

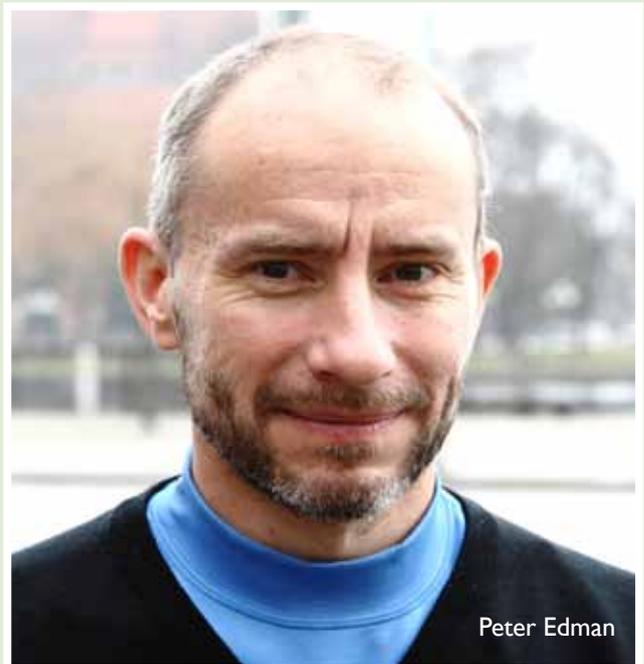
# GROWTH REGULATION WITH PRIMO MAXX ON NORDIC GOLF COURSES



*Sterk*



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## PREFACE

In the summer of 2011, Syngenta's growth regulator Primo MAXX was approved for use on Swedish golf courses. Besides other documentation, the approval was based on tests completed in 2007 and 2008 by Bioforsk Turfgrass Research Group in Norway, and by the Agricultural Research Centre (MTT) in Finland, on behalf of Syngenta. Later tests with Primo MAXX have been conducted on different types of grass and on different parts of the golf course, and Swedish greenkeepers have garnered a lot of practical experiences. The goal of this booklet is to compile these results and practical experiences into a guide for Nordic greenkeepers.

The publication of this booklet is financed by Syngenta through its industrial partnership agreement with the Scandinavian Turfgrass and Environment Research Foundation (STERF), but the writers are solely responsible for all assessments and recommendations. We would also like to thank Agnar Kvalbaein for excellent suggestions and constructive comments on the first version of the manuscript.

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**Image 1:** Cutting the *Poa annua* -green used for testing Primo MAXX at Bioforsk Landvik. Photo:Trygve S Aamlid

## THE DREAM OF CHEMICAL MOWING

Cutting is the most work- and energy demanding operation on golf courses. The need for cutting can be reduced by choosing weakly growing grass types, moderate fertilizing, rolling and other maintenance measures. However, there is a limit for how much the genetic growth potential can be reduced as we always have to but to ensure that the turf is able to repair itself after damage. Less growth can be especially important in places which are hard to reach with cutters, e.g. along bunker edges and in steep roughs.

Already immediately after the second world war, experiments with 'chemical mowing' were started in USA, that is: treatment of the grass with chemical growth regulators<sup>1</sup>. The products introduced at the time inhibited the plants' cell division, and the effect on the color and thickness of the grass was at times dramatic. In the USA, cell division-inhibitors like this are still in use to prevent the formation of seeds in *Poa annua* on golf courses.

In the 1960s and -70s, growth regulators were developed that do not primarily affect the cell division, but the cell elongation (see sidebar). Common to the cell elongation inhibitors is that they reduce the plants' production of the growth hormone gibberellic acid. Different forms of gibberellic acid are

synthesized through a series of biochemical reactions in the plants' cells, and the formation of the biologically active  $GA_1$ , from the inactive  $GA_{20}$  is the last step in this process.

Trinexapac-ethyl, the active substance in Primo MAXX, blocks this last and decisive step in the gibberellic acid biosynthesis. Other cell elongation inhibitors are less specific as they affect earlier steps in gibberellic acid biosynthesis. This is true for among others Cutless (active substance flurprimidol), and Trimmit/Turf Enhancer (active substance paclobutrazol) which are allowed in the USA and some European countries, but not in the Nordics. Chlormequat chloride (CCC, Cycocel) which is used in Scandinavian production of cereals and grass seeds, also belongs to this group.

A third group of growth regulators are those containing ete-fon, a synthetic form of the natural plant hormone ethylene. The most important commercial product in this group is Proxy, used on American golf courses to prevent flowerig of *Poa annua*.

