RESEARCH AND DEVELOPMENT YEARBOOK 2016

2006-2016
10 years

RESEARCH AND DEVELOPMENT YEARBOOK 2016. STERF. SCANDINAVIAN TURFGRASS AND ENVIRONMENT RESEARCH FOUNDATION

STERF - 10 YEARS OF EXCEPTIONAL PROGRESS

STERF's ambition is to stimulate and support the golf and turfgrass sector and industry to:

- Take the initiative

- Work proactively

- Create change

This is the only viable attitude if we want to overcome current challenges and develop a sustainable future. Today STERF is recognised as a substantial funder of turfgrass research, an international publisher of ready-to-use research findings and a highly valued partner to different stakeholders in the golf and turfgrass sector.

It all started in 2005/6, when a small Swedish regional foundation was transformed into a pan-Nordic research foundation, with the ambition to become "A leading international centre of competence and knowledge in environmental aspects of turfgrass management for golf, delivering 'ready-to-use research results'". The Scandinavian Turfgrass and Environment Research Foundation – STERF – was founded!

The driving force behind this change was an awareness of the global challenges the golf sector was facing.

Climate change - Regulation and development control - Limited natural resources - Loss of biodiversity - Public opinion and political support - Economic challenges are just some of the areas that need to be addressed with science and competence build-up.

To achieve the aim of becoming an international centre of excellence, STERF adopted some basic strategies:

- Increase scientific quality through a multidisciplinary approach and encourage cooperation and establishment of networks by scientists.
- Increase project funds through joint funding by STERF, public funding bodies and industry contributions.
- Strengthen research capacity by collaborating actively with other leading organisations.
- Support end-user driven research, delivering "ready-to-use results".

Now, 10 years later, we are proud to say that STERF has gained a leading position on the international turfgrass scene. Below are some highlights from each year to illustrate the story of STERF's development:

2007: Iceland joins STERF, fulfilling the vision of a pan-Nordic research co-operation, and all the national federations accept a tax of € (IPM)0.5 per registered player as a long-term strategy to fund research and competence building.

2008: STERF arranges its first innovation workshop, focusing on the challenge of climate change, which gathers more than 100 participants from all the Nordic countries, representing different stakeholders. As a result of discussions in the workshop, the first research programme is formulated.

2009: The Nordic greenkeepers' associations approach STERF with a proposal on strategic co-operation. Agreement on regular information about STERF projects in magazines, prioritisation of meetings comprising cross-communication between greenkeepers and researchers, participation by greenkeepers in advisory groups for projects etc. is reached.

2010: The project "Multifunctional golf facilities - an underutilised resource" is funded by the Nordic Council of Ministers. The main aim of the project is to create networks and permit exchanges of experiences between experts and groups in society with an interest in the land areas used by golf courses.

2011: STERF's open library on Integrated Pest Management (IPM) is set up, with support from the Swedish Board of Agriculture, to provide the park and golf sector with access to information and tools based on research and development for IPM. Information seminars, education materials, 20 fact-sheets and a large number of handbooks and other publications are launched.

2012: To strengthen the process of integrating strategic research and development all the way from producer to end-user, STERF's Industry Scientific Partner Programme is introduced. The partners contribute to funding STERF's open research programme. In addition, STERF recognises a need for international co-operation and signs an agreement on collaboration with the Canadian Turfgrass Research Foundation (CTRF), since both organisations have a common interest in promoting high-quality turf on golf courses and sports fields, while also guaranteeing ecosystem protection.

2013: The second Innovation workshop is held, resulting in four new strategic research programmes with an international outlook, namely Integrated Pest Management, Sustainable water management, Winter stress management and Multifunctional golf facilities. STERF also invites club managers, greenkeepers and other representatives of 700 golf clubs in the five Nordic countries to respond to an internet-based questionnaire about STERF's R&D priorities and 510 clubs submit their priorities – a highly valuable input!

2014: Seven industry partners contribute SEK 1.5 million to STERF's project portfolio, bringing the portfolio to a total volume of SEK 4.5 million, a 10-fold increase over 10 years. Four international R&D seminars are held by STERF, in Norway, Denmark, the Netherlands and China.

2015: STERF invites the Nordic authorities responsible for implementation of the EU Directive on Sustainable Pesticide Use to a contact meeting in Copenhagen, to inform them about STERF's present and planned Integrated Pest Management (IPM) projects and the digital IPM library, and also to discuss implementation of the newly revised procedures for registration of plant protection products. The authorities and delegates agree on joint communication strategies and important R&D areas for the Nordic countries.

2016: To increase the accessibility and impact of STERF research for practitioners, national websites for all Nordic countries are launched. Handbooks, guidelines, fact sheets and other publications are now available in English, Norwegian, Finnish, Danish, Icelandic and Swedish.

Despite 10 years of ongoing progress, the challenges are even greater today for the golf sector. The climate change impact is exceeding the worst expectations, strong restrictions on the use of chemicals, fertilisers and energy are expected and there is an accelerating loss of urban green areas and biodiversity. All this calls for more research and innovation for the future.

STERF's focus for the coming 10 years will be on:

- Increased co-operation and resources, to tackle the global challenges; and
- Improved dissemination of "ready-to-use research results" for better effect in solving today's problems.

For this cause, we must mobilise all good powers on the planet, so you are all….

….welcome to join STERF's struggle for a sustainable future!

Bruno Hedlund

STERF Chairman

IMPORTANT EVENTS IN 2016

NATIONAL WEBSITES

A lot of STERF material has been translated into Swedish, Norwegian, Danish, Icelandic and Finnish. To make it easier for end-users to find fact sheets, handbooks, articles and brochures etc., there are now five language subsites on the STERF website www.sterf.org Practitioners have asked for this service for a long time and the national subsites will inspire national golf federations to increase translation of STERF publications. Click a flag at the top banner on the website to find the preferred language.

REVISION AND EXTENSION OF STERF'S DIGITAL LIBRARY ON IPM

Thanks to funding from the Swedish Board of Agriculture, 18 fact sheets on Integrated Pest Management (IPM) for golf courses and other amenity grasslands were published on STERF's website in 2011.

Ever since, the digital library has been widely used in the education and training of greenkeepers throughout the Nordic countries, as well as for individual studies. In a meeting between STERF and the national authorities in May 2015, it was agreed that the digital library should be updated with the latest research findings, and also that it should be supplemented with about ten new fact sheets covering other aspects of IPM. STERF covered the revisions, while funding for the new fact sheets was granted by the Norwegian Ministry of Food and Agriculture, the Danish Ministry of Education and the Danish Environmental Directorate. The work started in autumn 2015 and ended in the release of eighteen updated and eleven new fact sheets at www.sterf.org in June 2016. The fact sheets are richly illustrated and can be downloaded in Danish, Swedish or Norwegian.

The fact sheets have been written by scientists involved in STERF projects, but equally important is that each sheet contains contact information for at least one greenkeeper in each of the countries Denmark, Sweden and Norway. These 'IPM ambassadors' have special experience within the topics covered by the individual fact sheets, and they constitute a valuable resource for helping colleagues with practical implementation of IPM on golf courses.


FAKTABLAD – Integrerat växtskydd

Etablering av golfbanor och andra grästäckta grönytor utan ogräs

Mars 2016

En god start är viktigt

Sammanfattning


FAKTABLAD – Integrert plantevern

Mekanisk skjøtsel
for minst mulig angrep av skadegjørere på golfbaner

Mars 2016

Mekanisk skjøtsel

Sammendrag

DEVELOPMENT OF A NEW DIGITAL LIBRARY ON WINTER STRESS MANAGEMENT

Global warming is likely to have an impact on certain types of winter damage in specific geographical regions, but winter survival continues to be of the foremost challenges for turfgrass management in the Nordic countries. As an aid to greenkeepers trying to prevent or escape the winter hazards, a joint Scandinavian/Canadian digital library consisting of ten fact sheets on winter stress management was published by STERF (www.sterf.org) and the Canadian Turfgrass Research Foundation (www.turfresearchcanada.ca) in 2016. Parallel texts are presented in English and Norwegian, and many of the fact sheets have also been translated into Swedish and Danish. Examples of topics covered are: 'When to break the ice ?', 'Warm spells during winter', 'Winter protective covers', 'Turfgrass acclimation and deacclimation' and 'The difficult transition from winter to spring'.

The value of STERF's new digital library on Winter Stress Management was witnessed by the following E-mail from Dr. P.J. Landschoot, Penn State University.

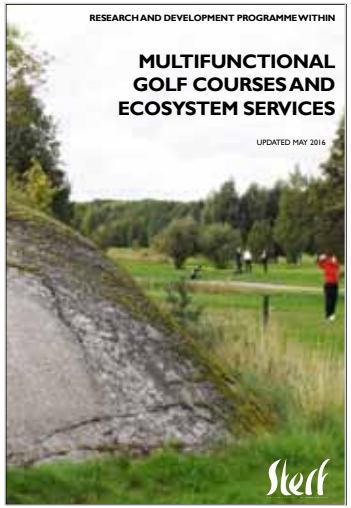
" *I love the series of fact sheets on acclimation and winter injury that were sponsored and produced by STERF. They are superior to anything I have seen here in the US, and I would like to send the links to these fact sheets to our superintendents this winter."*

REVISION OF THE R&D PROGRAMME ON INTEGRATED PEST MANAGEMENT

STERF's programme on IPM was published in 2010 as the first of the foundation's four R&D programmes. The IPM programme was developed in direct response to EU Directive 2009/128 on Sustainable Pesticide Use, which at that time was new to the golf industry and to the national authorities in the Nordic countries.

The revised programme for 2016-2021, published on www.sterf.org in August 2016, puts IPM on golf courses into a wider context, while the objective continues to be the promotion of high-quality turf with optimal use of inputs and integrated solutions for pest control. STERF, in collaboration with turfgrass managers, national authorities and industry partners, will continue to take responsibility for research, development and knowledge transfer on IPM, thus making the Nordic golf sector a role model with regard to sustainable societal development.
In accordance with the eight IPM principles, STERF's revised programme opens for new R&D projects within three thematic areas:

- Breeding, evaluation and management of species, varieties and turfgrass mixtures to create more disease-resistant, stress-tolerant and weed-competitive turf
- Identification, biology and proliferation of specific harmful organisms in various types of turf and under Nordic conditions, including possible effects of climate change
- Safer and more efficient use of pesticides, including alternative plant protection products.



REVISED R&D PROGRAMME ON MULTIFUNCTIONAL GOLF FACILITIES

STERF's programme on multifunctional golf facilities and ecosystem services was published in 2012. The revised programme for 2016-2020 published on www.sterf.org in May 2016 focuses on four central research and development areas: (1) The everyday landscape and peri-urban nature, (2) Nature and culture, (3) Dialogue and cooperation and (4) Business promotion.

This new version of the programme put high emphasis on the golf sector as an important actor in the collaboration on green infrastructure, including environmental quality work, and in implementation of the European Landscape Convention. It is therefore important that new knowledge is developed and good examples of multifunctional golf courses are docu¬mented, and that these are then communicated to dif¬ferent groups in society. It is also important that R&D activities relating to multifunctional golf courses are accommodated and prioritised by national and international authorities, for example those with responsibility for human health and quality of life, green infrastructure, the national environmental quality objectives and implementation of the European Landscape Convention, and by other parties in society.

GREEN ECONOMY FOR GOLF: MULTIFUNCTIONAL USE TO IMPROVE ENVIRONMENTAL AND SOCIETAL BENEFITS (GREENGOLF)

In December 2016, a proposal for a three-year international networking COST Action was submitted by Cranfield University (UK) and STERF, supported by 26 other partners.

The COST programme aims to foster cooperation in science and technology and is financially supported by the EU Framework Programme Horizon 2020. COST Actions have two underpinning attributes – openness and inclusiveness – encouraging pan-European engagement from researchers, industry (small to medium enterprises), non-government organisations and other organisations. The COST Actions provide financial support to organise networking activities, including workshops, field visits, seminars and technical meetings, in order to share ideas, promote new research and foster innovation and collaboration. For STERF, this could provide an invaluable opportunity to extend awareness of its activities across Europe, to support wider dissemination of its research and to develop new networks to strengthen its reputation in the global sports turf community.

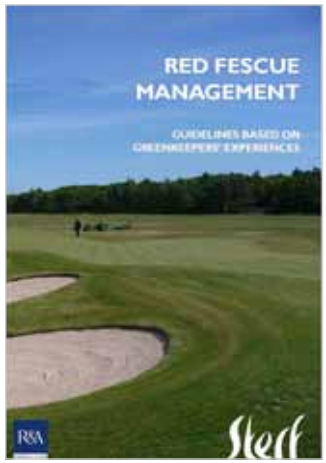
Our COST Action includes 28 individuals from 12 different Member States spread across southern, eastern/central and northern Europe. We also have participation by colleagues in Canada and the US. Nearly half the participants are early career researchers, an important evaluation criterion for COST.

Our COST Action aims to co-design a set of research initiatives to support the concept of a 'green economy for golf' in Europe and to facilitate multidisciplinary collaboration between natural, economic and social scientists, environmental and regulatory stakeholders and the sports turf industry. The Action will focus on three areas: (i) Turfgrass agronomy and management, (ii) Sustainable water management, and (iii) Multifunctional golf. Framed around these three areas, we have defined a set of research coordination objectives including establishing a network and engaging stakeholders to co-design research questions of fundamental importance to the EU sports turf sector; and a set of capacity-building objectives to include a programme of technical seminars, a scientific conference, researcher exchanges, summer schools and co-authored publications and policy briefings to promote scientific debate.

Finally, the COST Action will produce an information gateway (website) to act as a long-term resource for researchers, industry and policymakers with interests in the multi-functional use of green spaces and golf courses, and their impacts with the environment (land and water resources). A decision on funding will be announced in May 2017. If successful, this will be a new and exciting opportunity for STERF and its Nordic supporters to celebrate its activities and promote its impact to a wider European and international audience.

