Growth of golf turf as a function of light and temperature under Swedish conditions – a simulation study

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Background

Over the last 15 years, mean annual temperature has increased in Sweden and the greatest increase in monthly mean temperatures has been during winter months. This change in climate raises questions about how turf growth and overwintering will be affected. The aim of this study was to use a plant growth model to simulate biomass production and losses for three different shortcut turf grass species under present climate and a climate change scenario. For two of the grass species, we further applied a low temperature (LT) tolerance model, which describes LT acclimation and dehardening, to examine climate change effects on overwintering damage due to LT stress.

Materials and methods

A plant growth model (Eckersten et al., 2007) was used to simulate biomass production and losses of three different grass species (*Agrostis stolonifera, Festuca rubra* and *Poa annua*) used as golf green turf in Sweden. The model is based on the concept of radiation use efficiency (RUE), and growth is a function of intercepted light and temperature. The model simulates shoot and root growth, maintenance respiration and root turnover on a daily basis, including re-growth after mowing. A LT tolerance model (Fowler et al., 1999) was adapted for Swedish conditions and used to estimate LT tolerance on a daily basis in terms of LT_{50} (the soil temperature at 2 depth at which 50% of the plants are killed). The model accounts for the processes of low temperature hardening during the autumn and early winter, after which dehardening occurs when the plants are exposed to warmer temperatures, and they have limited ability to reharden if exposed to colder temperatures again. Recorded daily weather data and a climate change scenario for 2085 estimated by the Swedish Meteorological and Hydrological Institute (SMHI) were used as driving variables for the models. Only changes in temperatures (Table 1) affected the simulations, since optimum moisture conditions for the turf was assumed.

Table 1. Monthly mean temperatures (ºC) for present climate in central Sweden and for the climate change scenario (SMHI).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Present	-4.2	-4.2	-0.7	4.2	10.4	15.2	16.5	15.3	11.0	6.5	1.3	-2.6
Scenario	1.1	1.6	5.1	9.0	13.2	18.0	19.3	18.6	14.3	10.3	4.6	1.2

The models were parameterised according to available literature information on the different grass species and further calibrated to measured data on clippings from three experimental greens located at the Fullerö Golf Club outside Västerås in central Sweden. The calibration target was to fit values of grass clippings, which corresponds to daily growth in the model, and at the same time keep the biomass pool stable (no trends over years) and at a size similar to observations. The calibrated model was used to estimate the turf biomass flows for the three different species under present and changed climate. Acclimation and dehardening parameters for the LT tolerance model were adjusted for *Agrostis* and *Poa* to fit cold hardiness determination trials for similar species (Gusta et al., 1980; Tompkins et al., 2000), and was run for a period of 47 years of actual weather data to determine the risk for LT stress.

Results and discussion

Simulated growth corresponded to measurements in autumn 2007 and early spring 2008, but was overestimated during the summer months (Fig. 1). However, due to problems with the sampling during the second round of sampling in August 2007 measured data probably underestimated the real growth. Only the parameter values of RUE ($0.5*10^{-3}$ Kg MJ^{-1} for *Agrostis* and *Festuca* and $0.7*10^{-3}$ Kg MJ^{-1} for *Poa)* and the lower temperature limit for maximum growth rate (15 °C for *Agrostis* and *Festuca* and 10 °C for *Poa)* differed between the species.

The accumulated simulated biomass production was almost 80% higher for *Poa* than for *Agrostis* and *Festuca* under present climate (Fig. 2). Maintenance respiration losses corresponded to about 50% of growth, clippings and root turnover corresponded to approximately 25%, respectively, during present climate conditions for all species. During warmer climate did total growth increase by 26% for *Agrostis* and *Festuca* and 21% for *Poa*. Maintenance respiration increased slightly more, 27% for *Agrostis* and *Festuca* and 26% for *Poa*.

