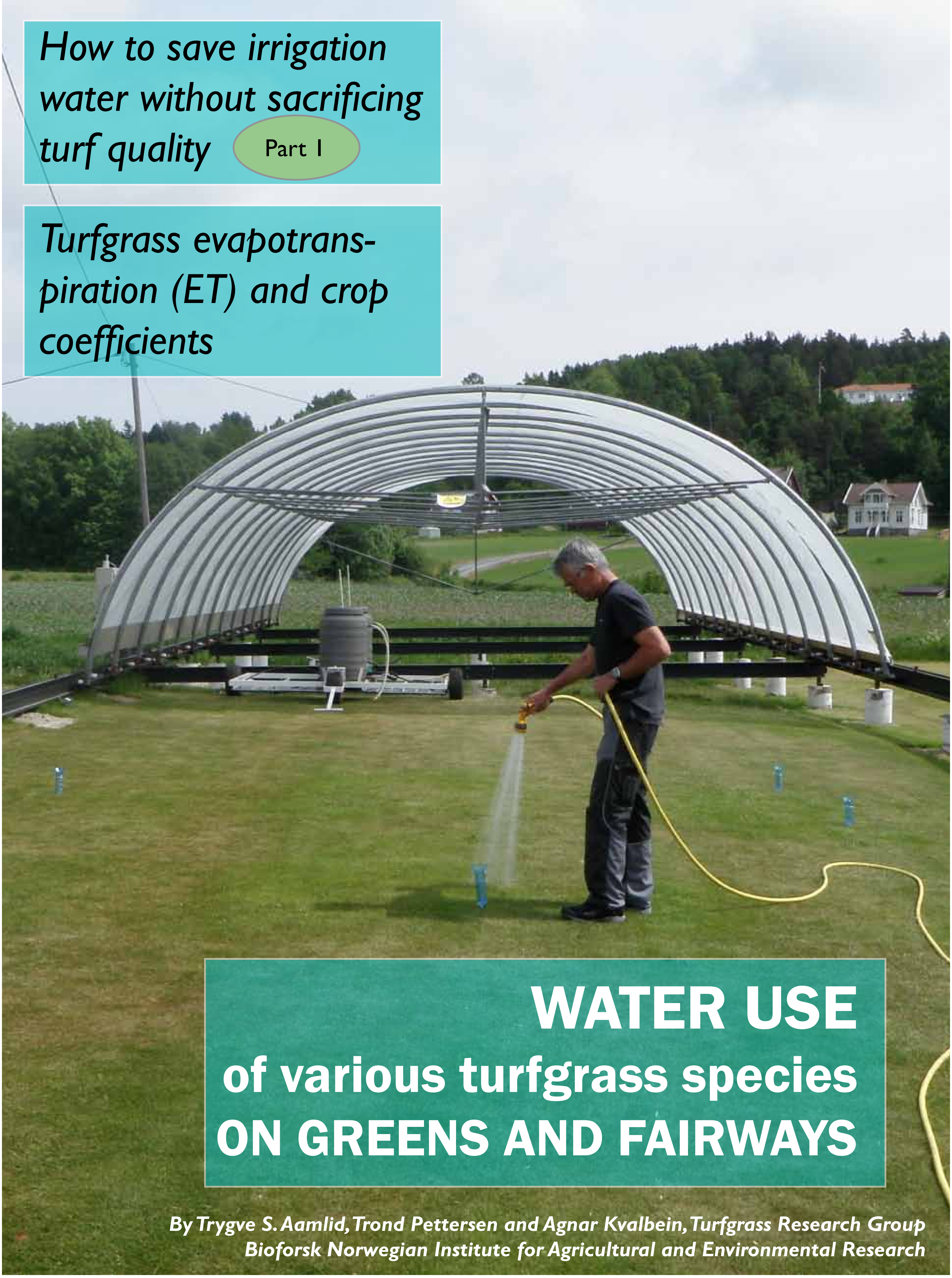

How to save irrigation water without sacrificing turf quality Part 1

Turfgrass evapotranspiration (ET) and crop coefficients

WATER USE
