SEM STUDIES ON THE SPERMODERM STRUCTURE OF SOME MEDICINALLY IMPORTANT SPECIES OF SOLANACEAE

G. N. SRIVASTAVA & G. D. BAGCHI

Botany & Pharmacognosy Division, Central Institute of Medicinal & Aromatic Plants, Post Box No. 1, R. S. M. Nagar, Lucknow 228 016, India

Abstract

Scanning Electron Microscopic (SEM) studies were conducted on the spermoderm pattern of 14 medicinally important species of Solanaceae, viz., *Atropa acuminata* Royle ex Lindley, *A. belladonnna* L., *Datura innoxia* Mill., *D. metel* E. var. *fastuosa* L., *D. stramonium* L., *Hyoscyamus muticus* L., *H. niger* L., *Nicandra-physaloides* Gaertn., *Physalis minima* L., *Solanum indicum* L., *S. khasianum* C. B. Clarke, *S. mammosum* L., *S.surattense* Burm. f. and *Withania somnifera* Dunal. Two main types of spermoderm patterns, the reticulate and papillose were distinguishable. These patterns have pharmacognostic value in their identification.

Introduction

Taxonomic value of spermoderm ornamentation as revealed by SEM studies has been emphasized by various workers (Tomb, 1974; Polhill, 1976; Brisson & Peterson, 1976; Lersten & Gunn, 1982). Heywood (1971) suggested the use of SEM as a tool for providing detailed information on spermoderm morphology in seed identification. Bagchi (1981) and Trivedi *et al.* (1982) during SEM studies on spermoderm pattern of various leguminous seeds observed that generally, the middle wide area of the seed is suitable for scanning due to the uniform structure.

SEM studies pertaining to spermoderm structure particularly in the family Solanaceae are limited to the works of Heywood (1969) on *Physalis*, Mayer & Poljakoffmayber (1975) of *Lycopersicum* and Edmonds (1983) on *Solanum* L. Section *Solanum*. Generally, seeds of various species of Solanaceae provide little morphological distinction and are difficult to be separated from an admixture (Srivastava & Bagchi, 1985 unpublished). SEM studies on the surface of various seeds in the present study show unique ornamentation for a particular species and may have pharmacognostic significance.

SEM was used to examine spermoderm patterns of 14 species that have medicinal value as a source for phytochemicals (Kirtikar & Basu, 1933; Mukerji, 1953; Chopra *et al.*, 1965). The species include: *Atropa acuminata* Royle ex Lindley, *A. Belladonna* L., *Datura innoxia* Mill., *D. metel* L. var. *fastuosa* L., *D. stramonium* L., *Hyoscyamus muticus* L., *H. niger* L., *Nicandra physaloides* Gaertn., *Physalis minima* L., *Solanum indicum* L., *S. khasianum* C. B. Clarke, *S. mammosum* L., *S. surattense* Burm f. and *Withania somnifera* Dunal.

Material and methods

Fully mature and dried authentic seeds samples of all the above mentioned species were collected either from natural sources or from CIMAP farm, Lucknow. Seeds were cleaned with air blower and were mounted on aluminium stubs with silver paint and coated with a thin layer of Palladium for 3 minutes at 10 mA and 1 kV in a Polaron sputter

coater. Five seeds of each sample were examined under SEM and to ensure uniformity, the flat-middle wide area of each seeds was scanned using a Cambridge Stereoscan-180 Scanning Electron Microscope at 20 kV.

Observations

In solanaceous seeds, distal part of the outer epidermis of testa, during maturation, disintegrates and becomes mucilaginous. This mucilage forms a coating on the seed surface and under SEM appears fibrillar or globular (Figs. 1 & 8). Sometimes, the mucilage during dehydration gets associated with fungus (Figs. 4 & 12) which are not easily removed without damaging the spermoderm surface. The seeds could not be treated chemically for cleaning, as this may damage the original surface. The surface as seen under SEM after cleaning thoroughly with the air blower is described below :

Atropa acuminata (Pl. 1, Fig. 1)—Spermoderm surface has reticulate ornamentation. Cavities, which are large and shallow, are enclosed with thick, rough and repand walls. Surface is further characterised by the presence of excessive fibrillar and globular structures.

Atropa belladonna (Pl. 1, Fig. 2)—Spermoderm surface characteristically has a reticulate pattern. Cell boundaries are usually slightly elevated and have sinuate canals which are narrow and occasionally deep. Cell cavities are shallow and the surface is almost smooth.

Datura innoxia (Pl. 1, Fig. 3)—Spermoderm surface exhibits prominent papillose ornamentation. Sometimes these papillae are compressed and appear flattened from above (shown by arrow). The surface also has scanty fibrillar structures.

