African Journal of Agricultural Research Vol. 2 (11), pp. 565-568, November 2007
Available online at http://www.academicjournals.org/AJAR
ISSN 1991- 637X © 2007 Academic Journals

Full Length Research Paper

Remote real-time monitoring soil water potential system based on GSM

Yongming Zhao, Xin Lu* and Haijiang Wang

Key Laboratory of Oasis Ecology Agriculture of Xinjiang Bingtuan, Shihezi University, Shihezi 832003, China.

Accepted 23 October, 2007

Aiming at the limitation of traditional measuring soil water potential, the paper presents an information system based GSM to real-time monitor data coming from multiple data sources. The monitoring system, which consisted of monitoring center, GSM transmission channel and data detection terminal, was given. The detection terminal included the measuring station and TS-2 negative pressure meter, which was applied to measure soil water potential. Nowadays the system has been successfully applied to drip irrigation in the cotton field on farm in Xinjiang region. The system provides a feasible technology frame-work for collecting and processing wide geographical distribution data in farmland.

Key words: Soil water potential, real-time monitoring, negative pressure meter.

INTRODUCTION

With the development of the planting area in Xinjiang, the crop needs a great deal of water to grow. Water source shortage is 38.6 × 10 m^3 every year (Yi Q et al., 2002). In general speaking, the efficiency of using the irrigation water is still quite lower in China, average about 0.4 (Honglie, 2002). Faced to the situation, we should develop the precise irrigation.

In 1996, drip technology under membrane was firstly introduced and applied in Xinjiang. It was very critical for crop manager (Fuyu et al., 1999; Fuyu and Yisui, 2002). In 2001, the automatic control management system was introduced from Australia and used to irrigate crop in Xinjiang (Fuyu et al., 2004). Following, some irrigation control management systems were developed in China (Xiuzhen et al., 2006; Li et al., 2006).

Managing irrigation water needs to combine a method of measuring soil moisture with some methods of irrigation scheduling. The measuring soil moisture requires timely application of the right state of water (Werner, 2002). The state of water in soil is described in terms of the amount of water and the energy associated with the forces which hold the water in the soil. The amount of water is defined by water content and the energy state of the water is the water potential (Bilskie, 2001).

Soil water potential of -0.1MPa (1 bar) tells us that a plant growing in this soil will have adequate moisture, regardless of the soil texture or the amount of water expressed as a percentage. For all types of soil , at the condition of the same soil water potential, the abilities of a crop, which is water physiology and root water uptake, are fundamental same. Soil water potential is more reasonable guide farmer to irrigate the crop.

Soil water potential was a very important parameter in the study of crop growth, surface run-off, soil erosion, farmland evapotranspiration and formulation of a irrigation plan for crops, and so on (Phene and Allee, 1989). The critical values for irrigation in several growing stages of corn were determined and presented (Yingpu et al., 2001). Lower soil water potential reduced rice yield by affecting the growth and development of root, stem and leaf in different growth periods and by decreasing the effective tillers (Yalong et al., 2004). With *Oryza sativa* Linn as materials, effects of low soil water potential (-40 KPa) on the main characters of superior and inferior grains quality and the properties of grain filling during the filling period were examined (Wei et al., 2005). In order to measure precisely soil water potential, many kinds of sensor were invented and applied in the agriculture production, such as the granular matrix sensor (Shock et al., 2005) and WP4-T soil moisture sensor (Decagon, 2005).

With the development of information technology, it is possible to remote measure soil water potential by mobile communication system. Testified by practice, the information system successfully real-time monitors soil water potential, further, guides farmer to precise irrigate the crop.