of various turfgrass species
ON GREENS AND FAIRWAYS

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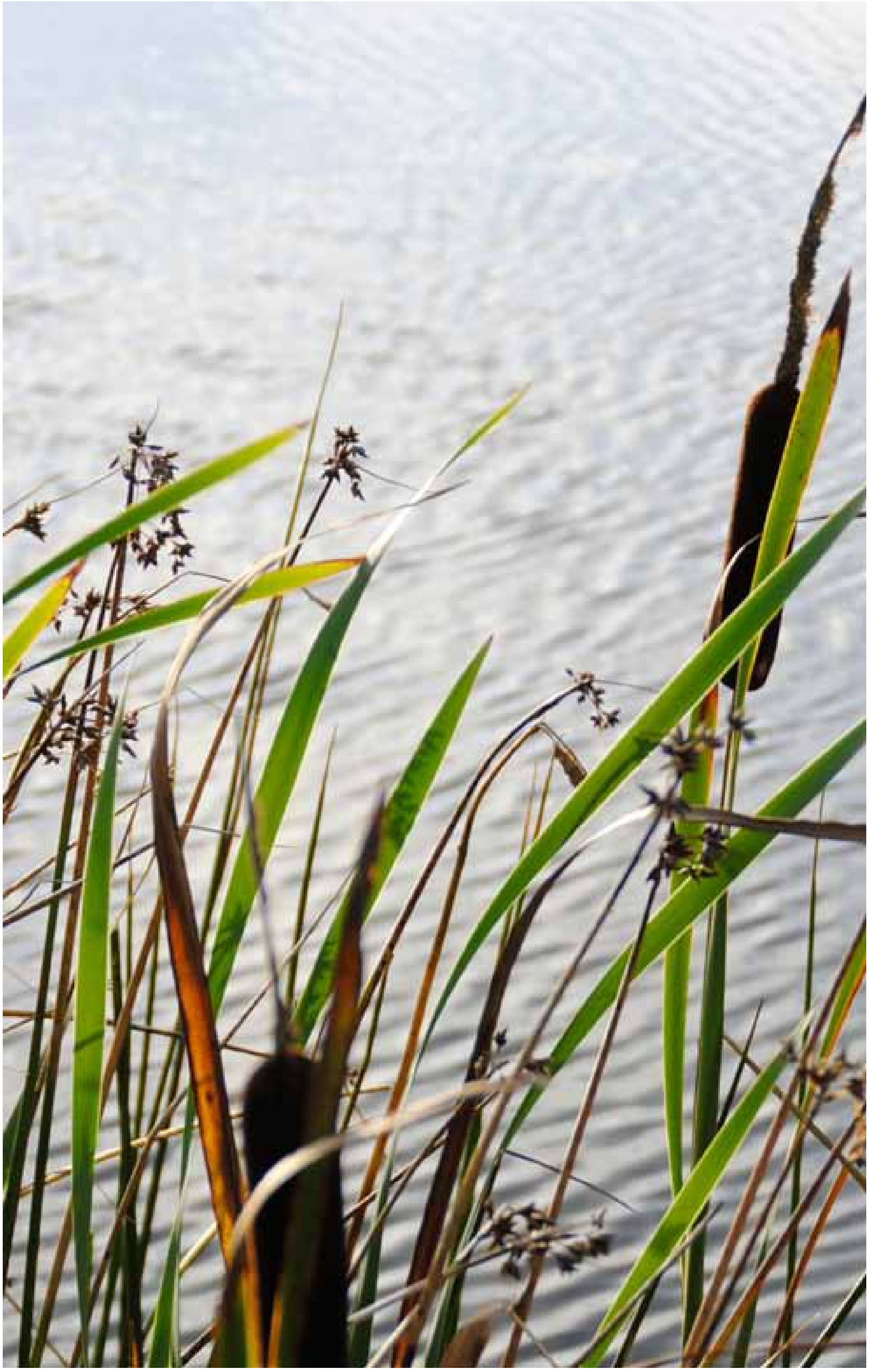

How to save water without sacrificing turf quality?

