IRRIGATION SYSTEM AND WATER USAGE AUTOMATION

AUTOMAÇÃO DO MANEJO DA AGUA NOS SISTEMAS DE IRRIGAÇÃO

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ABSTRACT

This automation system uses feedback on photosynthesis, the dynamics of soil water, weather and environmental conditions to control the application of water in a way that uses natural water only when it is needed to irrigate a portion of land (crop) thereby ensuring a high efficiency of water use.

Based on these parameters, the Photosynthesis System was developed. It is integrated by a micro processor which operates by using solar energy. It consists of a photovoltaic panel, a solar light sensor, a soil moisture osmotic sensor, a relative temperature and humidity air sensor and a rain sensor.

The performance of this system is controlled by a software - developed only with this purpose- that reads the digital signals given by the sensors, conditioning the water consumption of the irrigation systems produced by the plants during the photosynthetic processes in accordance to the air and soil moisture conditions in the absence of precipitations.

This project promotes reduction in water and energy consumption during the irrigation process and augmentation of water and crops productivity. It avoids soil saturation of the root zone, water depletion in the roots, leaching of soil nutrients and salinization and desertification of fertile areas. And finally, it provides resources for crops vitality, improves agricultural production and protects underground springs.

Key words: *Irrigation, Automation, Sensors, Micro processor, Photovoltaic, Brazil.*

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RESUME

Ce système l'automatisation utilise les commentaires sur la photosynthèse, les dynamiques de l'eau du sol, les conditions météorologiques et environnementales pour contrôler l'application d'eau d'une manière qu'il utilise l'eau naturelle quand elle est nécessaire pour irriguer une partie des terres (cultures) tout en assurant une haute efficience d'utilisation de l'eau.

Le système de photosynthèse a été développé compte tenu de ces paramètres. Il est intégré par le micro-processeur qui fonctionne en utilisant l'énergie solaire. Il se compose d'un panneau photovoltaïque, un détecteur de lumière solaire, un détecteur d'humidité osmotique du sol, un détecteur aérien d'humidité et de température et un détecteur de pluie.

La performance de ce système est contrôlée par un logiciel - développé uniquement à cette fin - pour étudier les signaux numériques des détecteurs, traitant la consommation d'eau des systèmes d'irrigation produite par les plantes lors des processus de photosynthèse conformément aux conditions d'humidité de l'air et du sol dans l'absence des précipitations.

Ce projet vise à réduire la consommation d'eau et d'énergie lors du processus d'irrigation, et à augmenter la productivité de l'eau et des cultures. Il évite la saturation de la zone racinaire des sols, l'épuisement d'eau dans les racines, le lessivage des nutriments et de la salinisation des sols, et la désertification des zones fertiles. Finalement, il fournit la vitalité aux cultures, augmente la productivité agricole et protège les sources souterraines.

Mots clés: *Irrigation, automatisation, détecteurs, micro-processeur, photovoltaïque, Brésil.*

1. INTRODUCTION

Water is a finite and vulnerable resource, essential for life and environment conservation and development. Among its multiple users, agriculture is the one that consumes the most. Of the total volume of water used in agriculture, just a minor part is effectively used by the crops (2 to 3%); the rest is wasted due to deficiencies in the irrigation facilities, negligence on operations or simply the inadequate control on water application and use.

As an aggravating factor, there is a habit or a wrong idea of irrigating plantations at night because people believe that without evaporation and cold soil, water is being economized. Besides, there is a big grant of electrical energy developed in some countries when used at night for irrigating. The excessive use of water in the irrigation systems promotes leaching of the soil nutrients contributing with the desertification process of fertile areas and pollution of underground potable water resources. Because of this, a radical and real change is necessary in terms of water usage when irrigating. In response to this situation, a self operated system that controls the efficient usage of water during the irrigation process was developed in Brazil. This system, based on photosynthesis, the dynamics of soil water, weather and environmental conditions, allows reduction in water and energy consumption during the irrigation process, augmentation of water and crop productivity, and avoids soil saturation of the root zone, water depletion in the roots, leaching of soil nutrients and salinization and desertification of fertile areas. Over all, it provides resources for crops vitality, improves agricultural production and protects underground springs.

2. PHOTOSYNTHESIS

Plants can be considered a thermal machine which uses the phenomenon and reactions of nature for their survival, growth and production; mainly through the photosynthesis phenomenon and the reactions of the water dynamic and soil nutrients.

The energy is provided by the sun and used by the plants to carry out the chemical processes of photosynthesis, synthesizing the organic material of the plants by the conversion of the atmospheric carbon dioxide in to plant food and absorbing nutrient solutions in the soil through the roots. Nutrient uptake by the roots is driven by osmotic pressure differential caused by evapotranspiration from the plant leaves promoted by the heat from the sun and atmospheric conditions of relative humidity, air velocity, etc.

