

## MACRO - AND MICROMORPHOLOGY OF THE FLOWER AND FRUIT OF AMARANTHUS CHLOROSTACHYS WILLD

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### ABSTRACT

The study of the macro - and micromorphology of the flower and fruit of Amaranthus chlorostachys Willd is presented with the aim of finding out the most diagnostic characters by which the plant could be easily identified in the entire and powdered forms.

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### INTRODUCTION

Amaranthus chlorostachys Willd, family Amaranthaceae, is a herbaceous plant growing wild in Nile - Delta, Egypt . In a previous work (1&2) , the phytochemical investigation as well as the macro - and micromorphology of the leaf, stem and root of Amaranthus chlorostachys Willd , family Amaranthaceae was presented.

In this study , the macro - and micromorphology of the flower and fruit has been described with the aim of finding out the diagnostic characters of these organs by which they could be easily identified both in entire and powdered forms.

### EXPERIMENTAL

#### Plant Material

Fresh samples of flowering plants of Amaranthus chlorostachys Willd were collected in July 1989 from a region 20 km west of Zagazig . The identity of the plant was kindly confirmed by Prof. Dr . Loutfy Boulos, National Research Center , Cairo , Egypt .

#### A- Macromorphology :

##### The Inflorescence : ( Fig.1 )

It is terminal cymose clusters increasing upwards to form spikes, few being axillary . The terminal inflorescence varying from a single to many spikes, each spike



Fig (1) : Sketch of flowering top of *Amaranthus chlorostachys* Willd. (X 0.5)  
ax.sp., axillary spike; l. leaf; t. inf., terminal inflorescence.

consists of 12 to 45 clusters . The male and female flowers are intermixed in each cluster. The terminal spike attains 30 cm in length and 10 cm in breadth.

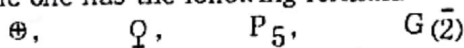
#### The Flower : (Fig . 2,A and E)

The flowers are whitish - green in colour , bracteate and present in clusters. The clusters are increasing upwards forming dense spike . Each cluster contains from 5 to 8 small flowers including 1 to 2 male flowers and 4 to 6 female flowers. The flower measures 1.5 to 5 mm in length and 1.2 to 2 mm in diameter .

The male flower has the following floral formula



While the female one has the following formula



#### Bracts : (Fig . 2,D) .

Bract is whitish-green, simple, membranous, exstipulate, ovate to lanceolate, sessile, with entire margin, acute apex, symmetric base and a greenish central keel. The green keel excurrent to form long erect arista. The bract measures 2.5 to 5 mm in length and 0.5 to 1.2 mm in breadth.

#### Perianth : ( Fig. 2,H ).

It is whitish-green, formed of 5 free segments, they are membranous , lanceolate, the midrib excurrent to form small arista, or have acute or notched apex. The perianth segment has entire margin, symmetric base and measures 1.5 to 4 mm in length and 0.5 to 1.4 mm in breadth.

#### The Androecium : ( Fig . 2, G )

It is formed of 5 free stamens; each consists of filament and anther lobes. Filaments are free, whitish in colour, cylindrical, measuring 2 to 5 mm in length and about 0.1 mm in diameter. The anther is brownish- yellow , bilobed, dorsifixed, oval and measures 1.0 to 1.5 mm in length and 0.3 to 0.7 mm in diameter.

#### The Gynaecium : ( Fig. 2,C)

It is bicarpellary , unilocular , superior ovary having a single basally placented ovule. Style is absent. The stigma is yellow in colour, sessile, bifid .The ovary measures 0.75 to 3 mm in length and 0.13 to 1mm in diameter, while the stigmatic lobe measures 0.2 to 0.8 mm in length , and 0.1 to 0.3 mm in diameter .

#### The Fruit : ( Fig. 3, A and B )

The fruit is sessile , dehiscent, dry capsule, pyxis, subglobose to ovoid, circumscissile , with persistent hairy bifid stigma. The fruit contains a single basally