RED FESCUE MANAGEMENT HANDBOOK

STERF's five-year project 'FESCUE GREEN: Best management of red fescue (Festuca rubra) on golf greens for high sustainability and playability' was officially terminated with the publication of a final version of STERF's 'Red Fescue Management Handbook' in 2016. A



Trond Pettersen collects samples from the green. They will be tested in the laboratory for freezing tolerance and resistance to anoxia and pink snow mold. Photo: Agnar Kvalbein.

preliminary version of the handbook, mostly based on greenkeeper experiences discussed in a workshop in 2012, had been issued in 2012, but the final version also includes references and a discussion of recent findings in 'FESCUE GREEN' and other research projects. The headings in the handbook are: 'Why red fescue?', 'Premises for success', 'Characteristics of red fescue', 'Disturbance theory', 'Agronomic challenges', 'Winter issues', 'Change to red fescue – how?' and 'Pure fescue or fescue/bent?'.

SIX NORDIC SEMINARS ABOUT WINTER STRESS MANAGEMENT

Results from the project 'Autumn application of nitrogen and sulphur' were presented at six seminars, in Oslo, Helsinki and four cities in Sweden. Preliminary results were presented that covered various aspects of turfgrass winter stress management. Winter conditions vary widely from Malmö to northern Sweden and Finland. This was confirmed by a survey of Nordic golf courses in 2015, the results of which were presented during these seminars. The results revealed that biotic winter stresses (snow mould) dominate south of latitude 60, while ice encasement causes major concerns north of the capitals Oslo, Stockholm and Helsinki. About 250 golf course managers participated in the six seminars.

CALL FOR PROPOSALS

In its call for proposals in 2016 and 2017, STERF decided to prioritise research and development within the four international thematic areas, according to the R&D programmes within each area: 'Integrated Pest Management', 'Sustainable water management', 'Winter stress management' and 'Multifunctional golf facilities'. STERF received 12 interesting and relevant project proposals within the four thematic areas. The total amount applied for from STERF was SEK 13 111 000, the suggested amount of match-funding was SEK 6 737 000 and the total amount sought for new projects was SEK 19 848 000.

The advisory committee and its subgroups have done very good and important work in evaluating the proposals. Especially important for the evaluation process were the subgroup coordinators, Nilla Nilsdotter-Linde and Asbjörn Nyholt. The evaluation process was coordinated with the Canadian Turfgrass Research Foundation´s (CTRF) call for proposals and evaluation process. The STERF board will decide in March 2017 which projects to prioritise for funding.

FIFTH EUROPEAN TURFGRASS SOCIETY CONFERENCE

Since the foundation of the European Turfgrass Society (ETS) in 2007, the biennial ETS conferences have been an important meeting place for the turfgrass industry. The fifth conference was hosted by the University of Algrave, Albuferia, Portugal, in June 2016. The focus of the conference was on 'Turfgrass – Towards sustainability and perfection for aesthetic, recreational and sports and 'Quality turf and efficient utilisation of resources'. More than 80 researchers and turfgrass professionals participated in the conference. The two-day programme included more than 70 oral and poster presentations. STERF researchers contributed eleven presentations.

ABOUT STERF

SCANDINAVIAN TURFGRASS AND ENVIRONMENT RESEARCH FOUNDATION, STERF

STERF is an independent research foundation that supports existing and future R&D efforts and delivers 'ready-to-use' research results that benefit the golf and turfgrass sector. STERF was set up in 2006 by the golf federations in Sweden, Denmark, Norway, Finland, Iceland and the Nordic Greenkeepers' Associations. Research funded by STERF should be carried out at universities or research institutes (or equivalent) where most relevant research capacity is concentrated. STERF helps to strengthen research capacity by encouraging and supporting networks and collaborating actively with international key organisations in the field of turfgrass management. STERF also arranges innovation workshops to help identify the golf and turfgrass industry´s future research needs, where researchers and industry representatives contribute to the planning process. STERF receives funding from participating golf associations, which can be complemented by funding from other sources.

STERF's vision is to be the leading international centre of expertise in sustainable golf course management.

To achieve the vision STERF focuses on:

- Ensuring that Nordic turfgrass research and development focuses on internationally important areas where concerted research and industrial efforts are required. These include the pressures generated by government demands for greater environmental regulation, the increasing pressure on natural resources (notably water, energy and land), the emerging role of turf management in supporting ecosystem services and enhancing biodiversity, the continued need to promote integrated pest management, and the looming challenges posed by a changing climate and the urgent need to adapt.

- Establishing a successful international research and development collaboration, including research facilities and expertise in all five Nordic countries. STERF will continue to initiate inter- disciplinary and multi-disciplinary research and support collaboration in Europe, Canada, USA and China, involving both researchers and stakeholders interested in land used for managed turfgrass areas.

- Developing and expanding the STERF industrial scientific partner programme by collaborating with leading international companies within the sector to further strengthen the strategy that research and development should be integrated from producer to end-user. The STERF industrial scientific programme can be found on: http://www.sterf.org

- Taking a lead in making research results and new knowledge easily accessible to end-users and to provide support to implement changes, a prerequisite for achieving improvements in the sustainable management of golf courses and other turfgrass areas.

- Making the turfgrass industry in the Nordic countries a role model regarding responsibility for sustainable societal development, i.e. in producing managed turfgrass areas of a high standard while at the same time ensuring the sustainable use of natural resources and contributing to functioning ecosystems.

ADVISORY COMMITTEE MEMBERS
Maria Strandberg, STERF Director (Chair)
Peter Landschoot, Penn State University (independent international expert)
Annick Bertrand, Agriculture and Agri-Food Canada (independent international expert)
Asbjörn Nyholt (coordinator for golf course consultants/agronomists employed by the Nordic golf federations and Scandinavian greenkeeper associations)
Nilla Nilsdotter-Linde (coordinator for researchers at universities/research institutes in the Nordic countries)

ADVISORY COMMITTEE SUB-GROUP MEMBERS

Consultants and practitioners:
Asbjörn Nyholt (coordinator)
Thomas Jepsen, Danish Golf Union
Boel Sandström, Swedish Golf Federation
John Riiber, Norwegian Greenkeepers Association
Bjarni Hannesson, Golf Union of Iceland
Jan Hellström, Finnish Golf Association
Per Sørensen, Danish Golf Association
Mikael Lagerstam, Swedish Golf Association
Agne Strøm, Norwegian Golf Association
Peter Fjällman, Icelandic Golf Association

Researchers:
Nilla Nilsdotter-Linde (coordinator) Researcher, SLU, Sweden
Arne Tronsmo, NMBU, Norway
Åslaug Helgadottir, Agricultural University of Iceland
Margareta Ihse, Stockholm University
Berit Charlotte Kaae, Copenhagen University , Denmark
Markku Niskanen, LUKE, Finland

BACKGROUND

Managed turfgrass areas such as golf courses, sport fields, landscaped amenity areas and public parks all provide an important social, environmental and economic resource for both urban and rural communities. These areas serve a multifunctional purpose by offering valuable open spaces for recreation, helping to improve the health and quality of life for individuals and, when designed and managed appropriately, enhancing biodiversity and supporting regulatory targets for environmental protection. Conversely, where turfgrass management practices are inadequate or inappropriate, their services to society are reduced and their impacts on the natural environment can be damaging and costly.

The challenges for the future of turfgrass and golf course management are many and diverse. They include increasing demands on natural resources (notably land use, water resources and energy) driven by economic development and population growth, coupled with government demands for greater environmental protection, which are creating conflicts at the interface between land management (including turfgrass) and the environment. The situation is particularly acute in peri-urban areas where the majority of managed turfgrass facilities are concentrated. Population growth, migration and climate change will exacerbate the current situation, by increasing the competition for resources between individual sectors, including agriculture, urban development, tourism and the environment.

Many golf courses, sport facilities and stadiums are under pressure due to the financial crisis of recent years. For example, in many countries there has been a decrease in the number of registered golf players. It is common for golf courses to base their financial stability on a constant inflow of members rather than a static membership. However, they are now facing the challenge of balancing this approach against the new concept of fewer members and new conditions in a more variable and more competitive market.

The key for golf course and turfgrass management will be to increase resource use efficiency, reduce maintenance costs and minimise the environmental impact. In this context, the protection and enhancement of ecosystem services will need to be fully integrated into the planning, design, construction and management of all golf and turfgrass facilities.

The Nordic golf federations have approx. 900 000 members, playing golf on more than 900 courses that cover a total area of more than 58 000 ha. Any societal activity as significant as golf must take responsibility for building knowledge through research and development (R&D). There are several important reasons why Nordic R&D is necessary. In Central Scandinavia, Oslo, Stockholm and Helsinki lie at the same latitude as the southern tip of Greenland (~60oN). This provides a unique climate resulting from a combination of factors such as light, temperature and precipitation during the playing season and particularly during the winter season. The Nordic climate creates conditions for plant growth and the construction and management of golf courses, sport fields etc. that are not found anywhere else in the world.

R&D is, and will continue to be, a necessary and strategically important investment for the golf sector in achieving economically and environmentally sustainable golf facilities of a high standard and in establishing the credibility of golf as an environmentally friendly sport. Golf facilities that are already using new knowledge are achieving cost savings through more efficient management strategies, while also enhancing the golf course, raising the profile of their golf facility and improving the environment.

The financial resources allocated to R&D in each country are very limited and the number of scientists actively working within each priority R&D area is also quite limited compared with agricultural and forestry research. The financial resources and efforts of these researchers should therefore be coordinated through STERF to optimise R&D within the golf and turfgrass sector.

RESEARCH OBJECTIVES AND R&D SUB-PROGRAMMES

STRATEGIC RESEARCH OBJECTIVES

The golf and turfgrass industry, like other land-based industries, has to take responsibility for sustainable societal development, i.e. it must produce golf courses and other turfgrass areas of a high standard while at the same time ensuring the sustainable use of natural resources and contributing to functioning ecosystems.

The aim of STERF is to support R&D that can help the golf industry to fulfil these ambitions. The activities of STERF are intended to lead to improvements in the quality of golf courses, as well as economic and environmental gains for the industry and society as a whole.

The strategic objectives for STERF-funded R&D activities are that:

- The design, construction, management and administration of golf courses provide optimal conditions for playing quality, degree of utilisation of the course and management inputs.
- The design, construction, management and administration of golf courses are economically and environmentally sustainable, for example with respect to plant nutrient requirements, water and energy use, drainage and control of weeds and plant diseases.
- Golf courses contribute to improving the relationship between golf and ecosystems, enhance the natural and cultural values of the landscape and promote biodiversity.

R&D SUB-PROGRAMMES

It is apparent that the golf and turfgrass industry faces a number of local and international challenges, all of which will need concerted and collective solutions, underpinned by robust, applied science. To meet the challenges the sector has to face, STERF has created four international and trans-disciplinary R&D sub-programmes:

- Integrated pest management
- Sustainable water management
- Turfgrass winter stress management
- Multifunctional use of golf facilities and ecosystem services.

Progress in these programme areas will collectively lead to improvements in the quality of managed turfgrass areas, as well as economic and environmental gains for the industry. The key objectives of the pro-

grammes are to coordinate the design and running of R&D activities and to manage the effective dissemination of outputs (new knowledge) through channels and formats which are easily accessible to end-users. STERF will play a key role in expanding the programmes on international level.

Integrated Pest Management
New regulations at national and international level relating to the turfgrass industry are becoming more demanding. A good example is the EU Directive on Sustainable Use of Pesticides, which includes strategies for Integrated Pest Management (IPM). STERF, together with the Nordic park and golf sector, universities, research institutions and authorities, takes responsibility for ensuring that R&D activities important for IPM are coordinated and executed and that new knowledge is delivered.

Sustainable water management
Water is essential to secure the future of the turf industry and the livelihoods of many rural communities that depend upon it. Working with industry and leading research institutes, STERF's goal is to provide science-based information to practitioners and stakeholders on integrated water management in turf. This will improve management practices relating to both irrigation and drainage systems, help protect environmental water quality and support the industry in adapting to the effects of future changes in rainfall and climate variability on water resources.

Turfgrass winter stress management
Winter damage is the foremost reason for dead grass, reducing the aesthetic and functional value of turf. UN-IPCC climate scenarios predict that due to high precipitation and unstable temperature, ice and water damage will become the most important cause of winter damage in the future. This is a complex but high priority area for STERF, as it has been estimated that about 70% of Nordic golf courses suffer from winter damage each year, and that the associated average annual costs per golf course are €35 000-40 000. STERF will take responsibility for developing strategic expertise and new knowledge to avoid and manage such damage.

Multifunctional use of golf facilities and ecosystem services
Multifunctional golf courses can contribute to the achievement of international and national environmental targets and help improve people's health and quality of life by providing facilities for active outdoor recreation. Through STERF´s R&D programme within multifunctional facilities, the societal benefits of golf can be improved and the Nordic area can become a model region as regards multifunctional golf courses and collaborations between different interests in society. Four central research and development areas have been identified: (1) The everyday landscape and peri-urban nature, (2) Nature and culture, (3) Dialogue and cooperation, and (4) Business promotion.

Programme coordinators
Programme coordinators appointed by STERF, together with the STERF board and its director, are responsible for developing STERF R&D programmes. Overarching duties to be fulfilled by the programme coordinators are:

- To be a 'champion' or nominal lead for their programme
- To make sure that the programme has a suitable mix of activities, not only research but also other industry-linked initiatives, including for example meetings, workshops and media outputs
- To help share programme workload
- To take 'ownership' of the activities/ initiatives that need to be developed over the next three years.

The full R&D programmes and presentation of programme coordinators can be found at: www.sterf.org

STERF'S INDUSTRIAL SCIENTIFIC PARTNER PROGRAMME

Because STERF is working globally and launching international programmes, it has invited important companies within the sector to become involved in its Industrial Scientific Partner Programme. The aim is to increase the credibility of STERF´s research and development programme, and also to increase financial support for programmes and projects.

The involvement of leading suppliers will also strengthen the important strategy that research and development should be integrated all the way from producer to end-user. STERF and the industrial scientific partners have had several discussions about creating combined R&D projects involving a number of different industrial partners and STERF. The aim of these projects will be to identify, explain and suggest solutions for complex problems relevant for the sector.

