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SMART SOLUTION FOR A GREENHOUSE WITH CONTROLLED BIOCLIMATE

Claudiu Ioan RATIU, Camelia Ioana UCENIC

Abstract: *The field of agricultural production became agro-industrial along with the evolutions and revolutions produced in the industrial environment. The spectacular developments produced in the last decades in the fields of informatics (hard and soft), sensors and data processing, chemistry and biochemistry or genetics, have begun to be transferred successfully and with spectacular effects in the agro-industrial environment. This is how applications have appeared, materialized through vegetable production farms with controlled microclimate, whose level of technology and especially computerization successfully competes with top applications in the industrial environment. All these are the result of effective collaboration and communication between specialists from apparently incompatible fields such as: agronomists, biologists, geneticists, hydraulics, automatists, and computer scientists*
Key words: *adaptive control, microclimate, integrative solutions, interdisciplinarity*

1. INTRODUCTION

Water resources management is an integrative concept for several subfields such as hydro energy, industrial water, domestic water, environment, irrigation, etc. An integrated perspective of water resources has economic, social, environmental, and technical-technological dimensions.

The spectacular evolutions produced in the last decades in the fields of informatics (hard and soft), sensors and data processing of chemistry and biochemistry or genetics, have started to be applied successfully and with spectacular effects in agricultural production. Thus, appeared applications materialized in plant production farms whose level of automation and especially computerization successfully compete with the top applications in the industrial environment.

These types of applications have incorporated a very high degree of computerization and autonomy, being able to function indefinitely without human intervention. The system contains pressure, clogging, pH, electro-chemical sensors, which provide information to a controller that, based on a dedicated program, filters and restores the properties of the water. In addition, the system self-diagnoses and maintains itself. Such water preparation systems have started to be currently used in agricultural and industrial applications [1], [2].

The big manufacturers of water equipment have also put on the market automatic dosing systems for liquid substances, which are basically the "kitchens" of agricultural plantations that automatically dose, based on the information received from electro-chemical sensors, the content, and proportions of nutrients. At this moment, an application with a medium level of complexity for equipping a "smart" greenhouse looks like the block diagram shown below.

These results are the effect of an efficient collaboration and communication between specialists from seemingly distant fields such as: agronomists, biologists, geneticists, plumbers, and computer scientists.

Also, the climate changes felt in our country lead to the re-evaluation of the strategies in the field and this confirms the opportunity of this research project.

2. HOW THE SYSTEM WORK

In this material, an autonomous system of irrigation and fertilization is analyzed. Three component parts are identified here (see fig.1):

- *Water management unit.* This unit fulfills two functions, it ensures the necessary flow of water, and it ensures water filtration. The peculiarity is that the filter system works in self-cleaning mode.
- *Nutrients/chemicals management unit.* The big manufacturers of water equipment have also put on the market automatic dosing systems for liquid substances, which are basically the "kitchens" of agricultural plantations that automatically dose, based on the information received from electro-chemical sensors, the content, and proportions of nutrients.
- At this moment, an application with a medium level of complexity for equipping a "smart" greenhouse looks like the block diagram shown below.
- *Soil management unit.* This part of the system is composed of a network of distribution pipes, drip lines, vent valves and distribution valves. All effects found in the soil are "read" by translators. This is how humidity, electroconductivity and pH are measured [3].

These three component parts with well-defined functions and mentioned above can work autonomously, according to their own cyclorama. But for an integrated application, the supervisor level ensures the optimization of their operation. This optimization results in the minimization of the stress factors that act on the plants [2].

