

## Macro- and Micromorphological study of the inflorescence of *Beta vulgaris* subsp. *perennis* L.

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### ABSTRACT

The macro- and micromorphology of the inflorescence of *Beta vulgaris* subsp. *perennis* L. family Chenopodiaceae are presented in order to give the diagnostic characters of the plant by which plant can be easily identified in both the entire and powdered form.

### INTRODUCTION

*Beta vulgaris* subsp. *perennis* L. is annual or perennial herb. It belongs to family Chenopodiaceae which comprises about 102 genera and over 1400 species, grow mainly naturally in halophytes and xeric habitats (Rizk, 1986; Sharma, 1993; Evans, 2002). It is widely distributed in the coastal areas of South and East to North Africa, Europe and Mediterranean coastal strip in Egypt (Boulos *et al.*, 1984; Boulos, 1999).

The chemical constituents of family Chenopodiaceae are variable and represented by different chemical classes. Certainly, these constituents include: alkaloids (Sandberg and Michel, 1967; Muhtadi and Hassan, 1981), volatile oils, lipids, phenolic acids, carbohydrates, organic acids (Darnley, 1974), flavonoids (Reznik, 1957), saponins (Darnley, 1974; Rastrelli *et al.*, 1996), proteins and amino acids (Silva and Pereira, 1976), cyanogenic glycosides (Darnley, 1974), pigments (Dreiding, 1961; Mario and Luigi, 1964; Darnley, 1974) amides and amines (Darnley, 1974) and minerals (Kingsburg, 1958; Darnley, 1974).

Phytochemical study of *Beta vulgaris* subsp. *perennis* L. revealed the presence of thirteen compounds were isolated and identified as unsaturated primary alcohol with molecular formula (C<sub>16</sub> H<sub>32</sub> O<sub>1</sub>),

saturated primary alcohol with molecular formula (C<sub>26</sub> H<sub>54</sub> O<sub>1</sub>), saturated primary alcohol with molecular formula (C<sub>27</sub> H<sub>56</sub> O<sub>1</sub>),  $\beta$ -sitosterol, saturated acid with molecular formula (C<sub>28</sub> H<sub>56</sub> O<sub>2</sub>),  $\beta$ -sitosterol-glycoside, syringic acid, ferulic acid, dehydro-vomifoliol, quercetin, 4' hydroxy-5 methoxy -6,7-methylenedioxy flavanone, quercetrin and rutin.

The biological study of different plant extracts showed: antioxidant effect (Kanner *et al.*, 2001; Pavlov *et al.*, 2005; Georgiev *et al.*, 2010; Gennari *et al.*, 2011), antihepatotoxic activity (Agarwal *et al.*, 2006; Kocsis and Blazovics, 2007), anticancer effect (Kapadia *et al.*, 2003; Vali *et al.*, 2006; Hoffman, 2007), anti-diabetic effect (Bolkent *et al.*, 2000; Andrade and Heinrich, 2005) and anti-inflammatory activities (Zade *et al.*, 2011).

Nothing, however, could be traced dealing with macro- and micromorphological characters of this plant. Therefore, the macro- and micromorphological study of the inflorescence of the plant is presented in order to facilitate its identification in both entire and powdered forms as well as its differentiation from closely related species.

### MATERIAL and METHODS

#### MATERIAL

The plant material of *Beta vulgaris* subsp. *perennis* L. (Figure 1)

was collected in December 2008 in flowering stage from farms of Behida Metghamr El-Dakhalia Governorate. It was kindly identified by Dr. Abd El-Halim Abd El-Magly Mohammed, Professor of Plant Taxonomy and Flora Researches, Horticulture Research Institute, Agriculture Research Centre, Land Reclamation and Agriculture Ministry, Dokki, Cairo, Egypt.

For the botanical study, either fresh or preserved samples in ethanol 70% containing 5% glycerol were used.

#### A- Macromorphology

The flowers (Figure 2) are axillary arranged in branched spike inflorescence. The flower is sessile, greenish to purple in colour and measuring from 3-5 mm in diameter. They are hermaphrodite, actinomorphic and pentamerous with the following floral formula:

Br,  $\oplus$ ,  $\ominus$ , P<sub>5</sub>, A<sub>5</sub>, G<sub>(3)</sub>—

The rachis (Figure 2A) is cylindrical in outline with 7-9 slightly prominent ridges, a solid and glabrous with green surface and measuring 12-20 cm in length 0.4-0.6 cm in width.

The bract (Figure 2B) is oval, green colour. It has acute apex, symmetric base, entire margin, glabrous surface and reticulate venation measuring 1-1.5 cm in length and 0.5 -1 cm in width.

#### The flower

The perianth (Figure 2C) is formed of five free sepaloid tepals, each measures 1-2 mm in diameter, green, fleshy, thickened and persistent.

The androecium (Figure 2D) consists of 5 stamens inserted on the rim of a glandular perigynous disc and arranged opposite to the tepals.

The gynaecium (Figure 2E) is tricarpellary formed of subinferior, small, globular unilocular ovary containing one campylotropous ovule adherent to the base of perianth.

### B-Micromorphology

#### The rachis

A transverse section in the rachis (Figure 3A) is concavo-convex in outline with 7-9 slightly prominent ridges. It shows an outer epidermis surrounding 4-6 rows of collenchyma followed by 5-9 rows of parenchyma. The cortex is lined by almost differentiated endodermis enclosing an arch of non lignified pericyclic fibres. The ring of the vascular bundles surrounds a wide parenchymatous pith.

The epidermal cells (Figure 3C) in the region between the ridges are polygonal, tubular cells, with straight anticlinal walls and covered with thin smooth cuticle. They measure 15-21  $\mu$  in length, 6 -9  $\mu$  in width and 6 -7  $\mu$  in height. Over the ridge (Figure 3D), the epidermal cells are similar to those inbetween the ridges, but they differ in being axially elongated, they measure 30-48  $\mu$  in length, 15-21  $\mu$  in width and 6-9  $\mu$  in height. Stomata are present only in the epidermal cells of region between the ridges. They are of anomocytic type, each is surrounded by 4 -5 cells and measures 6-8  $\mu$  in length and 4-5  $\mu$  in width.

