POSSIBILITY OF USING TOMATO PLANTS AS BIOSENSOR IN THE FERTILIZATION SYSTEMS

POSIBILITATEA UTILIZĂRII PLANTELOR DE TOMATE CA BIOSENZOR ÎN SISTEMELE DE FERTILIZARE

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Abstract. *The response of plants to external stimuli is manifested by different physiological and morphological changes. The results presented in this paper are related to the "neurophysiology of plants" and quantify the behavior of the plants to external stimuli, respectively the availability of water and nutrients, behavior expressed by quantitative modifications of the electric potential. The potential differences were continuously monitored, under controlled environmental conditions, in the greenhouse of the Institute of Agriculture and Environmental Research, within the UASVM Iasi, with readings 5 to 5 seconds, using two electrodes inserted into the stem of tomato plants, connected to a pico-ammeter. The systematic models of the variation of the electric potential, with values between 4.6 and 5.8 nA, can be used as tools for early evaluation of the conditions of water and nutritional stress, including the use of the system as a biosensor for fertigation.*

Key words: tomato, fertigation, electrical potential

Rezumat. *Răspunsul plantelor la stimuli externi se manifestă prin diferite modificări fiziologice şi morfologice. Rezultatele prezentate în această lucrare ţin de "neurofiziologia plantelor" şi cuantifică comportamentul plantelor la stimuli externi, respectiv disponibilitatea apei şi a substanţelor nutritive, comportament exprimat prin modificări cantitative ale potenţialului electric. Diferenţele de potenţial au fost monitorizate continuu, în condiţii de mediu controlate, în sera Institutului de Cercetări pentru Agricultură şi Mediu, din cadrul USAMV Iaşi, cu citiri la 5 secunde, folosind doi electrozi introduşi în tulpina plantelor de tomate, conectaţi la un picoampermetru. Modelele sistematice ale variaţiei potenţialului electric, cu valori între 4,6 şi 5,8 nA, pot fi utilizate ca instrumente de evaluare timpurie a condiţiilor de stres hidric şi nutritiv, inclusiv utilizarea sistemului ca biosenzor pentru o instalaţie de fertirigare.*

Cuvinte cheie: tomate, fertirigare, potenţial electric

INTRODUCTION

The nutritional solutions represent a technological lever of special importance in soiless crops, through which the hydric and mineral nutrition of the cultivated plants is managed with maximum rigor (Weissert and Kehr, 2017; Burzo *et al.*, 1999).

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Ensuring the optimal parameters of mineral and water nutrition leads to a specific way of obtaining high quality and high yields. Therefore, the complete list of nutrients, as well as the optimal concentrations or limits to which they may vary, but which do not produce imbalances in the growth and fruiting processes of plants, are of particular importance (Atheron and Rudich, 1994; Baker *et al*., 1987).

Therefore, it is desired to use the plants as a sensor in the fertigation systems, which, through precise readings, can guide the entire irrigation and fertilization activity within the tomato crops.

MATERIAL AND METHOD

The water and mineral nutrition was ensured by using the nutritional solutions applied in the open circuit, without recovering and recycling the excess nutrient solution. To prevent the application of water or nutrient solution at too short intervals, the culture substrate had a medium fineness to provide moderate retention capacity and to avoid root suffocation due to excess moisture.

The concentration of the solution was not determined directly, but indirectly, by measuring its electrical conductivity. When their molecules are fragmented into positive and negative ions, due to these electrically charged ions, the solutions in which mineral salts dissolve become electrically conductive.

The water and nutrients supply of the plant were measured using two electrodes, inserted into the stem of tomato plants, connected to a pico-ammeter. Electrical stimulation was realized using a source of electrical current stimulus that generates stimuli of very small value (2 fA).

In the experience were used 11 experimental variants, with 3 repetitions, each 5 plants / repetition, as follows:

- V1 - fertilization with magnesium sulfate (MgSO4);
- V2 - fertilization of potassium nitrate (KNO3);
- V3 - fertilization with potassium sulphate (K2SO4);
- V4 - fertilization with calcium nitrate (Ca (NO3) 2);
- V5 - fertilization with monopotassium phosphate (KH2PO4);
- V6 - fertilization with potassium chloride (KCl);
- V7 - fertilization with a mixture of magnesium sulfate + potassium nitrate + monopotassium phosphate;
- V8 - fertilization with a mix of potassium sulphate + calcium nitrate + potassium chloride;
- V19 - mixed fertilization (magnesium sulphate, potassium nitrate, potassium sulphate, calcium nitrate, monopotassium phosphate, potassium chloride);
- V10 - fertilization differentiated by days, for 6 days it will be fertilized separately with each product used in variants 1-6;
- V11 – control variant;

RESULTS AND DISCUSSIONS

The stimuli generated by an electrical signal, in response to changes in light conditions, water availability and nutrients, translate into a rapid response to the opening and closing of the stomata (Fromm and Fei, 1998). In response to the dawn, there is a gradual increase in the electric potential, which reaches a maximum value until noon, to decrease in the evening, reaching lower values at night. In the case of fertigation, there is a significant variation of the electrical potential measured at the beginning and during the fertigation event (Toma and Jitareanu, 2007).