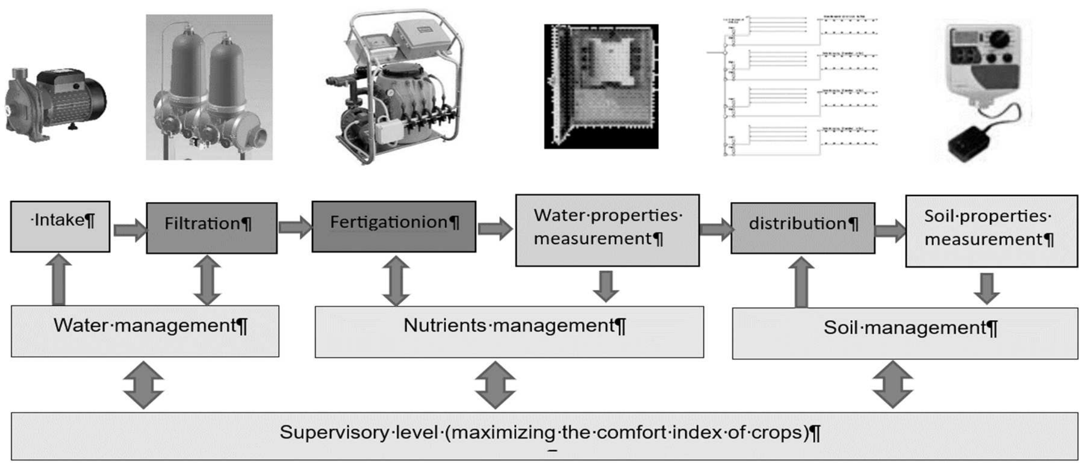

Fig.1. Diagram of the system

3. THE SELF-CLEANING FILTERING SYSTEM. WATER MANAGEMENT

The self-cleaning filter is a type of filter that uses the system's own pressure to clean itself. Removes unwanted particles or dirt by automatically performing the water treatment process. It provides continuous filtering without stopping the process. They clean themselves without the need for manual cleaning [4], [5.]

Certain properties such as reduced contamination, improved quality output, system cleanliness, least disruption to product flow, minimal product loss during production, minimal chance of injury and friendliness. The market has seen growth in the Asia-Pacific region due to various applications such as water treatment, wastewater treatment, food processing, and others. The growth of the market is due to the increase in the use of self-cleaning filters for various applications in sectors such as automotive, food and beverages, energy and power, and others. [6], [7].

Day-by-day increase in water pollution is causing an increase in demand for the self-cleaning filter market. Waste management systems in many economies are followed by rapid urbanization which in turn leads to demand for clean water. The improved quality, low maintenance, reduced contamination, and environmentally friendly nature of the filters are at the fore. A self-cleaning system minimizes clogging of the waste treatment piping system [8], [9].

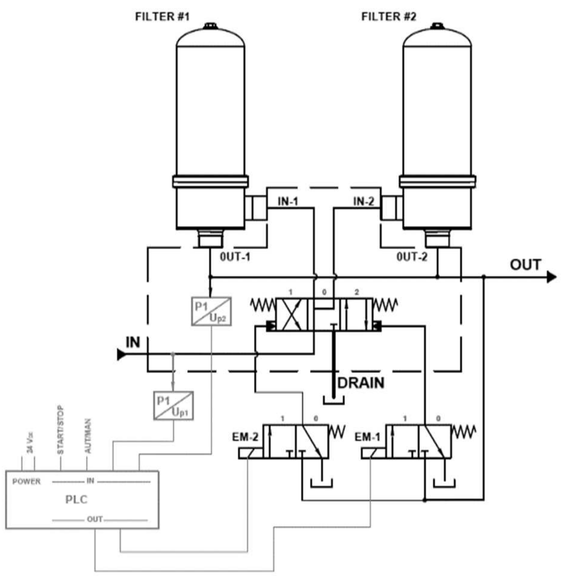

Fig.2. Hydraulic diagram of the filtering system

Based on the diagram, the mode of operation can be described: the fluid to be filtered reaches the two filters that operate in parallel. The fluid is accessed through two solenoid valves, one for each filter. Normally the two filters work in parallel [10].

