About Wavelike Mobility of Plasma Membrane in a Alive Cotton Cell-Hairs

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ABSTRACT
Direct experimental data about wavelike mobility of plasma membrane in alive cotton cell –hairs by video microscopy technique are resulted in real time. A features of sol-gel transformations in growing cotton cells and its localization in cellular structure are described. Movement of protoplasm in cotton cell is connected with electric signals (potentials) in plant which cause wave-like movement of plasmalemma surface. Waviness of a plasmalemma surface in a elongating cotton cell-hairs is confirmed by micrographs its gelatin press. The part of experimental data related to plasma membrane movement in alive cotton cell-hairs is presented in real time scale as video file, a link attached to this paper.

Key words: Gossypium, Fiber, Plasmalemma, Structure, Protoplasmic streaming, Plasma sol, Plasma gel, Phase transitions sol-gel.

INTRODUCTION

Intracellular protoplasm motility is an interesting phenomena for studying motional mechanisms in biological systems. From the earliest observations of cytoplasm streaming (Corti,1774), further their study (Ewart, 1903; Mast, 1926, Seifriz, 1953) and up to now the testable and reproducible measurements to explain these phenomena were relatively few to reveal the mechanism and nature of motility forces. Systematization of experimental data has allowed to reveal some the basic types so complex cytoplasm movement (Seifriz, 1953; Kamiya, 1959). Up to now most in detail a various types of protoplasm movement are classified by Kamiya (1959) as four basic types: oscillatory, circulatory, rotational and gushing.

Usually to see protoplasmic moving need to use video microscopy technique to observe movement of microscopic granules or particles in cytoplasm of cell. The oscillatory type of protoplasm movement is characterized by that some particles at the moment of watching can be in rest, others can slide to periphery and the some particles to the center of a cell, i.e. movement in local points as cytoplasm in general is not stable and has casual character. Despite of it, as mark Kamiya, it is not completely chaotic as , for example, in case of the Brownian movement.

Circulating movement is typical for cells with protoplasmic folders which crossing central vacuoles (Bushee , 1908). The important feature of protoplasm movement in folders is periodicity for changing of a liquid flow direction. In this case the direction of protoplasm movement alternately varies. Inside of a stream or a layer of protoplasm the behavior of particles is also specific and is difficultly explained. For example fine particles being even in immediate proximity from each other can move with different speed and in difference directions. They can move and towards each other.

In the case of rotational movement a protoplasm of some plant cells frequently situated on periphery of a cell contour and moves like to a driving belt (Kamiya and Kiroda, 1958). Unlike circulating movement rotational one represents ordered, long time observable type of a protoplasm movement. So type of movement is specific for cells of

many plants for example *Chara, Nitella* , water plants (*Eladea, Vollisneria),* root hairs and others.

For fountain like movement a protoplasm in central folder goes to top or to the base of a cell and close to cell wall layer goes in the opposite direction. So type of protoplasm movement we can see in pollen tubes of plants and in root hairs (Ivanami, 1956).

Besides of the above mentioned types of protoplasm movement there are also other types of movement for instance jerk like movement similar to inflow, shuttle movement and movement along guiding grooves (Strugger, 1949).

Consideration and analysis of the any possible kinds of protoplasm motility shows that the cytoplasm on its own account can not generate its movement. For any kinds of protoplasm motility the valuable role of boundary layer between plasmasol and plasmagel of cell is revealed (Kamiya, 1959). According to Kamiya origination of protoplasm motile force is namely connecting with this boundary layers of cell (Seifriz, 1953, Seifriz 1942). In first this hypothesis has been formulated by Went ((1938). But up to now we have not definite knowledge about the mechanisms of protoplasm movement. According to Corti (1774) and another authors ((Rachevskiy, 1939) the contractility was advocated as motile force. Seifriz (1942) suggests that a force may exist in the form of a peristaltic wave of contraction in the cortical area of cell. For early amphibian embryos Holtfreter (1946) concluded that amoeboid motility is due to autonomous expansions and contractions of the plasmamembrane layer of cells. But up to now there is not any precise documented measurements so kinds of plasmalemma motility.