As an Industrial Scientific Partner to STERF, companies have a whole range of benefits:

- Access to the leading research and innovation centre in the turfgrass and environmental field
- The opportunity to take part in creating STERF´s research programme through participation in the planning process
- Participation in STERF workshops and seminars
- A world-wide network of contacts with international universities and centres of research in the golf sector
- A contact day on which to present and discuss the particular company´s strategic development issues
- Information via the STERF newsletter and website
- Collaboration on research projects and product development
- Contacts with public authorities.

STERF's partners 2016

STERF is proud to present its current Industrial Scientific Partners:

- Aquatrols Europe Ltd.
- Botanical Analysis Group
- Envirom Group
- Melspring
- OGT
- Syngenta

SCANGREEN: TURFGRASS SPECIES, VARIETIES, SEED BLENDS AND MIXTURES FOR INTEGRATED PEST MANAGEMENT OF SCANDINAVIAN PUTTING GREENS

PROJECT PERIOD: JANUARY 2015 – DECEMBER 2018

FUNDING (kSEK)

	2015	2016	2017	2018	Total
STERF	481	638[1]	563	569[2]	2 251
Other sources	225	80	80	180	565
TOTAL	706	718	643	749	2 816

1) Includes an extra ear-marked grant of 78 kSEK from Norwegian Golf Federation in 2016 to write one popular article and give one additional talk on alternative seed mixtures and blends.
2) Reserved, but not granted

PRINCIPAL INVESTIGATOR / CONTACT PERSON

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Gudni Thorvaldsson, Agricultural University of Iceland, Iceland
Anne Mette Dahl Jensen, University of Copenhagen-IGN, Denmark
Pia Heltoft, Tatsiana Espevig, Trond Pettersen, and **Jan Tangsveen**, NIBIO, Norway

PROJECT OBJECTIVES

- To clarify which varieties of *Agrostis, Festuca, Poa* and *Lolium* are best suited for integrated pest management of putting greens at four experimental sites representing the two major climate zones in the Nordic countries.
- To investigate the effect on visual quality and uniformity in space and time of using tradtional and untraditional seed mixtures and blends on putting greens.
- To create meeting places for discussions between plant breeders, seed companies and greenkeepers in order to encourage variety awareness, integrated pest management and continued efforts into turfgrass breeding for northern environments.

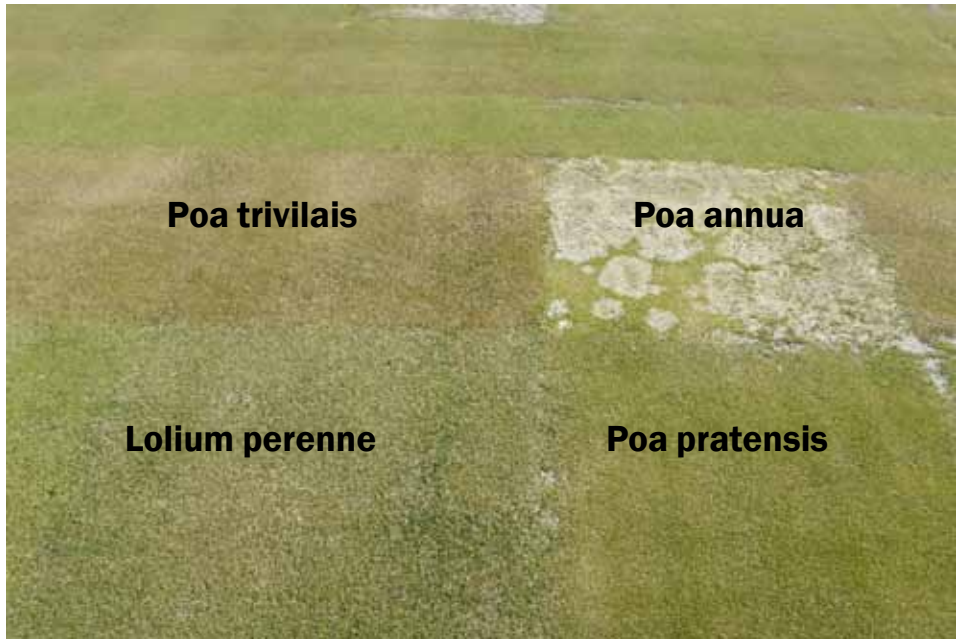
TALKS AT CONFERENCES MEETINGS, SEMINARS, FIELD DAYS, ETC IN 2016

14 Apr.: Visit by Barenbrug to SCANGREEN trial at Landvik (T.S. Aamlid)
12 May: Field day in trial at Korpa GC, Iceland (Bjarni Hannesson)
25 May: 50 Swedish seed growers visiting trial at Landvik (T.S. Aamlid)
21 June: Nordic Association of Agricultural Scientist: Herage Seed Seminar, Landvik (T.S. Aamlid)
26 Oct.: Visit by Sandmosen Greenkeeper Scholl to trial at Landvik (A. Kvalbein)
11 Nov.: Gress fra A til Å. Nytt fra forskingen. NGF's anleggsseminar, Fornebu, Norway.

PROJECT SUMMARY AND STATUS BY 1 JANUARY 2017

Breeding and evaluation of turfgrass varieties is a key factor to better turf quality. Since 2003, STERF has tested species and varieties under realistic green conditions, including wear from pedestrian-type wear machines equipped with golf spikes. Results are updated annually at www.scanturf.org and www.sterf.org.

SCANGREEN 2015-2018 is being carried out at NIBIO Apelsvoll, Norway (62°N) and Korpa GC, Reykjavik, Iceland (64°N) in the northern zone, and at NIBIO Landvik, Norway (58°N) and Sydsjælland GC, Denmark (56°N) in the southern zone. The trials include 25 candidate varieties and six controls representing seven different species. Unlike former variety testing on putting greens, the trials also include *Poa pratensis* (smooth meadowgrass) and a number of seed mixtures and blends.



Four species in the SCANGREEN trial at Landvik on 6 May 2015. The only variety with severe winter injury was Poa annua 'Two Put'. Photo: Trygve S. Aamlid.

SCANGREEN trial in Reykjavik, Iceland, on 1 September 2016. Photo: Gudni Thorvaldsson.

As of January 2016, the most promising of the new creeping bentgrass (*Agrostis stolonifera*) varieties is 'Luminary', followed by 'Flagstick' and 'Ignite'. With a top score for density but also lighter colour than the other varieties, 'Pure Distinction' is ranked slightly better than 'Independence'. In contrast, none of the new chewing's fescues (*Festuca rubra* ssp. *commutata*) and slender creeping red fescues (*F. rubra* ssp. *litoralis*) has so far outperformed the control varieties 'Musica' and 'Cezanne', respectively. The top-ranked varieties of colonial bentgrass (*A. capillaris*) are 'PPG AT 101' in the northern test zone and 'DLF PS-ATE3036' in the southern test zone, while there is little difference between the new entries of rough-stalked meadowgrass (*P. trivialis*). Within perennial ryegrass (*Lolium perenne*), 'Clementine' has so far produced denser turf with 13% less height growth than 'Chardin'.

The most surprising finding so far is perhaps the performance of smooth meadowgrass at 5 mm mowing height. The variety 'Limousine' has produced higher turf quality scores than any other variety across species in the Icelandic trial and has also performed very well at the other sites. At Apelvoll, the winter survival of smooth meadowgrass is on a level with creeping bentgrass and better than of the other species.

For greenkeepers wanting to mix creeping bentgrass seed with other species in order to speed up re-establishment after winter damage, our preliminary results suggest that rough-stalked meadowgrass is a better choice than perennial ryegrass. Percent coverage three weeks after seeding is 48% for pure 'Independence', compared with 76 and 81 % for 'Independence' plus rough-stalked meadowgrass and perennial ryegrass, respectively. However, the long-term negative impact on turf quality is much stronger with perennial ryegrass.

DANDELION MANAGEMENT AT VÄRPINGE GOLF COURSE

PROJECT PERIOD: APRIL 2014 - MARCH 2017

FUNDING (kSEK)

	2014	2016	2017	TOTAL
STERF	75	50	14	139
Other sources	21	6	0	27
TOTAL	96	56	14	166

PRINCIPAL INVESTIGATOR / CONTACT PERSON
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CO-APPLICANTS
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Roland Andersson, Toro, Sweden
Peter Edman, Swedish Golf Federation

PROJECT OBJECTIVES

- To obtain knowledge regarding dandelion occurrence and dandelion morphology/ appearance over the growing season and to determine whether it is affected by vertical cutting regime.
- To obtain some indications of how dandelions appear over the entire growing season under a frequent mowing/grazing regime.
- To evaluate the effect of superficial verticutting on playing quality.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2017

At Värpinge golf course, dandelions (*Taraxacum* sp.) affect the playing quality. Since 2010, special vertical cutting equipment has been tested (vertical cutting unit for a Toro 5610 – the unit has been modified; blades are mounted at a distance of 2.5 cm). The expectation is that this specially designed equipment can control dandelions and change the appearance of the weed. It performs superficial vertical cutting (leaf cutting) to approx. 1 cm above ground. This procedure might help to manage the dandelions and disrupt the leaves.

The theory is that mechanical treatment does not remove the dandelions, but after verticutting the plants are reduced due to stress on cutting the leaves. A change in size to smaller individuals might have a positive effect on playing quality for a period.

This theory was tested by analysing pictures taken at Värpinge golf course on the same spots over a five-year period in plots with 0, 1 or 2 verticutting events on each treatment day. Pictures were taken before the treatment and some days after the treatment. Data from 2010-2014 were available for analysis.

Pictures taken before verticutting were also used to obtain an impression of the dandelion occurrence threshold set by the course owner in relation to playing quality.

Picture analysis performed in 2015 demonstrated that it was a slow process to count dandelions in all 100 frames on each picture and not many data were available for the conclusions stated in the 2015 report. In 2016, the analysis process was changed in order to obtain more data within the budget. Therefore, only the first 50 frames on each picture were analysed in the 2010, 2011, 2013 and 2014 pictures.

With the 2016 data, there was still no clear effect of superficial verticutting (cutting leaves) on dandelion occurrence, overall and on each treatment occasion. There seemed to be a tendency for fewer weeds in general in 2014, compared with 2010 and 2011. However, the variation within each season, between seasons and between the two fairways was still pronounced, although the covering degree of dandelions was generally low, often below 5%.

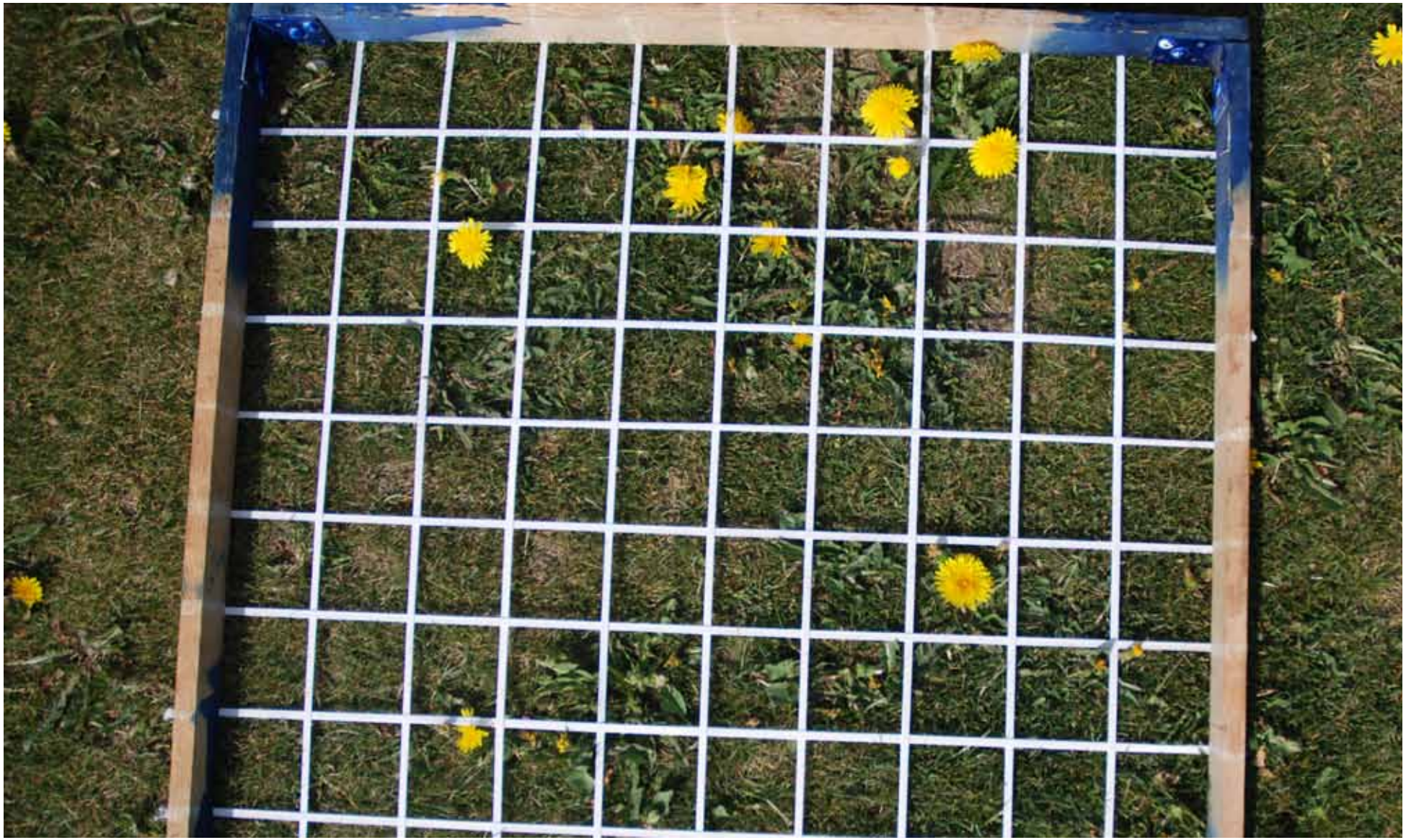

Photo: Anne Mette Dahl Jensen

ENGINEERING BETTER IRRIGATION IN TURF: QUANTIFYING IMPACTS OF APPLICATION UNIFORMITY ON TURF QUALITY IN GOLF

PROJECT PERIOD: OCTOBER 2014 - SEPTEMBER 2017

FUNDING (kSEK)

	2014	2015	2016	Total
STERF	437	237	75	749
Other sources	0	0	281	281
TOTAL	437	237	356	1 030

PRINCIPAL INVESTIGATOR / CONTACT PERSON

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CO-APPLICANTS

Trygve S. Aamlid, NIBIO, Norway

PROJECT OBJECTIVES

- To assess the environmental impacts of irrigation heterogeneity on turf quality, water use and nutrient uptake.
- To evaluate irrigation management practices using two case study golf courses in Norway (Oslo GC) and Denmark (Furesø GC).
- To review current irrigation practices, scheduling methods and equipment operation and management through fieldwork and industry survey.
- To calibrate a ballistic model to simulate irrigation application (uniformity, adequacy, efficiency) under contrasting climate and turf management scenarios.
- To interview greenkeepers, irrigation engineers and representatives from the Scandinavian golf industry in order to assess turf irrigation management practices and how these relate to system design.
- To develop best management practice guidelines for the Scandinavian golf industry.