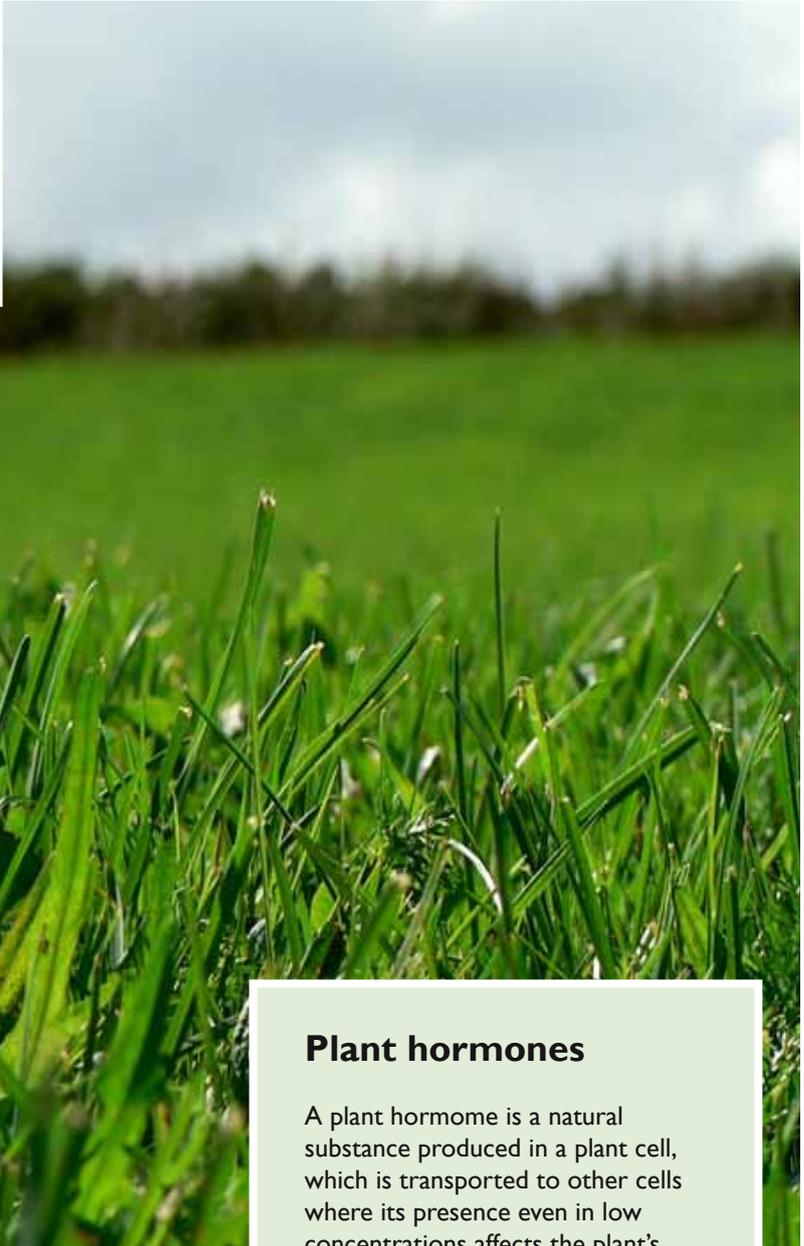
The following text concerns itself exclusively with Primo MAXX, since this is the only growth regulator approved for use on Nordic golf courses.

## How does the grass grow?

Two processes are necessary for the grass to grow, namely **cell division** and **cell elongation**.

Cell division takes place in definite parts of the plant - the so-called **meristems**. In grasses, the meristems are in the crown areas by the soil surface and in the tips of the roots, as well as in special zones in young leaves and stems.

Most of the visible growth is not due to the cells dividing, but to them stretching; increasing in length and volume.



## Plant hormones

A plant hormone is a natural substance produced in a plant cell, which is transported to other cells where its presence even in low concentrations affects the plant's growth and development.

We separate between four groups of plant hormones that enhance plant growth, namely auxines, gibberellic acids, cytokinins and brassinosteroids, and two groups that inhibit growth, namely abscisic acid and ethylene.

# PRIMO MAXX IN THE NORDIC COUNTRIES

## Approval

Agricultural products containing trinexapak-ethyl have been used in Nordic production of grass seed AND small grains since the late 1990s, but it's only in the last few years that the active substance has become available to golf courses. Primo MAXX is a formulation of trinexapak-ethyl developed especially for turf and it is currently the world's most widely used growth regulator on golf courses. In the Nordics, the Swedish government was the first to allow Primo MAXX in the summer of 2011. Prior to the 2013 growth season, the product was also approved in Finland. It is still unsure whether a new formulation of Primo MAXX will be approved in Norway and Denmark.

## Effects under Nordic temperature and light conditions

Plant scientists have claimed that the need for Primo MAXX is greater in the Nordic countries than in countries further south. This is due to the Nordic light conditions with long days increasing the production of gibberellic acid, and thereby cell elongation<sup>2</sup>. The hormone also reduces tillering (Image 2), thus causing the turf to grow less dense. In turfgrasses from more southern latitudes this daylength-response is not as marked as on the image, but differences have been found also in tests with American cultivars of creeping bentgrass. In those trials the weight of clippings increased by 22% when the daylength increased from 15 to 20 hours<sup>4</sup> (Image 3).

## Carbohydrate-status

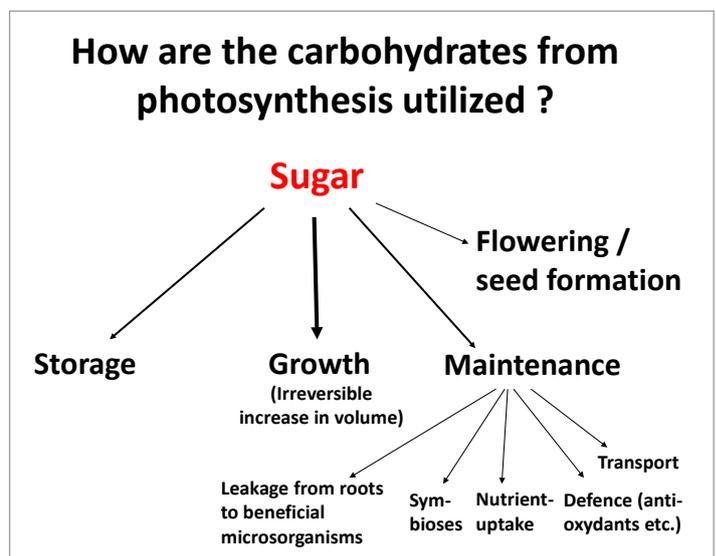
Primo MAXX is quickly taken up by the grass leaves and transported to the elongation zones in the leaves and stems and - to a smaller degree- to the growing points in the roots. The cells become smaller and more compact, and the concentration of chlorophyll increases. This normally leads to the grass turning darker. Most studies show that the net production of sugar (carbohydrates) does not change after spraying, but that less of the sugar is used for growth. This means that more of the sugar is available for defense against diseases, symbioses (e.g. mykorrhiza), nutrient uptake, leakage to micro-organisms in the root zone and other benevolent purposes (see sidebar). In *Poa annua* a part of the sugar will commonly be used for flowering and the formation of seeds, but these functions are hardly affected by Primo MAXX.



