

# Anatomy and surface characteristics of seeds of *Verbascum* species (Scrophulariaceae)

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Seed anatomy and surface characteristics of seeds in twenty four species of *Verbascum* L. are described. Although all the species studied show nearly similar pattern of seed surface under stereoscopic binocular microscope, however, some differences, observed under scanning electron microscope are helpful in grouping them under three tentative categories, namely, (i) deep-pitted surface, (ii) shallow-pitted surface and (iii) slightly depressed surface. Out of twenty four species, thirteen show shallow-pitted seed surface, which may be in general characteristic feature of the *Verbascum* species. In all the twenty four species of *Verbascum*, the seed coat consists of two prominent cell-layers and the outline of endosperm is wavy which is a result of irregular growth of the cells of inner layer of the seed coat.

**Key-words** – Angiosperm, Seed morphology, *Verbascum*, Scrophulariaceae.

## INTRODUCTION

THE genus *Verbascum* L. of the tribe Verbasceae of Scrophulariaceae comprises about 360 species (Airyshaw, 1973). Though considerable work has been done on the spermoderm pattern of small and medium-sized seeds under SEM in Scrophulariaceae and diverse families (Chuang & Heckard, 1972; Tomb, 1974; Brisson & Peterson, 1977; Canne, 1979; Chung & Heckard, 1983), no significant work is reported in *Verbascum*. During the present study, morphology, anatomy and spermoderm characteristics of twenty four *Verbascum* species are described along with seed development in one of the species, i.e. *V. phlomoides* which was grown locally.

## MATERIAL AND METHOD

Seeds of twenty four species of *Verbascum* were obtained from different countries (see Table 1). Seeds of *V. phlomoides* were grown locally and various stages of developing fruits and seeds till maturity were collected and fixed in F.A.A. for 48 hours and subsequently stored in 70% ethanol. Usual methods of dehydration in alcohol-xylene series, infiltration and embedding in paraffin wax were followed. Microtome sections cut between 8 to 10  $\mu$ m thickness were stained in safranin-fast green combination and mounted in canada balsam. For scanning purposes five to six seeds of each species were mounted on special stubs and were subsequently coated with Gold (200 Ao). Scanning was done on a

Jeol-SJM-35C SEM in the institute with acceleration voltage of 15kv. Shape, length and number of ridges of 10 seeds of each species were examined under zoom stereoscopic microscope putting the seeds over a scale. Average of ten seeds of these features are recorded in Table 1.

## OBSERVATION

*External morphology* -Seeds of all the twenty four *Verbascum* species are very small, oblong, pyramidal and rectangular in shape, having wavy prominent ridges and furrows (Table 1, Pl.3, figs 4-6). Colour of seeds ranges from yellowish brown to brownish black. Average size of the seeds is almost equal in all species except in *V. dumulosum* (Table 1), but the shape and size within each species are slightly variable which probably depend to some extent on the position of the seed in the capsule.

## Seed development

Seed coat development has been traced out only in *V. phlomoides* while in rest of the species only mature seeds have been studied. Although the integument is about 10-cell layers thick at the organized female gametophyte stage, however, the number is larger along the vascular strand on the ventral side. The cells of the inner epidermis elongate radially, accumulate dense cytoplasmic content and form the endothelium (Text-



