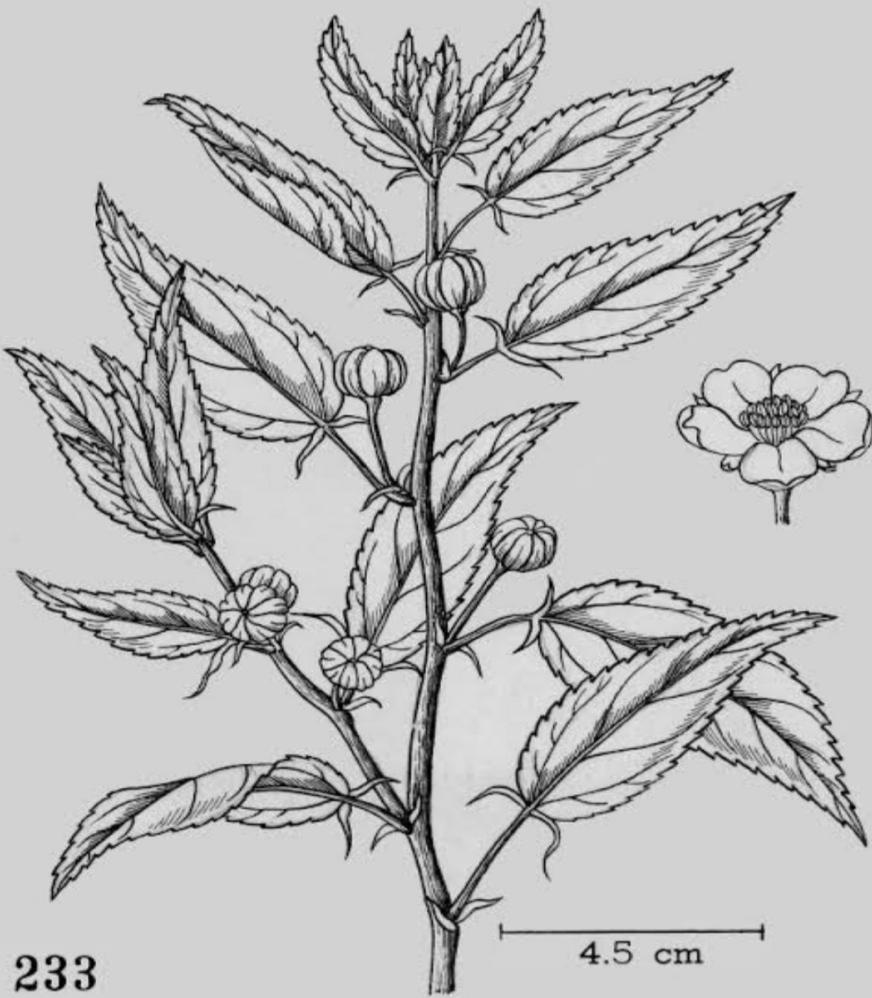


BOTA: SEM 4:CC9

JUTE:: MORPHOLOGY ,EXTRACTION AND USES

PRACTICAL STUDY;SPECIMEN, T.S of Stem;
TEST FOR LIGNIN ON T.S OF STEM
Study of fibre following MACERATION of stem.







3.2.2. Jute

Jute is a natural fibre obtained as an extract from the bark of the white jute plant *Corchorus capsularis* and to a lesser extent from tossa jute (*Corchorus olitorius*) [Mohanty 2005]. Jute is a long, soft and shiny fibre that can be spun into coarse, strong threads and is one of the cheapest natural fibres. It is also the most versatile, eco-friendly, natural, durable and antistatic fibre available. The plants are retted by the same method used for flax. The resulted jute strand, which are up to 3 m long, are composed of many very short fibres,

