

STRUCTURE, DISTRIBUTION AND TAXONOMIC SIGNIFICANCE OF CRYSTALLIFEROUS CELLS IN MALVALES

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Distribution of calcium oxalate crystals has been described in leaves of 27 genera and 50 species of Malvales. In 28 species only sphaero-crystals, while in other 21 sphaero and prismatic crystals were recorded. *Buettneria* is distinct from other species in lacking crystals. Fifteen crystalliferous cell's distributional patterns have been recognised. Based on the crystalliferous cell's distribution, a key for identification of the species is provided.

Key words : Calcium oxalate, crystals, Malvales, taxonomy.

Occurrence of crystals and Crystalliferous cells has been considered as an important taxonomic criterion in identification of divergent angiospermous taxa (Soleređer, 1908; Metcalfe and Chalk, 1950; Franceschi and Horner, 1980; Horner and Wagner, 1980; Prabhakar and Ramayya, 1980; Leelavathi *et al.*, 1984; Prabhakar *et al.*, 1988; Koteshwar Rao *et al.*, 1988). In spite of the above fact, its utility in plant taxonomy especially with reference to Malvales is little exploited. Hence presently the structure and distribution of these crystalliferous cells in 50 species of Malvales has been taken up.

MATERIALS AND METHODS

Mature leaves of 27 genera and 50 species of Malvales belonging to three families viz., Malvaceae, Sterculiaceae and Tiliaceae were collected from different places of Andhra Pradesh, India (Table 1). The leaves were fixed in Carnoy's fixative (Johansen, 1940). Permanent Canada balsam mounts of microtome sections of the middle part of the leaf (from midvein to margin) at 12-15 μm thickness were prepared following the usual paraffin method. The chemical nature of the crystals observed in the sections were histochemically tested (Johansen, 1940) and found to be calcium oxalate.

OBSERVATIONS AND DISCUSSION

Earlier sphaero-crystals were recorded in epidermis of *Gossypium arboreum* and *G. herbaceum* (Inamdar and Chohan, 1969), *Pterospermum acerifolium* and *Sterculia foetida* (Rao and Ramayya, 1984), hypodermal cells of *Plagiopteron fragrans* and *Heritiera littoralis* (Soleređer, 1908 Metcalfe and

Chalk, 1950) and in Leaf lamina of *Spermaminia africana* (Al-Rais *et al.*, 1971). Presently only sphaero-crystals of calcium oxalate are recorded in 28 and prismatic crystal in *Triumfetta pentandra* while in other 20 species sphaero- and prismatic crystals (Rectangular, squairish or rohmaboidal) are observed (Figs. A-S). *Buettneria herbacae* is unique from rest of the taxa in lacking any type of crystals (Table 1). Further the distribution of these crystals were found to vary not only from one species to the other but also from one region of the leaf to the other. Crystals are present in vascular bundles (Figs. O,Q) of all the species except in *Helicteres isora*, *Melhania incana*, *Sterculia foetida*, and *Waltheria indica*. Prismatic along with sphaero-crystals are present in vascular bundles (Fig. O) of only *Dombeya cayeuxii*, *Guazuma tomentosa*, *Kleinhovia hospita*, *Pterospermum acerifolium*, *Corchorus urticaefolius*, *Grewia flavescens*, *G. hirsuta* and *G. tiliaefolia* and in others only sphaero crystals are present. Similarly sphaero-crystals are present in guard cells of *Bombax malabaricum*, *Sida acuta*, *S. cordata*, *S. glutinosa*, *Pterospermum acerifolium* and *Sterculia foetida* only. Crystals are observed in epidermis (Figs. A-C, K) of 34 species ; in mesophyll of all (Fig. C-H; Table 1) except (*Eriodendron pentandrum*). While in ground parenchyma (at midrib) they are present in 42 species (Figs. L-Q) and in collenchyma of only 13 species (Figs. K,L; Table 1).