**Image 2.** Daylength response in individual plants of the Norwegian Kentucky bluegrass cultivar «Lavang» grown at 12, 16, 20 and 24 hours of light<sup>3</sup>. Photo: Trygve S.Aamlid



**Image 3.** From growth chamber tests with Primo MAXX used on creeping bentgrass, cut like fairway. The pot on the left had been exposed to 15 hours daylength, compared with 20 hours for the pot on the right. Photo: Trygve S.Aamlid



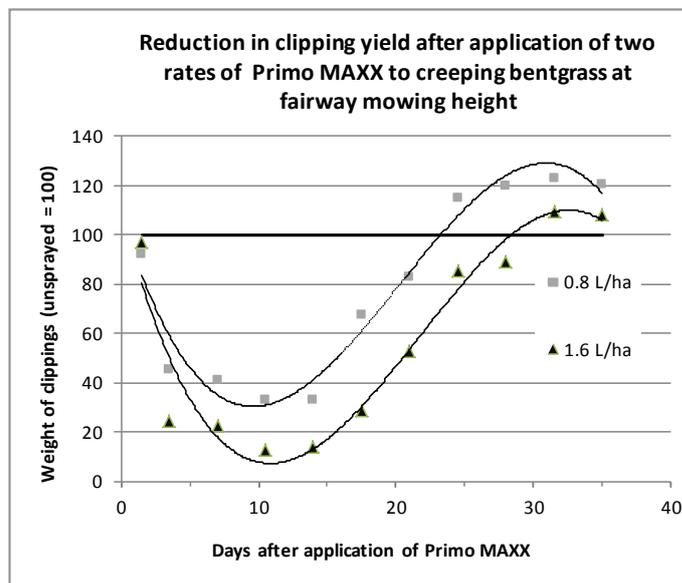
## Optimal application intervals for Primo MAXX

Trinexapac-ethyl, the active ingredient in Primo MAXX, is usually broken down in the plants in a matter of 2-4 weeks after spraying. The growth inhibiting effect is therefore quite short-lived, and when this effect ebbs out, the grass will grow more than it would have done if it had never been sprayed with Primo MAXX. Physiologically, this can be explained by the fact that in the period following spraying, GA<sub>20</sub> and reserve carbohydrates have accumulated in the plants, and these are utilized when the last step in gibberellin biosynthesis is no longer blocked.

This phenomenon is called «rebound», which means that the grass grows more strongly<sup>5</sup>. To achieve sustained growth regulation, regular spraying is therefore necessary.

In the first Nordic experiments with Primo MAXX on green and fairway, the interval between sprayings was four weeks. In those experiments, we quickly learned that growth reduction was much stronger in the first two weeks than in the third week after spraying. In the fourth week after spraying, the weight of clippings was even higher on non-sprayed than on sprayed plots<sup>6</sup>. This has later been confirmed in growth chamber trials which also show that rebound takes effect later with increasing dosage of Primo MAXX<sup>4</sup>. See figure.

Biochemical reactions in plant usually occur faster at higher temperatures. Because of this, American scientists recommend using day degree units instead of number of days to designate the interval sprayings. Day-degree numbers are found by adding up the daily mean temperatures (example in the sidebar). The American recommendation to repeat the spraying after about 200 day degrees (d°C)<sup>7</sup>. We've found that this norm is valid for the southern parts of the Nordic countries in the warmest period of July and August. However, in northern (and especially coastal) areas of the Nordic countries, and when the average day temperature is low in the first part of the season, the number of day degrees between spraying should not be higher than 150 d°C<sup>4</sup>. Many weather stations have software giving you the daily mean temperature directly, but you won't be making any big mistake if you have a maximum and a minimum thermometer and calculate the daily mean from that.



## How to calculate day-degree units (d°C)

The table shows daily mean temperature and accumulated day degree units at the Bioforsk turfgrass research center Landvik for the period June 1-15, 2013. Primo MAXX was applied on May 31. According to the American model, Primo MAXX would have to be reapplied after 200 d°C, i.e. on 14 or 15 June.

Date	Daily mean temp. °C	Day degrees after last spraying, d°C
June 1	17.5	17.5
June 2	16	33.5 (=17.5+16.0)
June 3	14.6	38.1 (=33.5+14.6)
June 4	12.6	60.7 (=48.1+12.6)
June 5	10.9	71.6
June 6	11.3	82.9
June 7	14	96.9
June 8	16	112.9
June 9	15.2	128.1
June 10	15.7	143.8
June 11	13.6	157.4
June 12	12.3	169.7
June 13	13.1	182.8
June 14	14.1	196.9
June 15	11.2	208.1

# DOCUMENTED EFFECTS OF PRIMO MAXX on cuttings, ball roll and visual quality in Nordic trials

Location / Ref	Year	Grass species	Application interval	Dose, L/ha	Effect of Primo MAXX		Comment
					Clippings	Ball roll	
Lepaa, Finland <sup>6</sup>	2007	Creeping bent-grass	4 weeks	0.20	- 8 %	Not measured	Rebound. No effect on visual quality
				0.40	- 15 %		
Ballerud, Norway <sup>6</sup>	2007	Creeping bent-grass	3 weeks	0.40	- 44 %	+ 13 %	Darker and more uniform color
Bogstad, Norway <sup>6</sup>	2007	<i>Poa annua</i>	3 weeks	0.40	- 26 %	Not measured	Darker color
Landvik, Norway <sup>8</sup>	2008	Creeping bent-grass	1 week	0.15	- 26 %	+ 4 %	Consistent reduction in clippings. Darker color
			2 weeks	0.30	- 23 %	+ 6 %	
Fullerö, S <sup>9</sup>	2010	Red fescue	2 weeks	0.30	- 37 %	+ 3 %	Better overall impression
Landvik, N <sup>10</sup>	2011	<i>Poa annua</i>	2 weeks	0.40	-19 %	+ 6 %	Tendency to yellowing
Landvik, N <sup>11</sup>	2013	Creeping bent-grass	2 weeks	0.20	- 11 %	+ 7 %	Darker color. Better overall impression
			2 weeks	0.40	- 10 %	+ 7 %	
Loimijoki, FIN <sup>11</sup>	2013	<i>Poa annua</i> / creeping bent/ velvet bent	2 weeks	0.20	- 8 %	Not measured	Darker color. Better overall impression
			2 weeks	0.40	- 22 %		

