1928

The Origin of Adventitious Roots In Coleus

Ethel Belk
South Dakota State University

THE ORIGIN OF ADVENTITIOUS ROOTS IN COLEUS

By

ETHEL BELK

A thesis submitted to the faculty of the South Dakota State College of Agriculture and Mechanic Arts in partial fulfillment of the requirements for the Degree of Master of Science.

BROOKINGS, SOUTH DAKOTA

June, 1928

THE ORIGIN OF ADVENTITIOUS ROOTS IN COLEUS

by
Ethel Belk

It has long been known that adventitious roots develop from shoots and that adventitious shoots develop from roots. This fact is an important one to the horticulturist in propagating plants by stem or root cuttings. The point of origin of these structures has not been fully presented. There have been various assumptions made as to where and how the adventitious structures arise. To avoid confusion, it is best to indicate that adventitious structures are those which are added to the plant; they are not the normal structures of the plant but are superfluous. They are not, however, superfluous for the biology of the plants concerned, and often are important organs in the life of certain plants or groups of plants. Coleus is a common house plant which is propagated by stem cuttings that develop roots very readily. It is the purpose of this paper to point out the origin of the adventitious roots in Coleus.

Historical Review

Van Tieghem (1) told of the origin and development of branch roots in both seed plants and ferns. His conclusion was that the lateral branches of roots arose from the pericycle in the seed plants and from the endodermis in the ferns. He does not specifically mention the origin of adventitious structures, but considers the roots which arise from other roots. This seems to be the classic work on the anatomy of secondary root development.

Jost (3) tells of adventitious roots developing in the Begonias, from leaf cuttings. He states thatthe adventitious

roots develop from epidermal cells in this case.

Pond (4) reviews the literature to his time on the emergence of lateral roots, rather than upon their point of origin.

Jeffrey (5) notes that the internal mode of origin in characteristic of all roots and rootlets except the primary root of the seedling. He does not make a definite statement as to the point of origin of branch roots or adventitious roots, except that the young root appears as a local development on the central cylinder of the main root. He does not consider adventitious roots in any special statements.

Chang (6) in his notable work on Pteris aquilina mentions the development of adventitious roots in the underground rhizome of that fern. Adventitious roots are important in the life of this fern. He points out that the adventitious roots arise so early and so near to the growing point of the rhizome that the root primordium appears before the pericycle and endodermis have been differentiated. Inasmuch as he finds the pericycle and endodermis to arise from a common initial cell which is stelar in origin, he considers the adventitious roots to arise from the outermost layer of the stele instead of from the innermost layer of the cortex as Van Teighem had believed to be the conditions in the ferns, and which is still the prevalent idea in regard to the situation in the Pteridophytes.

Material and Methods

The material used for the study was that of the stem of the common house plant Coleus. The small-leafed variety was easily obtainable in quantity sufficient to allow a surplus of material.

Coleus produces an abundance of adventitious roots within a short time, and is consequently particularly favorable for the study. The cells are large, the stems are herbaceous, and it is grown under ordinary room conditions with ease. The material was grown in tap water, in which medium roots appeared readily. The investigation was entirely microscopic, and the material was prepared for use with the microscope by the usual paraffin method. Formalin-acetic made up with alcohol was used as a killer. The stems were cut into pieces varying from 5 mm. to 1 cm. in length before killing. The microtome sections were cut 10 mu. in thickness, mounted on slides and stained for a minimum of six hours in safranin, counterstained in light green and mounted in balsam. The lignified material and nuclei took on a red stain and the cellulose walls a very light green.

Results

The stem of Coleus after being placed in water was found to produce visible papillae of young adventitious roots in from 36 to 48 hours at a normal room temperature. It was found that the roots appeared chiefly at the nodes if the nodes were placed under water. In order to facilitate investigation it was desired to have sections in which the adventitious roots were produced in the internodes. This was done by cutting the stems just above the nodes and allowing the internodes only to remain in the water. The time for appearance of roots in the internodes when the nodes were out of water was considerably longer than for their appearance at the nodes. The time was approximately twice as long.

A cross section of the stem (Fig. 1) showed the relation of the vascular system to the pith and cortex in Coleus, and showed the relation of the adventitious roots to the main bundles in the vascular cylinder. The main bundles in the vascular cylinder were four in number and several smaller bundles appeared between the larger bundles in the sections studies. The roots were found to arise just outside of the vascular system, in juxtaposition to a large bundle, and to proceed out through the cortex at approximately right angles to the vascular bundle.

Longitudinal sections were used for the study of the origin of the adventitious roots. The stem has a relatively narrow cortex composed of parenchyma to the inside, but with several layers of chlorenchyma just below the epidermis. The endodermis was evident and a two-layered pericycle is apparently the normal condition of the stem. Very rarely was there a single layer in the pericycle and occasionally a third layer was seen.

