ANCIENT CROP PLANT REMAINS FROM SRINGAVERAPURA, ALLAHABAD (C. 1,050-1,000 B.C.)

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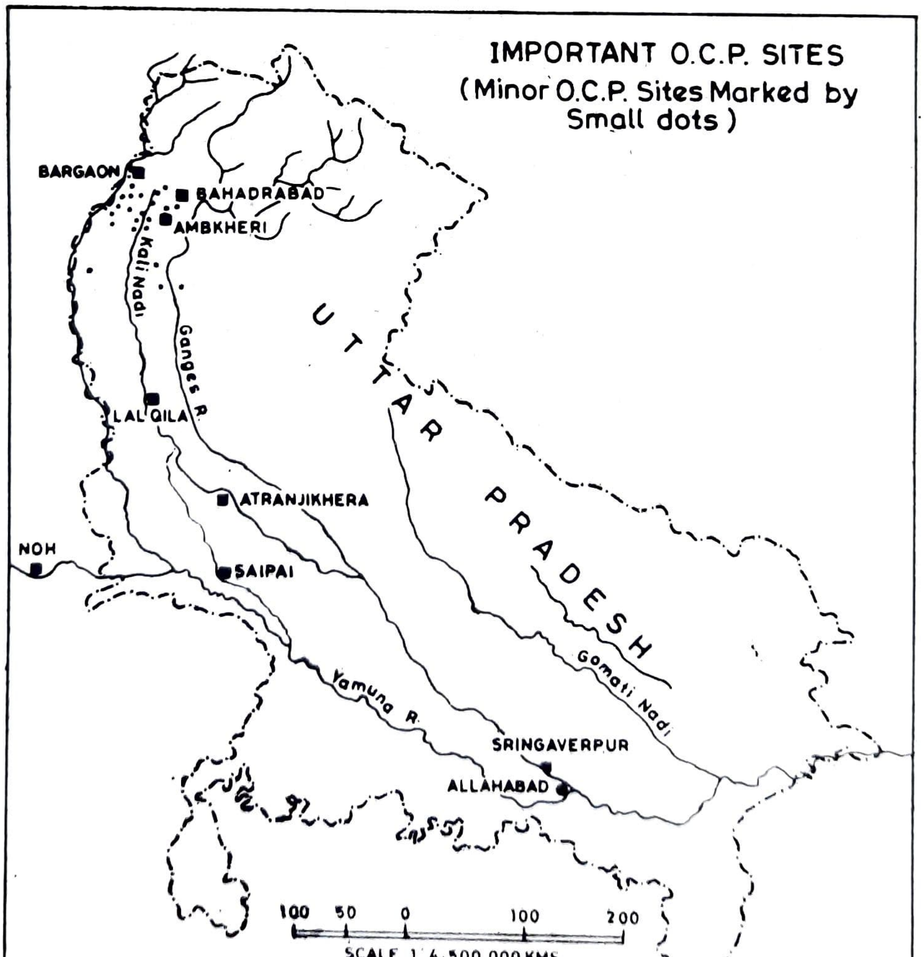
Abstract

Archaeological excavations at Sringaverapura, an ancient site on the left bank of river Ganges in Allahabad District, Uttar Pradesh, have revealed the cultivation of rice, barley, sesame and cotton, dating back to C. 1,050-1,000 B. C. The morphological and anatomical studies of the ancient plant remains have been discussed in the present paper.

Introduction

The massive mound of Sringaverapura sprawling roughly north-south on the left bank of river Ganges in Allahabad District of Uttar-Pradesh, is situated 36 km north-west of the district headquarters (Map 1). It lies in the revenue limits of a small village Singrur which occupies the sizable part of this ancient site. The mound is more than 10m in height



Map 1

and regarded as one of the key-sites related with the huge epic of Ramayana. It is in the vicinity of this place that Rama, prince of Oudh is said to have stayed for a night before the King of Nishadas who inhabited this area.

The extensive archaeological excavations have recently been carried out by Professor B. B. Lal, Indian Institute of Advanced Study, Simla and Shri K. N. Dikshit, Archaeological Survey of India, New Delhi. The excavations have revealed the successive human habitations starting from C. 1,050 B. C. to 700 B. C. and later.

The material relics of plant remains presented in this paper have been recovered from 30-60 cm thick deposit of yellowish clay (labelled as layer 19E) right on the natural soil in an archaeological trench SVP-1, YA3-Qd. 3. The layer 19E represents the earliest period of human occupation. The cultural deposit is characterized by a Red-Ware Industry associable with Ochre-Colour Ware, dating back about C. 1050-1000 B.C. (Lal & Dikshit, 1978-79; 1981). The scientific interpretation of the fragile and deceptive plant remains provides the direct evidence of ancient agricultural economy that the early settlers at Sringaverapura were then practicing.

