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Anatomy of Lignosus Bean *(Dipogon lignosus)* IV: Rachis of the Inflorescence

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Abstract: Anatomical investigation has been made on the rachis of the inflorescence of lignosus bean *(Dipogon lignosus* (L.) Verde.) following the standard paraffin method of micro technique. The epidermis of the rachis is single layered with multicellular hair and glandular trichomes. Beneath the epidermis there are 3-6 layers of cortical cells. The pericycle (sclerenchymatous band) forms a discontinuous ring outside the vascular bundles. The vascular bundles are collateral and arranged in a ring. The amount and size of vascular tissues gradually decrease from base to upper part of the rachis. Tanniniferous cells have been observed in the primary phloem region. A complete cambial ring has been found at the basal part of the rachis. The secondary growth is restricted more or less to the lower half of the rachis. In a particular point of the apical region of rachis the secondary growth is almost nil. Some undifferentiated or partially differentiated tracheary and sieve elements fail to mature in upper part of the rachis where the phloem is mostly composed of large parenchymatous cells. There are lots of fibre cells in xylem area.
Rays are radially elongated, uniseriate and multiseriate. The pith increases from base upward. The radial length of the rachis gradually decreases towards the apex. It may be concluded that the reduction of phloem tissues in the upper part of the rachis probably allows translocation of insufficient photosynthate, which perhaps contributes shedding of buds, flowers and pods.

Key words: *Lignosus bean, Dipogon lignosus,* anatomy, rachis, inflorescence

Introduction

Anatomical features of the root, hypocotyl and stem of lignosus bean *(Dipogon lignosus* (L.) Verde.) have been reported in the previous articles of the series (Bari and Prodhan, 2001a, 2001b; Prodhan and Bari, 2001). In this article the anatomy of rachis of the inflorescence will be described so that a clear picture about the internal structures of the taxon may be obtained.

Materials and Methods

Mature seeds of lignosus bean *(Dipogon lignosus* (L.) Verde.) were collected from Department of Crop Botany, Bangladesh Agricultural University, Mymensingh. The experiment was carried out in Bangladesh Agricultural University Farm as well as in Department of Crop Botany during the study period between August, 1999 and June, 2000. The seeds were sown in polybags.

The polybags were filled with thoroughly prepared soil of the plots. The seedlings of the polybags were transplanted in the pits of the plots (Bari and Prodhan, 2001a; Prodhan and Bari, 2001). The initiation of the rachis was considered as the zero hour age. From the 20th day of initiation rachises of the inflorescences were collected everyday from the plants till they were 30 days old. The samples of the rachis were fixed in Carf-III (Haque and Prodhan, 1987; Prodhan and Haque, 1986; Sass, 1958) after making small pieces (5 mm). Similarly samples of the rachis of 32, 34, 36 and 38 days old were also collected and fixed in FAA (Haque and Prodhan, 1987; Johansen, 1940). The materials fixed in Craf-III and FAA were dehydrated through the tertiary butyl alcohol (TBA) series (Haque and Engleman, 1978; Haque and Prodhan, 1987). The materials fixed in FAA were washed in running tap water for 2-3 hrs before dehydration (Haque and Prodhan, 1991). The succulent materials were dehydrated gradually making more grades of alcohol to avoid severe shrinkage (Alt *et al.*, 1999; Prodhan and Haque, 1986).

The dehydrated materials were gradually infiltrated with paraffin oil and low melting point (49-51°C) paraffin wax for 1-3 days (Haque and Prodhan, 1987; Prodhan and Bari, 2001; Prodhan and Haque, 1986). After infiltration the materials were embedded in high-melting-point (61-63°C) paraffin wax. There was less shrinkage when the materials were infiltrated for a longer period (Ali *et al.*, 1999; Prodhan and Haque, 1986; Sarwar and Prodhan, 2000). Serial transverse sections were made at 10 micron by a rotary microtome. The sections were stained with safranin and fast green and mounted in Canada balsam after proper dehydration with ethyl alcohol and clearing with xylene (Bari and Prodhan, 2001a, 2001b; Haque and Engleman, 1978; Johansen, 1940; Prodhan and Bari, 2001). Free hand sections were also made from fresh and fixed materials and temporary slides were made (Haque and Prodhan, 1987).

