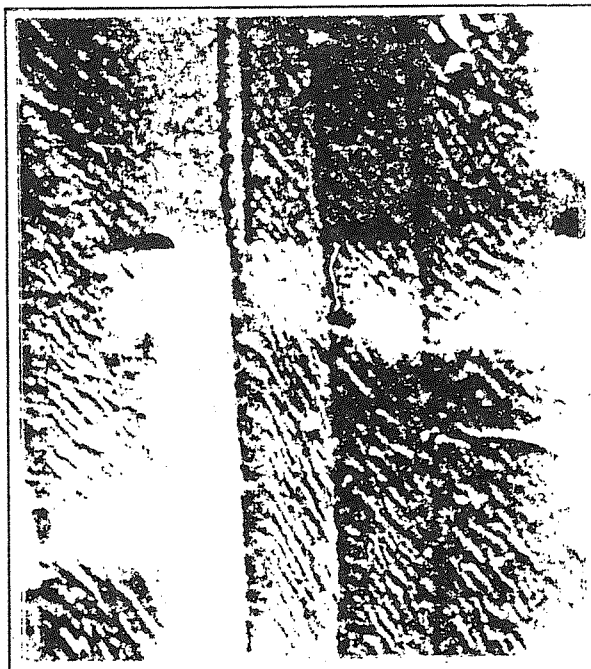

FIG. 16. Fibrils in jute fibres. x2770.

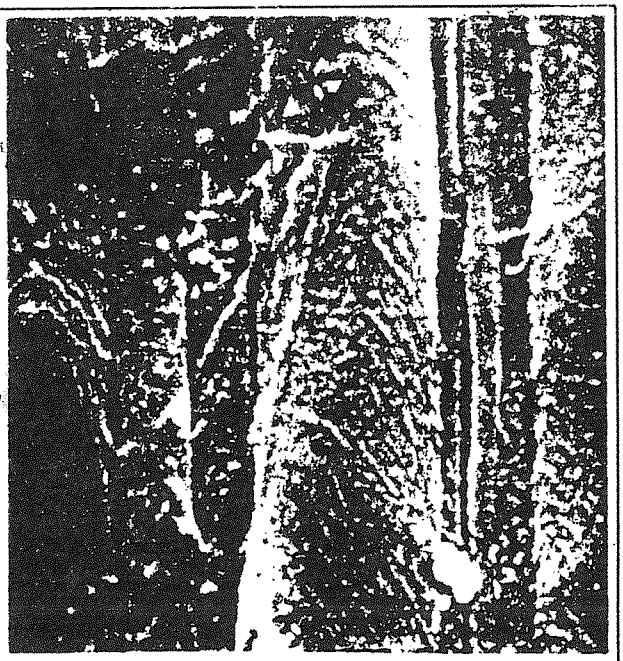

FIG. 17. Remnants of primary cell wall substances and partially visible secondary wall fikrils. x2700.

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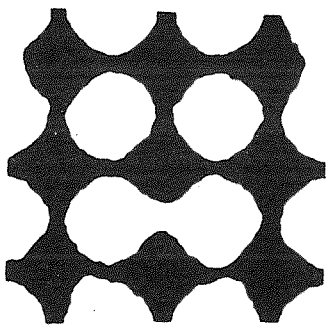


FIG. 11. Retted jute fibres, showing dirts and surface crystals (lignin-based) x500.

FIG. 12. Jute fibre ultimates with a buldge. x1050.

FIG. 13. Pits and tip (marked) of the jute ultimate cell in jute fibre bundles. x990.

