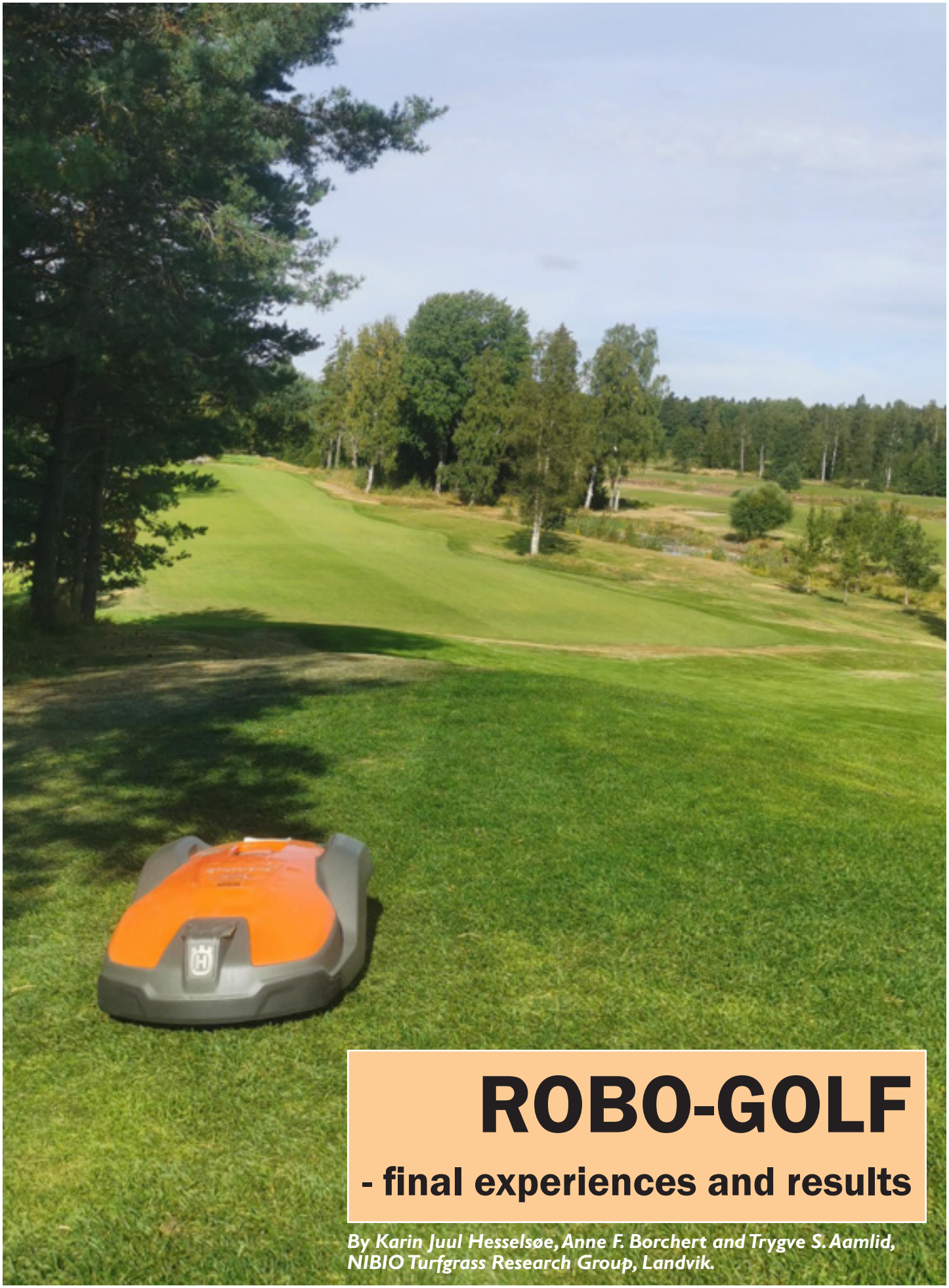

# ROBO-GOLF

## - final experiences and results

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# ROBO-GOLF - final experiences and results

**The objective of the ROBO-GOLF-project (2020-2023) was to study the consequences of switching to robotic mowing on golf course fairways and semi-roughs. Husqvarna 550 robotic mowers, working at random within boundary cables, were compared with ordinary fairway and rough mowers at five Nordic golf courses and at NIBIO Landvik, Norway.**

