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A NOVEL ANOMALOUS SPIRAL SECONDARY GROWTH IN ROOTS OF *TRIANTHEMA PORTULACASTRUM* L.

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ABSTRACT The subclass Caryophyllidae of Cronquist (Centrospermae of Engler) is characterized by abnormal secondary thickening like concentric circles of alternating xylem and phloem in stems which is believed to be the pattern in roots also. But in the roots of *Trianthema portulacastrum* L. (Aizoaceae), three types of anomalies are seen in secondary thickening. The first type, which is predominant, is a new "spiral" pattern in which secondary cambium arises from the conjunctive tissue near one of the primary phloem groups and it proceeds producing spirals of xylem inside and phloem outside and both the tissues end abruptly in cortex. In the second case, the secondary vascular tissues originate from the vicinity of both the primary phloem groups. In the third, both the primary phloem groups remain included in the encircling secondary xylem elements and secondary vascular tissues are formed in concentric rings of xylem and phloem.

KEYWORDS : *Trianthema portulacastrum* L, Root anomaly, spiral secondary thickening, embedded phloem.

INTRODUCTION

The subclass Caryophyllidae of Cronquist (Centrospermae of Engler) is characterized by abnormal secondary thickening and those of Amaranthus, and Bougainvillea are classic examples of abnormalities in the secondary structure of stem. Such anomalies takes place due to abnormal behavior of cambium or abnormal origin of cambium and generally studied in the stems. These are adaptations to the nature of stem and enables to adapt a twining habit or as in succulents to store more water and food in stems. The beetroot is an example of abnormal secondary thickening in root. A separate type of secondary anomalous structure is observed, we would name it as "Spiral secondary thickening" in roots of *Trianthema portulacastrum* root, and this is reported in this paper.

Boerrhavia diffusa L. (Nyctaginaceae), is a well-known medicinal plant of India, commonly known as "Punarnava" all over India. It is the root that is highly medicinal as a rejuvenating drug. But there is another plant *Trianthema portulacastrum* L. (Aizoaceae) which is used as a substitute for Punarnava and this plant is more popular in Kerala. Both the plants are treated as therapeutically equivalent (Sivarajan and Indira 1994,Sukhdev, 2006). Much data on the constituents, pharmacogosy and therapeutic activities of the former plant are known while the later plant is comparatively much poorly studied. The present study on the roots of *Trianthema portulacastrum*, was undertaken to understand their specific and distinguishing characters.

MATERIALAND METHODS.

Fresh plant materials were collected from Botanical garden of M.S. University of Baroda and compared with the Herbarium (BARO) in Department of Botany. Voucher specimen (D/292) was deposited in Baroda University Herbarium. Fresh roots were used for initial studies which involved hand sections. Later the roots collected were fixed in FAA (Johansen, 1940). Trimmed roots were embedded in paraffin and transverse sections were taken in a rotary microtome. Sections were selected and stained with safranin and after dehydration mounted in DPX.

RESULTS

The roots, when dry, appear twisted to right with many narrow ridges (Fig.1). The anatomical features of the young root are presented in Fig.2. The root is diarch with 3-7 celled primary xylem consisting of two protoxylem points and 3-5 metaxylem tracheids. Alternate to them, at right angles, are the two primary phloem groups (Fig.2). The secondary thickening is not uniform, but again abnormal in origin and behavior. Three types of secondary thickenings are observed. They are the following.

1. In a majority of cases, the secondary cambium originates from the conjunctive tissue outside of only one of the two primary phloem groups (Figs. 3), and it proceeds in a spiral manner encircling the primary vascular tissues, producing xylem towards centre and secondary phloem towards periphery while other primary phloem group remained embedded in secondary xylem (Figs. 4&5). Secondary xylem spiral consists of long curved patches separated by medullary rays or traversed by root traces (Fig.6). In a few cases there is an abruptness in spiral in that one xylem patch is seen continuous with another patch placed slightly above (Fig.7). This spiral ends abruptly in cortical region (Fig.8)

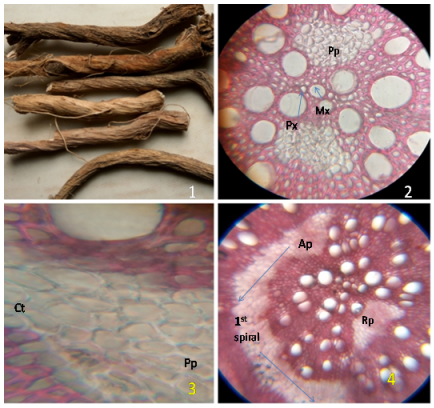

Fig.1. Dry roots of *T. portulacastrum*, ridges twisted to right , 2. Primary vascular tissues of root of *T. portulacastrum*. Pp- Primary phloem; Mx- Metaxylem; Px-protoxylem; 3.Initiation of secondary growth from one of the primary phloem groups due to conjunctive tissue (Ct) getting connected to one of the primary phloem (Pp) groups; 4. Secondary cambium proceeding as a spiral, Rp- Resting phloem, Ap- active phloem.

