Research on Water and Fertilizer Integrated Water Saving Irrigation and Energy Conservation Model Using Nonlinear Identification

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Abstract. Aiming at the problems of high control cost and high water consumption in the current commercial greenhouse automatic irrigation system, this paper presents an algorithm of crop water demand model based on nonlinear identification of water, fertilizer and medicine integrated water-saving irrigation, and establishes a model of crop water demand model based on nonlinear identification of water, fertilizer and medicine integrated water-saving irrigation, which can ensure the normal output of crops and save water In order to improve the estimation efficiency of crop water demand model, based on the empirical irrigation amount, Matlab simulation is used. Matlab simulation results show that the irrigation effect of water fertilizer is good and the nonlinear identification ability is strong. The results of the greenhouse tests in Tianshui City and Qingyang City of Gansu Province show that the control system reduces the water consumption by 30% and allocates water resources reasonably and effectively, which greatly reduces the waste of water resources.

1. Introduction

In the water source management of agricultural irrigation[1], water supply management is often paid attention to, but the efficiency of irrigation utilization, water saving and water conservation measures are relatively weak[2-12]. In the face of the above problems, combined with the concept of sustainable development, China has issued relevant policies on the application, development and management of water resources, adhered to the concepts of saving, high efficiency and environmental protection, strengthened the water-saving education and popularization for farmers, made good water-saving publicity, and improved the utilization efficiency of water resources from the aspects of management system, management mode and irrigation technology[13-20].

In recent years, many new water-saving technologies have been widely used in agricultural irrigation, such as canal seepage control [21-23], sprinkler irrigation, micro irrigation, rill irrigation and pipeline water delivery, which greatly improve the utilization efficiency of water resources in agricultural irrigation. Due to many influencing factors, the water demand of crops is often supplied by the combination of theoretical value and empirical value. In the irrigation area with low popularization rate
of modern technology, the empirical value is often the main supply, which causes serious loss of water resources and low irrigation efficiency [24-39].

In this paper, an algorithm of crop water demand model based on nonlinear identification of water, fertilizer and medicine integrated water-saving irrigation is given, and a model of crop water demand model based on nonlinear identification of water, fertilizer and medicine integrated water-saving irrigation is established. Under the condition of ensuring the normal output of crops, the effect of water conservation and water saving is maximized. In order to improve the estimation efficiency of crop water demand model, experience is used first based on the amount of irrigation, using MATLAB simulation. Matlab simulation results show that the irrigation effect of water, fertilizer and medicine is good, and the nonlinear identification ability is strong. The test results of multi span greenhouse in Tianshui City and Qingyang City of Gansu Province show that the control system can reduce the water consumption by 30% on the premise of achieving effective greenhouse irrigation effect, allocate water resources reasonably and effectively, and greatly reduce the waste of water resources.

2. Agricultural irrigation in Greenhouse

The system uses arm11-ok6410 as the server control platform and embedded Linux as the operating system. On the basis of the source system, the system carries out u-boot transplantation, kernel cutting, making root file system, loading driver files and other operations, so that the system has high efficiency in the running process.

In this paper, Water, fertilizer and medicine integrated water saving irrigation, as is shown in Figure 1. Parking test vehicle, as is shown in Figure 2.

![Fig 1. Water, fertilizer and medicine integrated water saving irrigation.](image1)

![Fig 2. Anti hail apple bagging in Greenhouse.](image2)
3. Identification of water saving irrigation model

Meteorological factors are the main factors affecting crop water demand, and the local water surface evaporation is the result of the comprehensive influence of various meteorological factors. Because evapotranspiration and water surface evaporation are both water vapor diffusion, the parameter of water surface evaporation can be used to estimate crop water demand:

\[ E_r = \beta \cdot E_o \]  
\[ E_r = \beta \cdot E_o + c \]  

In the formula (1) ~ (2), \( E_r \) the crop water demand in a certain period, calculated by the depth of water layer (mm):

\( E_o \) generally, the evaporation value of 80 cm diameter pan is used, if 20 cm diameter pan is used, then \( E_{80} = 0.8 \cdot E_{20} \);

\( \beta \) - water demand coefficient of each period, i.e. the ratio of water demand to water surface evaporation in the same period, is generally determined by experiments. Rice \( \beta = 0.98 \sim 1.485 \), dry matter \( \beta = 0.3 \sim 0.85 \); \( h \) - empirical constant.

Since the "\( \beta \) value method" only needs water surface evaporation data, it has been widely used in rice areas in China. In rice area, the influence of meteorological conditions on \( E_r \) and \( E_o \) is the same, so the application of "\( \beta \) value method" is closer to reality and more stable. The error of this formula is generally less than 20% - 30% for rice and dry crops with sufficient soil moisture. According to the daily evaporation of 20 cm diameter, the daily evaporation of 80 cm diameter can be obtained, and the comprehensive evaporation of growth period can be obtained:

\[ \sum E_i \beta = \beta \cdot \sum E_{70} = \beta \cdot \sum E_{80} \]  

According to formula (1), the comprehensive crop water demand in growth period can be obtained by using the value of water demand system \( \beta \), and the crop water demand in each growth stage can be obtained according to the distribution ratio of water demand in each growth stage of the region.