Table 1. Seed sources and morphological details of seeds in *Verbascum* species

S.no.	Name of the species	Seed donor country	Average length (mm)	Shape	Colour	Average number of ridges in L.S.	Average number of ridges in T.S.
1.	<i>V. austriacum</i> Schott	Germany	1	Oblong	Brownish black	7	7
2.	<i>V. boerhavi</i> L.	Germany	1	Oblong	Dark brown	6	7
3.	<i>V. blattaria</i> L.	Spain	1	Pyramidal	Yellowish brown	7	6
4.	<i>V. cheiranthifolium</i> Boiss	U.S.S.R.	1	Oblong	Yellowish brown	8	8
5.	<i>V. denudatum</i> Boiss & Heldr.	France	1	Oblong	Yellowish brown	8	7
6.	<i>V. damascanum</i> Boiss	Israel	1	Oblong	Yellowish brown	9	8
7.	<i>V. dumulosum</i>	Germany	0.5	Oblong	Yellowish brown	8	7
8.	<i>V. fruticosum</i>	Israel	1	Rectangular	Dark brown	11	8
9.	<i>V. gnaphalodes</i> Bieb.	Portugal	1	Pyramidal	Dark brown	8	7
10.	<i>V. lychnitis</i> L.	Hungary	1	Oblong	Yellowish brown	6	9
11.	<i>V. longifolium</i> Tenore	Germany	1	Pyramidal	Yellowish brown	7	8
12.	<i>V. majale</i> DC.	France	1	Pyramidal	Yellowish brown	8	10
13.	<i>V. nigrum</i> L.	Netherland	1	Pyramidal	Brown	6	6
14.	<i>V. olympicum</i> Boiss	Germany	1	Oblong	Dark brown	7	8
15.	<i>V. phlomoides</i> L.	Portugal	1	Pyramidal	Yellowish brown	8	9
16.	<i>V. phoeniceum</i> L.	U.S.S.R.	1	Oblong	Yellowish brown	7	8
17.	<i>V. sinuatum</i> L.	Portugal	1	Oblong	Yellowish brown	6	8
18.	<i>V. simplex</i> Hoffmgg. & Link	Portugal	1	Pyramidal	Yellowish brown	9	8
19.	<i>V. thapsus</i> Linn.	Germany	1	Pyramidal	Yellowish brown	6	10
20.	<i>V. thapsiforme</i> Schard	Germany	1	Pyramidal	Yellowish brown	7	6
21.	<i>V. pulverulentum</i> Vill.	Germany	1	Oblong	Dark brown	7	8
22.	<i>V. virgatum</i> Stokes	Portugal	1	Rectangular	Yellowish brown	7	8
23.	<i>V. pyramidatum</i> Bieb.	Germany	1	Oblong	Dark brown	10	9
24.	<i>V. wiedemannianum</i> Fisch et. May	Ireland	1	Pyramidal	Dark brown	9	8

fig. 1. The endothelial cells during seed development show differentiation into larger and smaller cells (Text-fig. 2), whereas the cells of the intermediary layers of the integument enlarge, become vacuolated and finally rupture and collapse. In a mature seed, the seed coat thus consists of two cell layers representing the outer epidermis and the endothelium. The seed coat encloses a ruminant (wavy outlined) endosperm and a dicotyledonous embryo (Text-fig. 1).

General appearance of the outermost epidermal layer of the seed coat is very similar in all the twenty four species, except the thickness and the size of lamellate projections present on it which varied considerably among species. The endothelial layer differentiates into large bulging cells and small cells which cause rumination of the endosperm. Arrangement of the large bulging and small cells is not uniform in all the species (Text-fig. 2). The endothelial cells of all the twenty four species are filled with granules and most of these get stretched in dried seeds (Text-fig. 1). The cells of the endosperm

