TECHNOLOGIES FOR PRECISION IRRIGATION IN HOTICULTURE

TEHNOLOGII PENTRU IRIGAȚII DE PRECIZIE ÎN HORTICULTURĂ

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Abstract. *Technologies refers to fixed sprinkler and drip irrigation systems for vegetables in land and glass houses, also for viticulture and urban areas. Its refers also to sprinkler self-propelled installations, used especially for vegetables. Its respond to spatial location needs. Have been analyzed components of regulation systems (sensor types, utilization conditions, controllers, regulation devices), possibility to recover of investments for these equipments, through water economy and water taxes diminishing.*

Rezumat. *Tehnologiile se referă la sisteme de irigație fixă prin picurare şi aspersiune pentru cultura legumelor în spații acoperite şi în camp, plantații vitipomicole şi spații verzi urbane, ca şi la sisteme de irigație prin aspersiune cu instalații autodeplasabile, folosite în special pentru culturile de legume în câmp. Ele răspund nevoilor de diferențiere spațială a regimului de irigație.*

În această lucrare sunt analizate componentele sistemelor de reglare (tipurile de senzori, controlere, dispozitive de reglare), condițiile de utilizare şi posibilitățile de recuperare a investiției pentru aceste echipamente prin economia de apă şi reducerea tarifelor pentru apă.

1. INTRODUCTION

In Prut River land and its adjacent zone were realized before 1989, irrigation arrangements on 75000 hectares approximately, spread in Botosani, Iasi, Vaslui and Galati counties. Also, there are smaller irrigation arrangements in hydrographic basins of Prut River tributaries, which use water from lakes.

Irrigation technology's becomes rapidly increasing, due to reduction consumptions demand in irrigation, by strictly laws relating environmental protection, by climatic changes, institutional reforms etc.

In horticulture's irrigation are used the most performed methods and techniques due to increasing profit in case of vegetables, flowers, orchards and urban recreational zones.

In glass houses and solar as well as in viticulture and orchards there are used either drip irrigation with fixed system or micro-sprinklers. Irrigation in land is done by aspersion as well as in urban areas. In this case the irrigation systems must be fixed with underground devices.

Technological progress for irrigation has as objective: increasing the watering efficiency, improvement of distribution uniformity and reducing water and energy consumptions. In the same time, has been studied and implemented measures for different irrigation scheduling in irrigated areas, tacking into account the differences between texture and hold capacity for water, infiltration and natural drainage capacity.

The aim of paper is to analyze technologies to implement precision irrigation which responds both spatial non-uniformity above indicated and temporal non-uniformity, determined by randomized regime of precipitations.

2. PRECISION IRRIGATION'S CONCEPTS AND THE ELEMENTS OF AUTOMATION SYSTEMS

Precision irrigation is part of precision farming. It induces a certain conception by structuring for irrigation systems and an adequate management of watering. Irrigation scheduling in this case must tack into account by three questions: when must be done a new irrigation rate, what volume of water will be used and where will be distributed.

Irrigation regime is established for different areas from irrigation arrangements related by hydric balance of soil for each of this. This assures major water and energy reduction, avoid over irrigation, leaching fertilizers and pesticides, assures crop enhanced than uniform irrigation, which considers the mean conditions from watering areas.

Precision irrigation needs also automation systems and differentiated technology related to irrigation method and equipments used. In this way are emphasized two situations: a. fixed system for drip and sprinklers and b. sprinkler irrigation systems with mobile self-propelled.

Automation system could be closed or open loop. Automation system's components are: sensors for monitoring of irrigation demands, transmissions cables, and conversion interfaces from analogical to digital signals, controllers or PC, control interface, cables for commands transmitting and local devices for command running. Cables for data transmitting could be replaced using wireless technology.

