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Research Article

Study on Corn Water Saving Irrigation Decision-making Model

Zhang Bing, Jiang HuiFeng and Han Xia
[1]Changzhou Institute of Technology, Changzhou 213002, China

Abstract: In order to obtain the optimum irrigation volume for summer corn, the fuzzy decision control system was designed based on leafage temperature difference-value and soil moisture which can receive optimal irrigation water volume. The results showed that the fuzzy model well matched experiment data. The fuzzy model can solve the uncertainty and non-linear of irrigation system and the model has high precision and got more accurate predicted value and fitted crop law of water.

Keywords: Fuzzy control, leaf temperature value, soil moisture

INTRODUCTION

The water resource in China is becoming scanty, in addition, the industrial water is increasing and thus the irrigation of agriculture should be water-saving and high-efficient. In agricultural irrigation, to gain high yields is not simply through increasing irrigation volume, but how to assign the limited water resource efficiently under limited water condition (irrigate insufficiently) (Teixerra, 1998). Especially when water resource is scanty, insufficient irrigation is the only way to be adopted. In order to obtain supreme yield or income, or minimize the yield losses caused by the lack of water, how to rationally distribute the limited water amount of irrigation at the proper time (different growing phases of the crop) and in the right space (different areas of the crop) is one of the most important problems in insufficient irrigating. The crop's requirements for water are different in different development stages, so we should study the water consumption law that are the water consumption distribution law of the crop during different phase and water consumption intensity and then determine the suitable periods for key irrigation. Though every phase has different sensitive degree to the lack of water, because of the continuity of growing, the lack of water in one phase will influence not only the growth of this phase, but also the further growth and the final yield. So it is essential to irrigate crops at the right time and with the proper amount of water according to the water consumption of the crop in different phase and rainfall. The research on the suitable irrigation periods of the crop in the past is mostly based on the soil moisture, which lacks better systematicness and comprehensiveness, because of the restrictions of the test condition and analytical ways and the insufficient integration and combination among such subjects as agronomy, plant physiology and irrigation and water conservancy. Besides, partly considering the compensation effect on the lack of water required by the crop, the irrigation theory under fully irrigation condition in the past has already could not meet the needs of water-saving and high-efficient agriculture at present (Jianwei *et al*., 2013).

In this study, in order to solve the uncertainty and non-linear of irrigation system and improve irrigation efficiency, the model of water saving irrigation was designed and studied (Frota Ribeiro, 1998).

RESEARCH METHODOLOGY

In this study, corn hydropenia was expressed by leafage temperature value and soil moisture and water demand was gained by fuzzy decision technology, so precision irrigation was implemented.

Suitable soil moisture: Soil moisture has obvious influence for corn growth and production volume. Appropriate weather temperature and soil moisture are very beneficial for corn growth, but there is a large difference for soil feature and climate in deferent growing region, even for the same crop, water demand is different in different growth stage. From years of experience, corn growth process can be divided into 4 growth stages. The most appropriate soil moisture in different stage is as Table 1 (Na *et al*., 2010).

Leaf temperature difference: Corn Leaf temperature is measured every 6 h by precise instruments CB-1301 and experimental data were acquired in sequential 60 days. Temperature difference between leaf and air is analyzed and the relationship between temperature difference and corn water shortage information (Zhang *et al*., 2013).

Corresponding Author: Zhang Bing, Changzhou Institute of Technology, Changzhou 213002, China

Table 1: Appropriate soil moisture

Growth stage	Sow stage-jointing stage	Jointing stage-heading stage	Heading stage-filling stage	Filling stage-maturation stage
Soil moisture content (%)	70	75	65	60

Table 2: Leaf temperature difference (ºC)

Growth stage	Sow stage-jointing stage	Jointing stage-heading stage	Heading stage-filling stage	Filling stage-maturation stage
Temperature difference value	-0.5-3.6	0-2.5	1.0-2.9	-1.5-3.1

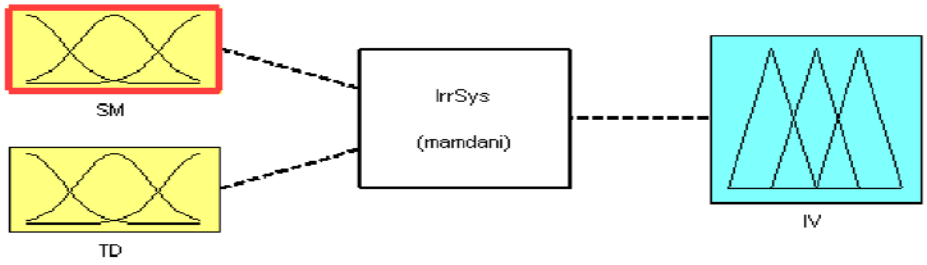

Fig. 1: Structure of fuzzy inference system

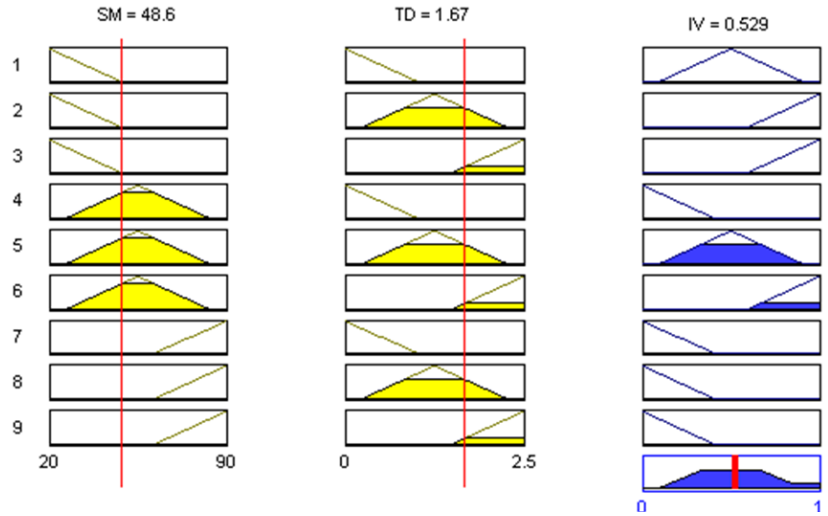

Fig. 2: Fuzzy inference process

From Table 2, leaf temperature difference can indicates crop water storage level and the larger leaf temperature difference, the worse crop water storage.