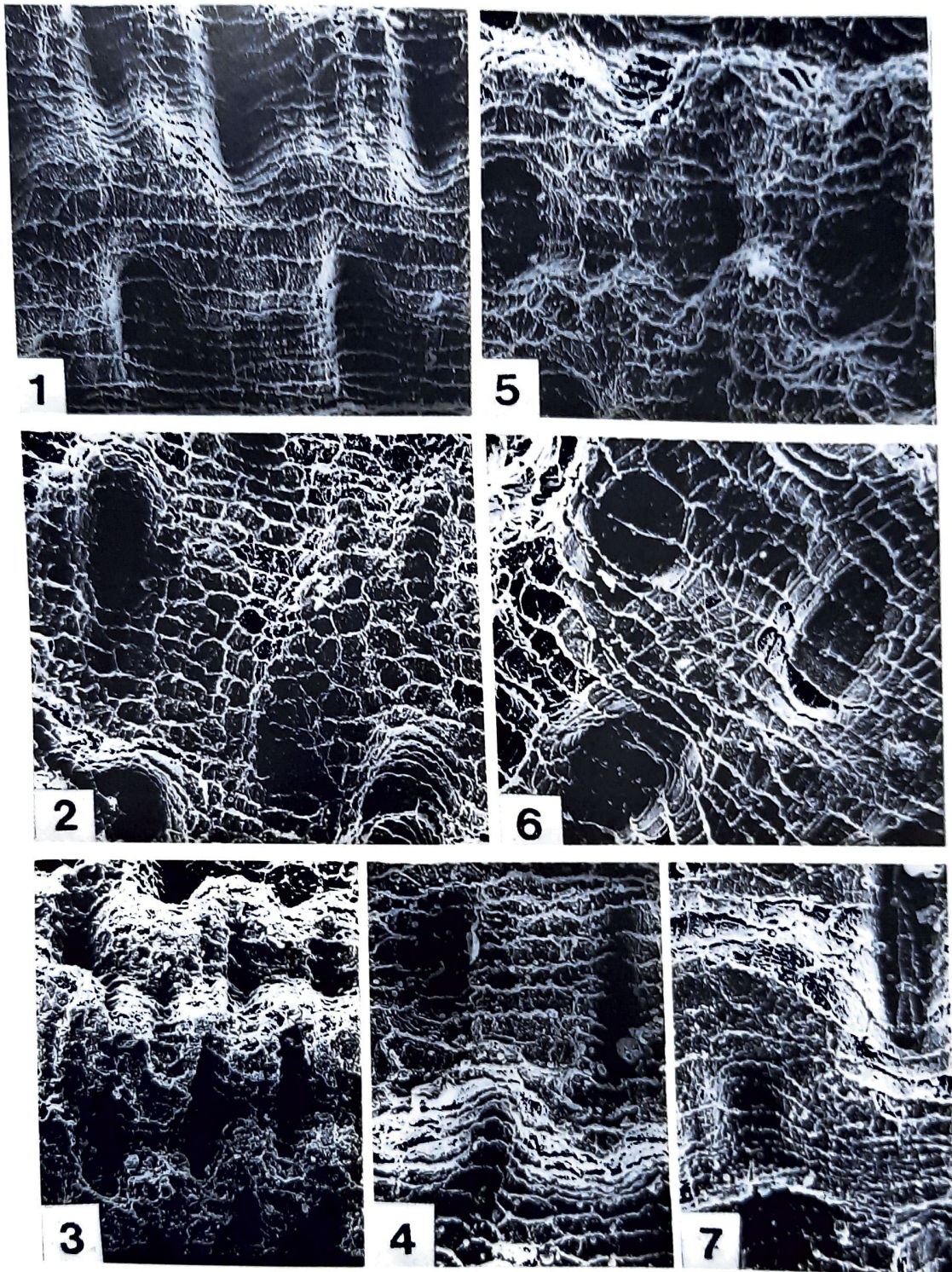
are thick walled and filled with deeply stained and shining crystalloid granules. The embryo is axial and slightly curved.

### SEM study

Although all the twenty four species of *Verbascum* have nearly similar spermoderm characteristics, some minor differences, however, are observed in few species showing varying depth in the pitting pattern. This enables to group them in three categories:

(i) *Species with deep-pitted surfaces* - Eight *Verbascum* species are kept under this type. Seed surface is reticulate-foveate. Ridges and furrows are prominent and pits are deep and broad to narrow and oblong (*V. phlomoides*, *V. fruticosum*, *V. majale*; Pl. I, figs 1,2). Comparatively more in number (*V. phoeniceum*; Pl. I, fig.3), deep and spindle to oval (*V. denudatum*, *V. wiedemannianum* respectively; Pl. I, figs 4,5), circular to oval (*V. cheiranthifolium*; Pl. I, fig. 6) or having different shapes and





