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Topic- Root Stem Transition in Plants

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Root Stem Transition in Plants

The change in orientation of vascular tissues from exarch radial type in root to endarch and conjoint collateral type in stem is designated as root-stem transition.

The continuity between the vascular strands of roots and stems is maintained but the orientational change takes place through splitting, twisting and inversion of xylem strands at the very short transition zone which is neither a root nor a stem. Transition occurs at the hypocotyl region either gradually or abruptly. There exist two main concepts on the nature of root-stem transition.

According to Eames and MacDaniels (1947) there are three types of root-stem transitions in dicot and single type in monocot. In the diagram (Fig. 5.84) the row of circles at the base represents the transverse sections of roots while the uppermost row is the transverse sections of stems. The three intermediate rows are the successive transverse sections through transition zone.

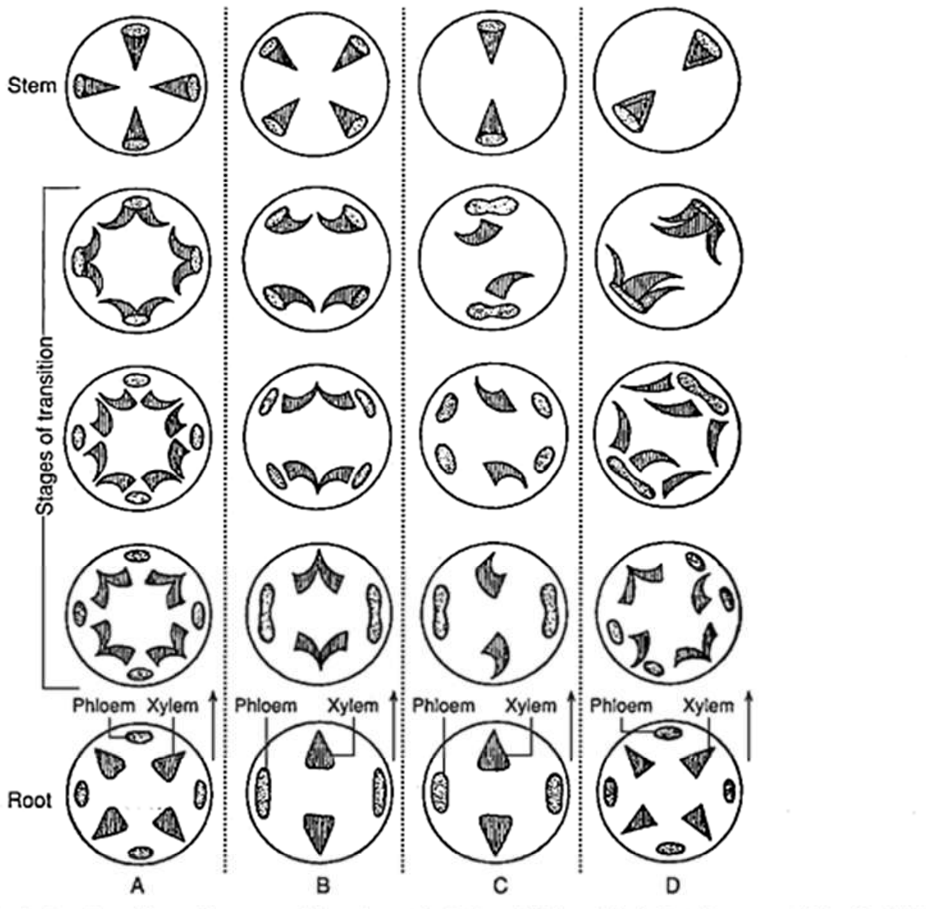

Fig. 5.84 : Root-stem transition : Diagrams of four types A, B, C and D (modified after Eames and MacDaniels)

Type I (Fig. 5.84A):

In this type there are four strands of xylem and phloem in the root and stem. The phloem remains in same position in both root and stem. Each xylem strand of root forks by radial division into two branches and gradually at the upper region they swing laterally to opposite directions by 180° and join the phloem strand in between.

Thus the two xylem halves are inverted and become conjoint and endarch in stem. In this way the radial bundles and exarch xylem become conjoint collateral with endarch (e.g., Mirabilis, Fumaria and Dipsacus) xylem orientation.

Type II (Fig.5.84B):

In this second type the number of bundles in stem is twice than in root. In root there are two alternate xylem and two phloem strands. Phloem in its upstream becomes elongated and dumb-bell shaped due to constriction at the middle. In the still upper region the constriction becomes deep and ultimately the phloem strand is divided into two.

Thus the number is doubled to four in the stem. The two xylem strands also split and become inverted like type I. The four xylem halves thus produced join with the phloem inside to become conjoint (e.g., Cucurbita, Tropaeolum, Acer and Phaseolus).

Type III (Fig.5.84C):

In this type, like type I, the number of vascular bundles in the stem remain same as that of phloem strands in the root after transition, but the xylem and phloem become conjointly oriented instead of radial. The xylem strands in the upstream do not split but get inverted through 180 degree.