*Corresponding author. E-mail: zhaoym99@yahoo.cn

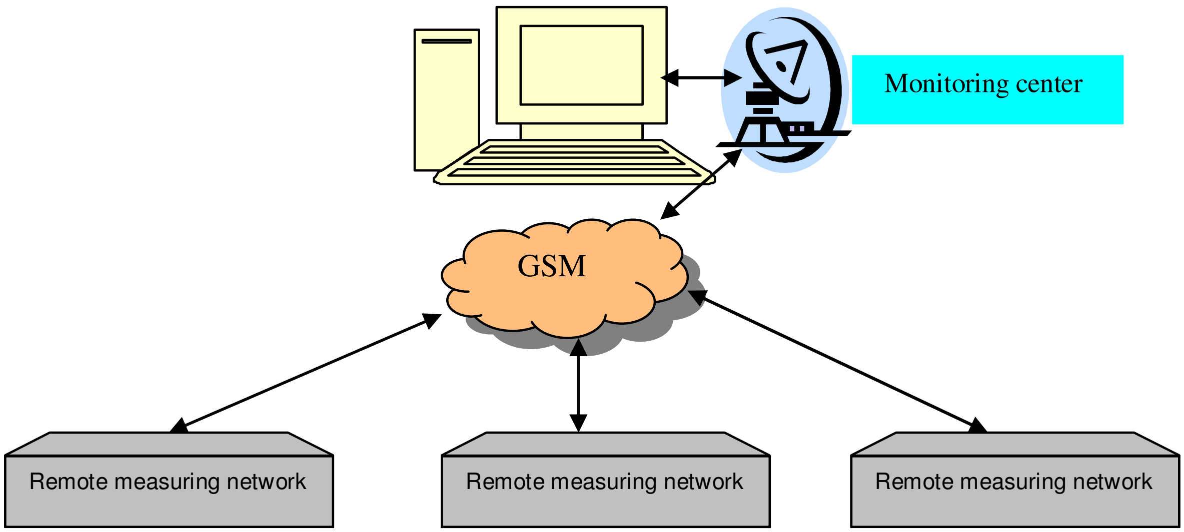

Figure 1. Structures and components of real-time information system.

Basic structures of an information system

The information system (Figure 1) may realize a series of functions including collecting, transporting, storing, centralization management, statistical analysis, forecast and browning of soil water potential data. Making the classification according to the function, the system is composed of monitoring center, data transmission channel and data detection terminal.

Design of information system

Module of application software

The monitoring software is developed by visual-c language and access database. It mainly includes several modules, which are short message processing module, remote communication processing module, instruction processing module, Modbus agreement processing module, task arrangement module and system error processing module. As follows, make a briefly explanation for the function of these modules.

Short message processing module: Send the data to COM and receive the data from COM, which is composed of data-frame. After the module accepts a data frame, it will send signal for meaning accepting a data frame. Before the data frame is treated, the module will stop renewing the data. After the module sends the data, it will make a feedback to finish the processor. Remote communication processing module: Complete the analysis of AT instructions. At the same time, carry out the different AT instructions by the different functions. Some AT instructions are as follows: establishing the working pattern for TC35, assigning short message service center and assigning the clock, and so on. Obtain the entire data for short message, store those in the special data block buffer cache and elimination the sign for accepting the data.

Instruction processing module: complete the analysis and response to the instruction.

Modbus agreement processing module: complete the analysis to Modbus agreement and form the Modbus agreement frame; accept the CRC proof for data and generate CRC data.

Task arrangement module: Dispatch each system task by the onstage and backstage in the computer. The module is the core part of overall software system. System error processing module: Treat and revive the system error.

Data collecting and management

Data is collected by three pathways in the information system. The first pathway according to the feature and request for the parameters measured by the meter, the data is automatically input into the software at the time-boxed everyday. For example, soil water potential data is input into the information system at am 9:00 daily. In the second pathway, the data is input by setting the time interval, in order to satisfy with some requests for the

Figure 2.TS-2 negative pressure meter to measure soil water potential in the cotton field.

special observation. For example, we may activate the program to collect the data at a fixed interval time (every few minutes), in order to master the time that water infiltrates the soil depth of 30 or 60 cm. In the third pathway we can directly knock at the handle collecting button to obtain the real-time information in order to master the dynamic parameter.