Material and methods

The clay samples from layer 19E showing superficial impressions of plant remains were collected by the author. The embedded plant material recovered from the mud, consists of some grains, a small piece of some grass stem and several minute epidermal peels of microscopic nature. Some of the pottery pieces collected from the same cultural horizon showed the clear impressions of grains on its surface. One of the potsherds revealed some fibres in deteriorated state lying inside a cavity on it (Pl. 3, Fig.17).

The first stage in the methods of study was to recover the plant-remains from clay samples. The grains and seeds were scooped out from the clay pieces with the help of a scalpel and sharp arrow-headed needle. The food grains associated with mud were treated with 5% glacial acetic acid for 10-15 minutes depending on the condition of material. Then the repeated washing in water enabled to get the grains dislodged from mud particles. Individually separate grains were further cleaned in acid-alcohol (Glacial Acetic Acid 10%+Ethyl Alcohol 50% in equal volumes) with the help of a soft camel-hair brush, under a stereobinocular microscope. Finally, the grains were left to be dried up in the normal conditions.

Under a stereobinocular microscope, the fibres were dislodged from inside the cavity on the surface of a pot-sherd (Pl. 3, Fig. 17) with the help of a pointed forcep and transferred to 5% acetic acid. They easily got rid of mud particles by the repeated acid treatment; dehydration was carried out in tertiary-butyl Alcohol series as suggested by Sass (1951) and finally, the fibres were mounted in canada balsam.

The small piece of stem was washed thoroughly in hot water, dehydrated in ethyl alcohol and embedded in celloidin-paraffin according to the method suggested by Chowdhury and Ghosh (1954-55). The sections were obtained by the rotary microtome.

For the recovery of epidermal peels, the selected clay pieces were soaked in 10% acetic acid for 4-6 hours in an electric oven running at 40°C. They were collected under a stereobinocular microscope with the help of a fine camel-hair brush. The repeated treatment of 30% glacial acetic acid brought out the detailed anatomical features of diagnostic value. Some dark coloured epidermal peels on being treated with conc. acetic acid, revealed the anatomical details. They were washed in distilled water, dehydrated in the upward series of tertiary butyl alochol (after Sass, 1951) and mounted in canada balsam.

For comparative study of the ancient material, I had at my disposal some authentically identified material of extant plants, obtained from I.A.R.I., New Delhi; Rice Research Institute, Cuttuck, and the herbarium collection at B. S. I. P., Lucknow.

Results

The plant-remains comprise the caryopses—typical fruits of family Gramineae, a few small sized complete and broken seeds, stem piece of graminaceous nature, some epidermal peels comparable with leaf and husk of some cereals, and the fibres. The results of study have been grouped under different heads as given below:

Cereals—The caryopses turned to be a mixture of two types showing marked differences in their external features. They have, therefore, been grouped under two lots 'A' and 'B'.

Lot 'A'—The five elongated caryopses (Pl. 1, Fig. 6) measuring 5-6 mm in length and 2.5-3 mm in breadth, have a longitudinal furrow on their ventral side. The furrow originates from the base and gradually widens towards the upper end of the grains. The embryo rests on the elongated end of almost flat dorsal side. The caryopses are enclosed within the thick husk showing longitudinal striations under the stereobinocular microscope.

Taking into consideration the above morphological features, the caryopses have been regarded belonging to hulled species of barley (Helbaek, 1960; Martin & Barkley, 1961; Chowdhury, 1963).

The hulled species of barley have been classified as two-rowed and six-rowed, depending on the number of fertile florets per node of spike-axis (Bor, 1960; Helbaek, 1960; Backer & Bakhuizen, 1968). In two-rowed barley, out of three florets per node only the median one turns into caryopsis and the lateral ones on either sides, remain sterile. In six-rowed forms all the three florets are fertile and develop into three rows of caryopses on either sides of spike axis. The median caryopsis has more prominent bulging in the middle and exerts pressure on both of the lateral ones. As a result, the lateral grains become asymmetrical and develop the characteristic twists on their ventro-lateral sides.

The ancient barley grains from Sringaverapura exhibit distinct twists on some of them (Pl. 1, Fig. 6) suggesting that they belong to six-rowed form of *Hordeum*. All the wild and cultivated species of barley belong to the same potentially interfertile population, and are grouped under the single species—*Hordeum vulgare* L. emend. Bowden (Bakshi & Rana, 1974; Harlan, 1976). The Sringaverapura barley has, therefore, been placed under the hulled, six-rowed *Hordeum vulgare* L. emend. Bowden, which is a predominantly cultivated species.

The recovery of a small stem piece and a minute leaf and husk peelings of barley has further supported the cultivation of this crop at Sringaverapura.

Transverse section of stem is somewhat oval in outline (Pl. 1, Fig. 7). The epidermis is subtended by thick-walled sclerenchymatous hypodermis with embedded columns of thin-walled tissue, possibly the chlorenchyma cells. The parenchymatous ground tissue shows the progressively wider diameters and thinner walls on passing towards the fairly large cavity at the centre of the stem. Vascular bundles are in two circles. Outer vascular bundles are smaller and partly embedded in sclerenchymatous zone and the vascular bundles in inner, more or less sinuous circle, are larger and lying in thin walled ground tissue. On comparison with the extant stem of barley, it shows close resemblance in all the anatomical features. It has, therefore, been identified as such.

