

Macro- and Micromorphological Study of the Leaf, Stem, Root and Rhizome of *Verbesina encelioides*

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ABSTRACT

The macro- and micromorphological characters of the leaf, stem, root and rhizome of *Verbesina encelioides* (Family Asteraceae) were studied in order to find out the diagnostic features of these organs by which the plant can be easily identified in both the entire and powdered form.

Key words: *Verbesina encelioides*; macromorphology; micromorphology; leaf; stem; root; rhizome.

INTRODUCTION

Verbesina encelioides, [(Cav.) Benth. et Hook. F. ex A.Gray], Golden Crownbeards, (family Asteraceae) is an annual herb, native to north and south America and now it is naturalized in Egypt⁽¹⁾.

Phytochemical investigation of the plant revealed the presence of bornyl ferulate, triterpenoides^(2,3), dihydroxyalkylacetamide⁽⁴⁾ and toxic principle galegine^(4,5).

The presence of galegine^(4,5), confirms the classification of *Verbesina encelioides* as poisonous plant material, with the potential to pose a hazard to livestock during periods of forage shortage⁽⁶⁻⁸⁾. No phytochemical reports has been recorded on the Egyptian species. Recently⁽⁹⁾, the author reported on the essential oil composition of the leaves and flowers, as well as their powerful antimicrobial activities. So, it was deemed of interest to complete the pharmacognostical study by carrying out the botanical study of this plant.

The present work comprises, the macro- and micromorphological study of the leaf, stem, root and rhizome of *Verbesina encelioides* grown in

Egypt to show the diagnostic characters of each organ by which one can identify it in both the entire and powdered form.

EXPERIMENTAL

Plant material

Fresh samples of *Verbesina encelioides* were collected in the flowering stage from the Experimental plants garden of Faculty of Pharmacy, Zagazig University, on spring 2006. The identify of this plant was kindly verified by Dr. H. Abd El- Basset, Assoc. Prof. of Plant Taxonomy, Faculty of Science, Zagazig University. A voucher sample of the plant is kept in the Pharmacognosy Department, Faculty of Pharmacy, Zagazig University, Zagazig, Egypt.

Fresh samples as well as samples preserved in 70% alcohol containing 25% glycerol were used.

A. Macromorphology

Verbesina encelioides (Fig. 1A) is an annual, erect, herb attaining 50 to 130 cm in height. It has monopodially branched stem, bearing petiolated, ovate to cordate and triangular-lanceolate leaves. The plant is greyish- green due

to covering of stiff hairs and bearing numerous axillary and terminal, yellow to bright yellow capitulae. Each capitulum consists of a wholly of ray florets at the margin and tubular florets within. The plant usually flowers from March to September. The leaves. (Fig. 1B)

The leaves are simple cauline, opposite decussate, exstipulate and petiolate. They measure 5 to 16 cm in length and 2.5 to 8 cm in breadth (wide). The petioles are winged with auricles at the base and measure 2 to 6 cm in length. The lamina varies from ovate, to cordate and triangular lanceolate, with acuminate apex, symmetric base, serrate margin and greyish- green hairy surfaces, the upper surface being darker. The venation is pinnately reticulate with 3- main veins from the base. The midrib and big viens are prominent on the lower surface only being slightly depressed on the upper one. The leaves have papery texture, characteristic odour and unpalatable taste.



Fig. 1(A): A photograph of the aerial parts of *Verbena encelioides* (x 0.1)

The stem (Fig. 1A&C)

The stem is erect and cylindrical. It is freely and monopodially branched, bearing both flowering and foliage opposite decussate branches.

The young stem is solid ridged, greenish to greyish- green and pubescent, while the old stem is cylindrical, longitudinally striated and has greenish- brown to purplish colour. The internode are 0.5 to 3 cm in diameter and 2 to 8 cm in length, being shorter near the apex. The fresh stem is flexible, while the dry one breaks with a short fibrous fracture, exposing a yellowish interior. The stem has characteristic odour and unpalatable taste.



Fig. 1 (B): A photograph of leaves of *Verbena encelioides* (x 0.58)



Fig. 1 (C): A photograph of root system of *Verbena encelioides* (x 0.3)

The root (Fig. 1C)

The root (Fig. 1C) is cylindrical, fusiform, fleshy tap root, measures 10-90 cm in length and 0.5 to 4cm in diameter. It bears several spreading, short, tapering lateral roots and thin fibrous rootlets, forming a well developed root system. Externally, the root is yellowish white with purplish tinge in colour and becomes brownish yellow on drying. The fresh root is flexible but the dry breaks with short fracture outside and a fibrous fracture inside.

The rhizome (Fig. 1C)

The rhizome is erect with rough, wrinkled, purplish green surface, it breaks with short fracture exposing whitish firm and compact interior.

B- The micromorphology**The leaf**

A transverse section of the leaf (Fig. 2) shows a dorsiventral structure with one row of palisade beneath the upper epidermis, interrupted by collenchymatous cells in the midrib region. The midrib shows a parenchymatous cortex with subepidermal collenchyma and a stele formed of a large central vascular bundle with two small lateral one on each side. Each vascular bundle shows a pericycle formed of an upper and lower area of collenchyma; endodermis is well differentiated surrounding the vascular bundles. A number of resin canals are present in the cortex and stained red with Sudan III and yellow colour with iodine solution.

The upper epidermis (Fig. 3A) consists of polygonal tabular cells with straight anticlinal walls and are covered with thin smooth cuticle. They measure 30-60 μ L, 13-40 μ B and 7-15 μ H.

The lower epidermal cells (Fig. 3B) are polygonal, having strongly wavy anticlinal walls and are covered with thin smooth cuticle. They measure 20-46 L, 15-40 μ B and 5-7 μ H.

The upper and lower neural epidermal cells (Fig. 3C & D) are polygonal, axially elongated with straight anticlineal walls and covered with moderately thick smooth cuticle. They measure 16-95 μ L, 12-60 μ B and 10-26 μ H.

Stomata (Fig. 3) of anomocytic type, are numerous on the lower surface, less on the upper

one. They are oval in outline measuring 15 to 40 L and 10- 28 B.

Both glandular and covering trichomes are present. The glandular trichomes (Fig. 4), formed of uni-to bicellular stalk 6-28 L and unicellular, biseriate multi cellular head 12-40 D.

Covering trichomes (Fig. 4) are numerous and present on both surfaces. They are uniseriate, multicellular (3-6 cells) with acute or sub-acute apices having moderately thick cellulosic walls and smooth cuticle with occasional collapsed cell. They measure 240- 850 L and 16-60 D.

The mesophyll (Fig. 2A& C) is dorsiventral showing a single row of palisade cells below the upper epidermis. The cells are cylindrical, columnar with rather straight walls. They measure 80-120 L and 10-26 D, interrupted by collenchyma in the midrib region.

The spongy tissue consists for 3- 5 rows of loosely packed parenchymatous cells with wide intercellular spaces.

The cortex of the leaf (Fig. 2A & B) is formed of rounded or polyhedral thin walled parenchymatous cells with narrow intercellular spaces and of 2-4 rows of thick walled subepidermal collenchyma. A number of resin canals 20-32 in diameter are occasionally scattered in the cortex.

The endodermis is distinct and consists of a single row of large tubular cells, with thin walls and containing minute starch granules, they are mostly simple, rarely compound, rounded to oval in shape and measuring 4-8 in diameter.

The pericycle (Fig. 2B) is formed of two upper and lower arcs of collenchyma abutting the vascular bundle. The cells are rounded with thick cellulosic walls.

The vascular tissue (Fig. 2A & B) is formed of a large central and two small lateral vascular bundles. Each vascular bundle is formed of a radiate xylem with a band of phloem underneath.

The xylem (Fig. 2& 3) is radiated and

formed of lignified vessels and cellulosic wood parenchyma, separated with wide medullary rays. The vessels (Fig. 3E) are annular, reticulated, spiral and pitted measure 12-42 D. Few tracheids, with pitted lignified walls measure 150-220 L and 20-45 D are also present. The wood parenchyma have moderately thick cellulosic walls.