**Table 1.** Summary of Nordic trials with Primo MAXX on green.

## Green

Table 1 sums up results from Nordic trials with Primo MAXX on greens. At 0.4 L/ha, which according to Swedish label is standard dosage of Primo MAXX on greens, the average cutting reduction has been 23%, and the visual overall impression has largely been better than in the unsprayed treatment, mainly due to the darkened color. Still, it's worth noting that smaller doses of Primo MAXX also give as good a growth reduction, provided you spray often enough. For example, in the trial at Landvik in 2008 there was a 26% reduction in clippings by spraying with 0.15 L/ha once a week. For some greenkeepers, this means that they can mix a small amount of Primo MAXX into the tank when applying liquid fertilizers to their greens.



**Image 4:** Measuring the ball roll in trials with Primo MAXX on green. Because the plots are not more than 2 meter long, a shortened stimp-meter is used. Photo: Trygve S.Aamlid

## Fairway

In our first trials on fairway (Table 2) we had achieving consistent growth reduction without it compromising the visual fairway quality (Image 5). This problem was resolved when we reduced the spraying interval to every two weeks. It is likely that we can achieve consistent growth reduction with a three week interval as well, at least if we use a dosage of 1.2-1.6 L/ha. The Swedish label for Primo MAXX states that a standard dose of 1.6 l/ha will yield «up to 50% reduction in grass growth for four weeks with minimal yellowing», but for those trying Primo MAXX for the first time it is safer to start with a lower dosage and a shorter spraying interval, e.g. 1.0-1.2 l/ha every other to every third week. Later, the dosage and interval can be increased as one gains more experience.

Table 2 shows that we in our Nordic fairway-trials have achieved more than 50% growth reduction in only one trial: at Loimijoki GC in Finland in 2013. In reality most greenkeepers should be satisfied if they by using Primo MAXX can reduce the fairway mowing requirement by one third, that is, from three to two times a week.



**Image 5:** At Byneset GK in Trondheim, the first application of 1.6 L/ha led to reduced fairway quality. Photo: Trygve S. Aamlid

Location	Year	Grass species (predominant species mentioned first)	Application interval	Dose L/ha	Clipping yield relative to unsprayed	Comment
Landvik, Norway <sup>7</sup>	2007	Red fescue/ Ken. bluegrass/ colonial bent/ <i>Poa annua</i>	4 weeks	1.0	- 1 %	Significant rebound. Yellowing, reduced visual quality
				1.5	- 15 %	
Lepaa, Finland <sup>7</sup>	2007	Kentucky bluegrass/ red fescue	4 weeks	1.0	- 8 %	Rebound. No reduction in visual quality
				1.5	- 21 %	
Ballerud, Norway <sup>7</sup>	2007	<i>Poa annua</i>	4 weeks	1.5	- 37 %	Tendency to rebound and yellowing
Lepaa, Finland <sup>8</sup>	2008	Kentucky bluegrass/ red fescue	2 weeks	0.8	- 23 %	No rebound. No reduction in visual quality
				1.6	- 34 %	
Landvik, Norway <sup>11</sup>	2013	Red fescue/ Colonial bent/ Kentucky bluegrass	2 weeks	1.2	- 38 %	No rebound. Darker color
				2.0	- 46 %	
Loimijoki, Finland <sup>11</sup>	2013	Kentucky bluegrass	2 weeks	1.2	- 64 %	No rebound. Darker color
				2.0	- 67 %	

**Table 2:** Summary of Nordic trials with Primo MAXX on fairway



**Image 6:** Spraying of semirough with 2.2 L/ha had poor effect on ryegrass. It led to tufts of ryegrass sticking up over Kentucky bluegrass. Photo: Tatsiana Espevig.

## RESPONSE TO PRIMO MAXX IN DIFFERENT GRASS SPECIES

Primo MAXX was first used in USA where creeping bentgrass and *Poa annua* are the dominant cool season grasses on greens, and where many courses also have creeping bentgrass on their fairways. Both of these species show good response to Primo MAXX. The benefits are perhaps bigger on *Poa annua*-greens, although the risk for yellowing is also higher than in creeping bentgrass.

None of our trials have so far been conducted on red fescue-greens, but it is likely that the benefits of Primo MAXX will be smaller there than on creeping bentgrass and *Poa annua*-greens. This is due to the lower growing potential and thus less use of fertilizer to red fescue greens. The effect on colonial (browntop) bentgrass will likely be somewhere between red fescue and creeping bentgrass/*Poa annua*. Because of

low leaf elongation, velvet bentgrass normally gives good ball roll without growth regulation, but in shade the quality of the green can still improve by using Primo MAXX<sup>13</sup>.

On fairway there are indications that growth reduction after spraying with Primo MAXX are larger for Kentucky bluegrass and annual bluegrass than for red fescue and colonial (browntop) bentgrass. On fairway, semirough and on football pitches, perennial ryegrass shows response to Primo MAXX only if the dosage is increased to 2.5-3.5L/ha, which means that it requires a significantly higher dosage than other turfgrass species. In a trial at Ballerud GC, Norway, spraying with 2.2 L/ha led to tufts of ryegrass sticking up like small 'islands' in semirough otherwise dominated by Kentucky bluegrass (Image 6).