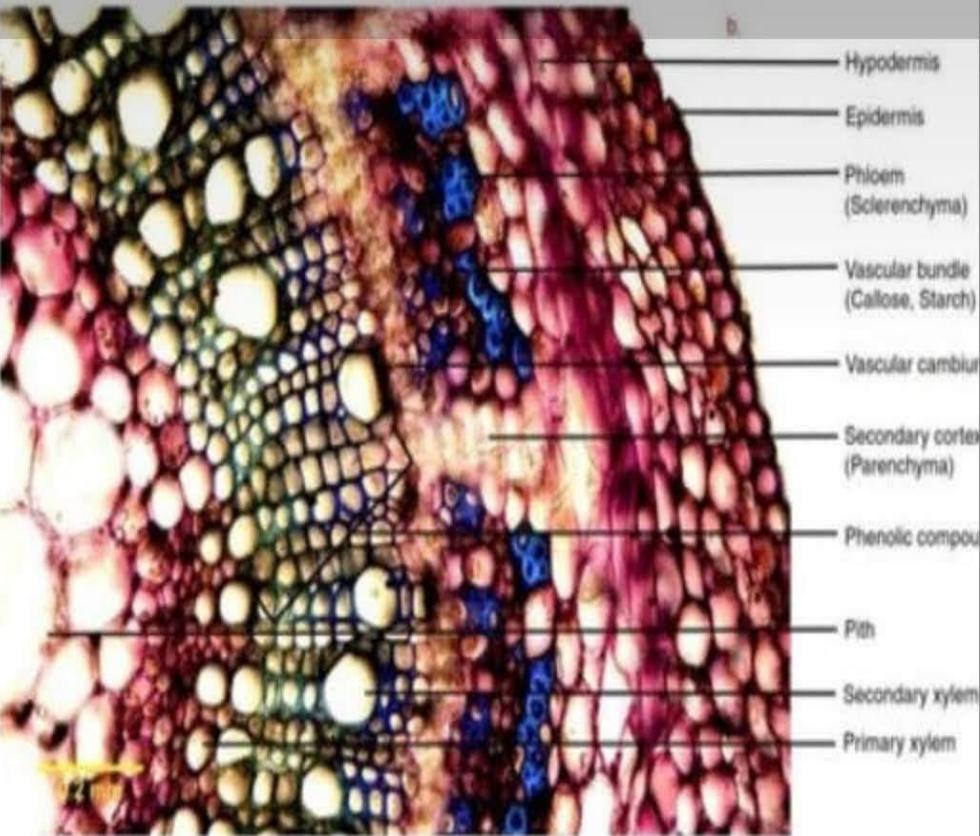
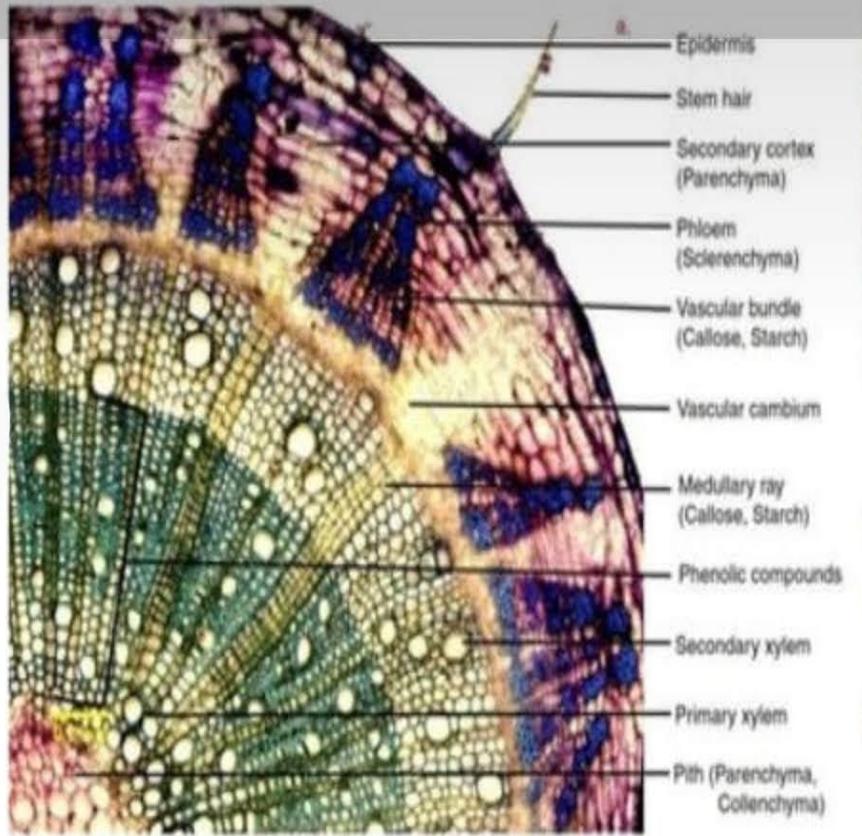
elementary fibres (length between 0.5-6.0 mm, diameter 26-30 µm) held together by lignocelluloses. The fibres contain between 61-71% cellulose, large amount of hemicelluloses (14-20%) and lignin (12-13%) and pectin (0.2%) [Mather 2011]. The cross-sections of bundles of jute fibres show a range in the size and number of fibres per bundle, in the thickness of the wall and in the shape and diameter of lumens. The fibre is generally smooth, with some dislocations. The individual fibres are mainly polygonal, with rounded corners and oval to round lumens (Figure

5) [Hearle 1963]. Jute has a moderate strength (30-45 cN/tex), however it is not as strong as flax or hemp. For fibres low extension at break (1-2%) is characteristic. Moisture regain of jute fibres is 12.6%, but it can absorb up to 23% of water under conditions of high humidity. Jute has high insulating and anti-static properties and low thermal conductivity [Cook 1993, Mwaikamno 2009].

