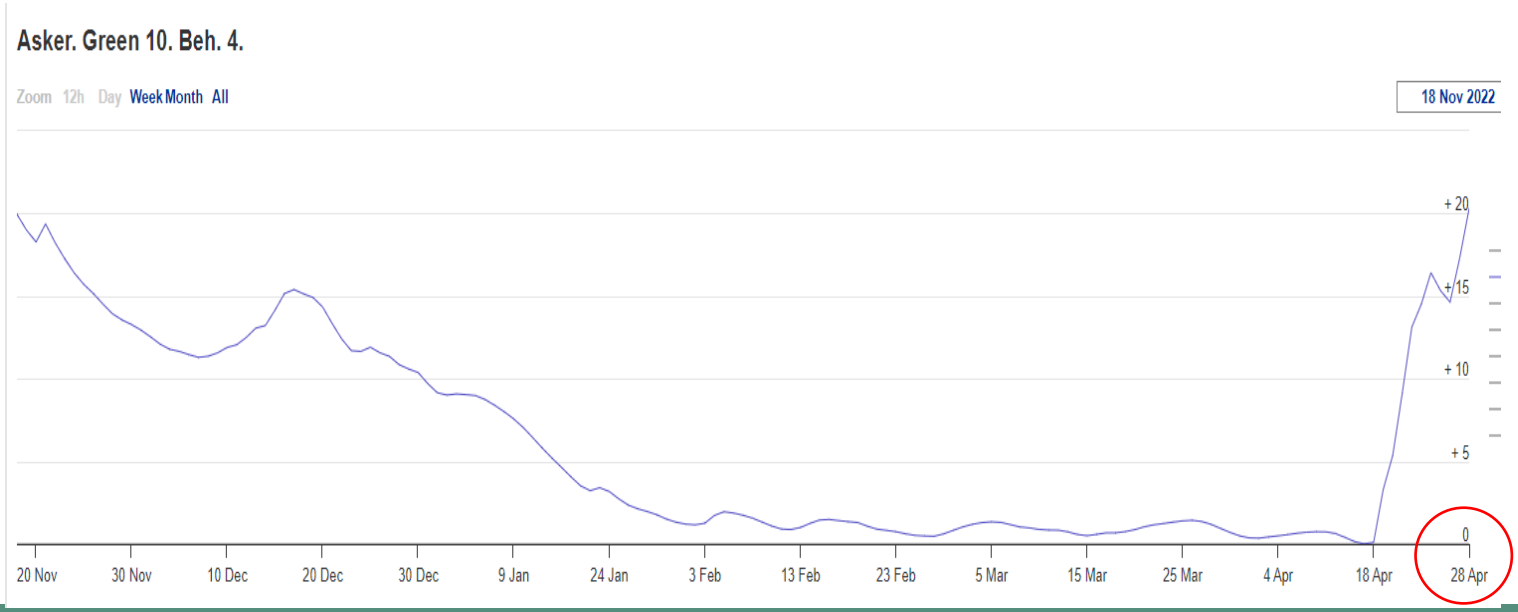
- With undercover
- Ventilation every 3 weeks, last time 6 Feb.
- Grass in a concave belt on both sides of the drainage pipe survived, convex areas on both sides were dead due to anoxia
- Plastic tighter to the grass on convex areas ?



