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Cent. Eur. J. Biol. • 7(6) • 2012 • 1066-1075
DOI: 10.2478/s11535-012-0085-5

Central European Journal of **Biology**

The effect of acetylcholine on Characeae K^+ channels at rest and during action potential generation

Research Article

Vilma Kisnieriene[1,*], Tatiana I. Ditchenko[2], Anatoly P. Kudryashov[2], Vidmantas Sakalauskas[1], Vladimir M.Yurin[2], Osvaldas Ruksenas[1]

[1]*Department of Biochemistry and Biophysics, Vilnius University, LT-03101 Vilnius, Lithuania*

[2]*Department of Plants Physiology and Biochemistry, Biological Faculty, Belarusian State University, 220030 Minsk, Belarus*

Received 11 January 2012; Accepted 24 July 2012

Abstract: The role of acetylcholine (ACh) as a signalling molecule in plants was investigated using a model system of Characeae cells. The effect of ACh on conductance of K^+ channels in *Nitella flexilis* cells and on the action potential generation in *Nitellopsis obtusa* cells after H^+-ATPase inhibition, where repolarization occurs after the opening of outward rectifying K^+ channels, was investigated. Voltage-clamp method based on only one electrode impalement was used to evaluate the activity of separate potassium ion transport system at rest. We found that ACh at high concentrations (1 mM and 5 mM) activates K^+ channels as the main membrane transport system at the resting state involved in electrogenesis of Characeaen membrane potential. We observed that ACh caused an increase in duration of AP repolarization of cells in K^+ state when plasmalemma electrical characteristics are determined by large conductance K^+ channels irrespective of whether AP were spontaneous or electrically evoked. These results indicate interference of ACh with electrical cellular signalling pathway in plants.

Keywords: *Characeae • Potassium channels • Acetylcholine • Plant electrical signaling • Action potential*

1. Introduction

Acetylcholine (ACh) has been well-characterized as a neurotransmitter, and has been found to be a local mediator in almost all life forms on earth. Over the past decade a considerable body of evidence has been collected, indicating that ACh is a cellular signaling molecule in nonneuronal cells [1-4]. Plants also contain ACh and the ACh appears to have roles in various physiological activities [5]. ACh in plants has been shown to be involved in basic cellular processes like gene expression, proliferation, differentiation and cytoskeleton functions [6]. As in animals, ACh seems to play a significant role in signal transduction in plants [7], however, the ACh-mediated system and its role in plant signalling are not yet fully understood. Most studies regarding the plant cholinergic system have been limited to detection and structural analysis of distinct components [8]. Nevertheless, molecular studies alone do not provide information regarding physiological processes in intact cells. Consequently, research on plant cholinergic system function *in vivo* is needed. Electrophysiological analyses can help elucidate the effects of ACh on the activity of plant membrane ion transport systems and reveal involvement of ACh in signal transduction. If ACh causes changes in membrane permeability similar to those found in the excitable membranes of animal cells, then ACh may interfere with electrical cellular signalling pathway in plants too.

Changes in plasma membrane potential or modulation of ion flux are amongst the earliest cellular events in response to light, temperature, osmotic stress, salinity, hormonal stimuli, elicitors and mechanical stimulation in many organisms [9-11]. Previous studies have indicated the presence and action of voltage-gated channels in the plant plasma membrane in these early cellular responses [12]. Among other processes, fluxes through ion channels are responsible for action potential

* *E-mail: vilma.kisnieriene@gf.vu.lt*