D. metel var. *fastuosa* (Pl. 1, Fig. 4)—As found in *D. innoxia*, the spermoderm surface of this species also shows a papillose pattern. The surface is uneven and the papillae are irregular in shape (shown by arrow). However, the surface pattern is partly masked due to the presence of excessive fibrillar structures.

D. stramonium (Pl. 1, Fig. 5)—The spermoderm surface shows papillose ornamentation. Papillae are usually present on the elevated reticulations, which makes the reticula rough. Some granular and fibrillar structures also occur on the surface.

Hyoscyamus muticus (P. 1, Fig. 6)—The spermoderm exhibits a reticulate pattern. Cavities are large, deep with nearly smooth surface. Sparsely distributed granular structures are present on the surface. Wavy walls, which are lacerated, have prominent swellings or protrusions (shown by arrow).

H. niger (Pl. 1, Fig. 7)—Spermoderm has reticulate pattern. Cavity is large, deep and has smooth surface. The walls of the cavity are repand, lacerated and do not have protrusions. Granular as well as fibrillar structures are present but sparsely distributed. Cavities are almost circular giving the surface a honey-comb like appearance.

Nicandra physaloides (Pl. 1, Fig. 8)—Spermoderm surface exhibits reticulate ornamentation. Cavities are large and shallow. They are surrounded by irregularly thickened, repand walls having a rough and granular surface (shown by arrow). Spermoderm also exhibits fibrillar structures.

Physalis minima (Pl. 2, Fig. 9)—Spermoderm surface has a reticulate pattern showing thin ridged lining on the wall (shown by arrow). Walls are smooth, uneven, highly thickened and do not appear lacerated. Slit like apertures occur in the centre of cavities.

Solanum indicum (Pl. 2, Fig. 10)—The spermoderm has papillose ornamentation on the surface. Papillae are irregular in shape and are arranged in irregular groups, which

are not much elevated as in the case of *D. innoxia*. The surface bears scanty granular structures.

S. khasianum (Pl. 2, Fig. 11)—The surface of the spermoderm has reticulate ornamentation. Walls are less prominent and gradually slope into a large and shallow cavity. The surfaces of the walls and the cavity have minute undulations. Over the walls, irregular, discontinued, thin linings are present (shown by arrow).

S. mammosum (Pl. 2, Fig. 12)—The spermoderm surface shows irregularly papillose ornamentation. The papillae are usually arranged in rows. The surface has fine granular and fibrillar structures.

S. surattense (Pl. 2, Fig. 13)—The spermoderm exhibits reticulate pattern. The wavy walls are thickened and compressed from above. Due to the excessive thickness of the walls, the cavities are narrow and shallow. Surface of the cavities are minutely wrinkled. At the joining areas of two adjacent cell walls, is a thin, continuous and ridged lining. The surface also possesses scanty granular structures.

Withania somnifera (Pl. 2, Fig. 14)—The spermoderm shows a reticulate pattern. Cavity is large and enclosed by a wavy wall. The surface of the cavity which is deep and smooth, has sparse granular as well as fibrillar structures. Walls are lacerated almost evenly thickened and do not have protrusions as found in *H. muticus*.

Discussion

Development of seeds in Solanaceae begins with radial elongation of the epidermal cells of the testa. Wall thickening starts internally but the distal ends of the epidermal cell walls remain thin. When the seeds mature, the distal part of the epidermis disintegrrates and becomes mucilaginous (Corner, 1976). This mucilage and the cuticle forms a layer, which during dehydration and maturation of the seed, collapses on the epidermal radial walls. The spermoderm surface patterns, which we observed with SEM, appear to be formed by dehydrated mucilage, collapsed cuticle and the underlying thickened radial walls of the seed-coat epidermis. Sometimes fungal hyphae and spores also get associated with the dehydrating mucilage, which are not easily removed.

