

Fuzzy Irrigation Decision Support System

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Water is a limiting factor in agriculture and when improperly managed reduces the yield potential of crops. The objective of this study is to develop a Fuzzy Irrigation Decision Support System (FIDSS) to optimize water management for soybean production.

Management of irrigation systems for greatest benefit requires an understanding of many physical, biological and chemical processes, and economical factors. Such processes are very complicated and involves many uncertainties. During the last 20 years, considerable progress has been made in developing computer crop growth simulation models. These models are developed with the desire to incorporate quantitatively the fundamental mechanisms controlling the above processes. However, this objective has been compromised by simplifying the mechanisms' representations by general process descriptions which use empirical relationships determined from experimental data. In most cases, it is not possible to collect and correlate data for all conditions due to the nature of these processes. For example, variables such as soil water uptake by roots, soil water content at various depths and water lost by evapotranspiration interact with each other in a complex way making it hard to determine fundamental quantitative relationships among these variables.

This study is therefore undertaken to begin the development of a mechanistic model using qualitative rather than quantitative relationships of the most important variables for making irrigation decisions. The Fuzzy set theory introduced by Lofti Zadeh in 1965 provides the framework to cope with ambiguity and unnaturalness of the traditional crisp method in this domain. Fuzzy expert systems utilize human experience and decision methods, and they have proven to be valuable when dealing with non-linear and complex relationships.

In FIDSS we have developed membership functions for 21 important variables of three primary components: 1) variables for plant, such as, leaf area index (LAI) and evapotranspiration (EP); 2) variables for water status and flow in soil, such as, soil-water content in a layer (θ_L) and infiltration (IN); and 3) variables for weather, such as, maximum temperature

(TM) and solar radiation (RAD). FIDSS has 163 rules in its knowledge base specified as follows:

IF (LAI IS HIGH) **AND** (RAD IS HIGH)
AND (TM IS HIGH) **THEN** (EP IS HIGH)

FIDSS is organized to receive crisp daily values of all state variables from an existing crop model, fuzzify the received inputs, perform evaluation with the knowledge base to give a fuzzy output, defuzzify the output to a crisp value which is then compared to a predetermined threshold condition for irrigation decision.

The existing soybean crop growth simulation model SOYGRO V5.42 developed at the University of Florida by James Jones et al. was used to update state variables. SOYGRO also has an irrigation management model in it which provided us an opportunity to compare decisions made by FIDSS with the ones of SOYGRO. The important additions in FIDSS are that it includes two days' predicted weather data for estimating soil water content and more additional variables for making decisions.

At this early stage of FIDSS development, only limited attempts have been made to tune the rules. However, the following comparison of FIDSS output with the outputs of SOYGRO shows promise for this approach. The output shown below is for soybean (cultivar 'Bragg') grown in Millhopper Fine Sandy soil for 1978 weather condition (for which field data is available). A further tuning of rules and a systematic evaluation of FIDSS is planned.

Table 1: Irrigation Outputs of SOYGRO and FIDSS

MODEL	Irrigation days (from planting) and final results
SOYGRO	73, 77, 82, 87, 93, 98, 115 <i>Yield = 3386.6(kg/ha)</i> <i>Total Water = 211(mm)</i>
FIDSS	8, 15, 68, 72, 76, 80, 84, 88, 92, 96, 110 <i>Yield = 3406.8(kg/ha)</i> <i>Total Water = 275(mm)</i>