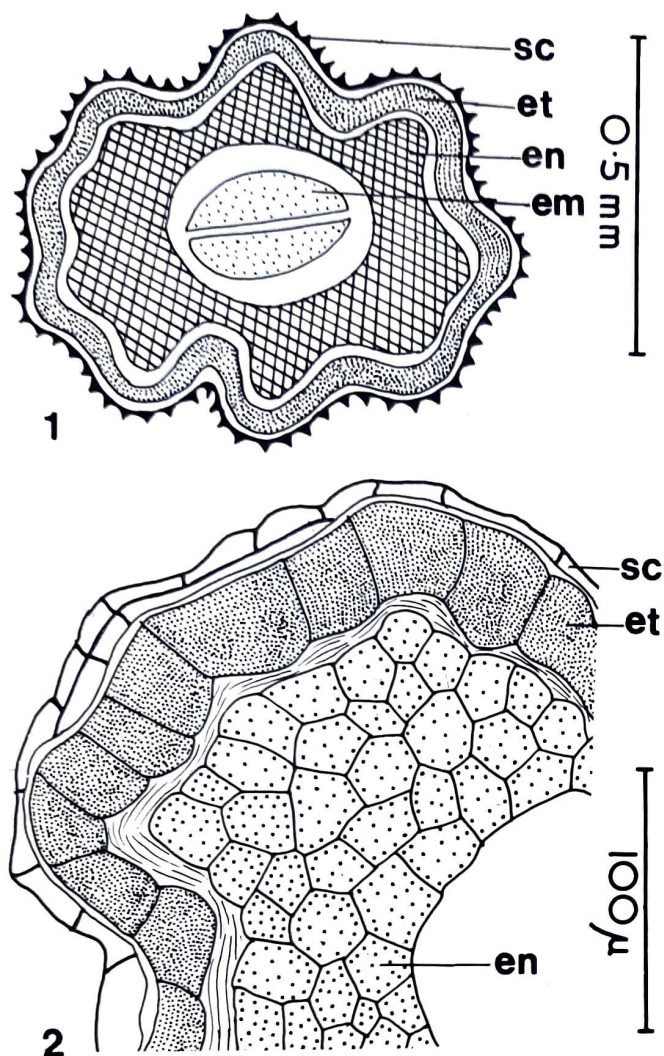
**Plate 1**

Figs 1-7. Deep-pitted spermoderms in *Verbascum* species

- 1. *V. phlomoides*
- 2. *V. fruticosum*
- 3. *V. phoeniceum*
- 4. *V. denudatum*

- 5. *V. wiedemannianum*
- 6. *V. chemanthifolium*
- 7. *V. gnaphalodes* (1 to 7  $\times$  200)





Text-figures 1-2 T.S. of mature seed and seed coat in *Verbascum phlomoides* L.

1. T.S. mature seed. 2. T.S. part of seed coat. (SC, seed coat; et, endothelial cell; en, endosperm; em, embryo).

sizes (*V. fruticosum*; Pl. 1, fig.2). Epidermal cells are scalariform (*V. phlomoides*; Pl. 1, fig.1), squarish to rectangular (*V. majale*, *V. gnaphalodes*, *V. cheiranthifolium*; Pl.1, figs 6,7), polygonal (*V. fruticosum*, *V. denudatum*, *V. wiedemannianum*; Pl.1, figs 2,4,5). Epidermal cells are not very clear in some places (*V. wiedemannianum*; Pl.1, fig.5), not in proper shape due to heavy deposition of wax on the cells (*V. phoeniceum*; Pl.1, fig. 3), inner cell surface is smooth (*V. majale*, *V. fruticosum*, *V. phoeniceum*; Pl.1, figs 2,3), rugose (*V. phlomoides*, *V. denudatum*, *V. wiedemannianum*, *V. gnaphalodes*; Pl.1, figs 1,4,5,7) or showing rungs of ladder (*V. cheiranthifolium*; Pl.2, fig.6). Epidermal cell wall is thick and highly beaded in *V. wiedemannianum*, *V. phlomoides*, *V. fruticosum*, *V. phoeniceum* (Pl. 1, figs 1,3,5). Small round knob like structures are seen in the seed surface (*V. denudatum*; Pl.1, fig.4). In *V. gnaphalodes* the whole seed surface is divided by a transverse line (Pl.1, fig.7).

