DEPENDENCE OF AMPLITUDE OSCILLATORY CHANGES IN POTENTIAL AND ELECTRICAL RESISTANCE OF *NITELLOPSIS OBTUSA* CELL MEMBRANES ON THE STAGE OF CELL DEVELOPMENT

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ABSTRACT

The amplitudes of oscillation changes of potential and electrical resistance of *Nitellopsis obtusa* cell membranes differing from each other in their individual evolution stages were determined. The first, third and fifth cells from the tops of the plants were collected for measurements and only those characterised by rhythmical changes in potential and electrical conductivity of membranes (which revealed one or simultaneously 2-3 types of oscillations) were selected. Visible dependence of the amplitude of investigated changes on developmental stages of the cells, correlating with the intensity of metabolic transformations, was established.

KEY WORDS: *Nitellopsis obtusa*, oscillations, resistance and potential changes.

INTRODUCTION

During our complex studies of oscillatory changes in electrical parameters of *Characeae* membrane cells, it was found that cells collected from different parts of a plant differ from themselves in these properties. In view of the results of our previous works (Skierczyńska et al. 1975, Śpiewła 1983), it seems worth-while to verify whether and to what extent the amplitude of oscillation changes of potential and electrical resistance of cell membranes of *Characeae* plants depend on the stage of their evolution.

These measurements form a part of wide range of investigations (planned for summer months 1994) of the dependence of oscillation phenomena in the cells of these plants on the period of their vegetation (frequency of occurrence, period and amplitude, generating factors etc.)

MATERIALS AND METHODS

Measurements were made on the internodal cells of *Nitellopsis obtusa*. Plants were gathered from the Lake Zagłębiec and cultured in the laboratory in an aquarium with natural pond water. The concentrations of basic ions in the water were as follows: 0.06 mM K⁺; 0.28 mM Cl⁻; 0.01 mM Mg²⁺ and 0.29 mM Na⁺ (pH 7.0±0.2). The experiments were conducted during two months i.e. August and September 1993.

Oscillation changes in the potential and electrical resistance of the cell membranes were observed and determined in the way as described in previous works (Skierczyńska et al. 1972, Śpiewła and Tokarska 1990, Tokarska and Śpiewła 1994 and others). In about 10% of cases, measurements were made by means of the (liquid) microelectrodes technique to check the correctness of the results obtained by means of the technique of external electrodes (silver chloride -Ag/AgCl).

In all experiments constant current in the form of square impulses of intensity $\leq 0.1 \mu\text{A}$ and duration of 2-4s were used. Natural lake water was used as an experimental solution. The cells were chosen and isolated from the plant and stored under room temperature and lighting conditions. For the basic measurements only those cells were taken, which revealed one or simultaneously 2-3 types of oscillation changes in the potential and electrical resistance of the membrane in the preliminary measurements.

RESULTS

The results presented below were obtained for about 30% of all the initially examined cells because oscillatory changes in potential and resistance occur only in this part of cells of *Nitellopsis obtusa* during August and September. The numerical values obtained are listed in tables 1 and 2 presenting the average values for each set of measurements of the cells: first, third and fifth from the top of the plant. Next to the average values calculated from measurements made by the microelectrode and external electrode techniques, spread in the values obtained for each cell and the values of average square errors are given.

In order to determine the values of amplitude of rhythmic changes in the potential, initially 220 internodal cells of *Nitellopsis obtusa* were examined from which were selected 71 cells revealing oscillations of one or simultaneously 2-3 types. Measurements were repeated many times for durations between several minutes and several hours.

In a similar manner, measurements of oscillatory changes in the membrane resistance were made. In this case, of 147 cells 49 revealed at least one type of oscillatory changes in the resistance. The average values from each set of measurements are listed in Table 2.

TABLE 1. Values of amplitude of oscillatory changes in the resting potential of *Nitellopsis obtusa* cells: first, third and fifth from the plant top.

Type of potential oscillation	Method of measurement	A 1st cells		A 3rd cells		A 5th cells	
		(mv)	Range (mV)	(mv)	Range (mV)	(mv)	Range (mV)
"1-h"	m-el. ext.el.	7.2(3)* 7.0(6)	3.7-12.0 4.2-11.1	5.0(2) 4.8(11)	4.5-5.6 3.6-8.4	– 3.9(4)	– 2.7-9.5
		Mean±SE:	7.1±1.3 mV	Mean±SE	4.9±0.8 mV	Mean±SE	3.9±1.1 mV
		Relative change:	8.9±1.6%	Relative change:	6.7±1.1%	Relative change:	5.6±1.6%
"15 min"	m-el. ext.el.	3.4(2) 3.4(19)	1.4-5.4 2.0-5.3	2.6(3) 2.5(20)	1.6-4.4 1.8-5.7	1.3(2) 1.6(13)	0.9-1.7 1.2-4.6
		Mean±SE	3.4±0.2 mV	Mean±SE	2.5±0.2 mV	Mean±SE	1.5±0.1 mV
		Relative change:	4.3±0.3%	Relative change:	3.4±0.3%	Relative change:	2.1±0.1%
"45 s"	m-el. ext.el.	– 1.9(4)	– 1.3-4.2	1.4(3) 1.5(5)	0.8-1.9 0.9-1.7	– 1.2(3)	– 0.9-1.4
		Mean±SE	1.9±0.3 mV	Mean±SE	1.5±0.1 mV	Mean±SE	1.2±0.3 mV
		Relative change:	2.4±0.4%	Relative change:	2.0±0.1%	Relative change:	1.7±0.4%

* – The examined cell numbers are given in brackets.