The cambium (Fig. 2) is formed of 2-3 rows of thin-walled meristematic cells.

The phloem (Fig. 2) is formed of small thin-walled shining cellulosic elements.

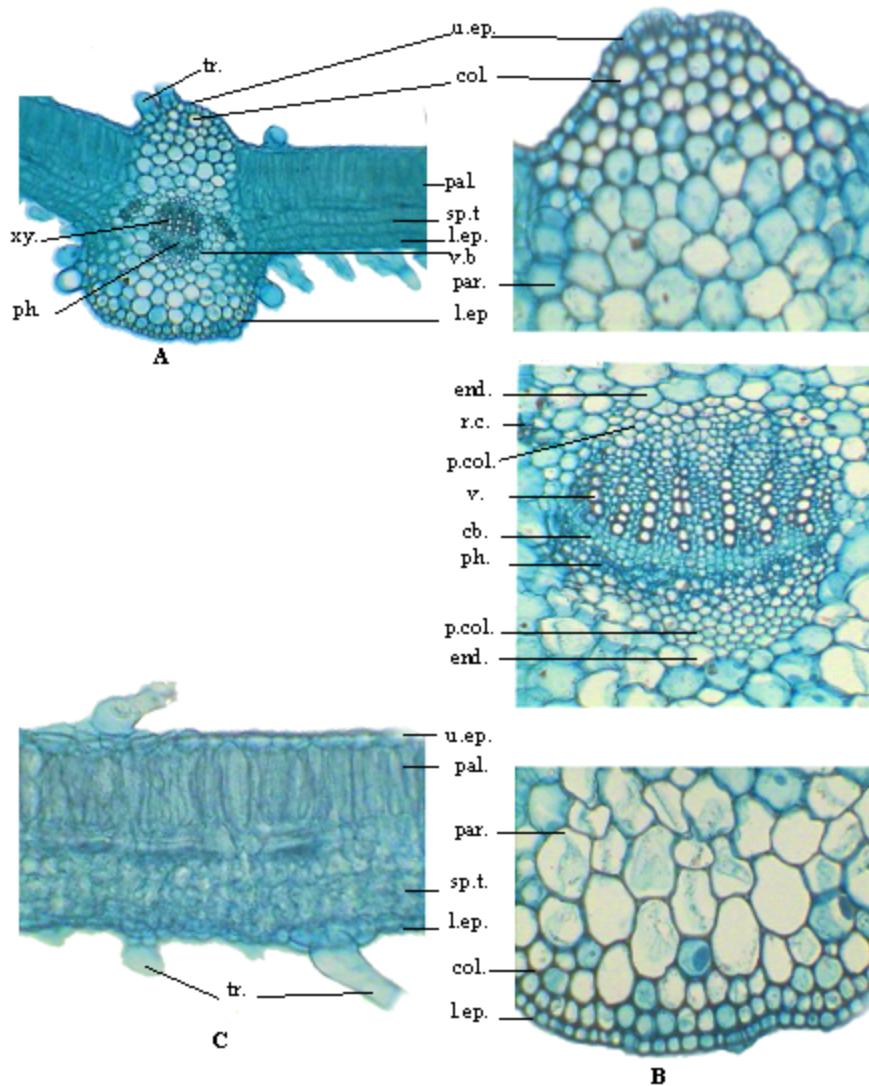


Fig. 2: The leaf

A- Diagrammatic transverse section of the leaf. B- Detailed transverse section of the midrib. C- Detailed transverse section of the lamina. (A x 65, Bx 230 and C x 135).

cb., cambium; Col., collenchyma; end., endodermis; l.ep., lower epidermis; pal., palisade; p.col., pericyclic collenchyma; par., parenchyma; ph., phloem; r.c., resin cell; sp.t., spongy tissue; tr., trichome; u.ep., upper epidermis; v., vessels; v.b., vascular bundle; xy., xylem.

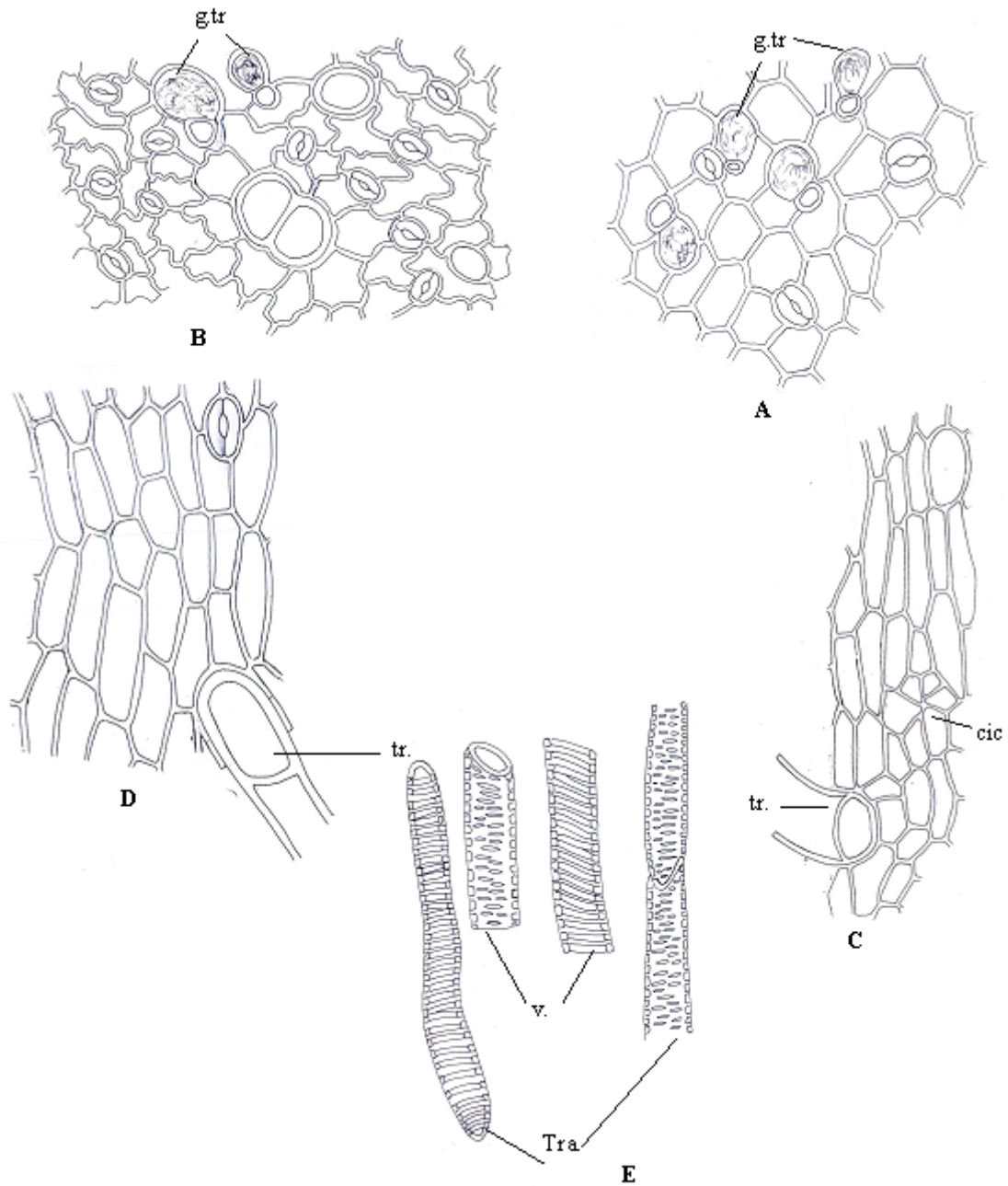


Fig. 3: The leaf

A- Upper epidermal cells of the lamina.

B- Lower epidermal cells of the lamina.

C- Upper epidermal cells of the midrib.

D- Lower epidermal cells of the midrib.

E- Vessels and tracheids.