(ii) *Species with shallow-pitted surfaces* - Thirteen *Verbascum* species are placed under this group. Seed surface is reticulate-foveate. Ridges and furrows are clear. Ridges are nearly compact, (*V. pyramidatum*; Pl. 2, fig.1) or wavy looking as narrow valley in between the two erosions (*V. lychnitis*; Pl.2, fig.2). Pits are of different shape and size such as big, narrow, shallow and oblong (*V. olympicum*, *V. longifolium*, *V. pulverulentum*, *V. vergatum*, *V. boerhavi*, *V. thapsus*; Pl.2, figs 3,7). Epidermal cells are varying in shape and size such as squarish to rectangular (*V. thapsus*, *V. blattaria*; Pl.2, fig.7), but in some species epidermal cells are not very clear (*V. blattaria*, *V. pulverulentum*, *V. pyramidatum*; Pl.2, figs 1,5). In some species rungs of a ladder are seen on epidermal cells (*V. lychnitis*, *V. austriacum*, *V. thapsus*, *V. simplex*, *V. boerhavi*; Pl.2, figs 2,6,7). Epidermal cell wall is beaded in all the species. A waxy deposition is seen on the epidermal cell walls in *V. pulverulentum* (Pl.2, fig.4).

(iii) *Species with slightly depressed surface* - Three *Verbascum* species fall under this category. Seed surface is reticulate-foveate having very slight depressions. Epidermal cells are varying in shape, i.e., squarish to polygonal (*V. thapsiforme*, *V. nigrum*, *V. sinuatum*; Pl.3, figs 1-3) having rungs of a ladder (*V. thapsiforme*; Pl.3, fig.1). Epidermal cell wall is thick and highly (*V. nigrum*; Pl.3, fig.2) or slightly beaded (*V. thapsiforme*; Pl.3, fig.1). In *V. sinuatum* epidermal cell wall is having waxy deposition on some places (Pl.3, fig.3).

## DISCUSSION

The present study showed that the seeds of all the twenty four *Verbascum* species are almost similar anatomically. Occurrence of ruminant endosperm is interesting. The unequal radial elongation of the endothelial cells participate in the formation of ruminant endosperm, while cells of intermediary layer of the integument get rupture and finally collapsed. This type of ruminant was described by Periasamy (1962) as *Verbascum* type. The pattern of the division of the endothelial layer into large bulging cells and small cells is same in all the *Verbascum* species, but the arrangement of these cells considerably varied among the species. Kapoor and Vijayaraghvan (1978) described the term 'Bothroblast' and 'Abothroblast' to the cells of endothelium which enlarge and do not enlarge respectively.

The study of spermoderm pattern carried out under scanning electron microscope revealed that, although the basic pattern of spermoderm is reticulate-foveate there are however slight variations in all the species according to which species may be placed under three categories, namely, (i) species with deep-pitted surface (8 species), (ii) species with shallow-pitted surface (13 species) and (iii) slightly depressed surface (3 species).