Worldwide, lack of irrigation water is the foremost limitation to further expansion of golf.

In the Nordic countries, surface water for irrigation is generally abundant in Finland, Norway and most of Sweden, but many Danish golf courses have to pay for groundwater and are only allowed to use 5-7000 m^3 per season. Regardless of country, limited capacity of water distribution systems often limits irrigation during dry periods, and pumping of water is usually a major item in the energy, CO_2 and cost budgets for golf course maintenance. Is it at all possible to use less water while maintaining turf quality on golf course greens and fairways ?

The STERF project '*Evaporative demands and deficit irrigation on golf courses'* started in 2009 and is now being concluded with the publication of scientific papers and a turfgrass irrigation handbook.

Turfgrass evapotranspiration (ET) and crop coefficients


Photo 1a,b. *Cylinder installed for measurement of actual ET on green (left) and fairway (right). Photos: Trygve S. Aamlid*

Evapotranspiration (ET) from surfaces with 100% turf coverage is mainly due to transpiration from turfgrass leaves, as soil evaporation is negligible.

The reference ET rate (ET_0) was formerly measured as evaporation from an open water surface. Nowadays, ET_0 is calculated from irradiance, temperature, wind speed and relative humidity recorded by automatic weather stations. The average daily ET_0 from May to September in the Nordic countries is usually in the range 2.5-3.0 mm, but values between 4 and 5 mm often occur on warm, sunny days in midsummer.

The crop coefficient (K_c) is defined as the ratio between actual ET (ET_a) from the turf canopy and the reference ET rate: $K_c = ET_a/ET_0$. For cool-season grasses this has often been assumed to be a constant value in the range 0.8-1.0. However, our research shows that this is an oversimplification.

In order to measure the Et_a from various grasses, we installed metal cylinders into four species/subspecies on a USGA-specification green and a golf course fairway situated on a silt loam soil (64% sand, 29% silt, 7% clay). The green was mowed three times per week to 5 mm for fescue and 3 mm for the bent grasses, and the fairway twice per week to 15 mm for all species. The cylinders had a diameter of 10 cm and were 30 cm deep, corresponding to the depth of the USGA root zone (Photo 1). For this depth, soil physical analyses showed a plant-available water-holding capacity of approximately 30 mm in the green trial and approximately 40 mm in the fairway trial.

During five periods without rainfall in 2009 and 2010, each period of 5-14 days duration, the cylinders were pulled out of their sleeves and weighed on a daily basis to determine ET_a. There were six cylinders (replicates) per species, of which three were irrigated to field capacity before reinstallation into the sleeves, while the remaining three were allowed to dry out.