Results and Discussion

Epidermis: The epidermis of the rachis of lignosus bean *(Dipogon lignosus* (L.) Verde.) is single layered (Fig. 1, 2, 3). It is composed of large and small cells (Fig. 1, 2, 3, 6). The abaxial, adaxial and lateral walls are more or less uniformly thick. The cuticle is moderately thick. The thickening of the cell wall as well as cuticle increases along with the age of the rachis (Haque and Prodhan, 1987). The cells of the epidermis are more or less round, oval or slightly rectangular in appearance as seen in transverse sections (Fig. 6). The epidermis bears multicellular hair and glandular trichomes (Fig. 2, 3, 7). Similar types of hair and trichomes have also been found in the stem of the same species (Bari and Prodhan, 2001b). Lots of epidermal hairs have been observed in the rachis of pigeonpea by Hossain (1999). The outer circumference of the epidermis is slightly wavy in the apical part (Fig. 1, 2, 3) and more or less smooth in the middle and basal regions of the rachis (Fig. 4, 5, 6, 7 and 8).

Cortex: There are 3-6 layers of cortical cells in the rachis. The cortex contains 3-4 layers of cells in the basal and middle parts (Fig. 5, 6, 8 and 9) and 5-6 layers in the apical part (Fig. 1, 2, 3). Most of the cortical cells are round, oval, polygonal or irregular in shape, while the others are tangentially flattened as seen in transverse sections. The layer just below the epidermis is compact. No intercellular spaces between the epidermis and this layer have been observed. The cells of this layer are not uniform in size. Some are tangentially flattened and others are round, oval or irregular in shape. The cell wall

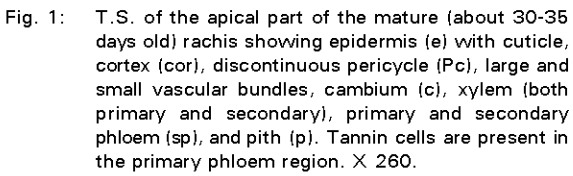

Fig. 1: T.S. of the apical part of the mature (about 30-35 days old) rachis showing epidermis (e) with cuticle, cortex (cor), discontinuous pericycle (Pc), large and small vascular bundles, cambium (c), xylem (both primary and secondary), primary and secondary phloem (sp), and pith (p). Tannin cells are present in the primary phloem region. X 260.

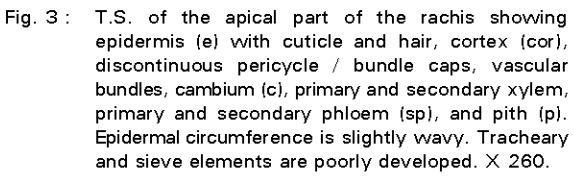

Fig. 3 : T.S. of the apical part of the rachis showing epidermis (e) with cuticle and hair, cortex (cor), discontinuous pericycle / bundle caps, vascular bundles, cambium (c), primary and secondary xylem, primary and secondary phloem (sp), and pith (p). Epidermal circumference is slightly wavy. Tracheary and sieve elements are poorly developed. X 260.

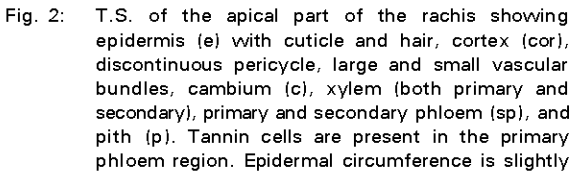

Fig. 2: T.S. of the apical part of the rachis showing epidermis (e) with cuticle and hair, cortex (cor), discontinuous pericycle, large and small vascular bundles, cambium (c), xylem (both primary and secondary), primary and secondary phloem (sp), and pith (p). Tannin cells are present in the primary phloem region. Epidermal circumference is slightly wavy. The T.S. shows the entire pith and vascular cylinder of the rachis. X 265.

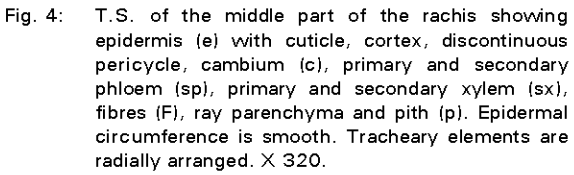

Fig. 4: T.S. of the middle part of the rachis showing epidermis (e) with cuticle, cortex, discontinuous pericycle, cambium (c), primary and secondary phloem (sp), primary and secondary xylem (sx), fibres (F), ray parenchyma and pith (p). Epidermal circumference is smooth. Tracheary elements are radially arranged. X 320.

thickness of this layer is similar to that of the epidermis. Similar arrangement has been observed in the hypocotyl of the same species (Bari and Prodhan, 2001a).
The remaining cells of the cortex are thin walled with prominent intercellular spaces.

Pericycle: The pericycle (sclerenchymatous band) lies below the cortex. It consists of sclerenchymatous cells. It forms a discontinuous ring outside the vascular bundles (Fig. 1, 4, 9).

