Influence of gravity on the structure of meristem of primary cress (*Lepidium sativum* L.) roots

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During seed germination, gravity influences the formation of plant's axial organs, which determine its orientation in space. Change of gravity causes redislocation of organoids in the gravisensory root-cap bearing cells. The physiological signals are transferred via the meristem to the zone of extension, where the information is converted into the curve-shaped growth. There is little probability that the zone of meristem will remain indifferent towards the changed gravity. This work contains the data about changes that which occur in a predmitotic meristem when its germination takes place in conditions of changed gravity. The latter factor changes the lineal parameters of cells in all tissues, and these changes vary depending upon their location regarding the center of tranquility. Most significant changes take place in the middle zone of the meristem. This zone can be characterized as more sensitive to gravitation. The lineal parameters of all tissues of the meristem cells grown in a slow clinostat differ from those of the test tissues.

Key words: roots, meristem, gravity

INTRODUCTION

A polar system of axial organs, which is formed at the stage of embryogenesis, is determined in the seed. Its further functional and structural polarization takes place during seed germination. The impact of the Earth gravity serves as one of evolutionary factors, that influence seedling growth, formation and orientation. As is known, changes in the root-cap growth cells caused by the influence of the changed gravity (response reaction, curved growth of the root) are expected in the zone of extension. However, a definite signal comes from the root-cap growth cell via the meristem to the zone of extension. Up to now, there is no unequivocal opinion about the processes that occur in meristematic cells when they grow and fission under conditions of changed gravity.

It is common knowledge that fission and self-reproduction of cells are the main functions of meristematic cells [1]. The cells of the meristematic zone seem to be the same from outside and, naturally, have no specialized cells determining the statocytes that could shift in response to the changed gravity. Thus, it can be expected that the reaction of meristematic cells to the changed gravity can be designated by different signs, if compared with the gravisensory cells [2].

A certain analogy can be drawn between a non-specialized meristematic cell and a cell of tissue culture. The tissue culture, every cell of which possesses full genetic information of the whole plant, could create a gravisensory system. However, nothing of the kind happens because genes are artificially activated in a certain way. Theoretically, these non-specialized cells should react towards gravisensory irritation as they possess genetically transferred components of the system, which react towards the changed gravity [3]. The exclusion of one or another component out of the system will probably cause changes in the remaining components of the system. Under the impact of gravity any organoid of meristematic cell changes its dislocation and is able to determine its cellular growth. It is ascertained that the changed gravity influences morphology, ultrastructure, growth intensity and integral biological processes. Changes in these parameters influence the metabolic processes responsible for the growth of non-specialized cells, which can be interpreted as a response to the changed gravity in correct experiments.

According to Prof. V. S. Ivanov [4], who is the author of the main works about the growth of root meristem cells, a meristem cannot be looked upon as a zone of the same cells [5]. The zone of the meristem is divided into a nearest, middle and distant zones in respect of the center of rest. Author [4] established the fact that the speed of fission of meristematic cells in the distant meristem can be more intensive than in the nearest meristem. The difference in speed of fission serves as a proof that a meristem is not an organization of the same cells but a system of cells, compiled in accordance with a definite law. Due to differences in growth rate, meristematic cells differ from the point of view of a definite law, and this difference depends upon their location towards the center of rest.

While leaving the center of rest, a meristematic cell has the increased quantity of RNA and total proteins. The vacuoles of these cells are reduced. While moving away from the center of rest, the inverse process is taking place, *i.e.* the volume of vacuoles increases and the quantity of RNA and total proteins decreases. With the increase of vacuoles, the number of rybosomes decreases in the cells. Sometimes the number of other organoids decreases in the cytoplasm [6]. The quantity of proteins and RNA increases in the forbear of the meristem, where the cells grow breadthwise. However, the reason of this phenomenon is notyet known.