(All x 350)

cic., cicatrix; g.tr., glandular trichomes; tr. Trichomes; tra., tracheids; v. vessels.

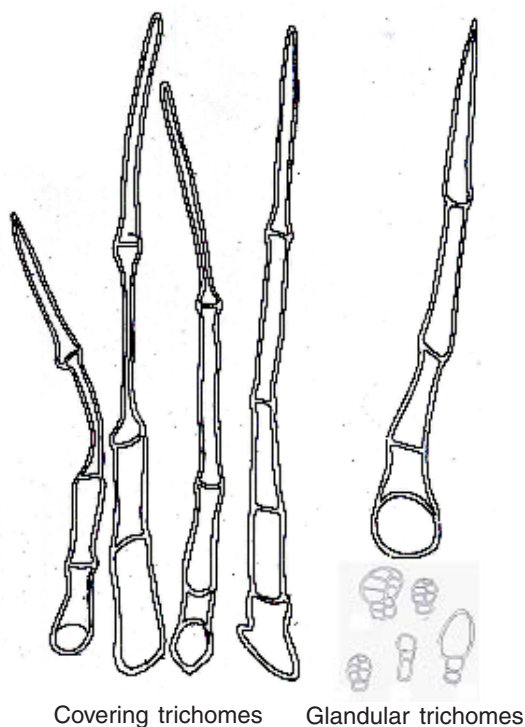


Fig. 4: Trichomes of the leaf. (All x250)

Numerical values of the leaf

Stomatal index, palisade ratio, vein-islet number and veinlet termination number are shown in Table 1.

Table 1: Microscopical numerical values of the leaves of *Verbesina encelioides*

The Numerical value	Recorded value
1. Stomatal index:	
a- Upper surface	12-16
b- Lower surface	14-22
2. Palisade ratio	2-3
3. Vein-islet number	2-4
4. Veinlet termination number	12-18

The petiole

A transverse section of the petiole (Fig. 5A) is biconvex in outline. Showing two wings from upper corners. It shows an outer epidermis surrounding a cortex formed of outer collenchyma

and inner parenchyma. The vascular system consists of a main central vascular bundle and two lateral ones.

The upper epidermal cells of wing (Fig. 5C) are polygonal and tabular with almost straight thin anticlinal walls and are evenly covered with thin smooth cuticle. They measure 20-48 μ L, 16-36 μ B and 10-18 μ H.

The cells of lower epidermis of the wings (Fig. 5D) are polygonal having strongly wavy anticlinal walls and thin smooth cuticle, they measure 16-55 μ L, 12-42 μ B and 8-15 μ H.

The epidermal cells of the petiole (Fig. 5E & F) are subrectangular axially elongated with straight anticlinal walls and are covered with moderately thick smooth cuticle, they measure 40-140 μ L, 16-30 μ B and 7-20 μ H.

Stomata of anomocytic type (Fig. 5), are present on both surfaces of the wing, being fewer on the upper surface. Also, few stomata are present on the lower epidermis of the petiole. They are oval to rounded in outline measuring 16-48 μ L and 12-32 μ B.

The epidermis bears both glandular and covering trichomes (Fig. 4 & 5). They are similar to those present on the leaf.

The cortical tissue (Fig. 5A & B) is formed of parenchymatous cells separated from the epidermis by one, up to three rows of collenchyma. The cells are similar to those of the midrib of the leaf. A number of resin canals 28-42 μ D are occasionally scattered in the cortex.

The endodermis is distinct and consists of a single layer of large tabular, thin walled cells containing minute starch granules which are mostly simple rarely compound, rounded to oval in shape and measure 4-10 μ in diameter.

The Pericycle is formed of two arcs of collenchyma abutting above and below the vascular bundles. The cells are rounded with moderately thick cellulose walls.

The vascular tissue (Fig. 5A & B) is formed of a large central and two small lateral ones. Each vascular bundle is formed of radiating xylem with a band of phloem underneath.

The xylem (Fig. 5B) is radiating and formed of lignified vessels and cellulosic wood parenchyma, separated with medullary rays (1-3 cells wide). The vessels (Fig. 5G) are annular or reticulated and

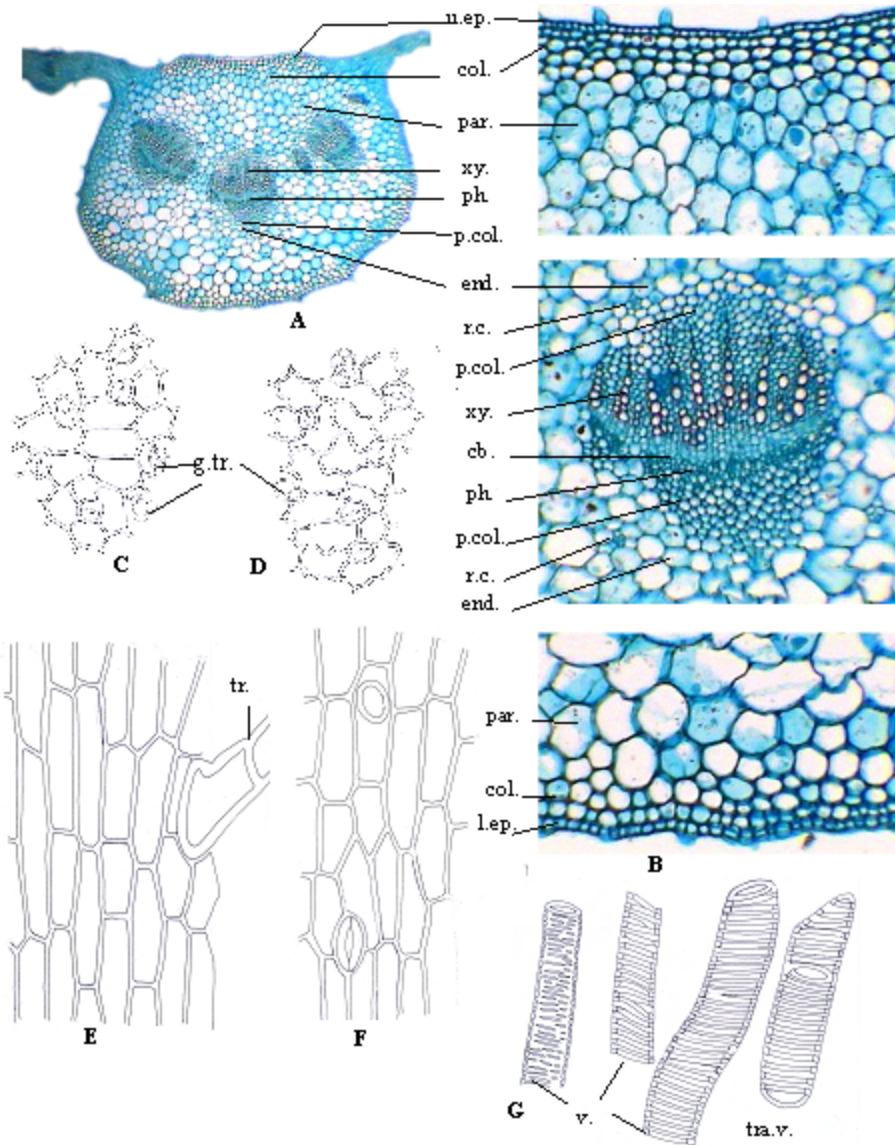


Fig. 5: The petiole

A- Diagrammatic transverse section

C- Upper epidermal cells of the wing

E- Upper epidermal cells of the midrib

G- Vessel and tracheidal vessels

B- Detailed transverse section

D- Lower epidermal cells of the wing

F- Lower epidermal cells of the midrib

(A x 23; B x 60; and C, D, E, F, G all x 250)

cb, cambium; col., cortical collenchyma; end., endodermis; g.tr., glandular trichomes; par., cortical parenchyma; l.ep., lower epidermis; p.col., pericyclic collenchyma; ph., phloem; r.c., resin canal; tr., trichomes; tra.v., tracheidal vessel; u.ep., upper epidermis; v., vessel; xy., xylem.

measure 10-50 μ m in diameter. Few tracheidial vessels with annular lignified walls are present and measure 100-180 μ m L and 30-50 μ m D. The wood parenchyma have moderately thick cellulosic walls.