Accentuated increases of the electric current immediately after the application of the irrigation norm were reported at V10 (fertilization differentiated by days, for 6 days it will be fertilized separately with each product used in variants 1-6), from 1.30×10^{-4}A to 1.46×10^{-4}A, reaching a maximum threshold of 1.74×10^{-4}A around 12:00 AM (fig. 1).

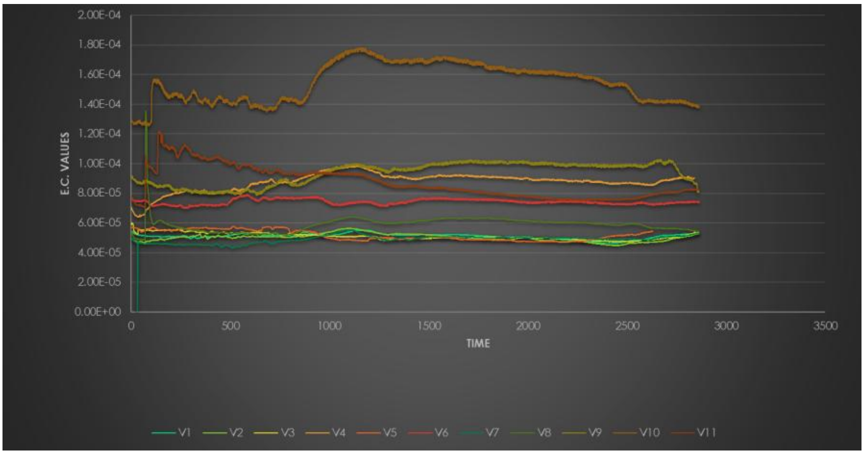

Fig. 1 Variations of EC for all 10 variants (24 hours)

At the same time, V8 (fertilization with a mix of potassium sulphate + calcium nitrate + potassium chloride) recorded a sharp increase in EC values from 5.27x 10^{-5}A to 1.35×10^{-4}A, following a sharp decrease to 5.95×10^{-5}A, with reduced fluctuations for the rest of the day (fig. 2).

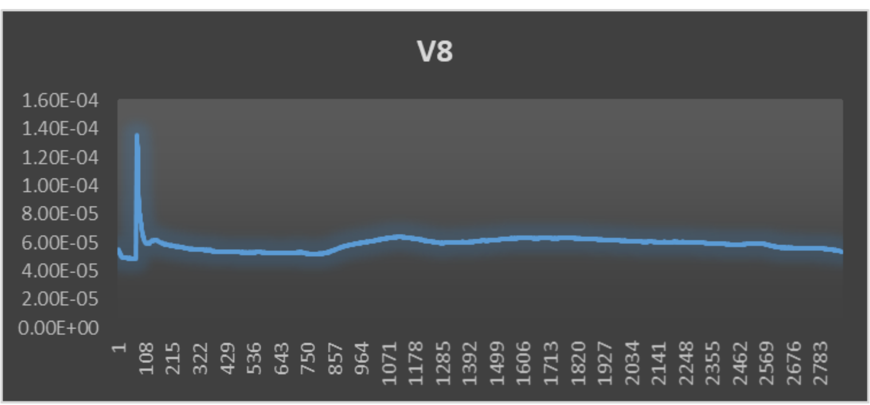

Fig. 2 Variation of EC for V8

Significant variations were also recorded in V4 (fertilization with calcium nitrate (Ca (NO3) 2)), which immediately after the application of the nutritional solution, registered a slight decrease from 7.50 $x10^{-5}$A to $7.28x10^{-5}$A, following a progressive increase to $9.80x10^{-5}$A, reached in around 12:00 AM.

Also, the control variant experienced a significant increase in EC values, from $7.69x10^{-5}$A to $1.10x10^{-4}$A, when applying the watering norm without nutritional solution, following a progressive decrease until the end of the day (fig. 1). Same results was present by Galle *et al*., 2015.

CONCLUSIONS

In conclusion, tomato plants generate an oscillating electrical signal, around $4.78x10^{-5}$, at a temperature of 20 degrees Celsius. The variation of the electrical signals is determined by the physico-chemical processes in the plant, but also by the permanent variation of the environmental factors. The registered electrical signal shows a decrease of the average values when the nutritional resources are exhausted or under stress conditions generated by the environmental factors. Elimination of stress factors determined by water and nutrients leads to a return of the signal to the values generated by the plant under normal conditions.

Using the measured EC values, determined by the variation of environmental factors, water and nutrients, the system can predict the needs of plant, controling the process of growth and development of plants under protected conditions.

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