CONSIDERATIONS CONCERNING THE AUTOMATION OF PROTECTED SPACES

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ABSTRACT

In the last period there is an intensification of the researches oriented towards the automation of the specific activities of the horticultural production in protected spaces. The greenhouses offer a shelter in which a microclimate suitable for plants is maintained, which is obtained by regulating / adjusting the heat and the amount of light coming from the sun, by means of actuation systems (actuators-technical devices that generate an action to reach a specific objective). The paper presents a brief communication on the main drive systems used in greenhouses: ventilation and cooling systems; heating systems; irrigation systems, whose drive systems are mainly composed of electrical devices, especially electric motors or pumps.

INTRODUCTION

Agriculture in protected areas undergoes an advanced transition determined by the advances of precision technology, data processing and intelligent agriculture (De Vleeschouwer, 2001).

Protected crops are grown in greenhouses with simple structures covered to real plants using advanced technologies that optimize plant productivity and human labor (Dumitraşcu et al., 2013).

A modern greenhouse functions as a system, therefore it can also be called agriculture in a controlled environment (CEA- controlled environment agriculture), plant production system with controlled environment (CEPPS- controlled environment plant production system) (Enoch and Enoch, 1999).

These structures use natural or artificial light under which optimal growth conditions are provided for the production of horticultural crops or for plant research programs. Experimental research has concluded that they also offer higher predictability, reduce production costs and increase crop production (Cuce et al., 2016; Muijzenberg, 1980; Woods and Warren, 1988).

The United Nations has predicted that by 2050, over two-thirds of the world's nine billion people will live in cities. Ensuring the supply chain of fresh fruits and vegetables in this new scenario will be an overwhelming challenge (Ponce et al., 2015).

If properly designed, managed and operated, CEA can significantly contribute, in this context, to the year-round production of fresh vegetables in urban areas. In order for such a system to operate successfully and achieve its production goals, attention must be paid to the technical aspects of automation (A), culture (C), environment (E) and system (SYS) (Shamshiri et al., 2018).

The research trends in this field are aimed at innovative methods for the transition from conventional greenhouses to controlled intelligent environments, which benefit from natural resources for eliminating harmful external conditions. The ultimate goal in this regard would be to achieve high productivity, as well as obtaining high quality vegetables and fruits at the lowest possible cost (Ting et al., 2016).

Innovations in the field of energy-saving sensors, communication devices, data processing and mobile applications, together with technological advances in the design of structures, simulation models and those related to engineering, have provided the most modern technologies for CEA.

MATERIAL AND METHOD

In greenhouses, it is intended that the tasks of carrying out crop maintenance work will be reduced, mitigated or human work replaced by intelligent equipment.

In the horticultural industry, the state of the art in the field of greenhouse automation must largely resemble the automation commonly encountered in the industry: machines based mainly on mechanical solutions capable of performing exactly the same task several times (seeding, transplanting, automatic spacing, grafting, spraying, sorting and sealing).

Various data acquisition platforms were used to improve the production performance of greenhouses.