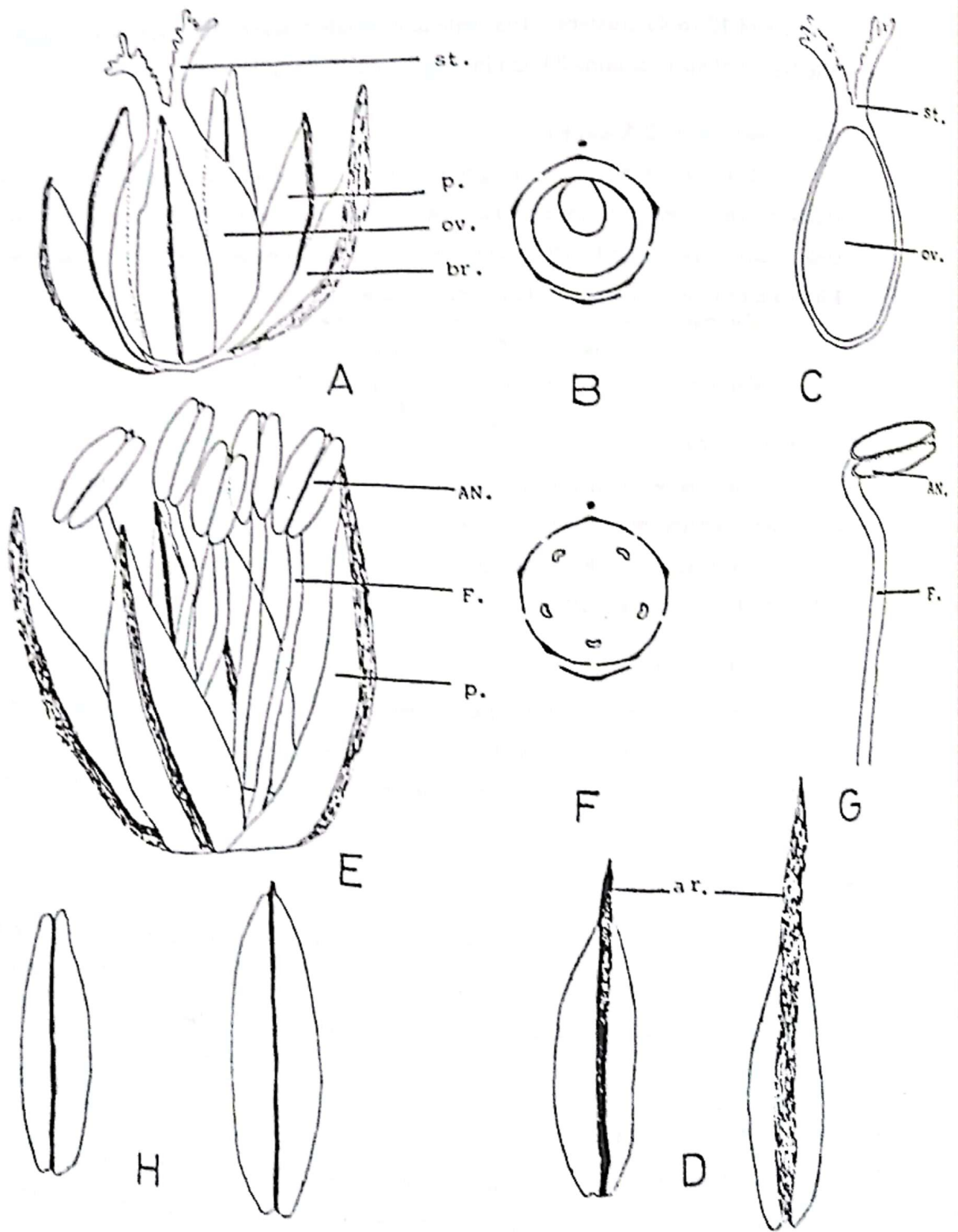


Fig.(2) A:Female flower B: Diagram of floral formula of female flower. C :The gynaecium  
 D:The bract E: Male flower F: Diagram of floral formula of male flower.  
 G:The androecium H: Perianth segment. ( All x 20 )  
 An., anther lobes; ar., arista; br., bract; F., filament; ov., ovary;  
 P., perianth; St., stigma.

placented seed . The pericarp is thin, leathery having whitish and smooth surface. It measures 2 to 3.5 mm in length and 0.5 to 1.5 mm in diameter.

### The Seed : ( Fig . 3,C 1)

The seed is minute , dark brown in colour . rounded in outline with laterally compressed surfaces. It is albuminous derived from campylotropous ovule; embryo is curved formed of two cotyledons and small radicle directed to the micropyle and surrounded by copious endosperm. The testa is thin , brownish in colour, with shining or pale , minutely reticulate surface. Hilum and micropyle are present in a small depression on the edge of the seed. It measures 0.75 to 1.25 mm in diameter .

## B - Micromorphology :

### The Bract :

The transverse section of the bract (Fig. 4,B) consists of an outer and inner epidermises enclosing a parenchymatous mesophyll . The cortical tissue is mainly sclerenchymatous traversed longitudinally by a small vascular bundle , showing one row of club - shaped cells and subepidermal layer of palisade like cells below lower epidermis.

The Epidermis of bract : ( Fig. 4,C, D , E & F) is formed of polygonal axially elongated with straight, occasionally curved , thin beaded anticlinal walls and covered with thin smooth cuticle . The inner epidermal cells being almost longer, narrower and its walls being not beaded.

Dimensions of the epidermal cells of bract are given in microns in table (1).

**Table (1):** Dimensions of the Epidermal Cells of Bract in Micron

Epidermis	Length	Breadth	Height
Outer epidermis			
At the apex	30-89	5-13	4-12
At the margin	46-86	6-15	4-12
At the middle	57-92	6-18	6-12
At the base	52-80	15-27	12-23
Inner epidermis			
At the apex	57-114	6-10	4-10
At the margin	35-80	9-12	8-13
At the middle	85-119	6-19	6-13
At the base	23-52	14-23	12-18
Over the vein	46-80	8-15	6-13
Of the arista	12-40	6-14	4-12

Stomata : absent .

Trichomes : ( Fig . 4,G) are non - glandular , and glandular types. They are present on the margin of bract especially near the base ; few are on the midrib region. The