RESULTS AND DISCUSSION

Fuzzy inference system is set up by MATLAB fuzzy toolbox, input variables are soil moisture and leaf temperature difference value and output variable is irrigation quantity. Because of space constraints, take jointing stage-heading stage for example (Zhen *et al*., 2011).

System structure: In jointing stage-Heading stage, soil moisture content is 75% of field capacity. Soil Moisture (short as SM) and leaf Temperature Difference value (short as TD) are divided into 3 fuzzy variables. Out variable is irrigation volume (short as IV) and structure of fuzzy inference system is depicted in Fig. 1.

From Fig. 1, input membership function used gauss type and output membership function used triangle type.

Fuzzy rules: On the basis of years of peasantry experience, fuzzy rules can be expressed as follows:

If (SM is sml) and (TD is sml) then (IV is mid)
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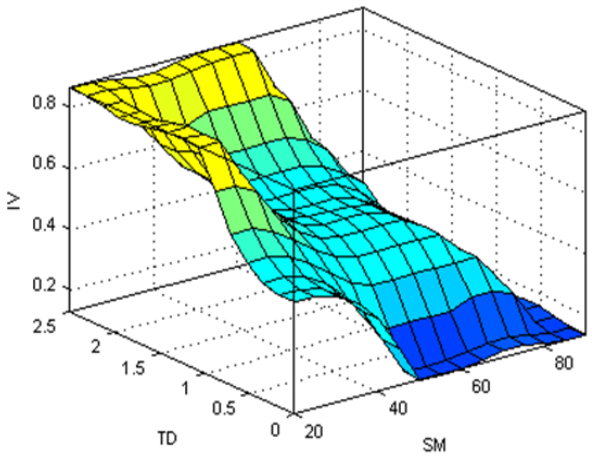

Fig. 3: Fuzzy inference surface

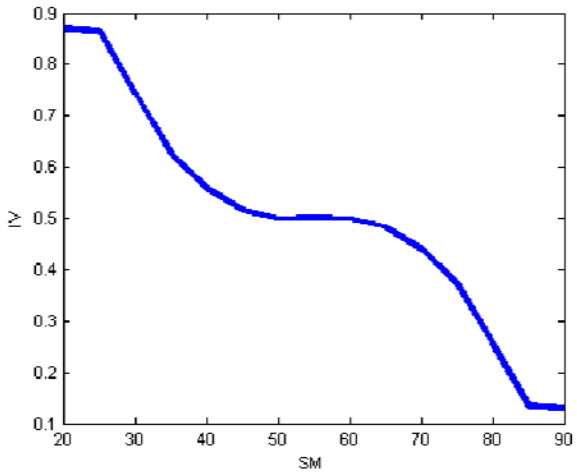

Fig. 4: Relation curve between SM and IV

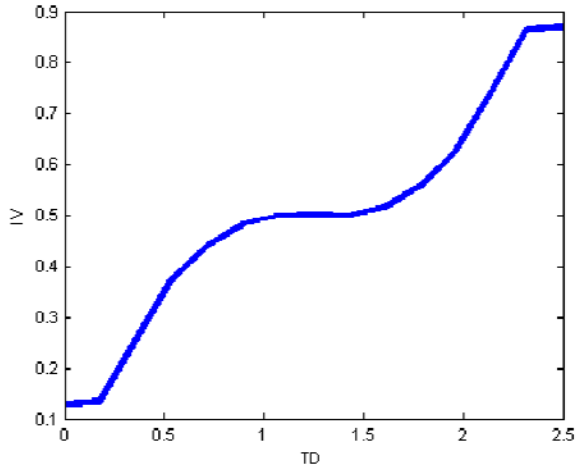

Fig. 5: Relation curve between TD and IV

Fuzzy inference: Fuzzy inference process showed the relation from input variables to output variable and in this process, system transformed input variables into fuzzy set firstly and then got fuzzy output variable on the basis of the rules (Fig. 2).

For example, when SM is 48.6 and TD is 1.67, then output variable IV is equal to 0.529 and actual irrigation volume is the value which multiplies 0.529 by standard irrigation volume.

Inference surface: For the clearer result, inference surface is obtained as follows.

Figure 3 showed the relations between input variables and output. The larger leaf temperature difference, the worse crop water storage and the larger soil moisture, the smaller crop water needed.

Figure 4 showed the relation between soil moisture and irrigation volume for summer corn was obvious. With The soil moisture decreasing, water demand of crop increased rapidly and Irrigation water volume was received.

Figure 5 showed the relation between Leaf temperature value and irrigation volume for summer corn was similarly distinct. With the soil moisture increasing, water demand of crop increased and Irrigation water volume was received.

CONCLUSION

In this study, decision system is designed based on leafage temperature difference-value and soil moisture which can receive optimal irrigation water volume. Fuzzy Inference System is trained by experimental data and we get optimal membership function and fuzzy rules. The fuzzy model well adapts the experiment data. The fuzzy model can solve the uncertainty and non-linear of irrigation system and the model has high precision. The results showed that the system can get more accurate predicted value and fit crop law of water.

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