3. SPATIAL VARIATION IN WATER REQUIREMENTS

In fixed irrigation systems, density, sensors number and cables for data acquisition and transmitting commands, depends by of soil conditions and water table variability. Thus, is necessary an analysis of these before designing of a distribution network (layout) for establishing the sub zones with similar conditions. Each sub zone will have the own sensor and a solenoid valve for turn water on and off. The solenoid valves are placed to entry in tertiary pipes, the water volume being regulated according to opening time of these devices.

In sprinklers irrigation systems with self propelled equipments, this irrigation's method is in incipient stage. Variation's variability in water requirements could be monitorized with fixed or mobile sensors (placed on watering equipments). Signal transmissions from fixed sensors to PC or controller are done through radio waves.

4. SENSOR'S TYPE

The sensors used in irrigation systems directly monitories the soil moisture or plant water status or water consumption through evapotranspiration, staring watering at trigging value [4]. They could be used also to assure feedback of controller when soil moisture is to a certain level and watering stopped. The soil moisture sensors for real time automated irrigation control are: tensiometers, gypsum blocks, Watermark granular matrix and dielectric sensors.

Tensiometers are used only for soil moisture more than -80kPa, thus there are no recommended for clay.

Gypsum blocks could be used if range of water soil tension is from 30 up to 1500 kPa, thus there are no indicated for sands. They are good in case of soils with fine texture, are cheeps but must be replaced yearly.

Watermark sensors determines the electric resistance of soil like gypsum blocks, but offers better precision for a range of soil moisture form 10 up to 200kPa. They could be calibrated related to salinity soil level.

Dielectric sensors through electromagnetic waves, directly determines soil permeattivity, which is correlated with soil moisture. The measurements are in real time continuous, if the sensors are included into the automated irrigation system.

Moisture sensors are layout pair in the same place. The first is placed at the medium of root maximum development depth and it indicates the starting watering. The second one is placed at the bottom of root zone and it indicates the end of watering. The moisture sensors are strictly necessary for management of regulated deficit or partial root zone drying irrigation. Both these management irrigation methods are used in Australian viticulture and they assure majors water economy and an upper production especially from qualitative point of view.

Sensors for physiological plant status are infrared thermometers type or infrared thermocouples [1,2,3]. They are easily to connect at a PC, data logger or controller. Both of them determine the temperature at leafs surface and the environment. Differences between them represents an indicator of water stress used for water scheduling. The triggering value of temperature depends on crops and vegetation phase but for watering starting it must also be defined the daily period in which this value are maintained. For example, in Georgia (USA) this period is up to 5 hours.

Water scheduling based on temperature measurements use crop water stress index (CWSI):

$$CWSI = \frac{(T_c - T_a) - T_i}{T_n - T_i},$$

where: T_c represents the plant temperature;

T_a – environment temperature;

T_n – the difference (T_c-T_a) when plant resistance to water loses is infinite (when stomata are closed thus there are no loses through transpiration);

T_i - the difference (T_c-T_a) when plant resistance to water loses are zero (optimal hydric conditions).

The values T_c and T_a are measured in the warmest day period and the values T_n and T_i are done in literature for each culture.

Other kinds of sensors for physiological plant status are based on radiation measurement on red band (range from 0.61 up to 0.68 μm) and near red (range from 0.79 up to 0.89 μm). With measurements obtained from the two sensors it could be calculated normal difference vegetative index (NDVI), which are closely correlated with leaf area index (LAI).

These together sensors were been used to command precision irrigation at self-propelled pivot center.

Sensors for monitoring evapotranspiration consumption have a large applicability to landscape irrigation. Practically, the meteorological stations are equipped with some kinds of sensors for monitoring of: air and soil temperature, relative humidity of air, insolation or solar incident energy, intensity of active solar radiation, and precipitation. Data from these sensors transmitted to a PC or controller with adequate software are used to compute evapotranspiration, daily hydric balance, and also indicate the watering dates. The controllers calibrate daily water scheduling for each deserved zone related to weather conditions.