Measuring soil water potential unit

In the condition of drip irrigation, 81.33% of the cotton roots are distributed the depth range of 0 - 60 cm (Changzhou et al., 2002). According to soil structure and the soil depth of mechanical work, the soil layer may take two parts, which are the 0 – 30 cm soil range and 30 – 60 cm range. In the cotton field, we put a negative pressure meter at every soil part (Figure 2) in the tested farmland. In order to compare with soil water potential data, the same distance is required from drip channel to each meter.

Theory of the soil water potential sensor

Currently, there are many types of sensor to measure soil water potential. Considered thepractice and the price factor, the TS-2 negative pressure meter, which was produced by the Nanjing institute of soil science, was used to measure soil water potential. The measuring range is 0~85 KPa at 25 ℃.

Water molecules in a soil matrix are subject to numerous forces. The fundamental forces acting on soil water are gravitational, matric, and osmotic. The matrix arrangement of soil solid particles results in capillary and electrostatic forces and determines the soil water matric potential. Most methods for measuring soil water potential are sensitive only to the matric potential. TS-2 negative pressure meter applies the principle to measuring soil water potential. Negative pressure meter is composed of pottery clay head, plastic pipe connector, pressure resistance sensor and vacuum gauge head. The pottery clay head, which has many tiny pores, is the sensor detector. When the pottery head is infiltrated, a water membrane will form in the tiny pores. When the sealed negative pressure mete filled with water is inserted in the soil, in which the moisture content is not saturated, the inner of instrument generates negative pressure. The pressure resistance sensor transforms negative pressure into electrical signal. The relation between them is linear. Therefore, the negative pressure will be transformed into electrical pressure, which is soil water suction. The instrument can reflect the dynamic change of soil water potential.

Feature parameter of pressure resistance sensor

Constant current source: 1.5~2 mA or 10 VDC. Zero bias: min-30 mV, STD0 mV, max+30mV. Zero drift: ±2.0 mV (0~50℃). Linear: STD ± 0.25%, max ± 1.0%Span. Duplication and sluggish: ± 0.15% Span. Reaction time: max 1.0 ms. Input impedance: 5.0 KΩ. Output impendence: 5.0 KΩ. Whole year drift: ± 0.5% Span. Run environment: -40℃ ~+85℃. Storage temperature: -55℃ ~+100℃. Full measuring range Output: AVG 225 mV, min 165 mV, max 285 mV. Overload characteristic: 45 psi

Data signal transmission

The electrical cable of four cores connects the measuring station with pressure resistance sensor. The measuring station is composed of multi-way switch array controlled by program, constant current source, isolation amplifier and 12 bites A/D converter. The sensor is periodical cycle detected by the station system, which is actuated by the application program in the computer. Output signal is sent to isolation amplifier by multi-way switch array, weak signal measured is amplified. The output range of signal volt is between -5 to 5V. The signal volt is transformed into 12 bites numerical signal by A/D converter, which is collected, treated, analyzed and stored in the memory by the computer. The result measured can be showed and duplicated by the form or curve form.

Communication system

The system mainly includes three kinds of communication agreement, i.e. wireless communication, server terminal and measuring station communication agreement. The data is transported by the short message server. Server agreement applies GSM07.05. Communication between communication module and computer or monolithic integrated circuit applies AT commands through the computer COM. Macrobus application agreement between server terminal and measuring station is professional agreement, which has function of inquiry and control.

DISCUSSION

Compared with traditional measuring way, the operation is easy and efficient. The application of information system can save a great of human resource and time. The system, which uses three ways to obtain the data, can meet the difference requires. The way, which uses GSM wireless communication as data transmission channel, may reduce construction cost and fee of run. The data processing and transmission course entirely realizes automation, in order to avoid data distortion in the transmission process by the human factor.