The cambium (Fig. 5B) is formed of 2-3 rows of thin walled meristematic cells.

The phloem is formed of small thin walled shining cellulosic elements.

The powdered leaf

The powdered leaf is greyish-green in colour with a faint characteristic odour and unpalatable taste. It is characterized microscopically by the following fragments:

1. Fragments of epidermal cells of the lamina, the cells are polygonal with straight or wavy anticlinal walls, thin smooth cuticle and showing anomocytic stomata, glandular and non glandular covering trichomes or their cicatrices.
2. Fragments of epidermal cells of the midrib and big veins. The cells are polygonal and elongated with straight anticlinal walls and moderately thick smooth cuticle.
3. Fragments of the lamina showing dorsiventral structure with a single layer of palisade.
4. Fragments of rounded thin walled parenchymatous cells and moderately thick walled collenchymatous cells of the cortical tissue.
5. Numerous covering trichomes which are multicellular, uniseriate 3-6 called trichomes having thin walls and smooth cuticle with acute apices, some of the cells are collapsed.
6. Few fragment of lignified annular, reticulated and pitted vessels.
7. Few fragment of lignified annular or pitted tracheids or tracheidial vessels.
8. Very few simple starch granules.
9. Absence of calcium oxalate crystals.

The stem

Transverse section of the stem (Fig. 6 & 7) is circular in outline. It shows an outer epidermis followed by a narrow parenchymatous cortex and subepiderm consists of interrupted bands of collenchyma and chlorenchyma. In the young stem the cortex is parenchyma with 2-4 rows of continuous

peripheral collenchyma. The cortex is limited internally by a well differentiated starchy endodermis surrounding poly vascular stele. The stele shows a complete ring of 13-25 open collateral bundles each with sclerenchymatous pericycle and surrounding a wide parenchymatous pith. In the young stem (Fig. 6) there is a band of collenchymatous pericycle abutting each vascular bundle. The vascular bundles are separated by wide primary medullary rays.

The cells of the epidermis (Fig. 6C & 8A) are square to subrectangular polygonal and axially elongated with straight anticlinal walls and are covered by smooth cuticle. They measure 24-63 μ m L, 15-50 μ m B and 12-20 μ m H.

The stomata (Fig. 6C & 8A) are few, oval, are mostly of anomocytic type, each is surrounded by 4-8 epidermal cells and measure 20-40 μ m L and 16-30 μ m B.

Covering trichomes are numerous and of the non glandular type. They are multicellular, uniseriate formed of 5-10 cells with moderately thick walls and moderately thick smooth cuticle, they show one to two collapsed cells, the terminal cell had blunt apex. They measure 500-850 μ m L and 10-40 μ m D.

The cortex (Fig. 7A & B) is narrow, having an outer zone of 3-7 rows of collenchyma interrupted by chlorenchyma opposite the interfascicular regions. The inner zone of the cortex is formed of 3-6 rows of rounded or irregular parenchymatous cells. In the young stem (Fig. 6A & B) the cortex is parenchymatous, having an outer zone of 2-3 layers collenchyma. The cortex shows resin canals. Filled with yellowish brown contents and are arranged opposite the interfascicular regions and in the pith opposite the xylems, they measure 30-45 μ m D.

The endodermis is well marked as a row formed of small tabular or tangentially elongated cell with no casparian strips. They contain starch granules, they measuring 7-10 μ m D.

The pericycle (Fig. 7B & 8C) is composed of large groups of thick-walled lignified fibres abutting each vascular bundle. Each group is 6-10 cells wide and 9-20 tangential cells. The fibres have

thick lignified walls with simple narrow ovoid or oblique pits, wide or narrow lumen and acute or subacute rarely forked apices. Occasional fibres show transverse lignified septa. They measure 600-1250 μ L and 15-50 μ D.

The pericycle of the young stem (Fig. 6B) is formed of collenchymatous cells abutting each vascular bundle formed of polygonal thick-walled cellulose cells.

The vascular tissue (Fig. 6 & 7) is formed of a ring of 13-25 vascular bundles separated by wide primary medullary rays. Each vascular bundle is formed of an outer phloem and inner xylem with cambium in between.

The phloem (Fig. 6 & 7) consists of moderately thin-walled cellulose elements. The cambium (Fig. 6 & 7) is formed of 3-5 rows of thin-walled tangentially elongated meristematic cells.

The xylem (Fig. 6 & 7) is much wider than the phloem and consists mainly of secondary xylem. It is wholly lignified and is formed mostly of fibres. The wood fibres (Fig. 8C) have moderately thick lignified and pitted walls, relatively wide lumen, acute to blunt apices. Occasional fibres show transverse septa. They measure 300-700 μ L and 15-40 μ D. Vessels (Fig. 8C) are scattered throughout the wood and occur either isolated or in short radial or oblique rows of 1-5 vessels. They are mostly pitted, with rounded or elliptical pits, few vessels are annular and reticulated. They measure 20-100 μ D. Tracheids (Fig. 8C) are few rectangular, showing moderately thick, lignified walls with numerous nearly rounded or oval bordered pits, wide lumen and oblique end walls, they measure 120-300 μ L and 12-50 μ D. Occasional tracheidal vessels (Fig. 8C) are present; with moderately thick lignified walls, showing oval bordered pits and having large rounded lateral perforations. They measure 125-325 μ L and 18-40 μ D.

Wood parenchyma (Fig. 8C) are diffused and formed of polygonal, axially elongated cells with moderately thick lignified walls showing simple pits. They measure 100-160 μ L and 40-65 μ D.

The secondary medullary rays are 2-4 cells, wide, being parenchymatous and cellulose in the phloem and lignified in the xylem. In the phloem region, the cells are thin-walled radially elongated and cellulose measuring 50-90 μ L and 29-34 μ D, but in xylem region, they are square radially elongated with thick and unequal lignified pitted walls, measuring 60-120 μ L and 20-50 μ D. The primary medullary rays are much wider and cellulose.

The pith (Fig. 6 & 7) is comparatively wide composed of large polyhedral, moderately thick-walled cells, with narrow intercellular spaces. The perimedullary zone is formed of smaller cells with thick lignified pitted walls and very narrow intercellular spaces.

The powdered stem

The powdered stem is yellowish-green in colour, with characteristic odour and unpalatable taste. It is characterized microscopically by:

1. Fragments of the epidermis consisting of polygonal isodiametric or elongated cells with straight or slightly wavy anticlinal walls, showing few stomata of anomocytic type and covered with moderately thick smooth cuticle.
2. Fragments of polygonal thick-walled and pitted lignified cells of the primary medullary rays.
3. Fragments of xylem showing wood fibres, they are lignified with moderately thick walls, wide lumen and acute or blunt apices and with few septa.
4. Fragments of lignified pitted, reticulate and spiral vessels.
5. Fragments of lignified tracheids with pitted walls showing oval or rounded bordered pits with blunt or rectangular apices.
6. Fragments of tracheidal vessels with moderately thick lignified walls, and having large rounded lateral perforations.
7. Fragments of rounded, isodiametric parenchymatous cells of the cortex with occasional resin canals.
8. Numerous fragments of lignified pericyclic fibres. They have thick, moderately thick lignified walls, wide or narrow lumen and acute or rarely forked apex.

