ABSTRACT

Keywords: irrigation, fertilization, biosensor, *Solanaceae*

The studies and researches carried out for the realization of the doctoral thesis entitled Research on the use of tomato plants as a biosensor in fertigation systems were carried out during 2019-2021, in the greenhouse in the experimental field Farm "V. Adamachi ”and in the laboratory of the Vegetable Culture discipline at the Faculty of Horticulture in Iași.

The doctoral thesis is structured in two parts and includes seven chapters.

Part I - Current state of the art on optimizing fertilization and irrigation of tomato crops;

Chapter 1 - General considerations regarding tomato cultivation;

Chapter 2 - General considerations on fertilization and irrigation of vegetable plants;

Chapter 3 - Cultivation of vegetables without soil;

Chapter 4 - Use of thermal and electric techniques to determine the degree of water supply and nutrients;

Part II - Results of own research;

Chapter 5 - The purpose and objectives of the research, the material used and the working methodology;

Chapter 6 - Results and discussions;

Chapter 7 - Conclusions and recommendations.

At the end of the thesis are presented the bibliography, which includes a number of 138 bibliographic references, both in Romania and abroad, and the annexes that include the list of figures, the list of tables, as well as the list of published scientific papers.

The first part of the doctoral thesis, the current state of the art on optimizing fertilization and irrigation in tomato cultivation, consists of four chapters and contains general information from the literature.

Chapter 1 - General considerations for tomato cultivation

This chapter is structured in three subchapters and contains information on the importance of tomato cultivation, botanical and biological characteristics of tomato plants, as well as information on the relationship of plants with environmental factors, respectively their requirements regarding temperature, light, humidity, soil, air and nutrients.

Chapter 2 - General considerations on fertilization and irrigation of vegetable plants

The next chapter contains two subchapters, which set out information on the importance of irrigation in the growth and development of vegetable crops. Data from the scientific literature have contributed to establishing an optimal system to cover the specific consumption of selected crops, depending on the purpose and

objectives of irrigation. Based on the elements of the irrigation regime, a classification of irrigation systems in protected areas (irrigation by gutters, sprinkler irrigation and drip irrigation) was made, taking into account the possibility of applying nutrients through them. Next, it describes the importance of nutrition in plant growth and development, by highlighting the roles that micro and macroelements play, while establishing the specific consumption of vegetable plants, but also the possibility of automating their application processes.

This information helps to develop the concept of concurrent irrigation and fertilization, being a key element in the development of the biosensor irrigation system.

Chapter 3 - The cultivation of vegetables without soil

The chapter is structured in three subchapters and has advantages and disadvantages for the use of techniques other than conventional cultivation (soil cultivation). Thus, after a detailed study in the field of hydroponic, aeroponic and substrate crops, taking into account the administration and data collection, for the experiment we opted for an organic substrate culture system (mixture of peat, compost, perlite and Orgevit).

Chapter 4 - Use of thermal and electrical techniques to determine the degree of water and nutrient supply

The chapter consists of two subchapters and brings to the fore the contributions of other researchers on the use of electrical or thermal signals to study the reactions of a morphological and physiological nature caused by external stimuli.

Studies on corn plants have shown changes in electrical and hydraulic signals. The values of the electrical signals decreased when the plants were subjected to water stress or day-night alternation. Similar studies have been conducted on vines, with significant increases in the amplitude of electrical signals at the time of irrigation.

Thermal techniques were used to determine the speed of sap flow through the plant stem, mainly measuring the effect on the sap at the time of heating or dissipation of thermal energy on a portion of the heated stem, or the propagation of a heat impulse.

The second part of the doctoral thesis, the results of his own research, is the most extensive and divided into three chapters.

Chapter 5 - The purpose and objectives of the research, the materials used and the working methodology

The chapter is structured in six subchapters.

The aim of the research was to evaluate the response of tomato plants to external stimuli and their interpretation in terms of the intensity of electrical signals.