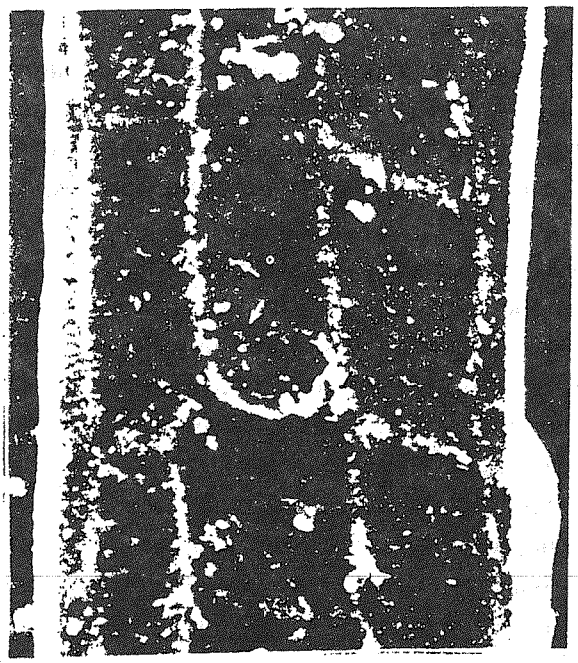


FIG. 15. Dewaxed jute fibres. x990.

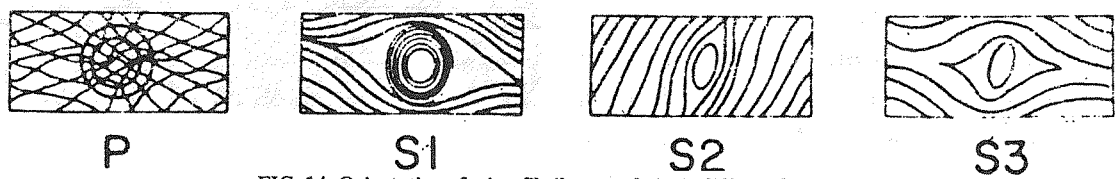


FIG. 14. Orientation of microfibrils around pits in different layers.

(which originally joined them together) is also visible in the figure. Pits found in jute fibres (figure 13) are small, and slit-shaped, with or without tapering ends; they occur in rows more or less parallel with the fibre axis. The pit cavities are generally very narrow and pass through the cell walls at various points, causing local deviation of the fibrils. Needle-shaped end of a jute fibre ultimate can be seen in the figure 13 that clearly shows an excellent example of how the individual ultimate cells in the bast fibres can form technical fibre by adhering intimaterly. A general view of layer by layer orientation of the fibrils around pits is shown in figure 14, adapted from Harada et al [11].

Samples of retted jute fibres, after dewaxing, were examined in the SEM in the normal emission mode of operation. The resultant electron micrographs did not show any marked difference in the surface topography of jute fibres, except that some of the details (such as pits etc) become visible (figure 15). The azimuth of the rows of the surface depressions is variable with reference to the fibre axis. Pits occurring in rows (marked with arrows) and parallel with the fibre axis are generally situated at the trough part of the depressions. Ultimate fibre cells are held together intimately (by the intercellular cementing materials of lignin complex) thus, not surprisingly, it is very often very difficult to identify the line of their separation i.e. middle lamellae. Remnants of the waxy substances as well as the surface crystals can also be seen in the figure 15.

Samples of jute fibres, after removal of water soluble components showed morphological features more distinctly than those previously observed in retted and, subsequently, dewaxed jute fibres. Surface of the jute fibre is clean and most of the adhering impurities and debris have been removed (figure 16). Fibrils (d≤100 nm) in the primary cell wall are seen clearly; the crystalline cellulosic fibrils and their aggregates are irregularly dispersed. The angle of orientation of the primary cell wall fibrils is not constant over the total length of orientation of the primary cell wall fibrils is not constant over the total length of the fibre and differs considerably from the secondary cell wall fibrils in their arrangement and orientation. In the figure 17 the non-fibrillar remnants of the primary cell wall materials can be observed (marked) although rest of the fibre surface showed no trace of the primary cell wall materials. The secondary cell wall fibrils are partially visible in the figure 17.

The detailed study of the effects of progressive delignification on jute fibres can be found in some other publications [4, 12].

