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Nitrogen uptake efficiency by white cedar under different irrigation and fertilisation strategies on a sandy soil: model calculations

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SUMMARY

A combined conifer growth-soil water balance model was extended and parameterised to simulate the nitrogen (N) dynamics of a common nursery stock system [i.e., white cedar *(Thuja occidentalis)* grown for 2 years on a sandy soil]. The model was used to explore the effects on N uptake efficiency *(N_{aue})*, N application rate *(N_{appl})*, and N loss *(N_{loss})* of three irrigation strategies combined with a single, or a split fertiliser application at a recommended rate, without or with a correction for the mineral N content of the topsoil Irrigation strategies used were: no irrigation, daily drip irrigation, or drip irrigation triggered by a pressure-head threshold value. Simulated N dynamics were in agreement with the measurements, but discrepancies were found between measured and simulated N simulated N reduced N_{appl}, especially in the non-irrigated strategy and in the threshold-irrigated strategy. Simulated N_{10} during the 2-year growing period ranged from 79 kg N ha $N_{min,ts}$ to 248 kg N ha^{-1} for the daily irrigated strategy with a split application. Simulated N concentrations in the percolating soil solution at a depth of 1 m exceeded the EU limit of 11.3 mg NO_3-N l^{-1} in almost all simulations. In conclusion, additional measures are necessary to improve N., especially in the year of planting, to be able to reduce N

Irrigation usually increases dry weight (DW) production in ornamentals (Pronk *et al.,* 2005), but it can also increase nitrogen (N) losses into the environment through increasing denitrification and nitrate leaching (Pionke *et al.,* 1990). The Dutch Government has implemented regulations on N-inputs in agriculture and horticulture, as an increasing number of groundwater monitoring sites exceed the critical level of 11.3 mg NO_3-N l^{-1} (Fraters *et al., 2004).* Regulation of N-inputs requires growers to optimise their management of N-sources in their production systems. The effectiveness of N-management can be evaluated from an assessment of the available-N uptake efficiency *[N_{aue};* i.e., total crop uptake divided by total available-N from fertiliser and N mineralised from soil sources, after Huggins and Pan (2003)]. Split N applications (Pronk and Challa, 2000) and adjusting N-fertilisation for mineral N in the topsoil (N useful strategies for increasing N_{aue} and hence decreasing nitrate leaching. The effectiveness of split N-applications and adjusting N fertilisation for N however, also depends on the irrigation strategy used. As yet, it is not known whether split N applications, adjusting N fertilisation for $N_{min,ts}$ or irrigation, optimise yields, improve N_{aue} and/or result in groundwater N concentrations below the regulatory limits.

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To answer these questions for field-grown conifers, we modified and parameterised a combined model consisting of a tree growth model CONGRO (Pronk *et al.,* 2003) and a water and N-balance model FUSSIM2 (Heinen and De Willigen, 2001). We simulated N uptake by white cedar *(Thuja occidentalis* effects of three irrigation strategies combined with a single or a split fertiliser application at a recommended rate, without or with a correction for $N_{min,,,,}$ on the available N uptake efficiency and on N leaching. The average results of simulations conducted for 30 stands, each over a 2-year cultivation period, with a first planting in 1970 and the last one in 1999, were analysed.

MATERIALS AND METHODS

Model structure

A combined conifer growth-soil water balance model (Pronk *et al.,* 2005) was extended and parameterised to simulate the nitrogen (N) dynamics of white cedar *(T occidentalis).* Th e CONifer GROwth model (CONGRO) simulates dry weight (DW) production (see Table I for abbreviations) in ornamental conifers (Pronk *et al.,* 2003), including root DW production and proliferation (Pronk *et al.,* 2002), daily potential water demand (Pronk *et al.,* 2005), and daily potential N