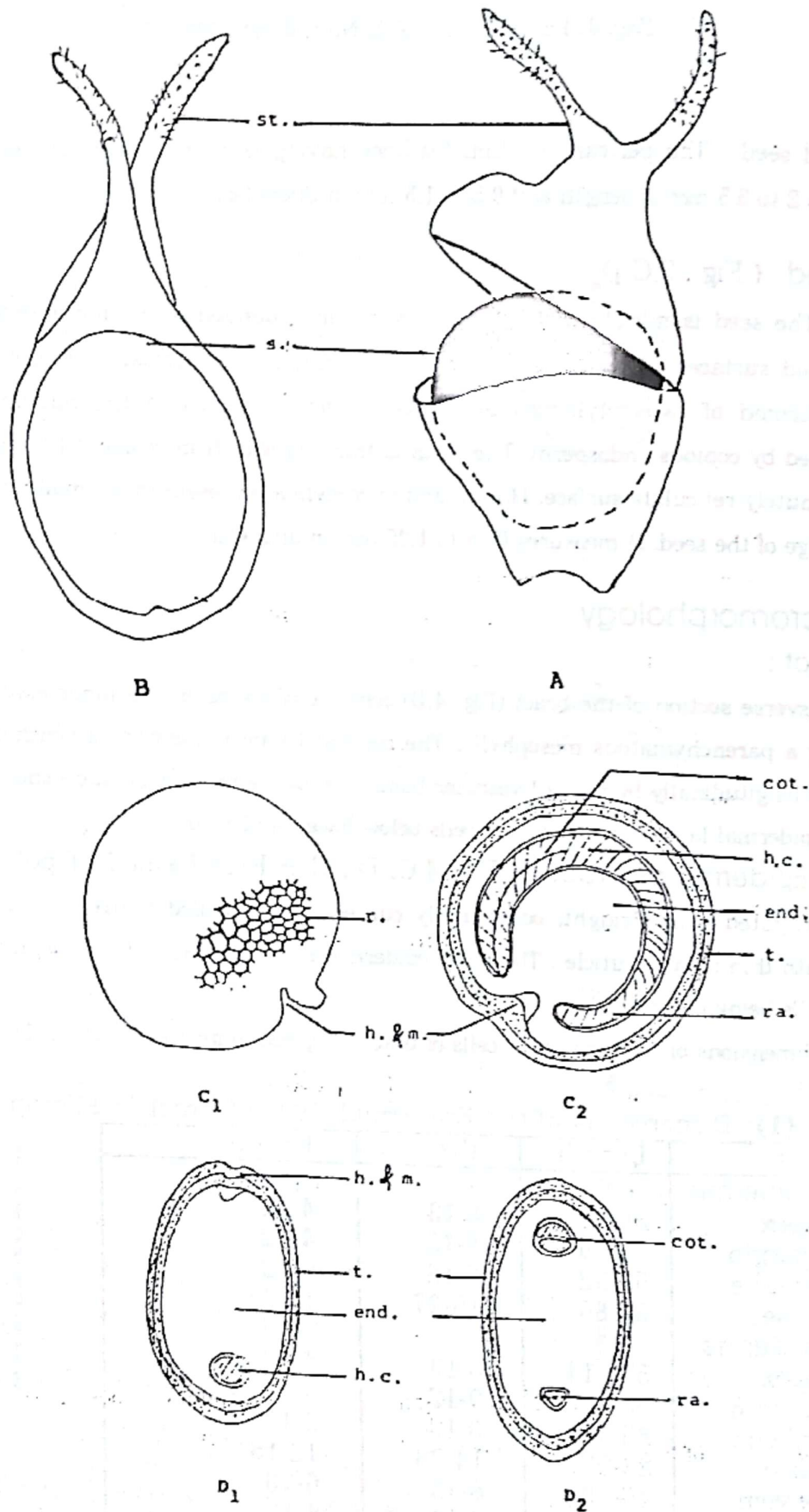


Fig.(3) A : Opened capsule. B : The fruit with persistent stigma; C<sub>1</sub>: The seed  
 C<sub>2</sub> : L.S. parallel to the flat surface of seed. D<sub>1</sub> : L.S. perpendicular to  
 the flat surface of seed. D<sub>2</sub> : Diagram of T.S. of seed. ( All x 35 )  
 Cot., Cotyledon; end., endosperm; h.c., hilum and micropyle; h & m., hilum and  
 micropyle; P., perianth; ra., radicle; r., reticulation; S., seed; St.,  
 persistent hairy stigma.