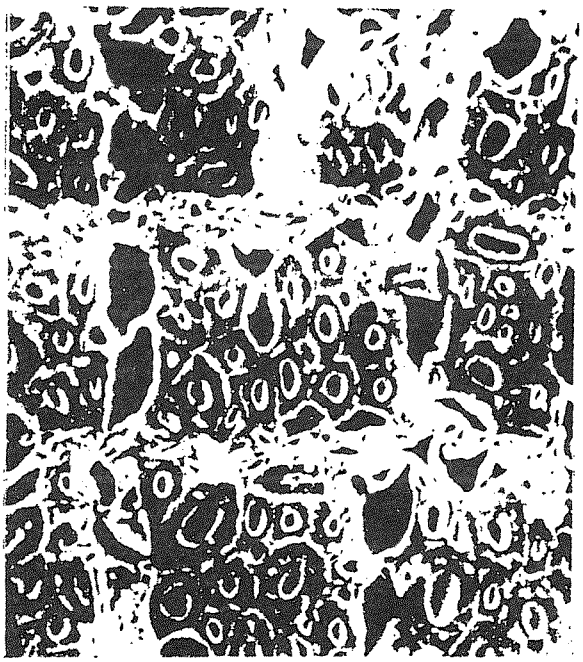


FIG. 10. Cross-sectional view of jute ultimate cells, showing lumen middle lamellae etc. x571.

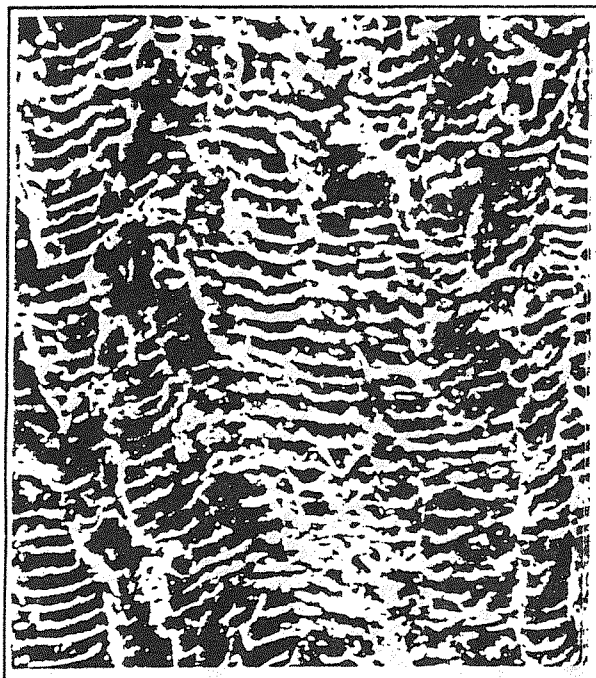


FIG. 6. Surface of jute bark, showing cuticular waxy layers. x 156.

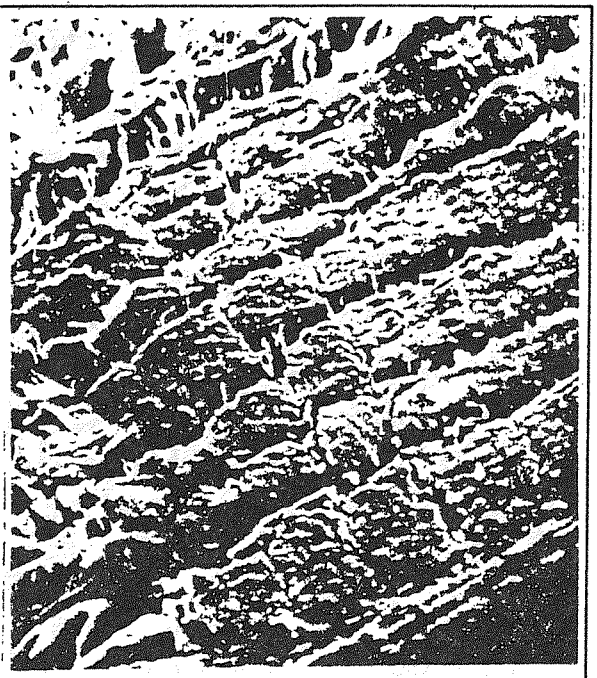


FIG. 7. Strands of jute fibre bundles in the bast & bark part of the stem. x 216.