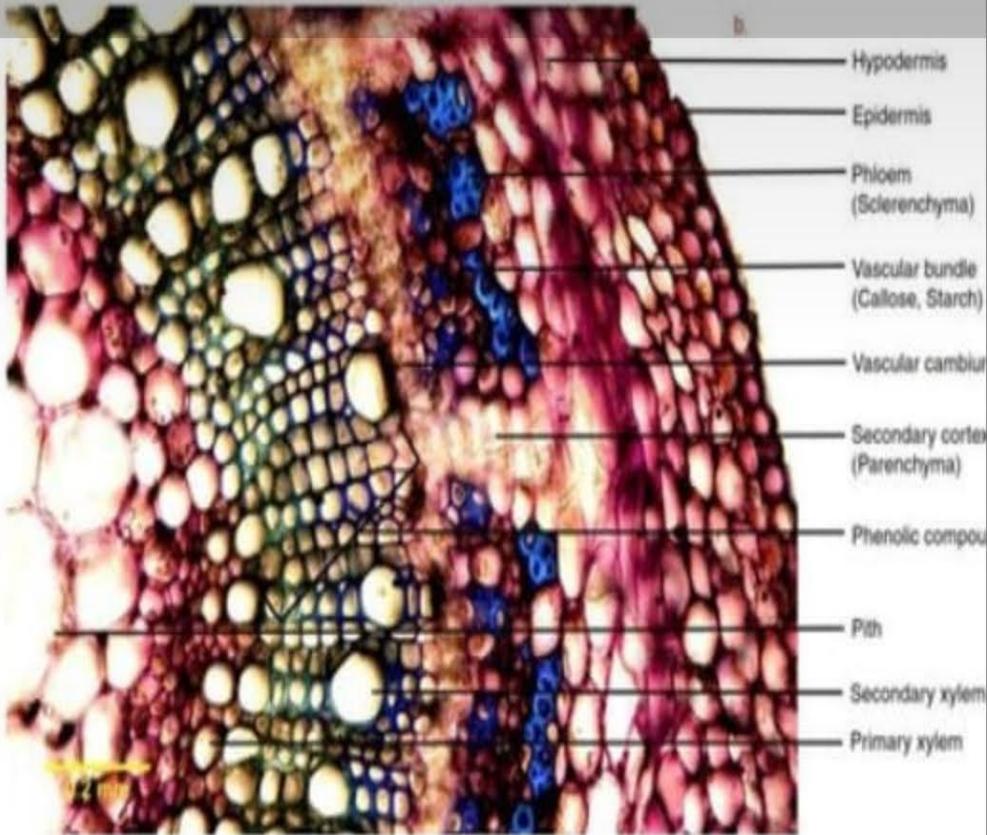
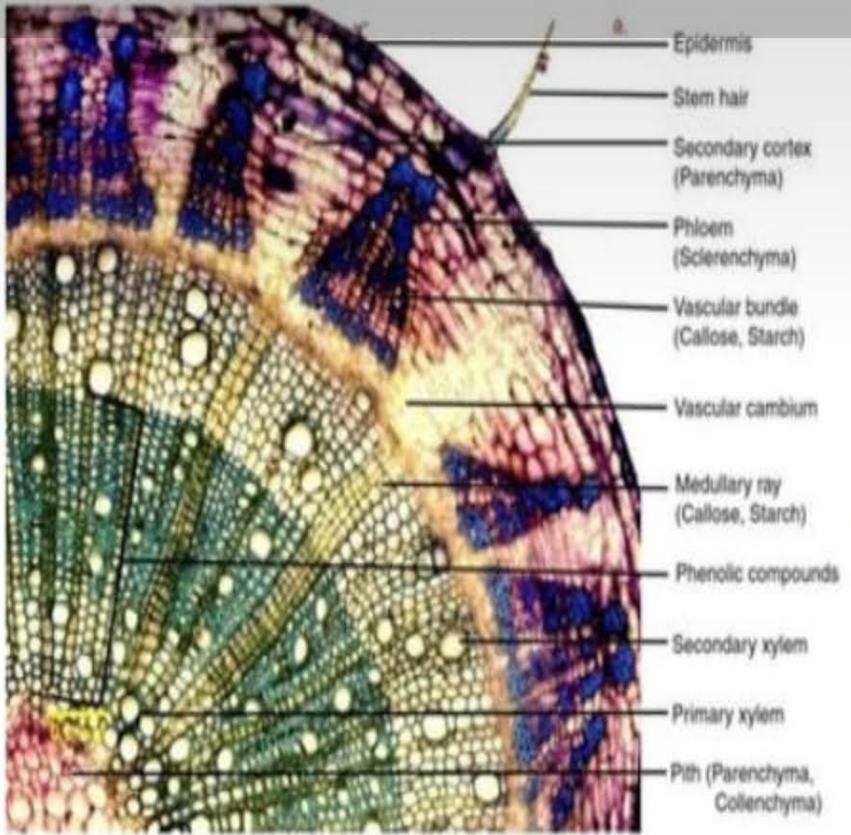


Figure 5.

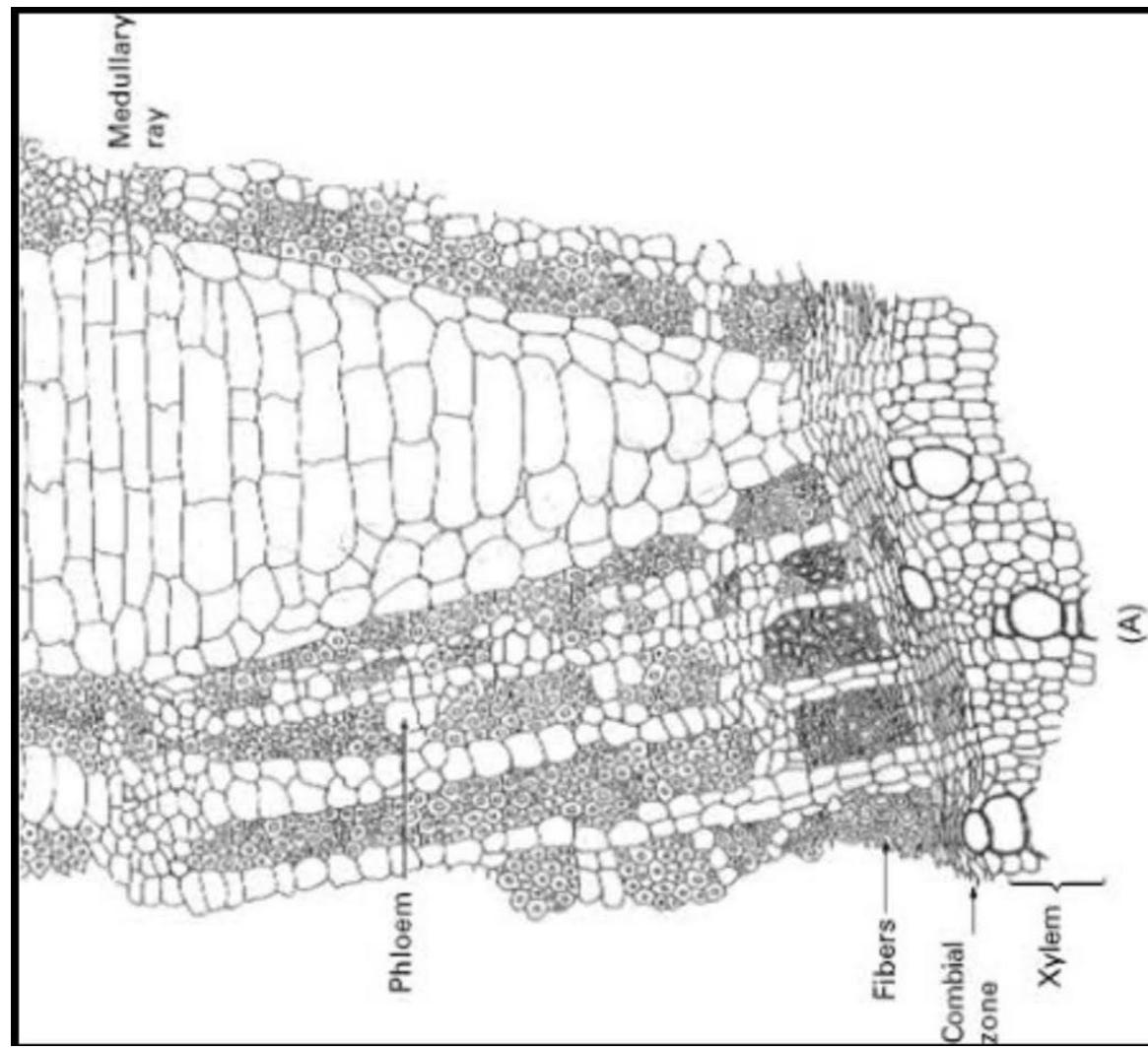
a) Longitudinal view (5000 \times magnification) and b) cross-section (180 \times magnification) of jute fibre