Experiences from the demo trials at five Nordic golf courses show:

- mowing quality of the robots comparable to cylinder mowing
- robots superior on roughs – especially at high growth rates
- reduced compaction/improved drainage due to less weight of the robots
- daily dew removal by the robots is an advantage
- golfers are positive or they do not care about the robots
- golfers' perception of robotic mowing is that the grass is denser and more uniform
- golfers need local rules when robots interfere with the game

Final results from experiments at Landvik show:

- the same high turfgrass quality with robotic and manual mowing on fairway
- less disease on robotic mown fairway
- less white clover on robotic mown fairway
- more white clover in robotic mown semi-rough
- less soil compaction with robotic mowing in semi-rough
- finer leaves with robotic mowing
- no difference between robotic and traditional mowing in fertilizer requirement

***Photo 1:*** *Husqvarna 550 robotic mower at Hirsala golf course, Finland. Photo: Janne Lehto.*

An article with preliminary results (Hesselsøe et al. 2022a) can be found at www.sterf.org and more detailed info on materials and methods in the experiment at NIBIO Landvik can be found in Hesselsøe et al. (2022b).

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## ROBO-GOLF field trials at five Nordic golf courses

Mowing with small light-weight robotic mowers were compared with ordinary mowing on fairway and semi-rough at five Nordic golf courses from 2020 to 2022 in Norway (Bærheim), Sweden (Jönköping), Finland (Hirsala), Iceland (Ness) and Denmark (Grenå).

***Photo 2**: Robo tool kit. Photo: Janne Lehto.*

On each course one designated fairway and one rough was chosen for the demonstration trials. Only few significant differences in turfgrass quality, and coverage of weeds and diseases were found. In periods with heavy rain and high growth in August and September, significantly higher turfgrass quality with robotic mowing was found on some of the courses. Course managers perceptions were that mowing quality was very high and that robotic mowing was superior in the rough. The robots removed dew, produced almost no clippings and labor could be allocated to other tasks on the golf course. The first years with robotic mowing was a learning process with challenges with fleet service, to get electricity out on the course (eventually solar powered) and a new way of maintenance and new tools (Photo 2).

An important observation by the course managers was that it is important to change knives on the robots every two weeks. A new job or role was created for the greenkeeping staff which could be titled: 'Golf course automation specialist'.

Surveys were conducted at the five courses in the beginning of the project (2020) and again in spring 2023 asking about the golfers' perceptions of the robots mowing fairway and semi-rough. Around 400 respondents answered the surveys in 2020 and around 500 in 2023. Golfers' attitudes were generally positive, or they did not care, and they were rarely disturbed by the robots when playing golf.

Many respondents noticed that they did not need to be afraid of hitting greenkeepers who were mowing the fairway or rough, and they did not have to wait for the greenkeepers to finish their job. The impression of the robotic mown turfgrass was that it was denser, more uniform with very few clippings ('same quality every day').

Challenges with robots interfering with the game ('robot hit the ball or golfer hit the robot') and how to deal with these issues were often questioned in the first survey in 2020. But when the survey was repeated in spring 2023 it seemed as most of these problems were solved with local rules on the courses. As the robots in this demo trial was operated by a cable and no GPS signal the mowing pattern was random with no system. The missing stripes in the mowing pattern on fairway was commented by some of the golfers, but they often added that this disadvantage was offset by the high quality of the robotic mowing. Some golfers noticed that the ball was lying on top of the denser and more upright grass in the robotic mown fairway compared to the cylinder mown fairway. Some of the respondents commented on economic and environmentally consequences of switching to robotic mowers. As one of the respondents summarized: 'If the robots enable the greenkeepers to spend more time on e.g., maintenance on greens, I think I can live with the disadvantages they entail'.