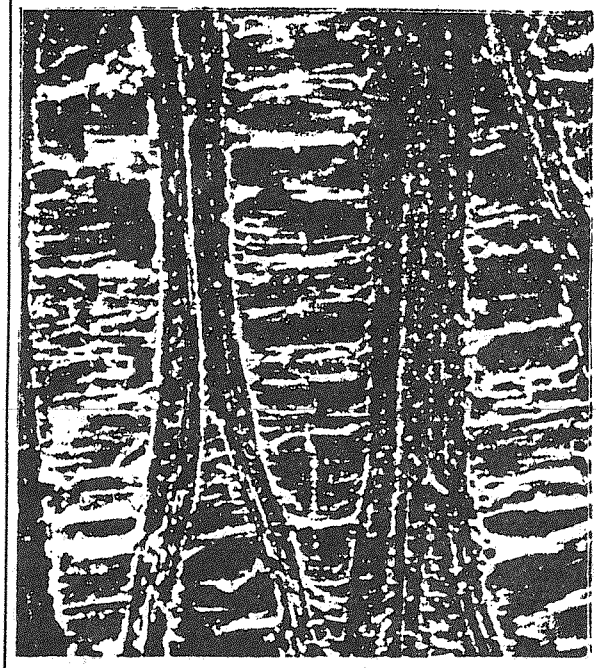


FIG. 8. Anastomosis in jute fibre strands; also showing parencymatous cells. x216.

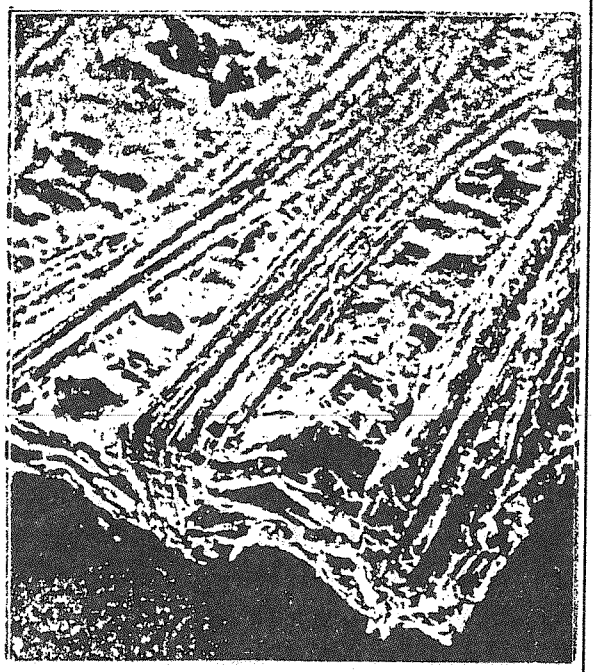


FIG. 9. Jute fibre network consisting of fibres in a wedged pattern. x145.

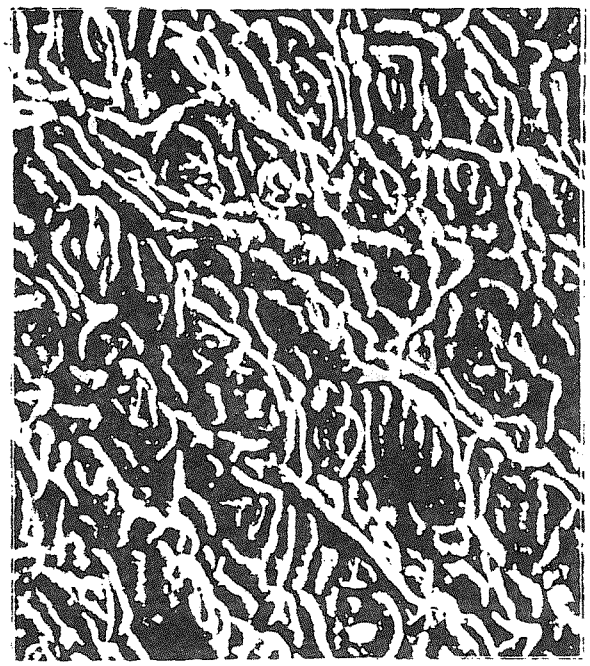


FIG. 4. Surface of jute leaf, showing stomatal guard cells. x 324.

FIG. 5. Surface of jute leaf, showing hairs. x 1215.