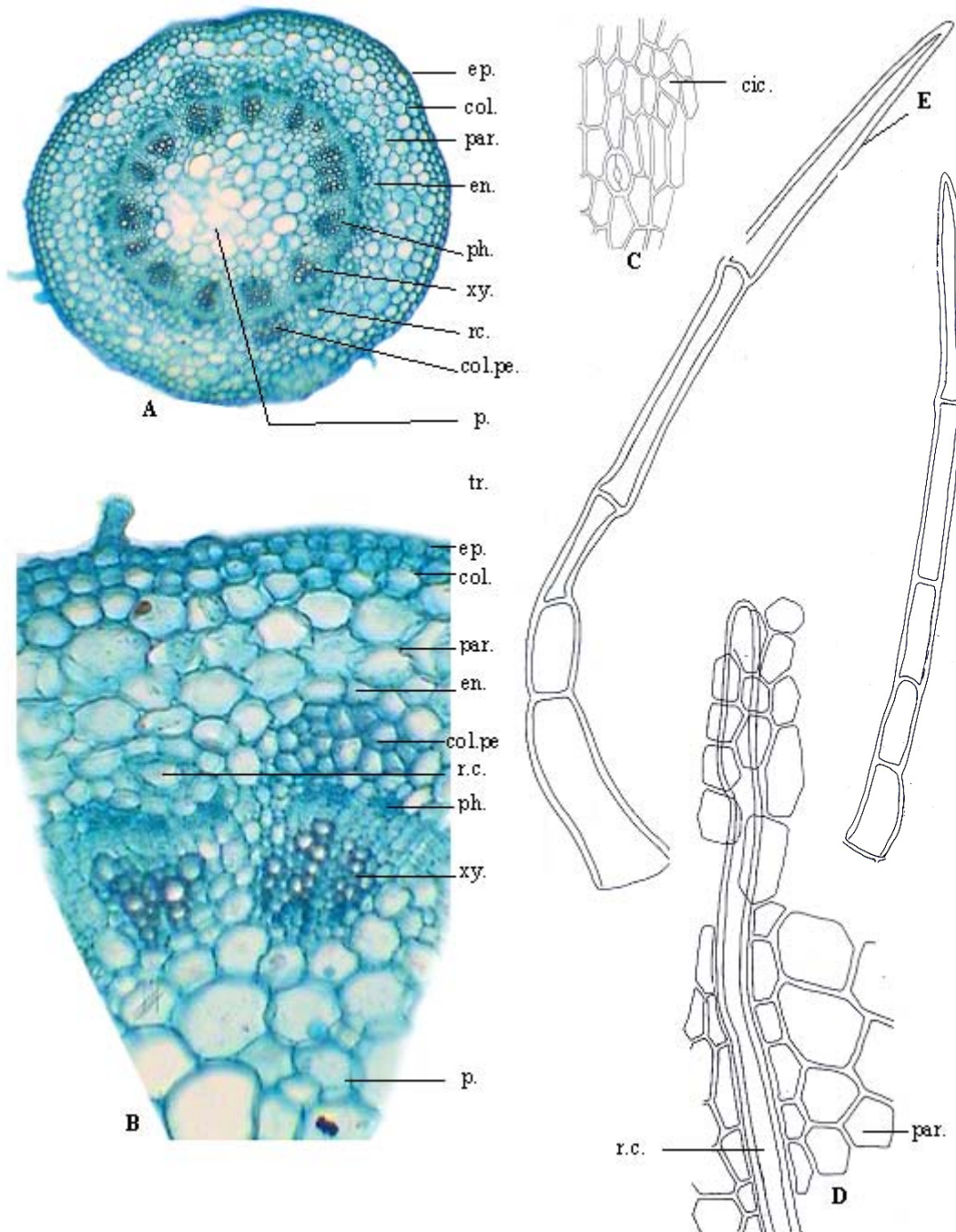


Fig. 6: The young stem

A- Diagrammatic transverse section

B- Detailed transverse section

C- Epidermal cells,

D- Resin canal

E- Covering trichome

(A x 68; B x 250 and C, D, E all x 250)

col., collenchyma; col.pe., collenchymatous pericycle; p., pith;
 par., parenchyma; ph., phloem; r.c., resin canal; tr., trichomes; xy., xylem.

9. Numerous of covering trichomes either broken or entire with multicellular, uniseriate of 5-10 celled trichomes having thin walls, smooth cuticle and acute apices with one collapsed cell.
11. Sclereides and calcium oxalate crystals are completely absent.

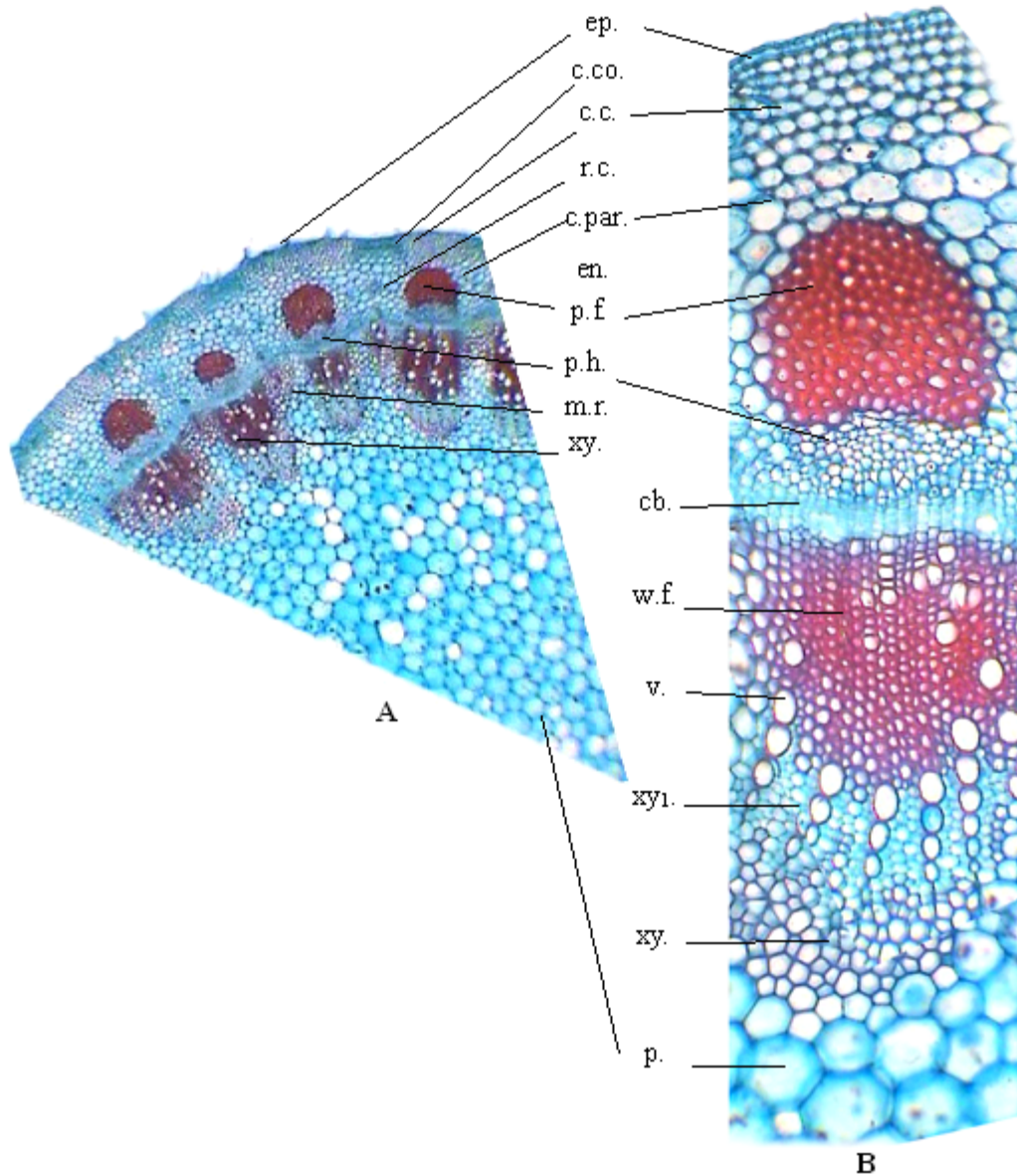


Fig. 7: The old stem

A- Diagrammatic transverse section of the old stem B- Detailed transverse section of the old stem
(A x 32; B x 188)

cb., cambium; c.c., cortical collenchyma; c.co., cortical chlorenchyma; c.par., cortical parenchyma;
en., endodermis; ep., epidermis; mr., medullar ray; p., pith; p.f., pericyclic fibers; ph., phloem;
r.c., resin canal; v., vessel; w.f., wood fibres; xy., xylem; xy1., primary xylem.