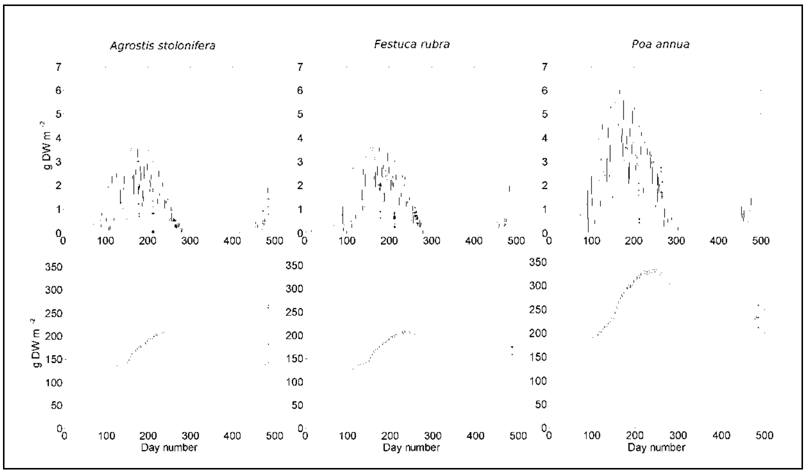

Figure 1. Simulated (line) and measured (dots) above ground daily growth (g $DWm^{-2}d^{-1}$) (above) and above ground biomass (g DWm^{-2}) (below) for the period January 2007 until April 2008.

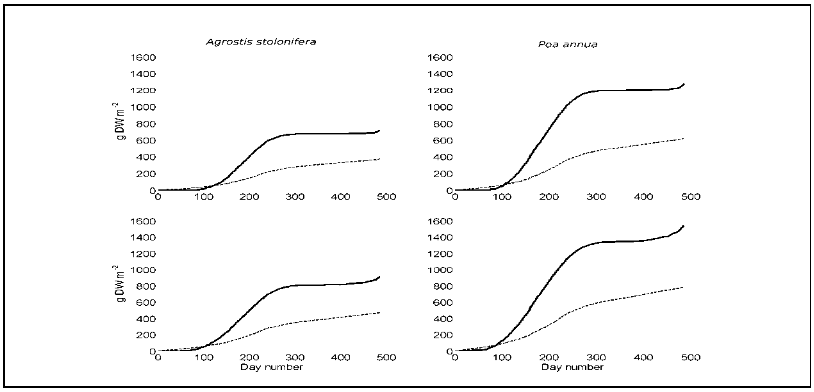

Figure 2. Accumlated biomass flows during the period January 2007 – April 2008 under present climatic conditions (above) and climate change conditions (below). Simulated results for *Festuca rubra* were the same as for *Agrostis stolonifera*, therefore not shown. Bold line = daily total growth, broken line = maintenance respiration, and line = clippings

Poa was more sensitive to low temperature stress during overwintering than *Agrostis* (Fig. 3). During 5 of the 47 years simulated, LT tolerance in *Agrostis* was not adequately developed to protect against mortality of at least 50% of the plants, while in *Poa* 17 of the 47 years LT tolerance was not adequate.

During the simulated climate change scenario, LT stress that caused 50% mortality increased in occurrence for *Agrostis* to 8 of 47 years while for *Poa* it increased to 25 of 47 years. The increased sensitivity to LT stress during the warmer winters was due partially to warmer autumns which negatively affected hardening; and partially due to more frequent warm spells during winter and early spring which hastened the dehardening process.

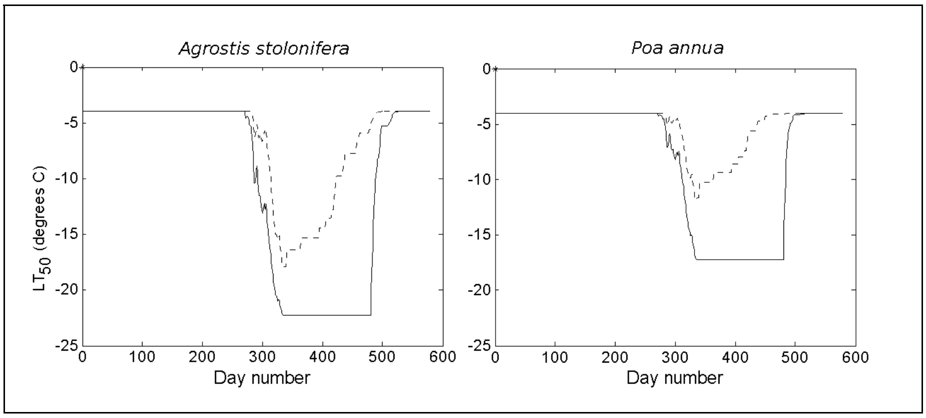

Figure 3. Simulated daily LT tolerance values for *Agrostis* and *Poa* species using real weather data from 2007 and 2008 (solid line) and weather data adjusted according to the SMHI potential climate change scenario (broken line).

Acknowledgements

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