In this connection in this paper we suppose that plasmalemma plays important role to generate the protoplasm movement in plant cells. Therefore to find clear proof existing above mentioned kinds of protoplasm movement we make attempt to visualize wavelike microstructure and oscillatory movement of cotton plant plasmalemma.

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MATERIALS AND METHODS

Alive cotton cell-hairs on ovule in cotton boll has been investigated after 1-10 days past anthesis (DPA). Microscopic observing carried off for 3 cotton variety: *Gossipium hirsutum* L. (Tashkent-1, 108-Ф) *G.barbadence* (C-6030, C-6524) and *G.arboreum* L. (Turfan guza). The time of flower opening was labeling every day in same time. A young cotton bolls depend on its age are prepared and investigated by using universal optical microscope Neophot-2 in reflected light with magnification ×910. Each time labeled ovule – fruits are detached off together with significant part of plant branch to prevent its drying during experiment. On the outside surface of green cotton boll a small hole (~1 mm^2) has been made to preserve natural conditions inside of cotton boll. Under optical microscope convenient for observing cotton cell-hairs has been selected and captured its microstructure by using TV camera. To image dynamical motility of protoplasm a optical TV system with record on the videotape has been used. This technique let us to see morphology as ovule surface and apex of separate cotton cell-hairs with magnification ×3700.

To get additional proof wavelike movement of plasmalemma of alive cotton cell-hair the replica-reprint method on gelatin is used also (Krakhmalev and Zakirov, 2000). In this case alive cotton hair is impressed to slightly humidified gelatin surface. After some minutes the cotton hairs were detached from gelatin and studied under reflected optical microscope Neophot-2.

RESULTS AND DISCUSSION

Investigation *in-vivo* alive plant cells is difficult task especially if it related to study of dynamical process in alive cotton cell-hair. It is well know that separate single cotton cell represents as cylinder with diameter 14-22 mkm and length up to 50-60 mm.. The basis building material of a cellular wall is a cellulose which synthesing by terminal complexes on plasmalemma surface (Muller and Brown, 1980). Cellulose micro fibrils deposits on inner side of primary cell wall around plasma membrane spiral shaped (Krakhmalev and Paiziev , 2006).

Plasmalemma in such huge cells have same length. Terminal complexes are located on plasmalemma surface and take part in synthesis of cellulose microfibrils and transportation of cytoplasm liquid toward apex. Movement of cytoplasm to apex and back performing due to wave like mobility of molecular layers of cytoplasm. Protoplasm mobility direction in cotton hairs coincides with a direction of wave like plasmalemma movement. To see video file please click here www.ndt.net/article/v12n09/paiziev.wmv [1.4MB]. On the present video image we can see a wavelike oscillations of the plasmalemma surface. The moving dark and light bands of plasmalemma represents on this picture the trough and the crest of a wave respectively. We suppose that motile impulses are transmitted from periodical contracting and expanding plasmalemma to cytoplasm of cell. Speed of the propagating wave along plasmalemma is not constant and changes from 1.35 up to 3.0 mkm/s. Often short time stopping of wave moving and sudden renewing its rhythmic movement are observed. For neighboring cotton cells the wavelike movement their surface very aligned but not always. Sometimes the wavelike movement their plasmalemma have opposite direction . Wave like pattern of plasmalemma surface for alive cotton hairs is well revealed when for some reason a plasmalemma movement is stopped (fig.1a).