There was confusion and contradiction in the published literature regarding the origin of bast fibres, and considering them as either i) pericyclic fibres or ii) pholem fibres. Van Tieghem [6], in developing the concept of the pericycle, used as evidence the stem of Cucurbita, in which a cylinder of sclerenchyma and subjacent parenchyma does occur outside the vascular system. Morot [7] concluded from his study that the pericycle was indeed a characteristic feature of organs reproduction. Many early workers have shown that the mechanical tissue occurring on the outer periphery of the vascular cylinder arises in the pholem and not in the 'pericycle' of the plants. The usual designation of flax fibres (bast fibres) as 'pericycle' has also been challenged by Winter [8', who concluded that the flax fibres of Linum usitatissimum arose from procambium, though close developmental relation between these fibres and the pholem escaped his attention. Kundu [9] has shown that the fibres of Corchorus and Cannabis develop from elongated cell elements amongst the pholem. Despite these researches and confirmations, the uncritical use of the concept of 'pericycle' continues in some of the recent works (e.g. Hayward [10]).

In retted commercial jute fibres (figure 11), the surface details, such as pits, fibrils in the primary cell wall etc, are not generally visible as the composite technical fibre is enveloped by a thin layer of waxy materials, pectins and inorganic matter. Regularly shaped deposits of surface crystals (lignin-based) are also observed in the figure. In the figure 12 two parallel ultimate jute cells (probably of unicellular nature) are observed, with a distortion (or buldge) which could be accounted for by axial forces applied during processing. The lignified middle lamellae between the two ultimate cells

are pholem fibres (e.g. textile fibres) and the xylem or tracheid fibres (e.g. pulping fibres). The term pholem fibres applies to long, narrow cells with closed ends (but not cotton fibre that has one open end). Jute fibre is pholem fibre and is usually occuring in strands (figure 7). Within a strand the fibre overlap. a feature that imparts strength to the fibre bundles. The strands are arranged vertically parallel along the length of the jute stem as well as around the stem axis (taking pith as the axis, cf. figure 1). Among the fibre strands, individual groups of jute fibres are however, arranged in network form (figure 8) called anastomosis. The anastomosis can be clearly observed in fibre strands of commercial jute fibres, even after retting, wherein all the parenchymatous cells has been removed. As the diameter of the jute plant is greatest at the bottom and correspondingly thinnest at the top, similarly the fibre strand networks is compact, thicker and firmer (containing higher fibres) at the bottom, becoming progressively less compact, thinner, losser (and containing less fibres) at the top (cf. figure 8). The complete sheet of jute fibre network consists of layers of fibres in 'wedged' pattern (figure 9) as well as concentric manner. In the figure 10 the transverse section of the jute fibre bundles is shown the lumens of the ultimates are clearly visible. The nature and shape of the lumens are irregular and their range of variation is wide i.e. from circular to triangular or even linear. The outlines of the individual ultimate cells can also be seen in the figure. As with the lumen the outlines of the individual ultimates varies widely i.e. from polygonal to triangular. Patches of parenchyma and pholem cells are also observable in the figure which have partially collapsed during specimen preparation. The cell wall of these parenchymatous cells are very thin.

FIG. 2. Jute plant (Corchorus Capsularis): 1) Flower, 2) Fruit.

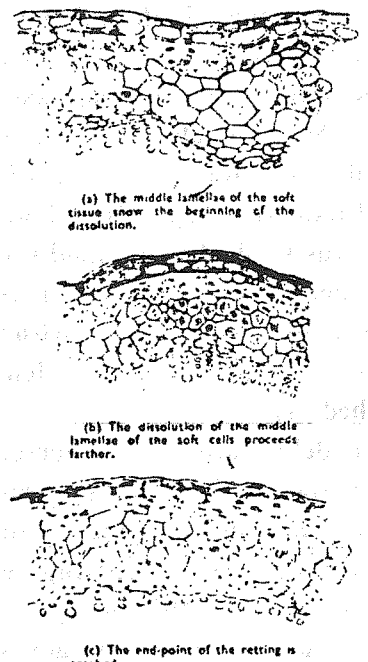


FIG. 3. Diagrammatic representation of retting.

known about their morphology. The study of the surface morphology of bast fibres is of great technological importance in elucidating the processing behaviour of fibres at various stages of industrial processing (i.e. from field to factory). In the present study a number of observations were made, using SEM, to study the nature, distribution and surface morphology of jute fibres; the plants are supplied by the Jute Technological Research Institute of Dacca, Bangladesh.