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2016

June 7: 5th ETS Conference, Albufeira, Portugal. Technical presentation based on the systematic review "Assessing evidence on the agronomic and environmental impacts of turfgrass irrigation management" (Carlos Gómez Armayones)
Dec: Czech Republic Greenkeepers' Conference. University of Mendel, Brno. STERF project outputs (Jerry Knox).

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2017

This project aims to quantify the links between irrigation heterogeneity (non-uniformity) and turf management and hence provide industry guidelines to improve irrigation management and reduce environmental impacts associated with golf course irrigation. This three-year PhD project combines extensive fieldwork in the UK, Denmark and Norway to calibrate an existing ballistics model to simulate irrigation performance and a biophysical crop growth model (STICS).

Literature review A systematic review to assess evidence on the effects of irrigation management on turf quality, growth, root development and impacts on nutrient and pesticide leaching has been completed. The key findings were presented at the 5th ETS Conference (Portugal) and a manuscript has been prepared and submitted to Crop Science, a peer-reviewed journal.

Industry survey A golf irrigation industry survey in four Nordic countries, involving an online questionnaire sent to 885 golf courses, was completed. A response rate of 13% was achieved. A report summarising the key findings was produced and is available on the STERF website.

Golf course irrigation evaluations Irrigation system evaluations were conducted on two golf courses in Norway (Oslo GC) and in the UK (Ashford Manor GC). The fieldwork included conducting irrigation uniformity tests and interviewing course management staff on their irrigation management practices. In summer 2017, further evaluations will be undertaken at Furesø GC in Denmark.

Experimental sprinkler irrigation fieldwork Extensive single-sprinkler irrigation field work was conducted at Cranfield University under different sprinkler (operating pressure and nozzle size) and environmental (wind speed/direction, temperature and relative humidity) conditions. The results from the trials were used to estimate wind drift and evaporation losses during irrigation and to calibrate an irrigation ballistics model (Sirias). This model was then used to simulate the water distribution patterns and irrigation heterogeneity under windy conditions from overlapping golf sprinklers. The results indicated that proper selection of sprinkler nozzle, operating pressure and sprinkler spacings are crucial in achieving high irrigation uniformity and appropriate discharge rates to minimise surface runoff. The results also suggested that wind speeds of >2 to 3 m s^{-1} can negatively affect irrigation uniformity.

Assessing turfgrass impacts due to irrigation non-uniformity The next stage in the research involves integrating the outputs from the Sirias ballistics irrigation simulations with management data from the golf course evaluations in a biophysical crop model (STICS) to assess the environmental impacts of irrigation heterogeneity on turfgrass growth, development and water use.

OPTIMAL APPLICATION OF NITROGEN AND SULPHUR IN AUTUMN FOR BETTER WINTER SURVIVAL OF PERENNIAL GRASSES – WITH EMPHASIS ON TURF

PROJECT PERIOD: MARCH 2014 - DECEMBER 2017

FUNDING (kSEK)

	2014	2015	2016	2017	Total
STERF	510	510	510	510	2 400
Other sources	779	784	861	866	2 930
TOTAL	1 289	1 294	1 371	1 376	5 330

PRINCIPAL INVESTIGATOR / CONTACT PERSON
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CO-APPLICANTS
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Trygve S Aamlid, NIBIO Turfgrass Research Group
Tatsiana Espevig, NIBIO Turfgrass Research Group

PROJECT OBJECTIVES

- To measure the effect of autumn application of nitrogen and sulphur on winter survival and leakage of nitrogen from two major turfgrass species on Scandinavian golf greens.
- To define effects of autumn application of nitrate of sulphur on resistance of creeping bentgrass and annual meadowgrass to snow mould (*Microdochium nivale*) and on tolerance of the same species to freezing temperatures and suffocation.
- To determine the impact of nitrogen fertilisation on the content of specific carbohydrates in the grass crown and to identify the relationship between carbohydrate content and resistance to winter stresses.
- To disseminate, confirm and illustrate the most significant findings.

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2016
May 23: : PMAC Meeting, Seattle. Optimal Application of Nitrogen in the Autumn for Improved Winter Survival of Nordic Golf Greens. (Waalen, W.M.)
Nov 11: NGF anleggsseminar, Oslo (Kvalbein, A.)
Nov 22: SGF Modern banskötsel, Malmö (Kvalbein, A.)
Nov 23: SGF Modern banskötsel, Göteborg (Kvalbein, A.)
Nov 24: SGF Modern banskötsel, Stockholm (Kvalbein, A.)
Nov 25: SGF Modern banskötsel, Sundsvall (Kvalbein, A.)
Nov 30: FGA seminar Tapiola GC, Helsinki (Kvalbein, A.)

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2017
In 2014 and 2015, three USGA greens were established with creeping bent (*Agrostis stolonifera*) and annual meadowgrass (*Poa annua)*. One of the experiments was conducted on the lysimeter facility at NIBIO Landvik. The other green was at NIBO Apelsvoll. During the acclimation period, half the green was shaded to about 70% of full sunlight.

From the end of August until the end of November, the greens were fertilised weekly with liquid, complete, balanced fertilisers. Only the nitrogen and sulphate content varied between the treatments. The application rate declined weekly. The total nitrogen rate in the experimental periods was 0 / 2.8 / 5.6 /8.5 g N/m^2. The 5.6 g/m^2 rate was also combined

Michrodochium nivale on green grass under laboratory conditons. Photo: Agnar Kvalbein.

with either an excessive rate of sulphate (N:S = 1:1.6) or no sulphate.

Grass plants from the experimental greens were sampled in November/December and at the end of February and tested in the laboratory for freezing tolerance, resistance to pink snow mould and suffocation.

SOME PRELIMINARY RESULTS

Nitrogen leakage On average for two autumns, 40% of the high nitrogen rate and 20% of the middle nitrogen rate leached through drains. Drainage water was collected and analysed every two weeks. The highest nitrate concentration found was 14 mg/L. Leaching from zero-N plots was on average 0.5 g N/m^2 and higher in the relatively dry autumn of 2015 than in the wet 2014.

Shade effects The green in shade had significantly more disease and the average freezing tolerance (LT_{50} value) in December in both years was less than 50% of that in the plants exposed to full daylight. Shade strongly reduced the tiller density and survival in the field. There were no negative effects of shade on the tolerance to anoxia when *M. nivale* was controlled sufficiently in the autumn.

Excessive sulphate High rates of sulphate did not reduce damage by *M. nivale* in field or laboratory tests.

Nitrogen rates in the autumn High rates of nitrogen significantly increased the severity of *M. nivale* disease in annual meadowgrass and made creeping bent more vulnerable to pink snow mould. Freezing tests showed that annual meadowgrass was not significantly affected by autumn fertilisation. In creeping bent there was a strong negative correlation between nitrogen rate and LT_{50} value.

Colour and growth

Nitrogen application had a significant impact on height growth in the autumn. The zero-N plots did not have acceptable autumn colour and the growth was negligible. The highest nitrogen rate gave the best spring colour for creeping bent and the medium nitrogen rate gave the best colour for annual meadowgrass. Spring growth could not be predicted by the colour. Medium and high nitrogen rates both gave good spring growth in creeping bent. The low nitrogen rate gave best spring growth in annual meadowgrass.

ONGOING WORK

The optimal nitrogen rate for autumn fertilisation remains to be defined. Three nitrogen application rates were used in full-scale experiments at Keilir GC (ISL), Roskilde GC (DK), Tapiola GC (FIN), Kungliga Drottningholm GC (SE) and Hauger GC (NO) in autumn 20016, to obtain more data for the project.

SUCCESSFUL REESTABLISHMENT OF GOLF GREENS FOLLOWING WINTER DAMAGES

PROJECT PERIOD: JULY 2014 - JULY 2017

FUNDING (kSEK)

	2014	2015	2016	2017	Total
STERF	75	222	174	108	579
Other sources	40[1]	60	60	20	180
TOTAL	115	282	234	128	759

1) SEK 20, as in-kind contributions from machine companies and golf courses, was omitted from the budget in 2014 as the demonstration sites were not established until 2015.

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CO-APPLICANTS
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Agnar Kvalbein, Bioforsk Landvik, Norway
Carl-Johan Lönnberg, Swedish Golf Federation, Sweden
Boel Sandström, Swedish Golf Federation, Sweden

PROJECT OBJECTIVE
To provide new knowledge that can help greenkeepers achieve faster re-establishment of turf after winter kill. More specifically, to:

- Provide species-specific guidelines for re-seeding after winter kill caused by anoxia.
- Investigate how sowing techniques influence the rate of success.
- Provide golf clubs with information that is useful when deciding the optimal time for reseeding.
- Disseminate research-based recommendations to the golf industry.

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2016
22 Nov: SGF Modern banskötsel, Malmö (Lönnberg , C. J.)
23 Nov: SGF Modern banskötsel, Göteborg (Lönnberg , C. J.)
24 Nov: SGF Modern banskötsel, Stockholm (Lönnberg , C. J.)
25 Nov: SGF Modern banskötsel, Sundsvall (Lönnberg , C. J.)

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2017
This project examines some important factors that can influence the success rate for re-establishing golf greens following winter kill.

Work package 1 examines how phytotoxic metabolites, which can be produced during long-lasting ice cover, affect the establishment of different green grass species used on golf greens. A field experiment was run at the NIBIO research facility at Apelsvoll in southern Norway in 2015 and 2016. Soil water extracts taken following ice encasement did not negatively affect germination of the various grass species tested in either of the years, compared with soil water extracts taken from an area that had been killed with glyphosate or saline water. However, soil water taken from the area treated with glyphosate had a negative influence on root growth of all species in 2016. In both 2015 and 2016, there were significant effects of species and the two germination temperatures (day/night) 25/15 and 15/5 °C. Annual meadowgrass (*Poa annua*) germinated faster than the other species, particularly at the lower temperature. The slowest species to germinate was red fescue. In a second experiment, root growth of annual meadowgrass was also shown to be significantly faster than that of the other species. These results have implications for competition between seedlings on a

Jan Tangsveen removing core samples from the plot that was ice-encased during winter 2015/16. Photo: Wendy Waalen.

golf green. A third experiment investigated whether aeration following ice encasement or postponed seeding could improve plant establishment. Germination was not influenced by the ice encasement treatments in either of the years, but the percent coverage and dry weight of plants samples was lower in core samples taken from the control area that had been killed by glyphosate. The aeration treatments did not have any impact on seedling establishment. Delayed seeding in 2015 improved seedling germination, most likely due to warmer temperatures and improved nutrient availability. The results of delayed seeding in 2016 were not consistent with those obtained in 2015.

In spring 2016, one trial was established on an ice-damaged green at Sundsvalls GK in Northern Sweden using the same four sowing machines as in 2015. The results of the trial showed, as in 2015, that sowing techniques that bury the seed and create good seed-soil contact result in an more even and dense plant cover than the drop methods.

The demonstration trial eight days after seeding. Photo: Boel Sandström

SELECTION AND MANAGEMENT OF BENTGRASS CULTIVARS (*AGROSTIS* SP.) FOR GENETIC AND INDUCED RESISTANCE TO MICRODOCHIUM PATCH AND PINK SNOW MOULD CAUSED BY *MICRODOCHIUM NIVALE*

PROJECT PERIOD: JUNE 2014 - DECEMBER 2017

FUNDING (kSEK)

	2014	2015	2016	2017	TOTAL
STERF	323	492	441	408[1]	1 663
Other sources	110	183	183	110	586
TOTAL	433	675	623	518	2 249

[1]Total funding from Canadian sources: CDN$ 148,000/yr for three years from 1 Jan 2015 to 31 Dec 2017.

PRINCIPAL INVESTIGATOR / CONTACT PERSON

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Boel Sandström, Swedish Golf Federation
Klaus Paaske, Århus University, Denmark
Oiva Niemeläinen and **Pentti Ruttunnen**, Finland
Tom Hsiang, University of Guelph
Annick Bertrand, Agriculture and Agri-Food Canada

PROJECT OBJECTIVES

Overall objective: To reduce the dependence on fungicides for control of diseases caused by *Microdochium nivale* on golf courses in Scandinavia and Canada.
Subgoals (each corresponding to a subproject (SP):

1. To screen *in vitro* top selling cultivars of *Agrostis* sp. for resistance to *M.nivale*, with and without cold hardening and with and without the application of Civitas One mineral oil, and to identify genotypes that are either resistant or show increased responsiveness to the defence activator.
2. To validate level of resistance and responsiveness to Civitas One of the most promising cultivars (from subgoal 1) in field trials in contrasting climates in Canada and at NIBIO Landvik and Apelsvoll, Norway.
3. To determine the effect of Civitas One on microdochium patch occurring during the growing season or under snow cover in registration trials on golf courses in the Nordic countries.

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2016

Nov 11: 'Gress fra A til Å'. Presentation at Norwegian Golf Federation Seminar, Fornebu, Norway. (T. Aamlid).

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2017

Microdochium patch is the most serious disease on golf courses in the Nordic countries. In the absence of fungicides, the most efficient approach to control this disease is to use resistant plant material. Genetic resistance to *M. nivale* can be present irrespective of environmental conditions, or it may require induction by defence activators. Canadian results suggest that Civitas One, a mixture of food-grade isoparaffins and emulsifiers, induces resistance to *M. nivale*.