Referring to the above-mentioned data, it can be stated that the process of differentiation starts in the meristem. However, its culmination is very slow and the whole metabolism is related to self-reproduction of cells. Thus, meristematic cells may be condifionally considered non-specialized. And, by drawing an analogy with the tissue culture, their modified growth can be forecasted and evaluated as their response to a changed impact of gravity.

METHODS

The roots of cress-salad (*Lepidium sativum* L.), which had been grown in conditions of changed gravity and supervision, were used for the research purposes. Changes in g were fixed in horizontal clinostats (HC) with quick (50 rp/min) and slow (4 rp/min) rotation. This allowed to touch indirectly upon a constant dilemma: which clinostating, quick or slow, better imitates microgravitation or weightlessness. Horizontal clinostats of a new generation have been designed in the Laboratory of Plants Physiology. Friction of bearings and vibration, which occur during horizontal revolutions, are reduced to the minimal level in them. The same conditions of experiment and check variant, except the check variant grown in the static position, vertically towards the gravity vector, prove the correctness of the experiment.

According to the literature sources, the first mitoses appear at a temperature of 24 °C in the root of cress-salad after 28 h of growth since seed germination [7]. For the purpose of analysis we used the primary roots up to the first mitoses, *i.e.* 26 h from the start of growth. In accordance with traditional methods [8], we prepared constant preparations (6μ thick), from equal rootlets 8 mm long (roots of average size were chosen from the population) and stained them with the mixture of Bromphenol Blue and sublimate dissolved in acetic acid [9]. The same preparations were used for the purpose of citophotometrical estimation of common total proteins and RNA in the distal and proximal poles of meristematic cells [10, 11]. The central cuts off along the meristem (up to 30 cells) were chosen for the morphometric purpose. The lineal parameters and cell area of certain tissues of cortex, epidermis and central stele were fixed. One to 10 cells from the center of rest is a nearest meristem, 10–20 cells from the center of rest is a middle meristem, and 20–30 cells is a distant meristem. Measurements of several central cuts of the roots in all variants have been taken.

RESULTS AND DISCUSSION

Cells of the epidermis, which grew on HC in the distant meristem, appeared to be of the same width, but by 22% shorter than the check cells. The change of the lineal parameters is more vivid in the central part of the meristem, *i.e.* the cells which grew on HC by 24% narrower and by 8% longer than the check cells. However, statistically their area is smaller. (Fig. 1). Cells of the epidermis in the far zone of the meristem extend and their average area in different variants becomes equal.

It appeared that the cells of meristematic tissues behave differently in each zone. The cells of the central stele, which grew in conditions of the changed gravity, in the nearest meristem appeared to be (statistically proved) by 20% wider and longer than the check cells. This difference is more significant in the middle meristem (Fig. 2). However, the cell area in all variants remained constant [12]. The lineal parameters of cells of the central spindle remained almost the same in the nearest meristem, depending upon the growth conditions.

Due to the impact of changed gravity, the cells of cortex in the nearest meristem were by 7% wider and a somewhat longer than the check cells. This tendency is typical of the middle meristem (Fig. 3). As regards the far meristem, the area of cells in both variants became equal. The middle zone of the meristem is more sensitive to the changed gravity.

Up to now, measurements of cell area haven't revealed any impact of gravity upon the growth of meristematic cells. Our measurements of lineal parameters of cells revealed their variability, depending upon their growth conditions and location regarding