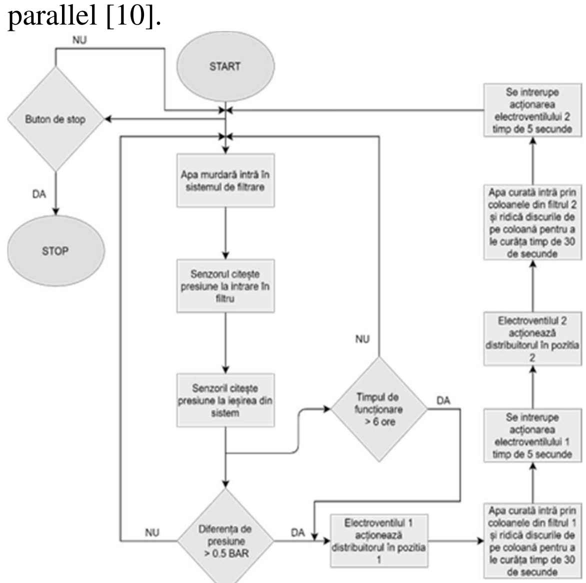

Fig.3. Filtering system. Logical scheme of operation

The clogging (fouling) state is detected by a differential pressure transducer whose signal transmitted to a controller triggers a self-cleaning cycle.

At this point the EM1 solenoid valve switches filter # 1 to self-cleaning mode and filter # 2 continues to filter and supply water to the system. Some of the filtered water is used to clean filter # 1. After a period, the EM1 solenoid valve switches to the idle state and filter # 1 returns to the filtering mode. Then the PLC activates valve EM2, and it passes filter # 2 to the self-cleaning state [11].

After a period, the EM2 solenoid valve switches to the idle state and filter # 2 returns to the filtering mode.

Furthermore, the two filters will operate in parallel until the differential pressure transducer announces the level of clogging that requires cleaning.

The description of the operation of the filter is represented synthetically and suggestively in the diagram in figure 2.

The next step is to develop a PLC program according to the above diagram. ¶

4. NUTRIENTS MANAGEMENT. THE FERTIGATION SYSTEM

Excessive and incorrect use of fertilizers in agriculture leads to large runoff into groundwater and harmful effects on the environment.

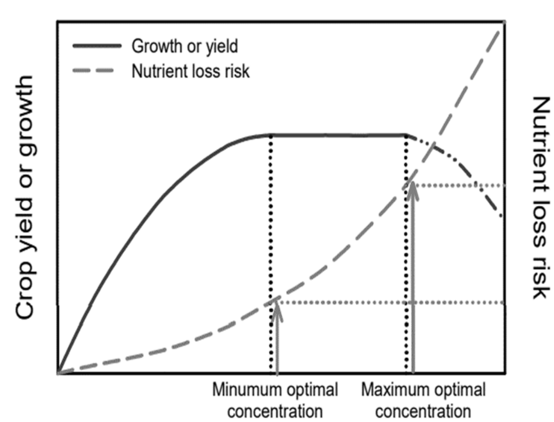

Fig.4. The effect of nutrients concentration

The main objective of this module is to optimize fertilization scheduling for a surface micro-irrigation system in different soils.

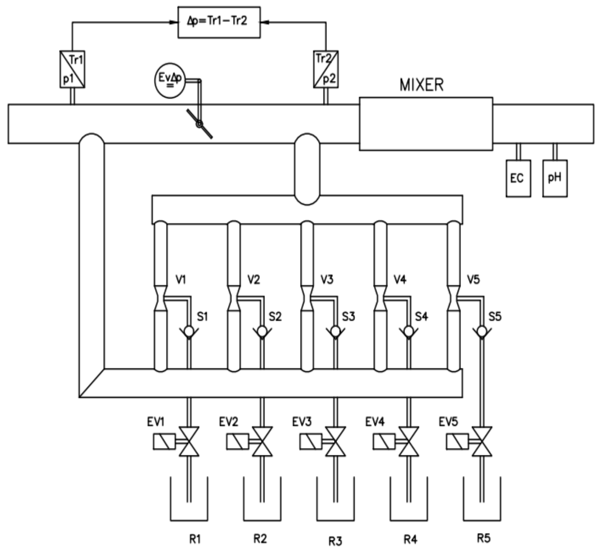

Fig.5. Hydraulic diagram of the fertigation system

The relationship between crop growth (or yield) and soil nutrient concentration in the root zone. Maintaining the optimal minimum concentration of nutrients allows reducing the risk of nutrient loss without affecting the products and quality of the crops, as highlighted in the diagram in figure 4 [12].

Excessive and incorrect use of nitrogen (N) phosphorus (P) potassium (K) fertilizers in agriculture leads to high leaching of nitrates into groundwater and harmful effects on the environment.