The trial at Landvik, where the colour of Civitas-treated plots was still very apparent at snow melt in March 2016. Photo: Trygve S. Aamlid.

Civitas-trial with various bentgrass cultivars at Apelsvoll, 19 April 2016. Photo: Trygve S. Aamlid

In Subproject 1 (SP1), the third replicate over time of a screening experiment with 36 varieties of creeping bentgrass (*Agrostis stolonifera)*, colonial bentgrass (*A. capillaris*) and velvet bentgrass (*A. canina*) was completed in 2016. Seedlings were grown in glass vials, inoculated with *M. nivale* and damage to the plants (%) and development of mycelium (%) were assessed. The final statistical analyses remain to be completed, but mean values suggest a stronger reduction in *M. nivale* due to Civitas One in velvet bent than in the two other bentgrass species. The interaction Civitas One x Variety was not significant in any species.

SP2 was sown in 2015 as an extension of the SCANGREEN trials at Landvik and Apelsvoll, Norway. Selected bentgrass varieties are compared on three main plots, one receiving Civitas One (54 L/ha every 3 wks from late Aug.), one treated with prothioconazole + trifloxystrobin in mid-October plus fludioxonil in early November, and one unsprayed control. At Landvik, winter 2015-16 had on/off snow cover, with the longest period being 3 wks. Here, Civitas One was equally effective as the fungicides in controlling *M. nivale*. In contrast, control by Civitas One was inferior to that of fungicides after more than 100 days of snow cover at Apelsvoll.

SP3 is funded by Petro Canada and includes registration trials. In 2015-16, trials were conducted at Sydsjælland GC, Denmark, and Lepaa GC, Finland. The Danish trial had no snow cover and showed 100% control of M. nivale after four applications of Civitas One at 54 L/ha from late August to late November. At 27 L/ha, the efficacy of Civitas One was slightly less and similar to that of two applications of prothioconazole at 0.2 kg a.i/ha. In the Finnish trial, Civitas One provided good control of *M. nivale* up to snow melt in March, but the natural green-up in spring was impeded after four applications of Civitas One at 54 L/ha from September to early December. In order to avoid this effect, lower rates and earlier termination of the Civitas regime in autumn are now being investigated in a new trial at Hillside GC, Finland.

FAIRY RINGS AND THATCH COLLAPSE

PROJECT PERIOD: NOVEMBER 2016 - NOVEMBER 2017

FUNDING (kSEK)

	2016	2017	Total
STERF	0	0	0
Other sources	72	8	80
TOTAL	72	8	80

PRINCIPAL INVESTIGATOR / CONTACT PERSON
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CO-APPLICANTS
Agnar Kvalbein, NIBIO, Norway

PROJECT OBJECTIVES

- To define fungal agents causing fairy rings and sunken spots on two Norwegian golf courses
- To test the effect of fertilisation, hand-spiking and application of wetting agents on these problems
- To write a short article providing insights into these issues based on practical tests and reports from other countries (in practice the United States)

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2017

Fairy rings have long been seen as a cosmetic problem on golf courses, but in the past two years we have received several questions relating to fairy ring spots that are reducing playing quality and leading to kill-off of the grass on golf greens.

We have also observed another type of patch on golf greens, namely soft, green sunken spots where the thatch is white and decomposed. These sunken spots later turn into dry spots.

The fungi causing fairy rings and the white-root fungi causing sunken spots both belong to the same fungal division, *Basidiomycota*. These fungi are not plant pathogens, since they do not infect the plant, and this group of fungi is not affected by the fungicides that are permitted in Norway. Thus, control measures must be linked to changes in management. The resurgence in these problems has been attributed to increased use of microbiological products whereby fungi were introduced on golf greens to create greater microbial diversity, but we have no evidence for this. We also do not know exactly which organisms are involved.

Therefore, in summer 2017 we intend to chart these problems on two Norwegian golf courses and test measures such as fertilisation, hand-spiking and application of wetting agents. We will then write a short article that can provide insights into these issues based on practical tests and reports from other countries (in practice the United States).

Type 1 fairy rings on green 4 at Bjaavann Golf Club in summer 2016. Photo: Agnar Kvalbein.

Superficial fairy rings on green 7 at Old Fredrikstad Golf Club in summer 2016. Photo: Agnar Kvalbein.

RISKS OF SURFACE RUNOFF AND LEACHING OF FUNGICIDES FROM GOLF GREENS VARYING IN ROOTZONE COMPOSITION AND AMOUNT OF THATCH

PROJECT PERIOD: MAY 2016 - DECEMBER 2018

FUNDING (kSEK)

	2016	2017	2018	TOTAL
STERF	303	294	161	758
Other sources	518	422	260	1200
TOTAL	821	716	421	1958

PRINCIPAL INVESTIGATOR / CONTACT PERSON

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PROJECT OBJECTIVES

Main objective The objective of this project is to minimise fungicide losses from golf courses
Subgoals:

- To determine sorption coefficient, degradation half-life and thus the risk of leaching of: fludioxonil, prothioconazole and boscalid. (Besides azoxystrobin and propiconazole, which have already been investigated, fludioxonil and prothioconazole are currently the most widely used fungicides on Nordic golf courses, while boscalid in used on golf courses in Germany).
- To determine the risk of leaching and surface runoff of these fungicides. (This is especially important in relation to freezing and melting episodes on sloping greens located close to open water).
- To quantify the influence of type of organic matter in the rootzone. (The hypothesis is that fungicide degradation occurs faster and pesticide losses are lower with compost than with peat in the rootzone).
- To determine the effect of turf age/thatch accumulation on fungicide leaching and runoff.
- To provide data for modelling leaching and runoff of fungicides from golf greens.
- To publish the results in *'Journal of Environmental Technology'* or a similar peer-reviewed journal and to disseminate the findings to the environmental authorities and the golf industry in the Nordic countries and Germany.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2017

EU Directive 2009/128/EC on Sustainable Pesticide Use is under implementation in most European countries. In the five Nordic countries, STERF has taken special responsibility for the turfgrass sector, particularly golf. Depending on country, 2-6 active fungicide ingredients are currently approved on golf courses. There is increasing demand for documentation of the environmental risks of these products, particularly on sand-based golf greens. Unlike earlier STERF projects on fungicide fate, this project also focuses on surface runoff and the risks posed by fungicide metabolites, which are sometimes more harmful than the fungicides themselves. The products are also being studied in Germany, which is why the German Greenkeepers' Association is supporting this project. The project is running from 1 May 2016 to 1 December 2018 in the USGA-green lysimeter facility at NIBIO Landvik, SE Norway. Part of the facility has been rebuilt to collect not only leachate, but also surface

water. The plots have a slope of 5% and a turf cover of creeping bentgrass (*Agrostis stolonifera*). The experiment has four blocks (replicates) and two factors, each with two levels (four treatment combinations), i.e. 16 plots in total:

Factor 1: Organic amendment to the sand-based (USGA) rootzone:	**Factor 2: Turf age / thatch thickness**
1.Sphagnum peat, loss on ignition 1.1 %	A. Green sown in May 2016
2.Garden compost, loss on ignition 1.0 %	B. Green established in May 2016 using two-year old sand-based sod, thatch layer 20 mm

A tank mixture of the systemic fungicides Delaro (prothioconazole + trifloxystrobin) and Signum (boscalid + pyraclostrobin) was sprayed on all plots on 25 October 2016. Three weeks later, after mowing had ceased for the season, the contact fungicide Medallion (fludioxonil) was sprayed on all plots. The effects are now being monitored by repeated collection of leachate and runoff from each individual plot until April 2017. Water samples are frozen and analysed for concentration of fungicides and their metabolites. The treatments and sampling will be repeated in 2017-18, and the sorption coefficients K_{oc} and K_d of the various fungicides at different depths on greens representing the four treatment combinations will also be determined. Results will be presented to the environmental authorities and turfgrass sector in a scientific paper and as popular articles. A one-day international seminar on pesticide leaching from golf courses has been scheduled for the end of the project, in November 2018.

Sodding and sowing completed, May 2016. Photo: Trygve S. Aamlid

DEVELOPMENT OF IPM GUIDELINES FOR GOLF COURSES AND OTHER GREEN AMENITY AREAS, AND REVISION/EXTENSION OF STERF'S DIGITAL LIBRARY ON IPM

PROJECT PERIOD: OCTOBER 2015 - DECEMBER 2016

FUNDING (kSEK)

	2015	2016	Total
STERF	96	50	146
Other sources	293		293
TOTAL	389	50	439

PRINCIPAL INVESTIGATOR / CONTACT PERSON

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CO-APPLICANTS

Anne Mette Dahl Jensen, University of Copenhagen-IGN, Denmark
Agnar Kvalbein, NIBIO Turfgrass Research Group, Norway
Karin Juul Hesselsøe, AMU Nordjylland Greenkeeper School, Denmark

PROJECT OBJECTIVES

Main objective: Coordinated and efficient implementation of EU Directive 2009/128 on Sustainable Pesticide use on golf courses and other green amenity areas in the Nordic countries.

Subgoals:

- Development of crop-specific guidelines for Integrated Pest Management (IPM) on golf courses and other green amenity areas.
- Revision/update of STERF's 18 existing fact-sheets on IPM.
- Development of 10 new IPM fact-sheets prioritised by the national authorities in Denmark and Norway.
- Compilation of five control questions per fact-sheet for use in self-studies and teaching situations.

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2016

7 June: 5th ETS conference, Portugal, A Nordic model for implementing integrated pest management (IPM) (A. Kvalbein)
22 Nov.: SGF Modern banskötsel, Malmö, Sweden. (Peter Edman)
23 Nov.: SGF Modern banskötsel, Gothenburg, Sweden. (Peter Edman)
24 Nov.: SGF Modern banskötsel, Stockholm, Sweden. (Peter Edman)
25 Nov.: SGF Modern banskötsel, Sundsvall, Sweden. (Peter Edman)
30 Nov.: FGA seminar Tapiola GC, Helsinki. Plant nutrients and stress resistance: The fact-sheets were launched and recommended by Agnar Kvalbein
11 Nov.: Golfforum, Norwegian Golf Federation. Seminar: Gress fra A til Å (T. Aamlid)
Autumn 2016: University of Copenhagen, Denmark. Education of Forest and Landscape Engineers, (A.M. Dahl Jensen)
31 Jan-1 Feb. 2017, Severin Kursuscenter, Middelfart, Denmark 'IPM- greenkeeper'. Two-day AMU course for greenkeepers (K. Juul Hesselsøe)

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2017

The programme on Integrated Pest Management (IPM) was initiated in 2010 in direct response to EU Directive 2009/128 on Sustainable Pesticide Use. Thanks to funding from the Swedish Board of Agriculture (Jordbruksverket), 18 fact-sheets on IPM of golf courses and other green amenity areas were published on STERF's website in 2011.

Since 2011, all Nordic countries (including those that are not EU members) have implemented 2009/128 EU, and the national authorities are working continuously on concrete measures to achieve the goal of less pesticide use. In a contact meeting between STERF and the national authorities on 27 May 2015, it was suggested that the digital library from 2011 should be revised to include the last four years of research and qualified experiences, and also that the library should be extended with more fact-sheets covering new aspects of IPM.

The project included revision of STERF's 18 existing fact-sheets and publication of 10 new fact-sheets. At the request of the Norwegian Ministry of Food and Agriculture, cultural-specific guidelines for IPM on golf courses were developed linked to the STERF fact-sheets. Most of the project funding was granted by the national authorities responsible for implementation of IPM in Denmark and Norway.

All fact-sheets include contact information on 'IPM ambassadors' – turfgrass managers with specialist practical experience within the topic covered by the fact-sheet. The fact-sheets were completed in May 2016 and are now available in three Scandinavian languages on the STERF website. The official Norwegian IPM guidelines for golf courses have been published, at www.nibio.no/ipv

The Ministry of Education in Denmark funded development of control questions and assignments for IPM education and private studies based on the fact-sheets.

DEVELOPMENT OF A DIGITAL LIBRARY FOR WINTER STRESS MANAGEMENT OF TURF

PROJECT PERIOD: AUGUST 2015 - DECEMBER 2016

FUNDING (kSEK)

	2015	2016	Total
STERF	80	149	229
Other sources	0	0	0
TOTAL	80	149	229

PRINCIPAL INVESTIGATOR / CONTACT PERSON

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CO-APPLICANTS

Wendy Waalen, NIBIO Turfgrass Research Group
Trygve S Aamlid, NIBIO Turfgrass Research Group

PROJECT OBJECTIVES

To create a internet-based library on topics related to winter stress management of turfgrass with emphasis on golf greens

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2016

Nov 11: NGF anleggsseminar, Oslo (A. Kvalbein)
Nov 22: SGF Modern banskötsel, Malmö (A. Kvalbein)
Nov 23: SGF Modern banskötsel, Göteborg (A. Kvalbein)
Nov 24: SGF Modern banskötsel, Stockholm (A. Kvalbein)
Nov 25: SGF Modern banskötsel, Sundsvall (A. Kvalbein)
Nov 30: FGA seminar Tapiola GC, Helsinki (A. Kvalbein)

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2017

Winter injuries are common in the Nordics, and golf course superintendents have gained a lot of experience on how to prepare and treat their greens to keep them alive through extreme winter conditions.

STERF has funded several research projects highly relevant to turfgrass winter stress management. This project sought to integrate practical experiences, research results and general science into synthesised texts accessible to professional turf managers.

Members of NIBIO's turfgrass research group wrote the texts and provided illustrations. Turfgrass agronomists and golf course managers evaluated some of the texts during the process. Barb Manifold read the fact-sheet manuscripts on behalf of the Canadian Turfgrass Research Foundation.

An old aerator used for ice cracking on a golf course in Trondheim, Norway where ice causes big challenges almost every winter. Photo: Ole Albert Kjøsnes.

