Bottle Gourd Plant Tendril-Role of Electric Charge in Rapid Contact Coiling

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Abstract- Bottle gourd plant has evolved a special senso-motor organ in the form of tendril. The tendril provides sensory detection of foreign material and mobility to the plant. There are motor cells clustered at strategic locations on the tendril which are at the heart of rapid contact coiling of the tendril. In tendril the motor cell has additional sensory mechanism. Thus these motor cells may be called as SENSO-MOTOR CELLS. The role of electrostatic charge in the functioning of these SENSO-MOTOR cells and other factors involved in rapid contact coiling are discussed.

Index Terms- Bottle gourd, Tendril, Electric Charge, Coiling.

I. Introduction

In an earlier study it was found that besides touch rapid contact coiling could also be initiated by immersing the tendril in liquid containing electrolytes. It pointed to the role of electric charge in the initiation of rapid contact coiling.[1]

The physical properties of the tendril were studied and role of electric charge in rapid contact coiling of bottle gourd tendril was explored.

II. Materials, Methods and Results

1. A charged comb was brought near the tendril. The tendril was attracted by the comb. (Fig. 1)

Photograph # 1.Showing attraction of tendril to the comb.

2. Fibro-foam granules were sprinkled on the tendril. The granules stuck to the tendril. (Fig. 2) Again pointing to the static charge on the tendril.

Photograph # 2.Showing attraction of Styrofoam granules to tendril.

3. Tendril was suspended in a static electric field. It moved with the movement of the field.

4. A powerful magnet was brought near the tendril. No effect was seen.

The results indicated that tendril behaves like a dielectric and carries an electric charge and no magnetic properties.

III. DISCUSSION

Plants are known to have MOTOR CELLS (Buliform cells) which act like a hinge at joints to enable the movements of plant parts, such as the closing and opening of leaflets in response to light intensity[2]. Motor cells alter their turgidity, and hence the cell shape. The movement is amplified by lever action. The movements resulting from the changes in motor-cell turgor are relatively gradual, taking minutes or hours.

Tendrils have motor cells situated at strategic locations (inner-side of tendril close to the tip) responsible for rapid movement of tendril giving rise to its coiling on coming in contact with an object. When the surface of these cells comes in contact with an object there is loss of electric charge as shown in the diagram No. 1.

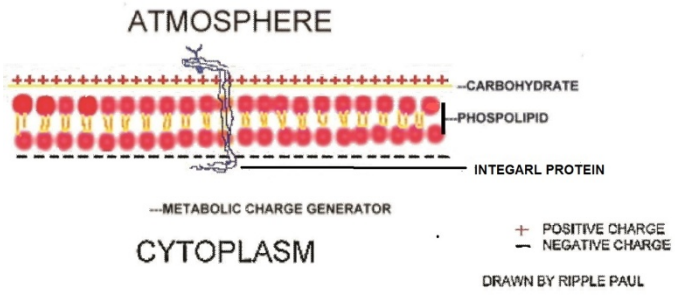

Diagram No.1.Schematic diagram of the cell wall of tendril with integral protein acting as a micro-electric switch.

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 and acts like a touch screen switch. A number of motor cells are affected when even few cells are touched (Plate Effect seen in electrostatic charge).

IV. MECHANISM OF LOSS OF TURGIDITY BY MOTOR CELL

The opposite cell wall of the Motor Cell which is in contact with extracellular fluid is made of plasma membrane. Plasma membrane has ion channels which control influx and efflux of various ions and liquids. These ion channels are well documented in animal cells and have been visualized by crystallography.[3,4]

Crystallographic structural studies of a potassium channel have shown that, when a potential difference is introduced over the membrane, the associated electric field induces a conformational change in the potassium channel. The conformational change distorts the shape of the channel proteins sufficiently such that the cavity, or channel, opens to allow influx or efflux to occur across the membrane.

An economical and simpler mechanism of these voltage gated channels (better called CHARGE GATED CHANNELS) is described below :

It is proposed that in bottle gourd plant these ion channels are operated by static electric charge (CHARGE GATED ION CHANNELS).The charge on the ribbon like helix provides the force for closing and opening of the ion channel gate.

The ribbon like helix keep the ion channel closed when charge is present (Diagram No. 2). Loss of electric charge leads to opening of the ion channel. The opening of these channels lead to movement of ions along with water from inside the cell to interstitial fluid. Loss of fluid from inside of the cell leads to its shrinkage and movement..

Channel Closed Channel Open

Diagram No. 2. Schematic Diagram of Charge Operated Ion Channel

Like Charges repel each other. Under normal circumstances electric charge on the helices keeps the ion channel closed. Loss of charge leads to opening of channel and loss of ions and fluid.

The motor cell in bottle gourd tendril is more than simply motor cell. It has sensory receptors on external surface of the cell (responsible for sensory input) and ion channels on the interstitial side of the cell responsible for motor activity of the cell. Thus it is a SENSO-MOTOR CELL.

Rapid Contact Coiling of Bottle gourd tendril is a three step operation.

When distal part of tendril comes in contact with an object it makes a weak attachment because of a static charge. The tendril has a positive charge and it sticks to an object carrying a negative charge. Though the attachment is very weak but it serves the purpose. (It is to be noted that tendril will not be attracted to other tendril as it will also be carrying a positive charge. Like charges repel each other. Though feeble but it is an attempt to distinguish self from non-self).Besides the attachment to object is helped by other physical factors. The hook like configuration of the tendril tip and blowing of wind aids in attachment.

The contact of the tendril to the object leads to the shortening of the charge of the motor cells. This in turn leads to opening up of charge gated ion channels with loss of ions and fluid to interstitial space and collapse of the motor cell. Because of plate effect several motor cells are affected resulting in coiling of tendril. This is a reversible process. In the meantime excessive multiplication and growth of cell on the opposite side gives rise to more permanent coiling.

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