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THE COMPLETE ARCHITECTURE OF FRUIT *CYAMOPSIS TETRAGONOLOBA* (L.) DC.

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Histologically the pod fruit wall is distinguished into exocarp, mesocarp and endocarp. The multilayered exocarp is constituted of the outer single layer of epidermis and 2-3 layers of outer hypodermis. The whole transection of the ovary is angular in shape. The outer epidermal cells are interrputed with anomocytic stomate and 'T' shaped trichomes. Outer hypodermis is made up of thick walled stone cells and thin walled parenchyma. The mesocarpic lateral region embeds 13-15 vascular bundles. There are two vascular bundles in the ventral stature of the meture pericarp, i.e. one vascular bundle on either side of the groove in each valve. The endocarp is composed of 10-12 layers of fibres with smooth walls and single layer of inner epidermis.

Keywords : *Cyamopsis tetragonoloba;* Dehiscence; Development; Pericarp.

Introduction

Family Fabaceae has been worked out for its anatomical features of the pericarp of many species (Fahn and Zohary, 1955). Then some more work is also done in Fabaceous fruits (Deshpande and Untawale, 1971; Leela *et al.*, 1972; Shah *et al.*, 1975; Bhasin, 1976; Behl and Tiagi, 1977; Narang and Govil, 1978; Pate and Kuo, 1981). But no information is yet available on the depelopmental aspects of *Cyamopsis tetragonoloba* fruit. The purpose of this investigation is to present a detailed developmental study of pericarp and its pattern of dehiscence. *Cyamopsis tetragonoloba* fruits are used as vegatable (Fig. 1 A). The Fabaceous pod *Cyamopsis tetragonoloba* is formed from a uni carpel. The fruit consists of 9-14 subtetragonous seeds enclosed in each compartment formed by the ingrowth of thin walled parenchymatous endocarpic septum.

Materials and Methods

Materials of *Cyamopsis tetragonoloba* at successive developmental stages were collected from the University Botanical garden, Vallabh Vidyanagar.

Table 1

Stage	Length in cm	Breadth in cm	Remarks
1	0.2	0.03	Ovary from young bud
2	0.4	0.05	Ovary from open flower
3	0.8	0.10	Young fruit
4	1.5	0.15	
5	2.5	0.20	
6	3-3.5	0.30	Developing stages of fruit
7	4.5-5	0.60	
8	6-7	0.80	Mature fruit
9	6-7	0.80	Dry fruit.

The fruits and ovaries in their developmental and mature stages were measured in length and breadth (Table 1), and fixed in F.A.A. Small pieces of their basal, middle and terminal parts were processed seprately for dehydration and embedding was done as per usual methods using series of alcohol-xylene-paraffin grades (Johansen, 1940). The microtome sections (6-8 μm thick) were stained with tannic acid ferric chloride and safranin and fast green (Foster, 1934) and made permanent by the usual procedures. Starch grains were localized with I_2KI (Johansen, 1940). For maceration, material is boiled in $KClO_3$ and conc. nitric acid. Carl Zeiss photomicroscope was employed in taking the photomicrographs. For scanning electron microscopic study material was air dried and coated with a thin conducting film of Gold-palladium. Samples were observed with the cambridge steroscan S4-10 microscope at 'ATIRA' Ahmedabad.

Results and Discussion

Ovary – In whole transection the ovary appears angular in shape (Fig. 1 B). The outer epidermis is single layerd with dense cytoplamic contents and cell walls are thin. In most of the cells, spherical nuclei are seen on the inner tangential wall side. Cuticle is totally absent in the outer epidermis of the overy wall (Fig. 1 C). Only anticlinal divisions are observed in the outer epidermis. Mesoderm is 9-10 layers thick (Fig. 1 C) and cells are thin walled, polygonal and compactly arranged with dense cyto-