EVALUATION OF AQUATROLS EXPERIMENTAL BIOSTIMULANT FORMULATIONS ON FINE TURFGRASS SUBJECTED TO WEAR, DROUGHT (NUTRIENT) AND WINTER STRESS

PROJECT PERIOD: JUNE 2015 - MAY 2016

FUNDING (kSEK)

	2015	2016	Total
STERF	0	0	0
Other sources	130	108	238
TOTAL	130	108	238

PRINCIPAL INVESTIGATOR / CONTACT PERSON

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CO-APPLICANTS

Trygve S. Aamlid, NIBIO Bioforsk Turfgrass Research Group

PROJECT OBJECTIVES

To determine the effects of Aquatrols treatments on golf green turf under nutrient stress.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2017

Five experimental biostimulant formulations were applied biweekly to a USGA green that was sown with a blend of creeping bentgrass (*Agrostis stolonifera*) varieties. The treatments lasted from 3 June to 6 October and the experimental design was a complete randomised block with four replicates.

The green was fertilised biweekly with a complete balanced fertiliser. The seasonal nitrogen rate was 10 g/m^2, which is about 60% of the normal rate for Scandinavian creeping bentgrass greens.

Observations throughout the season included visual assessments of turfgrass (overall impression, colour and density). Chlorophyll index, soil moisture content and root development were also measured. Winter injuries and turf performance were recorded from 20 February to 20 April 2016.

Aquatrols evaluated experimental products at this creeping bent green at NIBIO Landvik. Photo: Agnar Kvalbein.

EVALUATION OF THE SOIL SURFACTANT QUALIBRA ON TURF QUALITY AND THATCH ACCUMULATION ON A CREEPING BENTGRASS GREEN UNDER TRAFFIC AND DIFFERENT WATER AVAILABILITY

PROJECT PERIOD: APRIL 2014 - JULY 2016

PRINCIPAL INVESTIGATOR / CONTACT PERSON
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CO-APPLICANTS
Agnar Kvalbein, NIBIO Turfgrass Research Group, Norway
Trond Pettersen, NIBIO Turfgrass Research Group, Norway

PROJECT OBJECTIVES
To determine the effect of the soil surfactant Qualibra on soil water content, turf quality and thatch accumulation on a creeping bentgrass (*Agrostis stolonifera*) green under varying water availability.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2017
Soil surfactants applied to turfgrass can be polymers that retain water in the rootzone, penetrants that improve water percolation or dual-purpose products combining both functions. The ability of surfactants to prevent dry spots is well documented, but less information exists about surfactants in situations with excessive rainfall or irrigation. Thus, the objective of this project was to study turfgrass responses to monthly applications of Syngenta's dual-purpose surfactant Qualibra under restricted or excessive water supply on a USGA-spec. putting green at NIBIO Landvik, Norway. Restricted water supply involved irrigation to field capacity (FC) once a week (FC1) in 2014, a warm, dry summer, and deficit irrigation to 60% of FC (DEF1) in 2015, a cool, wet summer. Excess irrigation was carried out twice a week (EX2) with 50% more water than needed to replenish FC in both years.

On average for irrigation treatments, Qualibra decreased the volumetric soil water content (SWC) of the 7.5 cm topsoil from 19.3 to 16.6 % ($P<0.01$) in 2014 and from 19.1 to 17.1 % ($P<0.05$) in 2015. This shows that Qualibra primarily acted as a penetrant under these irrigation treatments. In 2015 there was a tendency ($P<0.10$) for an interaction, as the reduction in SWC was stronger with EX2 than with DEF1 irrigation, and this was accompanied by reductions ($P<0.05$) in thatch thickness and loss on ignition on plots receiving EX2 irrigation. The surfactant significantly reduced soil water repellency, as shown by the water droplet penetration test, regardless of irrigation treatment, and improved turf quality significantly on plots with DEF1 irrigation.

In conclusion, the dual-purpose surfactant Qualibra has varying benefits depending on the amount of natural rainfall/irrigation.

Plots with deficit irrigation photographed on 24 July 2015. Left: Untreated control; Right: treated with Qualibra. Photos: Trygve S. Aamlid.

SUSTAINABLE FAIRWAY MANAGEMENT

PROJECT PERIOD: MAY 2014 - JANUARY 2017

PRINCIPAL INVESTIGATOR / CONTACT PERSON

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CO-APPLICANTS

Agnar Kvalbein, NIBIO, Norway
Trond Pettersen, NIBIO, Norway

PROJECT OBJECTIVES

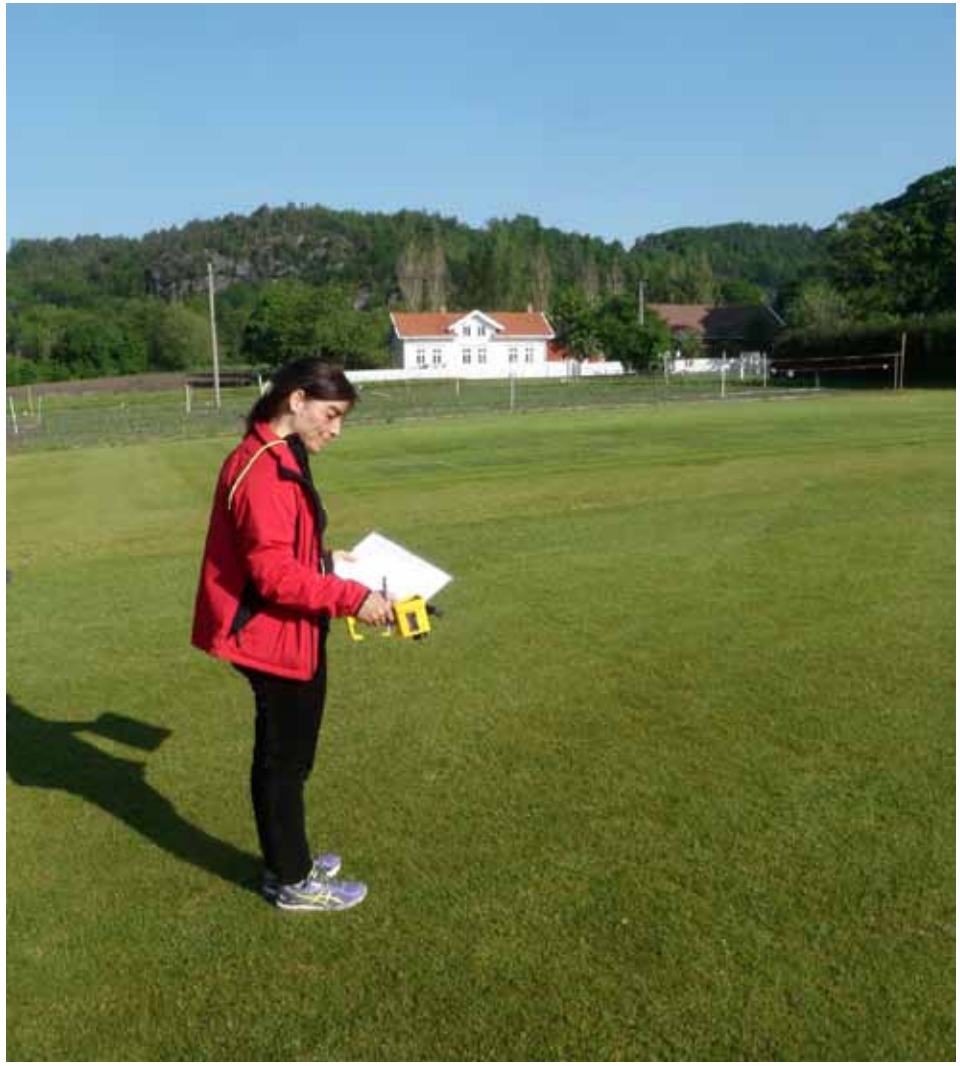
To quantify the effect of the soil surfactant Qualibra and/or the plant growth regulator Primo Maxx II on irrigation requirements, mowing requirements and nutrient uptake on a soil-based fairway.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2017

Development of more sustainable fairway management requires a reduction in the energy and workload spent on mowing and irrigation, while at the same time maintaining optimal turfgrass quality and playability. Syngenta's soil surfactant Qualibra and the plant growth regulator Primo Maxx II can help drive fairway management in a more sustainable direction. A 2x2x2 factorial trial with four blocks comprising two irrigation levels (unirrigated and irrigated to field capacity once a week); with and without Qualibra (20 L in an application volume of 800 L/ha every four weeks); and with and without Primo Maxx II (1.0 L in an application volume of 400 L/ha every three weeks) was established on a recently sown fairway on a sandy soil (field capacity 25 vol% water, botanical composition 52% red fescue, 42% smooth meadowgrass (*Poa pratensis*) and 6% annual meadowgrass (*P. annua*)) at Landvik, Norway. The fairway is mown to 15 mm twice a week, exposed to wear/compaction from a wear machine with golf spikes, and receives controlled-release fertiliser every six weeks for a total nitrogen input of 9.6 g/m^2.

Preliminary observations from 2016 indicate significantly darker turf (measured with a SPAD chlorophyll meter), a 24% reduction in clippings yield and a 23% reduction in nitrogen removal in clippings due to Primo Maxx II. Turfgrass height growth in 2016 was bimodal, with the main reduction due to the plant growth regulator occurring in May/early June and late August/September. Qualibra increased the average concentration of nitrogen in turfgrass clippings from 3.35 to 3.45 %, but otherwise had only small effects due to higher than normal rainfall during most of the growing season.

The project is being carried under the industrial partnership agreement between STERF and Syngenta.



Sara Calcvache Gil measuring leaf chlorophyll content in the fairway trial, 26 May 2016. Photos: Trygve S. Aamlid

Sustainable fairway trial on 10 June 2016. Irrigated and unirrigated plots are easlily distinguishable.

EFFECT OF IRRIGATION, FERTILISER TYPE AND SOIL AMENDMENT ON TURF QUALITY AND ORGANIC MATTER ACCUMULATION/THATCH CONTROL ON CREEPING BENTGRASS GREENS

PROJECT PERIOD: MAY 2016 - DECEMBER 2017

FUNDING (kSEK)

	2016	2017	Total
STERF	0	0	0
Other sources	257	333	590
TOTAL	257	333	590

PRINCIPAL INVESTIGATOR / CONTACT PERSON

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CO-APPLICANTS

Trond O. Pettersen, NIBIO, Norway

PROJECT OBJECTIVE

To evaluate the effect of Melspring's soil conditioners Matrix and Stor-it, and of Melspring's controlled-release fertiliser Marathon, on turfgrass grow-in, visual quality, playing quality, soil water content, turfgrass nitrogen uptake, root development and thatch accumulation on a creeping bentgrass putting green under deficit and excess irrigation.

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2016

Nov 14: Sustainable and Intelligent Turfgrass Management with emphasis on rootzone compositions and nutritional aspects. Breizh Algae Tour 2016, Amsterdam, (T.S Aamlid and T. Espevig.)

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2017

The use of peat in turfgrass rootzones is not sustainable, as excavation of peat from bogs is a major source of CO_2 emissions. This project is evaluating the alternative sand/soil improvers Matrix and Stor-it, both containing natural zeolite and various additives, in comparison with an unamended control. Preparations started in May 2016 on a sand-based green with an initial organic matter content of 0.8%, under a mobile rain-out shelter, at NIBIO Landvik, Norway. Matrix or Stor-it were mixed at 10 % (v/v) ratio into the top 5 cm of the USGA-spec. rootzone. Creeping bentgrass (*Agrostis stolonifera*) was sown on 9 June and the green subjected to normal grow-in procedures. Both Matrix and Stor-it resulted in faster grow-in than the unamended control, the coverage after 4 weeks being 89, 86 and 67 %, respectively.

Once grow-in was completed, two more experimental factors were added in a factorial combination with the soil treatments: (1) From 5 August to 2 September, the rainout shelter was activated and main plots were subjected to either deficit irrigation to 80% of field capacity (FC) once a week or excess irrigation twice a week with 50% more water than needed to replenish FC; and (2) Marathon controlled-release fertiliser was applied at 4-wk intervals in comparison with Wallco liquid mineral fertiliser at 2-wk intervals, both providing 10 g N/m^2 from 5 August to 1 November. Major results during this period were:

- As measured with a TDR instrument, Matrix increased the green's soil water content (SWC) at both 0-200 and 0-38 mm soil depth, regardless of irrigation treatment. Stor-it had no significant effect on SWC.
- The conditioners had no effect on turfgrass density, but colour was significantly improved in the order Control<Stor-it<Matrix.
- Matrix reduced the average root depth significantly, from 162 to 144 mm, with Stor-it giving intermediate values.

Preparing the experimental green using various substrates on subplots, 2 June 2016. Photo: Trygve S. Aamlid

- Stor-it gave firmer playing surfaces on plots receiving excess irrigation, but Matrix produced the firmest surfaces on plots receiving deficit irrigation.
- Clippings yield was not significantly affected by the conditioners, but the average nitrogen content in dry matter increased from 2.8 % on unamended plots to 3.1 and 3.3 % on plots amended with Stor-it and Matrix, respectively.
- Marathon produced lower turfgrass quality than Wallco during the first six weeks after the first application on 5 August, but this was reversed after 15 September.
- This research was commissioned by Melpring BV through its industrial partner agreement with STERF. The evaluation continues in 2017.

Grow-in was faster on plots where the top 5 cm of the USGA rootzone had been amended with 10% (v/v) Stor-it (left) or Matrix (centre) than on unamended control plots (right). Photo taken on 5 July by Trygve S. Aamlid.

EFFECT OF FERTILISER TYPE, SILICON AND COPPER ON TURF QUALITY AND MICRODOCHIUM INFECTION ON *POA ANNUA* PUTTING GREEN

PROJECT PERIOD: MAY 2016 - JUNE 2018

FUNDING (kSEK)

	2016	2017	2018	Total
STERF	0	0	0	0
Other sources	95	95	47.5	237.5
TOTAL	95	95	47.5	237.5

PRINCIPAL INVESTIGATOR / CONTACT PERSON

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CO-APPLICANTS

Trygve S. Aamlid, NIBIO, Norway
Trond O. Pettersen, NIBIO, Norway

PROJECT OBJECTIVES

To determine the effect of the patented long-lasting organic mineral fertiliser Marathon and the micronutrient mixtures Melgreen Si and Melgreen Cu on microdochium patch and turf quality on an annual meadowgrass golf green.