Generally the size of the crystals in a given species is more or less same throughout the leaf. However in nineteen taxa there are two distinct size classes of crystals (Figs. C,H). In these taxa the crystals may be small throughout the leaf except in epidermis (eg.

Table 1: Distribution of crystals in leaves of Malvales

Name of the species	EPIDERMIS			MESOPHYLL			MIDRIB			Dist. patt. No.
	Ep. Cells Ad/Ab	Cos Cells Ad/Ab	Pal	ML	SP	BS	Coll Ad/Ab	GP Ad/Ab	Per	
MALVACEAE										
1. <i>Abelmoschus ficulneus</i> (L.) W. & A. ex W.S.	-/-	-/-	S	-	-	-	-/-	-/S	-	8
2. <i>Abutilon crispum</i> (L.) Medic.	-/-	-/-	S	-	-	S	-/-	S/S	-	6
3. <i>A. glaucum</i> (Cav.) Sweet	S/-	S/-	S	-	-	S	S/-	S/S	-	3
4. <i>Adansonia digitata</i> L.	S/-	S/-	S	S	-	S	S/S	S/S	-	3
5. <i>Althaea rosea</i> Cav.	-/-	-/-	-	S	-	S	-/-	S/-	-	6
6. <i>Bombax malabaricum</i> Dc.	S/S	S/S	S	-	-	S	S/S	S/S	S	1
7. <i>Eriodendron pentandrum</i> Kurz.	-/-	-/-	-	-	-	S	S/S	-/S	S	5
8. <i>Gossypium arboreum</i> L.	-/-	-/-	S	S	-	S	-/-	S/S	-	6
9. <i>G. herbaceum</i> L.	-/-	-/-	S	S	-	S	-/-	S/S	-	6
10. <i>Hibiscus cannabinus</i> L.	S/S	S/-	S	S	S	S	-/-	S/S	-	7
11. <i>H. lobatus</i> (Mex.) Kuntze	P/P	-/-	S	S	S	S	-/-	-/S	-	7
12. <i>H. micranthus</i> L.	S/P	-/-	S	S	S	S	-/-	S/S	-	7
13. <i>H. rosa-sinensis</i> L.	P/P	-/-	S	S	S	-	-	S/S	-	8
14. <i>H. sabdariffa</i> L.	-/-	-/-	S	S	-	-	-	-	-	15
15. <i>H. tiliaceus</i> L.	S/-	-/-	S	-	S	S	S/S	S/S	S	1
16. <i>H. vitifolius</i> L.	-/-	-/-	S	-	S	S	S/-	S/S	-	12
17. <i>Malvastrum cormandelianum</i> (L.) Garcke	S/S	S/S	S	-	S	S	-/-	S/S	-	7
18. <i>Malva viscosa</i> Cav.	P/-	-/-	P	S	-	S	-/-	S/S	-	7
19. <i>Pavonia odorata</i> Willd.	P/-	-/-	S	S	-	-	-/-	-/-	-	11
20. <i>P. zeylanica</i> (L.) Cav.	P/P	-/-	S	-	S	-	-/-	-/-	-	11
21. <i>Thespesia lampas</i> (Cav.) Dalz. ex Dalz & Gibs	-/-	-/-	S	-	S	S	S/S	S/S	-	12