The cortex (Figure 3B) is formed of parenchymatous cells with subepidermal collenchyma. The collenchymatous layer consists of 4-6 rows of small, thick and cellulose-walled cells. The parenchyma is formed of 5-7 rows of large cellulose thin-walled cells with narrow intercellular spaces. The endodermis is differentiated into slightly elongated cells.

The pericycle (Figure 3B) consists of an arc of non lignified fibres.

The vascular tissue is formed of 12 -15 rings of collateral vascular bundle each consist of:

The xylem (Figure 3 B) is formed mostly of fibers in addition to vessels, tracheids and wood parenchyma. The

fibers have thick, lignified walls, wide lumen and blunt or acute apices. They measure 8 to 12  $\mu$  in diameter and 480 to 520  $\mu$  in length. The vessels are lignified, mostly spiral measuring 15 to 21  $\mu$  in diameter. The tracheids are few, spindle shaped, with pitted lignified walls. They measure 106 to 130  $\mu$  in length and 15 to 18  $\mu$  in diameter. The wood parenchyma is diffused and formed of moderately thick-walled, pitted, lignified polygonal axially elongated cells. The phloem bands embedded in the xylem forming interrupted rings are similar to the outer phloem.

The pith (Figure 3B) is formed of polyhedral, moderately thick-walled, cellulose parenchyma with narrow intercellular spaces. Some cells contain a large sandy crystal of calcium oxalate and starch granules which measure 3 to 4.5  $\mu$  in diameter.

The bract (Figure 5) A transverse section of the bract consists of an outer and inner epidermises enclosing inbetween a homogenous mesophyll transversed by few small vascular bundles.

The outer epidermis (Figure 6A) is formed of polygonal cells with slightly wavy anticlinal walls and covered with thin smooth cuticle. They measure 18 to 27  $\mu$  in length, 6 to 9  $\mu$  in width and 3 to 6  $\mu$  in height.

The outer and inner epidermises over the midrib and big veins (Figure 6C and D) are axially elongated with straight anticlinal walls and covered with thick smooth cuticle. The outer epidermis measure 48 to 75  $\mu$  in length, 18 to 21  $\mu$  in breadth and 9 to 12  $\mu$  in height. The inner one measure 21 to 45  $\mu$  in length, 9 to 12  $\mu$  in breadth and 6 to 9  $\mu$  in height.

The inner epidermis (Figure 6B) is formed of polygonal cells with very sinuous walls and covered with thin

smooth cuticle. They measure 18 to 30  $\mu$  in length, 12 to 15  $\mu$  in width and 3 to 6  $\mu$  in height.

The stomata are present on both surfaces being absent over veins. Stomata are mostly anisocytic occasionally of the anomocytic type, each being surrounded by 3 to 4 epidermal cells. Stomata are oval or rounded measuring 9 to 12  $\mu$  in length, 6 to 9  $\mu$  in width.

The mesophyll (Figure 5B) is undifferentiated and consists of 3 to 7 rows of rounded or polyhedral thin walled cellulose cells with narrow intercellular spaces. It is traversed by 3 to 5 vascular strands.

The vascular tissue (Figure 6E) consists of xylem formed of few lignified spiral vessels 15 to 21  $\mu$  in diameter and phloem of thin-walled cellulose elements.

#### The flower

**The perianth** (Figure 7) A transverse section through the perianth is triangular, composed of an outer and inner epidermises, enclosing inbetween a homogenous mesophyll traversed by a small vascular strand.

The inner (upper) epidermis (Figure 8A and B): At the base consists of tubular polygonal, elongated cells with straight anticlinal walls and covered with thin smooth cuticle, they measure 19 to 22  $\mu$  in length and 8 to 9  $\mu$  in width (Figure 14B). At the tip, the cells are more or less isodiametric with straight walls covered with smooth cuticle measuring 11 to 14  $\mu$  in width and 17 to 23  $\mu$  in length (Figure 14A).

The outer (lower) epidermis (Figure 8C and D): At the base consists of tabular polygonal, elongated cells with straight anticlinal walls and covered with thin smooth cuticle, they measure

18 to 28  $\mu$  in length and 5 to 7  $\mu$  in width. At the tip, the cells are more or less isodiametric with straight walls covered with smooth cuticle measuring 9 to 17  $\mu$  in length and 6 to 9  $\mu$  in width.

Stomata are of the anomocytic type, present on the lower surface. They measure 7 to 9  $\mu$  in length and 5 to 8  $\mu$  in width.

The mesophyll (Figure 7B) is homogenous formed of several rows of more or less rounded parenchymatous cells.

The vascular strand (Figure 8E) shows small collateral vascular bundle with narrow spiral xylem vessels measure 8 to 10  $\mu$  in diameter and delicate thin walled cellulosic phloem elements.

#### **The Androecium**

##### **The stamen:**

##### **A. The Filament (Figure 9A):**

A transverse section in the filament is flattened, with a very small vascular strand, surrounded by homogenous parenchyma cells. The epidermis of the free and adnoted parts (Figure 9B) of the filament is formed of elongated cells with straight anticlinal walls and covered by thin smooth cuticle. They measure 14 to 18  $\mu$  in length, 5 to 7  $\mu$  in width and 3 to 5  $\mu$  in height. Stomata and trachoma are absent.

##### **B. The Anther (Figures 9C and D):**

A transverse section in the anther shows two anther lobes, attached by the connective tissue, which has vascular strand in the center, each lobe contains numerous pollen grains.

##### **The thecae (Figure 9C):**

The wall of the thecae is thin and consists of an epidermis followed by fibrous layer:

##### **The epidermis (Figure 9E):**

The epidermis consists of polygonal cells with straight anticlinal walls, and covered by a thin smooth cuticle, measuring, 12 to 15  $\mu$  in length, 8 to 11  $\mu$  in width and 3 to 4 in height.