**Image 7:** From trials with Primo MAXX on creeping bentgrass green, Lepaa GC, Finland, spring of 2008. The control plot with the most snow mold on the front left had not received Primo MAXX in 2007. Photo: Oiva Niemelainen.

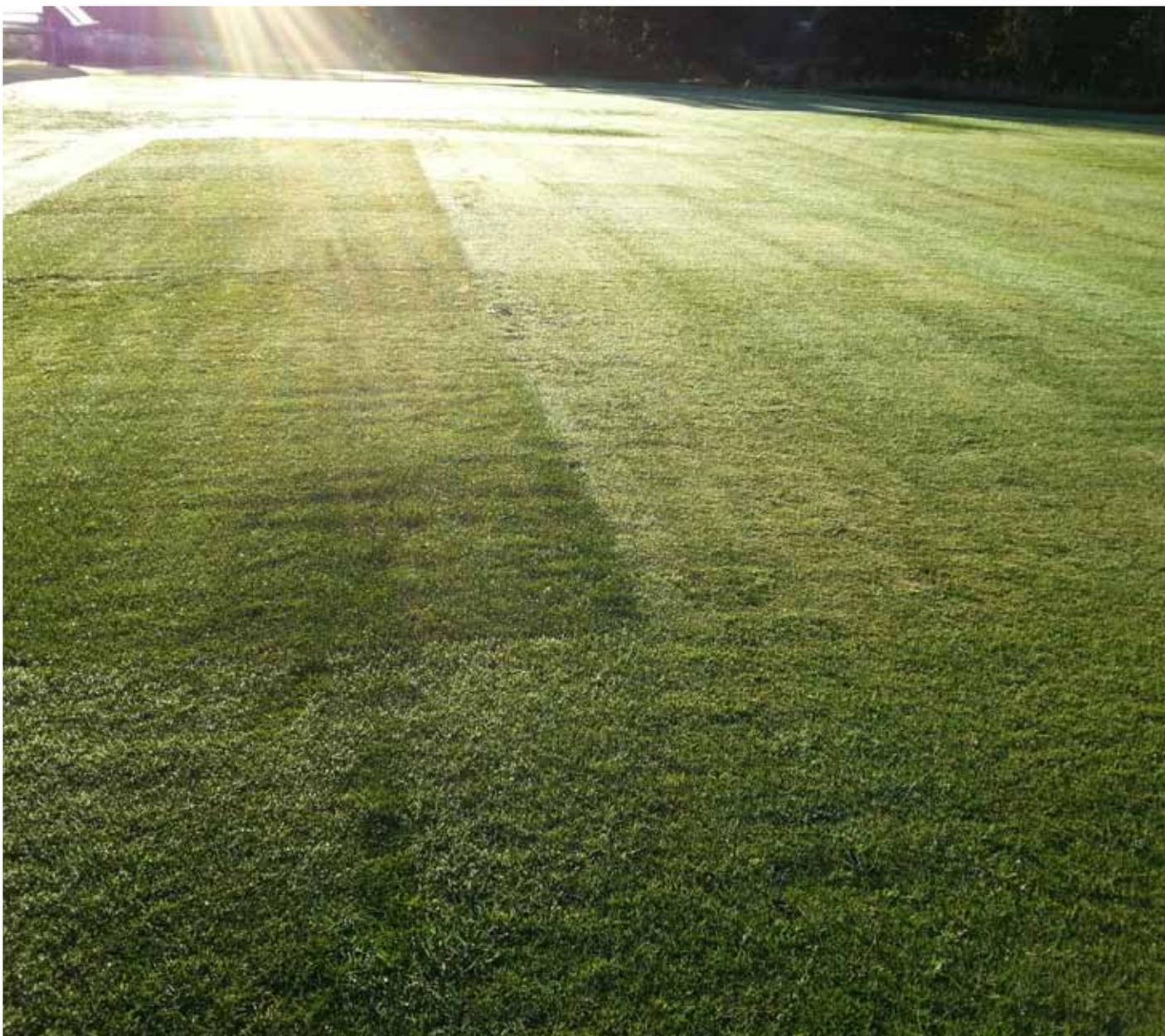
## PRIMO MAXX AND STRESS TOLERANCE

### Winter hardiness

Short cut grass is susceptible to winter damage, and better ability to survive the winter can be an important argument for using Primo MAXX on Nordic golf courses. In the first trials on greens and fairways in Finland, regular spraying with Primo MAXX led to significantly less damage from pink snow mold (*Microdochium nivale*) in the next spring<sup>8</sup> (Image 7), and in a later trial the same effect was documented on a *Poa annua*-green at Landvik<sup>10</sup>. A possible cause of this can be that Primo MAXX in itself has a weak fungistatic (fungi preventative) effect, but more important is the fact that the increase in carbohydrate reserves makes the grass better capable of both resisting and repairing winter damage.

The effect on snow mold is not sufficient for Primo MAXX to replace fungicide; in the trial at Landvik<sup>10</sup>, snow mold attack in the next spring was reduced from 23% to 14% of plot area, while preventive spraying with fungicide reduced the attack to less than 1%. In another trial Primo MAXX led to increased frost tolerance in hardened plants of creeping bentgrass, although the effect was marginal (-31°C after regular spraying with 0.4 L/ha compared to -29°C in the control treatment<sup>11</sup>).

We conclude that Primo MAXX is one of several measures that might reduce overwintering problems on Nordic golf courses.