22. <i>T. populnea</i> (L.) Sol. Ex. Corr.	S/-	-/-	S	-	S	S	-/S	S/S	-	3
23. <i>Sida acuta</i> Burm.	S/S	-/-	S	-	S	S	-/-	S/S	-	7
24. <i>S. cordata</i> (N. Burm.) Borss.	S/S	-/-	S	-	-	-	-/-	S/S	-	8
25. <i>S. cordifolia</i> L.	-/-	-/-	S	-	S	S	-/-	S/S	-	6
26. <i>S. glutinosa</i> Cav.	S/S	-/-	S	-	S	S	-/-	S/S	-	7
27. <i>S. rhombifolia</i> L.	-/-	-/-	S	-	-	S	-/-	S/S	-	6
28. <i>S. spinosa</i> L.	S/-	-/-	-	-	S	-	-/-	-/S	-	8
STERCULIACEAE										
29. <i>Buettneria herbacea</i> Roxb.	-/-	-/-	-	-	-	-	-/-	-/-	-	-
30. <i>Dombeya cayeuxii</i> Hort.	P/-	P/P	P	-	-	SP	P/P	SP/SP	SP	1
31. <i>Guazuma tomentosa</i> Kunth.	S/-	-/-	-	-	-	SP	P/P	SP/SP	SP	2
32. <i>Helicteres isora</i> L.	P/-	-/-	S	-	-	S	-/-	-/-	-	10
33. <i>Kleinhovia hospita</i> L.	-/-	P/P	S	-	-	S	-/-	SP/SP	P	4
34. <i>Melochia corchorifolia</i> L.	-/-	-/-	S	-	-	S	-/-	-/-	-	13
35. <i>Melhania incana</i> Heyne ex W. & A.	-/-	-/-	S	-	-	-	-/-	-/S	-	4
36. <i>Pterospermum acerifolium</i> Willd.	SP/SP	SP/SP	S	-	-	S	-/S	SP/SP	SP	1
37. <i>Sterculia foetida</i> L.	S/S	S/S	S	-	-	S	-/-	S/S	-	9
38. <i>Waltheria indica</i> L.	-/-	-/-	S	-	-	-	-/-	-/S	-	14
TILIACEAE										
39. <i>Corchorus acutangulus</i> Lamk.	SP/-	-/-	S	-	S	S	-/-	-/S	-	7
40. <i>C. fascicularis</i> Lamk.	S/-	-/-	S	-	S	S	-/-	S/S	-	7
41. <i>C. olitorius</i> L.	SP/-	-/-	P	S	-	P	-/-	S/S	-	7
42. <i>C. tridens</i> L.	SP/-	-/-	S	S	P	S	-/-	-/S	-	7
43. <i>C. trilobularis</i> L.	SP/-	-/-	SP	S	-	S	-/-	-/SP	-	7
44. <i>C. urticaefolius</i> W. & A.	SP/-	-/-	SP	S	-	P	-/-	SP/SP	-	7
45. <i>Grewia flavescens</i> Juss.	-/-	P/-	P	-	-	SP	SP/SP	SP/S	S	1
46. <i>G. hirsuta</i> Vahl.	-/-	P/-	P	-	-	P	-/-	SP/SP	-	7
47. <i>G. tiliaefolia</i> Vahl.	-/-	P/-	P	-	-	S	P/S	-/S	S	1
48. <i>Muntingia calabura</i> L.	-/P*	-/-	SP	-	-	S	-/-	P/P	-	7
49. <i>Triumfetta pentandra</i> A. Rich.	-/-	-/-	P	-	P	P	-/-	-/-	-	13
50. <i>T. rhomboidea</i> Jacq.	S/-	S/-	S	S	S	S	-/-	-/S	-	7