***Photo 3:** Player and robotic mower at Bærheim golf course. Photo: Atle R. Hansen.*

***Photo 4:*** *ROBO-GOLF experimental area at NIBIO Landvik. Upper part is fairway mown by robots and cylinder mower (15 mm). Lower part is semi-rough mown by robots and rotary mower (35 mm). Photo: Karin J. Hesselsøe, August 2021.*

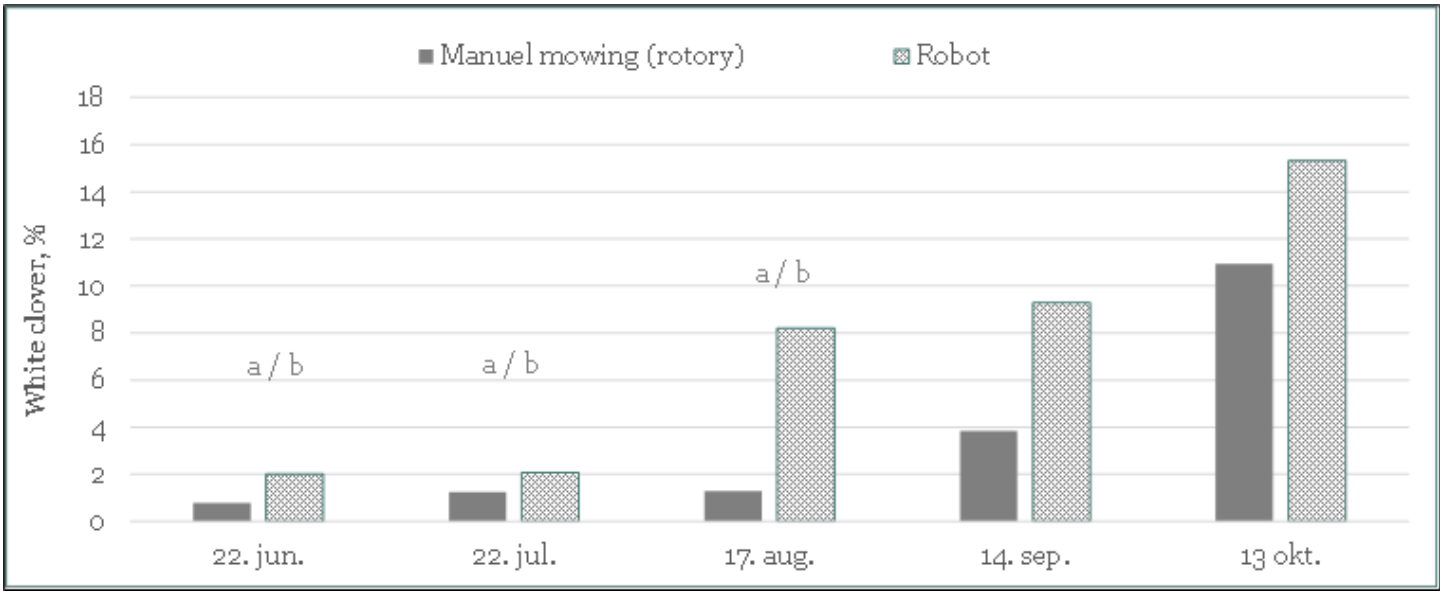
## ROBO-GOLF experiments at NIBIO Landvik

At NIBIO Landvik experiments were conducted at a 5000 $m^2$ area of fairway and semi-rough with different grass species (Photo 4).

Daily robotic mowing was compared with cylinder mowing three times pr. week in fairway (both at 15 mm) and daily robotic mowing with rotary mowing twice pr. week in semi-rough (both at 35 mm). For more details on the experiment see Hesselsøe et al. (2022a) and Hesselsøe et al. (2022b).

High turfgrass quality was found in both robotic and manual mown fairway with a trend to higher quality in robotic mown browntop bentgrass plots in 2021 compared to manual mowing. This could be explained by less disease because of dew removal by the robots every morning. White clover was planted into the experimental area, and these plants developed more seed heads in the ordinary (cylinder) mown plots compared to the robotic mown plots (Photo 5) at the same mowing height (15 mm).

***Photo 5:*** *To the left lesser and lower white clover in robotic mown fairway, to the right more and higher white clover in cylinder mown fairway. Photo: Anne F. Borchert.*