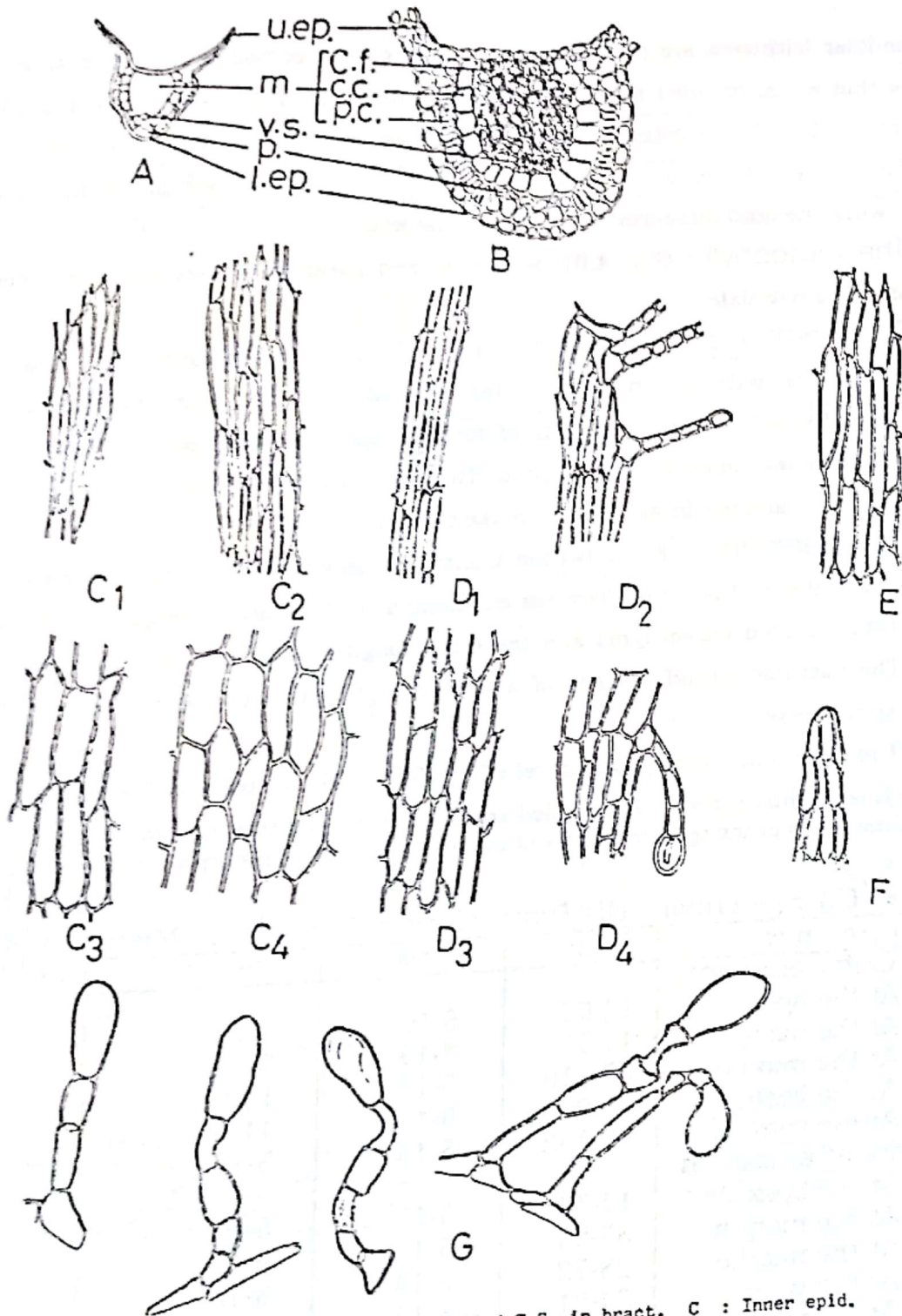


Fig.(4) A : Diagram of T.S. bract. B : Detailed T.S. in bract. C : Inner epid. cells of bract. C<sub>1</sub> : At the apex. C<sub>2</sub> : At the margin C<sub>3</sub> : At the middle. C<sub>4</sub> : At the base. D : Outer epid. cells of bract. D<sub>1</sub> : At the apex. D<sub>2</sub> : At the margin D<sub>3</sub> : At the middle. D<sub>4</sub> : At the base E : Epid. cells over the vein. F : Epid. cells of the arista. G : Trichome  
 ( All x260 except A x 23, B x 60 and G x 483).  
 C.C., Club-shaped cells; C.F., Cortical fibre; L.ep., Lower epidermis., m., Midrib region; P., parenchyma; P.C., Palisade like cells; U.ep., Upper epidermis; V.S., Vascular strand.

non - glandular trichomes are multicellular uniseriate with occasionally collapsed cells; they have thin walls, rounded apices and smooth cuticle. They measure 48 to 152  $\mu$  in length and 5 to 16  $\mu$  in diameter. Glandular trichomes are multicellular uniseriate stalk and oval unicellular head, the stalk measures 48 to 110  $\mu$  in length and 4 to 17  $\mu$  in diameter while the head measures 12 to 20  $\mu$  in diameter.

The mesophyll : (Fig. 4,B) is narrow and parenchymatous contains sandy crystals of calcium oxalate.

The midrib : (Fig. 4,B) the cortical tissue of the midrib is mainly sclerenchymatous with a small vascular strand abutting the lower side of sclerenchyma. The sclerenchyma consists of fusiform axially elongated cells with thick pitted walls, narrow lumen and blunt apices. The rest of cortical tissue include one row of club - shaped cells and one layer of palisade like cells.

The perianth : ( Fig. 5,B ) the transverse section of a perianth segment is formed of an outer and inner epidermises enclosing a homogeneous mesophyll, of 1 to 3 rows of thin - walled parenchyma and traversed longitudinally by one small vascular strand. The vascular strand consists of a cellulosic phloem and a xylem showing few lignified spiral vessels.

The outer and inner epidermal cells (Fig. 5 ,C & D) are polygonal, elongated cells with wavy, or slightly curved, thin beaded anticlinal walls and thin smooth cuticle.

The dimensions of the epidermal cells of perianth are shown in microns in table (2) .

**Table (2):** Epidermal Cells Dimensions of Perianth in Micron

Epidermis	Length	Breadth	Height
I - Outer epidermis			
At the apex	14-64	5-16	5-15
At the margin	11-75	3-17	5- 20
At the middle	39-110	5-18	11-30
At the base	28-96	9-19	11-25
At the vein	52-152	5-14	5-16
II - Inner epidermis			
At the apex	17-76	5-15	5-20
At the margin	39-95	3-16	5-17
At the middle	28-79	5-14	3-16
At the base	34-91	6-18	11-25
At the vein	57-140	7-15	5-11

Numerous sandy crystals of calcium oxalate are present in all the parenchymatous cells of the hypodermis of the inner epidermis.

Stomata are completely absent. Trichomes are very few, glandular and non - glandular and similar to those of the bract.