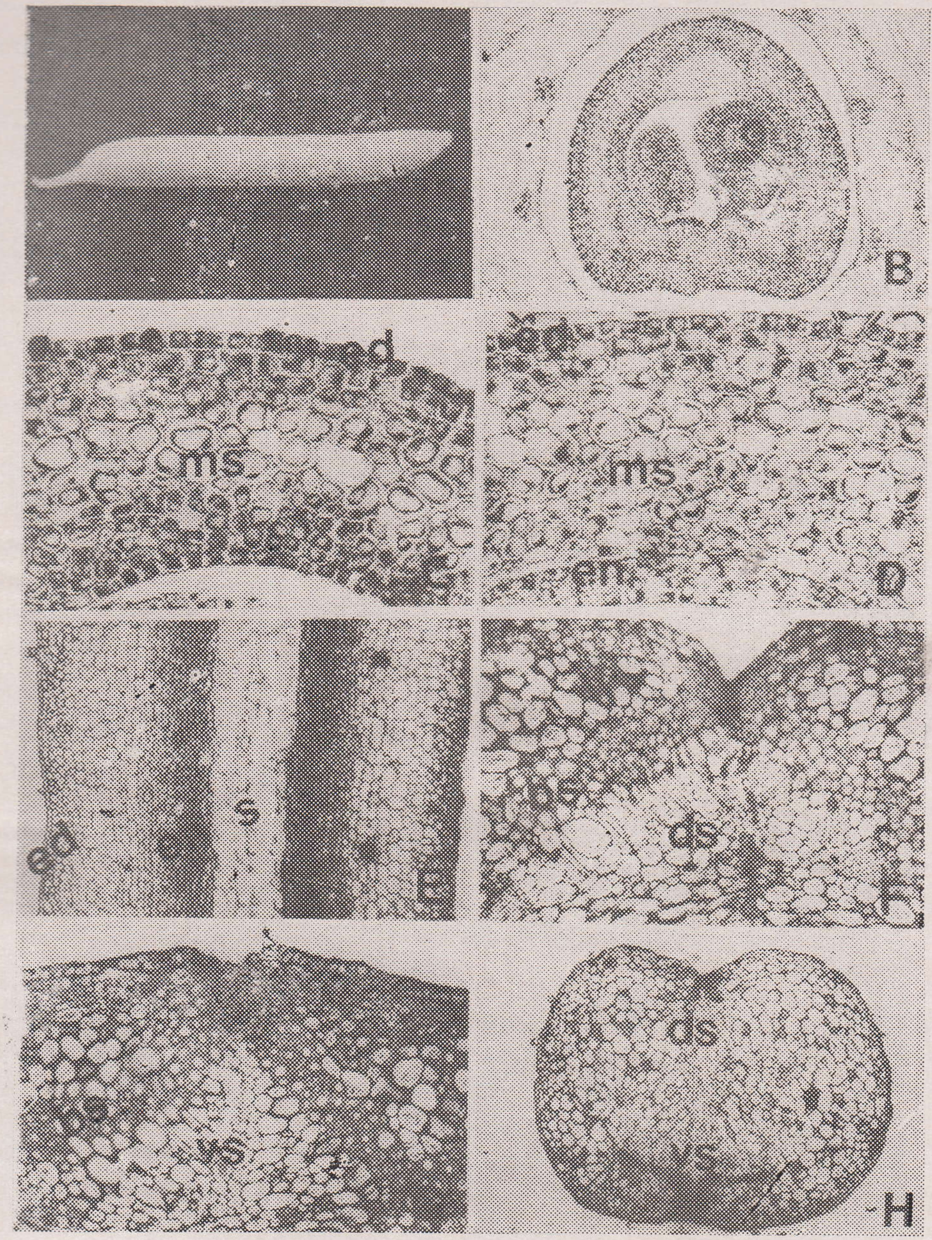

Fig. 1 A. A mature pod of *Cyamopsis tetragonoloba;* B. Ovary in transection (260 x), C. Ovary wall enlarged (832x); Pericarp of young fruit (832x); E. Lateral side of intermediate fruit (260x); F. Dorsal side of terminal region of mature pod (260x); G. Ventral side of terminal region of mature pod (260x); H. Extreme terminal region of mature pod (260x).