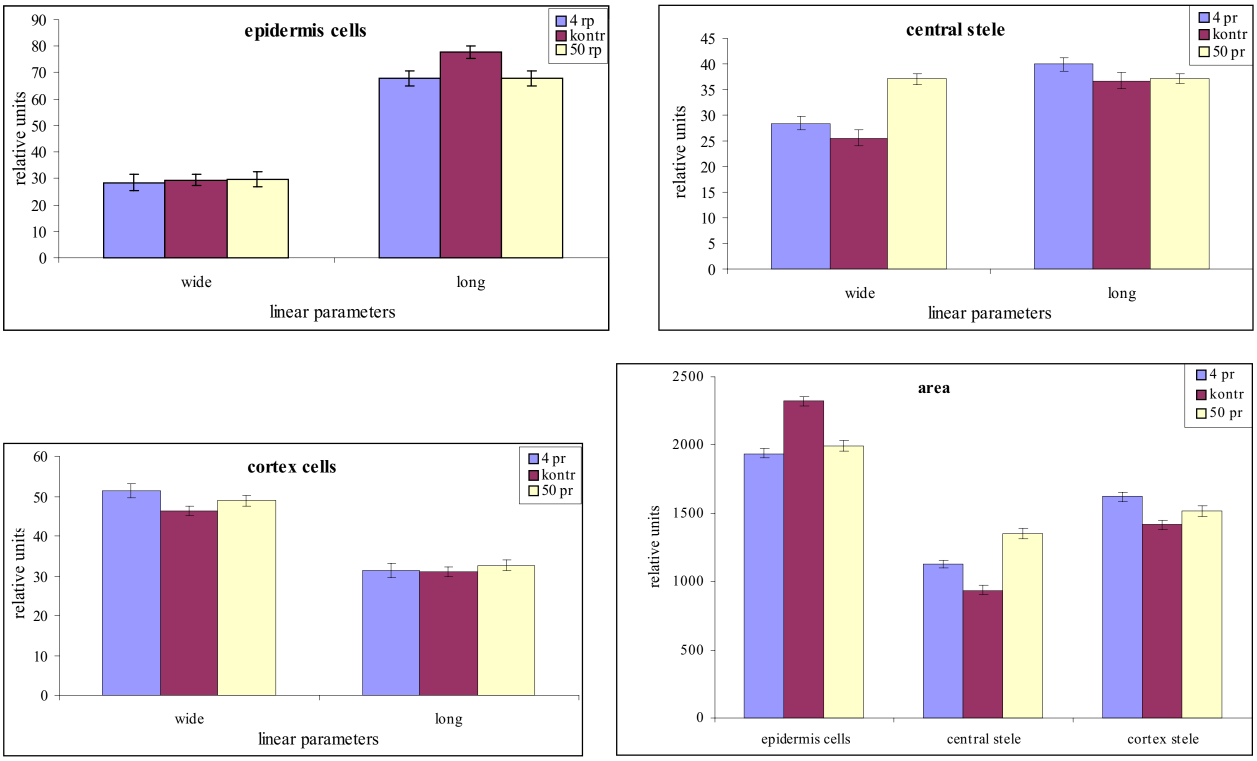

Fig. 1. Morphometric parameters of the nearest part of meristem

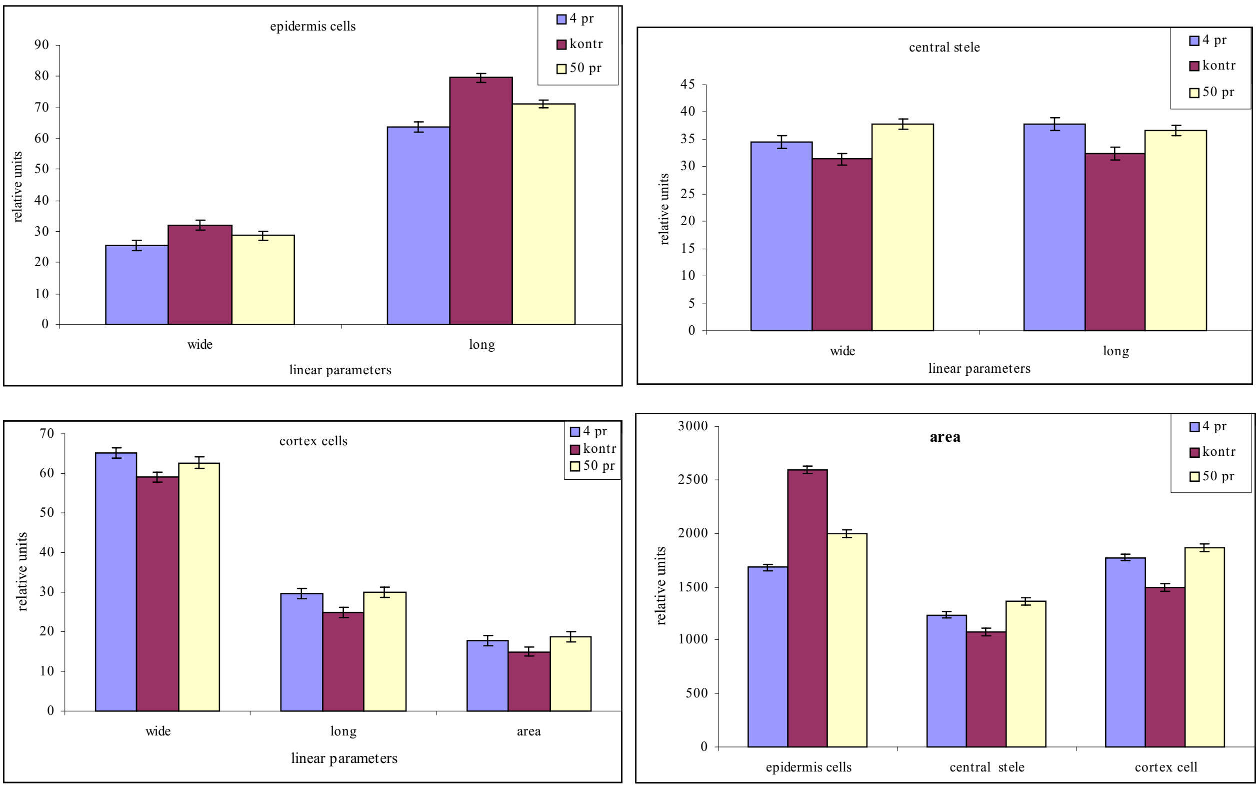

Fig. 2. Morphometric parameters of the middle part of meristem

the center of rest. Under the influence of the changed impact of gravity, meristematic cells acquire another configuration, whereas the cell area remains constant in the distant zone, and this difference in growth can be regarded as an influence of gravity on predmitotic cells of the root meristem.