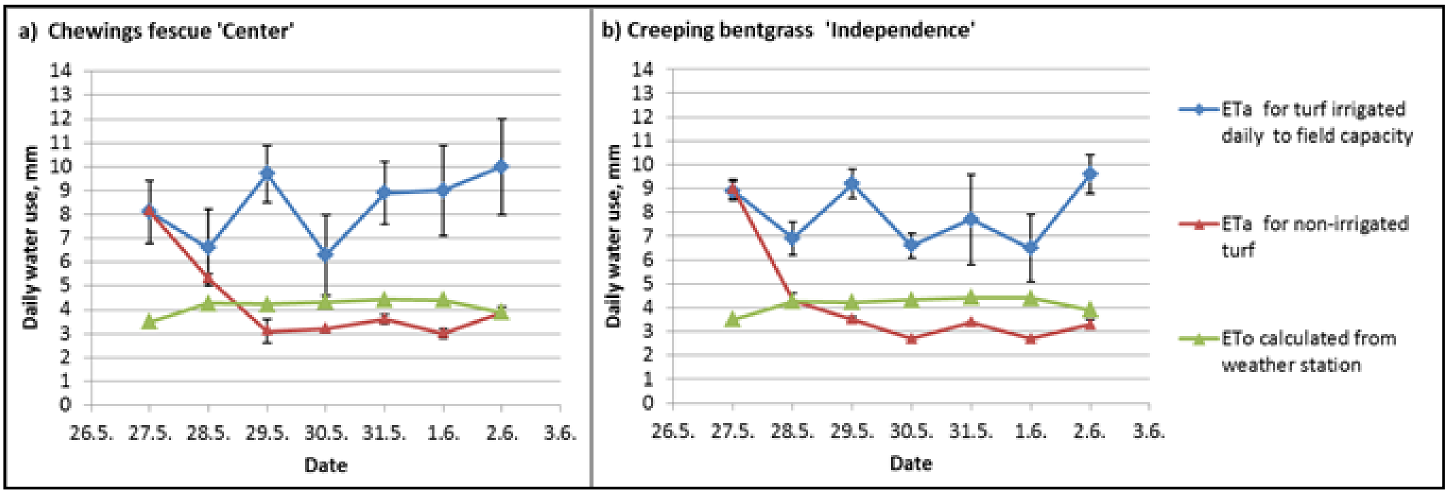

Figure 1a,b. *Actual ET rate (ET_a) determined by weighing mini lysimeters of chewings fescue and creeping bentgrass and reference ET (ET_0) calculated using the FAO 56 version of the Penman-Monteith equation during the observation period 26 May – 3 June 2009. All minI lysimters were irrigated to field capacity at the start of the observation period. Standard error (± 1 SE, n=3) is indicated.*