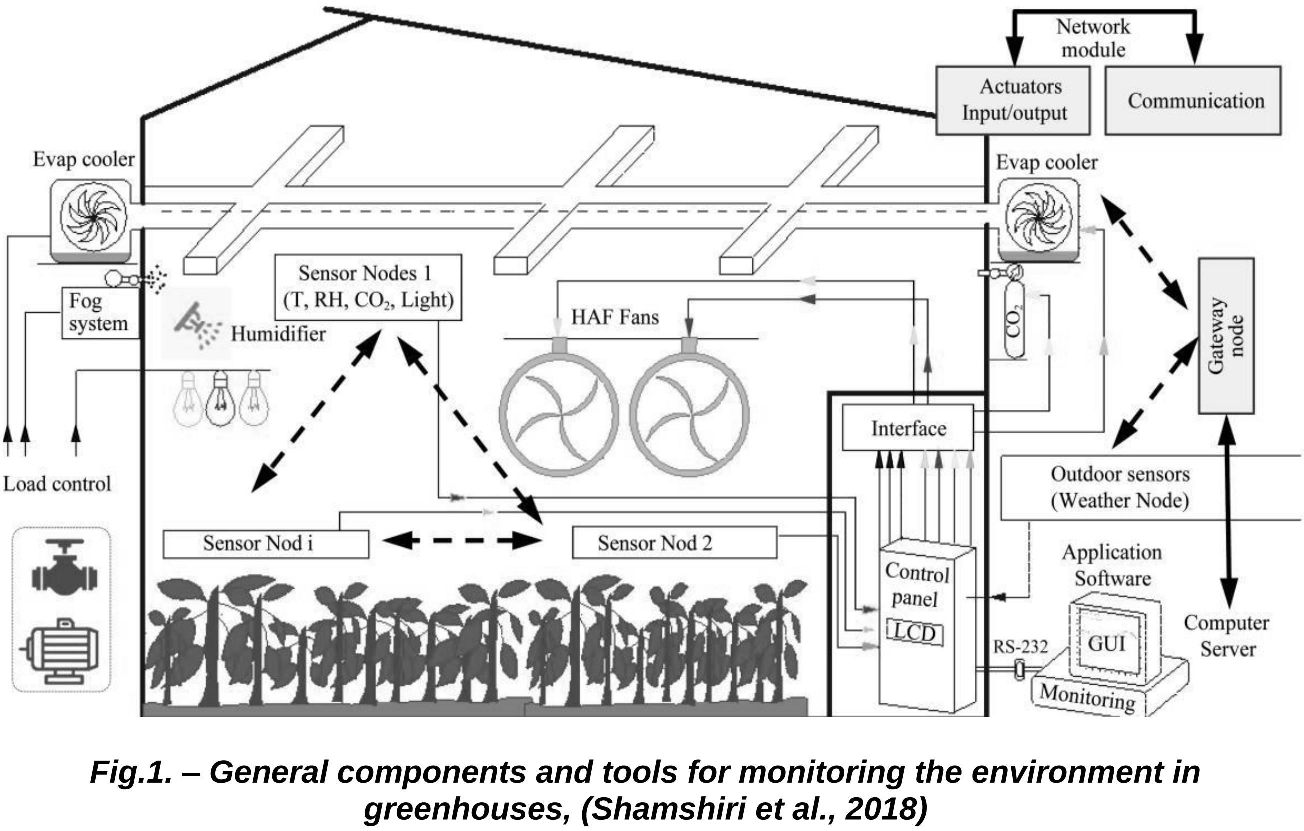

Fig.1. – General components and tools for monitoring the environment in greenhouses, (Shamshiri et al., 2018)

An effective greenhouse requires environmental control for air quality, disease reduction, pest control and nutrient and water uptake.

The inputs and outputs of a greenhouse are shown schematically in Figure 2.