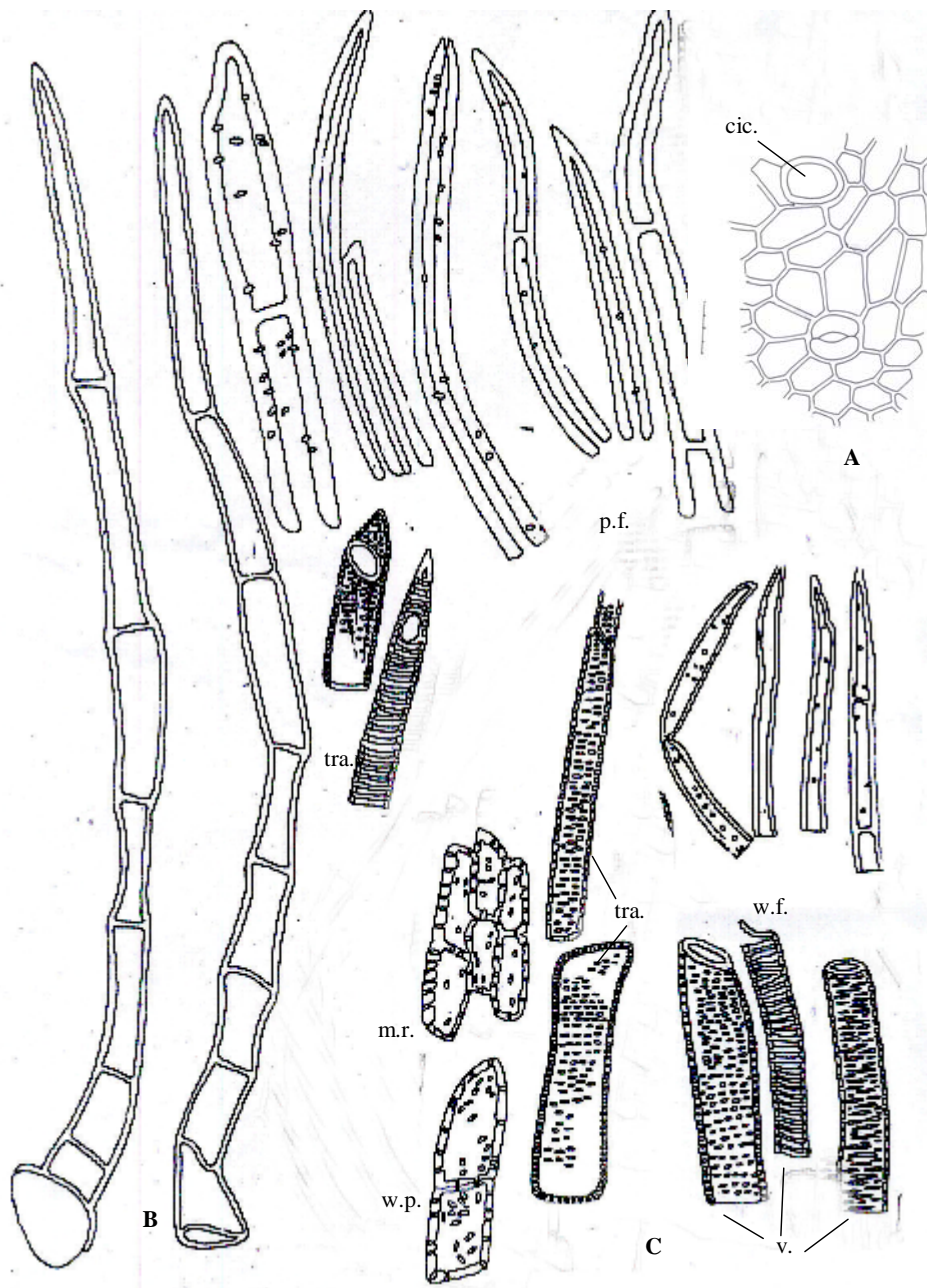


Fig. 8: powder of the old stem

A- Epidermal cells of the old stem.

B- Trichomes of the old stem.

C- Isolated elements of the old stem (all x 250)

cic., cicatrix; m.r., medullary ray; p.f., pericyclic fibres; tra., tracheids;
tra.v., tracheidal vessel; v., vessels; w.f., wood fibres; w.p., wood parenchyma.

The root

The transverse section of the root (Fig. 9A & 10B) is nearly circular in outline. It shows externally a cork, followed by a parenchymatous phelloderm. The vascular system is composed of a central cylinder of vascular elements, formed of a narrow phloem enclosing a wide cylinder of radiating xylem with a central di-arch primary xylem. Both the phloem and xylem are traversed by two wide primary medullary ray and numerous narrow secondary rays. A transverse section in the young root (Fig. 10A) shows a piliferous layer followed by a wide parenchymatous cortex, an endodermis, a parenchymatous pericycle enclosing the di-arch vascular system.

The cork (Fig. 9A & 11CK₁) consists of several rows of polygonal, tabular cells, arranged in radial rows, the cells have moderately thick yellowish-brown suberised occasionally lignified walls. They measure 40-84 m L, 30- 52m B and 26-32 m H.

The phellogen arises in the pericycle and is indistinguishable.

The phelloderm (Fig. 9A) is parenchymatous formed of 4-8 rows of thin walled cells with narrow intercellular spaces.

The vascular tissue (Fig. 9A) is formed externally of narrow phloem, surrounding a wide cylinder of xylem. The phloem (Fig. 9A) is relatively narrow and showing in its periphery small groups of collapsed primary phloem elements. The secondary phloem consists of slightly thick walled, cellulosic elements but no phloem fibres. The cambium (Fig. 9A) is formed of 4-6 rows of thin walled tangentially elongated sub-rectangular meristematic cells.

The xylem (Fig. 9A & 11) consists of a wide cylinder of lignified elements. It is composed mainly of wood fibres, tracheids, tracheidal vessels, vessels and wood parenchyma.

The wood fibres (Fig. 11) are spindle shaped with thin lignified walls showing slit like pits, wide lumen and blunt, acute apices. Occasional fibres show transverse septa. They measure 270-

475 u L and 12-30 u D.

The vessels (Fig. 9A & 11) are diffused through the wood, being either solitary or in small groups of 2-4 vessels. They are scalariform and pitted with numerous oval openings. They measure 30-75m D.

The tracheids (Fig. 11) are elongated rectangular, with lignified walls showing numerous oval or transversely elongated pits; they measure 75-225 u L and 12-40 u D.

The tracheidal vessels (Fig. 11) are few, showing rounded to oval lateral perforations, having lignified pitted walls with oval or transversely elongated pits and having large rounded to oval lateral perforation. They measure 25-60m D.

The wood parenchyma (Fig. 11) are diffused and formed of rectangular axially elongated with pitted lignified walls, they measure 25-100 m L and 19-40 m D.

Medullary rays (Fig. 9A) are usually 3-5 cells wide, the primary medullary rays being 4-7 cells wide, they are cellulosic and funnel-shaped in the phloem and lignified in the xylem region, where it is formed of rectangular or radially elongated cells with thick and pitted walls. They measure 40-12 m L and 10-25 m D.

The rhizome

The transverse section of the rhizome (Fig. 9B & 10C) shows an outer layer of the cork with parenchymatous phelloderm, showing scattered resin canal. The pericycle is parenchymatous showing scattered groups of fibres. The vascular system is composed of a narrow phloem enclosing a wide cylinder of radiating xylem with a central parenchymatous pith.

The cork (Fig. 9D & 11CK₂) consists of 3-5 rows of polygonal, tabular cells, arranged in radial rows, the cells have moderately thick yellowish-brown lignified walls. They measure 40-80 m L, 30-60 m B and 20-38 m H.