The discontinuous pericycle is also found in the root, hypocotyl and stem of lignosus bean (Bari and Prodhan, 2001a, 2001b; Prodhan and Bari, 2001). Hossain (1999) has reported continuous pericycle in the rachis and discontinuous pericycle in the stem of pigeonpea. A continuous ring of sclerenchyma constituting the pericycle has been reported for pigeonpea stem (Bisen and Sheldrake, 1981). The cells of the pericycle are hexagonal or pentagonal in shape. The walls of the cells are very thick with small lumen. Radially each group of sclerenchyma consists of more or less 2-5 cells. Two adjacent groups are connected by one or two layers of

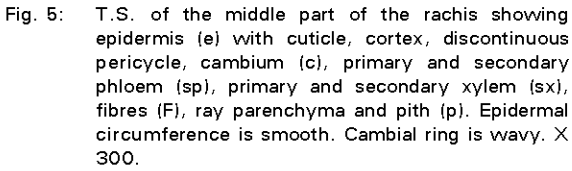

Fig. 5: T.S. of the middle part of the rachis showing epidermis (e) with cuticle, cortex, discontinuous pericycle, cambium (c), primary and secondary phloem (sp), primary and secondary xylem (sx), fibres (F), ray parenchyma and pith (p). Epidermal circumference is smooth. Cambial ring is wavy. X 300.

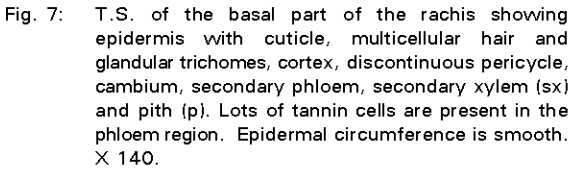

Fig. 7: T.S. of the basal part of the rachis showing epidermis with cuticle, multicellular hair and glandular trichomes, cortex, discontinuous pericycle, cambium, secondary phloem, secondary xylem (sx) and pith (p). Lots of tannin cells are present in the phloem region. Epidermal circumference is smooth. X 140.

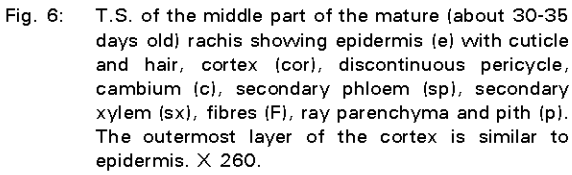

Fig. 6: T.S. of the middle part of the mature (about 30-35 days old) rachis showing epidermis (e) with cuticle and hair, cortex (cor), discontinuous pericycle, cambium (c), secondary phloem (sp), secondary xylem (sx), fibres (F), ray parenchyma and pith (p). The outermost layer of the cortex is similar to epidermis. X 260.

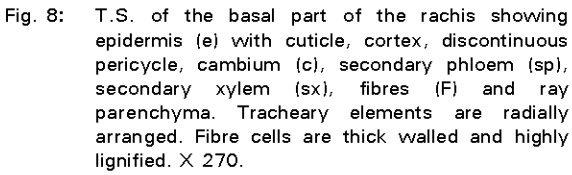

Fig. 8: T.S. of the basal part of the rachis showing epidermis (e) with cuticle, cortex, discontinuous pericycle, cambium (c), secondary phloem (sp), secondary xylem (sx), fibres (F) and ray parenchyma. Tracheary elements are radially arranged. Fibre cells are thick walled and highly lignified. X 270.

sclerenchyma.
Sometimes 2-3 or more vascular bundles, either large or small, contain a single band of sclerenchyma on their abaxial sides.

Vascular tissue: The arrangement of vascular bundles of the rachis is collateral and is similar to that of the stem of lignosus bean but the amount and size of the bundles vary (Bari and Prodhan, 2001b). The amount and size of vascular tissues gradually decrease from the base to the upper part of the rachis (Fig. 3, 5 and 7). Similar results have also been reported for the rachis in pigeonpea (Hossain, 1999). The primary vascular tissue forms within a very short time along with the rapid elongation of the rachis. The vascular bundles are arranged in a ring. There are two types of vascular bundles, small and large. The large vascular bundles contain a number of tracheary elements along with a limited number of sieve elements. The small vascular bundles may contain primary xylem and primary phloem or may contain either one. It happens due to the prompt initiation and quick differentiation of secondary vascular tissues. Tanniniferous cells have been observed in the primary phloem of the rachis. The tanniniferous cells have been found in the phloem region of

Fig. 9: T.S. of the basal part of the rachis showing epidermis (e) with cuticle, cortex (cor), discontinuous pericycle (Pc), cambium (c), secondary phloem (sp), secondary xylem (sx), fibres, ray parenchyma and pith (p). Two adjacent groups of sclerenchyma in the pericycle are connected by one or two cells of sclerenchyma. X 265.