Edmonds (1983) observed a uniform spermoderm pattern in *Solanum*, and did not consider this trait for diagnostic purposes. However, in our study two types of spermoderm patterns have been recognised which bear no relation in the systematic classification of these seeds. The most common spermoderm pattern in Solanaceae is of reticulate followed by papillose pattern. On critical observation, these patterns show minute variations in their structure and are further differentiated from each other. SEM studies have been found useful in the seed identification at the species level. Seeds of various species belonging to same genus may or may not show similarity in their surface pattern, eg. seeds of *Hyoscyamus* and *Atropa* show reticulate spermoderm pattern, which can be further distinguished from one another on the basis of sinuation frequency and structure of their radial walls. In *H. niger*, the wall is repand as compared to *H. muticus*. *A. acuminata* also possesses less wavy wall and differs from *A. belladonna* where the walls are slightly elevated and have narrow canal on it. All the three species of *Datura*, viz., *D. innoxia*, *D. metel* var. *fastuosa* and *D. stramonium* have papillose ornamentation but these vary from one another in minute details such as in *D. metel* var. *fastuosa*, the spermoderm possesses less prominent papillae while in *D. innoxia*, these papillae are distinct and flattened and in *D. stramonium*, the papillae are arranged on the reticula. Various species of *Solanum* show much variation in their spermoderm ornamentation. Sinuate radial walls

of *S. khasianum* are less prominent, while in *S. surattense*, the walls are distinct and bear ridged linings on it. However, both the species have reticulate ornamentation. Spermoderm of *S. indicum* and *S. mammosum* show altogether different patterns from the above mentioned species. Like *D. stramonium*, *S. indicum* also shows papillose ornamentation which are arranged on reticula but in the latter, the reticula are less regular while in *S. mammosum*, the papillae are arranged in rows.

There are, however, instances when species of a genus show some resemblance in their spermoderm pattern with the species of some other genera, eg. *Atropa acuminata* with *Nicandra physaloides*, *Datura stramonium* with *Solanum indicum*, *Hyoscyamus muticus* with *Withania somnifera* and *Physalis minima* with *Solanum surattense* but on the whole the spermoderm surface of each species is characterised and distinguished by its own specific characters. From the foregoing discussion, it is evident that each species exhibits its own characteristic spermoderm pattern and has pharmacognostic value in the identification.

Acknowledgements

The authors are grateful to Dr Akhtar Hussain, Director, CIMAP, Lucknow for his interest and encouragement in this work and providing Laboratory facilities.

References

Bagchi, G. D. (1981). Light and scanning electron microscopic studies on seeds of some economically useful Leguminosae. *Ph. D. thesis*. Botany Department, Lucknow University.

Brisson, J. D. & Peterson R. L. (1976). A critical review of the use of scanning electron microscopy in the studyof seed coat. *IITRI/SEM*/1976/II : 477-495.

Chopra, R. N., Badhwar, R. L. & Ghosh, S. (1965). *Poisonous plants of India*. Vol. **II,** Indian council of Agricultural Research, New Delhi.

Corner, E. J. H. (1976). *The Seeds of Dicotyledons*. Vol. I & II. Cambridge University Press, London.

Edmonds, J. M. (1983). Seed coat structure and development in *Solanum* L. section *Solanum* (Solanaceae). *Bot. J. Linn. Soc.*, **87** : 229-246.

Heywood, V. H. (1969). Scanning electron microscopy in study of plant materials. *Micron.*, **1** : 1-14.

Heywood, V. H. (1971). The characteristics of the scanning electron microscope and their importance in biological studies, pp. 1-16, in : Heywood V. H. (Ed.)—*Scanning electron microscopy, systematics and Evolutionary applications. The systematics Associations*. Vol. **4.** Academic Press (London) Ltd., England.

Kirtikar, K. R. & Basu, B. D. (1933). *Indian Medicinal Plants*, Vol. **III.** Lalit Mohan Basu, M. B. 49, Leader Road, Allahabad (India).

Lersten, N. R. & Gunn, C. R. (1982). Testa characters in tribe Vicieae, with notes about tribes Abreae, Cicereae and Trifolieae (Fabaceae). *Technical Bulletin No.* 1667, US Dept. of Agriculture, Iowa State Univ., USA.

Mayer, A. M. & Poljakoff-Mayber, A. (1975). The germination of seeds. *Int. Sci. Monogr. Pure & Applied Biology*. Vol. **5,** 2nd Ed. Pergamon Press, Oxford, England.

Mukerji, B. (1953). *The Indian Pharmaceutical Code*. Vol. **1,** Indigenous Drugs, CSIR, New Delhi.

Polhill, R. M. (1976). Genisteae (Adans) Benth. and related tribes (Leguminoseae), pp. 143-368, in : Heywood V. H. (Ed.) *Botanical Systematics, An occasional series of monographs*. Academic Press (London) Ltd., England.