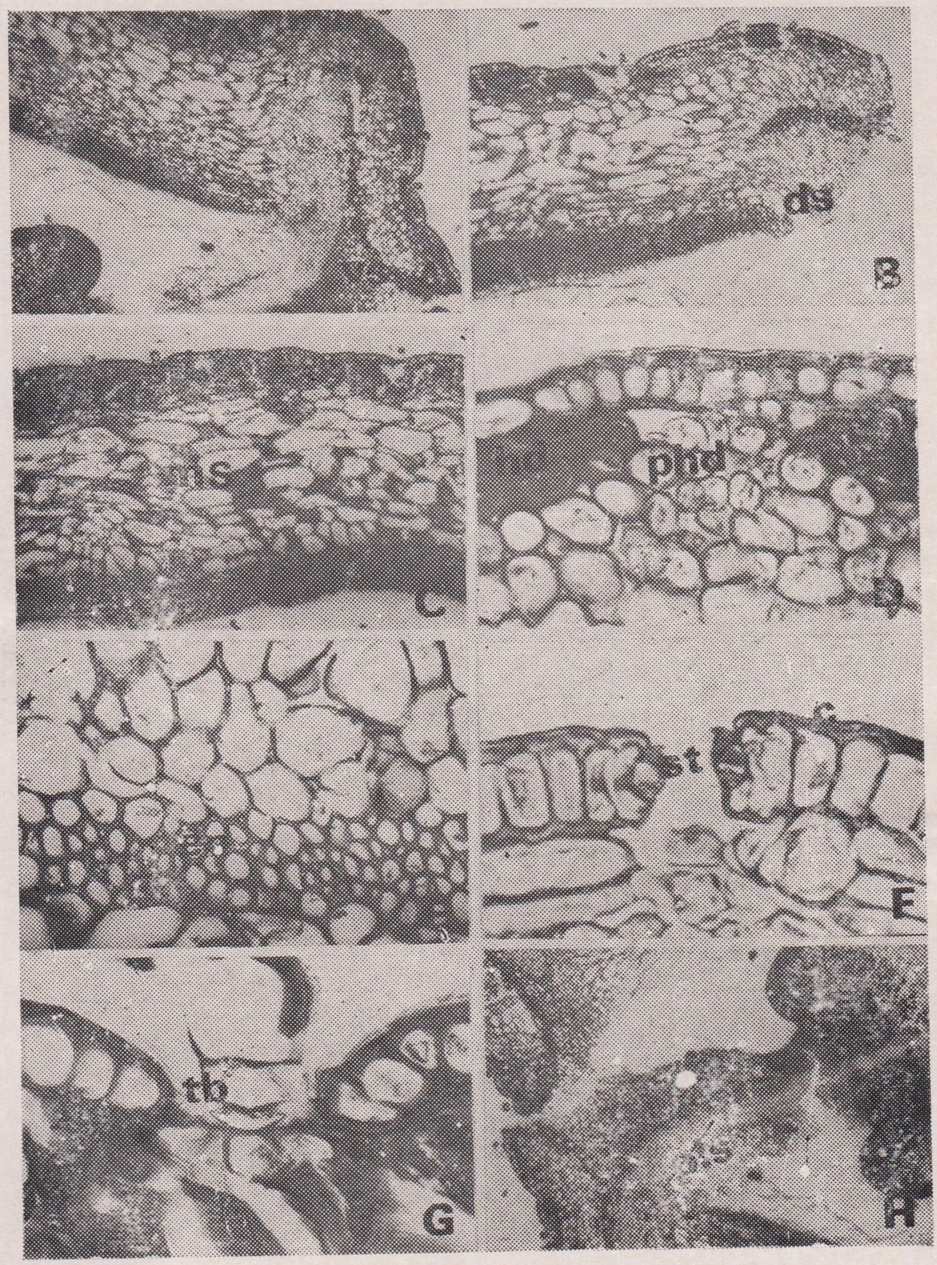

Fig. 2 A. A mature pod, ventral side (260x); B. dorsal side of mature pod (260x); C. lateral side of mature pod (260x); D. Exocarp of mature pod (832x); E. Endocarp of mature pod; F. Stomata in transection (960x); G. Trichome base in transection (960x); H. Mature pod ventral side with placental stock.