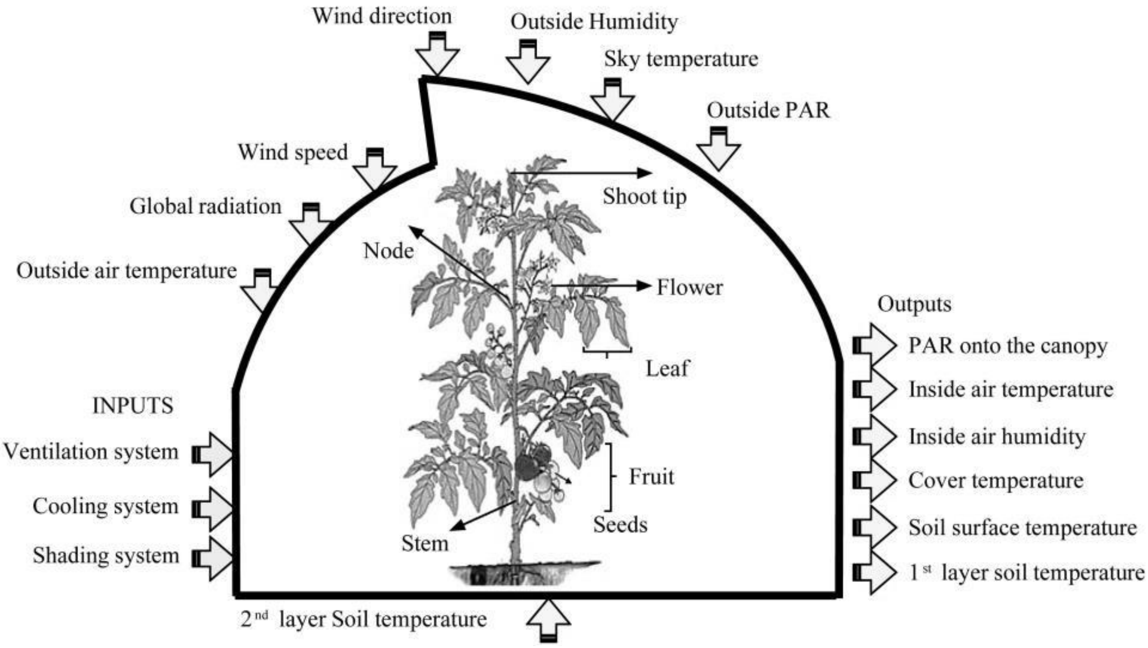

Fig.2. – Inputs and outputs regarding the development of agriculture in protected areas, (Shamshiri et al., 2018)

Potential greenhouse applications can be presented in several configurations.

The general components of environmental monitoring of greenhouses based on the wireless sensor network are illustrated in Figure 3.

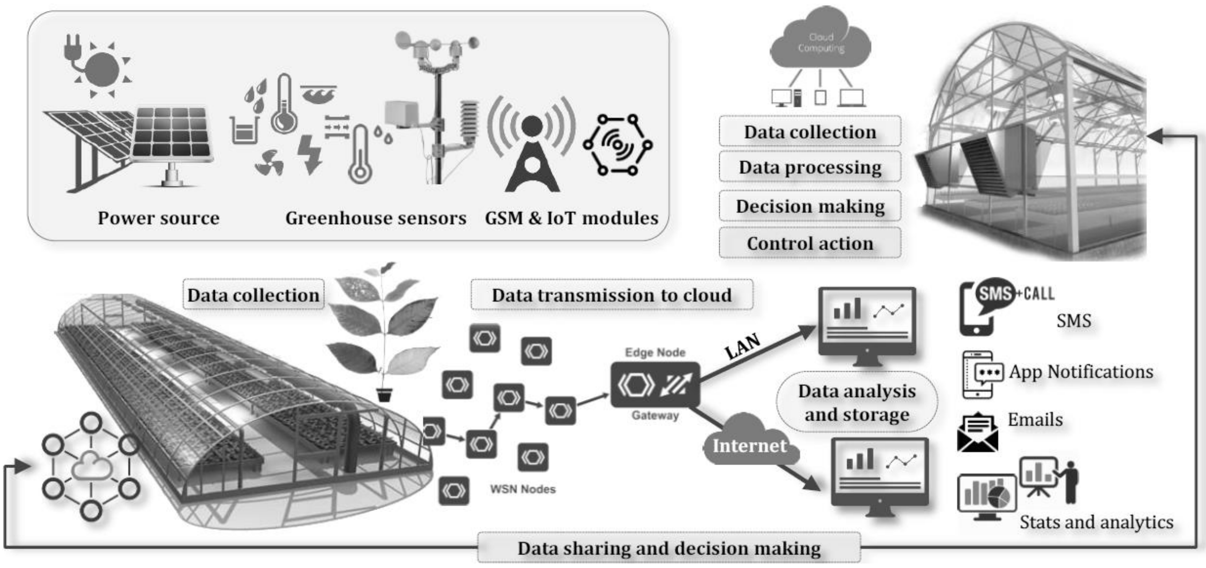

Fig.3. – General components of a greenhouse environment monitoring based on the wireless sensor network, (Shamshiri et al., 2018)

The main approaches for controlling the level of light and light radiation consist of controlling the density of plants, shading screens and artificial lights.