Ab= Abaxial; Ad= Adaxial; Bs= Bundle sheath; Coll = Collenchyma; Cos = Costal cells; Dist = Distribution; Ep = Intercostal epidermal cells; Gp= Ground parenchyma; ML = Middle layer; P = Prismatic crystal; Pal = Palisade; Per = Pericycle; S= Sphaero-crystals; Sp= Spongy parenchyma. * = confined to trichome base.

Hibiscus lobatus, *H. rosa-sinensis*, *Pavonia odorata* and *P. zeylanica*; Fig. B), mesophyll (eg. *Abelmoschus ficulneus*, *Althaea rosea*, *Hibiscus cannabinus*, *H. micranthus*, *H. vitifolius*, *Sida acuta*, *Helicteres isora* and *Thespesia lampas*; Figs. C-F, epidermis and mesophyll (eg. *Malvaviscus arboreus*, *Grewia flavescens*, *G. hirsuta* and *G. tiliifolia*), epidermis and ground parenchyma (eg. *Hibiscus tiliaceus*; Figs. B, S) and only in ground (eg. *Dombeya cayeuxii* and *Pterospermum acerifolium*; Figs. M,P), where they are large. In *Abutilon glaucum* and *Dombeya cayeuxii* the relative frequency of crystals in mesophyll and bundle sheath is comparatively more (Fig. J), while in *Abutilon crispum*, *A. glaucum*, *Adansonia digitata*, *Bombax malabaricum*, *Gossypium herbaceum*, *Hibiscus cannabinus*, *H. Tiliaceus*, *H. vitifolius*, *Thespesia populnea*, *Sida cordata*, *S. cordifolia*, *S. spinosa*, *Dombeya cayeuxii*, *Guazuma tomentosa*, *Pterospermum acerifolium*, *Corchorus olitorius*, *C. tridens*, *C. urticaefolius* and *Muntingia calabura* they are more frequent in midrib zone (Figs. M,P,S.).

Based on the differential distribution, the following crystalliferous cells distribution patterns have been recognised:

Crystalliferous cells distribution patterns in leaf tissue:

Pattern 1: Distributed throughout leaf (epidermis, mesophyll, ground parenchyma, collenchyma, bundle sheath, pericycle and vascular bundle), as in *Bombax malabaricum*, *Hibiscus tiliaceus*, *Dombeya cayeuxii*, *Pterospermum acerifolium*, *Grewia flavescens* and *G. tiliifolia* (Table 1)

Pattern 2: Distributed throughout leaf, except in mesophyll, as in *Guazuma tomentosa* (Table 1).

Pattern 3: Distributed throughout leaf except in pericycle, as in *Abutilon glaucum*, *Adansonia digitata* and *Thespesia populnea* (Table 1).

Pattern 4: Distributed throughout leaf except in hypodermal collenchyma, as in *Kleinhovia hospita* (Table 1).

Pattern 5: Distributed throughout leaf except in epidermis and mesophyll, as in *Eriodendron pentandrum* (Table 1).

Pattern 6: Distributed throughout leaf except in epidermis, hypodermal collenchyma, pericycle, as in *Abutilon crispum*, *Althaea rosea*, *Gossypium arboreum*,

G. herbaceum, *Sida cordifolia* and *S. rhombifolia* (Table 1).

Pattern 7: Distributed throughout leaf except in hypodermal collenchyma and pericycle, as in *Hibiscus cannabinus* and 15 other taxa (Table 1).

Pattern 8: Distributed throughout leaf except in hypodermal collenchyma, pericycle and bundle sheath, as in *Abelmoschus ficulneus*, *Hibiscus rosa-sinensis*, *Sida cordata* and *S. spinosa* (Table 1).

Pattern 9: Distributed throughout leaf except in hypodermal collenchyma, pericycle, and vascular bundles, as in *Sterculia foetida* (Table 1).

Pattern 10: Distributed only in epidermis, mesophyll and bundle sheath, as in *Helicteres isora* (Table 1).

Pattern 11: Distributed only in epidermis, mesophyll and vascular bundle, as in *Pavonia odorata* and *P. zeylanica* (Table 1).

Pattern 12: Distributed throughout leaf except in epidermis and pericycle, as in *Thespesia lampas* and *Hibiscus vitifolius* (Table 1).

Pattern 13: Distributed in mesophyll, bundle sheath and vascular bundle, as in *Melochia corchorifolia* and *Trimuffetta pentandra* (Table 1).