plasmic contents. In the middle region of the mesoderm in 1–2 layers the cells are larger in size with less cytoplasmic contents and more vaculations (Fig. 1 C & D). Five to six provascular bundles are observed in the inner region of the mesoderm. Provascular cells are rectangular and with denser cytaplasmic contents. Some cells are in divinding stage. Sutural sides have 15–16 layers of cells which are thin walled and have less cytoplasmic contents. There are two ventral and one dorsal vascular bundle. Placenta is lined by a single layer of large columnar cells which are dense with cytoplasmic contents and nuclei in their centers (Fig. 1 B). Placental stalk has polygonal thin walled cells with denser cytoplasmic contents. Inner epidermis is made up of columnar or tabular thin walled cells in a single layer.

Developing and mature fruit—After pollination and fertilization the ovary does not show any increment in cell layers. In transection young fruit is angular in shape. The outer epidermal cells in young stage are filled with dense cytoplasm and appear columnar or tabular in shape (Fig. 1 D). Cuticle is absent on the outer epidermis. At maturity of the fruit the cells of the outer epidermis appear columnar or tabular (Fig. 2 D & F) and are more vacuolated. The cuticle becomes very thick at maturity (Fig. 2 D, F & G). In scannicg electron microscopic study the surface of the fruit shows reticulate type of cuticular folding (Fig. 3 C). The outer epidermal cells are interrupted with anomocytic stomata and 'T' shaped trichomes. Stomata is seen in the same level or is immersed in the outer epidermal cells (Figs. 2 F and 3 B). In SEM observation of the trichome the surface shows pores (Fig. 3 A & D).

The outer hypodermis is a single layer of polygonal or tabular cells below outer epidermis of the ovary wall (Fig. 1 D). The cells are thin walled with dense cytoplasmic contents and in initial developing stage they do not show any noticeable differences. In the later stage (3rd) these cells of single layer start dividing, obliquely, periclinally or anticlinally and produce 2–4 layers. In the fourth stage, the cells become spherical or oval (Fig. 1 E). At maturity of the fruit the outer cells become very much thick walled (Fig. 2 A, B, C, D). The cells lose cytoplasmic cotents and become sclerenchymatous stone cells. The thick walled outer hypodermis is not a continuous layer below the outer epidermis. At sutural and lateral sides the outer hypodermal cells remain thin walled (Fig. 2 B & D). The elongated outer hypodermal cells are arranged paralleley with the long axis of the fruit.

Mesocarpic region is 5–17 layered broad and with starch grains stage (Fig. 1 D & E). The cells of the outer 4–5 layers are larger than those of the inner layers. They are thin walled, spherical, oval or polygonal and compactly arranged. In this region of mesocarp, number of layers does not change as the pericarp matures, but the size and shape undergo considerable change. The remaining 4–5 layers of the mesocarp present on the outside of the sutural bundles are small polygonal and compactly arranged cells. At maturity these cells become lignified and form a sclerenchymatous zone (Fig. 2 A–C & E). Inner region of the sutural bundles has 4–6 layers of thin walled cells. The vascular bundles in the developing pericarp are two in the ventral sutural side and one in the dorsal side. Each vascular bundle is conjoint, collateral, endarch and open. The tracheary elements are arranged in 6–8 radial rows; 3-5 in each row; the inner most elements of protoxylem show the signs of disintegration as can be judged by deeply stained irregular mass. In the apical region of the fruit the inner ground tissue consists of thin walled parenchyma with thick walls (Fig. 1 F, G & H).

The mesocarp in the lateral region is 8–10 layers thick and homogenous in the young pericarp. The mesocarpic cells are polygonal, spherical or oval in shape. They are thin walled parenchymatous with dense cytoplasmic contents. On developing or mature stage, the mesocarpic cell layers do not increase. At maturity, some cells become oblong and empty of cytoplasmic contents (Fig. 2 C). Lateral vascular bundles are arranged in the inner region of the mesocarp.