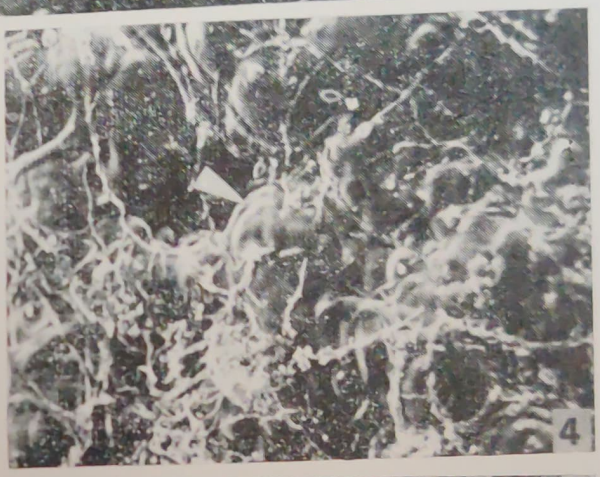
Tomb, A. S. (1974). SEM studies on small seeds. *IITRI/SEM:* 375-380, 638.

Trivedi, B. S., Bagchi, G. D. & Singh, P. (1982). Scanning electron microscopic studies on some medicinally important seeds of Caesalpinioideae and Mimosoideae (Leguminosease). *Biol. Mem.*, **7**:(2) 124-130.