The small piece of leaf-peel shows thin-walled and non-sinuous long cells, and a portion of vein bearing the characteristic prickles (Pl. 2, Figs. 8, 9). No short cells could, evidently, be observed. The cells adjacent to the vein are very long and some of them tend to be hexagonal in shape (Pl. 2, Fig. 8). The stomata with parallel sided subsidiary cells are arranged in longitudinal rows (Pl. 2, Figs. 8, 9).

The long cells between the veins having thin, non-sinuous walls, prickles on the veins, and the stomata tending to be with parallel-sided subsidiary cells are the diagnostic features of *Hordeum* leaf epidermis (Metcalfe, 1960). The ancient leaf peel has, therefore, been identified as of the barley.

The epidermal peels (Pl. 2, Figs 10, 11) consisted of the long cells having narrow and round sinuousities in the horizontal walls, and the short cells with characteristically elliptical and round silica-bodies, have been found belonging to the husk-epidermis of barley (Buth & Chowdhury, 1971; Saraswat, 1972; Vishnu-Mittre & Savithri, 1975).

Lot 'B'—This lot consists of three grains (Pl. 1, Fig. 4) and an impression of caryopsis on a pot-sherd (Pl. 1, Fig. 5). Out of three kernels, two are elongated in shape (Pl. 1, Fig. 4A & C) and the middle one is somewhat oblong (Pl.1, Fig. 4-B). All the grains are flattened and prominently ribbed. The position of embryo is well marked on the lateral side.

The measurements and the ratio of length (L), breadth (B) and the thickness (T) of the grains are shown in the table as given below:

	Length (L) (mm)	Breadth (B) (mm)	Thickness (T) (mm)	L/B×T
Grain-A	4.0	1.8	1.25	1.78
Grain-B	4.4	2.3	1.50	1.27
Grain-C	5.0	1.8	1.50	1.84

The impression of caryopsis (Pl. 1, Fig. 5) measures 7 mm in length and 3.5 mm in breadth. It shows distinct fertile glumes, i.e. the lemma and palea which cover the kernel. The lemma is boat-shaped with convex outer surface and shows the longitudinal ribs on its surface. The impressions of lemma and palea clearly exhibit the tissue under a stereo-binocular microscope; the stalk of caryopsis is also clearly visible (Pl. 1, Fig. 5). Taking into consideration the peculiar shape of ribbed kernels with laterally placed embryo, the boat-shaped lemma, and the presence of "chess-board" pattern of tissue on the surface of fertile glumes, the unknown impression of caryopsis and the kernels (Pl. 1, Figs. 4, 5) have been identified as of *Oryza* in grass-family (Chowdhury & Ghosh, 1954-55; Musil, 1963; Vishnu-Mittre, 1974; Saraswat, 1972, 1980).

It is difficult to differentiate the cultivated rice from the wild one because of the great diversity noted in the taxa, both in shape and size of the kernels. The exhaustive investigations on the shape and ornamentation of *Oryza* grains, epidermal studies of lemna and palea and the statistical evaluation of length, breadth and thickness ratios in the kernels of wide range of the wild and cultivated species of *Oryza*, have been carried out at Birbal Sahni Institute of Palaeobotany by Savithri (1976) and Sharma (1983). Earlier also L/(B×T) ratio calculated by Vishnu Mittre (1974) gave the convincing results to differentiate the grains of wild and cultivated *Oryza* species. The L/(B×T) ratio in the cultivated forms, falls below 2, while in wild species it is above 2. In this broad perspective, the ancient grains from Sringaverapura belong to the cultivated taxa. The two grains (Pl. 1, Fig. 4 A & C) with their L/(B×T) indices as 1.78 and 1.85, according to the statistical assay suggested by Vishnu-Mittre (1974), approach nearly to the 'spontanea' form of *Oryza sativa*. However, the diagnostic features considered to be valid, cannot be regarded reliable enough as I have the opportunity to examine only a few spikelets. Further, the forms of cultivated *O. sativa* and its varieties grown in different geographical and climatic conditions show enormous divergence in the shape, size and other diagnostic features of grains. Being aware of limitations, I therefore, tentatively regard the Sringaverapura rice grains belonging to *Oryza sativa* L., the only cultivated species in Asia.

In the case of leaf pieces (Pl. 2, Figs. 12, 13) the epidermis consists of long and short cells. The long cells found in the grooves (between the veins) have thick, sinuous and pitted walls (Pl.2, Fig.12). The short cells occur singly as well as in pairs, composed of cork cells and silica cells often including silica bodies. They are abundantly present over the veins (Pl. 2, Fig. 13) but their distribution in the grooves is rather scanty (Pl. 2, Fig. 12). The silica bodies in short cells found in the grooves, are characteristically crescent shaped. However, over the veins, short cells are arranged in longitudinal rows, having cork cells and silica cells alternating with each other (Pl. 2, Figs. 12, 13). The short cells, like these, are termed as 'Dumb-bell' shaped and classified under '*Oryza* type' by Metcalfe (1960).