The endocarp consists of the inner epidermis and 2-3 layers of very small thin walled polygonal cells of inner hypodermis (Fig. 1 D). These cells have dense cytoplasmic contents. The inner epidermis lining the seed cavity consists of compact rectangular or tabular cells. The endocarp layers increase to 6–8 in number by anticlinal and periclinal divisions in the subsequent stages. These layers gradually loose contents and the cell wall gets highly thickened. At the terminal region endocarpic thick walled cells are totally absent (Fig. 1 H). The endocarpic septum is formed by the cell divisions in inner epidermis of the ovary. The septal cells are polygonal or tabular and compactly arranged. The cells possess denser cytoplasmic contents at its young stage (Fig. 1 D). In developing and mature stage, the cells in septa have cytoplasmic contents which become very less or are lost. The growth of the septum is more, near the dorsal side, but at dorsal and ventral sides the growth is totally absent.Both septa develop

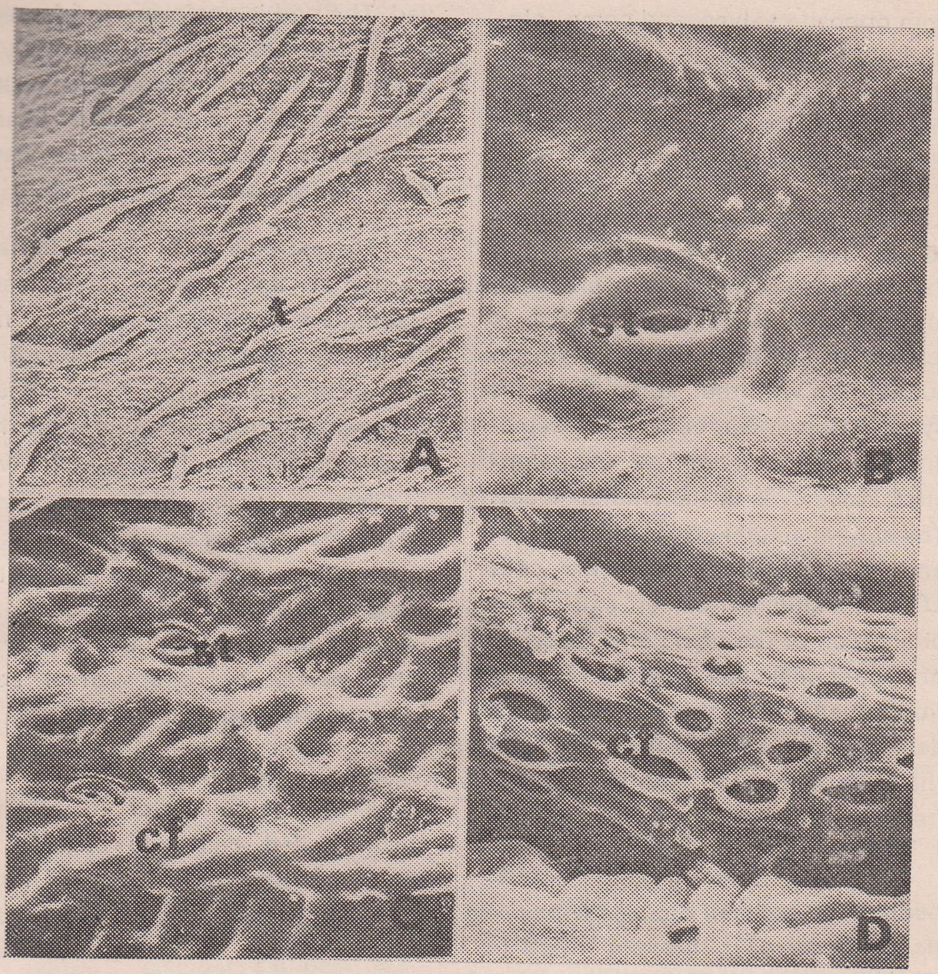

Fig. 3 A. Sem of 'T' shaped trichome (300x); B. SEM of stomata (1320x); C SEM of cuticular folding (600x); D. SEM of basal region of trichome (1440x).