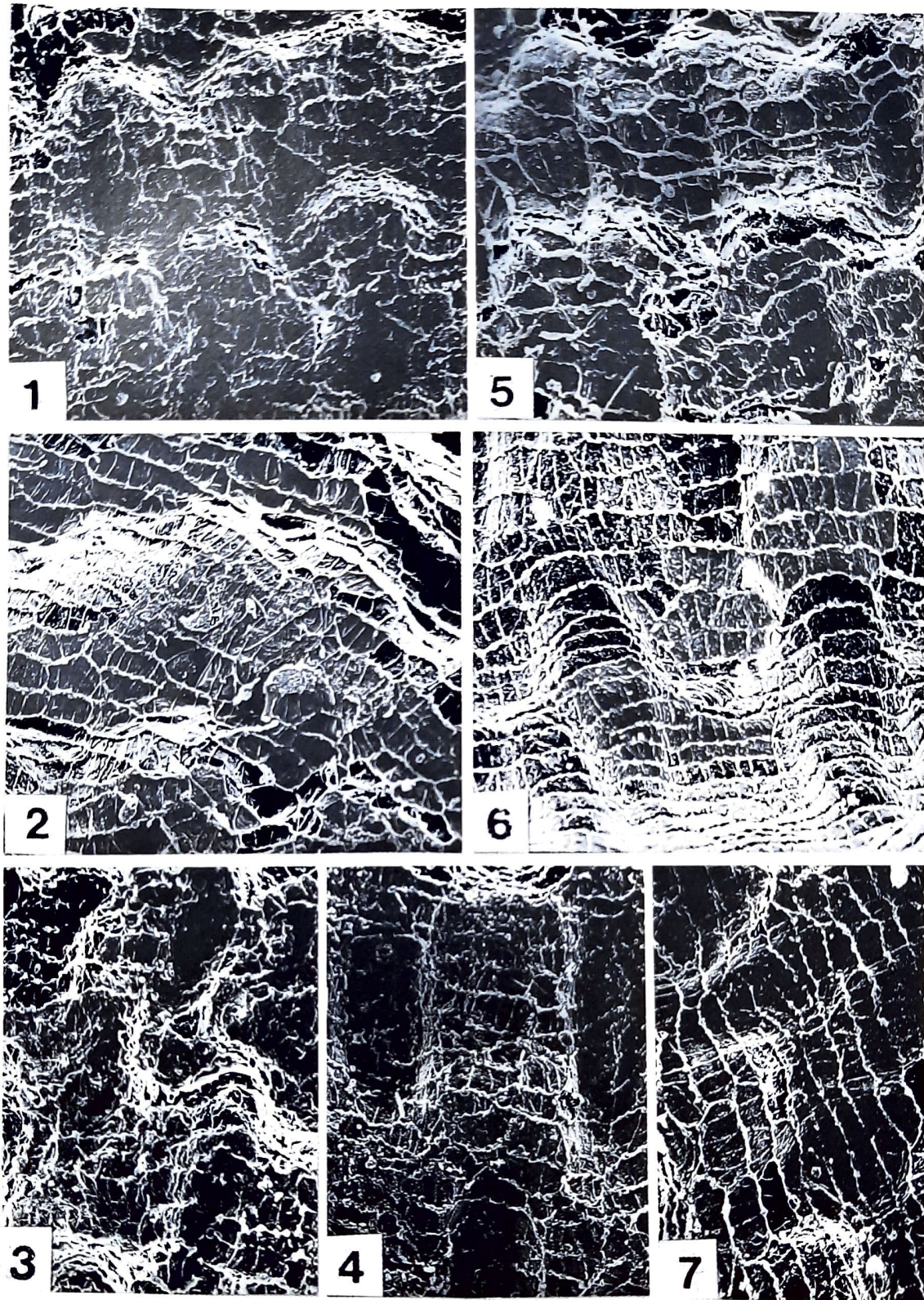


Plate 2

Figs 1-7. Shallow-pitted spermoderms in *Verbascum* species.