In order to achieve the proposed purpose of the research, the following specific objectives were elaborated:

- Documentary study, research in the country and abroad on the doctoral topic, namely, studies on current technology of tomato cultivation, considerations on fertilization and irrigation of crops, as well as the realization of vegetable crops without soil;
- Establishing the experimental variants according to the macro and microelements necessary for the development of tomato plants;
- Measurement of electrical signals generated by the presence or absence of nutrients;
- Analysis and interpretation of data on the influence of treatments on biometric, physiological and biochemical indicators of tomato culture and their correlation with the intensity of electrical signals

As a biological material, the experiment used the Brilliant F1 tomato cultivar, a productive tomato hybrid, with undetermined growth, suitable for greenhouse crops.

The experiments were performed in the greenhouse of the experimental stationary Farm "V. Adamachi ". This chapter also includes a climatic description of the area as well as the environmental conditions provided in the greenhouse for the research period.

The tomato culture was carried out on an organic substrate, the plants being grown in plastic containers, with a volume of 12 l, using as a substrate a mixture of peat (with a caliber of 0-25 mm), compost, perlite and Orgevit.

Ten macroelement fertilization treatments were used in the experiment, applying a quantity of 30 ml solution / day / plant.

The biosensor system involves the use of electrical monitoring signals as input data, which have the role of guiding the fertilization system, and not only, but also the control system of the entire complex of environmental factors.

The degree of supply of plants with nutrients was achieved by determining the intensity of the electrical signal, through a system consisting of a source generating 9V direct current, two electrodes installed on the plant stem, the measuring instrument and the recording unit.

Measurements were made over 24-hour periods, from 10:00 AM to 9:59 AM the next day. The distance between the electrodes was set at 40 cm, the lower electrode being inserted into the plant at a distance of 25 cm from the substrate surface. The electrodes were inserted in such a way as to intersect the xylem of the plants. To monitor the intensity of the electric current, a sensitive unit was used, capable of measuring values in the range of 0.01 fA - 20 mA, produced by Keysight, model B2981A Femto / Picoammeter.

From a technical point of view, the following steps are required to complete the installation:

- Preparation of the database;
- Carrying out measurements and monitoring electrical signals;

- Filtering electrical signals;
- Deconvolution of electrical signals;
- Analysis of electrical signals;
- Establishing a working protocol;
- Correlation of readings with the circadian rhythm of biochemical and physiological processes of plants;
- Providing nutrients;

Chapter 6 - Results and discussions

This chapter is structured in six subchapters and follows the way in which the nutritional treatments influenced the biometric indicators of the plants from the tomato culture, the Brilliant F1 cultivar, determined by measurements on the plant height, leaf area, number of fruits, fruit mass, quality index. of fruit and total production.

The influences of the nutritional treatments applied on the physiological indicators were evaluated by determinations on the physiological indicators such as: the intensity of the photosynthesis processes, perspiration, the stomatal conductance of the water, the substomatal CO_2 concentration and the chlorophyll content.

In the case of biochemical indicators, the water content, the ash content, the crude fiber and dietary fiber content, the nitrogen and crude protein content, as well as the mineral content were monitored.

The electrical signals received from plants were analyzed using a computer system, consisting of a computer and specialized software, which is based on the principle that nutrient type, environmental factor, circadian rhythm of biochemical and physiological processes of the plant, has a specific electrical signature.

They had unique values for each type of treatment (V_1-V_{11}), which are differentiated by numerical values and forms.

In order to be able to associate electrical signals with the circadian rhythm of biochemical and physiological processes of plants, as well as their variations depending on nutrient consumption, measurements were made on specific parameters of the photosynthesis process (photosynthesis rate, evapotranspiration rate, content of carbon dioxide, amount of light, leaf temperature, air pressure) throughout the day.

The obtained variations were analyzed, related to the time factor and were correlated with the results of the electrical signal.

Chapter 7 - Conclusions and recommendations

The last chapter contains conclusions on morphological indicators, conclusions on physiological indicators, conclusions on biochemical indicators, as well as conclusions on recorded electrical signals.