##### **The fibrous layer (Figure 9F):**

The fibrous layer is formed of one row of radially elongated cells nearly polygonal in surface view showing lignified bar-like thickening, they measure 15 to 17  $\mu$  in length, 4 to 5  $\mu$  in width and 5 to 7  $\mu$  in height

##### **The Pollen grains (Figure 9G):**

The Pollen grains are spherical in outline, with numerous germ pores and devoid of germinal furrows, measuring 27 to 36  $\mu$  in width. The exine has smooth surface.

#### **The Gynaecium**

##### **The ovary**

A transverse section in the ovary (Figure 10 A) is more or less cordate in outline. It shows an epidermis enclosing the cortex with one locule containing one campylotropous ovule. The epidermal cells of the ovary (Figure 10D) are polygonal, with straight anticlinal walls, covered with smooth cuticle, measuring 9 to 13  $\mu$  in length 4 to 5  $\mu$  in width and containing prisms of calcium oxalate.

##### **The Style**

The epidermal cells of the style (Figure 10B) are rectangular, axially elongated with straight anticlinal walls and covered by thin smooth cuticle.

##### **The stigma**

The epidermal (Figure 10 C) cells are rectangular, papillosed with straight anticlinal walls. The cells become shorter and smaller near the tip of the stigma.

## RESULTS and CONCLUSION

The pharmacognostical study provides the characteristic features of the inflorescence by the following key elements:

1- The flowers are axillary arranged in branched spike inflorescence. The flower is sessile, greenish to purple in colour.

2- The flowers are hermaphrodite, actinomorphic with five free tepals, five stamens with yellow anthers and gynaecium is tricarpellary formed of half-inferior, small, globular unilocular ovary containing one campylotropous ovule.

3- The epidermal cells of the rachis in the region between the ridges are polygonal, axially elongated, tubular, with straight anticlinal walls and cover with thin smooth

cuticle. Stomata (Figure 10A) are present in the epidermal cells of region between the ridges and are absent in the epidermal cells over ridges. They are of anomocytic type.

4- The epidermis of the bract is formed of polygonal cells with slightly wavy anticlinal walls and covered with thin smooth cuticle and showing anomocytic stomata.

5- The Pollen grains are spherical in outline, with numerous germ pores and devoid of germinal furrows

6- The epidermal of the stigma cells are rectangular, papillosed with straight anticlinal walls. The cells become shorter and smaller near the tip of the stigma.

7- Calcium oxalate prisms are present in the ovary wall.



Figure 1. A photograph of the herb *Beta vulgaris* subsp. *perennis* L.

The aerial parts (x 0.2)

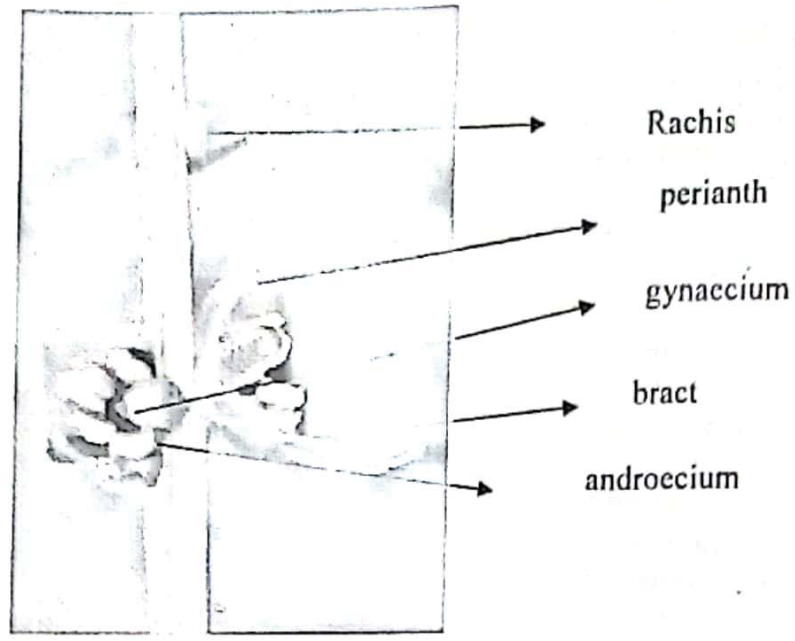


Figure 2. photograph of the inflorescence of *Beta vulgaris* subsp. *perennis* L. (x 14)