On the one hand, the monitoring center is far away from the measuring field. Moreover, the change speed of soil water potential in the cotton field is slower. It will take more time to obtain the data. On the other hand, because of the lower measuring frequency, the way to get the soil water information is convenient. We use the PM 818A GSM module to realize the data remote transportation by the mobile communication system. The measuring station may immediately collect the data, and then transport them to monitoring center in any place covered by the mobile network.

In the cotton critical growing period, the reasonable vary range for soil water potential is 10~50 KPa (Qikai et al., 1998). Farmer may combine the conclusion with the information system to irrigate the cotton in farmland.

REFERENCES

Changzhou W, Fuyu M, Yongwen L, Junhua L, Jun Y, Fusuo Z (2002). Study on cotton root development and spatial distribution under film mulch and drip irrigation. Cotton Sci. 14(4): 209-214.

Decagon (2005). Generating a soil moisture characteristic using the WP4. Online Resource. http://www.decagon.com/appnotes/SoilCurve.pdf

Fuyu M, Junhua L, Mingsi L (1999). Increased yield mechanism drip irrigation under mulch and main coordination techniques. Economic and Environmental Sustainable Development in Middle and Western Region of hina in 21st Century. Inner Mongolia: Inner Mongolia People's Publishing House. pp. 486-490.

Fuyu M, Yisui Y (2002). Cotton drip technology theory and practice under membrane. Urumqi: Xinjiang University Publishing House. pp 8-9.

Fuyu M, Zhiguo Z, Zhong Z, Xurong Z, Mingsi L, Zhengshang L, Weiguo Z, MingLiang X, Dongli X (2004).The development and improvement of drip irrigation under plastic film on cotton. Agric Res Arid Areas. 22(3):202-207.

Honglie S (2002).The primary task and strategy of ecological construction in west China. Bull. Mineral. Petrol Geoche. 21(1): 3-6.

http://agbiopubs.sdstate.edu/articles/FS876.pdf.

http://www.campbellsci.com/documents/apnotes/soilh20c.pdf

http://weather.nmsu.edu/Teaching_Material/Soil252/CHAP9.HTM.

Li S, Xi C, Jun W, An-ming B , Qing Z(2006). The application of automatic control system for drip irrigation under plastic film on cotton farming. J. Arid Land Resources Environ. 20(1):184-189.

Phene CJ, Allee CP, Pierro JD (1989). Soil matric potential sensor measurements in real time irrigation scheduling. Agric Water Manage.16: 173-185.

Qikai W, Jiandong S, Quanjia C, Wen-ying Y, Guojian Z, Sheng-ze Z, Qi C (1998). Studies on different irrigation quota and soil moisture of cotton fields in northern Xinjiang. J. Arid Land Resources Environ. 12(3): 53-57.

Shock CC, Flock RJ, Feibert EBG, Shock CA,. Pereira AB and Jensen LB (2005). Irrigation monitoring using soil water tension. Oregon State University Extension Service.EM 8900 6p. <http://extension.oregonstate.edu/catalog/pdf/em/em8900.pdf>.

Wei W, Yixia C, Zujian Z, Youzhong L, Jianchang Y, Qingsen Z (2005). Effects of low soil water potential on the grain—filling characters and the main quality properties of superior and inferior grains in rice during filling period. Bull. Chin Agric Sci 21(9):170-173.

Xiuzhen L, Decong Z, Jun M, Lina G (2006). Accurate to irrigate and apply fertilizer automatic research of administrative system and realize. J. Soil Water Conservation. 20(5):197-200.

Yalong L, Yuanlai C, Yuan-hua L, Zhichen L (2004). Research on water saving irrigation by using soil water potential as irrigation criterion. J. Irrigation Drainage. 23(5):14-16.

Yingpu Z, Wuquan H, Jian H (2001). Suitable irrigation indexes in different growing stage of corn. J. Irrigation Drainage. 20(4):18-20.

Yi Q, Jun L, Hua Z (2002). The main problem and countermeasures of Water-saving agriculture in Xinjang. Xinjiang Agric Sci. 39(2):128-130.