

## ABSTRACT

**Keywords:** tomato, electric current, magnetic field, smart horticultural culture

Studies and research carried out in order to complete the PhD thesis with the title *Optimization of tomato cultivation technology in protected areas through the use of direct current* took place in 2019-2021, in the didactic and research greenhouse existing in the vegetable sector from Research Institute for Agriculture and Environment and in the discipline laboratory of Vegetable Growing from the Faculty of Horticulture Iași.

The PhD thesis is structured in two parts and includes six chapters.

**I<sup>st</sup> PART** – Current state of the art on the use of continuous electricity in tomato crops

Chapter 1 – General considerations regarding tomato crops

Chapter 2 – Current state of the art on the use of electric current in plant cultivation

**II<sup>nd</sup> PART – OWN RESEARCH RESULTS**

Chapter 3 – Aim and objectives of the research. Material and research methodology

Chapter 4 – Study of natural framework conditions

Chapter 5 – Results obtained and discussions

Chapter 6 – Conclusions and recommendations

At the end of the thesis the bibliography is presented and it includes a number of 133 bibliographic references, both from Romania and abroad, as well as the annexes that include the list of figures, the list of tables, respectively the list of published scientific papers.

*The first part* of the PhD thesis, „The current state of the art on the use of direct electricity in tomato cultivation”, consists of two chapters that include a series of general information within the specialized literature.

### **Chapter 1 – General considerations regarding tomato crops**

This chapter is structured in seven subchapters in which a series of introductory notions are presented, from the need to grow tomato, the correlation of production with the areas and level of the global market, the origin of tomato, the distribution of this crop globally, the morphophysiological peculiarities of tomato plants, their ecological requirements, up to the aspects regarding the nutritional and therapeutic value of tomato fruits. These notions present the recommended cultivation technology and the general ecological requirements of tomato, respectively data on their nutritional importance. Therefore, this chapter

attests to the fact that tomato plants are widely cultivated worldwide, due to the nutritional properties of the fruits, as well as their pleasant taste, which is why numerous studies have been carried out to support the beneficial properties that results from the consumption of tomato fruits.

## **Chapter 2 – Current state of knowledge on the use of electric current in plant cultivation**

This chapter includes four subchapters in which the history of the discovery and use of electrical conductivity in plants is presented, studies that have been done both on the Earth's surface and on orbital stations to avoid the interaction of the electromagnetic field that is naturally generated by the Earth.

In the first subchapter there are presented the studies that refer to the discovery of the capacity of plants to conduct electricity. Here I have detailed the history of the studies conducted both at the Earth's surface and research conducted in outer space. In this subchapter, the most representative publication is the one that demonstrated the effects present at the cellular level, for plants that were removed from the area of interaction with the electromagnetic field that is naturally generated by the Earth. The importance of these studies is a special one, as this can provide the fundamental material basis for this research which attests to the possibility of obtaining favorable results compared to those which were obtained by other scientists until now.

The second subchapter highlights the interpretations of research results obtained at an international scale in other official studies that have been documented through scientific publications. Based on the data from the available scientific basis, a centralization of the main effects that the use of electricity or the magnetic field has on different plant species is exposed, depending on the plant organ subjected to stimuli, being presented punctually the registered positive or negative effects.

In the third subchapter, the notions related to plant electrophysiology are presented, by the way of the plant's reaction at the cellular level, due to the modification of the membrane potential. In order to have a clearer understanding of how the plant organism allows the transmission of electrical impulses through their body, a series of mechanisms in plant electrophysiology are briefly presented. Also, at the level of this subchapter the possibility of developing biosensors, by exemplifying the way of obtaining human immunosensors is presented.

At the end of this chapter, through subchapter four, the results obtained in scientific research conducted by researchers interested in the development of this branch through which plant crops can be revolutionized with the application of external stimuli of a physical nature are then correlated and discussed. These stimuli

consist in the use of electric currents or magnetic fields, applied in different ways, intensities or durations, in order to obtain sustainable, richer and higher quality crops.

*The second part* of the PhD thesis, which includes the results of his own research, is the most extensive, here being found the other four chapters.

**Chapter 3 - Aim and objectives of research. Material and research methodology**, it is structured in five subchapters.

The first subchapter represents the motivation for conducting this scientific research given by the extremely limited number of researchers who began to study the effects of electricity on plants, the favorable results obtained by them, respectively by the personal scientific challenge to study the behavior of the plant organism according to the mode, intensity and moment of application of the electric current.

In the second subchapter, the need of establishing the purpose of this study arose, namely to assess the influence of direct current that is permanently applied on tomato plants, in order to be able to establish optimal crop indices in order to obtain maximum yields from a quantitative and qualitative point of view. This goal, once established, led to the achievement of the objectives of evaluation, determination and study of the morphological, physiological and biochemical peculiarities of electrostimulated tomato plants.

The third subchapter presents the material and the research methodology used in the research polygon of the vegetable cultivation discipline within the Research Institute for Agriculture and Environment Iași, during the study years of 2019, 2020, respectively 202. As biological material was used the tomato hybrid *Qualitet* F1, due to the characteristics which this hybrid presents in the culture conditions present in the protected areas. For the biotechnical material a substrate in the form of a homogeneous mixture was used, composed of peat, compost, perlite and orgevite. During the vegetation period, fertilizers were applied at well-established intervals, due to the limited volume of nutrients found inside the culture vessel. These nutritional stimuli were applied similarly for all plants subject to scientific research.