When there is an excess of nutrients in the soil and little water, the solution of soil will be more concentrated than in the plants, and the plants will perish due to draining its water into the soil. On the other hand, if there were excess of water and little nutrients in the soil, the plants will absorbed big amounts of water without getting the nutrients they need and as a consequence they will have a reduced growth as well as a poor production. The balance between the solar radiations, the water content in the soil, the nutrients, the air, are of vital importance for the obtaning good yields.

3. WATER DYNAMICS IN THE SOIL

The water and mineral salts are constantly moving. They emigrate from the areas of minor gradients to those of higher gradients until they are balanced. This way, during higher temperatures in summer, the roots take water and nutrients from the soil which is around the plants and at night, when they stop absorbing water, the soil tends to get standardized again to balance the concentration gradient. Because of this, it can be said that plants promote the movement of water and nutrients in the soil.

Normally, gravity and surface tension create a balance: when gravity pushes the water down the force of surface tension tends to retain the water in the same place. In this way, when the roots absorb moisture from the soil, they create an energy gradient, and the water from the neighboring regions migrates to the homeostasis resumption of the system, provoking a change of moisture to the root area. These movements are slow. In this sense, there can be lack of moisture in the root region during the peak times of transmission, through the contiguous area may have high moisture. An efficient irrigation system should always begin as long as the root area be susceptible to start in the temporal stress level, which normally occur during the times of high temperatures.

From these factors, two important aspects must be highlighted: **the ferti-irrigation:** must be done in the late afternoon, because plants stop absorbing water from the soil at night, it means that when there is no energy necessary for this, there will be enough time to balance the system through the movements of the soil nutrients and as a consequence the compost can be spread better. **Irrigation:** if it is the system chosen, it is more efficient right before the beginning of the photosynthetic processes, in such way that, when they start plants can

already be humid in the root region. And during the high temperature moments of the day, they can avoid temporary water failure in the root area.

The irrigation process is efficient when it uses the disposable water in such way that keeps the soil moisture at an optimal level. There would be two options: **Excess water:** if there would be no limits when using water for irrigating, there will be more areas without irrigating with the same quantity of water. **Lack of water:** plants will not develop all their potential.

To obtain a good control of the soil moisture, it is necessary to have some devices that indicate the values obtained and irrigation programs based on these controls. Taking this into consideration, an efficient control of moisture it will be seen that the cycles of irrigation vary much in space and time, and also the amount of water used in every cycle.

The conventional irrigation system is characterized for having a definite irrigation cycle with a permanent and predetermined quantity of water to be used. This procedure produces lack of moisture during the peak evapotranspiration times and excess of water in the periods of lower evapotranspiration.

4. CLIMATIC ASPECTS

During the night the stomata are closed and the leaves do not transpire. Meanwhile, the roots keep producing the pressure that pushes the water up, and a small quantity of water goes out through the leaves to relief the excess of pressure. If the environment is wet some drops around the leaves can be observed; this is called guttation. Such process is of minor importance.

When there is not enough water in the leaves, their internal water pressure diminishes, forcing the stomata to get closed partially or completely. This is a self-defense mechanism of the plants against water deficit.

High temperatures, wind, and low atmospheric humidity accelerate the evapotraspiration process. During the periods under such conditions, there should be more attention to the plants in terms of water necessity. Even though, there was enough water in a piece of land, it could not reach the leaves rapidly via the roots. Thus, a humid microclimate should be created around the plants. The key to succeed in terms of water usage is to have an optimum moisture soil during critical periods of absorption of the plants.

An efficient management is characterized by releasing differentiated quantities of water at intervals between the cycles and time cycles different in each situation.

5. PROPOSAL

The system presented acts using phenomena and reactions from nature to control the dispensation of water in a way that it only allows taking out the necessary amount of water from the environment for irrigating, in the right moment on the plantations. This system is based on the essential principles of the plant life, which ensure the water use efficiency: Photosynthesis, Water dynamic in the soil and Weather and environmental conditions.

Based on these parameters, the Photosynthesis System was developed. It is integrated by a micro programmable processor which operates by using solar energy; in turn, it consists of a photovoltaic panel, a solar light sensor, a soil moisture osmotic sensor, a relative temperature and humidity air sensor and a rain sensor.

The photovoltaic panel provides the necessary energy which makes the system work; the light sensor prevents the application of water during the night, and it has the capacity to detect when the solar radiations begin allowing the water application before the photosynthetic process starts. The osmotic moisture sensor, compatible with the permeability of each type of soil, indicates humidity in the root region. The temperature and relative air humidity sensor indicates the atmospheric conditions and inhibit the application of water in high temperatures when the stomata are closed and the rain sensor identify the rainfall.