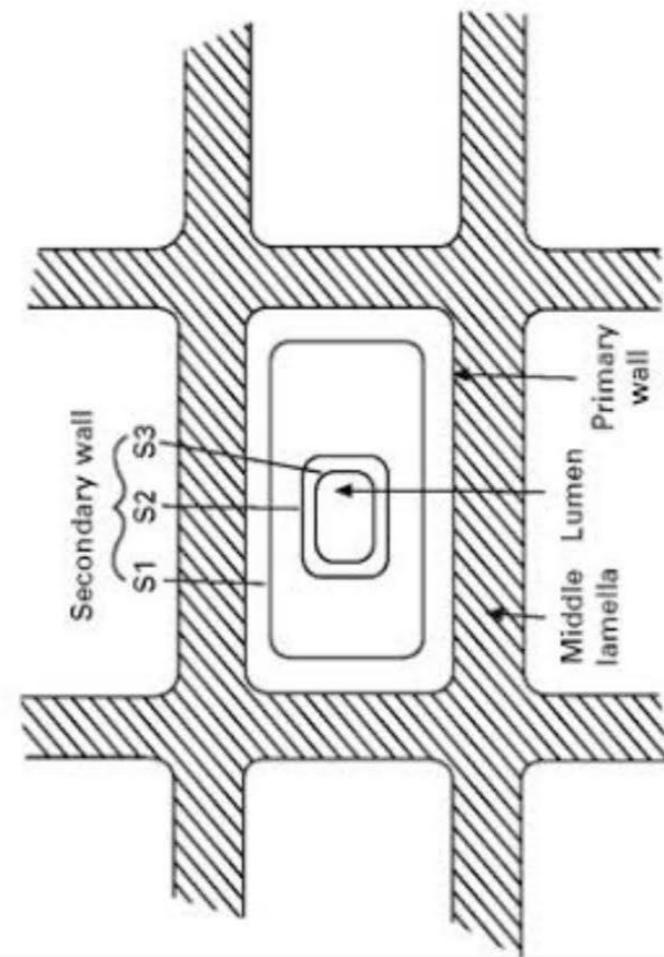
Jute stem section, stained with tubulin blue. a. *C. olitorius* var 0-4 and b. *C. olitorius* var 0-4

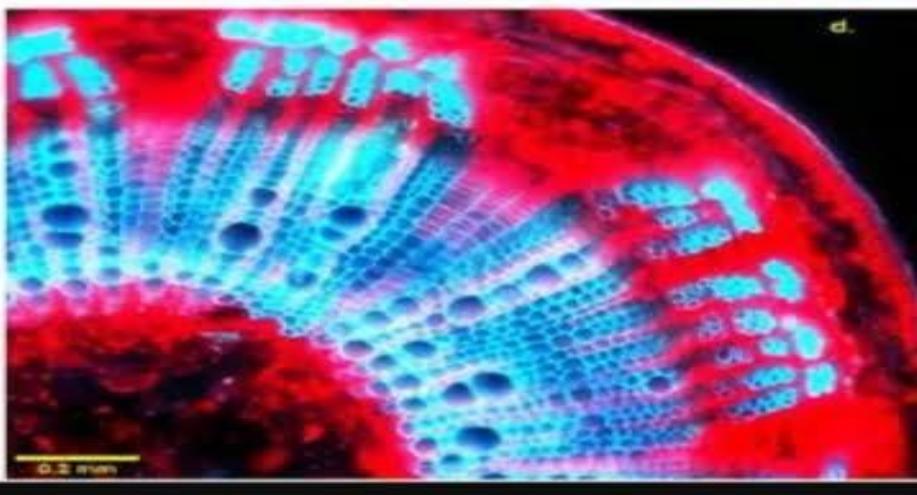
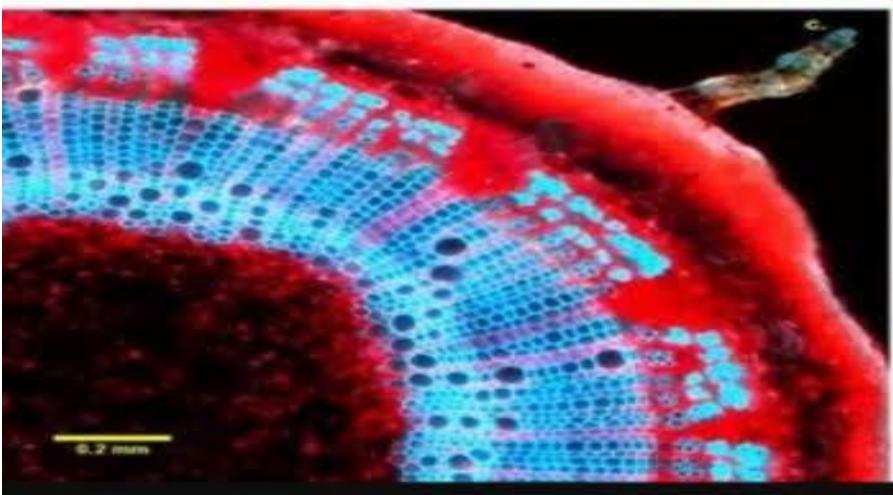
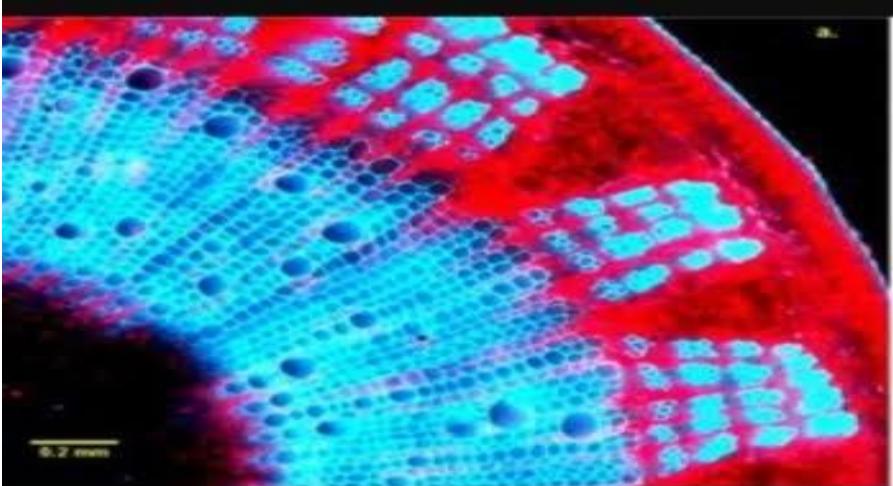