The earliest stage studied (Fig. 2) showed the pericycle as the point of origin of the root initial. The outer layer took on a meristematic function, and the adventitious root arises therefore in the outermost layer of the pericycle. The initial divisions appear to be periclinal in cells which have enlarged laterally. Three cells are apparently involved in the early stage of the root development. The periclinal divisions result in two layers of cells in the initial region in the pericycle. These cells enlarge and the outer layer divides again tangentially. Divisions follow each other rapidly in the outer layer until a lenticular mass of cells is developed in the region of the original three cells (Fig. 3). Meanwhile the tangential divisions

have been extended to adjoining cells in the original outermost layer of the pericycle, enlarging the base of the mass of cells. The activity of the cells is the most rapid in the region of the original three cells and soon causes the mass to bulge out the endodermis very conspicuously toward the outside and exert a little pressure resulting in a slight bulge on the inside toward the vascular strand. The young root pushes against the endodermis making the cells stretch very much. It progresses about half way from the stele through the cortex toward the epidermis before the pressure causes the endodermal cells and cortical cells to break.

Just before the young root breaks through the epidermis the vascular elements begin to differentiate. The elements laid down back of the growing point of the root consist of the usual annual and spiral elements of protoxylem. The development of this adventitious root is like that of the normal root, and it performs the same functions as the normal branch roots. Also before the young adventitious root has broken through the epidermis it is evident that the internal layer of the pericycle and the phloem of the vascular strand between the adventitious root and the vascular bundle of the main cylinder become differentiated into xylem. This xylem, unlike that formed back of the growing point, is metaxylem, consisting of scalariform elements like those of the metaxylem in the main vascular strand to which the root joins.

Discussion

The above results show that the origin of adventitious roots in Coleus is distinctly endogenous. Also that they arise in the pericycle, and establish a connection with the main vascular system.

The connection is established with the main vascular system very early, just before the root pushes through the epidermis of the stem.

Pond found in his work that the lateral roots made their way through the cortex by a mechanical action rather than by digesting the cells as Van Tieghem had thought. As to this point, the observations were not made with a view to determining the action of the root, but the indications seemed to show a mechanical rather than a digestive action.

When the root initial first appears the cells divide rapidly, and the outside layer divides the most rapidly, until the regions calyptrogen, dermatogen, periblem and plerome appear, when it becomes evident that the meristematic function is restricted in large part to the growing point.

Summary

1. Coleus shows a marked development of adventitious roots in water.

2. Adventitious roots develop at the nodes if the nodes are placed under water, but will develop in the internodes if there is no node below water.

3. The origin of adventitious roots is endogenous in Coleus.

4. The adventitious roots arise just outside of the vascular system in juxtaposition to a large vascular bundle.

5. The point of origin of the adventitious roots in Coleus is the outermost layer of the pericycle.

6. The number of cells involved in the earliest initial observed was three.

7. The pericycle becomes activated to divide periclinally.

8. The young root pushes about half way through the cortex before there is any rupture of the surrounding tissue.

9. The young root establishes a connection with the vascular system in the stem.

Literature Cited

1. Van Tieghem, Ph., et Douliot, H., Recherches comparatives sur l'origine des membres endogenes dans les plantes vasculaires. Ann. Sci. Nat. Bot. VII, 8:1-660, pls. 1-40. 1888. (Cited by Pond and Chang.)

2. Eames and McDaniels, Introduction to Plant Anatomy, McGraw-Hill Co., 1925.

3. Jost's Plant Physiology, Gibson (1907), p. 284.

4. Pond, Raymond H., Emergence of Lateral Roots, Bot. Gaz., Vol. XLVI, 1908.

5. Jeffrey, The Anatomy of Woody Plants, University of Chicago Press, 1917.

6. Chang, C. Y., The Origin and Development of Tissues in the Rhizome of Pteris aquilina, Bot. Gaz., Vol. LXXXIII, 1927.

The writer wishes to acknowledge the advice and assistance of Dr. Arthur T. Evans, who suggested the problem, and under whom it was worked. Thanks are also due to Mr. George Lynn Cross for valuable suggestions given during the course of the work.

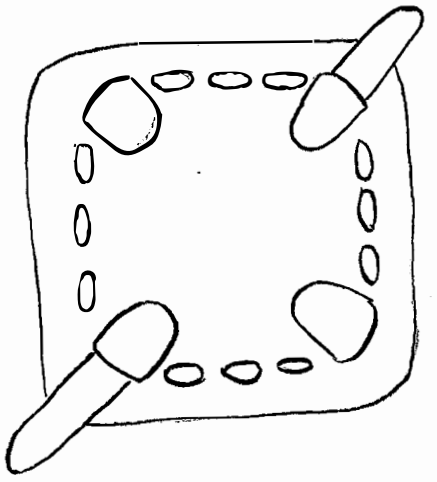

Figure 1

Diagrammatic cross-section of the stem of Coleus, showing the relation of the adventitious roots to the main bundles in the vascular system.