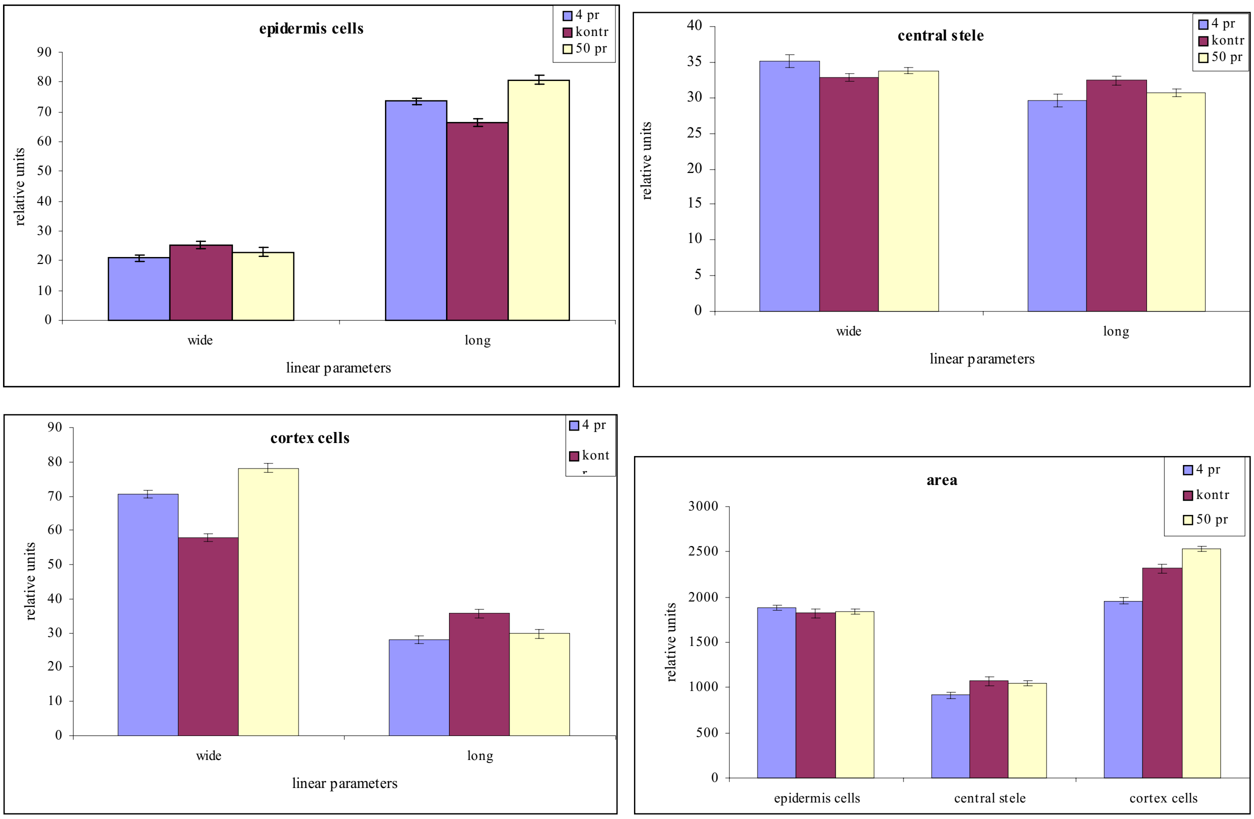

Fig. 3. Morphometric parameters of the distant part of meristem

More significant deviations from the check variant are observed in the variant of slow clinostating.

References

1. Иванов В. Журнал общей биологии 1961; 22 (2): 100.
2. Иванов В. Клеточные основы роста растений. 1974.
3. Laurinavičius R. Eksperimentinė biologija 1992: 4.
4. Иванов В, Максимов В. Физиология растений 1999; 46 (1): 87–97.
5. Литинская Т. Цитология 1970; 12 (7): 854.
6. Данилова М, Бармичева Е. Дифференциация клеток в ризодермисе *Raphanus sativus* L. Ультраструктура растительных клеток. 1972.
7. Clowes F. Apical Meristems. Oxford, 1986.
8. Прозина МН. Ботаническая микротехника. Москва, 1970.
9. Агроскин Л, Папаян Г. Цитофотометрия. 1977.
10. Burstrom H. Physiol Plantarum 1971; 25 (3): 509.
11. Mia A, Pathak S. Bot Gaz 1965; 123 (3): 204.
12. Таирбеков МГ. Сер Биологическая 1986; 5.

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SVORIO JĖGOS ĮTAKA PIPIRNĖS (*Lepidium sativum* L.) PIRMINIŲ ŠAKNŲ MERISTEMOS STRUKTŪRAI

S a n t r a u k a

Sėklai dygstant, formuojasi augalo ašiniai organai, nuo kurių priklauso jo orientacija erdvėje. Svorio jėgos pakeitimas perdislokuoja organoidus šaknies šalmelio ląstelėse. Iš jų fiziologiniai signalai per meristemą sklinda į tįsimo zoną, kurioje įvyksta poveikio realizavimas, būtent šaknies augimas išlinkimu. Mažai tikėtina, kad meristema lieka indiferentiška, kai dėl gravitacijos vyksta tokie pakitimai šaknies šalmelyje ir tįsimo zonoje. Šiame darbe aptinkama, kaip pasikeičia priešmitotinės šaknies meristemos ląstelių morfometriniai parametrai, kai šaknis išauga pakeisto svarumo sąlygomis. Ląstelių linijiniai parametrai pasikeičia visuose meritemos audiniuose, ir šie skirtumai priklauso nuo ląstelių padėties ramybės centro atžvilgiu. Vidurinė meristemos zona yra jautriausia gravitacijai, ir lėtas klinostatavimas (4 aps/min) labiausiai paveikė meristemos linijinius parametrus.