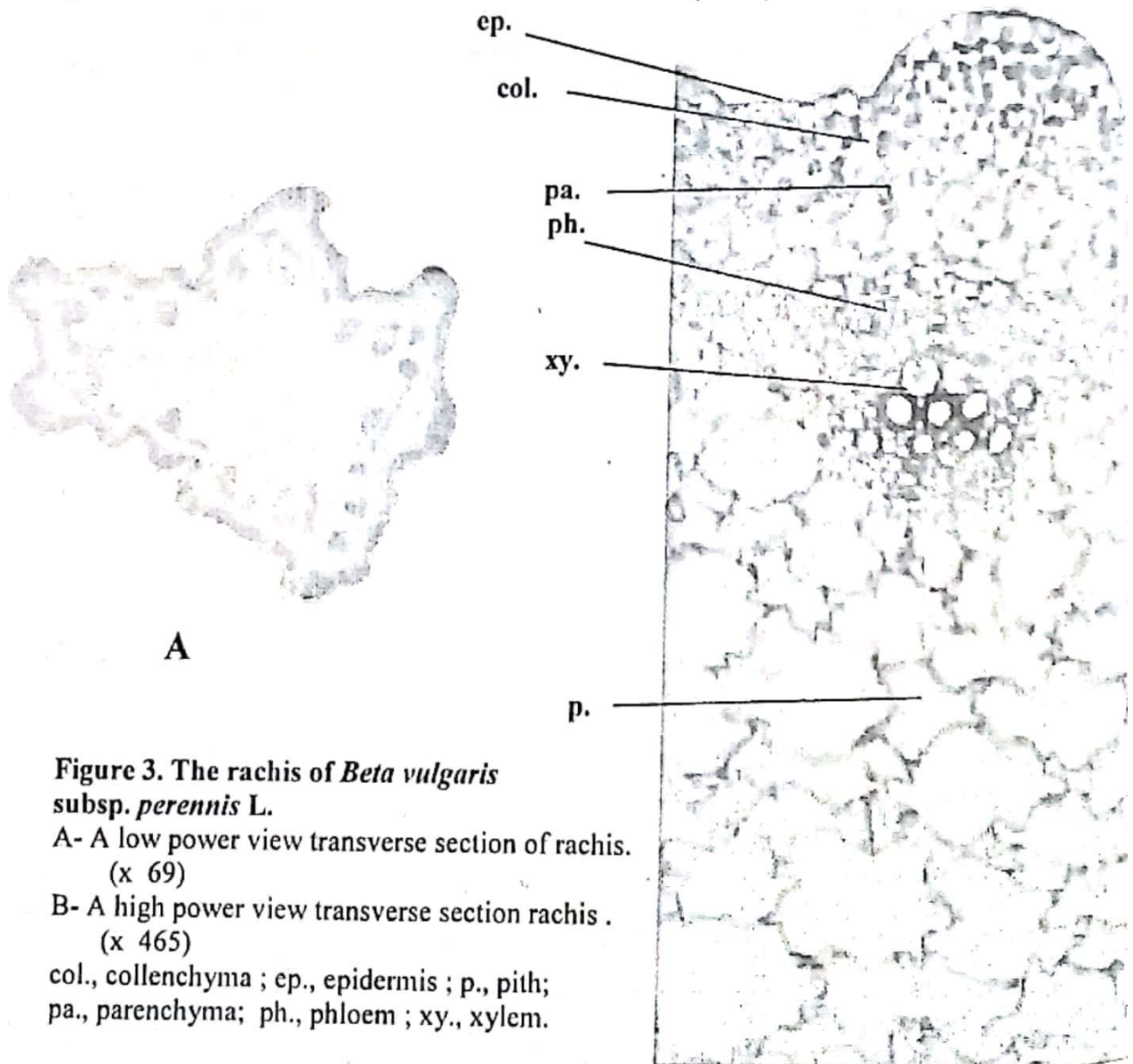


Figure 3. The rachis of *Beta vulgaris* subsp. *perennis* L.

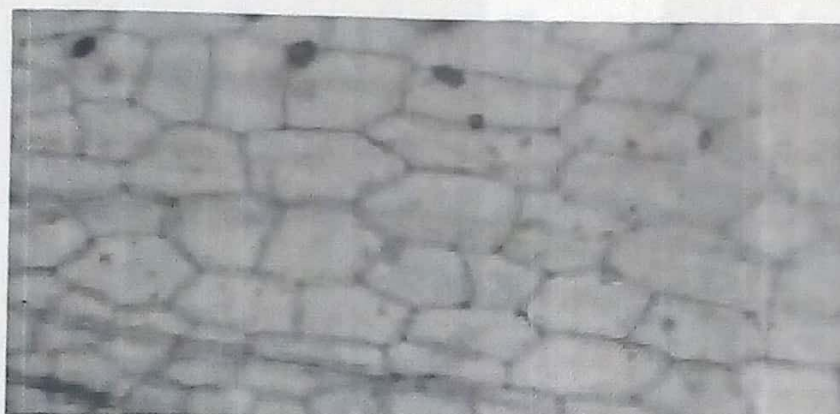
A- A low power view transverse section of rachis. (x 69)

B- A high power view transverse section rachis. (x 465)

col., collenchyma ; ep., epidermis ; p., pith; pa., parenchyma; ph., phloem ; xy., xylem.