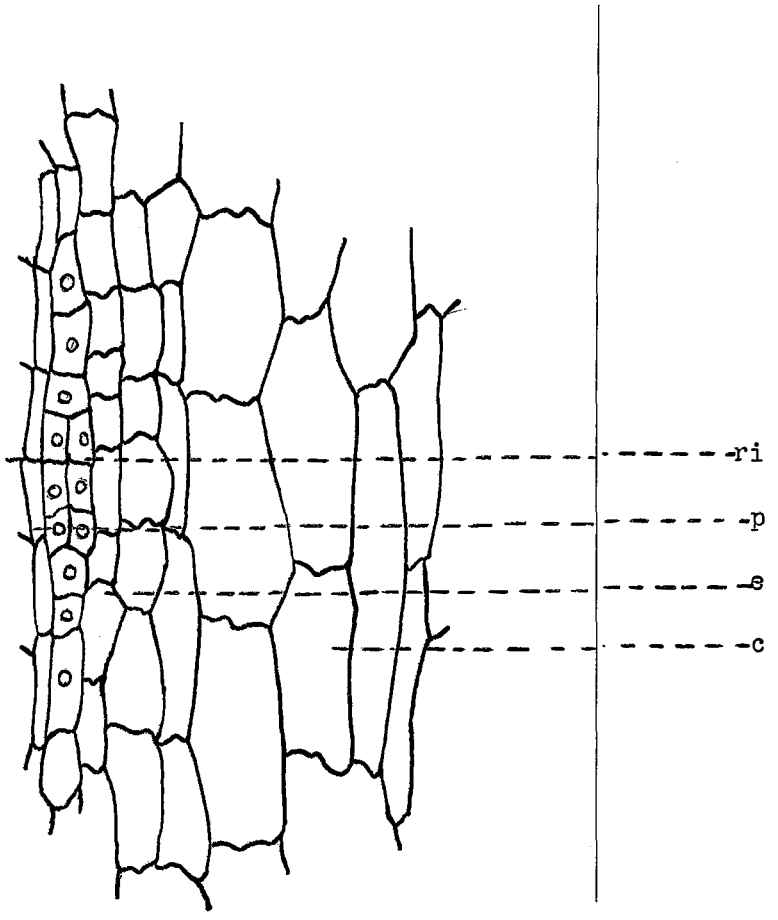

Figure 2

First appearance of root initial

ri-- adventitious root initial, arising in pericycle
p -- pericycle
e -- endodermis
c -- cortex parenchyma

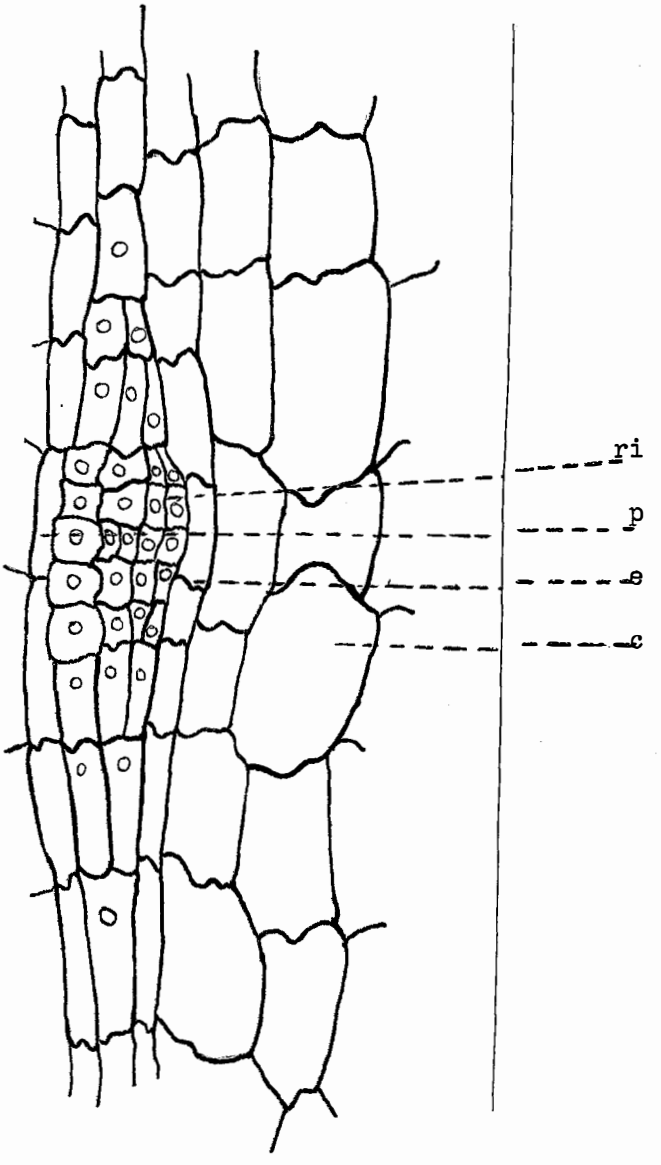

Figure 3

Later stage in origin of adventitious root

ri -- adventitious root initial, pushing out endodermis
p -- pericycle
e -- endodermis
c -- cortex