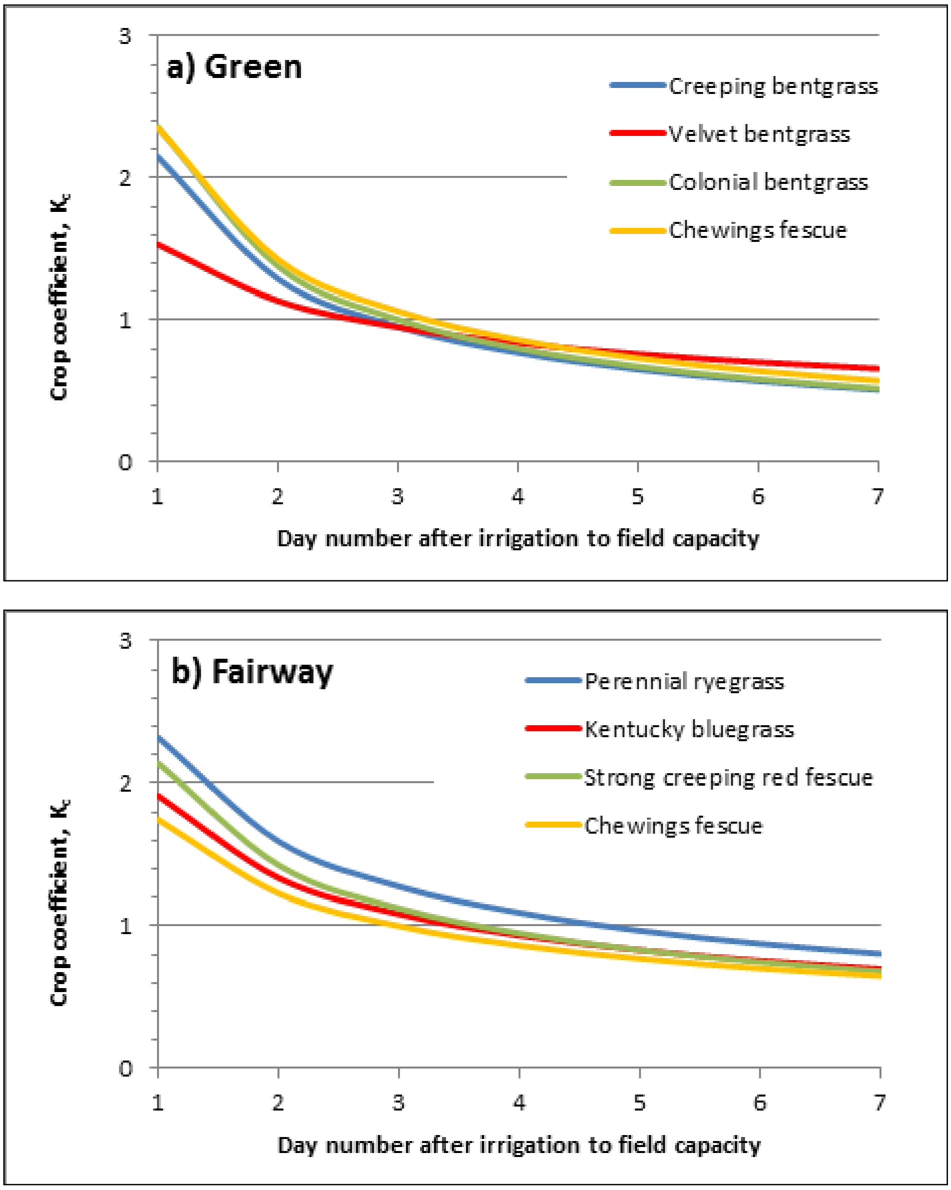

Figure 2a,b. *Crop coefficients for turfgrass species growing on a USGA green expressed as a hyperbolic function of day number after irrigation to field capacity.*

Finding no 1: Turfgrass water use is a function of day number after irrigation to field capacity

Figure 1 shows actual ET from chewings fescue and creeping bent grass growing on the USGA green during the first observation period in 2009. The high water consumption of turf that received daily irrigation to field capacity surprised us, but the pattern repeated itself during the following periods, on greens as well as fairways. In other words, if the turf has free access to water, it will use it!

Based on data from all observation periods, we produced crop coefficients for various species on green and fairway as hyperbolic functions of day number after irrigation to field capacity (Figure 2).

The calculations showed that Kc values in the range 0.8-1.0 were only valid at soil water contents corresponding to days 3-4 after irrigation to field capacity in the green trial and days 4-6 (depending on species) in the fairway trial.

On the condition that irrigation replenished the total water-holding capacity of the soil, K_c values were always 2-3 times higher on the first day after irrigation.

Photo 2a,b. *Higher density and finer leaves result in more guttation droplets and a more humid microenvironment over a velvet bent grass canopy (left) than over a creeping bent grass canopy (right). Photos: Agnar Kvalbein.*

Finding no 2: Water use on greens depends on turfgrass density and thus microclimate

Velvet bent grass was an exception to the general pattern in that the water use on the first day after irrigation to field capacity was not as redundant as in the other species. This may be due to a more humid microclimate that limits transpiration from extremely dense turfgrass canopies (Photo 2).

Based on the K_c hyperbolic functions (Figure 2) and an assumed daily ET0 of 3 mm, the weekly water consumption on golf greens decreased in the order chewings fescue > colonial bent grass > creeping bent grass >> velvet bent grass (Table 1 - p.6). Many Scandinavian greenkeepers using the traditional mixture of fescues and colonial bent grass are surprised by this ranking, as they have observed their greens to be dominated by fescue after dry periods and by bent grass after wet periods. However, there is no conflict between these observations and our finding that pure fescue greens with open canopies cut at 5 mm and minimal amounts of thatch consume more water than denser and more thatchy bent grass greens cut at 3 mm. The fact that root dry weight was 410 g m^{-2} for chewings fescue and 429 g m^{-2} for velvet bent grass compared with 329 g m^{-2} for colonial bent grass and 244 g m^{-2} for creeping bent grass may help to explain why the former two species were able to maintain higher K_c values towards the end of the dry-down period.

Finding no 3: Highest water use from the most deeply rooted species in fairway trials




Photo 3a-d. *Drought tolerance of Kentucky bluegrass 'Limousine' (upper left), chewings fescue 'Center' (upper right), strong creeping red fescue 'Celianna' (lower left) and perennial ryegrass 'Bargold' as indicated by colour retention after a two-week drought period in the fairway trial. Three of six mini lysimeters in each plot received daily irrigation to field capacity. The remaining three lysimeters and the surrounding plot area were not irrigated. Photos: Trygve S. Aamlid.*

Assuming one weekly irrigation to field capacity, Table 1 presents the relative water use of various species/subspecies in the fairway trial. Here the results are perhaps more in line with what most turfgrass managers would expect, i.e. decreasing water consumption in the order perennial ryegrass >> creeping red fescue > Kentucky bluegrass > chewings fescue.