The main objective of this research was to optimize fertilization scheduling for a surface micro-irrigation system.

The irrigation water that reaches the roots of the plants through the distribution network is used as a transport vehicle for nutrients.

Venturi tubes were used to introduce nutrients into the irrigation water, which is under pressure (usually 5 bar). To increase the dosing precision of the mixed nutrients, the pressure drop on the Venturi tubes is permanently corrected through an automatic adjustment loop. This acts on a flap that adjusts the passage section on the main circuit [13].

The designed fertilization module contains 5 Venturi tubes that ensure the following mixes (fig. 5):

- three tubes mix the main nutrients, namely nitrogen, phosphorus, and potassium solutions.

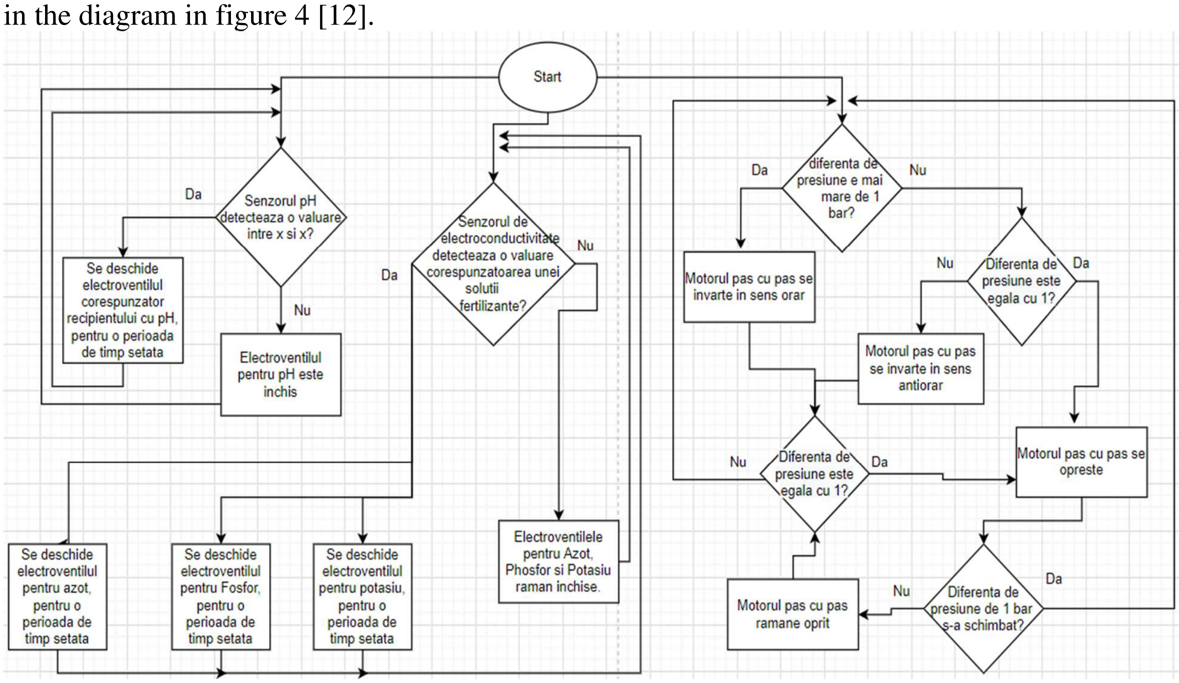

Fig.6. Fertigation system. Logical scheme of operation

- A tube mixes a diluted chlorine solution that aims to sanitize the distribution network.
- A tube mixes a solution whose purpose is to maintain the pH within the recommended limits.

The mixing of nutrients and maintenance substances is done according to the information received from the chemical sensors. These sensors are incorporated in automatic adjustment loops.

Practically, this logical scheme represents the decisions of an agronomist engineer for the presented application and represents the preparatory stage for the implementation of artificial intelligence [14].

This fertilization module with Venturi tubes (fig.