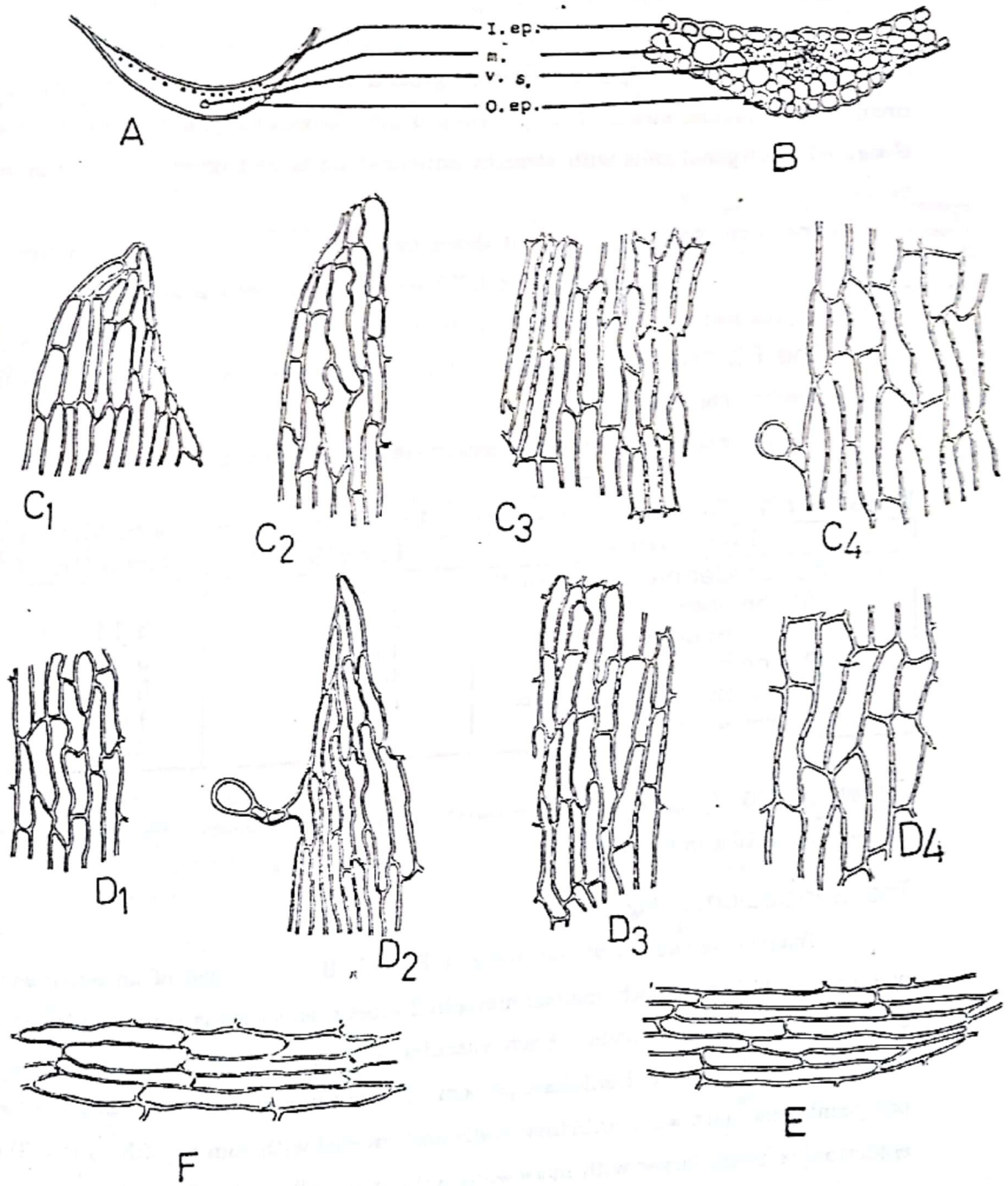


Fig.(5) A : Diagram of T.S. in the perianth. B : Detailed T.S. in the perianth.  
 C : Outer epid. cells. C<sub>1</sub> : At the apex. C<sub>2</sub> : At the margin  
 C<sub>3</sub> : At the middle C<sub>4</sub> : At the base E : Over the vein  
 D : Inner epid. cells. D<sub>1</sub> : At the apex. D<sub>2</sub> : At the margin  
 D<sub>3</sub> : At the middle D<sub>4</sub> : At the base. F : Over the vein  
 (all X 285 except A X 23 and B X 65).  
 I.ep., Inner epidermis; m., merophyll; O.ep., Outer epidermis; V.S.,  
 Vascular strand.

### The Androecium : ( Fig. 6 )

The Filament : the transverse section in the filament ( Fig. 6, A ) is formed of an epidermis surrounding a parenchymatous ground tissue traversed longitudinally by a small central vascular strand. The epidermis of the filament ( Fig. 6, B ) consists of axially elongated , polygonal cells with straight anticlinal walls and covered with thin smooth cuticle.

The Anther : ( Fig. 6, C ) it shows two anther-lobes separated by a connective. The epidermal cells of the anther ( Fig. 6, F ) are polygonal , with moderately thin straight anticlinal walls and covered with thin smooth cuticle .

The Fibrous layer : ( Fig. 6, E ) is formed of one row of elongated cells having usually lignified bar-like thickenings.

The measurements of the androecium elements in micron are listed in Table (3) .

**Table (3) :** The Dimensions of the Androecium Elements in Micron

The element	Length "L"	Breadth "B"
1- The epidermis of filament		
At the apex	23-47	5-14
At the middle	46-81	5-11
At the base	40-50	5-13
2- The epidermis of anther .	13-25	11-23
Fibrous layer	31-64	5-13

Pollen grains : ( Fig. 6, G ) are yellowish - brown , spherical each with porous exins and measures 9 to 16  $\mu$  in diameter.

### The Gynaecium : ( Fig. 7 )

Transverse section of the ovary ( Fig. 7, B ) is formed of an outer and inner epidermises with a parenchymatous mesophyll inbetween which is traversed longitudinally by 3 small vascular strands. Each vascular strand consists of a xylem showing few lignified spiral vessels and cellulosic phloem. The outer epidermis of the ovary is formed of polygonal cells with wavy anticlinal walls and covered with thin smooth cuticle. The inner epidermal cells are larger with more wavy anticlinal walls and thin smooth cuticle.

The dimensions of the epidermal cells of the gynaecium in microns are listed in table (4).

The Stigma : ( Fig. 7, E ) Transverse section shows an epidermis enclosing an elongated parenchymatous cells with lacuna inbetween and traversed longitudinally by small vascular strands . The epidermal cells ( Fig. 7, F ) at the apex are polygonal cells with straight anticlinal walls and thin smooth cuticle. The outer periclinal walls of the cells are prolonged into long cylindrical unicellular papillae with blunt or curved ends. At base, the