Jute stem section, stained with tubulin blue. a. *C. olitorius* var 0-4 and b. *C. olitorius*

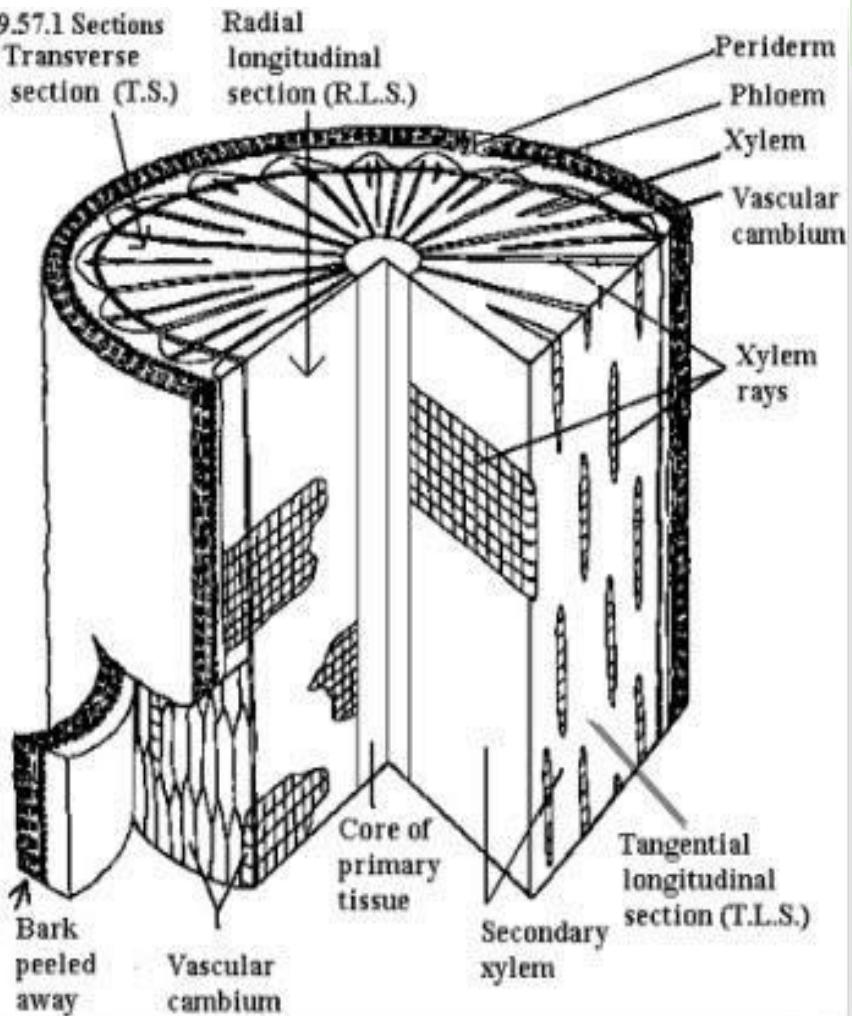


(A)



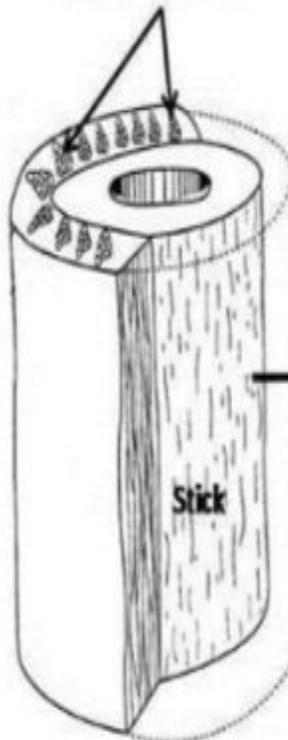


9.57.1 Sections
Transverse
section (T.S.)



JUTE FIBRE

Bundles or fibres

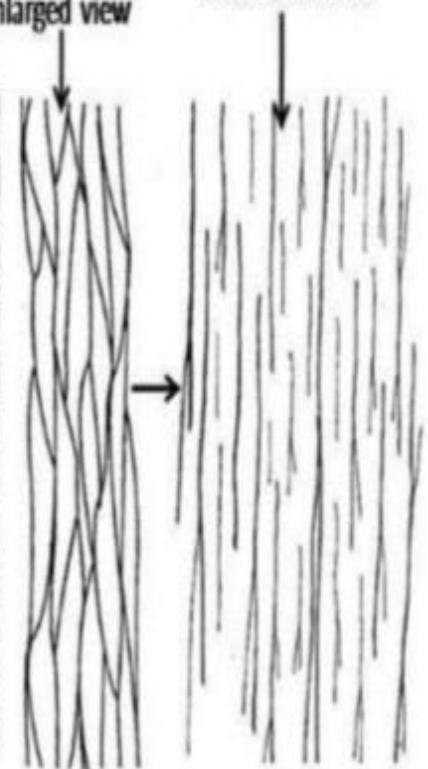


Meshy structure in jute reed

a) Close view b) Enlarged view



Individual fibres



(Before retting)