A



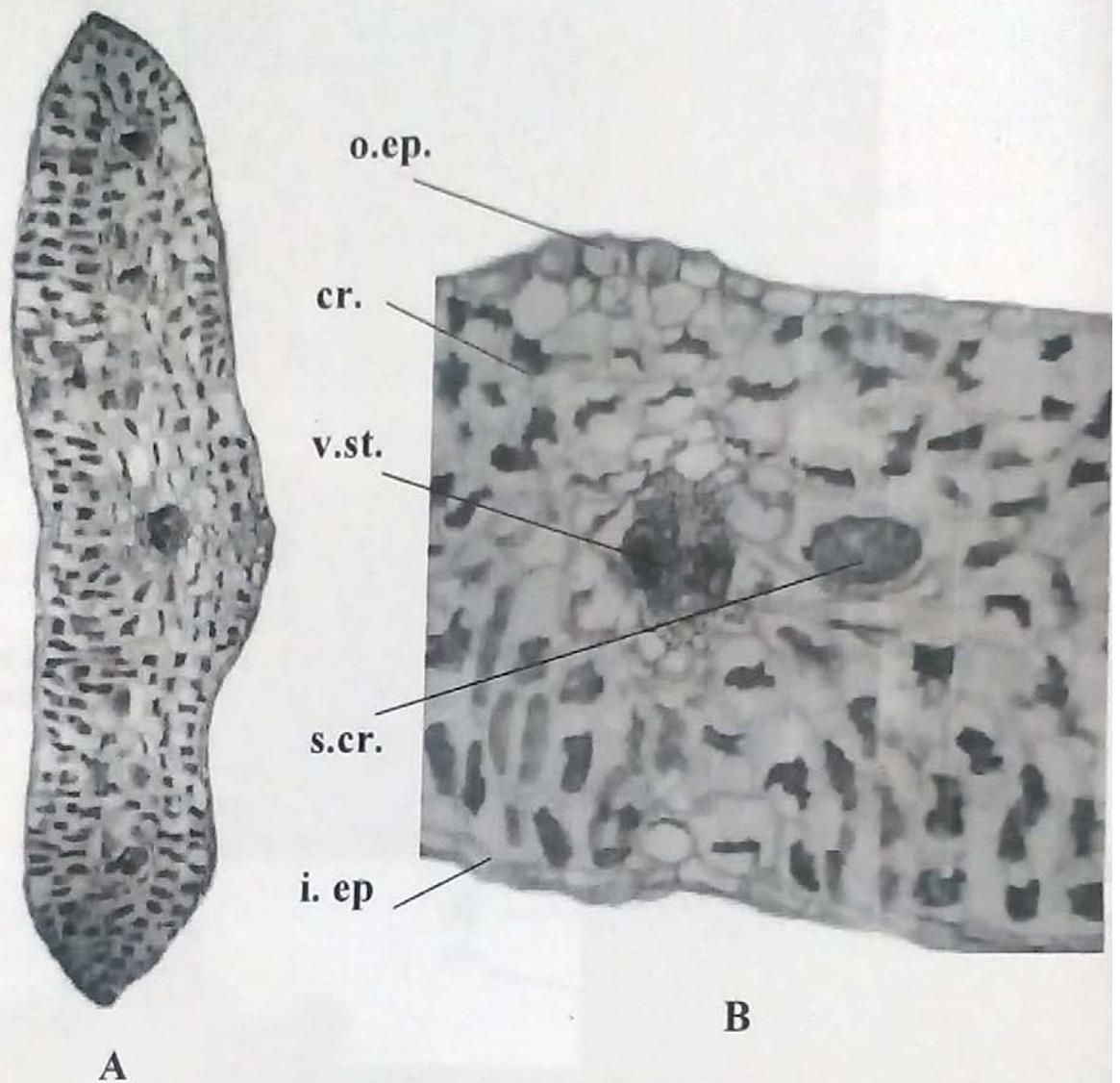
B



C

**Figure 4. The epidermal cells and isolated elements of rachis of *Beta vulgaris* subsp. *perennis* L. :**

- A- Epidermal cells of the rachis in between ridges. (x 472 )  
B- Epidermal cells of the rachis above ridges. (x 472 )  
C- Spiral vessel. (x 667 )