(bs—bundle Sheath, cf—cuticular foldings, ds—dorsal side, ed—epidermis, en—endocarp, hd—hypodermis, o—ovule, pls—placental stock, st—stomata, s—septum, ms—mesocarp, vb—vascular bundle, vs—ventral side, tb—trichome base, tc—tannin cells).

from opposite valves, and come closer but do not fuse to partition the chamber (Fig. 1 E). Developing and mature fruit shows tannin cells in the placental stock (Fig. 2 H).

The dry fruit shows active dehiscence. The fruit starts splitting along the ventral sture and then proceeds towards the dorsal side. This is formed by a line of seprution in continution with the inner epidemis by 2–4 parenchma cells. The sepration occurs by tearing of the parenchpmatous cells in the sntural sides. The sutural sclerenchma also contract and separate the yarenchyma cells of ventral side and dorsal side. The orientation of the fiber and position of hypodermal cells halp the ssparation of values. At this time the seeds detach from the placental stock and the two separated values become free from the axis of the fruit.

Fahn and Zohary (1955) described several types of fruits. *Cyamopsis tetragonoloba* is broadly fitted to coronilla type. That means in *Cyamopsis tetragonoloba* the pods have single zone of sclerenchymatous fibers oriented parallel to the longitudinal axis. The smooth walled ovary of the small flower bud is unilocular with many ovules attached by marginal placenta. The entire pericarp develops from a homogenous tissue of the ovary wall. The mature pod is thick and constricted between the seeds, and the pericarp is bivalved. The pod is enclosing 9–14 seeds and each seed is separated by a narrows layer of endocarpic septa. Such separation is noticed in *Cassia occideutnlis* and *Cassia tora* (Patel *et al.*, 1976; Rao and Dave, 1980).

The extreme basal region in transection of the pod is circular and stimulate a dicot stem and do not show any histological differentation of the pericarpic zones. The epicarp is developed from the outar most thin walled epidermis of the ovary wall in *Cicer arietinum* (Bhhl and Tiagi, 1977). The outer epidermal cells of the present epicarp are elongated radially and are unlignified. At maturity of the fruit of *Cyamopsis tetragonoloba* outer epidermal cells appear periclinally elongated.

In *Cicer arietinum* (Behl and Tiagi, 1977) the outer hypodermal thick walled calls are absent. At maturity of the fruit *Cymopsis tetragonoloba* the outer hypodermal cells become more thickned and multi layeren and are without cytoplasmic contents, and in later stages of the developing pod, contribute in the exocarpic formation. Pate and Kuo (1981) observed one or two layers of thick walled outer hypodermis in some papilionaceous fruit walls. Deshpande and Untawale (1971) also observed a layer of outer hypodermal layer in the fruit wall of *Indigofera enneaahylla*. Fahn and Zohary (1955) found only one sclerenchymatous layer of stone cells in the hypodermis. Leela *et al.*, (1972) have failed to observe histological zonation of the pericarp in the pod of *Dolichos lablab*.

Palisade like parenchyma and chlorenchyma cells in the mesocarp give very much relation to leaves (Pate and Kuo, 1981). *Cyamopsis tetragonoloba* also possesses chlorencyma cells and palisade like parenchymatous mesocarpic cells. At matutity of the fruit dorsal and ventral sides show very much thick walled sclerenchymatous zone. In *Cassia tora* (Rao and Dave, 1980) basal region possesses tanniniferous contents but in the *Cyamopsis tetragonoloba* it is observed that only the placental stock posses tanniniferous contents. The difference in number of vascular bundles from base, middle terminal parts of the fruit indicates their branching in the pericarp. Only few branches like 2-3 reach at the extreme terminal part of the mature fruit. The sclerenchymatous arches seen in the dorsal and ventral vascular bundles are significant in giving mechanical support to the fruit when the dehiscence takes place. Complete ring of sclerenchyma is observed at the extreme base and not in any other part of the fruit wall.

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