SPECIMEN PREPARATION:-

Jute stem block was cut into small cubes (approximately 1 to 2 cm) with the help of sharp razor blade; from bottom, middle and top part of the green jute plants. From the above cubes the stem block was separated into two distinct parts: i) one containing bark and bast parts and ii) the other xylem or woody parts (cf. figure 1) by manual method. The parts containing bark and bast (cubes) (reduced to 5-7 mm cube by further cutting) were fixed at 4^0C for 12 hour with Caufield Botanical fixative [3,4]. After fixation, the specimen was washed in distilled water (3 x 50 ml baths per 0.1 g specimen) till free from excess fixatives. After washing with distilled water, the fixed jute blocks were dehydrated as described [4].

After dehydrating, transverse, radial and tangential surfaces were exposed for SEM study by splitting and cutting with sharp razor blades; splitting exposed information about the morphology of different tissue components intact, whereas cutting revealed information about their relative (tissue) position and anatomical details. Retted [5] (figure 3) commercial jute fibres were chemically treated as described [4] and then examined in the SEM without going through the above mentioned fixation and dehydration processess.

Samples exposing transverse, radial and tangential faces were then mounted on the aluminium specimen holder with adhesive. The samples were then immersed in 'Duron' solution in isopropyl alcohol (dilution 1: 10^6) and after shaking off the large droplets, evaporation of the solvent was accelerated by using hot-air blower. Finally, the samples were coated with a layer of platinum/carbon film of about 17 nm in thickness. A beam voltage of 10 KV was maintained when examining the specimen in the SEM chamber.