The stomata aligned in straight rows and far apart from each other, are confined to the grooves (Pl. 2, Fig. 12). The subsidiary cells are low-domed to somewhat triangular in shape.

Taking into consideration the characteristic 'Dumb-bell' shaped short cells over the veins and with crescent-shaped silica bodies in the region between the veins, and the stomata with low-domed to triangular subsidiary cells, the ancient peel of leaf-epidermis has been identified as of *Oryza sativa* (Metcalfe, 1960; Buth & Chowdhury, 1971; Saraswat, 1972, 1980).

Several cuticular peelings recovered from the mud, have epidermal cells thrown up into long, straight and pointed projections. Silica bodies are wanting (Pl. 2, Figs. 14, 15). In the light of the features revealed, the unknown peels have been referred to that of the paddy husk (Saraswat, 1972; Vishnu-Mittre & Savithri, 1975). The comparison with the extant husk epidermis of *Oryza* has also confirmed the identification.

Seeds—The lot consists of five flattish-ovate seeds in carbonized state, three complete and the two broken ones (Pl. 1, Fig. 1). The impressions of the seeds have also been noticed on the mud (Pl. 1, Fig. 3). The complete seeds measure 2—2.5 mm in length and 1—1.5 mm in breadth. Seed surface is smooth. Under a stereobinocular microscope, two well preserved seeds show faint lines running along the margins (Pl. 1, Fig. 2).

The flat and ovate seeds of small size are regarded to be of Sesame (*Sesamum* sp.) in family Pedaliaceae (Purseglove, 1974; Nagar, 1976) and the faint marginal lines and the equally faint central lines are the diagnostic features of *Sesamum indicum* L. (Martin & Barkley, 1961). The seeds from Sringaverapura reveal the presence of marginal lines (Pl. 1, Fig. 2) but the faint central lines are not visible, probably due to the preservation of material in charred state. The comparison of ancient seeds with the extant seeds of *Sesamum indicum*, the only cultivated species in India (Purseglove, 1974), shows the close resemblance in all the morphological respects. *Sesamum mulayanum* is a wild species found in north-western region of India. Its seeds with reticulate-rugose surface can easily be differentiated from those of *S. indicum* having smooth seed-surface (Nair, 1963, 1978). The Sesame seeds from Sringaverapura with smooth seed-surface have, therefore, been identified as of *Sesamum indicum* L., vernacularly known as Beniseed, Gingelly and Til. It is an important oil-seed crop in India.

Fibres—While examining the surface of a pottery piece (Pl. 2, Fig. 16) under stereo-binocular microscope for the study of paddy-husk impressions, some fibres in deteriorated state and light to deep brown in colour, were noticed inside a small cavity on it (Pl. 3, Figs. 17, 18). They were coarse, exceedingly tender and used to break under a slight stress. However, it could be possible to obtain some permanent preparations for detailed study (Pl. 3, Figs. 19-22). Some of the fibres have been recovered attached with the minute bits of carbonized seed-coat (Pl.3, Figs.19, 20). Most of the fibres were in the form of fragments. Only three complete fibres could be measured 10 mm., 17 mm and 18 mm in length. Thickness varies from 18 μm to 26 μm (average 22.6 μm).

The fibres are distinctly of two types, the long and short ones. The long fibres are characteristically flat having a wide lumen and convolutions or twists throughout the length (Pl. 3, Figs. 19-22). Only a few short fibres, rounded in cross-view and without any convolutions, could be observed on the seed-coat surface (Pl. 1, Fig. 19).

The long and short fibres on the seed-coat surface and the flat, long fibres with convolutions, are the diagnostic features of true cottons of commerce, i.e. the cultivated species of *Gossypium* suitable for spinning and turning into yarn (Carpenter & Leney, 1952; Hutchinson, 1959; Purseglove, 1974).

The long fibres are called as 'lint' or 'staple' and the short ones, the 'fuzz'. The lint grows to a greater length and the deposition of cellulose is reduced forming a lumen so that the hairs collapse and become flat on being dried. The deposition of cellulose is in spiral pattern and the change in the direction of deposition results in the formation of twists, which permits the spinning of lint for the textiles (Phillips, 1976). On the other hand, the wild *Gossypium* species are lintless and with short and unconvulated fibres only. The ancient cotton from Sringaverapura has revealed all the features of cultivated cotton. It is, therefore, identified as such.

There are four cultivated species of cotton with spinnable lint, viz., the diploid Old World cottons—*Gossypium herbaceum* L. and *G. arboreum* L. and the tetraploid New World cottons-*G. barbadense* L. and *G. hirsutum* L. (Hutchinson, Silow & Stephens, 1947). The ancient cotton from Sringaverapura falls under the category of Old World cottons; it would, therefore, be desirable to restrain the present study to only the diploid *Gossypium herbaceum* and *G. arboreum*.