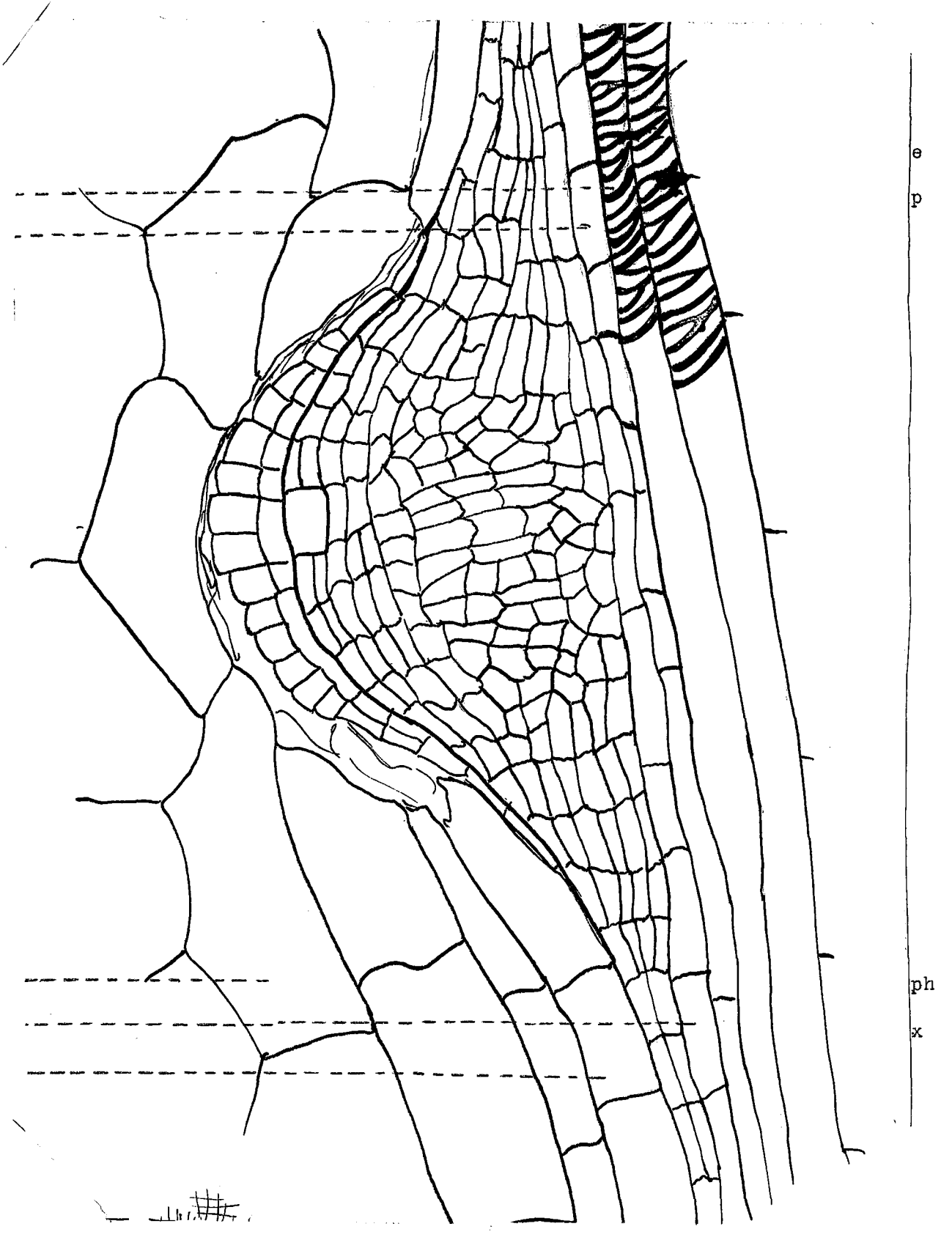

Figure 4 (See next page for explanation.)

Figure 4

Root initial well developed

e -- endodermis
p -- pericycle
c -- cortex parenchyma
x -- scalariform element of xylem
ph-- phloem of vascular strand

The young root has begun to develop very rapidly, the root cap has appeared and the different regions in the root are also beginning to take on their characteristics.