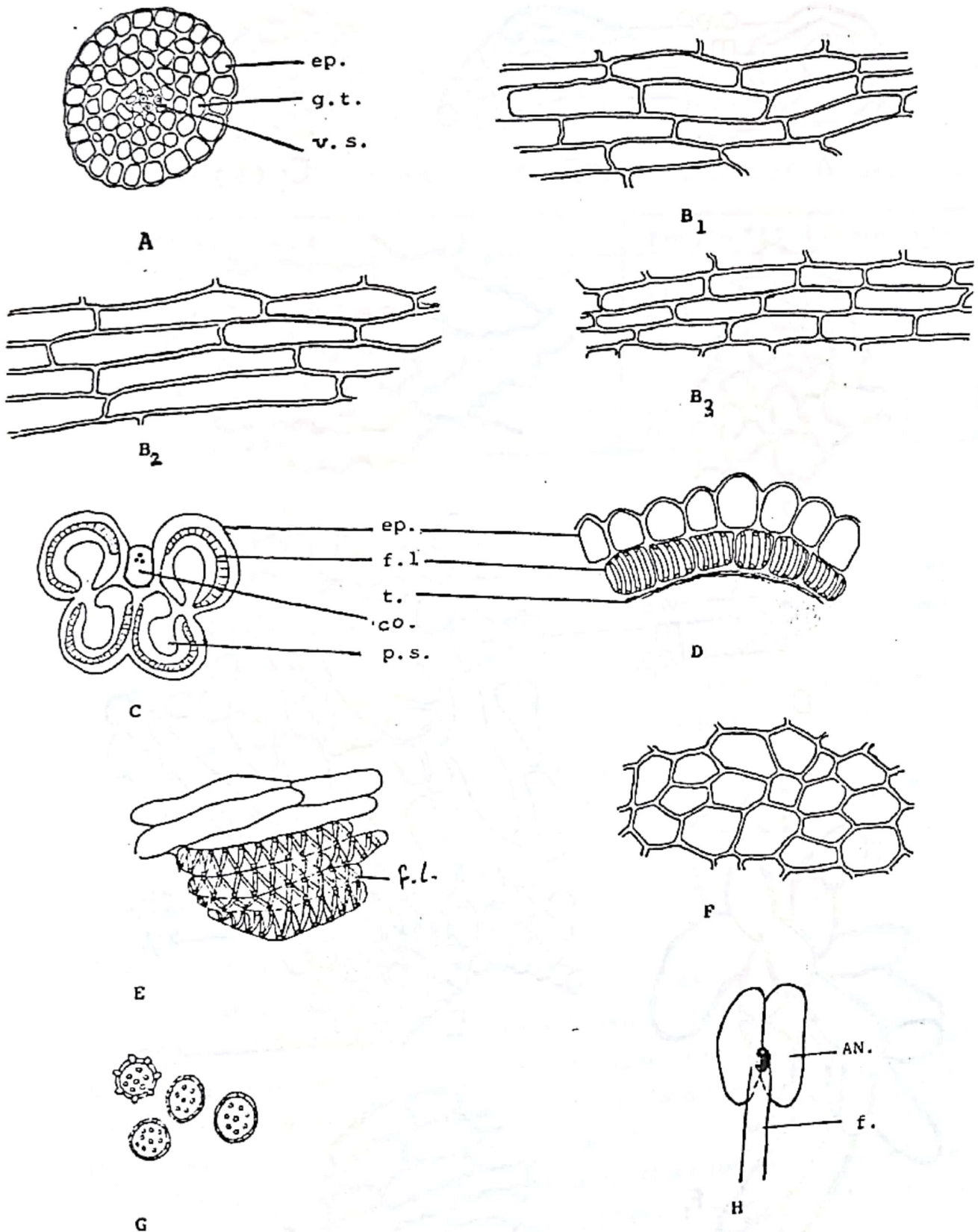


Fig.(6) A : Detailed T.S. in the filament B : Epid.cells of the filament  
 B<sub>1</sub> : At the apex. B<sub>2</sub> : At the middle B<sub>3</sub> : At the base  
 C : Diagram of T.S. of the anther lobe D : Detailed T.S. in anther wall.  
 E : Fibrous layer F : Epid.cells of the anther G : Pollen grains  
 H : Dorsifixed anther (All X550, except A X255, c X 45 and H X20)  
 Co., Connective tissue; ep., epidermis of anther wall; F.l., Fibrous  
 layer; g.t., ground tissue; P.S., pollen Sac; t., tapetum; V.S.,  
 Vascular strand.