Light and air temperature are the two most important environmental factors that influence the growth of plants.

RESULTS AND DISCUSSIONS

Ventilation is the process that allows fresh air to enter a closed area by removing the air with inappropriate properties.

In the case of greenhouses, ventilation is essential for temperature reduction, CO_2 refueling and relative humidity control.

The ventilation requirements for greenhouses vary widely, depending on the cultivated crop and the season of production.

Usually, greenhouses that are used seasonally use only natural ventilation.

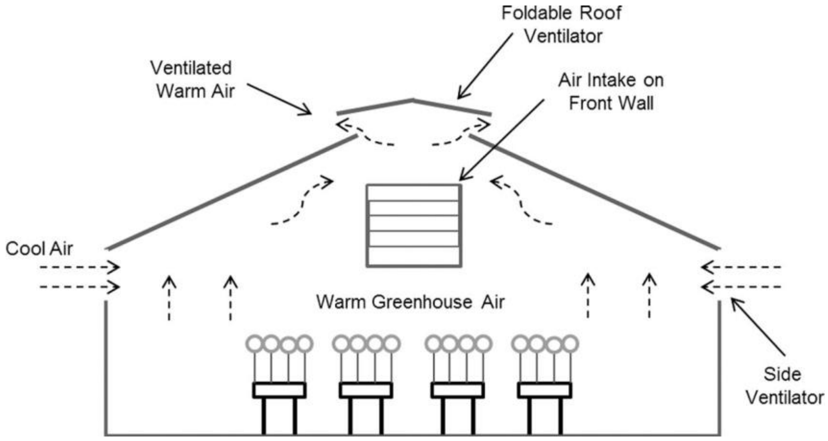

Fig.4 – Passive cooling system (natural ventilation), (Ponce et al., 2015)

The plate cooling systems shown in Figure 5 consist of fans positioned at one end of the greenhouse and a pump that circulates water through a porous plate installed at the opposite end of the greenhouse.

If all air vents and doors are closed when the fans are on, the air is circulated through the damp porous plate and the water evaporates.

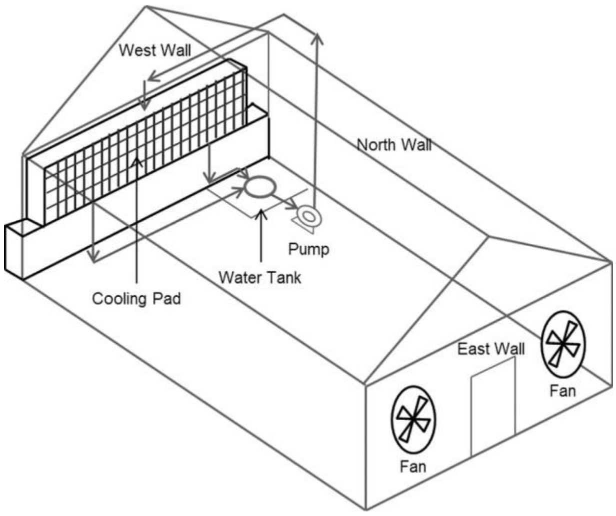

Fig.5. – Cooling systems buffer plate, (Ponce et al., 2015)

The air will have the lowest temperature immediately after passing through the buffer system (porous plate). As the air moves through the greenhouse through the fans, it receives heat from the plants and soil, and the air temperature will gradually increase.The result is a temperature gradient in the greenhouse, the part of the plate system being cooler and the part of the fan warmer.