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2016

Nov 14: Sustainable and Intelligent Turfgrass Management with emphasis on rootzone compositions and nutritional aspects. Breizh Algae Tour 2016, Amsterdam, (T.S. Aamlid and T. Espevig.)

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2017

The experiment was conducted on USGA-spec. annual meadowgrass (*Poa annua*) golf green at Landvik research station (NIBIO) in 2016-17 and will continue in 2017-18. The experiment was designed as a two-factorial randomised complete block with four replicates. Factor 1 is two fertiliser regimes: conventional Wallco liquid mineral fertiliser vs. long-lasting Marathon.

The two programmes started on 15 August 2016 and lasted through October; Wallco and Marathon were applied at 2-wk and 4-wk intervals, respectively. Factor 2 consists of four treatments: (i) negative control (no treatment), (ii) positive control (fungicide treatment), (iii) micronutrient mixtures (Melgreen Si and or Melgreen Cu) and (iv) combination of (ii) and (iii). The fungicide was applied each time microdochium patch exceeded 2%, on a total three occasions as of 10 January 2017 (4 Oct. 2016, 21 Nov. 2016 and 4 Jan. 2017). Microdochium patch has been registered weekly since the disease appeared in late August 2016, and visual turf quality, density and colour have been evaluated monthly from the middle of August. We are continuing registrations in the field through the winter when there is no snow or frost on the soil. Until now, we have had only a brief snow cover (6-13 Nov. 2016). On 3 October, clippings were collected for determination of clippings yield and the samples were sent to NovaCropControl for chemical analysis.

Preliminary results show that there was better colour on Marathon plots than on Wallco plots. Regarding effects of fertiliser and silicon and copper products on microdochium patch, it appears that there was less disease after the period with snow cover in Marathon plots than in Wallco control plots. The effects of the silicon (Melgreen Si) and copper (Melgreen Cu) products are not clear yet and they will be reported later when all data are collected and analysed.

There was better colour and visual quality in Marathon plots than in Wallco plots on 22 August 2016, 1 week after the first experimental fertiliser treatment (left) and on 15 November 2016, 4 weeks after Marathon and 2 weeks after Wallco treatment (right). Photos: Tatsiana Espevig. Photos: Tatsiana Espevig

TESTING THE EFFECT OF ALGAEGREEN ON WINTER STRESS TOLERANCE

PROJECT PERIOD: JUNE 2016 - MAY 2017

FUNDING (kSEK)

	2016	2017	Total
STERF	0	0	0
Other sources	100	100	200
TOTAL	100	100	200

PRINCIPAL INVESTIGATOR / CONTACT PERSON

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CO-APPLICANTS

Trygve S. Aamlid, NIBIO Bioforsk Turfgrass Research Group

PROJECT OBJECTIVES

To evaluate the effect of a seaweed product on winter stress tolerance of turf grass species.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2017

Seaweed or algae products have become a tool for turfgrass management, acting as biostimulants. In this experiment, four different grass species (creeping bent (*Agrostis stolonifera*), red fescue (*Festuca rubra*), perennial ryegrass (*Lolium perenne*) and annual meadowgrass (*Poa annua*)) were established on a USGA green. AlgaeGreen was applied according to the label from 1 September until end of November. Plant samples were tested for freezing tolerance to determine the LT_{50} values.

There were no significant differences in the field regarding disease or visual performance. Grass treated with AlgaeGreen had significantly lower LT_{50} than untreated grass plants, on average for all species, -21.5 versus -20.4 °C.

The commissioning partner will receive a confidential report after spring evaluation of the field experiment.

One week after the freezing test, Knud Høeg Rasmussen finds it difficult to decide whether test plants are alive or not. Photo: Agnar Kvalbein

IDENTIFICATION AND RISK ASSESSMENT OF DOLLAR SPOT ON SCANDINAVIAN GOLF COURSES

PROJECT PERIOD: APRIL 2014 - DECEMBER 2017

FUNDING (kSEK)

	2014	2015	2016	Total
STERF	165	186	0	351
Other sources	305	136	0	441
TOTAL	470	322	0	792

PRINCIPAL INVESTIGATOR / CONTACT PERSON

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CO-APPLICANTS

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May Bente Bruberg, NIBIO Plant Health and Plant Protection (Norway)
Åslög Dahl and **Mariana Usoltseva**, Botanisk Analysgrupp / Gothenburg University (Sweden)
Karin Normann, Asbjørn Nyholt ApS (Denmark)
Jo Anne Crouch, Systematic Mycology & Microbiology Lab, US Dept. of Agriculture (USA)
Sandra Wright and **Anita Ejderdun**, Dept. of Electronics, Mathematics and Natural Sciences University of Gävle (Sweden)

PROJECT OBJECTIVES

- To identify and monitor dollar spot on 2-3 golf courses in Norway, Denmark and Sweden and provide scientific documentation in the form of a BSc dissertation on dollar spot distribution on Scandinavian golf courses with respect to geography, climate conditions, type of turf, turfgrass species, maintenance practices etc.
- To compare Scandinavian and American Sclerotinia homoeocarpa isolates.
- Based on results from this project, the Integrated Pest Management principles, the BSc project and literature studies, develop a STERF fact-sheet on dollar spot risk assessment.

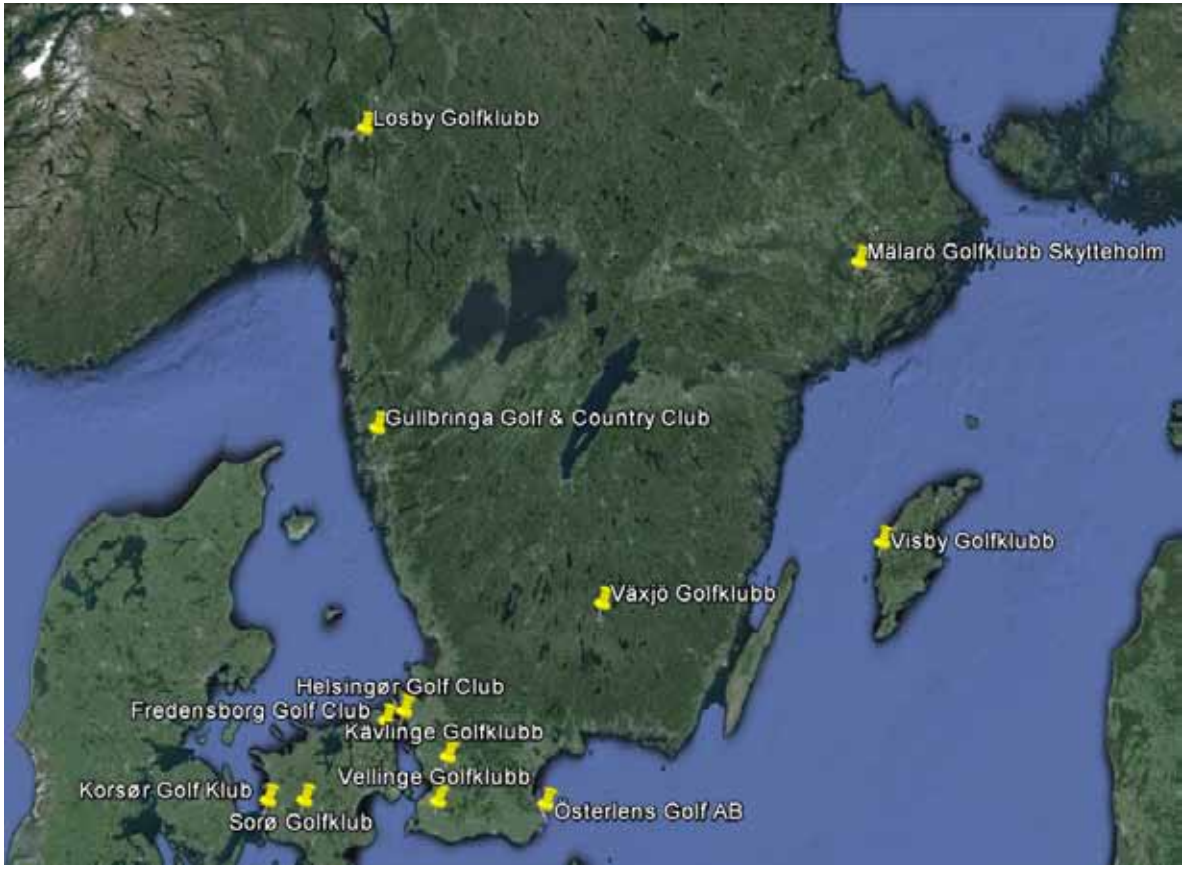
TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2016

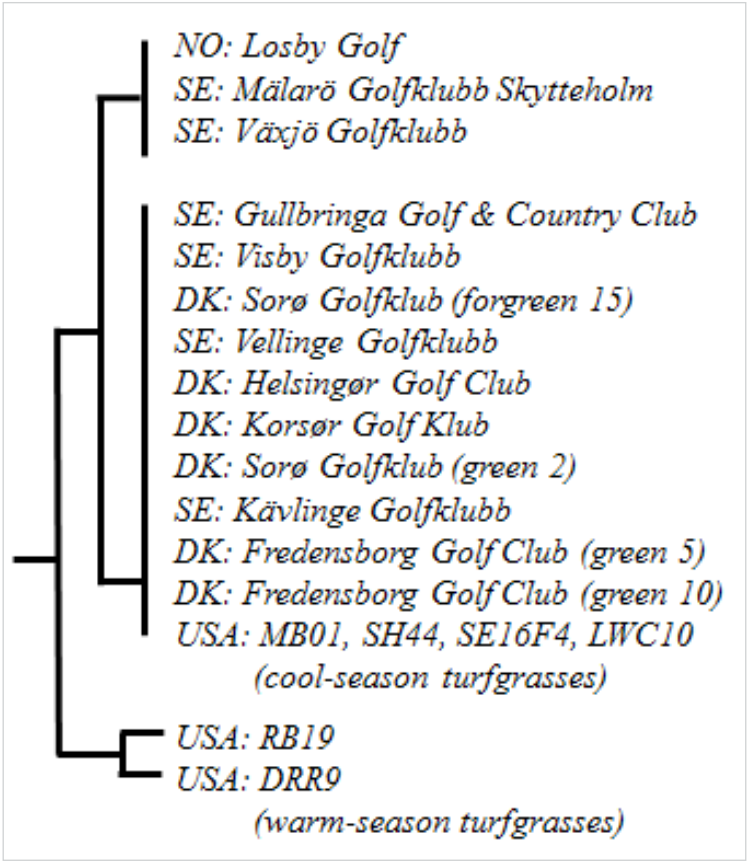
15 Jan.: Ny forskrift om plantevernmidler. Konsekvenser for golf- og fotballanlegg. Gresskurs, Lingfield, England (A. Kvalbein).
11 Nov.: Golfforum / NGF Anleggsseminar, Fornebu, Norway (A. Kvalbein).

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2017

Dollar spot is a common disease (caused by the fungus *Sclerotinia homoeocarpa*) on amenity turf in Australasia, North and Central America and continental Europe. During recent years, the disease has been identified on many golf courses in Scandinavia since it was first officially documented in Norway in summer 2013 (Espevig et al., 2015) and in Sweden in 2014 (Espevig et al., in press). Thus, there is need for risk assessment of dollar spot. From July to October 2014, around 30 samples of turf with dollar spot symptoms were collected in Sweden, Denmark and Norway, and presence of *S. homoeocarpa* was confirmed on seven Swedish, four Danish and one Norwegian golf course. Molecular analysis of the isolates showed that they could be divided into two genetic groups (with 97.6% similarity between the groups).

Group 1 consisted of all Danish and most of the Swedish isolates, while Group 2 contained the Norwegian isolate and two Swedish isolates. The consensus internal transcribed regions (ITS) of the ribosomal DNA of the first group was identical to ITS previously reported in e.g. the USA (GenBank), while the second group clearly constituted a distinct variant or perhaps even a new species of *Sclerotinia*. In December 2014, we also received four isolates from cool-season grasses and two isolates from warm-season grasses from the Systematic Mycology & Microbiology Lab, US Department of Agriculture, for comparison. These





Golf courses in Denmark, Sweden and Norway where dollar spot disease has been confirmed (left) and phylogenetic tree showing isolates from Scandinavia and USA belonging to four genetic groups (right).

isolates represent a wide swathe of diversity for *S. homoeocarpa* and they were sequenced by NIBIO Plant Health and Plant Protection in 2015. All four isolates from cool-season turfgrasses belonged to Group 1, while two isolates from warm-season turfgrasses belonged to two other groups (3 and 4). In compliance with the project description, the second project year (2015) was largely devoted to knowledge transfer and publication of the results. Thus, a fact-sheet about dollar spot (*myntflekk* in Norwegian) was published in English, Swedish and Norwegian on the STERF website, and BSc student Anita Ejderdun at the University of Gävle defended her dissertation on dollar spot disease. She received four isolates of *S. homoeocarpa* from NIBIO (one from Sweden, two from Denmark and one from Norway) and tested their pathogenicity at 6 °C, 15 °C and 24 °C on creeping bentgrass (*Agrostis stolonifera*) from two golf courses. Her findings indicated that the optimal temperature for disease development varied between the isolates and that the pathogen had potential for growing under relatively cold climate conditions.

COMPLETED PROJECTS

The projects listed below were funded by STERF during the period 2001-2014. More information about the projects can be found on the STERF website www.sterf.org

1. The effects of soil organic matter, content, and quality on soil biological activity and turfgrass root development in sand dominated golf greens. Karin Blombäck, Swedish University of Agricultural Sciences (1999–2001)

2. Nitrogen utilisation efficiency in different golf green constructions of Creeping Bentgrass golf greens. Karin Blombäck, Swedish University of Agricultural Sciences (2001-2004).

3. Effects of demand-driven fertilisation on growth, appearance and nitrogen use efficiency of turfgrass. Tom Ericsson, Swedish University of Agricultural Sciences (2003-2004).

4. Leaching of fungicides from golf greens: Quantification and risk assessment. Nicholas Jarvis, Swedish University of Agricultural Sciences (2004-2005).

5. Benefits and environmental risks of fungicide use on Scandinavian golf greens. Trygve S. Aamlid, Norwegian Institute for Agricultural and Environmental Research (2004-2005).