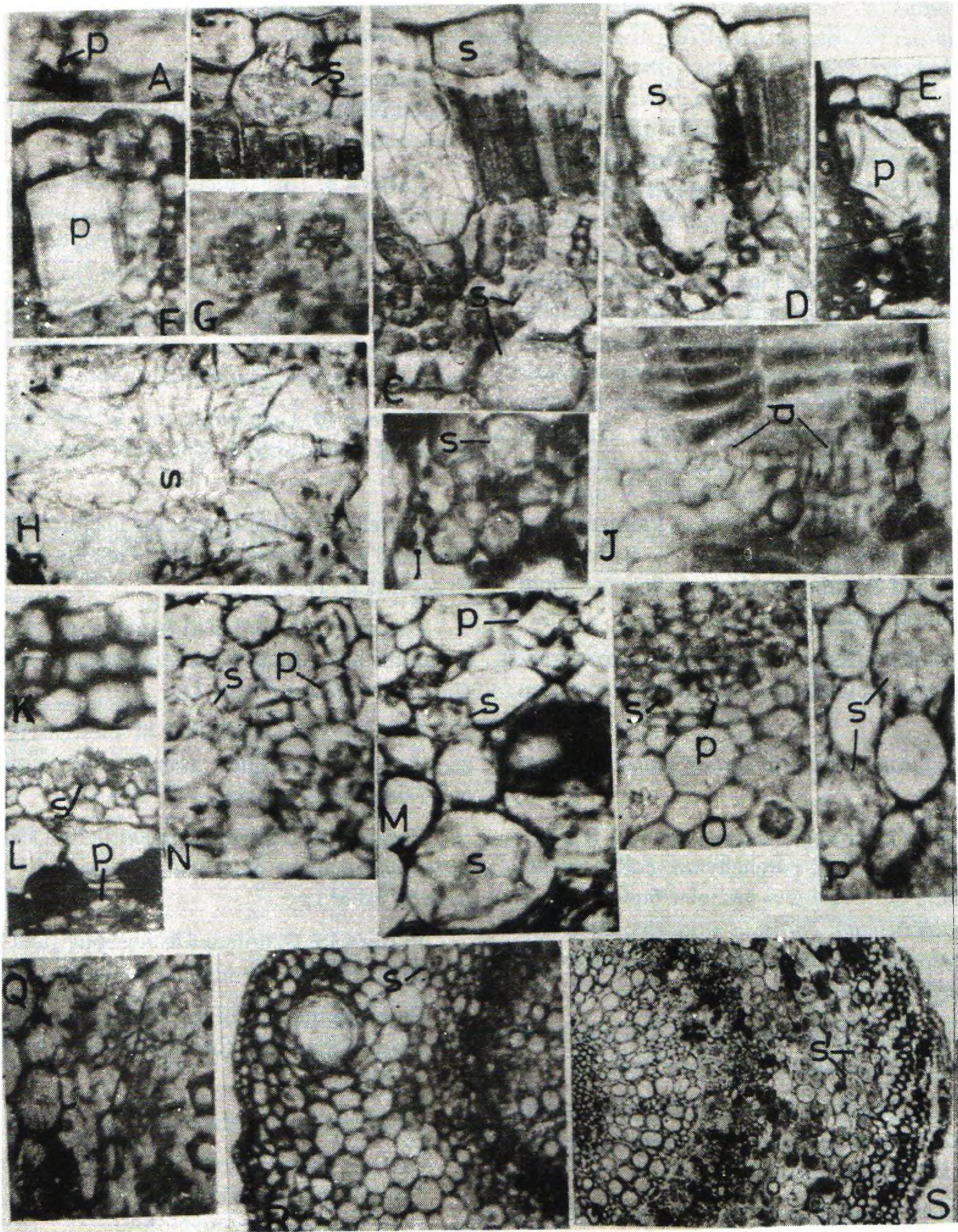
Pattern 14: Distributed in mesophyll and ground parenchyma, as in *Melhantha incana* and *Waltheria indica* (Table 1).

Pattern 15: Distributed in mesophyll and vascular bundle, as in *Hibiscus sabdariffa* (Table 1).