Fig.6. – Cooling plate, (Ponce et al., 2015)

Convection-tube cooling. An exhaust fan, located anywhere in the greenhouse, is turned on to create a vacuum. Cold air comes in through a hatch on the roof of the greenhouse as a result of vacuum. A fan at the end of the convection tube is actuated to lift cold air entering the tube, which has openings at distances between 0.3 to 0.6 m. Cold pressure air in the convection tube creates on both sides of the turbulent jet convection tube. The cold air mixes with the warm greenhouse air above the height of the plants. The cold air mixture, being harder, falls slightly on the greenhouse floor, cooling the plant area.

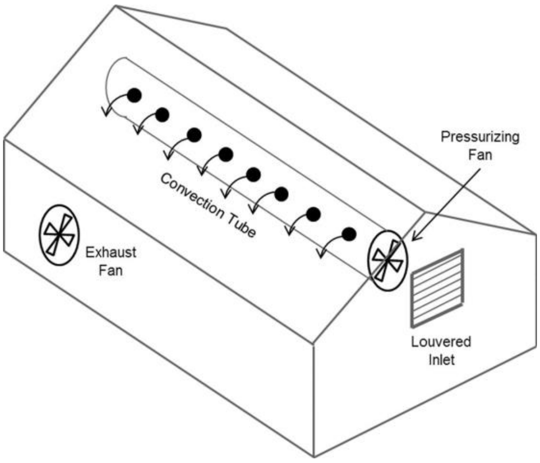

Fig.7. – Convection-tube cooling, (Ponce et al., 2015)

Heating of greenhouses is necessary in cold weather, when the existing heat is not sufficient for the growth of plants during the night.

The heating system must provide heat in the greenhouse at the same rate as lost through conduction, infiltration and radiation.

There are three types of greenhouse heating systems:

➢ Unit heaters - In this system, the hot air is blown from heating systems that have independent fire sources. The heating systems are located throughout the greenhouse, each heating an area between 186 and 558m^2. These heating systems consist of three functional parts:

- fire source;
- heat exchanger with metal tubes;
- heat distribution fan.

Fig.8. – Unit heaters, (Ponce et al., 2015)

Unit heating systems are the most common form of heating for the following reasons:

➢ Central heaters - consists of a central boiler that produces steam or hot water, plus a radiation mechanism designed to dissipate heat;

- ensures the necessary air circulation;
- can be combined with ventilation systems;
- they can ensure a uniform level of temperature;
- low price;
- rapid response to temperature changes;
- are easy to install;
- offers protection against snow.

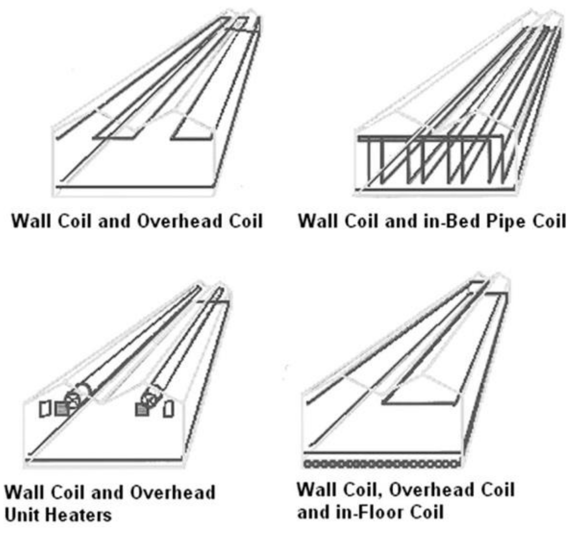

Fig.9. – Heating piping arrangements, (Ponce et al., 2015)

➢ Radiant heaters - in this system, the gas is burned in pipes suspended above the greenhouse. Hot pipes radiate heat to plants. Low intensity infrared radiant heaters can save approximately 30% of the fuel compared to conventional heaters;

➢ Solar heating system - the general components of the solar heating system, shown in Figure 8 are collectors, heat storage facilities, exchanger to transfer the derived solar heat to the greenhouse air, backup heater that activates when the solar heating is not sufficient *(Ponce et al., 2015)*.

