Note

The Bioelectrical Potentials of Young Woody Plants*

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Abstract——The microelectrode method was applied to the measurement of bioelectrical potentials in young woody plants. Japanese cedar (*Cryptomeria japonica* D. Don) and poplar (*Populus nigra* Linn.) were used in this experiment. The resting potential was about −40 mV in both species.

Light affected the potentials of the shoots, petiols and leaves. The potential changes were the most sensitive in the leaves. And this change occured immediately whenever the light turned on/off. After on/off, the potential recovered to the resting potential in a whole plant and a rootless poplar shoot incubated in water, while it did not recover in rootless poplar shoot incubated in 0.25 M sucrose solution. The surrounding light conditions but not the inner rhythm in trees might control the changes.

Introduction

It has been confirmed that all plants and their cells have a negative bioelectrical or membrane potential against their surroundings. And these potentials reflect ion fluxes across cell membranes in the metabloic processes.

In bacterial[1], algal[2] and fungal[3] cells, the active transport of sugars through the membrane was suggested to be coupled to an H^+ influx. Recently in autotrophically growing cells of higher plants, the proton-hexsose cotransport has been found. In *Lemna* the uptake of sugars is accompanied by the depolarization of membrane and the transient alkalinization of external medium[4~6]. It is concluded that sugars would be transported along an electrochemical proton gradient maintained by a proton-extrusion pump[7].

The method with microelectrode has been used for the measurement of potentials. The microelectrode which has very fine tip does less damage to plant cells.

This microelectrode method was applied to young trees of Japanese cedar (*Cryptomeria japonica* D. Don) and poplar (*Populus nigra* Linn.). And their potentials in the light and dark condition were measured to clarify the difference of ion transport between the both conditions.

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Materials and Methods

Japanese cedar and poplar had been cultured for several months in the phytotron of our Institute. Japanese cedar were germinated at early Jully, 1982 and poplar were planted a cutting at late September, 1982. The phytotron was controlled at 25°C in the lighting-time of 15 hrs. and at 20°C in the dark of 9 hrs.

In the measurement they were moved to a growth cabinet working at a constant temperature of 25°C and the illumination intensity of about 7000 lux near the apex.

The potentials were measured between a microelectrode impaling into a shoot, a petiol and a leaf and a reference microelectrode in the culturing pot or beaker. The microelectrode was made from a glass capillary tube (1.5 mm in diameter) by a puller (Narishige Scientific Instrument Laboratory). The tip diameter of the microelectrode used was less than 10 μm and thus its resistance was 20–30 MΩ. The inner microcapillary was filled with 3M KCI by the alcohol substitution method and and Ag-AgCI wire was inserted in the other end of the microelectrode. The micro-electrode and the refernce electrode were connected through a probe, a preamplifer, an oscilloscope and a chart recorder (Fig. 1).

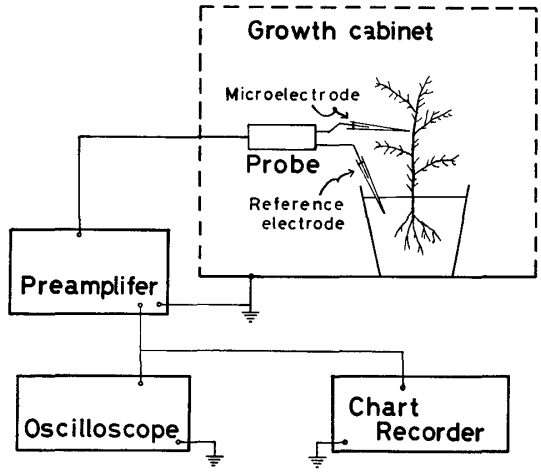

Fig. 1. Schematic diagram of the apparatus.

At the measurement of shoot, a small epidermis was peeled off by a blade on the middle of whole shoot for an easy work of impaling the microelectrode. The pot was full of water. The beaker was used for the rootless poplar shoots immersed in 0.25 M sucrose solution or water. The light in the growth cabinet was turned on or off by a timer according to the light periods treated.