1

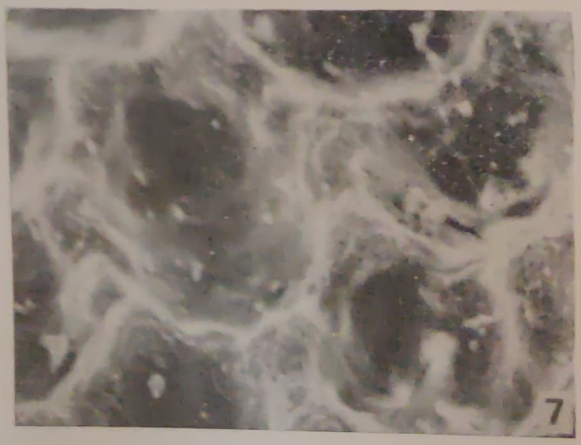

2


3

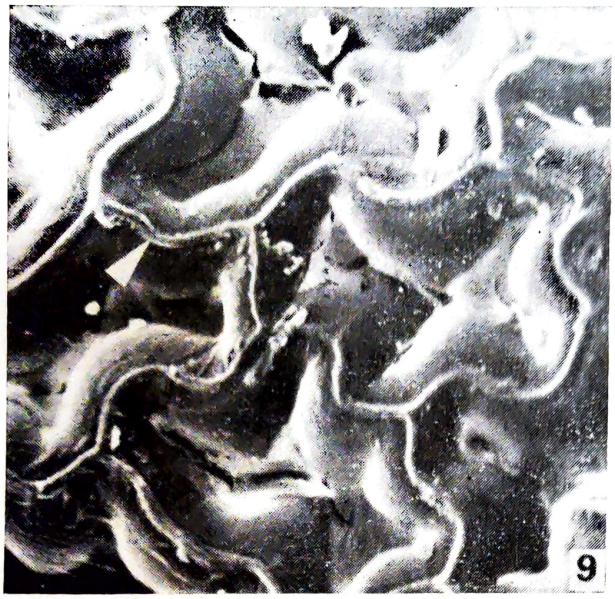

4

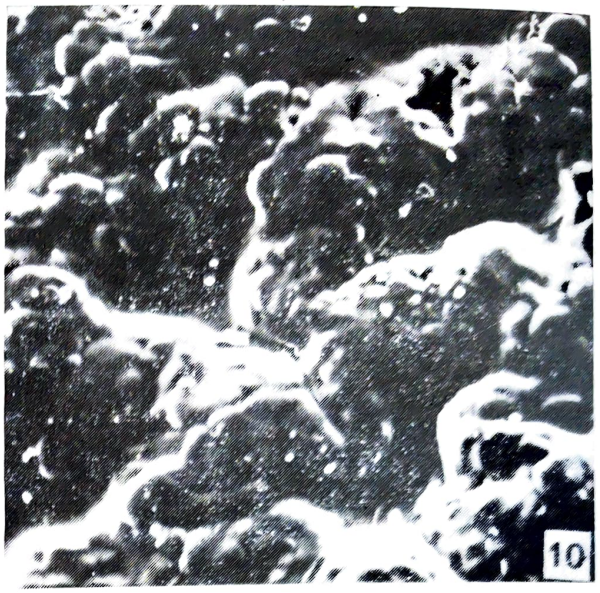

5

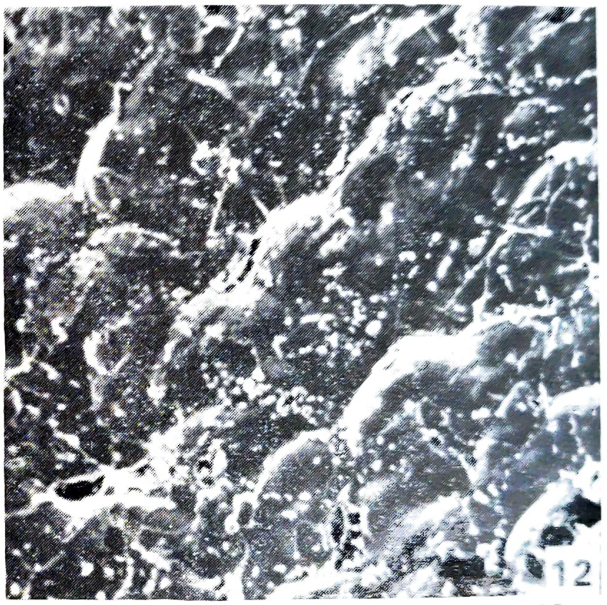

6

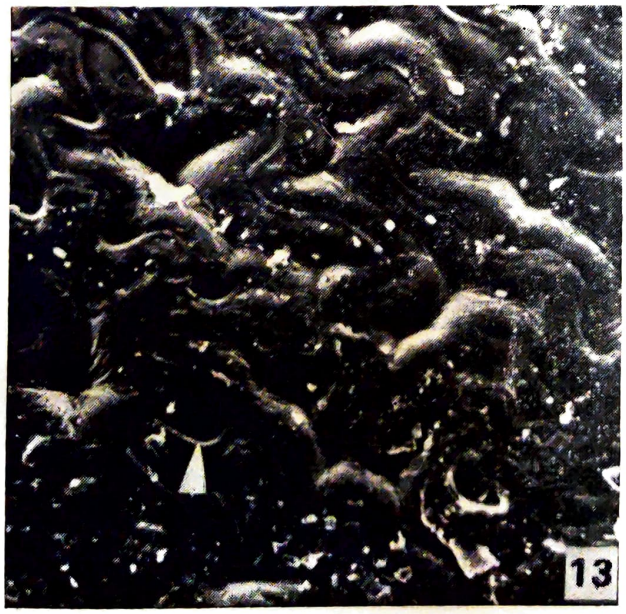

7

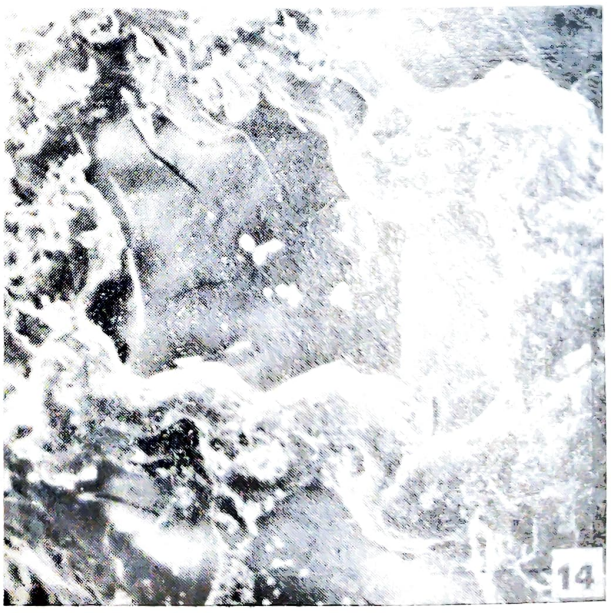

8











Srivastava & Bagchi—Plate 2

Explanation of Plates

PLATE 1

Figs. 1—8. SEM microphotographs showing spermoderm structure of Solanaceae.

1. *Atropa acuminata.*
2. *A. belladonna*—Arrow indicates sinuate canal.
3. *Datura innoxia*—Arrow shows some of the compressed papillae.
4. *D. metel* var. *fastuosa*—Arrow indicates papillae of irregular pattern.
5. *D. stramonium.*
6. *Hyoscyamus muticus*—Arrow indicates the portrusions of the wall.
7. *H. niger.*
8. *Nicandra physaloides*—Arrow indicates irregularly thickened wall (All × 500).

PLATE 2

Figs. 9—14. SEM microphotographs showing spermoderm structure of Solanaceae.

9. *Physalis minima*—Arrow indicates thin ridged lining on the wall.
10. *Solanum indicum*
11. *S. khasianum*—Arrow indicates discontinued lining on the wall.
12. *S. mammosum*
13. *S. surattense*—Arrow indicates the ridged lining on the wall.
14. *Withania somnifera* (All × 500).