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Online decision support for irrigation for farmers

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ABSTRACT

Online decision support for irrigation has been available in Denmark since 1996. This paper describes an Internet implementation of a previous stand-alone PC-program; the Internet version has undergone several modifications and upgrades. The system has a morphological model for crop development based on temperature sums, and a hydrological model for calculating soil water balance. Weather data are supplied automatically from weather databases, precipitation data can be overrode by user inputs. Users can initiate the system with data on fields and crops, and add data on irrigations. Irrigation advice and explanation are provided in tables and graphics. The system had 322 active users in 2004 and 490 in 2005.

1. Introduction

The Internet has matured as a commonly available communication means in developed countries and increasingly in developing countries. Internet applications open new possibilities for the use of decision support systems (DSS) in agriculture with its strong advantages in remote maintenance of programs and, from the users' point of view, automatic update of dynamic data required by the DSS. For crop production, weather data are important for many purposes covered by DSS applications, among these DSS for irrigation.

In Denmark, PlanteInfo (planteinfo.dk), an Internet-based information and decision system for crop production, was launched in 1996 (Jensen et al., 2000). Danish Institute of Agricultural Sciences and Danish Agricultural Advisory Service operate PlanteInfo jointly in co-operation with Danish Meteorological Institute. Weather observations and weather forecasts, localised in a 10 km × 10 km grid, are downloaded every 6 h to the PlanteInfo website and made available for Danish farmers and advisers in weather applications as well as output from weather dependent models. See Jensen et al. (2000) and Thysen and Jensen (2004) for details.

In 1997, a DSS for irrigation, PlanteInfo Irrigation Manager, was added to the programs in PlanteInfo. The DSS was originally developed for the PC with facilities for downloading weather data by modem (Olesen and Plauborg, 1995). The crop and water model was re-implemented exactly as in the PC version and coupled to the weather database in PlanteInfo. The user interface, however, was redesigned completely according to the formats, requirements and layout principles of the web browser.

PlanteInfo Irrigation Manager was redesigned, expanded and refined over the years, in response to reactions from users (farmers and advisers). The uptake by potential users was quite modest for some years, but increased significantly in 2004, mainly due to increased efforts by advisers in encouraging and supporting farmers in using the DSS. The advisers were motivated by observations of frequent low performance in farmers' irrigation practises.

DSS for irrigation is extensively studied in the literature, but only few operational decision support systems have been reported (Mateos et al., 2002). Of these, only a limited number is web-based. Most irrigation systems are expert systems, Mohan and Arumugam (1997) give a review.

A web-linked and producer oriented program for irrigation scheduling called WISE (Washington Irrigation Scheduling Expert) is described by Leib et al. (2001). The authors report that one of the fundamental principles for WISE was to create

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a tool that could be used without the aid of professional consultants. This meant a minimum of data input. They also wanted to allow for users to apply their own expertise to irrigation scheduling. WISE is not a black box calculation of when and how much to irrigate since important steps are displayed and made apparent to the user. WISE was written in JAVA, which enables it to be downloaded and run on differing computers and operating systems.

Adoption of DSS by farmers has been discussed extensively during the last decade. Developers of DSS do not always understand why their system is not used. As a follow-up of the development of WISE, Leib et al. (2002) investigated the adoption and adaptation of scientific irrigation scheduling in Washington. One conclusion was that growers of high-value crops were more likely to use DSS in order to ensure the quality of their crops.

In Slovenia, a prototype of the system SAgMIS is being implemented and tested (Susnik and Kurnik, 2004). SAgMIS uses meteorological data, soil data and crop data as input and produces output in terms of water balances. The model is available both in a mobile version and a web version.

An online DSS on irrigation, IRRINET, developed by Rossi et al. (2004), is used in the region Emilia Romagna in Italy. IRRINET uses input data from crop and soil, geographic location, meteorological data and characteristics of the irrigation devices used on the farm. Output is the expected evapotranspiration, the cumulated water deficit, the date of the next recommended irrigation, and the relative amount of water to be distributed. The service is available via the Internet but also with the possibility of setting up an SMS service to deliver the results.

Baldrich et al. (2005) report on the development of E-service for irrigation scheduling in Catalonia, Spain, which offer access to advices through Internet, email and SMS.

PlanteInfo Irrigation Manager distinguishes from the above mentioned systems by being entirely web-based in terms of input of farm and field data, automatic supply of weather data as well as consulting for advice. The purpose of the paper is to describe the user interface of PlanteInfo Irrigation Manager and explain the considerations behind the design principles employed in the DSS's interactions with the users. The layout of the paper is to describe the calculation model and the weather data support briefly, and then to present the web pages constituting the user interface in details. The acceptance of the DSS by farmers is discussed briefly. Finally, the rationale behind the layout of the web-based user interface is discussed.

2. Methods

2.1. *Irrigation model*

The irrigation model on which the web-system is build is described in details in Olesen and Plauborg (1995). A brief description follows.

The model supports the major agricultural crops in Denmark: beets, pea, potato, maize, spring and winter barley, rye, spring and winter wheat, spring and winter rape and grass. The model runs with daily timesteps.

Crop growth and development are modelled by three state variables, root depth, phenological stage, and leaf area index (LAI). All three variables are determined by degree-days with base 0 °C since emergence or growth start in spring, depending on crop specific parameters. The model supports multiple cuts of grass.

Soils are classified by the Danish soil type system (Breuning-Madsen et al., 2001), and each soil type is attributed with a set of hydrological parameters. Some of these parameters can be calculated from soil texture.

Soil water is calculated by a simple book keeping system for daily input of water from precipitation and irrigation and daily outputs from evaporation (evaporation from soil and crop surface and transpiration).

2.2. *Weather data*

The irrigation DSS is embedded in the PlanteInfo website (Jensen et al., 2000), which is updated every 6 h with weather observations and weather forecasts in a collaboration with Danish Meteorological Institute (DMI). The weather data are in a 10 km × 10 km grid covering Denmark, the Agricultural Meteorological Information System (AMIS).

Weather observations originate from a network of weather stations comprising 40 stations with temperature and precipitation measurements and 23 stations measuring global radiation. A further network of 400 manual daily rainfall stations is included. Potential evaporation is calculated by Makkink's formula (Makkink, 1957).

Weather forecasts are raw climate model output from European Centre for Medium-Range Weather Forecasts (ECMWF) and DMI's HIRLAM models.

The model uses daily weather observations and forecasts calculated from 08:00 a.m. to 08:00 a.m., and a first version of the data are normally available at 09:00 a.m. The data will change in subsequent weather data updates when more weather stations are added and weather forecasts are renewed. The data from the manual rainfall stations are, for example, not available until about 11:00 a.m.

2.3. *System implementation*

The irrigation DSS is coded in SAS® (Pratter, 2003) and uses procedures from SAS Graph®. The web server is running SAS IntrNet®. Users attend the DSS by a web browser. Javascript is used to provide client-side interactivity. The system is organised in three tiers: data, logic and presentation. This allows for different versions of presentation, e.g. for web browsers, mobile and pda browsers and SMS.

The DSS is intended for operational use during the irrigation season. It is accessed over the Internet by a standard web browser. Confidentiality of users' data is secured by password protection. The DSS is free of charge for Danish farmers.

3. Presentation

3.1. *Soil water status and irrigation needs*

Farmers interact with PlanteInfo Irrigation Manager by a web browser, navigating in a collection of pages by means of a traditional web page menu.