The Effect of Electric Field on Callus Induction with Rape Hypocotyls

Maria Fileka,*, Magdalena Hołda, Ivana Macháčková, and Jan Krekule

a Institute of Plant Physiology, Polish Academy of Sciences, 30-239 Kraków, Niezapominajek 21, Poland. Fax: +48124253320. E-mail: mariafilek@excite.com

b Institute of Experimental Botany, Academy of Sciences of the Czech Republic, Rozvojová 135, 160502 Praha 6, Czech Republic

* Author for correspondence and reprint requests

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The influence of electric field treatment on dedifferentiation and calli formation on rape hypocotyls was investigated. Segments, 10 mm long, of the upper part of rape (Brassica napus L., cv. Górcza∆ski) hypocotyls were stimulated by different combinations of voltage/time (1.5 V/120 h, 3 V/3 h, 10 V/15 min and 30 V/30 s) under in vitro conditions. With all electric field treatments, segments oriented with their apical part towards the cathode produced more calli as compared to control (non-treated with electric field). Under opposite orientation slight inhibition of callus growth was observed. As the strongest effect on callus growth was observed after treatment with 30 V/30 s, this electric field treatment was selected for following analyses: the incorporation of [14C]-2,4-D (2,4-dichlorophenoxyacetic acid) and [14C]-BAP (benzylaminopurine) from the culture medium, changes in ACC (1-aminocyclopropane-1-carboxylic acid) level and the redox activity in apical and bottom parts of hypocotyls during 18 d of culture.

In contrast to changes in fresh weight, electric field treatment (30 V/30 s) stimulated a higher accumulation of 2,4-D and BAP in basal parts of hypocotyls than in apical ones. Moreover, orienting the apical part towards the cathode resulted in lower uptake of hormones as compared with the opposite orientation. The ACC concentration increased, especially in the basal parts of hypocotyls, independently on electric field application. However, the highest level was observed after electric field treatment with orientation of the apical part towards the anode. The distribution of oxidative substances (measured as the amount of ferric ions) between the apical and bottom part of hypocotyls was not changed when the apical parts were oriented towards the cathode. Under these conditions a decrease in apical and an increase in basal parts was observed during culture. Opposite orientation influenced the redistribution of oxidative substances from the first day of electric field treatment. Based on these results we suggest that electric field action can be connected with its influence on specific concentration of oxidative substances and hormone distribution in cells.

Key words: Electric Field, Rape, Growth Regulators

Introduction

The physical properties of lipids and proteins, the main compounds of biomembranes, predetermine the membranes to originate an electric field (Chermomordic et al., 1987; Tsong and Astumian, 1988). Endogenous currents occur in the form of transcellular potentials (Mycielska and Djamgoz, 2004). These electric fields are believed to play a significant role in biological processes (Le Saux et al., 2001). Long-standing interest in the effect of electric fields was concentrated on animal systems (Robinson, 1985). However, analysis of its influence on biological molecules raises several problems. The main experimental problem is to apply a transmembrane electric potential of comparable magnitude as the one existing in physiological conditions. When the applied potential exceeds a critical value, mechanical instability and electro-poration (pore formation) of membranes occur (Wothers et al., 2001).

It was observed in animal cells that exogenous electric fields induce a variety of cellular responses. It can influence cell surface charge redistribution (Cho et al., 1994), cytoskeletal reorganization (Cho et al., 1996) and changes in the intracellular calcium ion concentration (Walleczek, 1992). Because Ca^{2+} ions regulate numerous biological processes including signal transduction cascades, cell orientation and migration and cell differentiation and proliferation, changes in Ca^{2+} concentration have been hypothesized to mediate cellular effects induced by an exogenous electric field (Cho et al., 1999).

In our earlier studies we observed the interaction of an external electric field with generative