**Figure 5 . The bract of *Beta vulgaris* subsp. *perennis***

A- A low power view transverse section of the bract. (x 130 )

B- A high power view transverse section of the bract. (x 454 )

cr., cortex ; i.ep., inner epidermis ; o.ep., outer epidermis; s.cr.; sandy crystal ; v.st., vascular strand;



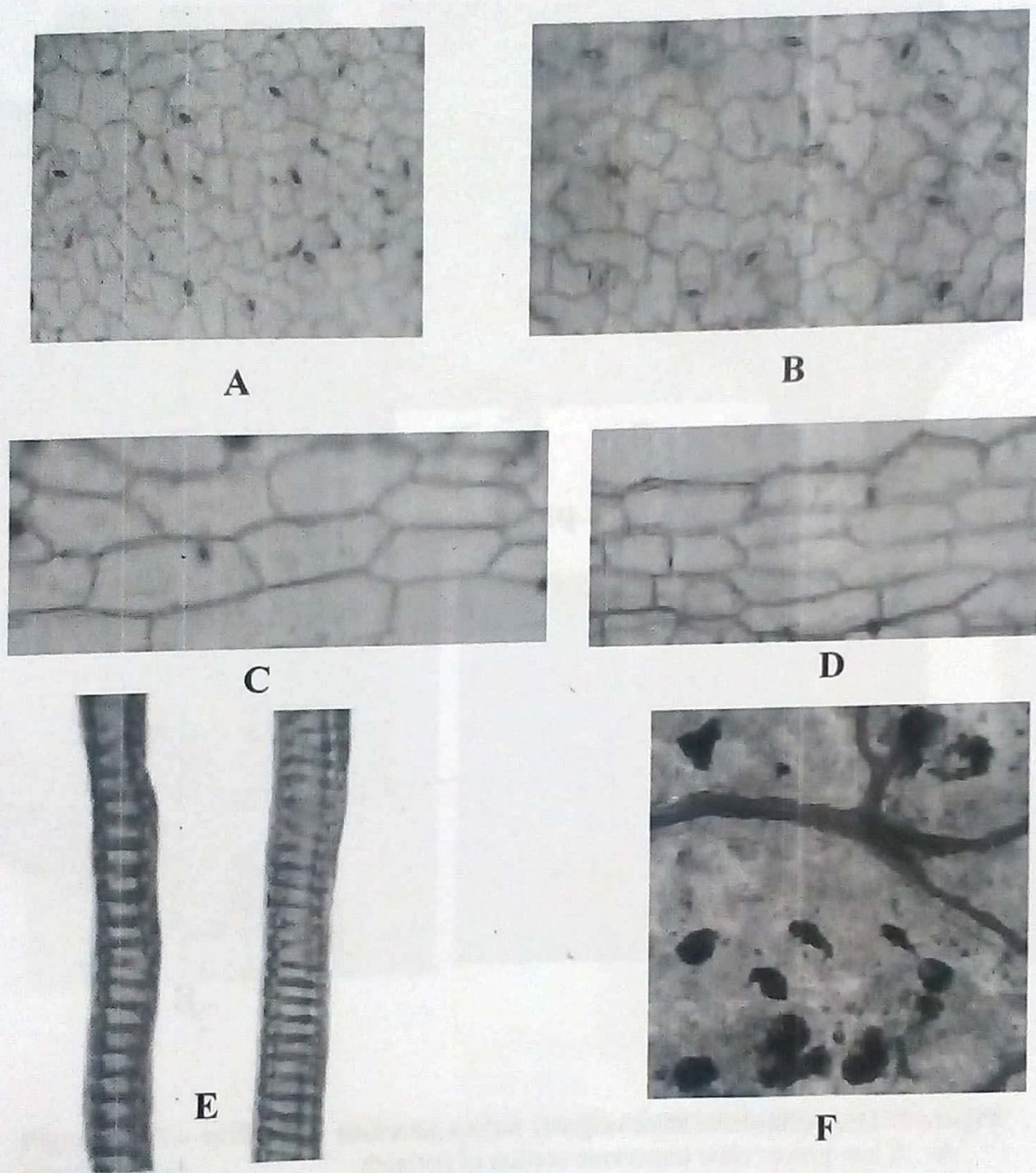
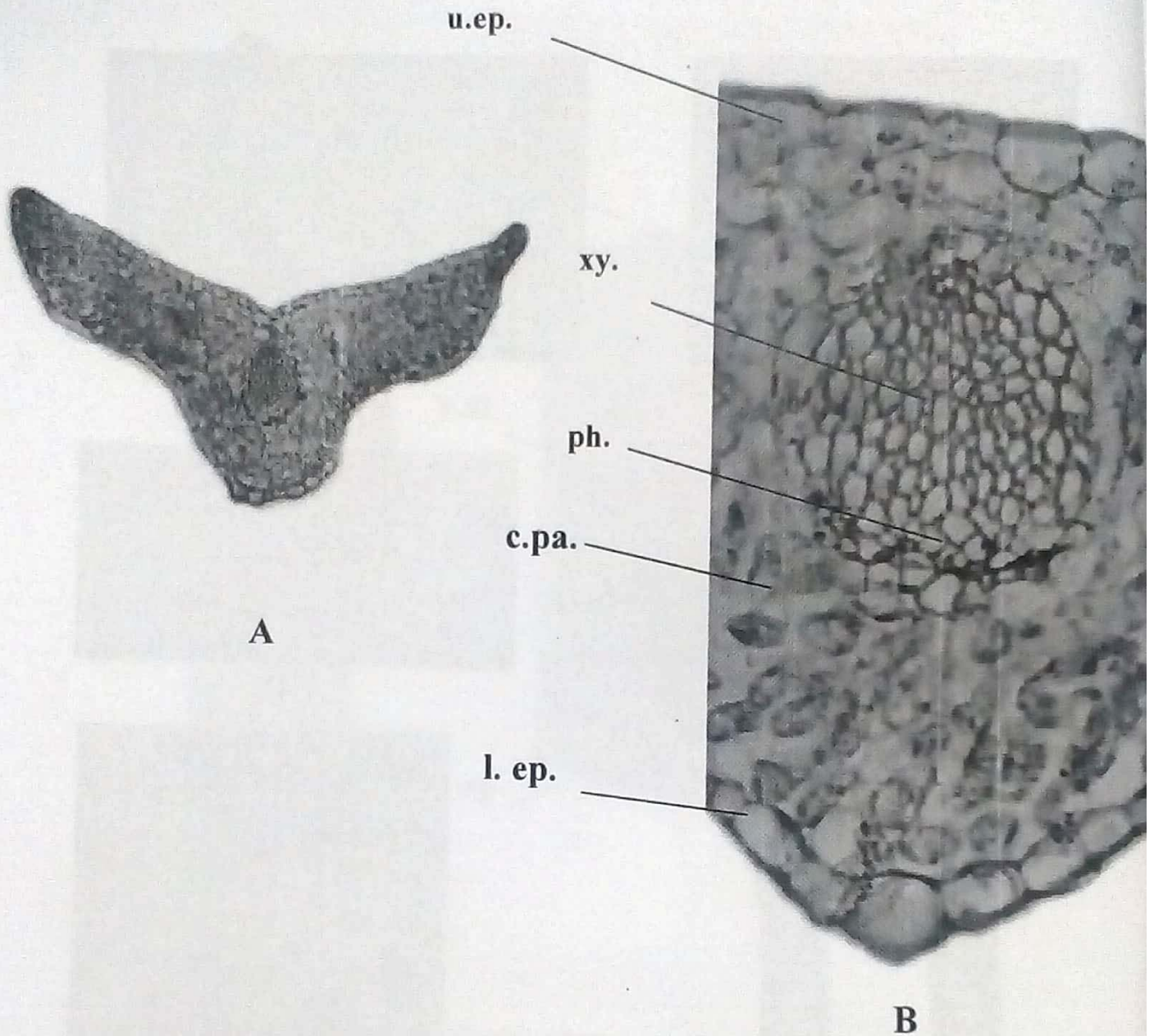