**Image 8.** From a fairway trial with Primo MAXX at Landvik an early morning in 2013. The plots on the left had received Primo MAXX in different doses and formulations. Photo: Agnar Kvalbein

## Drought tolerance

We have often observed less guttation water in the morning, i.e. a drier surface after application of Primo MAXX (Image 8). This can indicate a lower uptake of water, which conforms to American literature showing less evapotranspiration (ET) after spraying with Primo MAXX! In the first fairway trials at Landvik we observed a slightly lower water percentage in the clippings from plots sprayed with Primo MAXX<sup>7</sup>,

and later trials documented a slightly negative effect from Primo MAXX on the root depth of *Poa annua* at greens<sup>10</sup>.

All in all there is no reason to believe that spraying with Primo MAXX has a significant impact on the drought tolerance and thus irrigation requirements on golf courses in Nordic climates.



**Image 9.** Primo MAXX increases the shadow tolerance of the grass. Photo:Trygve S.Aamlid

### **Shade tolerance**

Grass growing in shade will normally develop less tillers, but longer and thinner leaves to catch more sunlight. In the same way as the effect of long days, this is at least partially a gibberellin response, and from the US it is well documented that Primo MAXX has a stronger positive effect on visual quality and playing quality in shade than in full sunlight<sup>1</sup>. Although we have no Nordic trials to verify this, better shade tolerance is probably one of the greatest benefits of Primo MAXX on *Poa annua* and creeping bentgrass-greens even in the Nordic countries.

### **Wear tolerance**

Spraying with Primo MAXX will normally increase tiller density and simultaneously lead to more compact cells with slightly less water content. This increases the grass' resistance to trampling and other wear and tear, but at the same time, the reduced growth rate will also result in less ability to repair damages that have already occurred. In the rebound phase the reparation ability of grass treated with Primo MAXX can be better than with non-sprayed grass, and this is something greenkeepers can exploit if special tournaments are planned on the golf course.

### **Competitiveness to weeds**

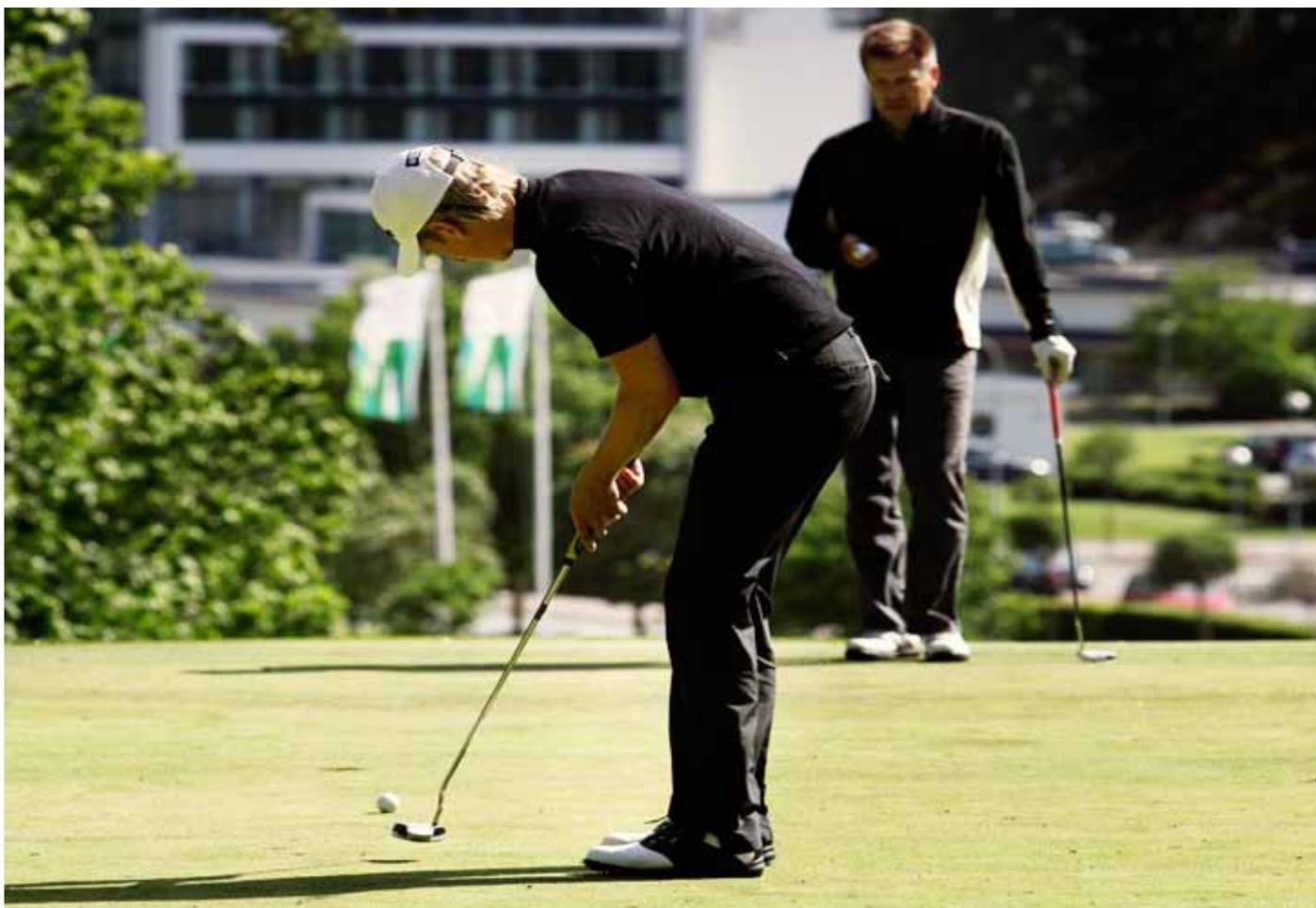
Primo MAXX has no or small effects on the growth of dandelions plantains, white clover and other dicotyledons. The competitiveness of the grass with regards to weeds will therefore subside while using Primo MAXX, and in our trials we have repeatedly seen that weeds become more prominent in sprayed fairways as opposed to non-sprayed fairways (e.g. Image 5). Courses that do not want to spray herbicides must therefore be careful with the use of Primo MAXX.