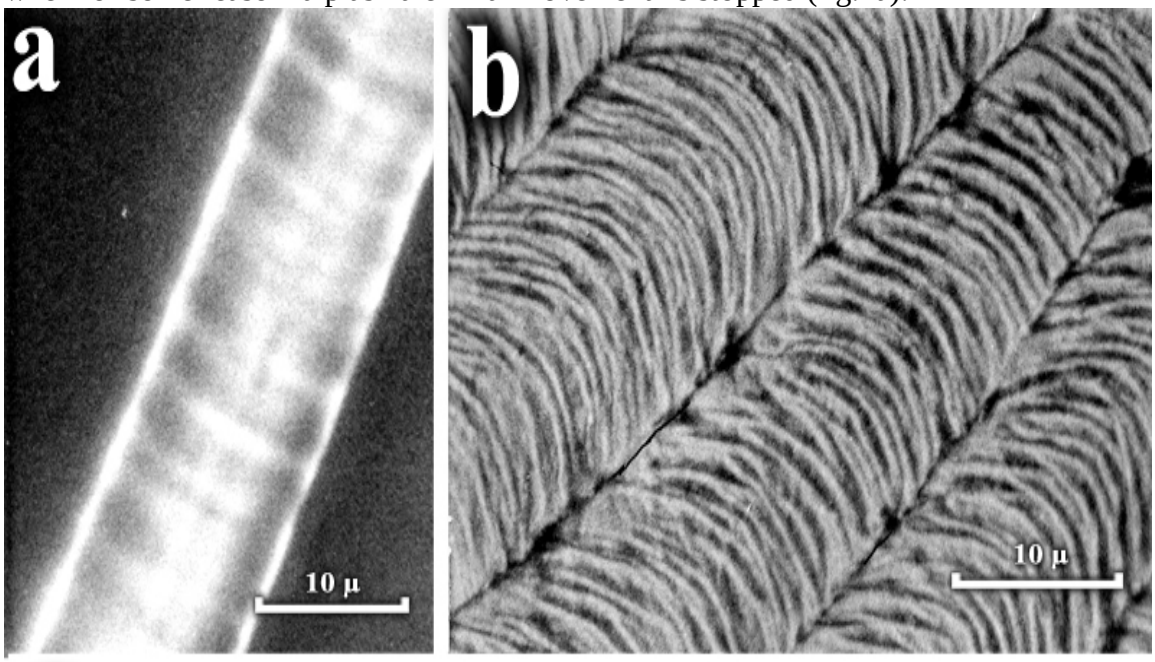

Fig.1 Transversal pattern of plasmalemma surface for cotton variety *Gossipium hirsutum* L. (Tashkent-1, 108-Ф) revealed under videomicroscopy (a) and by gelatin replica-reprint method.(b).

Wavelike pattern of plasmalemma surface is revealed on the micrographs by using replica-reprint method of alive cotton hairs and optical reflected microscopy (fig.1b). That is achieved by using plasmolysis phenomena when under osmotic forces the plasmalemma surface press on gelatin across primary cell wall (what have 1-2 molecular layer thickness at early growth stage of cotton hair) and reveals the wavelike pattern of plasmalemma. Here we have to note that at early growth stage (1-10 DPA) primary cell wall thickness consist of 1-2 molecular layers and is no barrier to reveal of plasmalemma.

Sometime we can see more fine pattern of the wavelike plasmalemma surface. One period of the plasmalemma wave have size about 4-5 mkm . In turn the period of more fine wave oscillations on plasmalemma surface have size ~1.25-1.37 mkm. The separate elementary waves are grouped in bundles from 4-6 elementary waves. As the cotton cell-hair age increases, the fine pattern of its plasmalemma becomes more rough.