Results and Discussions

1. Resting potential

The potential of a shoot showed the highest value immediately after impaling the

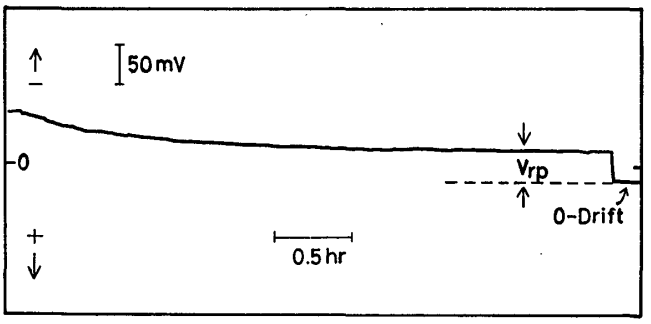

Fig. 2. An example of measurement in shoot of Japanese cedar. V_{rp} indicate "resting potential".

Table I. The resting potentials in shoot

	V_A (mV)	V_B (mV)
Populus	-37 ± 9.5	-42 ± 12
Cryptomeria	-41 ± 13	-39 ± 12

V_A: mean of five values from the same sample.
V_B: mean of five values from five samples.
The value indicates mean$\pm$95% confidence limits.

microelectrode and then decreased gradually to a stable value, which should be the " resting optential " (Fig. 2).

Table I shows the means and their 95% confidence limits of the resting potentials in poplar and Japanese cedar. The difference between them is not significant at 5% level. Therefore repeating measurements in tree has the same mean as a measurement in many trees. And the resting potential in poplar and Japanese cedar is the same value of about -40 mV.

2. Potential changes induced by the light on/off

The light on resulted in a depolarization, while the light off resulted in a hyperpolarization (Fig. 3–5). Furthermore, these potential changes recovered to the resting potential. In algae, the light-induced change is a hyperpolarization and the change at light off is a depolarization, and hyperpolarized or depolarized potential is usually maintaincd[8]. These results will be discussed again in the later.

A short initial response appeared at the light on/off (Fig. 5). The " on "-response was hyperpolarization and the " off "-response was depolarization. Sometimes, however, this short initial response did not appear. This short initial response also appeared in *Spirogyra*[8], but the reason has not been understood.

3. Comparison with shoots, petiols and leaves

In poplar, the potential changes at the light on/off were measured in shoots and petiols. The potential change in petiol was slightly larger than that in shoot (Fig.

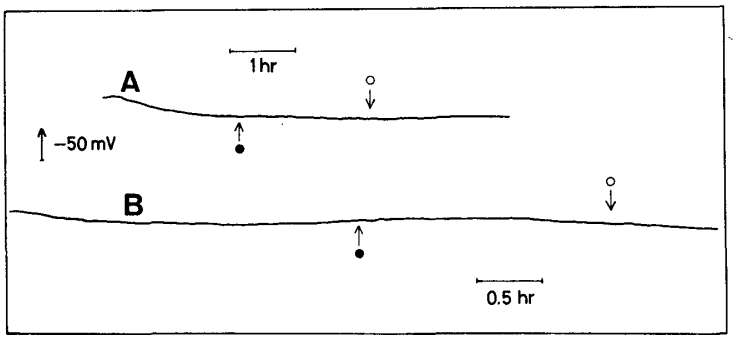

Fig. 3. Potential changes induced by the light condition in shoot. A: Japanese cedar, B: poplar, ♀ : Light ON, ↑ : Light OFF.