The fact that perennial ryegrass was able to uphold water consumption and retain colour during dry periods better than chewings fescue, strong creeping red fescue and Kentucky bluegrass is illustrated by Photo 3 and reflects the fact that perennial ryegrass had a significantly higher dry weight of roots in the 0-30 cm topsoil layer: 617 g m^{-2} as opposed to an average of 342 g m^{-2} for the other species.

These results on root development and colour retention must not interpreted as a recommendation of perennial ryegrass for Scandinavian golf courses that lack irrigation on their fairways. The overriding disadvantages of perennial ryegrass continue to be high growth rates and poor winter hardiness and, especially for the latter, in our experience there has been little improvement in new varieties coming from European breeding programmes. On the other hand, Photo 4, taken in an earlier fairway variety trial, suggests that the advantage of strong creeping red fescue over chewings fescue during dry periods is often more pronounced than was observed in the present project.

To improve drought resistance, we therefore usually recommend strong creeping red fescue as a component in fairway mixtures otherwise dominated by chewings fescue and Kentucky bluegrass.

	GREEN	FAIRWAY
Velvet bentgrass 'Legendary'	77	
Creeping bentgrass 'Independence'	91	
Colonial bentgrass 'Barking'	98	
Chewings fescue 'Center'	100 =32 mm	100 = 21 mm
Kentucky bluegrass 'Limousine'		109
Strong creeping red fescue 'Celianna'		113
Perennial ryegrass 'Bargold'		128

Table 1. *Relative water consumption of various turfgrass species/subspecies over a seven-day period assuming twice weekly irrigation to field capacity on the green and once weekly irrigation to field capacity on the fairway. Values calculated from the* K_c *functions derived for various species and an assumed daily* ET_0 *of 3 mm per day.*