Above described picture of cotton cell plasmalemma motility will not completed without one very important features its cell wall pattern. The matter is that in living cotton hairs especially at early growth stage the plasmalemma is not tight against the inner cell wall. At this period primary cell wall consist of 2-3 cellulose microfibrilar layers (Vlasova, 1974). There is thin transparent layer between plasmalema surface and primary cell wall. This interlayer consist of transparence sol-gel substance what is well revealed by electron microscope (fig.2). Its pattern is revealed by optical microscope also by using so named Schweitzer's reagent for swelling and dissolution of cellulose cell wall (Muller, 1929). Indeed to see sol-gel phase transitions in cotton cell-hairs we were using optical videomicroscopy equipped TV

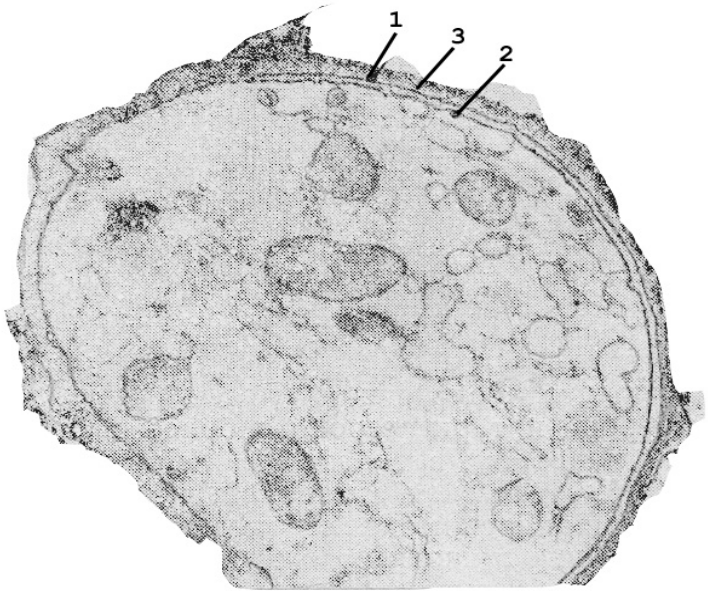

Fig.2 Electron micrograph of mature cotton hair cross section (variety Gossipium hirsutum L. 108-Ф). 1- inner side of the primary cell wall, 2- Plasmamembrane surface, 3- protoplasmic interlayer.

camera. This phase transitions of plasma sol between plasmamembrane and primary cell wall are clearly visible due to structural change of high molecular compounds in this cell wall

interlayer (protoplasmic interlayer). The amorphous plasma sol of a protoplasmic interlayer turn into ordered structure of plasma gel and have an impact on its reflectivity and birefringence. Therefore in reflected optical microscope the paracrystalline structure becomes visible due to intensive light reflection.

There is hypotheses about sol-gel transitions in interlayer between plasmalemma and primary cell wall but up to now there is not any documental microscopic observing this phenomena . What is morphological structure this interlayer? What is space image of sol-gel transitions? What is of amorphous sol structural alteration direction: from inner side of primary cell wall to cell center or along perimeter of cell wall?

In cotton hairs a sol –gel phase transitions, which take place at above mentioned protoplasm interlayer, are observed luminous ring –shape with thickness ~ 0.27 mkm and running along hair from its base to apex. Probably it is moving boundary of plasma sol – plasma gel transition area which periodically make stop and resumes its movement again. The moving luminous rings follows one after another constantly in field of microscope. It is remarkable that gel-sol periodical rearrangements , propagating along cotton hair, do not prevent wavelike motility of plasmalemma but accompanies it. What is the reason of sol-gel transitions and wavelike oscillations of plasmalemma surface in cotton hairs? What is the nature of motility forces? This questions remains non answerable up to now.

We suppose that origin this motility forces is well know electric signals generated in plant according to its developing programs. Original experiments of Kamiya (1959) are good proofs in favor electric nature motility forces. It is shown that protoplasm movement is closely connected with changing of potentials protoplasmic streaming of cell.

Conclusion

1. By two independing methods (gelatin replica-reprint method and video microscopy) the wavelike pattern of plasmalemma of cotton cell-hairs is revealed.
2. We assume that motile forces of protoplasm streaming may be contractile movements of plasmalemma.

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