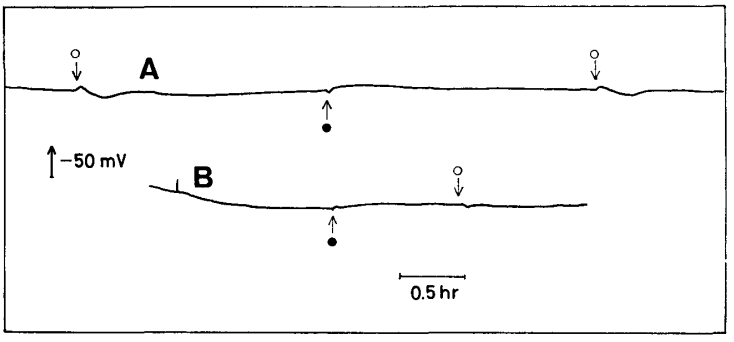

Fig. 4. Potential changes induced by the light condition in (A) base of leaf of Japanese cedar and (B) petiol of poplar. ♀ : Light ON, ↑ : Light OFF.

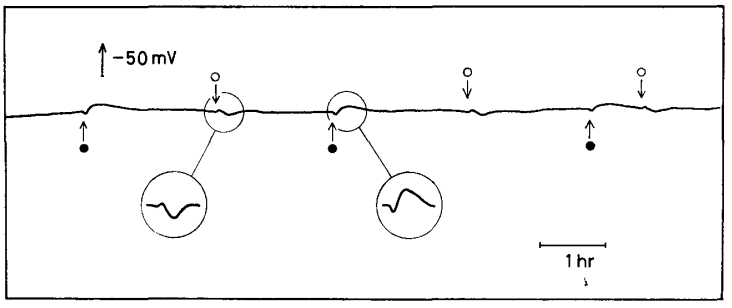

Fig. 5. Potential changes induced by the light condition in leaf of Japanese cedar. The scale of vertical axis in large circles expands three times. ♀ : Light ON, ↑ : Light OFF.

3B and 4B). In Japanese cedar, they were measured in shoots, bases of a leaf and leaves which increased successively (Fig. 3A, 4A and 5). Namely the leaf was the most sensitive part for the light change. Chlorophyll contents were low in the shoot, petiol and base of leaf, but they were abundant in the leaf. It is supposed that this change might be related to photosynthesis.

4. On the diurnal rhythmic change

The potential depolarized at the light on and hyperpolarized at the light off, when the cycle of light on/off was 2-3 hrs. Therefore, it is confirmed that the potential change should not be controlled by the diurnal rhythm but by the light condition. The same tendency is also found in the change of the sem diameter[9].

5. Effects of medium of surroundings

The rootless poplar shoot was immersed in water or in 0.25 M sucrose solution. The light on/off resulted in the followings: In 0.25 M sucrose solution, the light on resulted in hyperpolarization and the light off resulted in deloparization, and this hyperpolarization or depolarization did not recover (Fig. 6A). In water, the light on resulted in depolarization and the light off resulted in hyperpolarization as a whole plant (Fig. 6B).

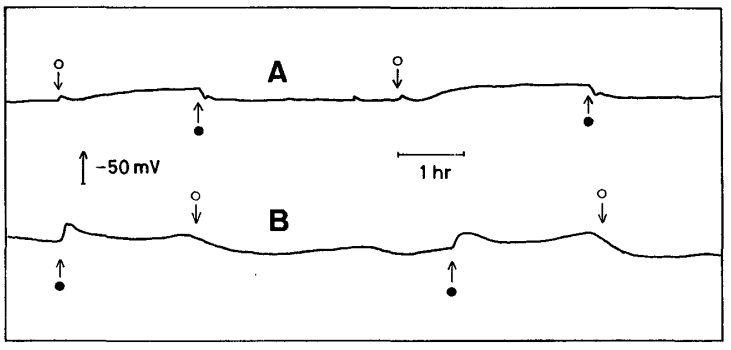

Fig. 6. Potential changes induced by the light condition in rootless poplar. A: in 0.25 M sucrose solution, B: in water, ♀: Light ON, ♝: Light OFF.

Consequently in rootless poplar shoot, the response to the light condition in 0.25 M sucrose solution differs from that in water. A difference between water and 0.25 M sucrose solution is the osmotic pressure in addition to that sucrose could be a C-resourse. Therefore, further biochemical investigations are neccessary to elucidate the effect of osmotic pressure and sucrose on the potential.

Reference

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