Based on the type of the crystals and their differential distribution a key for identification of the species is provided:

Key for identification of the species :

1. Crystals absent in leaf *Buettneria herbacea*
1. Crystals present in leaf
 2. Crystals present in epidermis
 3. Crystals present in trichome base
 4. Crystals absent in vascular bundles
 - *Sterculia foetida*
 4. Crystals present in vascular bundles
 5. Crystals absent in guard cells
 - *Muntingia calabura*
 5. Crystals present in guard cells
 6. Both sphaero- and prismatic crystals present
 - *Pterospermum acerifolium*



Figures: A-S Section of leaf showing A. prismatic crystals in epidermis of *Dombeya cayeuxii*; B. sphaero-crystals in epidermis of *Hibiscus tiliaceus*; C. sphaero-crystals in epidermis, palisade and spongy parenchyma of *Hibiscus micranthus*; D. sphaero-crystals in palisade of *Hibiscus micranthus*; E.F. prismatic crystals in palisade of *Grewia flavescens* and *G. tiliaefolia* respectively; G. sphaero-crystals in spongy parenchyma of *Hibiscus vitifolius*; H. sphaero-crystals in middle layer of *Hibiscus cannabinus*; I, J. sphaero- and prismatic crystals in bundle sheath of *Dombeya cayeuxii* and *Eriodendron pentadrum* respectively; K. prismatic crystals in costal epidermal cells zone and collenchyma of *Dombeya cayeuxii*; L. sphaero-crystals in collenchyma and prismatic crystal in pericycle of *Guazuma tomentosa*; M. large and small sphaero- and prismatic crystals in ground parenchyma of *Pterospermum acerifolium*; N. small sphaero and prismatic crystal in ground parenchyma of *Dombeya cayeuxii*; P. sphaero-crystals (large) in ground parenchyma of *Hibiscus tiliaceus*; O. sphaero- and prismatic crystal in vascular bundle of *Dombeya cayeuxii*; Q. sphaero-crystals in vascular bundle of *Hibiscus vitifolius*; R.S. sphaero-crystal in ground parenchyma (less frequent) in *Gossypium arboreum* and (more frequent) in *Hibiscus tiliaceus* (P-Prismatic crystal, S-Sphaero-crystal).