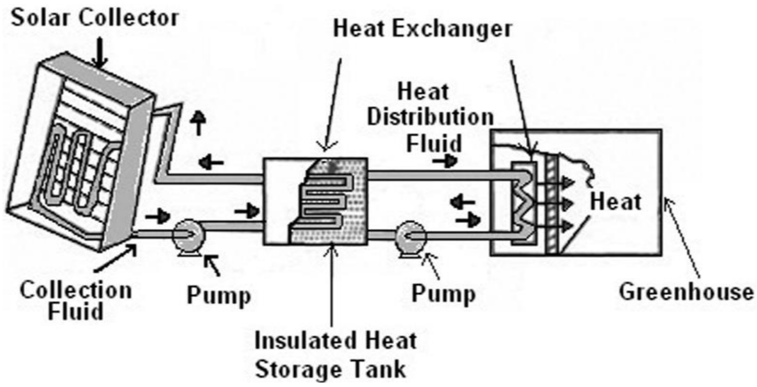

Fig.10. – Solar heating system, (Ponce et al., 2015)

Heat pumps use electricity to transfer heat from the outside environment into the greenhouse.

A refrigerant, such as dichlorodifluoromethane (R-12) or 1,1,1,2-tetrafluoroethane (R-134a) is passed through a heat exchanger, where it absorbs energy from the outside environment and vaporizes.

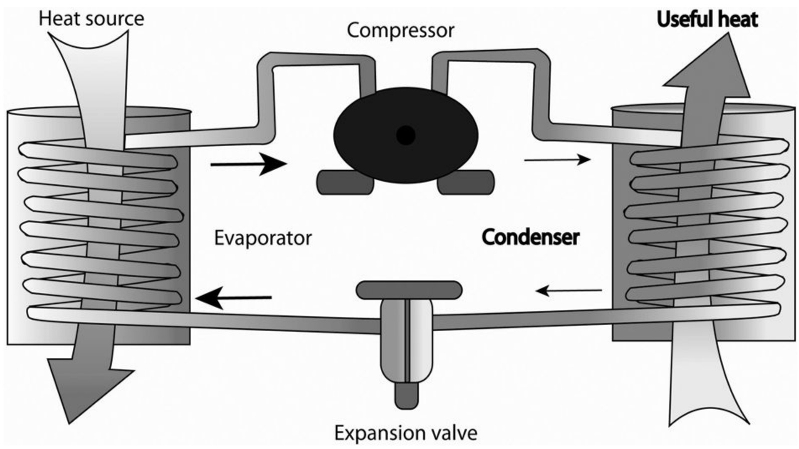

Fig.11 – The operating principle of the heat pump, (Ponce et al., 2015)

CONCLUSIONS

The equipment intended for the mechanization of the technological processes from available greenhouses is largely based on the principles of industrial automation, which consist of mechanical solutions with limited accuracy and "intelligence".

It is concluded that the slow progress in the field of robotic harvesting is largely due to the uncertainty in the working environment of the robot, due to the biological variability and the typical structure of the growth systems used.

Progress in the field of robotics in greenhouse production technologies will not only be based on innovations in the field of robotics, but also on innovations in the field of plant growth systems to reduce variability and thus simplify equipment loads.

By mechanizing and automating the horticultural production of greenhouses, first of all, the tasks of the workers are eased or even the human work is replaced by the machines. In horticultural production, the stage of using mechanization and automation is largely similar to the one commonly encountered in industry: machines based mainly on mechanical solutions capable of performing exactly the same task several times.

ACKNOWLEDGEMENT

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