The results of evapotranspiation monitoring from a local automated meteorological station could be loaded on a website and then downloaded by the farmers. With these downloaded data, the farmers could realize their own water scheduling. After that, the farmers could transmit the command to the controller through the modem, for turn on or off the solenoid valves. If the irrigation system has the own pumping station, the controller has to manage also this objective. Some municipalities from Italy use the MAXICOM software packages in automated management of irrigation for landscapes, having a PC linked through telephone cables with local control stations.

5. REGULATION METHODS OF WATER RATE

The energy consumption in these conditions is more appropriate to relate at surface unit (hectare):

In case of automated fixed irrigation system with fixed local control station, the water rate is regulated function by opening time of solenoid valves from these stations. Its maximum opening permits to transit a certain discharge.

In case of sands, because of the moisture front advances relative rapidly, the water rate calibration is done by moisture sensors feedback.

In case of irrigated system equipped with self propellers, the water rate is regulating in the first instance through modifying of traveler velocity of equipment because of velocity is inverse proportional with water lay depth.

Thus, the hose self traveler equipment produced by certain firms has controllers which assure: time delay of watering and movement at the ends of irrigated zones, variability of water lay depth on part of watered zone, turn off the water in case of precipitations or strong wind. Into advanced automation stage the controller could receive information from sensors situated on the carriage, regarding physical plant status.

At self propelled center pivot and linear move irrigation system it could be regulated the intensity of irrigation depth too in length of equipment through modify the working regime of sprinklers. Information regarding location of installation to any moment is done by a GPS located at downstream end.

6. PERFORMANCE OF EQUIPMENT FOR PRECISION IRRIGATION

The energy consumption in these conditions is more appropriate to relate at surface unit (hectare):

In table 1 is shown a comparative analyze of possibilities to investment recovery for precision irrigation equipments, considering a specific water volume for irrigation season about 1500 m^3/ha.

Table 1

Possibility to recover of supplementary investment due to precision irrigation through water economy and reduction of water tariff on 10 years

System	**Features**	**Minimum surface of irrigation systems (ha)**	**Specific invest-ment (RON/ha)**	**Water saved (%)**	**Tariff reduction per 10 years (RON/m^3)**		
					ANIF tariff		Urban tariff
					0.15	0.30	1.20
Controller with meteorological station, regulating vanes, cables link (for landscape, vegetables, orchards, viticulture drip or micro sprinkler irrigated)	Regulating valves density						
	1/0.5 ha	15	725	30	675	1300	5400
	1/1 ha	30	580				
	1/2 ha	60	510				
	1/5 ha	150	470				
Controller GPS, infrared sensor of temperature, regulating valves (for self propelled center pivot and linear move irrigation system)	3 regulating valves for each sector of irrigation equipments	40-50	700	20	450	900	3600

Evaluating criteria refers to costs, to monitoring and regulating precision, to feasibility and length of service, to maintain service, to water and energy economy and increased production realized.

Previous experiments and evaluating shows precision irrigation assures great water economy, especially for vegetables [5]. Thus, for tomatoes in Florida (USA), using tensiometers placed at 15 cm depth in sand soil and set for starting watering for retaining water tension about 10 and about 15 kPa, it was reduced the water consumptions without effect on production. In the same conditions a irrigation controller associated with a dielectrical sensor transiting electrical signals correlated with soul humidity, achieved a reduction of water consumption about 70 % at tomatoes drip irrigated.

CONCLUSIONS

Precision irrigation has more and more applicability to fixed drip and sprinkler irrigation systems but also to self-propelled irrigation systems.

There are many types of sensors who monitoring either soil moisture, either plant water status or evapotranspiration. They are the most important elements into automated system. Their choice taking into account by: soil and cultures conditions, accuracy and speed to sensing of monitorised factors variation, easy to install, in situ calibration needs, operation and maintenance, costs etc.

The actual technology for precision irrigation use computers and controllers with adequate software, which realize the irrigation scheduling for a large variety of soils water ground and cultures conditions.

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