The cortex constitutes one tenth of the whole diameter. It consists of thin-walled

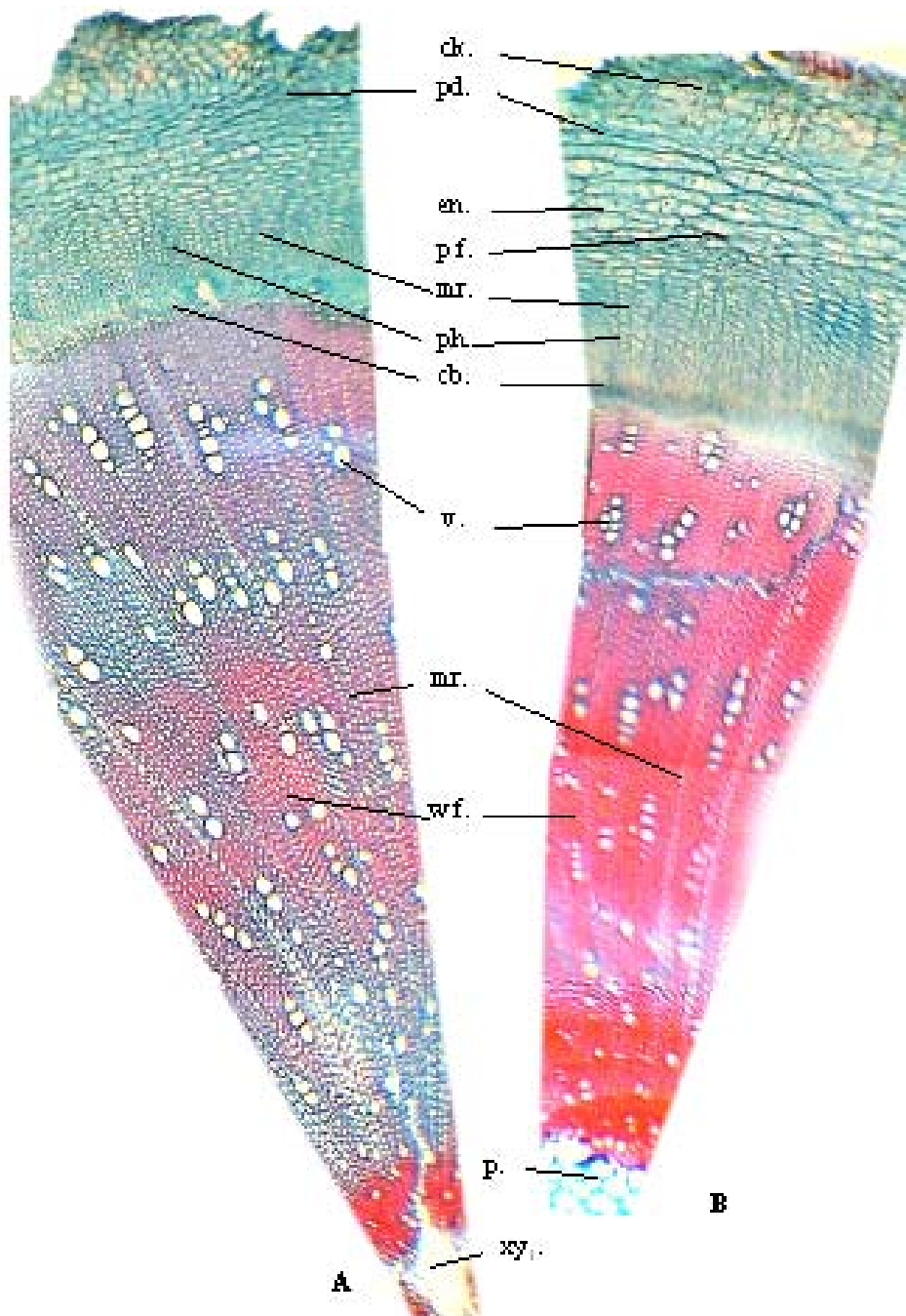


Fig. 9: the root and rhizome

A- Detailed transverse section of the old root B- Detailed transverse section of the rhizome
(A x 64.5 and B x 70)

cb., cambium; ck., cork; en., endoderm; mr., medullary ray; p., pith; pd., phelloderm;
p.f., pericyclic fibre; ph., phloem; w.f., wood fibre, w.p., wood parenchyma; xy., primary xylem.

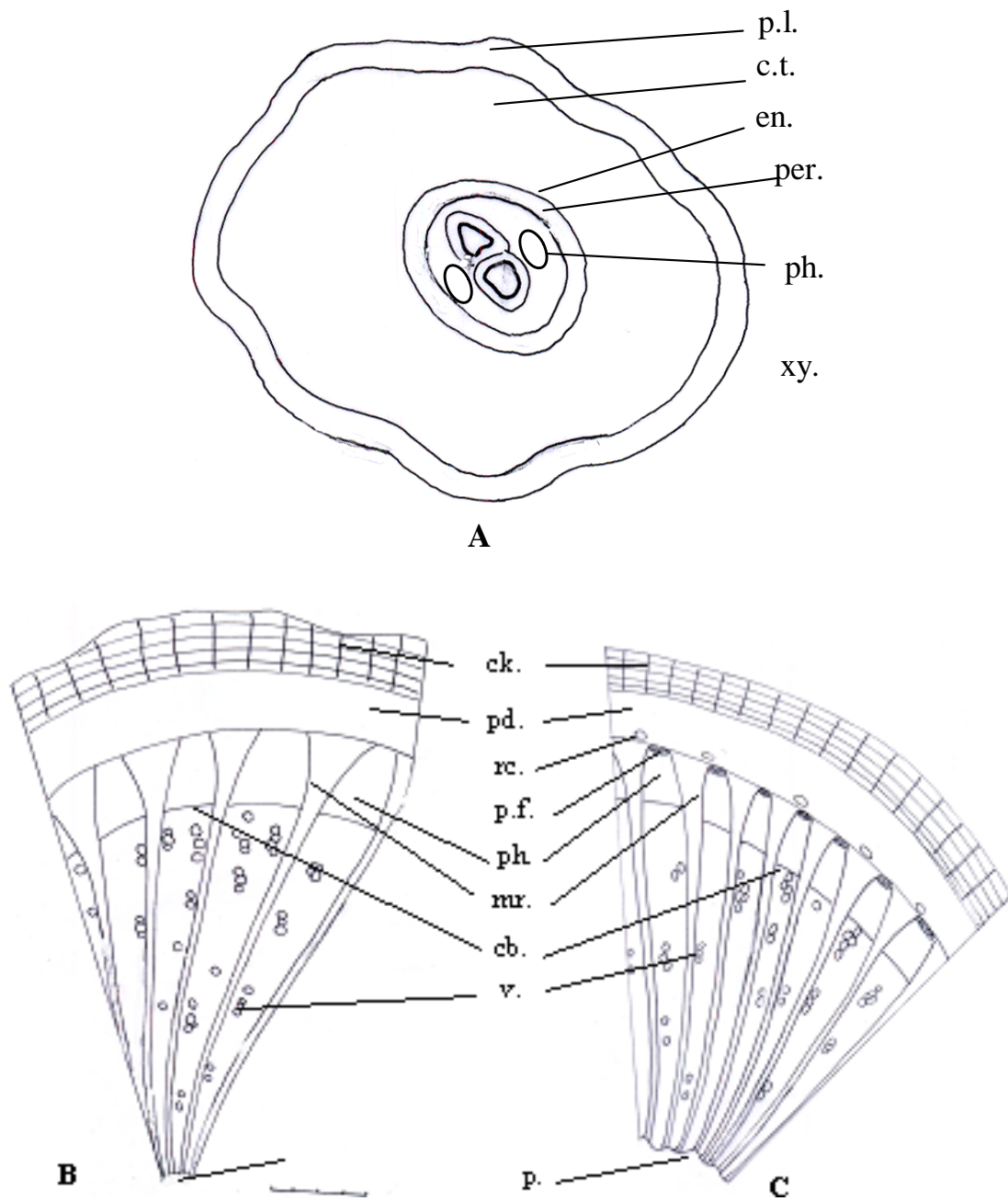


Fig. 10: The root and the rhizome

A- Diagrammatic transverse section of the young root B- Diagrammatic transverse section of the old root
 C- Diagrammatic transverse section of the rhizome (A x 193 ; B & C x 28)

cb., cambium; ck., cork; en., endoderm; mr., medullary ray; p., pith; pd., phelloderm; p.f., pericyclic fibre;
 ph., phloem; p.l., piliferous layer; r.c., resin canale; v., vessel; xy₁, primary xylem.