Both the Old World species of cotton fall under 'Genome-A' group of the Conventional system of classification given by Beasley (1942), based on cytological grounds. Though, both the species are different from taxonomic point of view, yet there is no difference in the seed-coat anatomy and the hairs (Chowdhury & Buth, 1971). Further, the physical nature of the fibres depend to a considerable extent on the region of seed surface from which they are extracted. The fibres from the apex (micropylar end) of seed, are shorter, coarser, stronger and more mature than those taken from the flanks and the base (chalazal end). The former possess higher ribbon width, lower convolutions per unit length and higher rigidity than the latter (Wealth of India, 1956). According to Dr. N. B. Patil (Personal Communication) a detailed analysis leading to identification of species requires atleast a few milligrams of intact fibres. Being aware of the limitations due to insufficient quantity of the material and that too in the form of fragments, it has not been possible for me to resolve the mystery of ancient cotton as to which species of Old World Cottons it belongs. While comparing the ancient cotton fibres with those of the modern species, one should also keep in mind that ancient cotton may not resemble the present species because of the different directions in its evolution at different rates depending upon its adaptation to an environment and the mutations it has undergone. The ancient cotton from Sringaverapura has, therefore, been referred to *Gossypium herbaceum* L./*G. arboreum* L.

Discussion

The plant remains recovered from Ochre-Colour Pottery (O. C. P.) phase of human occupation dating back from C. 1,050 to 1,000 B. C. at ancient Sringaverapura, consist of rice (*Oryza sativa*), barley (*Hordeum vulgare*), sesame (*Sesamum indicum*) and cotton (*Gossypium arboreum*/*G. herbaceum*). These finds are significant enough from the archaeobotanical point of view as other information on the plant economy of O. C. P. sites are not known, except from Atranjikhera in the Etah District of U.P., dating back from C. 2,000-1,500 B. C. (Saraswat, 1980). A comparable Neolithic plant economy is known from Chirand (C. 1,900-1,400 B.C.) in northern Bihar (Vishnu-Mittre, 1972). The remains of the crop-plants from Atranjikhera and Chirand suggest that the cereal crops of rice, wheat and barley were cultivated with the pulse crops of gram, lentil, pea, khesari, green-gram (mung), etc. in the plains of northern India since second millennium B. C. The occurrence of rice and barley in ancient agricultural economy at Sringaverapura is well understood and self-explanatory.

Northeastern and eastern part of India is the ancestral home of rice. Over the millennia, the annual ancestral forms of *Oryza sativa* began to emerge at the periphery of their wild annual progenitors in this region. Alternating periods of drought and pronounced temperature variation in northeastern India, further accelerated the development of annual *O. sativa* (Swaminathan, 1984). The oldest remains of rice (both wild and cultivated) known from Neolithic Koldihwa (C. 6,000 B. C.) in the Allahabad District (Vishnu-Mittre, 1978; Vishnu Mittre & Savithri, 1980) are suggestive of emerging the intermediate forms between the cultivated rice and their wild relatives due to human intervention, either unwitting or deliberate, during the Neolithic farming about 8,000 years ago. Thus, rice at Sringaverapura is regarded to have been domesticated locally in this region.

The barley is of west Asian origin, while the crops of sesame and cotton are of African origin. These crops are common to the plant economy of the Harappans and their occurrence in northwestern Indian sub-continent predates the O. C. P. cultures in Uttar-Pradesh. In past two decades, a fairly large number of new Harappan sites have been discovered and as a result the area of Harappan culture complex has widened enormously far beyond its earlier limits. The Harappan civilization extended, in the present state of our knowledge, towards the east throughout the regions of Punjab and Haryana, and further up to Hulas (District Saharanpur) and Alamgirpur (District Meerut) in western Uttar Pradesh. The introduction and spread of barley, sesame and cotton beyond eastern borders of Harappan culture, should indeed be attributed to the credit of Harappans.

The sesame (*Sesamum indicum*) has been claimed to be the most important oil seed known to man since ancient times. As a source of oil, its importance was so great in Vedic period that its name meant oil, the metonomy being from oil (Tel) to sesame (Til); and in that case all the other oil seeds raised would be secondary to sesame at the time when sesame obtained its name in the context of ancient civilizations in India. The only record of sesame was known from Harappa (C. 2,300 B. C.). Next to Harappa, Sringaverapura (C. 1,050-1,000 B.C.) has provided the evidence of this oil seed crop in Gangetic Valley.

Until 1960, the only evidence of cotton was known from Mohenjo-daro (C. 1,750 B. C.). This knowledge was increased by the discovery of cotton fabrics at Nevasa (C. 1,500-1,000 B. C.) in Maharashtra (Gulati, 1961) and cotton impressions on pottery at Rupar (C. 500 B. C.) in Punjab (Sankalia, 1970). Now the discovery of cotton in the O. C. P. deposits at Sringaverapura, has further increased the knowledge of this fibre crop in Gangetic plains.