6. Only sphaero-crystals present
...*Bombax malabaricum*
3. Crystals absent in trichome base
7. Crystals present in costal cells but absent in intercostal cells.
8. Mesophyll consists of only sphaero-crystals
...*Kleinhovia hospita*
8. Mesophyll consist of only prismatic crystals
9. Crystals absent in hypodermal collenchyma
...*Grewia hirsuta*
9. Crystals present in hypodermal collenchyma
10. Parenchymatous cells in midrib consist only sphaero-crystals
...*Grewia tiliaefolia*
10. Parenchymatous cells in midrib consist of both sphaero and prismatic crystal
...*Grewia flavescens*
7. Crystals present in intercostal or costal and intercostal cells
11. Crystals present in costal and intercostal zone.
12. Both sphaero-and prismatic crystals present in leaf
...*Dombeya cayeuxii*
12. Only sphaero-crystal present in leaf
13. Crystals present in adaxial and abaxial epidermis
14. Crystals nearly of similar size (10-15 μ m) in mesophyll
...*Malvastrum cormandelianum*
14. Crystals of two sizes (Vary large 36-45 μ m and small size 9-12 μ m) in mesophyll
...*Hibiscus cannabinus*
13. Crystals absent in adaxial but present in abaxial epidermis
15. Crystals absent in hypodermal collenchyma
...*Triumfetta rhomboidea*
15. Crystals present in hypodermal collenchyma
16. Crystals present in middle layer of mesophyll
...*Adasonia digitata*
16. Crystals absent in middle layer of mesophyll
...*Abutilon glaucum*
11. Crystals present in intercostal cells but absent in costal zone
17. Only sphaero-crystals present in leaf
18. Crystals present in adaxial and abaxial epidermis
19. Crystals absent in bundle sheath ...*Sida cordata*
19. Crystals present in bundle sheath
20. Crystals large (40-50 μ m) in mesophyll
...*Sida acuta*
20. Crystals small (6-10 μ m) in mesophyll
...*Sida gultinosa*
18. Crystals present in adaxial but absent in abaxial epidermis
21. Crystals absent in palisade cells ...*Sida spinosa*
21. Crystals present in palisade cells
22. Crystals absent in spongy mesophyll
...*Abelmoschus ficulneus*
22. Crystals present in spongy mesophyll
23. Crystals absent in hypodermal collenchyma
...*Corchorus fascicularis*
23. Crystals present in hypodermal collenchyma
24. Crystals in mesophyll small (9-12 μ m) but in midrib they are large (36-42 μ m)
...*Hibiscus tiliaceus*
24. Crystals of similar size (10-15 μ m) in mesophyll and midrib region
...*Thespesia populnea*
17. Both sphaero-and prismatic crystals present in leaf
25. Crystals present in adaxial epidermis but absent in abaxial
26. Crystals absent in mesophyll
...*Guazuma tomentosa*
26. Crystals present in mesophyll
27. Only prismatic crystals present in epidermis
28. Only prismatic crystals present in palisade
...*Malvaviscus arboreus*
28. Only sphaero-crystals present in palisade
29. Crystals absent in vascular bundle
...*Helicteres isora*
29. Crystals present in vascular bundle
...*Pavonia odorata*
27. Both prismatic and sphaero-crystals present in epidermis
30. Only sphaero-crystals in ground parenchyma
31. Only sphaero-crystals present in palisade
32. Only sphaero-crystals present in spongy parenchyma
...*Corchorus acutangulus*
32. Only prismatic crystals present in spongy parenchyma
...*Corchorus tridens*
31. Sphaero-and prismatic crystals present in palisade
...*Corchorus olitorius*
30. Both sphaero-and prismatic crystals present in ground parenchyma
33. Prismatic crystals present in bundle sheath
...*Corchorus urticaefolius*
33. Sphaero-crystals present in bundle sheath
...*Corchorus trilocularis.*
25. Crystals present in adaxial and abaxial epidermis
34. Crystals absent in bundle sheath
35. Crystals absent in ground parenchyma
...*Pavonia zeylanica*

35. Crystals present in ground parenchyma
....*Hibiscus rosa-sinensis*
34. Crystals present in bundle sheath
36. Epidermis consists of only prismatic crystals
...*Hibiscus lobatus*
36. Epidermis consists of both sphaero-and prismatic crystals
...*Hibiscus micranthus*
2. Crystals absent in epidermis
37. Crystals absent in palisade
38. Crystals present in middle layer of mesophyll
...*Althaea rosea*
38. Crystals absent in middle layer of mesophyll
....*Eriodendron pentandrum*
37. Crystals present in palisade
39. In mesophyll zone crystals present only in palisade
40. Crystals absent in bundle sheath
....*Melhania incana. Waltheria indica*
40. Crystals present in bundle sheath
41. Crystals absent in ground parenchyma in midrib zone
...*Melochia corchorifolia*
41. Crystals present in ground parenchyma in midrib zone
...*Abutilon crispum, Sida rhombifolia*
39. Crystals present in palisade and middle layer of spongy mesophyll
42. Crystals present in palisade and middle layer of mesophyll
43. Crystals absent in ground parenchyma
....*Hibiscus subdariffa*
43. Crystals present in ground parenchyma
....*Gossypium arboreum. G. herbaceum*
42. Crystals present in palisade and spongy mesophyll
44. Crystals present in hypodermal collenchyma
45. Mesophyll consists of large (55-60 μm) size crystals
....*Hibiscus vitifolius*
45. Mesophyll consists of small (15-20 μm) size crystals
....*Thespesia lampas*
44. Crystals absent in hypodermal collenchyma
46. Only prismatic crystals present in leaf
....*Triumfetta pentandra*
46. Only sphaero-crystals present in leaf
....*Sida cordifolia*

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