Figure 6. The epidermal cells and isolated elements of bract of *Beta vulgaris* subsp. *perennis* .

- A- Outer epidermis of the bract near the apex. (x 437)
- B- Inner epidermis of the bract near the apex. (x 437)
- C- Epidermal cells over vien of outer surface. (x 478)
- D- Epidermal cells over vien of inner surface. (x 478)
- E- Xylem vessel. (x 441)
- F- Sandy crystal of calcium oxalate. (x 457)



**Figure 7. The perianth of *Beta vulgaris* subsp. *perennis* .**

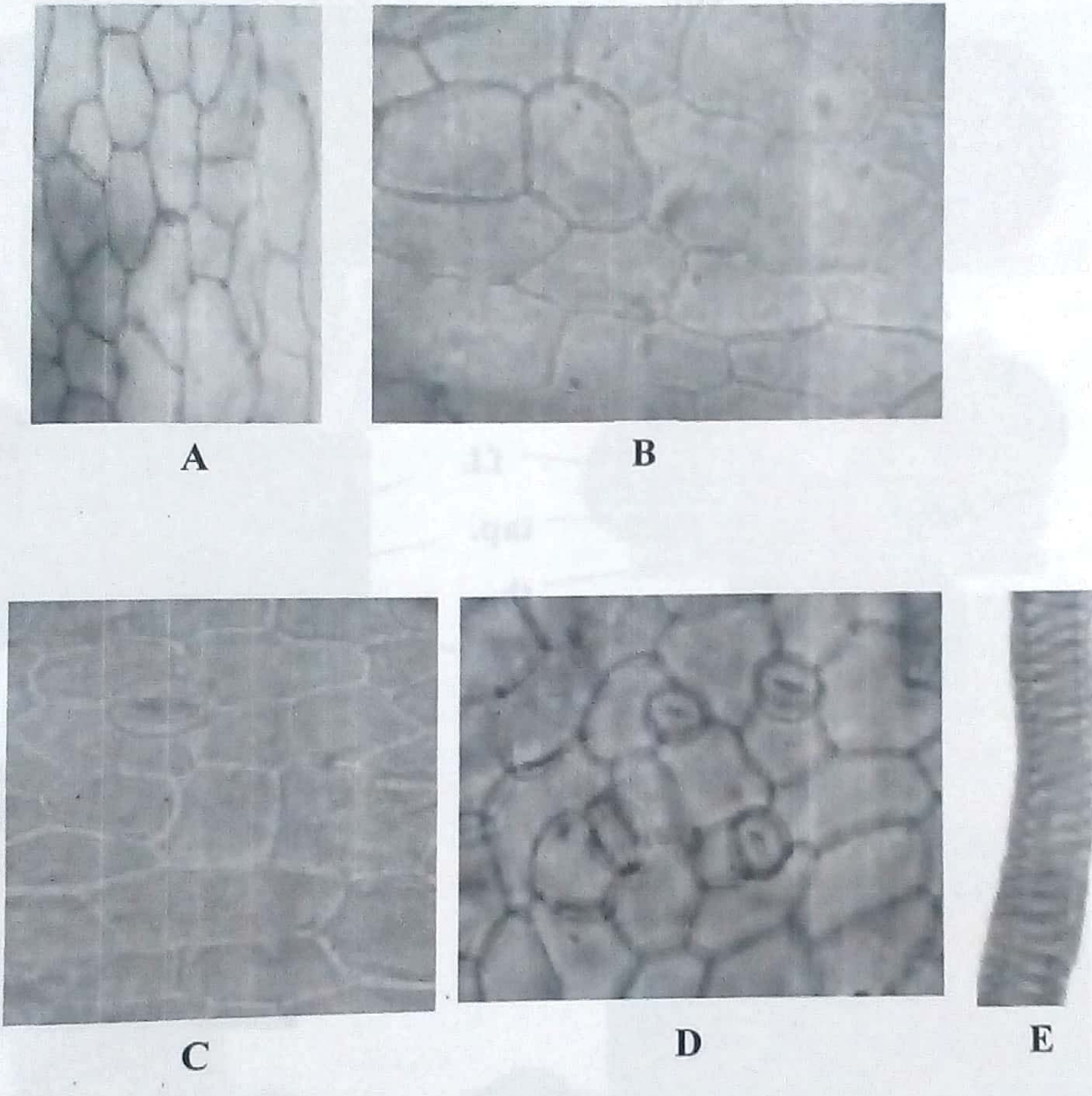
A- A low power view transverse section of perianth.

(x 174 )

B- A high power view transverse section of perianth.

(x 1250)

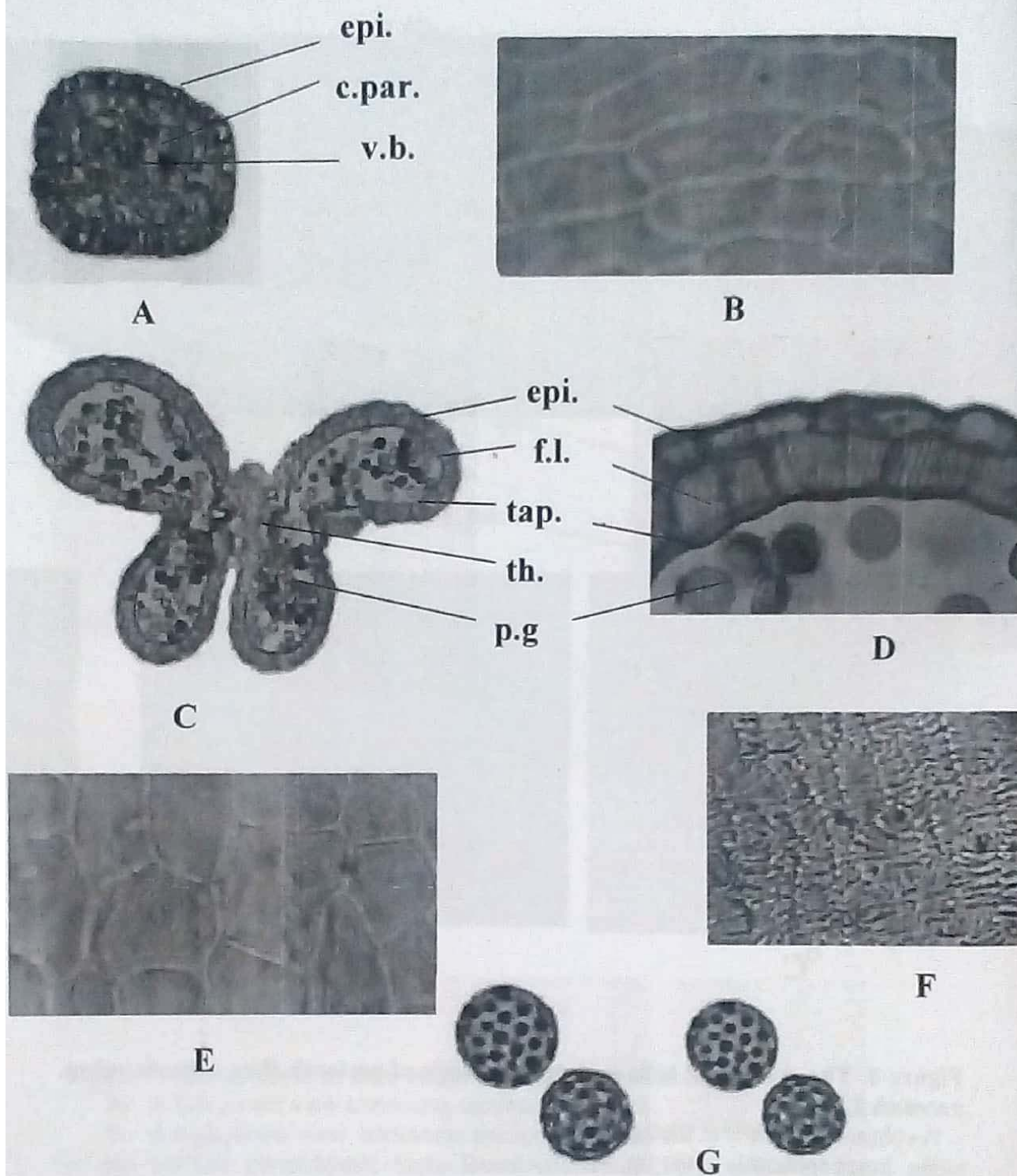
c. pa., cortical parenchyma; l.ep., lower epidermis ; ph., phloem; u.ep., upper epidermis xy., xylem .