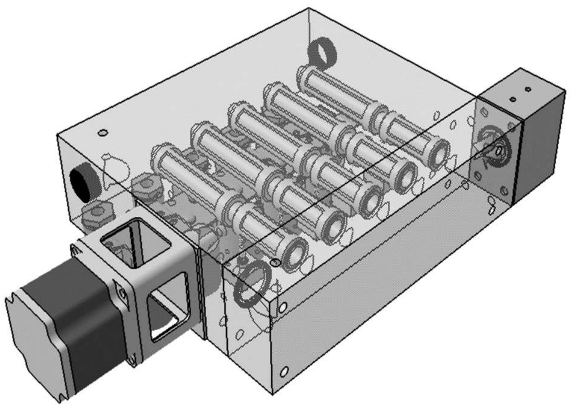

Fig. 7. 3D view of the fertigation system

7) has been dimensioned, designed, made and is in the testing stage.

5. SOIL MANAGEMENT

The whole assembly includes three systems. The water management systems and the nutrient management system were described.

The third is the soil management system (fig. 1).

This system operates on two levels:

- Distribution of water with or without nutrients in the mixture. The distribution is carried out through main pipes connected by solenoid valves and a network of secondary pipes on which drippers with controlled flow are positioned.

The electro valves ensure the distribution of water on different land surfaces depending on the information transmitted by humidity transducers. The algorithm by which the solenoid valves open or close are controlled by a PLC.

- acquisition of information provided by physical and chemical sensors. This information goes to the water management system and to the nutrient and maintenance substance management system [15].

6. SUPERVISORY LEVEL

The three systems that make up the whole assembly can work independently, but in applications they are always found together.

Connecting the systems is done on two levels:

- on the water circuit: pump, filters, fertilizer and,
- on the information flow provided by the transducers.

The filtration system has clogging transducers that provide information to the system to ensure operation in the automatic cycle of the self-cleaning process.

The fertilization system consists of pH, pressure and electroconductivity (EC) transducers.

The soil management system has moisture transducers and chemical transducers.

Connecting to the information flow provided by the translators has the effect of optimizing the functioning of the entire system so that the stress factors acting on the plants are reduced to the maximum possible [9].

7. CONCLUSION

If the objective needs of technology, for the alignment with efficient and ecological standards, but also the pressure generated by climate changes require taking measures, even these should be taken into consideration of the cause and based on as objective and complete information as possible so that the effects are the desired.

The topic successfully fits into this context because it aims to make contributions in the field of technology improvement, deeper understanding of phenomena and interactions, early and correct identification of risk factors, their modeling/simulation, respectively it can lead to the improvement of production, quality and the safety of agri-food products.

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SOLUTIE INTELIGENTĂ PENTRU O SERĂ CU BIOCLIMAT CONTROLAT

Rezumat: Domeniul producţiei agricole a devenit agroindustrial odată cu evoluţiile şi revoluţiile produse în mediul industrial. Dezvoltarile spectaculoase produse in ultimele decenii in domeniile informaticii (hard si soft), senzorilor si prelucrarii datelor, chimiei si biochimiei sau geneticii, au inceput sa fie transferate cu succes si cu efecte spectaculoase in mediul agroindustrial. Așa au apărut aplicații, concretizate prin ferme de producție legumicolă cu microclimat controlat, al căror nivel de tehnologie și mai ales informatizare concurează cu succes cu aplicațiile de top din mediul industrial. Toate acestea sunt rezultatul unei colaborări și comunicări eficiente între specialiști din domenii aparent incompatibile precum: agronomi, biologi, geneticieni, hidraulici, automatiști și informaticieni.

Cuvinte cheie: control adaptiv, microclimat, soluții integrative, interdisciplinaritate

Claudiu Ioan RATIU, professor, Technical University Cluj-Napoca, Department of Design Engineering and Robotics, claudiu.ratiu@muri.utcluj.ro , +40 264 40 1648, Aleea Micus, nr. 2/39, Cluj-Napoca, RO, +40 745 610 963.

Camelia Ioana UCENIC, associate professor, Technical University Cluj-Napoca, Department of Management and Economic Engineering, cameliaucenic@gmail.com , +40 264 41 5374, Aleea Peana, nr. 3/60, Cluj-Napoca, RO, +40 753 957 436.