Asker, treatment 4: No undercover, no ventilation

Hypoxia, not anoxia

Photos: Jimmy Johansson



Anoxia

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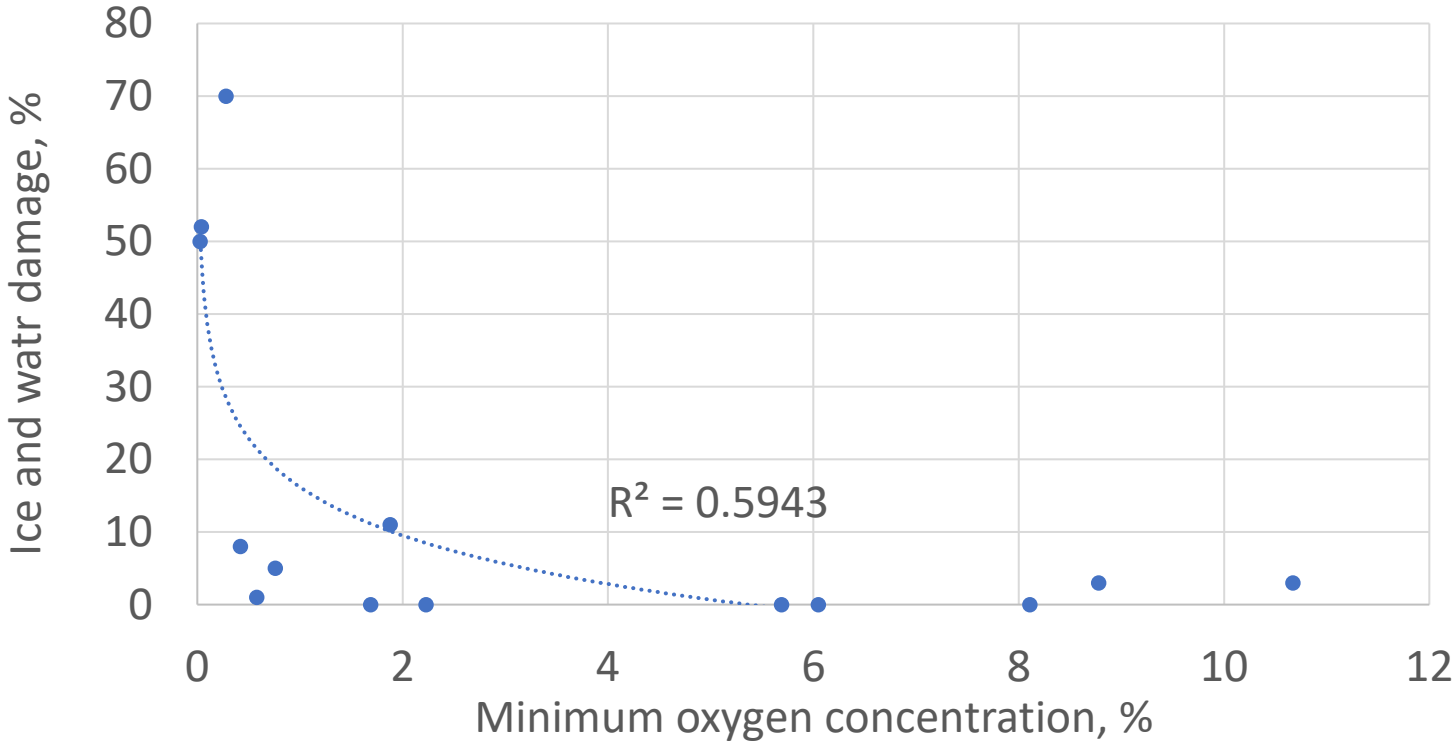
Relationshionship between minimum oxygen concentration and winter damage

(greens at Haga, Holtsmark and Asker, Bærum excluded because of confounding with snow mold damage)



Unlike the three other courses, Bærum had snow mold in addition to ice and water damage

Green 6: Sensor-based ventilation
Mainly snow mold

Big Putting green: Treatment 4, no undercover
50 % snow mold / 50 % ice & water damage

Why so much disease at Bærum ?

	Asker	Bærum	Haga	Holtsmark
Fungicide appl. in fall	2 x Delaro (systemic) 1 x Medallion	2 x Delaro (systemic) 2 x Medallion	1 x Delaro (systemic) 2 x Medallion	2 x Delaro (systemic) 1 x Medallion
Last application before coverage on 14-19 Nov.	11 Nov.	16 Nov.	14 Nov.	28 Oct.
Total N, kg/100m2 1 Sep.- coverage	0.29	**0.42**	0.17	0.37
Last N major N input (>0.1 kg N/100 m2)	4 Oct.	**25 Oct.**	5 Oct.	19 Sep.
Number of aerations in fall	2 x	**3 x**	2 x	2 x
Last aeration before coverage	10 Oct.	**7 Nov.**	26 Oct.	24 Oct.

The combination of a high N input and aeration 2-3 shortly before coverage may have resulted in more snow mold

Winter damages at Bærum were altogether rather bad compared with previous years

Green no 3

29 April, 2022,
after 120 day coverage

28 April, 2023:
After 150 days with
anoxia and melting water

Green no 17

28 April, 2023: Heavy snow and ice above covers precluded effect of ventilation

To summarize

- Impermeable plastic covers prevented ice and water damage and resulted in a better spring start in four out of five years.
  → *The use of plastic covers is recommended (despite damage during the winter 2022-23)*
- Sensor-based ventilation through drainage pipes under covers improved survival in one year with 150 days coverage, was not necessary in two years with < 130 days coverage.
  → *Ventilation before the snow and ice becomes too heavy is recommended as an insurance, especially on Poa-dominated green and greens with a high concentration of organic matter in the thatch layer*
- Permeable undercover prevents the plastic from freezing to the grass and was favorable in a year with 120 days coverage, but made litte difference in a year with 150 days coverage and heavy snow / ice above the plastic.
  → *A permeable spring tarp between grass and plastic is recommended*
- The grass tolerates oxygen concentrations down to 4-5% for an extended period of time but concentrations below 2 % are critical, especially on Poa dominated greens.
  → *There is a need for more robust and reliable sensors than those used in this project*
- The risk for anoxia increases with soil temperature and the concentration of organic matter in the thatch/mat layer.
  → *Use of covers can never compensate for inadequate greenkeeping practises.*
- Melting water is even more detrimental to the grass than ice encasement
  → *Properly shaped greens and green areas are critical*

Thanks for your attention !

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Acknowlegdments

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