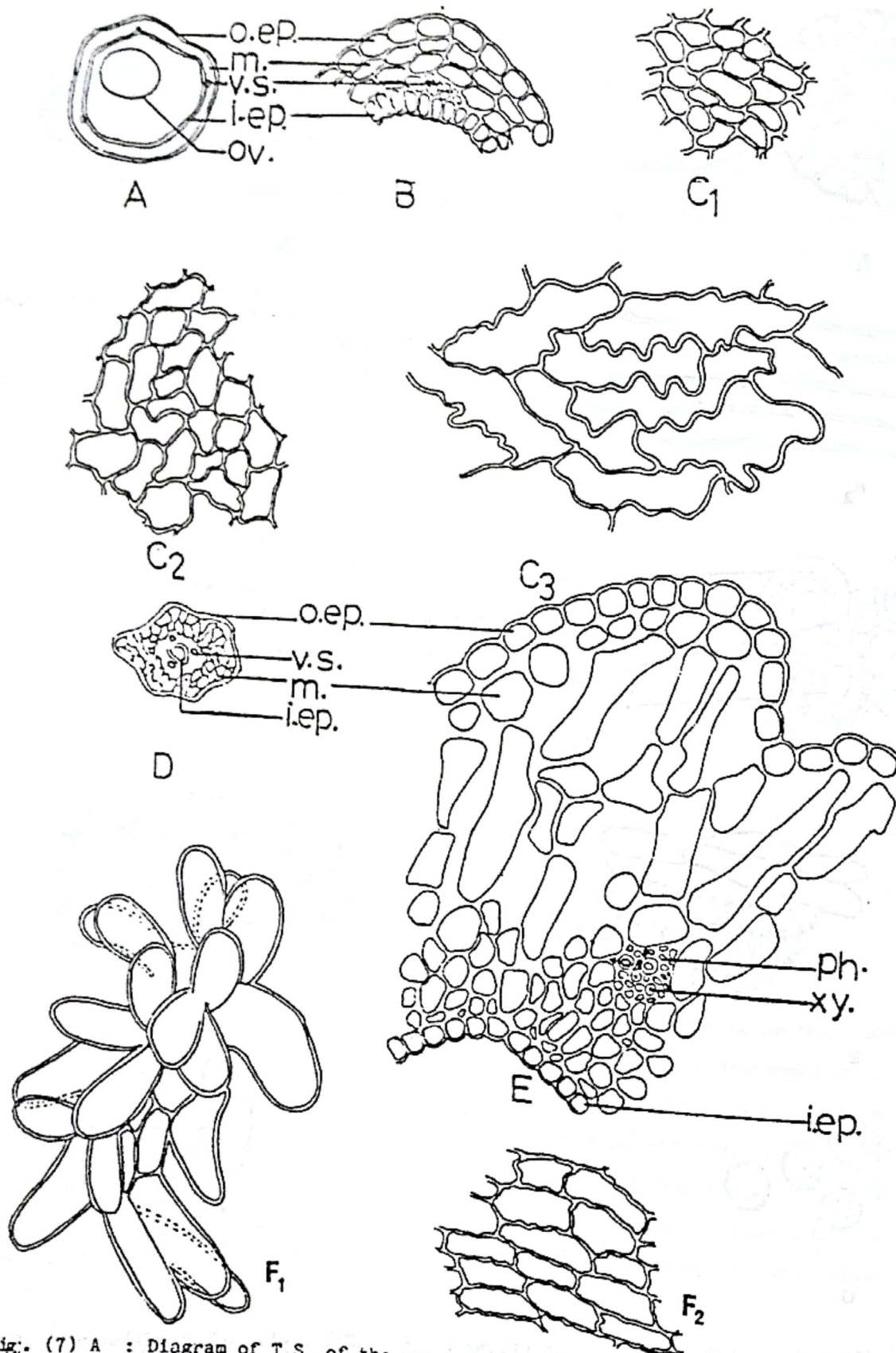


Fig. (7) A : Diagram of T.S. of the ovary. B : Detailed T.S. in ovary wall.  
 C : Outer epid cells of ovary. C<sub>1</sub> : At the middle C<sub>2</sub> : At the apex.  
 C<sub>3</sub> : Inner epid cells of ovary. D : Diagram of T.S. of the stigma.  
 E : Detailed T.S. of the stigma. F : Epid cells of the stigma  
 F<sub>1</sub> : At the apex F<sub>2</sub> : At the base (All X465 except A X77 and DX 51)  
 I.ep., Inner epidermis; m., mesophyll; ph., phloem; O.ep., Outer epidermis; OV.,  
 Ovule; V.S., Vascular strand; XY., Xylem.

cells are polygonal with wavy anticlinal wall and thin smooth cuticle. The dimensions of the epidermal cells of gynaecium are shown in table (4).

**Table (4):** The Dimensions of the Epidermal Cells of Gynaecium in Microns

The element	Length "L"	Breadth "B"
The outer epidermis of ovary		
At the apex	11-26	8-23
At the middle	9-15	4-11
The inner epidermis of ovary	58-85	7-41
The epidermis of stigma		
At the apex	23-50	4-29
At the base	16-38	7-17

#### The Fruit : ( Fig. 8, B )

Fruit wall is composed of an epicarp, mesocarp and endocarp.

The epicarp : ( Fig. 8,C1 ) is formed of polygonal nearly isodiametric cells with thin, wavy anticlinal walls and thin smooth cuticle. It shows neither trichomes nor stomata. They measure 40 to 50  $\mu$  in length and 23 to 36  $\mu$  in breadth.

The Mesocarp : ( Fig. 8,B ) is formed of 2 to 3 rows of thin-walled parenchyma, traversed longitudinally by small vascular strands. Each vascular strand consists of xylem showing few spiral vessels and thin-walled cellulosic phloem.

The Endocarp : ( Fig. 8,C2 ) is formed of polygonal, axially elongated thin-walled cells having wavy anticlinal walls and thin smooth cuticle. They measure 58 to 106  $\mu$  in length and 7 to 14  $\mu$  in breadth.

#### The Seed : ( Fig. 8 )

The Testa ( Fig. 8,E ) : It is formed of the following layers.

The Epidermis : ( Fig. 8, F 1 ) is formed of polygonal cells with straight anticlinal walls and thin smooth cuticle. The periclinal walls are thick protruding into bar-like thickenings appearing polygonal in surface view. The cells contain brown pigments, and measure 9 to 38  $\mu$  in length and 14 to 24  $\mu$  in breadth.

The Hypodermis : ( Fig. 8, F 2 ) is formed of one row of polygonal cellulosic cells with straight anticlinal walls. They measure 17 to 24  $\mu$  in length and 11 to 24  $\mu$  in breadth.

The Striated Layer : ( Fig. 8,F3 ) consists of polygonal cells with straight striated anticlinal walls, appearing striated radially in transverse section. They measure 15 to 47  $\mu$  in length and 8 to 15  $\mu$  in breadth.

