Electrochemical Signaling in Green Plants Induced by Photosensory Systems: Molecular Recognition of the Direction of Light

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Plants generate different types of extracellular electrical events in connection to environmental stress [1-11]. Action potentials in higher plants may be the information carriers in intercellular and intracellular communication in response to environmental changes [4]. A potential pathway for transmission of this electrical signal might be the phloem sieve-tube system since it represents a continuum of plasma membranes [4]. A phloem is an electrical conductor of bioelectrochemical impulses over long distances. Phloem consists of two types of conducting cells, the characteristic type known as sieve-tube elements and another type called companion cells. Sieve-tube elements are elongate cells that have end walls perforated by numerous minute pores through which dissolved materials can pass. Such sieve-tube elements are connected in vertical series known as sieve tubes. Sieve-tube elements are alive at maturity, although their nuclei disintegrate before the element begins its conductive function. Companion cells, which are smaller, have nuclei at maturity and are living; they are found adjacent to the sieve-tube elements and are believed to control the process of conduction in the sieve tubes.

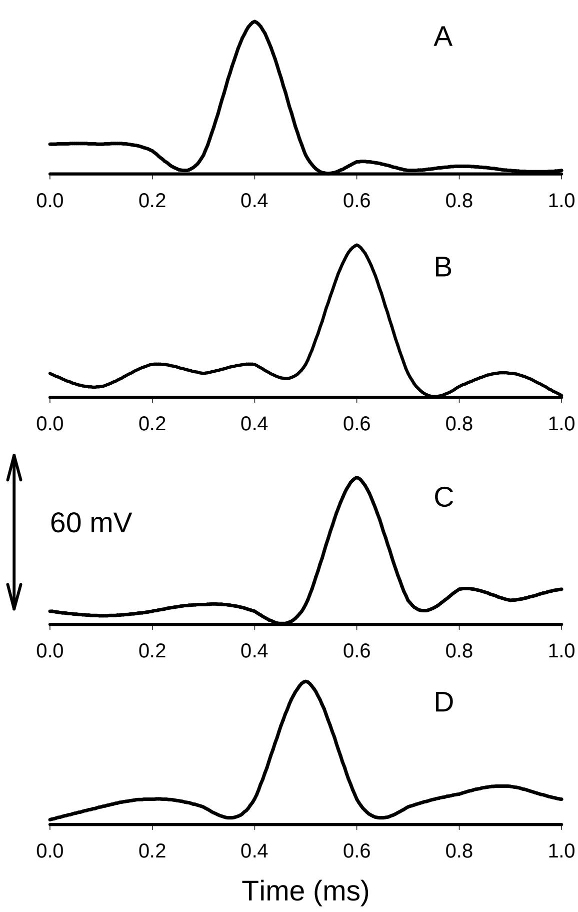

Fig. 1. Action potentials in soybean induced by irradiation at 450 nm (A), 470 nm (B), 671 nm (C), and 730 nm (D). Irradiance was 8.5 $\mu E/m^2s$.

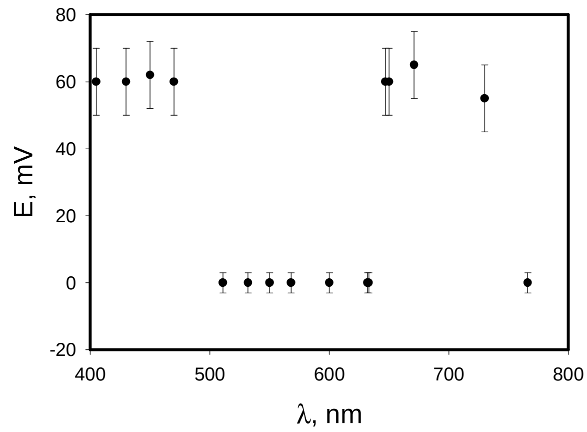

Fig. 2. Action spectrum: dependence of action potential amplitude on wavelength of irradiation

The generation of electrophysiological responses induced by blue and red photosensory systems was observed in soybean plants. A phototropic response is a sequence of the four following processes: reception of the directional light signal, signal transduction, transformation of the signal to a physiological response, and the production of directional growth response. It was found that the irradiation of soybean plants at 450 ± 50 nm, 670 nm, and 730 nm induces action potentials with duration times of about 0.3 ms and amplitudes around 60 mV. The speed of propagation of the action potential neither depends on the location of the working electrode in the stem of the plant, in the leaves of the plant, nor on the distance between the working and reference electrodes. Action potentials play an active role in the expedient character of response reactions of plants as a reply to external stimuli.

Acknowledgement

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