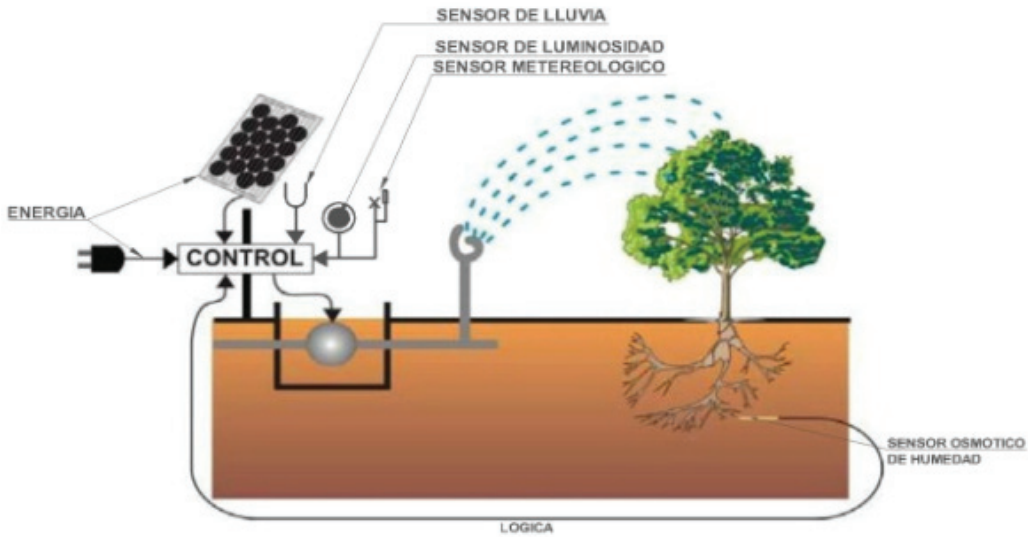

Fig. 1. Photosynthesis system schematic drawing (Detalhe esquemático do sistema fotossintético)

This system is intended to provide automation in the irrigation process to guarantee the proper distribution of water on the selected crops, assuring the efficiency of each drop of water used.

The performance of this system is controlled by a software-developed only with this purpose- reads the digital signals given by the sensors, conditioning the water consumption of the irrigation systems produced by the plants during the photosynthetic processes in accordance to the air and soil moisture conditions in the absence of precipitations.

The system has digital outputs for monitoring and transferring data, in a direct or indirect way (wireless); that allows the driving of pumping sets for the ferti- irrigation and /or pressurized irrigation systems.

The technological difference contain in this system, relies on the self operating modality which promotes an interaction between atmospheric and environmental conditions and

the adequate distribution -according to needs-of water on the crops without human interference.

The prototype of the system, developed by AGC- Eletroeletronica (Brazil- 2004) was experimentally tested in one sprinkler irrigating system in "Fazenda California, Se-Brazil, 2005-2006" property; in the yields shown in Table 1 during the phases of: transplanting, growing and production, where production of 40% percent in the consumption of water was verified.

Table 1. Results obtained extrapolated to 1000ha (resultados)

Crops	Water consumption per year (m^3/ha)	Energy consumption per year (Kw/ha)	Water consumption per year in photosynthesis (m^3/ha)	Energy consumption per year in photosynthesis (KWh)/m^3
Rice	19.862	2.599	11917	1559
Melon	11.896	1.556	7138	934
Watermelon	11.729	1.535	7037	921
Grape	10.624	1.390	6374	834
Vegetables	10.288	1.346	6173	808
Tropical fruits	9.679	1.266	5807	760
Potato	6.176	808	3706	485
Corn	6.057	793	3634	476
Tomato	5.900	772	3540	463
Onion	5.348	699	3209	419
Garlic	4.870	637	2922	382
Beans	4.573	598	2744	359
Wheat	3.640	476	2184	286
Soybean	2.824	370	1694	222

Source/Fuente: PLANVASF, 1989.Brasil (x1000ha)

The reduction of water consumption obtained allows expanding the irrigated area in the same proportion increasing the current production of food significantly, with the same amount of water that is taken from the environment.

6. CONCLUSIONS

This proposal promotes reduction of water and energy consumption during the irrigation process, the augmentation of water and crop productivity, avoids soil saturation of the root zone, water depletion in the roots, leaching of soil nutrients and salinization and desertification of fertile areas, provides resources for crops vitality, improves agricultural production and protects underground springs.

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