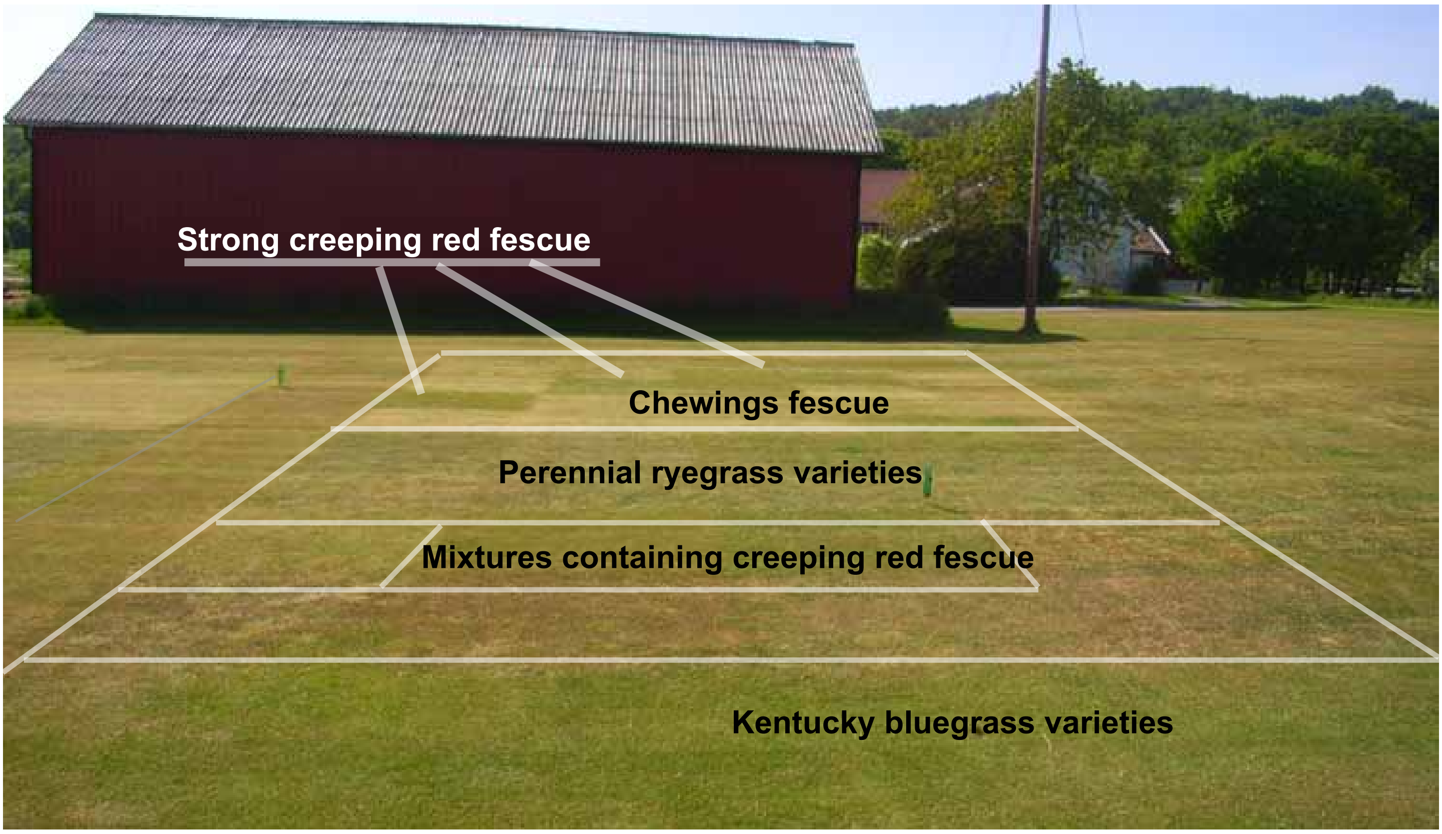

Photo 4. *Colour retention of turfgrass species after five weeks without rainfall in an unirrigated fairway trial at Bioforsk Turfgrass Research Centre in 2008. Photo: Trygve S. Aamlid*

SCANDINAVIAN TURFGRASS AND ENVIRONMENT RESEARCH FOUNDATION

STERF is a research foundation that supports existing and future R&D efforts and delivers 'ready-to-use research results' that benefit the Nordic golf sector. STERF was set up by the golf federations in Sweden, Denmark, Norway, Finland, Iceland and the Nordic Greenkeepers' Associations.

Vision
The Nordic golf sector's vision with respect to golf course quality and the environment is:

To promote high-quality golf courses, whilst guaranteeing that ecosystem protection and enhancement are fully integrated into golf facility planning, design, construction and management.

The aim of STERF is to support R&D that can help the golf sector to fulfil this vision. The activities of STERF are intended to lead to improvements in golf course quality, as well as economic and environmental gains.

STERF prioritises research and development within the following international thematic platforms:

Integrated pest management
STERF together with the golf sector, universities and research institutions and authorities takes responsibility for ensuring that R&D activities that are important for integrated pest management are coordinated and executed and that new knowledge is delivered.

Multifunctional golf facilities and healthy ecosystems
Multifunctional golf courses can contribute to the achievement of environmental goals and help improve people's health and quality of life, especially in areas surrounding dense conurbations, where there are a large number of golf courses. Through utilising joint expertise, our region can become a role model with respect to multifunctional golf courses and collaborations between different interests in society.

Sustainable water management
STERF´s goal is to provide science-based information on integrated management practices, based on existing knowledge and new research results, to reduce water consumption, protect water quality and document the effects – both positive and problematic – of well-managed turfgrass areas on water resources.

Overwintering
Winter damage is the foremost reason for dead grass, reducing the aesthetic and functional value of turf. UN 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. STERF takes responsibility for developing strategic expertise and new knowledge to avoid and manage such damage.

More information about STERF and ongoing research projects can be found on **http://sterf.golf.se**