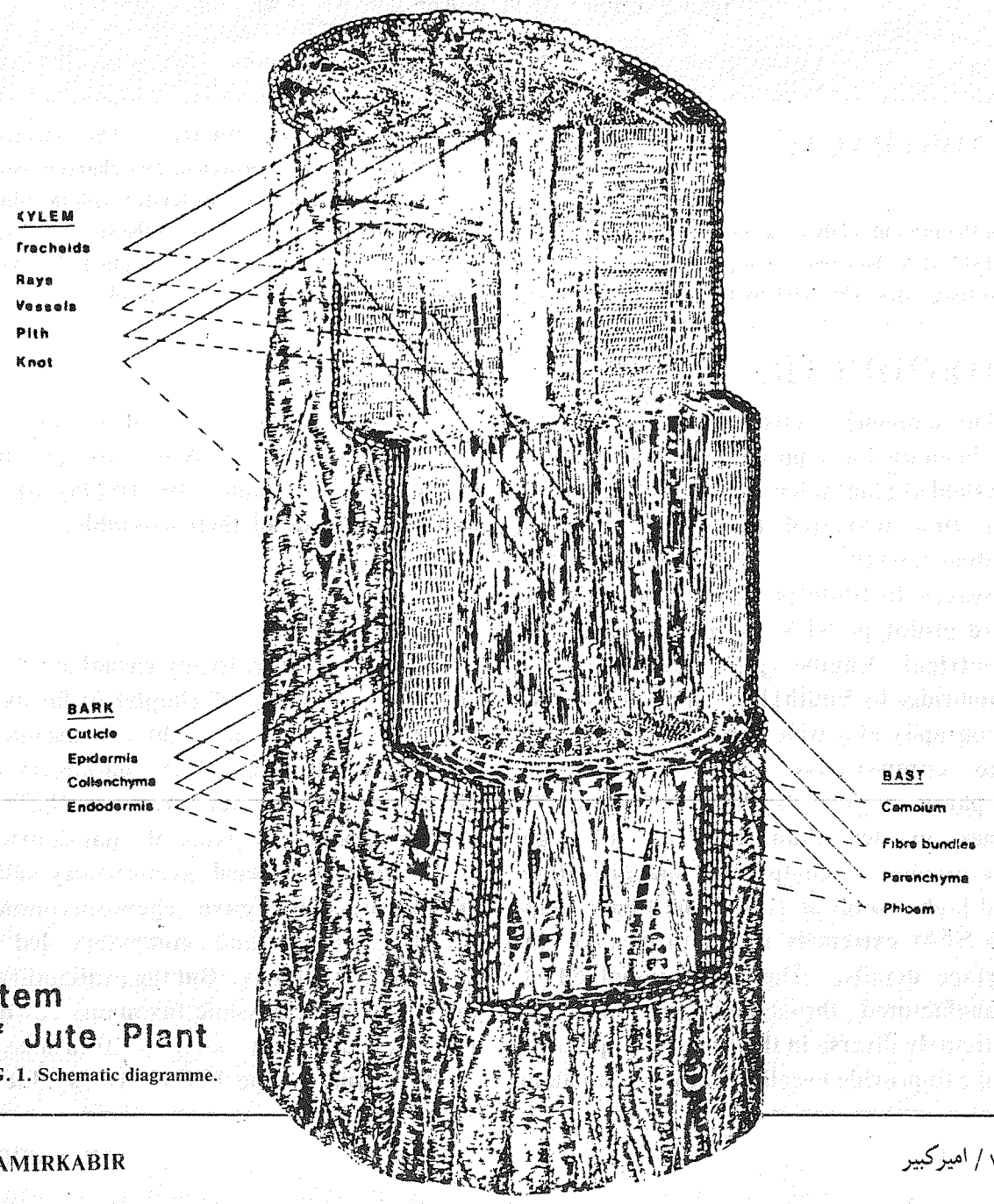
RESULTS AND DISCUSSION

The elaborate structure of the surface of the jute leaf is shown in the figure 4. where in addition to the epidermis and the cuticle, the stomatal guard cells can be easily seen. Functionally and morphologically the above cells are not uniform and among them, apart from ordinary cells, many other types of cells are found in jute leaf, such as hairs (figure 5). The surface of the jute leaf as well as the outer surface of the bark (figure 6) is not wholly waterproof but is sufficiently impervious to water, in order to reduce its loss by evaporation from interior cells and also concerned with restriction of transpiration and with aeration. Cutin and vegetable waxes are also seen in the above figures.

The term fibre is frequently applied loosely to materials that include, in botanical sense, any type of cells besides fibre and also to structures that are not fibres at all. They

resolution better than 0.2 nm. However, from the anatomical and morphological point of view, the SEM is to be preferred because, in addition to the ease of specimen preparation, relatively large samples can be examined directly and three-dimensional image can be readily reconstructed by using stereo-techniques.

An overwhelming majority of jute fibres processed by the textile and related industry are obtaind from the bast part (figure 1) of the stems of dicotyledonous herbaceous plants (figure 2), i.e. such plants whose stem perish together with leaves (such as jute, hemp, flax, kenaf, ramie etc) with the coming of winter. Although among the natural cellulosic fibres, the total consumption of bast fibres in second to cotton, very little is



Stem of Jute Plant

FIG. 1. Schematic diagramme.

SEM STUDY OF JUTE FIBRES

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-:ABSTRACT:-

In the present study an attempt was made to study and elucidate the important topographical features of jute fibre, after chemical treatments, with scanning electron microscope (SEM). The electron micrographs showed improved surface characteristics by removing the impurities associated with the fibres as well as revealed fibrillations in the secondary cell wall. The nature and distribution of jute fibres in the stem of the jute plant was also studied.

INTRODUCTION:-

The scanning electron microscope (SEM) has been used as a powerful scientific tool in the field of plant sciences, since 1965 when it was first marketed for commercial and routine scientific use. The Pulp and Paper Research Institute of Canada installed the third prototype SEM (built in 1959, in the Electrical Engineering Laboratory at Cambridge by Smith [1]) to study the surface topography of a wide variety of specimens. The comparative ease of specimen preparation, great depth of field (some 300 times greater than that of the light microscope, at comparable magnification) and high resolution (say 50 nm) have made the SEM extremely useful to observe fine surface details. The conventional SEMs manufactured throughout the world are extremely diverse in their mode of operation and can provide excellent information about the internal gross structural features of biological cells (provided suitable specimen preparation techniques are employed), as well as the mode of their assembly.

OBJECTS:-

Plant anatomy, to any casual observer, appears to be a 'closed' chapter as far as its investigation with the light microscope is concerned. But the plant anatomists are always on the lookout for the methods of examining and classifying of what Scurfield et al [2] have termed 'evolutionary solid'; chromatography gave chemotaxonomy; whilst statistics and computers led to numerical taxonomy. But the availability of the SEM made possible taxonomy down to 10 nm, although modern transmission electorn microscope (TEM) is capable of