The two phloem strands during transition divide into four strands, swing laterally and unite to form two strands that join the xylem on outside. Thus the same number of xylem and phloem is maintained in root and stem (e.g., Lathyrus, Medicago and Phoenix).

Type IV (Fig.5.84D):

This is a reductional transition in which the number of vascular bundles in stem becomes half of the number of phloem strands present in root. There are four strands of phloem in root which during the course of root-stem transition unite to form two strands. One of the two diagonal pairs of xylem does not split but inverted through 180° rotation and joins with the phloem inside.

The other diagonal pair of xylem splits radially into two halves and during upstream transition one of the two halves swings laterally to right and the other to the left and ultimately all the three xylem strands (one full and two half strands) join with the phloem inside. Thus a single conjoint vascular bundle of stem consisting of the five vascular elements of root is formed (e.g., Anemarrhena in the family Liliaceae).

The above transitional types are based on the study of continuous serial sections of the fully differentiated transitional zone. A completely different picture is offered by the developing transitional zone. According to Esau (1965) during ontogeny, vascular continuity is established between root and cotyledon through hypocotyls for the first time.

After differentiation the epicotyl traces are superimposed over the root-hypocotyl-cotyledon traces and the tissues present between them are mutually accommodated. This view is now considered as recent concept of root-stem transition. The vascular transition of Beta vulgaris and Daucus carota has been cited based on ontogeny in favour of this recent concept.

There is an epicotyl shoot in between the two cotyledons of the Beta vulgaris seedling and the hypocotyl and root on the lower side. Anatomically, the root shows two exarch xylems and two phloem strands arranged alternately in radial fashion. The cotyledon traces consist of two vascular bundles that are partially fused along the protoxylem.

The exarch protoxylem position in the root is maintained up to hypocotyl. But at the more upstream level two metaxylem are gradually differentiated towards the periphery on the lateral side of protoxylem leading to the endarch arrangement of xylem. The diarch root xylems thus gradually become four stranded cotyledonary traces.

The two phloem strands in the root at the hypocotyl region branch into four phloem strands. Each phloem strand associates with one metaxylem plate outside. Thus conjoint collateral vascular bundles are produced which persists in the cotyledons.

The collateral, endarch epicotyl traces develop after the root-hypocotyl-cotyledon vascular strands are partly differentiated. The epicotyl traces remain connected with similarly oriented tissues in the root they seem to be superimposed over the root-hypocotyl-cotyledon vascular traces. So in Beta vulgaris there is no vascular transition between root and stem. But there exists a mutual accommodation of vascular tissues.

In Daucus carota also the vascular continuity exists between radicle and cotyledon. The epicotyl traces join with root-cotyledon traces. Each cotyledon possesses three vascular bundles. Of them the median one consists of exarch protoxylem continuous with that of the root. Two phloem strands remain lateral to the median xylem strand in root.

The other two lateral vascular bundles are collateral with endarch xylem. These two bundles originate from the diarch xylem of root. So the primary vascular tissues of cotyledon and root remain unaltered. The epicotyl traces develop later that are conjoint and collateral and they ultimately join with radicle- hypocotyl-cotyledon traces.

In conclusion, it may be concluded that the ontogenetic studies of vascular transition of Beta and Daucus reveals no root-stem transition as illustrated by Eames and MacDaniels (1947) in the earlier common concept.

The modern concept, which is based on developmental studies, reveals that during ontogeny vascular connections are established between radicle and cotyledon via hypocotyl. The epicotyl traces are developed later from procambial strand, which ultimately join with the fully differentiated radicle- hypocotyl-cotyledon unit and the tissues between the traces are accommodated mutually.

Significance of Root-Stem Transition:

In the transition zone the internal tissue arrangement is completely different from that of root and stem. Thus, this region does not belong to any of those categories. Several interpretations are available to describe the structure and evolutionary significance of the transition zone.

The old and most common concept is that the seedling has a unit vascular system which is morphologically equivalent to root and stem. The anatomical differences in this zone are due to splitting, twisting, rotation, inversion etc.

According to this concept the protoxylem, metaxylem and phloem differentiate in the same positions where they occur in the mature state. At the transition zone, these vascular elements are differentiated in such a way that they can maintain the continuity of unit vascular system.

According to the other concept there is double origin of the vascular system. There are two discontinuous parts of the vascular system in the seedling. One is the radicle-hypocotyl part and the other is the cotyledon part. These two parts of the vascular system are joined at the upper region of hypocotyl.

The root and shoot tips of the seedling have their own meristem which forms the root and stem, respectively. During development, vascular connections are established between radicle and cotyledon via hyopocotyl. The epicotyl traces are joined with the radicle-hypocotyl-cotyledon unit and tissues between the traces are mutually accommodated (Esau, 1965).

The radial arrangement of xylem and phloem is usually considered as primitive whereas the collateral arrangement of them is regarded as advanced. Therefore, the xylem and phloem arrangements at the upstream transition zone represent the different evolutionary stages which culminate into collateral arrangements in the stem.