Next to Sringaverapura, the sesame has also been discovered with other food grains of wheat, barley, rice, pea, black gram, green-gram, etc. in the Northern Black-Polished (N. B. P.) Ware period (C. 400 B. C.) at Narhan in Ghagra Valley of Gorakhpur District in U. P. (Saraswat & Sharma, 1985- in press). Here also, the evidence of cotton textile has been encountered, but in much later period (1st-2nd century A. D.). The information on the crop economy in period-I of Sringaverapura is, however, scanty. There may have been other plant remains as well, but factual evidence is lacking However, the present findings are significant as the sesame and cotton are new additions to our knowledge in the ancient agricultural economy in the Gangetic plains of northern India.

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Explanation of Plates

Plate 1

1. Sesame seeds. × 5.
2. Sesame seeds (Enlarged) × 12. Note the marginal lines.
3. Impressions of sesame seeds on mud. × 16.
4. Rice kernels. Note difference in their size and shape. × 10.
5. Paddy husk impression on a pottery piece. × 5.5. Note the characteristic lemma & stalk or rachilla.
6. Barley grains. × 5.5.
7. Cross section of barley stem. × 60.

(CAV—Cavity; CHB—Chess-board pattern of tissue;
EMB—Embryo; FU—Furrow; GT—Ground tissue; LM—Lemma;
ML—Marginal line; RA—Rachilla; RB—Rib; TW—Twist;
VB—Vascular bundle)

Plate 2

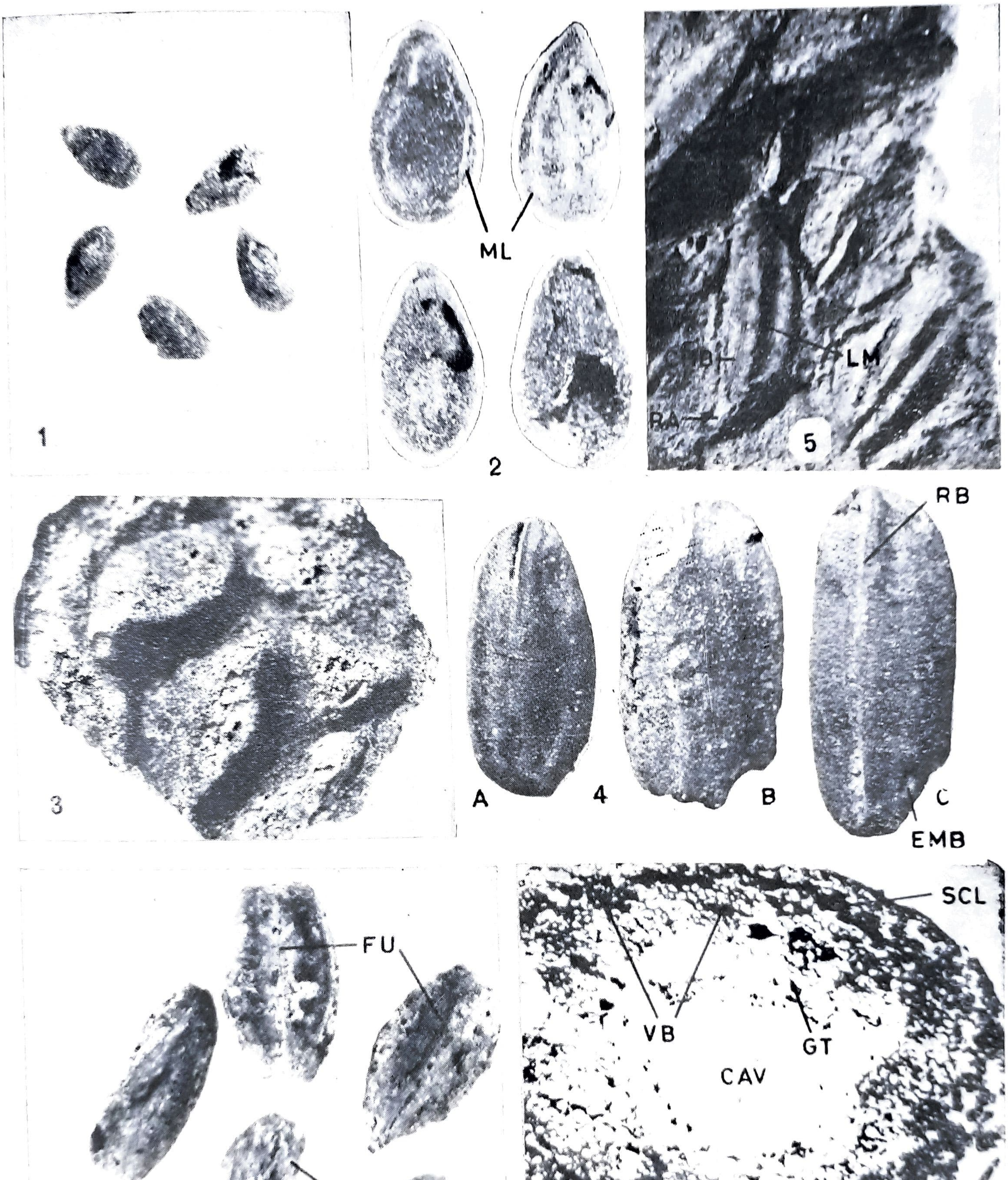
8. Barley leaf-epidermis. × 80.
9. Barley leaf-epidermis (highly magnified). × 275. Note the stomata with parallel sided subsidiary cells.
10. Barley husk-peel. Note short cells with somewhat elliptical silica bodies. × 60.
11. Spherical or rounded silica bodies in barley husk-peel. × 175.
12. Rice leaf-peel showing characteristic "Dumb-bell" shaped short cells over the vein and stomata with triangular and domed subsidiary cells. × 150.
13. Rice-leaf vein with "Dumb-bell" shaped short cells. × 175.
14. Paddy husk under low magnification. × 60.
15. Paddy-husk enlarged. × 550. Note the long, straight projections of the cell wall.
16. Pot-Sherd. Reduced to 3/4 of original size.