**Figure 8. The epidermal cells and xylem vessels of perianth *Beta vulgaris* subsp. *perennis* L.:**

- A- Inner epidermis at the base.
- B- Inner epidermis at the tip.
- C- Outer epidermis at the base.
- D- Outer epidermis at the tip.
- E- Xylem vessel.

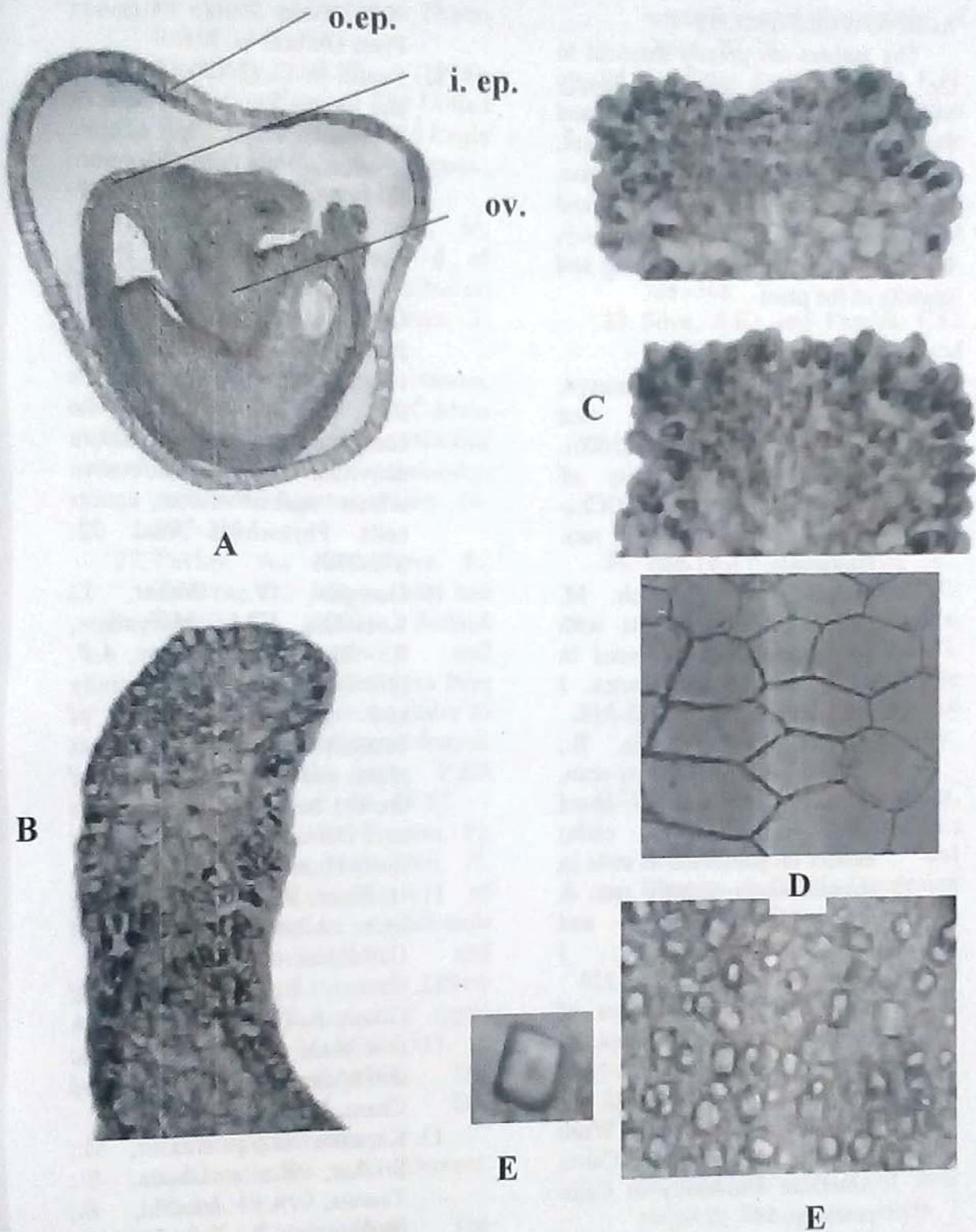
( All x 1250 )



**Figure 9. The Androecium of *Beta vulgaris* subsp. *perennis* L.:**

- |                                                |          |
|------------------------------------------------|----------|
| A- Transverse section of the filament.         | (x 1630) |
| B- Epidermal cells of the filament.            | (x 1538) |
| C- Transverse section of anther.               | (x 472)  |
| D- Detailed transverse section of anther wall. | (x 1666) |
| E- Epidermal cells of the anther.              | (x 1538) |
| F- Fibrous layer in surface view               | (x 1538) |
| G- Pollen grains.                              | (x 400)  |

c.pa., cortical parenchyma ;ep., epidermis ; f.l., fibrous layer ; p.g., pollen grain;  
 tap., tapetum ; th., thecae ; v.b. ,vascular bundle.



**Figure 10. The Gynaecium of *Beta vulgaris* subsp. *perennis* .**

- A- Transverse section of the ovary. (x 304)
  - B- Epidermal cells of the style wall. (x 428)
  - C- Papillosed epidermal cells of stigma. (x 500)
  - D- Epidermal cells of the ovary wall. (x 1535)
  - E- Prisms of ca. oxalate. (x 1535)
- i.ep., inner epidermis ; o.ep. , outer epidermis; ov. ovule.

## ACKNOWLEDGMENT

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## الصفات العيانية و المجهرية لنورات نبات بيتا فولجارييس نوع برينيس ل. ( السلق )

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يشتمل هذا البحث على دراسة الصفات العيانية و المجهرية لنورات نبات بيتا فولجارييس نوع برينيس ل. وقد اثبت هذا البحث امكان التعرف بسهولة على هذا النبات عن طريق النورات صحيحة كانت او على هيئة مسحوق