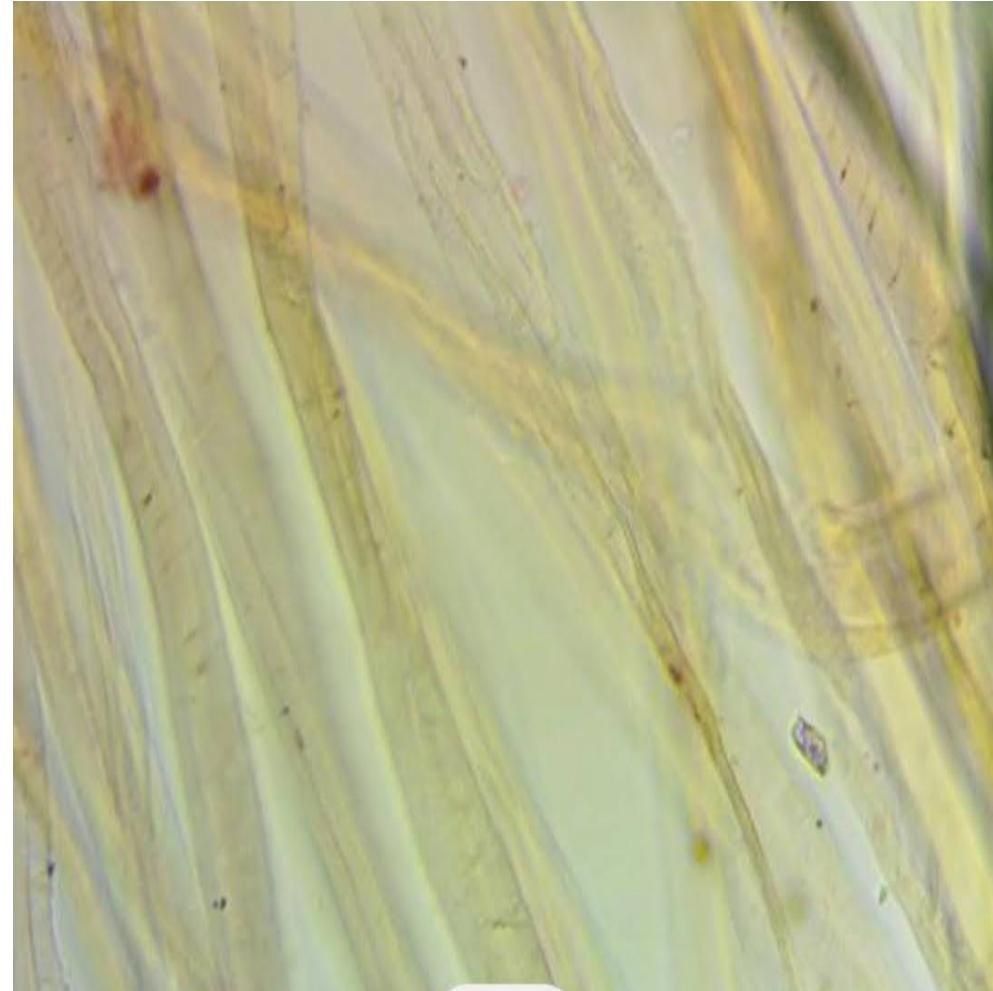
(After retting and fibre extraction)

(Before spinning)





microbeauty.blogspot.com



Natural Fibers - Jute Fibers

7. Preparation of macerated plant materials

Macerated plant materials are excellent for the study of plant cell types. A small quantity of the macerated tissues may be mounted in glycerine and observed under microscope.



Procedure

1. Cut the plant tissue (stem or root) into small pieces of not more than 1 mm thick.
2. Put the tissue into freshly prepared macerating fluid. The fluid is prepared by mixing equal volumes of 10% chromic acid with 10% nitric acid.
3. Leave the tissue in the macerating fluid for about three days. (The exact number of days required depends on the type of plant material being used.)
4. Tease the tissue with dissecting needles. If the cells do not separate readily, leave the tissue in the macerating fluid for another day. If the cells separate easily, they are ready for the next step.
5. Filter off the macerating fluid and wash away the acids from the macerated material with water.
6. The macerated plant material may be stored in 70% alcohol.
7. The macerated material is ready for temporary mounting.

Note

1. Flowering Chinese cabbage, Chinese kale and Zebrina are suitable plant materials.

CA
nitr
Ave

15.10 Wood Macerations Are Useful for Species Identification, Product Identification, and Forensics

In order to visualize the individual cells of wood from virtually all directions, a process of cellular separation is often employed that chemically and/or enzymatically dissolves the middle lamella and then allows for the individual cells to be viewed. This process is termed maceration. □ Figure 15.10a–d reveals such structures from a variety of woods. The maceration process typically involves treating small pieces of wood with 10% nitric and/or chromic acid or potassium chlorate, which breaks down the middle lamella but does not damage the primary and secondary walls. After up to 24 h in that solution, the cells are washed in distilled water and can be examined by light (or laser confocal) microscopy. If greater contrast is required, staining with safranin (red) or methyl green solutions can be employed.

In maceration the plant tissue is treated with chemicals which dissolve the middle lamellae and also some or most of the cells with thin cellulose walls and allow the remaining cells to become separated from one another.

