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Electric Charge Signaling in Plant Tendrils

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Summary: Disturbance of electric charge on cell surface can initiate rapid contact coiling in bottle gourd tendril.

Abstract- Touch initiates rapid contact coiling in plant tendrils. Besides touch rapid contact coiling could also be initiated by immersing the tendril in liquid containing electrolytes. Liquids with poor electrolyte or non electrolytes did not initiate rapid contact coiling. This observation is strongly suggestive of involvement of electrical charge in the initiation of rapid contact coiling in plant tendrils. Disturbance of electrical charge by touch (like modern touch screen) is likely used to send a signal to the interior of the cell affecting its turgidity. It is proposed that tendril of bottle gourd uses neutralization of electric charge for signaling.

I. Introduction

The movement in plants has engaged the attention of scientists as far back as the time of Darwin (1). The contact coiling happens when the tendril touches an object it forms a spiral coil around a support to involve it (2). The mechanics of coiling have been studied in detail by Gerbode et al (3). Coiling of plant tendrils around an object on contact is a two step process. First step is known as "rapid contact coiling" and second step is known as "Thigmotropism".(4)

Rapid contact coiling occurs due to decreased turgidity in the contact side cells and increased turgidity on the non-contact side cells. This process allows for the initial, rapid bending of the tendril. This rapid bending is then followed by a slower process of differential growth of cells. (Thigmotropism).

Evidence is presented to show that rapid coiling of tendrils can also be initiated by solutions containing electrolytes. It is suggested that tendrils have receptors on the surface which act like bell push type electrostatic micro-switches. Initiation of rapid coiling of tendrils by contact (touch) may also be operating through activation of electrostatic micro-switches.

EXPERIMENT # 1. Tendrils of six weeks old bottle gourd plants (*Lagenaria siceraria* family) attached to the plant were immersed in 250 ml. capacity glasses containing various liquids as follows:

1. Distilled water
2. Distilled water containing 1% sodium chloride
3. Distilled water containing 1 % glucose.

It was observed that only tendril immersed in distilled water containing 1% sodium chloride showed coiling of the tendril within 30 minutes of immersion. No coiling of the tendril was observed even after 6 hours of immersion in distilled water or distilled water containing 1 % glucose.

Water is a poor electrolyte and does not conduct electricity. Some part of sodium chloride when dissolved in water dissociates into sodium and chloride ions and conducts electricity .Glucose is a non-electrolyte and does not conduct electricity. It can be safely concluded that in addition to touch electro-conductive liquids can also initiate rapid coiling in plant tendrils.

EXPERIMENT # 2. After occurrence of rapid coiling of tendril initiated by touch or immersion in electrolyte solution were allowed to hang in the air or removed from the liquid rinsed in distilled water twice and immersed in fresh distilled water. The tendrils were observed for 24 hours.

It was observed that gradually coiling was undone and tendrils straightened and assumed original form in both the cases.

The rapid coiling of tendrils on touch as well as initiated by electrolyte solution is reversible in initial period of six hours or so. Rapid coiling of tendrils required continuous pressure (touch) or effective electrolyte for 4-6 hours to make permanent coiling. Prolonged continuous stimulus is required before it enters next step of permanency.

EXPERIMENT # 3.

Several electrolytes solutions including 1% acetic acid, 1% citric acid, 1% sodium bicarbonate, 1% sodium hydroxide, solution containing 0.5% citric acid and 0.5% sodium bicarbonate were studied for initiation of rapid coiling of tendrils.

Significant coiling was observed within 30 minutes and maximum coiling was observed in 6 hours. Solution containing 0.5% citric acid and 0,5% sodium bicarbonate were more effective (Photograph # 1&2).

II. Discussion

Rapid coiling step in plant tendril is initiated by pressure of an object on the tendril which causes decreased turgidity in the contact side cells and increased turgidity on the non-contact side cells. Current experiments show that rapid coiling can be also initiated by immersion of tendril in fluid containing electro-conductive ions. It is not dependent on pH (acid-base balance) but on the presence of ions in the liquid which can conduct electric charge. There was no relationship to the time of day or sunlight or watering of the plant. It is strongly indicative of electric charge involvement in the process in the initiation of rapid coiling step.

Reversal of the coiling on removal of electro-conductive ions from the fluid or pressure of touch indicates a bell push type switch. It further strengthens the role of electric charge in the initiation and maintenance of rapid coiling step.

It is quite likely that electro-conductive ions shorten the electric-switch which is normally operated by mechanical pressure (touch). A schematic diagram of the proposed biological electric switch is given in the diagram.

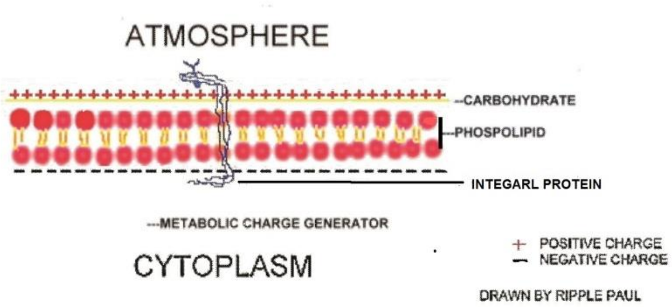

Diagram No.1.Schematic diagram of the cell wall of tendril with integral protein acting as a biological micro-electric switch.

The metabolic machinery inside the cell generates an electric charge. The double layer of phospholipids in the cell wall acts as an insulator so that –ve charge is retained inside the cell and a +ve charge is spread on the outer surface of the cell wall. The integral protein acts as a conductor from inside to outside for the switch.

It is hypothesized that loss of charge difference between the interior and exterior of cell across the cell wall leads to migration of fluid from intracellular space to extracellular space and loss of turgidity.

The finding that liquids containing electro-conducting ions were more effective in initiating rapid coiling then mechanical pressure (touch) supports the above hypothesis. The liquid shortens far more switches than switches turned on by mechanical pressure.

It is concluded that disturbance of electric charge on the surface of the tendril sends a signal to inside the cell causing loss of turgidity thus initiating first step of rapid contact coiling.

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Photograph # 1: Showing coiling of tendril after two hours of immersion in distilled water containing 0.5% citric acid and 0.5% sodium bicarbonate

Photograph # 2: Showing coiling of tendril after six hours of immersion in distilled water containing 0.5% citric acid and 0.5% sodium bicarbonate. There is increased coiling and tendril has moved upwards.