(DMB—Dumb-bell shaped cell; IC—Long cell; SB—Silica body; SC—Short cell; SN—Sinuous wall; SP—Spicule; ST—Stomata; V—Vein).

Plate 3

17. Cavity on pot-sherd (Fig. 16). × 2. Note some fibres in the cavity.
18. Fibres inside the cavity. × 20.
19 & 20. Cotton fibres attached to seed-coat fragments. × 70.
21. Cotton fibres. × 70. Note the flattened nature with convolutions.
22. Cotton fibres enlarged. × 300. Note the distinct convolutions and wide lumen.

(C—Convolutions; FB—Fibres; FZ—Fuzz (Short hair); LT—Lint (long hair); LU—Lumen; SDC—Seed-coat fragment).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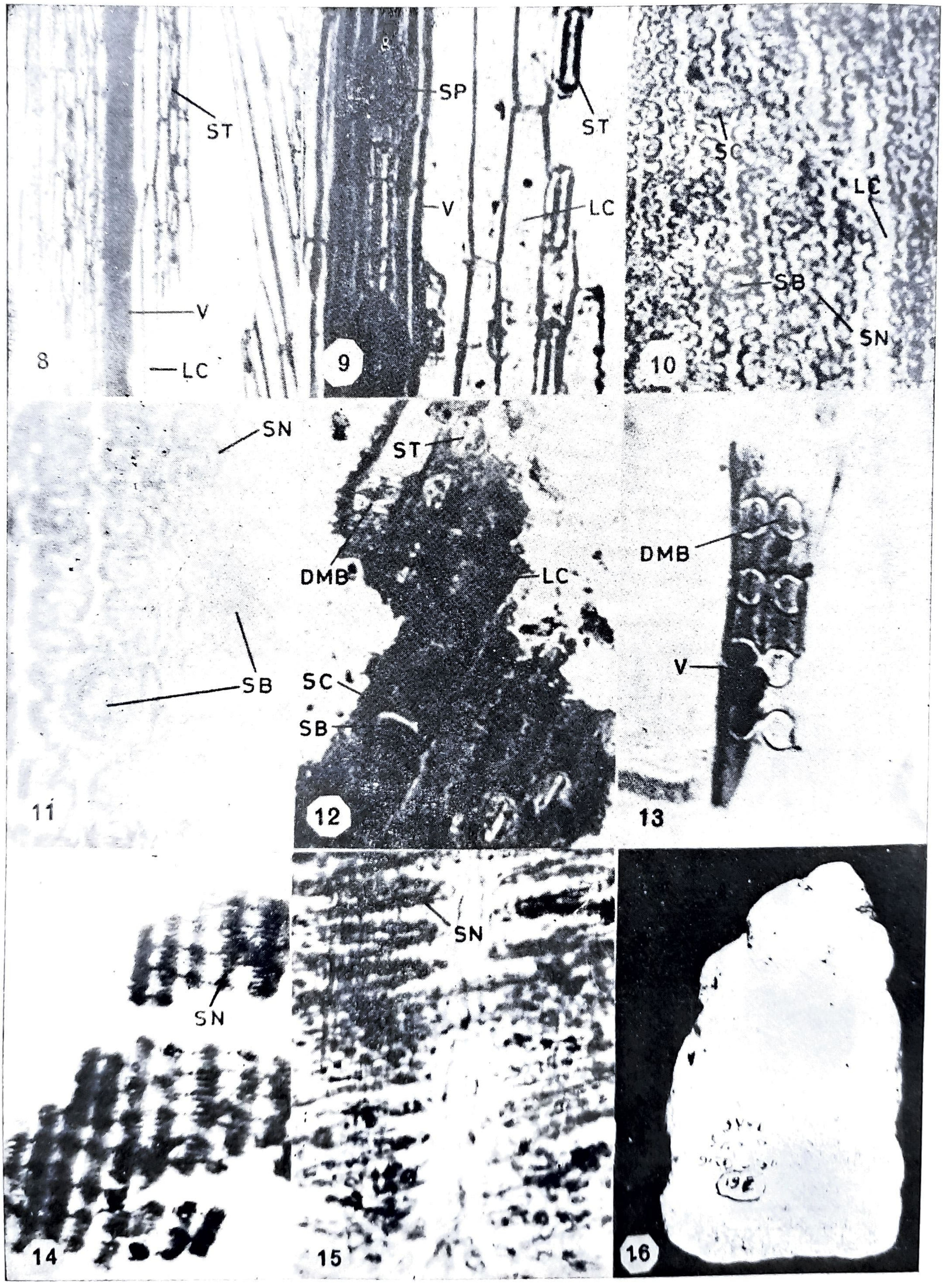
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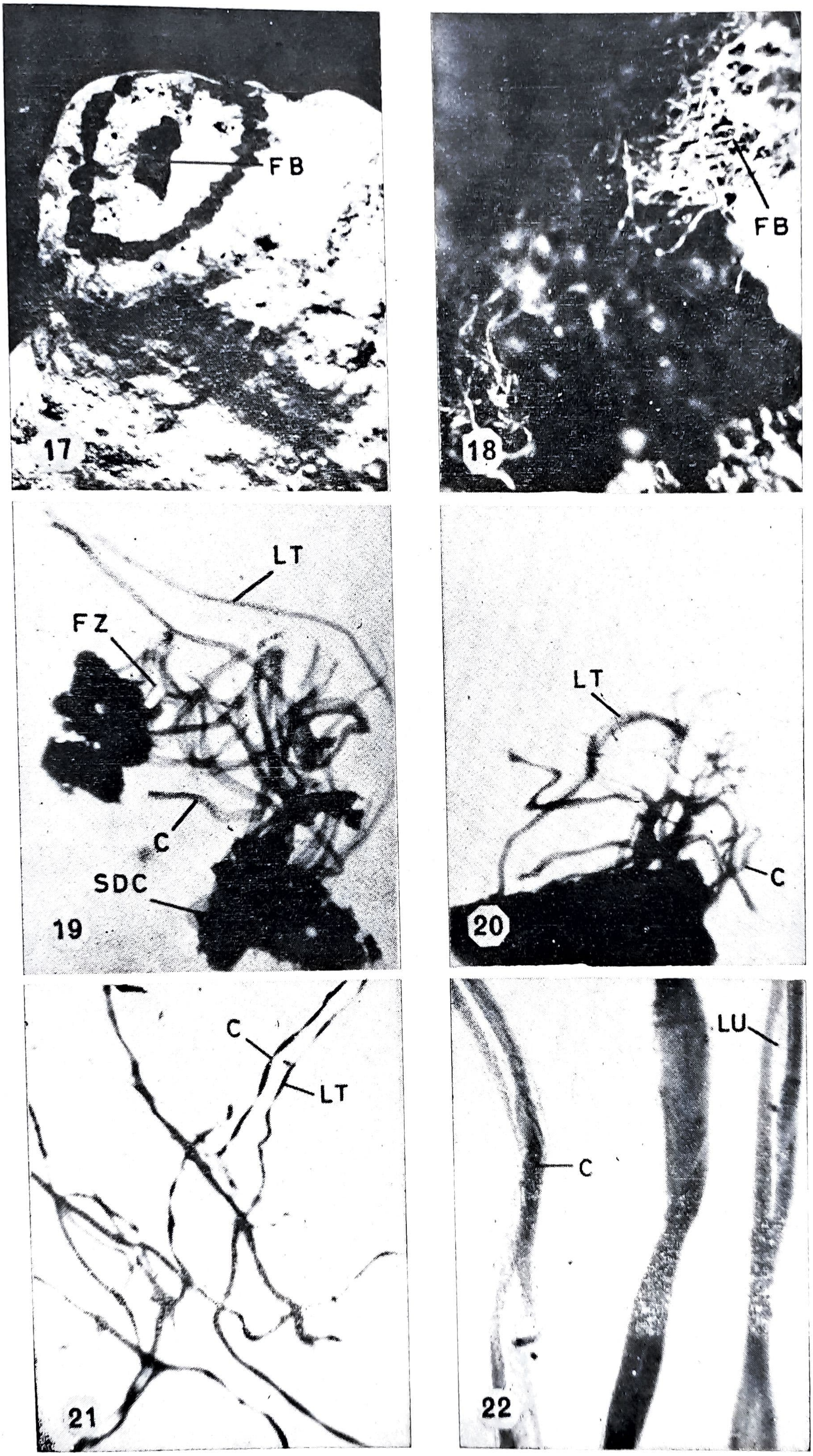
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