Jeffrey's Method:

Cut the material (dry or fresh) into small slices about 0.5 mm thick. Boil and cool repeatedly until they become free of air. Macerate in a solution of equal parts of 10% nitric acid and 10% chromic acid. The material with the solution may be heated in a paraffin bath for woody tissues but not for soft and herbaceous tissues.

The duration of treatment depends on the hardness of the tissue, but cells begin to separate in about 24 hours' time. A glass

rod with rounded end may be used to tap the material gently in order to loosen the cells. If the material does not crumble easily, change the macerating fluid and continue treatment. Wash thoroughly in water to remove the acids.

Usually, the macerated tissue along with the fluid mixture is poured into a large volume of water and the macerated bits are picked up with a brush. A centrifuge may be used to separate the macerated tissues, if it is available. The material is now stained with any suitable stain, such as eosin or water soluble safranin, mounted in 50% glycerine and observed.

Nitric acid reacts with KClO_3 to produce potassium perchlorate (KClO_4) which is highly reactive and toxic. It should never be allowed to bump and the fumes must not be inhaled. Always keep the mouth of the test tube directed away from your body.

Shake the tube regularly. Take it away from the burner frequently. Minor accidents often occur due to negligence. Maceration takes place very quickly and the entire tissue dissolves, if it is slightly overdone. Wash the tissue immediately when maceration appears to be still incomplete. Stain as before.

2. Both woody and herbaceous materials can be macerated in a mixture of 10% nitric acid and 10% chromic acid taken in equal proportions. Cut the materials into thin slices and take them in a test tube along with some macerating fluid. Boil as before, taking greater precaution to avoid bumping. AVOID INHALING THE VAPOUR as nitric acid vapour is highly toxic. Wash and stain as before.

3. Very hard, woody materials are macerated with conc. nitric acid along with a pinch of potassium chlorate (KClO_3). Cut the materials into thin bits and take them in a test tube along with a little conc. nitric acid. Add a pinch of KClO_3 and boil taking utmost care.

There are other methods which are much quicker:

1. Herbaceous materials, such as Cucurbita stems are cut into thin slices and taken in a test tube along with a little 10% or 20% KOH solution.

Hold the test tube with a test tube holder and boil it over a burner keeping the mouth of the test tube away from your body. Shake the tube frequently to avoid bumping of the material. Add more KOH solution, if necessary. When the tissue comes out in shreds, wash and stain as before.

The material is now stained with any suitable stain, such as eosin or water soluble safranin, mounted in 50% glycerine and observed.

For permanent staining, leave the macerated tissue in 1% safranin for 6 hours, rinse thoroughly in water and then dehydrate by rapid addition of hygrobutol. Give two changes of pure hygrobutol and then add a little balsam highly diluted with hygrobutol. Evaporate it down to a mounting consistency. Mount this on slides.

The duration of treatment depends on the hardness of the tissue, but cells begin to separate in about 24 hours' time. A glass rod with rounded end may be used to tap the material gently in order to loosen the cells. If the material does not crumble easily, change the macerating fluid and continue treatment. Wash thoroughly in water to remove the acids.

Usually, the macerated tissue along with the fluid mixture is poured into a large volume of water and the macerated bits are picked up with a brush.

Standard macerating procedure is to use 1 part 30% hydrogen peroxide soln, 5 parts glacial acetic acid and 4 parts water - prepared just before use. This is obviously corrosive so care should taken.

For non-woody tissues bits of the material are put in screw top vials and left at 60 °C for 12-24 h WITH THE SCREW CAPS LOOSE. Test a chunk of the material to see if it will tease apart. If not add abit more fluid and return to the oven. When maceration is complete drain off the fluid and wash the tissue several times with water.

For woody tissue the procedure is the same except that it may take several days to achieve a result. The vials can be vigously shaken to disperse the cells or a small chunk of material can be placed on a slide in a drop of water, a cover slip placed over the top and then gentle tapping applied with the end of a seeker or similar.

I seem to remember that you can also simply boil material in NaOH solution.

Stains that could be used are phloroglucinol-HCl or Toluidine Blue O.