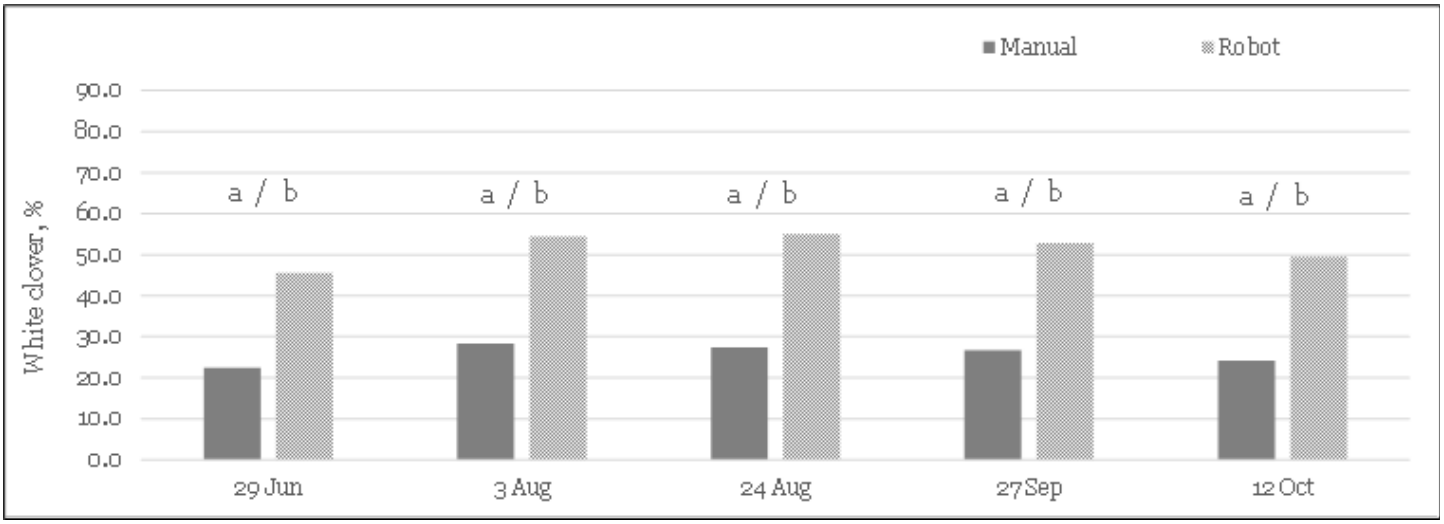




***Figure 1**:Significantly higher coverage of white clover was found in robotic mown plots in semi-rough (35 mm) compared to manual (rotary) mowing in 2021 (upper figure) and in 2022 (lower figure). Note different scales on the y-axes in 2021 and 2022.*

***Photo 6:** The same area as photo 4 in August 2022. Note the spread of white clover (dark green patches) in some of the plots, and most in robotic mown perennial ryegrass. Photo: Karin J. Hesselsøe.*

In the semi-rough the situation was opposite with increasing coverage of white clover in robotic mown plots - At 35 mm mowing height, the white clover seemed to be more competitive to the grass with daily robotic mowing than with mowing three times per week, and this was especially apparent on perennial ryegrass plots which had a low density after the tough winter 2020-21 (Photo 6 and Figure 1).

The increased spread of white clover in robotic mown rough was not observed in any of the demo trials at the golf courses.

Soil compaction was measured with penetrometer in August every year from 2020 to 2022, and as observed by the course managers in the demo trials, lower soil compaction was found in the robotic mown semi-rough. No differences in soil compaction between robotic and manual mown plots were found in the fairway at Landvik.

Leaves were collected after two years of robotic and manual mowing to compare leaf morphology. In the plots with Kentucky bluegrass significantly finer leaves were found with robotic mowing. This can be explained as an adaptation to the higher mowing frequency in the robotic mown plots.

Tiller density in robotic mown fairway was also higher compared to manual mowing, which confirmed the golfers' observations reported in the survey from the five golf courses.

In terms of fertilizer demand, our hypothesis was that the daily return of small clippings from the robotic mowers would lead to greater fertilizer savings than the return of longer clippings using ordinary (cylinder) mowers on fairway. However, two years results did not confirm this hypothesis, so we must conclude that fertilizer requirements are the same whether using robotic or manual mowing.

## Conclusion

Since the start of the ROBO-GOLF-project in 2020 robotic mowing on golf courses has increased a lot. Today bigger mowers (like CEORA from Husqvarna) that run systematically and are controlled via GPS are usually preferred.

In the new project FAIRWAYS4FUTURE starting in 2023, we will draw on some of the experiences from ROBO-GOLF and investigate combinations of mowing system (robotic mowing with CEORA versus traditional mowing), mowing height, fertilizer level and weed encroachment to find the most sustainable way of mowing fairways and roughs.

## References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