6. Evaluation of *Agrostis* and *Festuca* varieties for use on Scandinavian golf greens. Trygve S. Aamlid, Norwegian Institute for Agricultural and Environmental Research (2004- 2007).

7. Environmental management programmes for golf facilities - a case study in the Stockholm golf district. Mårten Wallberg, Swedish Society of Nature Conservation, Stockholm (2005-2007)

8. Evaluation of Agrostis and Festuca varieties (Nordisk sortguide). Trygve S. Aamlid, Norwegian Institute for Agricultural and Environmental Research (2007).

9. Evaluation of biodiversity and nature conservation on golf courses in Scandinavia. Bente Mortensen, GreenProject (2006-2007).

10. Effects of organic amendments and surfactants on hydro-phobicity and fungicide leaching from ageing golf greens. Trygve S. Aamlid, Norwegian Institute for Agricultural and Environmental Research (2006-2007).

11. The role of golf course management in the support of wetland-associated organisms in greater metropolitan Stockholm. Johan Colding, Beijer Institute of Ecological Economics, Royal Swedish Academy of Science (2006-2008).

12. Ageing of a sand-based rootzone. Karin Blombäck, Swedish University of Agricultural Sciences (2006-2008).

13. Turfgrass demonstration trials in Dalarna. Erik Svärd, Swedish Golf Federation (2006-2008).

14. Improved strategy for control of *Microdochium nivale* on golf courses. Anne Marte Tronsmo, Department of Plant and Environmental Sciences, Norwegian University of Life Sciences (2006-2008).

15. The influence of golf on nature and environment – analyses and evaluation of the environmental performance in Scandinavia. Bente Mortensen, GreenProject (2006-2008).

16. Evaluation of the plant growth regulator trinexapac-ethyl (Primo MAXX®) on Nordic golf courses. Trygve S. Aamlid, Norwegian Institute for Agricultural and Environmental Research (2007-2009).

17. Development, evaluation and implementation of playing quality parameters in a continuous golf course evaluation concept – user survey. Anne Mette Dahl Jensen, Forest & Landscape, University of Copenhagen (2007-2009).

18. Prediction of turf growth as a function of light and temperature under Nordic conditions. Karin Blombäck, Swedish University of Agricultural Science (2007-2009)

19. Re-establishment of green turfgrass after winter damage, spring 2009. Agnar Kvalbein, Norwegian Greenkeepers' Association (2008-2009).

20. Impact of mowing height and late autumn fertilisation on winter survival of golf greens in the Nordic countries. Agnar Kvalbein, Norwegian Greenkeepers' Association (2008 -2010)

21. Multifunctional golf course with unique natural and cultural values. Carina Wettemark, Kristianstads Vattenrike Biosphere Reserve, Kristianstads kommun (2008 – 2010)

22. Evaluation of turfgrass varieties for use on Scandinavian golf greens, 2007-2010. Trygve S. Aamlid, Norwegian Institute for Agricultural and Environmental Research (2007-2010)

23. Demonstration trials with winter cover protection. Boel Sandström, Swedish Golf Federation (2007-2010)

24. Breeding of winterhardy turgrass varieties for central and northern Scandinavia. Petter Marum, Graminor AS, Bjørke Research Station (2007-2010)

25. VELVET GREEN: Winter hardiness and management of velvet bentgrass (*Agrostis canina*) on putting greens in northern environments. Tatsiana Espevig, Norwegian Institute for Agricultural and Environmental Research (2007-2011)

26. Fertiliser strategies for golf turf: Implications for physiology-driven fertilization. Tom Ericsson, Department of Urban and Rural Development. Swedish University of Agricultural Sciences. (2007- 2011)

27. Nordic cooperation between authorities and non-governmental organisations for creating multifunctional golf courses and healthy ecosystems. Maria Strandberg, Scandinavian Turfgrass and Environment Research FoundationJanuary (2010–2011)

28. The Nordic Turfgrass Guide 2012 and Variety Lists. Trygve S. Aamlid, Norwegian Institute for Agricultural and Environmental Research (2011-2013)

29. Optimal maintenance for hardening and early spring growth of green turfgrass. Karin Blombäck, Department of Soil and Environment, Swedish University of Agricultural Sciences (2006-2013)

30. Development of methods for non-pesticide weed control on golf fairways. Anne Mette Dahl Jensen, Forest & Landscape, University of Copenhagen-LIFE (2008-2013)

31. Preservation of cultural landscapes and cultural heritage elements on golf courses. Ole R. Sandberg, Department of Landscape Architecture and Spatial Planning, Norwegian University of Life Sciences (2009-2013)

32. Interactive map with navigation to learn and understand environmental work and impacts at a golf course. Magnus Enell, Enell Sustainable Business AB (2011-2013)

33. Integrated pest management - communication project within the park and golf sector. Maria Strandberg, Scandinavian Turfgrass and Environment Research Foundation (2011-2013)

34. Evaporative demands and deficit irrigation on sand-based golf greens. Trygve S. Aamlid, Norwegian Institute for Agricultural and Environmental Research (2008-2014)

35. Large-scale demonstration trials: Silvery thread moss on greens. Mikael Frisk, Swedish Golf Federation (2011-2014)

36. SCANGREEN: Turfgrass species and varieties for integrated pest management of Scandinavian putting greens. Trygve S. Aamlid, Norwegian Institute for Agricultural and Environmental Research (2011-2015)

37. Increasing rates of the current and a new formulation of Primo MAXX® for plant growth regulation on greens and fairways. Ingunn M. Vågen, Norwegian Institute for Agricultural and Environmental Research (2013-2015)

38. Effects of mowing height, N-rate and P-rate/ mycorrhiza on quality and competition against annual meadowgrass on putting greens with red fescue as predominant species. Tatsiana Espevig, Norwegian Institute for Agriculture and Environmental Research (2011-2015)

39. Validation of the GreenCast prediction model for microdochium patch on golf greens in the Nordic region. Tatsiana Espevig, Norwegian Institute for Agricultural and Environmental Research (2012-2015)

40. Testing of alternative plant production products for the control of *Microdochium nivale* and other diseases on golf greens.Trygve S. Aamlid, Norwegian Institute for Agricultural and Environmental Research (2011-2015)

41. Better turfgrass survival in a changing winter climate Tatsiana Espevig, Norwegian Institute for Agriculture and Environmental Research (2011-2015)

42. A comparison of the soil surfactant Qualibra and Revolution on creeping bentgrass greens varying in water availability. Trygve S. Aamlid, Norwegian Institute for Agricultural and Environmental Research (2014-2015)

43. GreenCast validation of anthracnose (*Colletotrichum graminicola)* on golf greens in the Nordic region. Tatsiana Espevig, Norwegian Institute for Agricultural and Environmental Research (2014-2015)

44. FESCUE-GREEN: Best management of red fescue (Festuca rubra) golf greens for high sustainability and playability. Trygve Aamlid, NIBIO (2011-2016)

45. Overseeding of Fairways - A strategy for finer turf with less broad-leaved weeds and Poa annua. Anne-Mette Dahl Jensen, University of Copenhagen (2011-2016)

46. Identification and risk assessment for dollar spot on Scandinavian golf courses. Tanja Espevig, NIBIO (2014-2016)

47. Experience mapping and multifunctional golf course development - enhanced possibilities of increased and more varied use of golf courses. Ole Hjorth Caspersen, University of Copenhagen (2011-2016)

48. Multifunctionality in golf courses – effects of different management practices on the ecosystem services carbon sequestration and biodiversity. Thomas Kätterer and Jörgen Wissman, SLU (2014-2016)

STERF KEY INDICATORS 2006 - 2016

Year	Funding	Applications		Ongoing projects	Scientific publications		Popular publications	Presentations at seminars, conferences etc.	Handbooks, Fact sheets, Programmes
		Received	Approved for funding						
2006	1 500 000 SEK	17	7	12	7		23	46	
2007	4 900 000 SEK	1	1	13	3		12	26	1
2008	4 500 000 SEK	22	6	18	11		29	42	2
2009	5 500 000 SEK	1	1	15	16		20	49	1
2010	3 000 000 SEK	16	9	13	7		29	46	1
2011	3 700 000 SEK			19	4		32	50	25
					Peer-reviewed papers	Publications and reports			
2012	3 400 000 SEK			18	9	12	24	98	25
2013	4 100 000 SEK			14	2	11	36	71	11
2014	6 300 000 SEK	19*	8**	22	13	18	33	84	12
2015	4 400 000 SEK			17	6	7	23	77	9
2016	4 100 000 SEK	15***	1	19	14	6	25	86	126

*Project proposals received by 1 December 2013 **New projects approved for funding in February 2014. Funding of new projects started in 2014.
***Project proposals received by 9 December 2016. A decision regarding funding of new projects will be taken in March 2017.

These key indicators are based on information in project annual reports. STERF has an open call for proposals approximately every second year. If there are specific reasons, a project application may be approved for funding by STERF board in between the open calls for proposals.

FINANCIAL SUMMARY

INCOME STATEMENT

	01/01/2015 12/31/2015	01/01/2016 12/31/2016
Revenue		
Net revenue	4 204 888	3 912 283
	4 204 888	3 912 283
Expenses		
Other external expenses	-28 772	-31 775
	4 176 116	**3 880 508**
Income from financial items		
Interest	0	0
Surplus	**4 176 116**	**3 880 508**

BALANCE SHEET

	2015	2016
Other receivable	0	0
Cash and bank balances	6 993 343	6 655 667
Total assets	**6 993 343**	**6 655 667**
Liabilities and equity		
Equity		
Restricted reserves	262 719	262 719
Non restricted reserves	5 030 624	4 772 948
Total equity	**5 293 343**	**5 035 667**
Current liabilities		
Other current liabilities	1 700 000	1 620 000
Total current liabilities	**1 700 000**	**1 620 000**
Total liabilities and equity	**6 993 343**	**6 655 667**

LIST OF PUBLICATIONS

FULL PAPERS IN INTERNATIONAL PEER REVIEWED JOURNALS

Aamlid, T.S., B. Molteberg, F. Enger, Å. Susort, Å. & A.A. Steensohn 2005a. Evaluation of *Agrostis* and *Festuca* varieties for use on Scandinavian golf greens. International Turfgrass Society Research Journal 10: 52-53.

Aamlid, T.S., M. Larsbo & N. Jarvis 2007. Effects of a surfactant on turfgrass quality, hydrophobicity and fungicide leaching from a USGA green established with and without organic matter to the sand-based rootzone. In: Adjuvants on our World. Eighth International Symposium on Adjuvants for Agrochemicals. Abstracts. p. 24.

Aamlid, T.S., M. Larsbo & N. Jarvis 2008. Effects of wetting agent on turfgrass quality, hydrophobicity, and fungicide leaching from a USGA green with and without organic amendment to the sand-based root zone. In: S. Magni (ed.): Proceedings, 1st European Turfgrass Society Conference, 19th-20th May 2008, Pisa, Italy. pp. 39-40.

Aamlid, T.S., T. Espevig & A. Kvalbein 2009. The potential of a surfactant to restore turfgrass quality on a severely water-repellent golf green. Biologia 64: 620-623.

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Aamlid, T.S., T. Espevig, T.O. Pettersen, S.L.G. Skaar & A. Kvalbein 2009. Evaluation of the surfactant Aqueduct® for recovery of turfgrass quality on a severely water repellent golf green. International Turfgrass Society Research Journal 11: 43-44. (Annex).

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Aamlid, T.S. & O. Niemalainen 2009. Evaluation of the plant growth regulator trinexapac-ethyl (Primo MAXX®) on Nordic golf course greens and fairways. International Turfgrass Society Research Journal 11: 70. (Annex)

Aamlid, T.S. & O. Niemelainen 2010. Evaluation of the plant growth regulator trinexapac-ethyl (Primo MAXX®) for use on Scandinavian golf courses. In: Proceedings 2nd European Turfgrass Conference, Angers, France 11-14 April 2010 pp. 15-17.

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Aamlid, T.S., G. Thorvaldsson, F. Enger & T. Pettersen 2012. Turfgrass species and varieties for Integrated Pest Management of Scandinavian putting greens. Acta Agriculturae Scandinavica Section B Soil & Plant Science 62 (Supplement 1): 10-23.

Aamlid, T.S. et al. 2012. Turfgrass water consumption on green and fairway as a function of turfgrass species and day number after irrigation to field capacity. Reviewed abstract presented at the 3rd ETS Conference, 25-27 June 2012. Bioforsk FOKUS 7(8): 45-47.

Aamlid, T.S. et al. 2012. Irrigation strategies and soil surfac tant on golf course fairways. Reviewed abstract presented at the 3rd ETS Conference, 25-27 June 2012. Bioforsk FOKUS 7(8); 55-57.

Aamlid, T.S. & T. Pettersen 2013. Effect of the plant growth regulator trinexapac-ethyl on turf quality, concentration of total nonstructural carbohydrates, and infection of *Microdochium nivale* in greens-type *Poa annua* in Scandinavia. International Turfgrass Society Research Journal, Volume 12, 2013. pp. 801-803.

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Aamlid, T.S., T.E. Andersen, A. Kvalbein, T. Pettersen & A.M.D. Jensen 2013. Composted garden waste as organic amendment to the USGA-green rootzone and topdressing sand on red fescue (*Festuca rubra*) greens. European Journal of Horticultural Science 79(3): 87-96.

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Aamlid, T.S., W.M. Waalen & T. Espevig 2014, Fungicide strategies for the control of turfgrass winter diseases. Acta Agriculturae Scandinavica, Section B - Soil & Plant Science, DOI: 10.1080/09064710.2014.985249.

Aamlid, T.S. 2015. Testing of turfgrass varieties for northern environments: The SCANTURF and SCANGREEN evaluation programs. European Journal of Turfgrass Science 8: 53-58.

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Espevig, T., T.E. Andersen, A. Kvalbein, E. Joner & T.S. Aamlid 2014. Mycorrhizal colonization and competition against annual bluegrass on golf greens with red fescue as the predominant species. In: Zuin, A. and K. Mueller-Beck. (eds.) European Journal of Turfgrass Science (Special Edition) pp. 41-42 (ISSN 1867-3570).

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