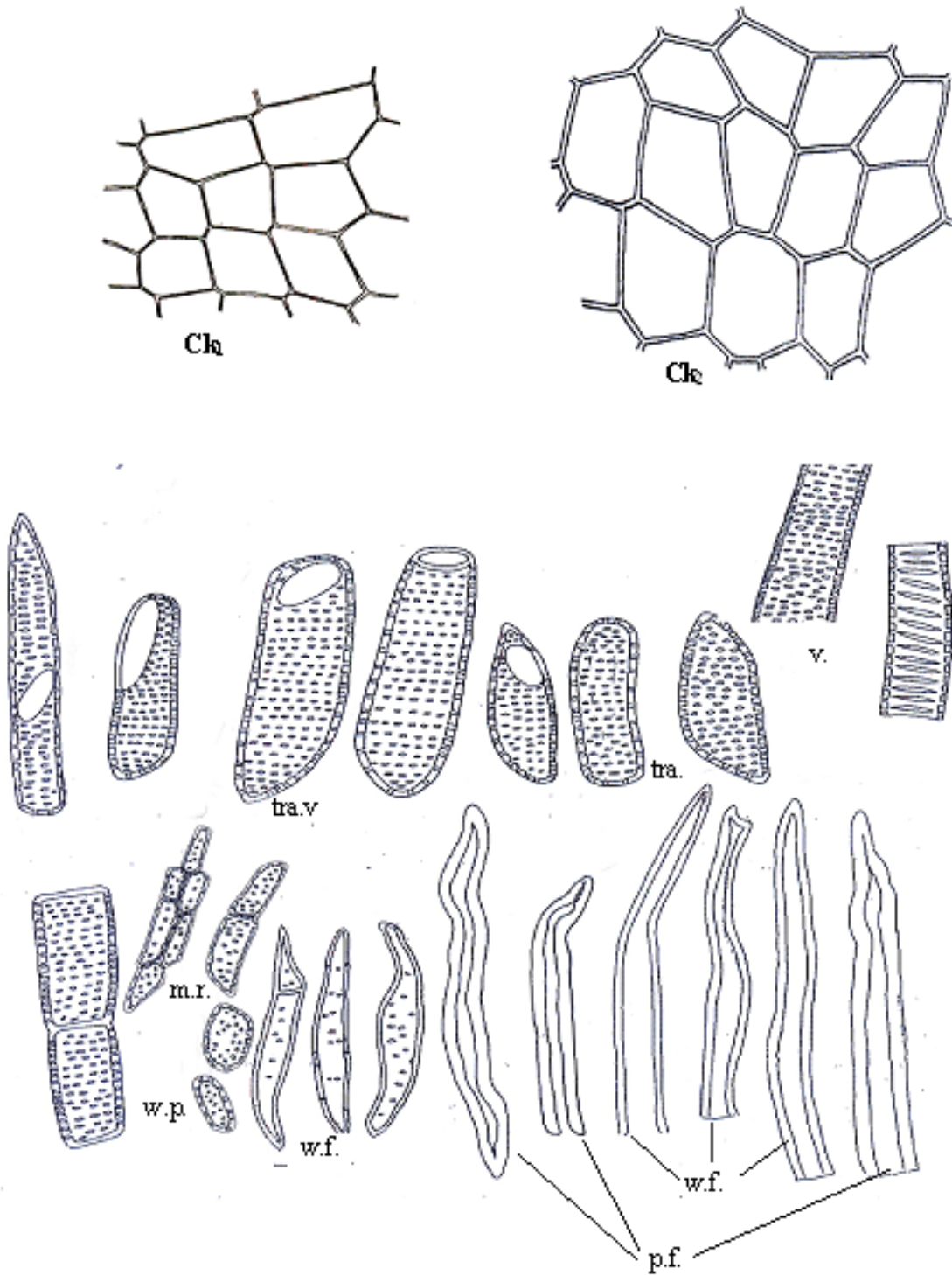


Fig. 11: isolated elements of the root and rhizome (All x 250)

ck₁., cork of the root; ck₂., cork of the rhizome; mr., medullary ray; p.f., pericyclic fibre; tra., tracheids; tra.v., tracheidal vessel; v., vessel; w.f., wood fibre; w.p., wood parenchyma.

tangentially elongated, subrectangular to polyhedral parenchymatous cells. Resin canals are scattered in the cortex; the epithelium lining formed of polygonal cells of thin brownish walls measuring 50-62 μ m D. The cortex is lined by an endodermis of regularly arranged, tangentially elongated cells.

The pericycle (Fig. 9A, 10C and 11) is composed of numerous groups of fibres arranged in a ring interrupted by parenchyma, each group is 3-5 fibres wide and up to 7 fibres tangentially. The fibres have thick, cellulosic walls, wide or narrow lumen and acute, sub-acute or occasionally forked apices. They measure 15-40 μ m D and 270- 600 μ m L. The parenchyma of the pericycle is formed of moderately thick-walled polygonal cells with very narrow intercellular spaces.

Vascular tissue, is formed of a narrow phloem, surrounding a wide cylinder of xylem with cambium in between.

The phloem (Fig. 9B) is formed of thin walled soft shining cellulosic elements. The cambium zone is formed of 3-6 rows of tangentially elongated, sub rectangular meristematic cells.

The xylem (Fig. 9B) consists mainly of secondary xylem. It is wholly lignified and is formed of fibres, tracheids, few tracheidal vessels, vessels and wood parenchyma.

The wood fibres (Fig. 11) are spindle shaped with moderately thick lignified walls with slit-like pits, and acute or blunt apices occasional fibres shows transverse septa. The vessels (Fig. 9B) are diffuse, being either solitary or in small radial groups of 2-4. They are either reticulate or pitted with numerous pits with slit-like openings and measure 25-60 μ m D. The tracheids (Fig. 11) are elongated rectangular with pitted lignified walls; the pits are oval or transversely elongated with slit like openings. They measure 25- 27 μ m D and 200 μ m L. Tracheidal vessels (Fig. 11) are rectangular to axially elongated, pitted lignified walls with large oval or rounded lateral perforation, they measure 80-220 μ m L and 28- 60 μ m D. The wood parenchyma are diffused formed of subrectangular cells, with pitted lignified walls; they measure 75- 90 μ m L and 12-15 μ m B.

The pith is small central, formed of rounded thinwalled cellulosic parenchyma with wide intercellular spaces.

The powdered root and rhizome

The powdered root and rhizome is yellowish in colour with a faint characteristic odor and unpalatable taste. It is characterized microscopically by the following fragments:

1. Abundant fragments of lignified wood fibres with moderately thick lignified walls showing slit like spits, wide lumen and acute or rounded apices. Occasional fibres showing transverse septa.
2. Fragments of the cork showing polygonal cells with yellowish suberized or lignified walls.
3. Fragments of the wood showing either lignified, pitted, reticulate, or scalariform vessels, pitted tracheids, tracheidal vessels or lignified pitted parenchyma.
4. Fragments of the cortex showing cellulosic parenchyma with narrow intercellular spaces.
5. Fragments of pericyclic fibres, they are cellulosic with moderately thick walls, wide or narrow lumen and acute or forked apices.
6. Fragments of thin-walled parenchymatous cells of pith they are polygonal or rounded with wide intercellular spaces.
7. Few simple starch granules.
8. Calcium oxalate crystals are completely absent.

CONCLUSION

Verbesina encelioides is one of the poisonous plant. So, from the fore-mentioned study, one can conclude the characteristic features of the plant in both entire and powdered forms.

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