The organization of the research described in the fourth subchapter presents the way of organizing the research, by grouping the total number of thirty plants in six variants of study with five plants per repetition. For each variant a distinct method of application of electrical stimuli was used. In the case of the first three variants the current being applied at different intensities by means of spirals mounted around the aerial organs of the plants. For the fourth variant the current administration was performed directly in the body of the plants, in the fifth variant the current was administered at the root level with the help of some electrodes, while a group of five plants remained to fulfill the role of reference plants. In the case of all the five

variants where the electrical stimuli were applied, the duration of the current application was from 1<sup>st</sup> of May, until 31<sup>st</sup> of August of each year of study, for 24 hours / day.

Also at the level of this subchapter were established the determinations that were made on the tomato crop, respectively specified and described the equipment with the help of which I performed the necessary measurements, being presented images that demonstrate the effort made in this research paper.

Subchapter five presents the method of statistical analysis by which the data resulting from the determinations are presented in the PhD thesis.

#### **Chapter 4 – Study of natural framework conditions**

At the level of this chapter there are seven subchapters where the research conditions are detailed from the geographical and geomorphological point of views, with the influence of the hydrological network, pedological components, climate data, also of the way of organizing the didactic greenhouse where the scientific experiment was conducted.

The place of the experiment was located in a modern research greenhouse, equipped at the European standards level of cultivation in a protected regime. The research took place in the number II compartment within the didactic complex of the Research Institute for Agriculture and Environment, where the greenhouse which belongs to the discipline of vegetable growing within the Faculty of Horticulture is located. The climatic conditions provided during the three years of research were identical for all six study variants (light, temperature, relative air humidity). At the same time, the watering norm applied to the plants was also identical for each plants group, as is the case with all the applied care.

At the level of the last subchapter, the emphasis was especially put on the ecological data recorded during the scientific research, precisely with the idea of showing that the data provided by the computer system of the greenhouse were similar during the years of study.

#### **Chapter 5 – Results obtained and discussions**

Within this chapter there are four subchapters where the entire research balance is structured in terms of grouping the data according to the characteristics of the indicators followed.

In order to present the morphological characteristics, a series of determinations were performed on the height of the plants, the number of leaves, the number of fruits, their dimensions (height and diameter of the fruits), the mass of the harvested fruits, the leaf areas were determined. and finally, the masses of the plants for their aerial part. Following these determinations, favorable results were obtained,

these indicating either a series of statistically significant differences or insignificant variations, which may lead to impact factors with the extrapolation of the results to area units for the cultivation of these plants in the production regime. The most significant difference obtained in these determinations was made in the case of the plant's height regime.

In the second subchapter is presented the influence that the direct electric current has on tomatoes from the perspective of physiological indices, this time following the next aspects: chlorophyll content index, the rate of photosynthesis, light radiation index from the leaf surface, at the same time determinations being made on stomatal conductance, substomatal cavities carbon dioxide concentration as well as on evapotranspiration. The role of the physiological determinations was to evaluate the level of similarity in the culture of the tomatoes subjected to the experiment, by comparison with the control plants. The results obtained for these indices were insignificant, during all the three years of study, aspect due to the fact that all the plants were placed at the level of same compartment within the teaching greenhouse.

In the subchapter three are presented the results obtained from biochemical determinations. These determinations are of particular importance as they are specific to the quality of the fruits obtained, a decisive aspect in the selection of products by potential customers. In order to present a more relevant image, on this aspect, determinations were made on a category of indicators as complex as possible, respectively: fruit firmness, acidity, total soluble solids, dry matter complementary to the moisture content of the fruit, lycopene content, polyphenols and  $\beta$ -carotene. Also determinations were made on antioxidant activity, crude lipids, crude protein, crude fiber and dietary fiber, calorific value, mineral content (potassium, calcium, magnesium, iron, zinc, sodium), respectively on the antinutrient content in the fruits, where the phytic acid, tannins, oxalates, saponins, trypsin inhibitors and  $\alpha$ -amylase inhibitor were monitored. As a result of the analyzations performed, results that either marked a series of statistically significant differences, as is the case with most of these indicators, especially for the plants that were electrically stimulated, obtaining maximum values or statistically insignificant differences, the latter being specific to a number more restricted by indicators were obtained. As a result of the biochemical determinations, it is indicated that the stimulated plants present phytotherapeutic, nutritional and organoleptic characteristics superior to the control plants.

In the last subchapter, the results on the production obtained are presented, as an average for the three years of study. These results are presented to see if a contrast was achieved between qualitative and quantitative indices or if both showed a favorable evolution, aspect of which, as a result, it was found that both indicators present favorable results through the use of direct electric current in the cultivation of tomato plants.

## **Chapter 6 – Conclusions and recommendations**

In the last chapter of doctoral thesis, are presented the conclusions on morphological, physiological and biochemical features, as well as the data on production under experimental conditions, conclusions that indicate favorable results, as a result of the research activity carried out. At the same time, it was shown that by using electricity as a stimulus factor, positive results can be obtained, thus meeting the current needs of meeting increasingly stringent food requirements worldwide, needs mainly due to the increase of the population number, but also due to the degradation of the environment due to pollution. This has led to the recommendation of using such a smart automation system and to encourage the continuation of such research on a wide range of plant species.