4. Water balance equation

\[ \omega_o - \omega_o = \omega_r + P_o + K + m - E_r \]  

In the formula (3) ~ (4), \( \omega_o \), \( \omega_o \) —the water storage in the planned wetting layer at the beginning of the period and at any time \( t \);

\( \omega_r \) —the amount of water increased due to the planned increase in wetted layer;

\( P_o \) —rainfall infiltration, i.e. effective rainfall. The rainfall infiltration of irrigation area can be calculated according to the effective utilization coefficient \( p \) of rainfall and rainfall:

\[ m = \omega_{max} - \omega_{min} = 667 \eta \cdot h \cdot \left( \theta_{max} - \theta_{min} \right) \]  

In the formula (5):

\( m \) - irrigation quota (m³/mu); \( h \) - depth of planned wetting layer in a period of time (m); \( \eta \) - the dry bulk density of soil in planned wetting layer (t/m³); \( \theta_{max} - \theta_{min} \) - maximum and minimum moisture content of soil in a period of time.
That is: when the soil water content is lower than the lower limit of suitable water content, irrigation is needed; when the soil water content is higher than the field capacity, drainage is needed.

5. Calculation of upper and lower limit of allowable water storage depth

Therefore, the real-time expression of soil water content \( h \) is as follows:

\[
\begin{align*}
    h_{\text{max}} &= \frac{\omega_{\text{max}}}{667} \times 1000 = \frac{667 \eta H \cdot \theta_{\text{max}}}{667} \times 1000 \\
    h_{\text{min}} &= \frac{\omega_{\text{min}}}{667} \times 1000 = \frac{667 \eta H \cdot \theta_{\text{min}}}{667} \times 1000
\end{align*}
\]

(6)

(7)

In the formula (8) ~ (9): \( t \) - irrigation quota. Where \( t = 0 \), the soil water content is the initial value, and the water content in the soil layer is converted into the depth of the water layer:

\[
    h_{\text{initial value}} = h_g \times \eta \times 667/1000
\]

(9)

In the formula (8) ~ (9): \( h_{\text{initial value}} \) - initial soil water content (mm); \( h_g \) - depth of soil layer (mm), selected according to different growth stages; other symbolic meanings are the same as before.

6. Research and analysis

In this paper, an algorithm of crop water demand model based on nonlinear identification of water, fertilizer and medicine integrated water-saving irrigation is given, and a model of crop water demand model based on nonlinear identification of water, fertilizer and medicine integrated water-saving irrigation is established. Under the condition of ensuring the normal output of crops, the effect of water conservation and water saving is maximized. In order to improve the estimation efficiency of crop water demand model, experience is used first. Based on the amount of irrigation, using MATLAB simulation. Integrated irrigation device of water, fertilizer and medicine, as is shown in Figure 3.
In this paper, Generalized predictive model control, Nonlinear identification model control and Generalized predictive nonlinear identification model control, as are shown in Figure 4-7.

Fig 4. Generalized predictive model control.

Fig 5. Nonlinear identification model control.

Fig 6. Generalized predictive nonlinear identification model control.

Comparative analysis of Simulation of crop water demand model based on nonlinear identification of water saving irrigation.1, Comparative analysis of Simulation of crop water demand model based on nonlinear identification of water saving irrigation.2, Comparative analysis of Simulation of crop water demand model based on nonlinear identification of water saving irrigation.3 and Comparative analysis of Simulation of crop water demand model based on nonlinear identification of water saving irrigation.4, as are shown in Figure 7~10.
**Fig 7.** Simulation of crop water demand model based on nonlinear identification of water saving irrigation.1.

**Fig 8.** Simulation of crop water demand model based on nonlinear identification of water saving irrigation.2.

**Fig 9.** Simulation of crop water demand model based on nonlinear identification of water saving irrigation.3.
In Figure 4-10, simulation results show that the irrigation effect of water, fertilizer and pesticide is good, and the nonlinear identification ability is strong. The test results of multi span greenhouse in Tianshui City and Qingyang City of Gansu Province show that the control system can reduce the water consumption by 30% on the premise of achieving effective greenhouse irrigation effect, allocate water resources reasonably and effectively, and greatly reduce the waste of water resources.

7. Summary

In this paper, an algorithm of crop water demand model based on nonlinear identification of water, fertilizer and medicine integrated water-saving irrigation is given, and a model of crop water demand model based on nonlinear identification of water, fertilizer and medicine integrated water-saving irrigation is established. Under the condition of ensuring the normal output of crops, the effect of water conservation and water saving is maximized. In order to improve the estimation efficiency of crop water demand model, experience is used first Based on the amount of irrigation, using MATLAB simulation. Matlab simulation results show that the irrigation effect of water, fertilizer and medicine is good, and the nonlinear identification ability is strong. The test results of multi span greenhouse in Tianshui City and Qingyang City of Gansu Province show that the control system can reduce the water consumption by 30% on the premise of achieving effective greenhouse irrigation effect, allocate water resources reasonably and effectively, and greatly reduce the waste of water resources.

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