### **Susceptibility to disease**

We have already mentioned that Primo MAXX can reduce the problems with snow molds on golf courses. With regards to anthracnose, another common disease on *Poa annua*-greens, American trials show that Primo MAXX has either none or a slightly preventative effect<sup>14</sup>. The latter is especially true if, as a result of growth regulation, greenkeepers fertilize a little stronger without it affecting the ball roll.

As mentioned in Table 2 we have in our fairway trials sometimes seen more red thread after treatment with high doses of Primo MAXX. This risk is also mentioned on the Swedish label of the product.

# PRACTICAL EXPERIENCES WITH PRIMO MAXX ON SWEDISH GOLF COURSES IN 2012 AND 2013



## Background

The growing season of 2012 was the first whole season when Swedish golf courses were given the opportunity to spray with Primo MAXX. In the autumn of 2012, the Swedish Golf Association conducted a survey asking greenkeepers how they had used Primo MAXX and what their experiences were.

Before being allowed to use Primo MAXX, Swedish golf courses must submit a form to the environmental office of their municipality. This is the same rule as for other pesticides. Most municipalities have approved the spraying of Primo MAXX.

The number of responses to the survey was around 130 of around 430 Swedish golf courses. Most were from the southern part of Sweden, along the latitude of Stockholm and south of it. We estimate that about 100 courses bought and used Primo MAXX in 2012, and that this number stayed relatively unchanged in 2013.

The dominant use of Primo MAXX was on greens. Less than 10 percent of the courses used Primo MAXX on tee, fairway or rough. More than 80% of the courses had pure *Poa annua*-greens or mixed greens with elements of other species, first and foremost creeping bentgrass. A few had pure creeping bentgrass, colonial (browntop) bentgrass or red fescue-greens.

On most courses, the interval of spraying corresponded well with the Swedish label. A few exceptions were found, as a few courses had used lower dosage and/or longer application intervals. A very few courses experienced problems with the rebound effect.

The following is a presentation of some of the experiences which emerged in the survey.

## Experiences on greens

### *Smoother and better ball roll*

Most clubs reported that their greens had improved in quality after starting using Primo MAXX. The green speed (stimp value) had become more uniform with less variation during the day. Most courses saw this as the greatest benefit of using Primo MAXX.

### *Darker color*

Most courses saw it as an advantage that pure *Poa annua*-greens and mixed greens with *poa annua* and creeping bentgrass had turned to a darker green color after spraying with Primo MAXX. Yellowing after spraying had occurred some places, but this was not seen as a big problem as long as Primo MAXX was applied at the recommended rate.

### *Dense greens - problems with topdressing*

Some courses reported that *Poa annua* greens had grown so dense that it was difficult to get the sand incorporated into the turf. For this reason some courses had stopped using Primo MAXX. Others had continued, but focused more on aeration and vertical cutting in their maintenance program.

### *Shorter seed stalks in Poa annua*

According to the Swedish label Primo MAXX has an insignificant effect on flowering and seed formation in *Poa annua*. Most courses agreed with this, but many said that the blooming was less noteworthy because the seed stalks had become shorter.

### *Less anthracnose*

Several courses experienced a decrease in the fungus disease anthracnose on *Poa annua*-greens. There may be several reasons for of this, among others that the ball roll has improved so much that greenkeepers cut a little higher or skip a few cuttings in periods of less growth, especially in late summer or early spring. Some also reported that they combined Primo MAXX with slightly more fertilizer, which resulted in a fresher color without affecting the ball roll.

### *Shadow tolerance and overwintering*

Many reported that Primo MAXX is most effective on shaded greens. The shaded *Poa annua* plants become more compact and healthier. Some also believed that the greens had become more resistant to winter damage, especially snow mold. As for winter survival, it is, however, difficult to conclude after only a couple of winter seasons, and because many greenkeepers had forgotten to leave a non-sprayed reference plots.

### *Primo MAXX in connection with over-sowing or reparation after winter damage*

Few courses had experience with Primo MAXX in connection with over-sowing or re-sowing after winter damage, but some warned against spraying partly winter damaged greens in the spring. The main rule must be that winter damage must be healed before starting with Primo MAXX in spring.

### *Effect on different species*

Many golf courses with noble grasses, i.e. different bentgrasses or red fescue, were of the opinion that there was little reason to start spraying with Primo MAXX. Especially for red fescue most meant that there would be little effect of Primo MAXX on clipping yields or ball roll.

## Experiences on tees

Few courses had sprayed with Primo MAXX on tees, but the experiences were good, and most of the courses that had tried Primo MAXX would most likely continue to do so in the future. The benefits highlighted were first and foremost less mowing and denser turf. Tees often have a mixture of Kentucky bluegrass and red fescue with Kentucky bluegrass as the dominant species, but there were no reports of different effects on the different species in the mixture.

## Experiences on fairways

On fairways there was likewise few who had tested Primo MAXX. Of those who had tried it, some reported more even quality and reduced work- and energy costs by decreasing the cutting frequency from three to two times a week. The majority meant, however, that it would not be worthwhile economically or in terms of quality to spray regularly with Primo MAXX on fairways. Some courses had experienced a reduction in fairway quality because dandelions and other weeds became more visible.

Fairways on Swedish golf courses usually have a mixture of different grass species. Some had experienced that long intervals between spraying gave uneven fairways because of greater differences in the growth rates. Especially prominent was this effect on fairways with both *Poa annua* and perennial ryegrass.