1. *V. pyramidatum*

2. *V. lychnitis*

3. *V. olympicum*

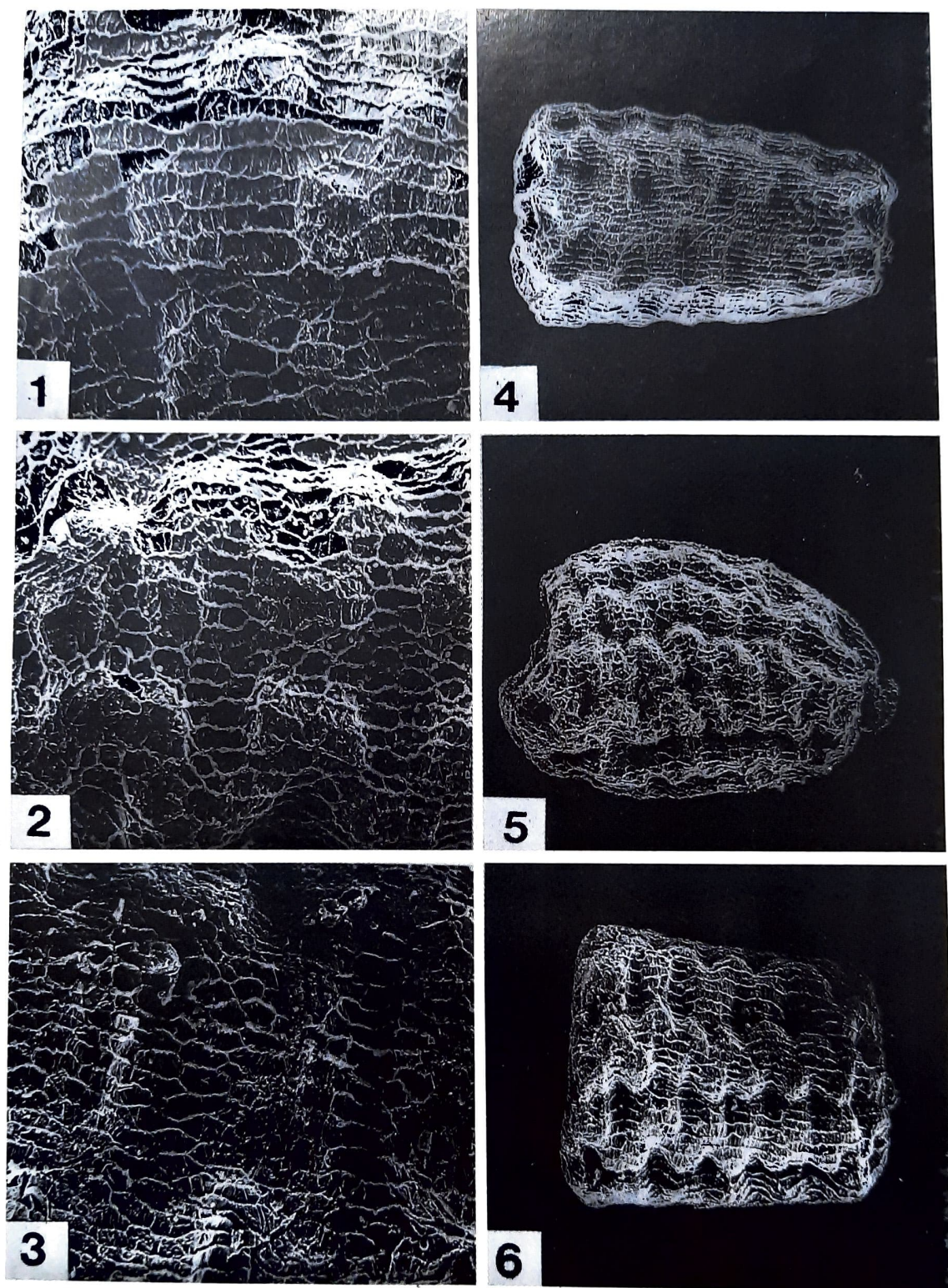
4. *V. longifolium*

5. *V. pulverulentum*

6. *V. boerhavia*

7. *V. thapsus* (1 to 7 x 200)





### Plate 3

Figs 1-3. Slightly depressed spermodermis; 4-6. Different shape of mature seeds in *Verbascum* species.

1. *V. thapsiforme*
2. *V. nigrum*
3. *V. sinuatum*

4. *V. phlomoides* (pyramidal)
5. *V. pyramidatum* (oblong)
6. *V. virgatum* (rectangular) [1 to 3 x 200, 4 to 6 x 60].



Therefore shallow-pitted spermoderm surface in general is characteristic feature of the *Verbascum* species, while slightly depressed surface is rare.

There is some controversy about the merger of the two genera *Celsia* and *Verbascum* into one. Some worker concluded their study in support of this point. Ferguson (1971) reported that presence of four (*Celsia*) and five (*Verbascum*) stamens is not always a constant feature in both the genera. Species with four fertile stamens and one staminode are also present in both *Celsia* and *Verbascum*. Chandra and Singh (1988) reported 'Crucifer' or 'Onagrad' type of embryogeny in *Verbascum*. This type of embryogeny is also reported by Kapoor *et al.* (1975) in *Celsia*. Present study also supports that *Celsia* and *Verbascum* should be placed under same genus due to their seed coat structure and its developmental similarities with each other.

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