Fig. 10: T.S. of the basal part of the rachis showing epidermis (e) with cuticle, cortex, discontinuous pericycle (Pc), cambium (c), secondary phloem (sp), secondary xylem (sx), fibres (F), ray parenchyma and pith (p). Cambial ring is wavy. Primary tracheary elements are evident. X 280.

the younger hypocotyl and stem but not in the root of lignosus bean (Bari and Prodhan, 2001a, 2001b; Prodhan and Bari, 2001).

The cambium appears shortly after the elongation of the rachis. Gradually it extends towards the upper part. The cambium at first initiates in the vascular bundles. Gradually it extends into the interfascicular region and forms the cambial ring (Haque and Prodhan, 1987). A complete ring has been found at the basal part of the rachis and gradually it extends upward. The cambial ring is not complete in the upper part of the rachis. The ring is interrupted by parenchyma cells. In many places, the pith is continuous with the cortex through ray regions. Whether the cambium forms a ring or not, it gives rise to secondary xylem adaxially and secondary phloem abaxially (Haque and Prodhan, 1987). At the apical region of the rachis, the secondary growth is restricted to the large vascular bundles. The secondary tissue gradually decreases from base upward. In a particular point of the apical region of the rachis the secondary growth is almost nil. The procambium is not very active there. As a result of which some immature or partially differentiated tracheary and sieve elements fail to mature (Haque and Prodhan, 1987). At this region some large vascular bundles show a few secondary tracheary elements as a result of the activities of fascicular cambia in them.

At the middle and basal parts of the rachis, the cambium has been found to be more active on its adaxial side and as such it gives more secondary xylem than secondary phloem (Fig. 4, 6, 8 and 9). The vessels of the secondary xylem are arranged radially. Some vessels are, however, scattered. The vessels are not uniform in size. Some vessels have been found to be large while the others are small. The matured vessels are round, oval, polygonal or hexagonal in shape. They are fully devoid of protoplasm with prominent secondary thickening and large lumen (Haque and Prodhan, 1987).

Rays are radially elongated. They are uniseriate or multiseriate. There are lots of fibre cells in xylem area. Fibre cells are thick walled with small lumen and highly lignified. Fibre cells are rectangular, pentagonal, hexagonal, triangular or square in shape. Similar results have been reported for the rachis of pigeonpea by Hossain (1999). The size and number of vessels gradually decrease towards the upper part of the rachis (Fig. 2, 6, 10). The xylem area is also narrow in the upper part compared to that of the lower one (Fig. 1, 10). Most of the vessels in the upper part of the rachis are smaller in size. Hossain (1999) has reported similar results in the rachis of pigeonpea.

Radially the ray cells are longer in the upper part than those in the basal part. The fibre cells in the upper part are smaller in size and thin walled compared to the basal part. The fibre cells are fewer in the upper part than the basal part. In the upper part of rachis the tracheary elements are poorly developed compared to that of the basal part (Fig. 3, 8). Similar results have been reported for the rachis of the pigeonpea by Hossain (1999).

The activity of the cambium gradually decreases from base upward and as a result, the amount of vascular tissue (xylem and phloem) decreases gradually from the base to the apex of the rachis (Haque and Prodhan, 1987). The cambium is less active on its abaxial side and produces less secondary phloem. As a result, secondary phloem becomes narrow gradually towards the upper part of the rachis (Fig. 1, 10). Similar reports are available in pigeonpea (Hossain, 1999) and in mustard (Haque and Prodhan, 1987). At the basal part of the rachis, the phloem is both primary and secondary in origin.

It is difficult to distinguish the secondary sieve elements from the primary one as the phloem zone becomes narrower from base upward. In the upper part of the rachis, some undifferentiated or partially differentiated sieve elements fail to mature. Similar results have been reported for mustard (Haque and Prodhan, 1987). The phloem is mostly composed of large parenchymatous cells (Fig. 2, 6, 10). The amount of sieve elements decreases from base upward. Sieve tube members also become narrower towards the apex.

The reduction of phloem tissues in the apex (top) of the rachis probably allows translocation of insufficient photosynthates to support few or no flowers to set pods. Thus, the insufficient photosynthate supply in the top of the inflorescence perhaps contributes shedding of buds, flowers and pods. The reduced phloem area in the upper portion of the inflorescence also

contributes abscission of flowers and buds in soybean (Wiebold *et al.*, 1981), in mustard (Haque and Prodhan, 1987) and in pigeonpea (Hossain, 1999; Rawson and Constable, 1981). However, detailed developmental study of the primary and secondary sieve elements in relation to the growth and development of this crop is necessary to ascertain the phenomena.

Pith: The pith increases from base upward. The parenchymatous cells constituting the pith are round, oval or polygonal in shape as seen in transverse sections (Fig. 1, 5, 9). A central mass of large and thin walled cells shows prominent intercellular spaces and the surrounding cells are comparatively small and thick walled with small intercellular spaces (Haque and Prodhan, 1987; Hossain, 1999).

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