## SUMMARY AND RECOMMENDATIONS

Both trials and practical experiences shows that the use of Primo MAXX must be adapted to the individual golf course. Turfgrass species, external conditions (e.g. light and shade), weed occurrence, wear, fertilizer and maintenance practises are important for the outcome. Usually it will pay off to start carefully on the greens to gain experience. As for tees, fairway and rough, it's important to weigh the benefit against cost and consider whether spraying is economically profitable. The cost of the growth regulator increases with area and dosage, but the greater the area, the greater is also the potential for less mowing.

The Swedish label for Primo MAXX gives a normal duration of effects of 4 weeks and a standard dose of 0.4 L/ha on green, 1.6 L/ha on fairway and 2.4 L/ha on semirough and rough (cutting height over 18 mm). At least for greens, we

feel that this spraying interval is too long. Rather than four weeks, we recommend that greenkeepers starting with Primo MAXX to calculate day dregree units and apply the product with an interval of 150-200 d°C, with the longest interval under warm condition in late summer. In order for the grass to adapt to Primo MAXX one should at first spraying in the spring always begin with half of the dose recommended on the label, and then gradually increase the dose to achieve the desired growth reduction. Higher doses are needed on tees or fairways dominated by perennial ryegrass, but this is seldom an issue on Nordic golf courses.

Under the right circumstances we think that Primo MAXX will become an important tool in turfgrass maintenance on Nordic golf courses.

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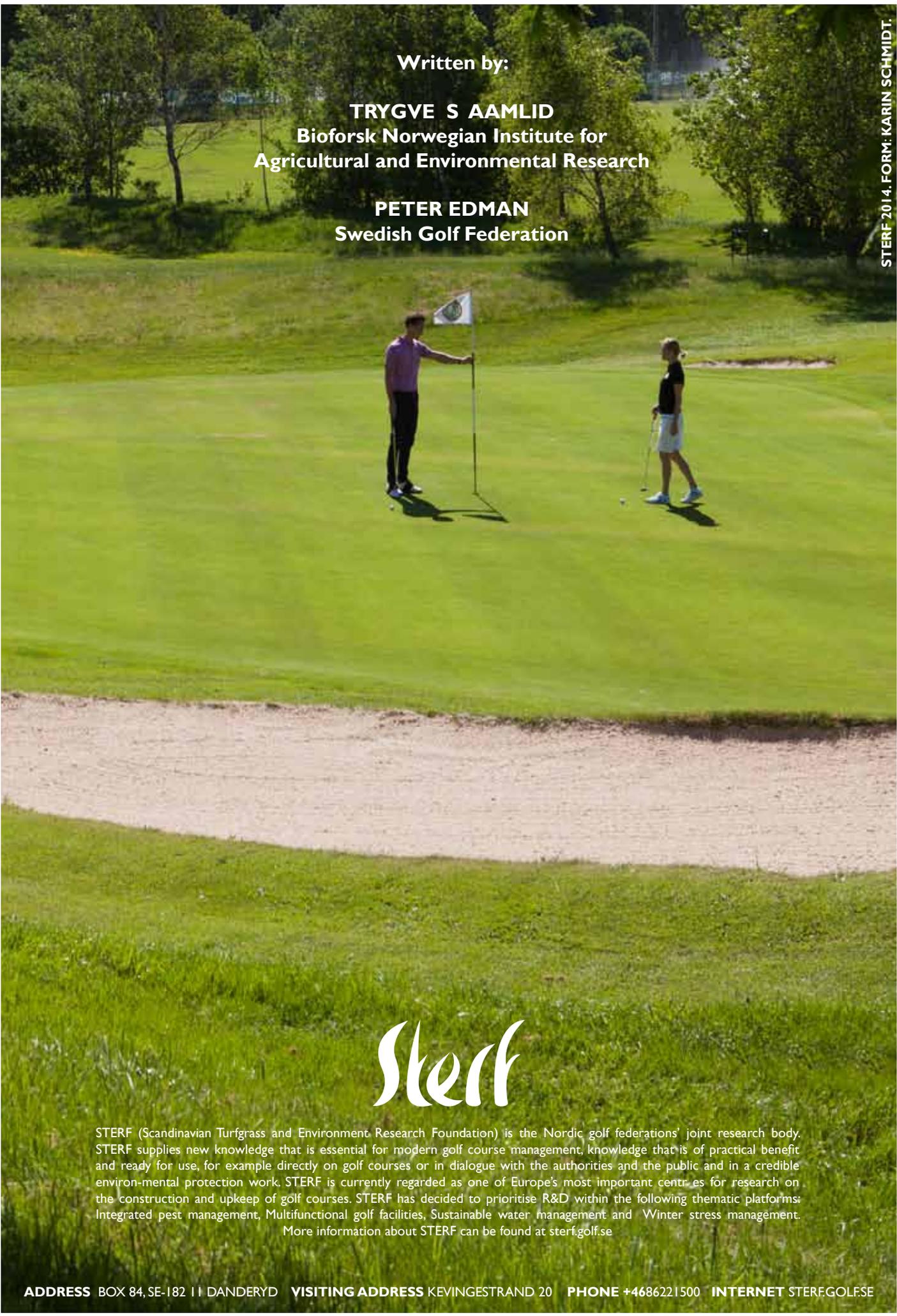
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# STERF

STERF (Scandinavian Turfgrass and Environment Research Foundation) is the Nordic golf federations' joint research body. STERF supplies new knowledge that is essential for modern golf course management, knowledge that is of practical benefit and ready for use, for example directly on golf courses or in dialogue with the authorities and the public and in a credible environmental protection work. STERF is currently regarded as one of Europe's most important centres for research on the construction and upkeep of golf courses. STERF has decided to prioritise R&D within the following thematic platforms: Integrated pest management, Multifunctional golf facilities, Sustainable water management and Winter stress management.

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