2. In some other (a few) cases, the secondary cambium develops the conjunctive tissues outside primary vascular tissues especially outside the xylem, which produces only xylem towards centre and phloem towards outside. This results in both primary phloem groups getting included

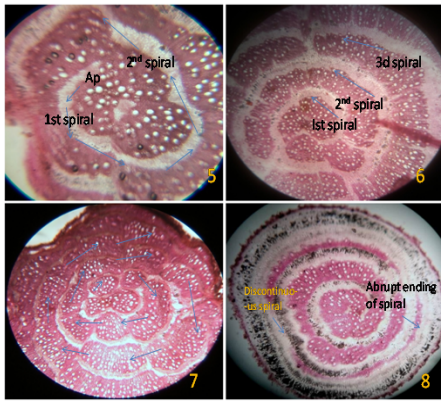

Fig.5. Formation of second spiral. Ap- Active phloem: Fig. 6.

Formation of third spiral; Fig.7. Abruptness in spiral in that one xylem patch is seen continuous with another patch placed slightly above, Fig. 8. Vascular tissues in spiral abruptly ending in cortex and also discontinuous at certain places.

Within secondary xylem (Fig.9). This ring of cambium produces a complete ring of xylem towards inside and a ring of phloem outside. It stops functioning after some time. This is followed by development of another secondary cambium from conjunctive tissue outside the

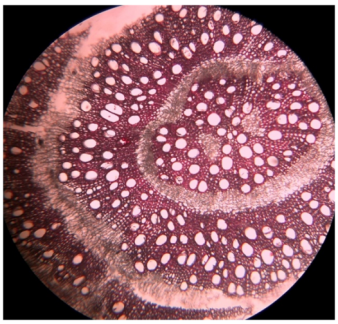

Fig.9. Both primary phloem groups included and concentric rings of sec.xylem and sec. phloem.

secondary phloem. This secondary ring also produces a ring of sec xylem towards inside and sec. phloem outside and ceases it's activity after producing a second ring of xylem and phloem. This process is continued and successive rings of sec. xylem and sec. phloem are produced . This type of anomaly is similar to that of stem of the same plant, except for the included phloem at the centre.

3. In a few cases the initial secondary cambia originate from conjunctive tissue connecting both the primary phloem groups on one side and they join one another producing an incomplete ring.

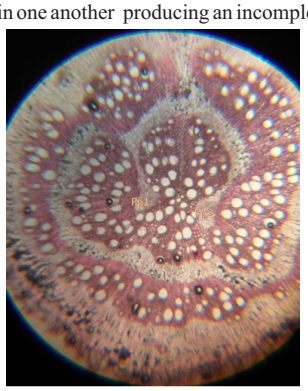

Fig.10 Secondary cambium develops from outside both primary phloem groups(Pp1- primary phloem 1 and Pp2- primary phloem 2)

Further secondary growth is by a new ring of cambium developing from outside this phloem. But here also the spiral nature of the secondary tissues is visible (Fig.10).

In many cases all the three types of anomalies are observed at different lengths of the same root.

DISCUSSION.

The spiral secondary thickening produced in the many samples of roots of Trianthema is indeed a unique phenomenon observed in this species as no such reports are available so far. The abrupt ending of vascular tissues especially xylem, which is a mechanical tissue, in the cortex causes a dent on the surface and this explains the spirally ridged surface of the dry root. Though there was an earlier study on Trianthema root (Patilet al, 2016), the authors did not come across the spiral nature of secondary tissues in their specimens.

The abnormal secondary growth found in the Caryophyllidae, as a whole, may be considered as adaptation to the xeric succulent nature of the plants included within. The inclusion of phloem rings within xylem rings is interpreted by Fahn and Shchori (1967) as means of protecting the phloem, which is a delicate tissue and rich in nutrients, from desiccation and from soil microbes. But the relevance of spiral nature of both xylem and phloem will be evident only after further detailed studies.

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