A – Amplitude of oscillation changes in potential of membrane cells from the plant top.

m-el – microelectrode method.

ext.el. – external electrode method.

TABLE 2. Values of amplitude of oscillatory changes in the resistance of membrane of *Nitellopsis obtusa* cells: first, third and fifth from the plant top.

Type of resistance oscillation	Method of measurement	A 1st cells		A 3rd cells		A 5th cells	
		(kΩcm ²)	Range (kΩcm ²)	(kΩcm ²)	Range (kΩcm ²)	(kΩcm ²)	Range (kΩcm ²)
"1-h"	m-el. ext.el.	– 10.0(7)*	– 4.0-32.8	9.1(2) 9.6(5)	7.8-10.4 5.4-29.0	13.0(2) 10.9(12)	7.0-19.0 7.8-45.5
		Mean±SE:	10.0±1.4 (kΩcm ²)	Mean±SE	9.5±1.2 (kΩcm ²)	Mean±SE	11.0±1.8 (kΩcm ²)
		Relative change:	31.3±4.4%	Relative change:	25.7±3.2%	Relative change:	27.5±4.5%
"15 min"	m-el. ext.el.	8.7(3) 9.2(7)	5.0-14.2 6.0-26.2	8.6(2) 9.7(8)	7.1-10.2 5.0-40.2	11.0(2) 9.3(11)	8.0-13.9 6.3-36.0
		Mean±SE	9.1±1.2 (kΩcm ²)	Mean±SE	9.5±1.6 (kΩcm ²)	Mean±SE	9.5±1.5 (kΩcm ²)
		Relative change:	28.4±3.7%	Relative change:	25.7±4.3%	Relative change:	23.7±3.7%
"45 s"	m-el. ext.el.	6.1(2) 7.8(8)	5.4-6.8 4.1-21.0	– 8.0(6)	– 3.5-17.8	– 8.3(4)	– 7.1-30.0
		Mean±SE	7.6±1.4 (kΩcm ²)	Mean±SE	8.0±2.2 (kΩcm ²)	Mean±SE	8.3±2.2 (kΩcm ²)
		Relative change:	23.8±4.3%	Relative change:	21.6±4.8%	Relative change:	20.7±5.5%

* – The examined cell numbers are given in brackets.

A – Amplitude of oscillation changes in unitary resistance of membrane cells.

m-el – microelectrode method.

ext.el. – external electrode method.

DISCUSSION

From the data presented in tables 1 and 2 it follows, that the average values of amplitude of the oscillatory changes in the potential and the resistance of the membrane the *Characeae* differ clearly in the case of the growing (first from the top of the plants) and ripe cells. The amplitude of rhythmical potential changes of the cells first from the tops is almost twice as large than that of the ripe cells, counted as fifth from the tops of the plant. Similarly, the relative changes in the amplitude oscillation of resistance are clearly greater in younger cells than in the ripe ones, despite the fact that the absolute values of unitary resistances of the latter cells are greater than those of the former ones.

Measurements were also made in older cells (from the entirely lower parts of the plants), which confirmed that as the cells grow older, the oscillations in the potential and the resistance occur rarely and are characterised by a clearly smaller amplitude, worse regularity and shorter period of occurrence.

The results of measurements presented in the tables and the observations made indicate that the intensity of generation of oscillatory changes in the potential and the conductivity, and their characteristics are strongly related with the intensity of metabolic transformations. They also demonstrate that, apart from the known behaviour of membrane cells displayed by variability, e.g. periodic and heterogeneity, they also reveal dynamism as an important factor of understanding the physiology of membrane transport. During the present investigation it was established, among others, that the oscillations in a part of the cells are stable and occur in an unchanged form for several days. In some cases, they appeared suddenly without any reason and also disappeared equally unexpectedly. Often, after the removal of oscillations, particularly in young cells, irregular disturbances occurred both in the potential and the conductivity, lasting for a sufficiently long period. In several

cases it was also observed that the rhythmic changes in potential and resistance in the same cells significantly differed from each other in period, amplitude and form in the following days of measurements made under the same conditions.

In the light of the results presented here, the divergences in values of electrical and transport parameters of biological membranes, obtained by different workers, become understandable. It also seems that it is necessary to carry out more systematic studies of the oscillatory behaviours on the cell level.

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ZALEŻNOŚĆ AMPLITUDY OSCYLACYJNYCH ZMIAN POTENCJAŁU
I OPORU ELEKTRYCZNEGO BŁONY KOMÓRKOWEJ *NITELLOPSIS OBTUSA*
OD ETAPU ICH ROZWOJU OSOBNICZEGO

STRESZCZENIE

Wyznaczono amplitudy oscylacyjnych zmian potencjału i oporu elektrycznego błon komórek *Nitellopsis obtusa* różniących się między sobą etapem rozwoju osobniczego. Do pomiaru pobierano pierwsze, trzecie i piąte komórki od wierzchołków roślin i selekcjonowano tylko te, które charakteryzowały się rytmicznością zmian potencjału i przewodnictwa elektrycznego błon (wykazywały jeden lub równocześnie 2-3 typy oscylacji). Wykryto wyraźną zależność wielkości amplitudy badanych zmian od etapu rozwoju komórek, korelującą z intensywnością przemian metabolicznych.

SŁOWA KLUCZOWE: *Nitellopsis obtusa*, oscylacje, zmiany potencjału i oporu.