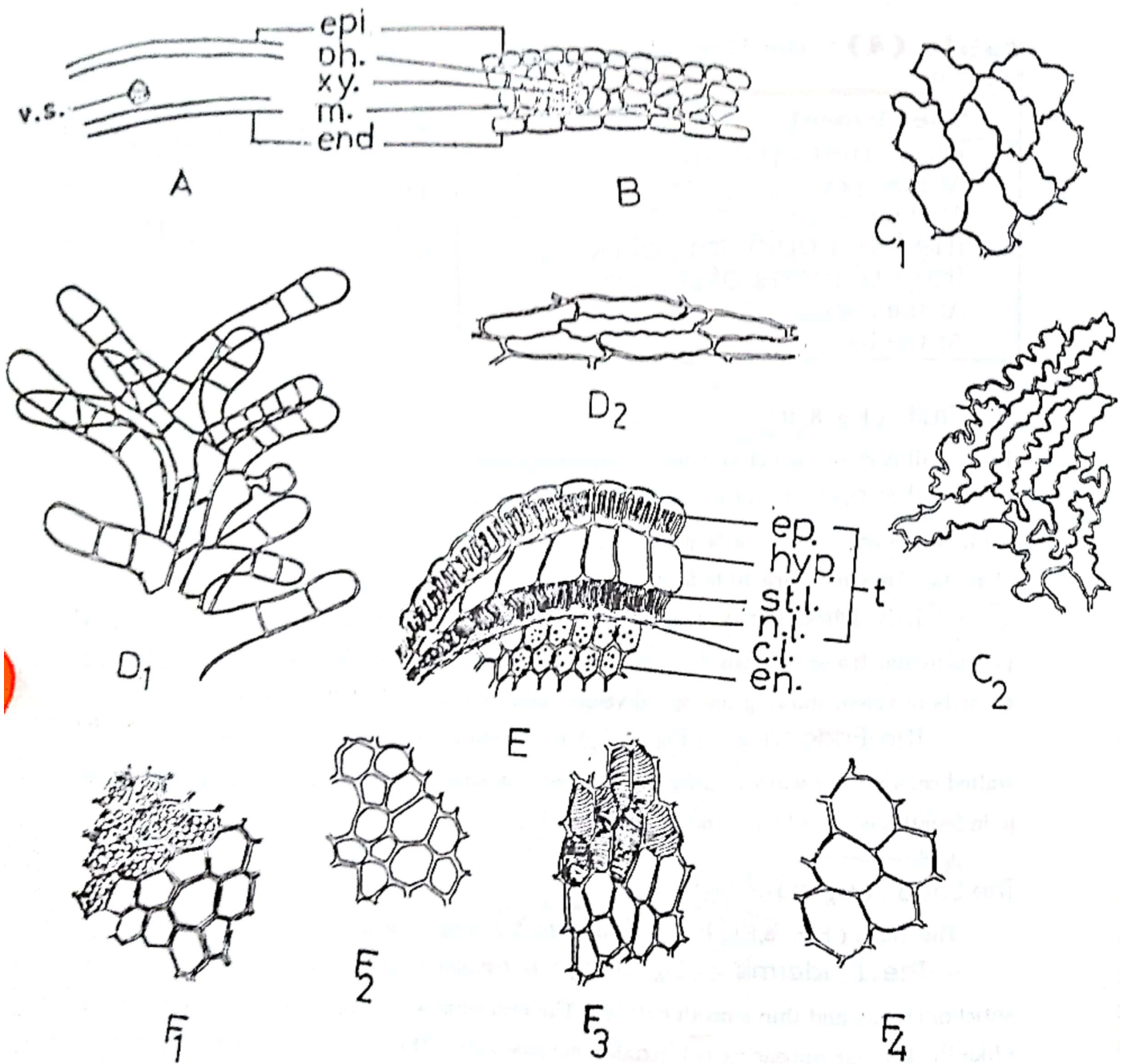


FIG. (B) A : Diagram of T.S. of part of the pericarp. B : Detailed T.S. of the pericarp.  
 C<sub>1</sub> : Epicarp C<sub>2</sub> : Endocarp D : Epid cells of the persistent stigma.  
 D<sub>1</sub> : At the apex D<sub>2</sub> : At the base E : Detailed T.S. of the seed.  
 F<sub>1</sub> : Epid of the testa. F<sub>2</sub> : Hypod of the testa. F<sub>3</sub> : The striated layer.  
 F<sub>4</sub> : The nutritive layer. ( All X 290 )

C.L., Collapsed layer; en., endosperm; end., endocarp; ep., epidermi, of testa; epi., epicarp; hyp., hypodermis, m., mesocarp; N.l Nutritive layer; ph., phloem; St.L., Striated layer; t., testa; Xy., Xylem; v.s., Vascular strand.

The Nutritive Layer : ( Fig.8. F<sub>4</sub> ) consists of tangentially elongated cells , but in surface view, consists of polygonal isodiametric cells with straight anticlinal walls. They measure 29 to 41  $\mu$  in diameter.

The Endosperm : ( Fig. 8 ,E ) is formed of polygonal thick - walled cellulosic cells containing fixed oil droplets and aleurone grains .

## CONCLUSION

The study reveals the following characteristic features :

- 1- The inflorescence is terminal cymose clusters increasing up word to form spikes and few are axillary .
- 2- The plant is monoceious showing whitish - green bracteate unisexual male and female flowers intermixed throughout the spikes .
- 3- Perianth, whitish - green, 5 segments , the androecium consists of 5 free stamens. The gynaecium is bicarpellary showing unilocular ovary with sessile bifid stigma.
- 4-The fruit is dehiscent, dry capsule, circumscissile , with persistent hairy stigma and single seed.
- 5- Seed is dark brown, shining, ovoid, albuminous , campylotropous having curved embryo.
- 6- Epidermal cells of bract and perianth are polygonal with straight or wavy beaded anticlinal wall covered with smooth cuticle .
- 7- Glandular trichomes have multicellular uniseriate stalk unicellular head .Stomata rarely anomocytic.
- 8- Pollen grains are yellow, spherical, having smooth exine with 8-10 germ pores
- 9- Testa show two integments, the outer formed of polygonal cells with barlike thickening arising from its periclinal walls and contain brown pigments , the second is large polygonal cells . The inner integment consists of outer polygonal cells with straight striated anticlinal walls and inner tangentially elongated cells.
- 10- Sandy calcium oxalate are present.

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### الدراسة العيانية والمجهريّة لزهره وثمره وبذرة نبات الرعاف

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سبق أن قام الباحثون بدراسة كيميائية لنبات الرعاف الذي ينمو في مصر وقد أمكن فصل خلاات الليبيول والليبيول ومادتين إستر اليقاتي والألفا سبينا ستيرول وألفا سبينا ستيرول جلوكوزيد وبيتا سيتو ستيرول جلوكوزيد والروتين والكويرستين وصابونين ومواد نتروجينية قاعدية مثل الكولين .

وأيضاً قام الباحثون بدراسة عيانية ومجهريّة لأوراق وساق وجذر نبات الرعاف. لذا فقد رؤي أن يتم دراسة الصفات العيانية والمجهريّة لزهره وثمره وبذرة هذا النبات حتي يسهل التعرف عليه سواء في حالته الصحيحة أو علي هيئة مسحوق .