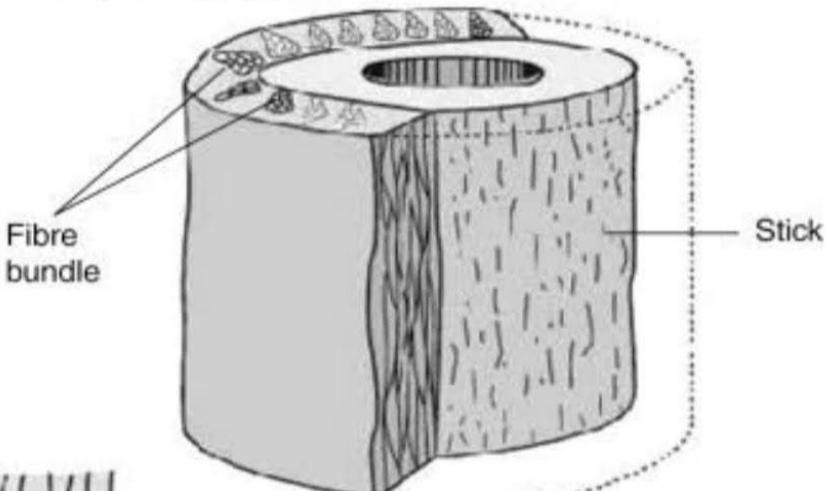
Longitudinal view



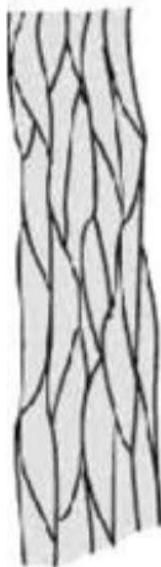
Cross-sectional view

Middle Lamella

Section of a jute stem



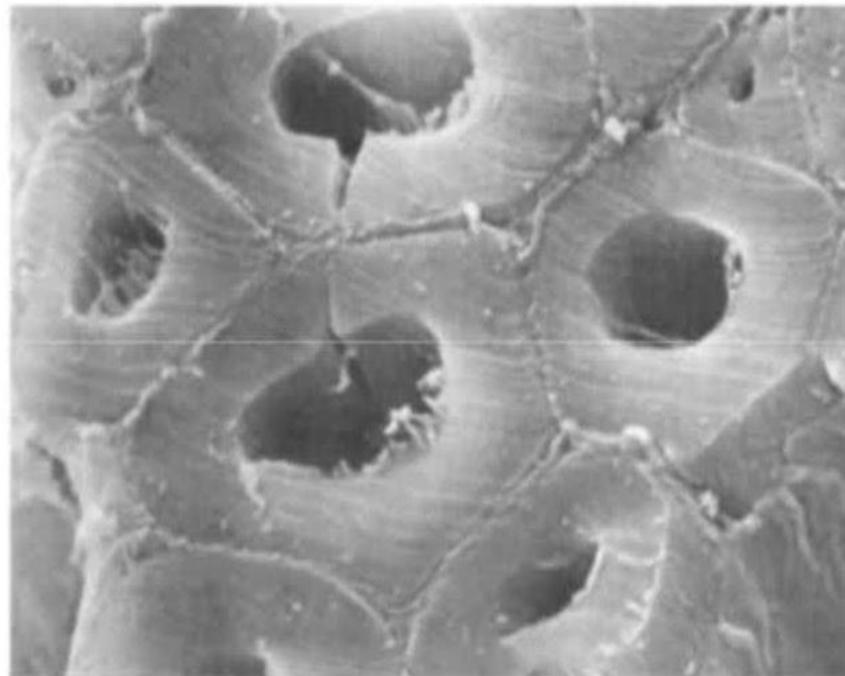
After retting



Jute reed section
(with meshy structure)



Cross-sectional view



Part of a fiber bundle of jute as seen in transverse view under the scanning electron microscope. The cementing material between the ultimate fibers can be clearly seen. Magnification 7600.

20 μm

7.4 FIBER STRUCTURE

In each plant, the rings of fiber cell bundles form a tubular mesh that encases the entire stem from top to bottom. Two layers can usually be distinguished and connected together by lateral fiber bundles, so that the whole sheath is really a lattice in three dimensions [14]. The cell bundles form the links of the mesh, but each link only extends for a few centimeters before it divides or joins up with another link. After extraction from the plant, the fiber sheath forms a flat ribbon in three dimensions.

The jute or kenaf fiber of commerce refers to the sheath extracted from the plant stems, whereas a single fiber is a cell bundle that forms one of the links of the mesh. Staple length, as applied to cotton and wool fibers, has no counterpart in the base fibers, and, as a preliminary to spinning, it is necessary to break up the sheaths by a carding process. The fragments so produced are the equivalent of the staple fibers of the cotton and wool industries.

When a transverse section of a single jute fiber is examined under the microscope, the cell structure is seen clearly. Each cell is roughly polygonal in shape, with a central hole, or lumen, comprising about 10% of the cell area of cross section, as shown in Figure 7.2. In the longitudinal view the fiber appears as in Figure 7.3, which shows the overlapping of the cells along the length of the fiber. The cells are firmly attached to one another laterally, and the regions at the interface of two cells is termed "the middle lamella." Separation of cells can be effected by chemical means, and they are then seen to be thread-like bodies ranging from 0.75 to 5 mm in length, with an average of about 2.3 mm. The cells are 200 times longer than they are broad, and, in common terminology, are referred to as "ultimate" cells. A single fiber thus comprises a bundle of ultimates.

Transverse sections of single fibers show that the number of ultimate cells in a bundle ranges from a minimum of 8 or 9 to a maximum of 20 to 25. Bundles containing up to 50 ultimate cells are reported.

7.8 FINE STRUCTURE

The location of the three main chemical components of the fibers are reasonably well established. Alpha cellulose forms the hulk of the ultimate cell walls, with the molecular chains lying broadly parallel to the direction of the fiber axis. The hemicellulose and lignin, however, are located mainly in the area between neighboring cells, where they form the cementing material of the middle lamella, providing strong lateral adhesion between the ultimates. The precise nature of the linkages that exist between the three components, and the role played by the middle lamella in determining the fiber properties, are not completely understood. Lewin [26], some years ago, in an interesting literature survey on the middle lamella of base fiber, brought together a great deal of relevant information that highlighted many of the problems, but a thorough understanding of the intercell structure is still awaited.

X-ray diffraction patterns show the basic cellulose crystal structure, but, in jute and kenaf, although the crystallite orientation is high, the degree of lateral order is relatively low in comparison with, for example, flax. There is also considerable background x-ray scattering arising from the noncellulosic content of the fiber.

The cellulose molecular chains in the secondary walls of ultimate cells lie in a spiral around the fiber axis. The effect of this is to produce double spots in the x-ray diffraction

7.9 PHYSICAL PROPERTIES

Jute and kenaf are strong fibers, exhibiting brittle fracture, but having only a small extension at break. They have a high initial modulus, but show very little recoverable elasticity.

Ultimate length	1.5-4 mm	Strength	3-4 gm/den	Resiliency	Bad
Ultimate diameter	.015-.020 mm			Dimensional Stability	Good
No. of ultimate in X-section	6-10	Elongation	1.7% at the break	Abrasion Resistance	Average
Fibre length	5-12 feet	Specific Gravity	1.5	Effect of Light and Heat	Average
Color	White, Off white, Yellow, Brown, Grey,	Moisture Regain	13.75%	Effect of Micro Organism	Good (better than cotton)

Chemical Properties:

1 . Effect of Acids: Easily damaged by hot dilute Acids and conc. cold Acid.

2 . Effect of Alkalis: Fibers are damaged by strong alkali. Fibers

3 . Effect of Bleaches: Resistant to bleaching agents (Bleaching agent, H_2O_2 , NaOCl , NaClO_2 , Na_2O_2 , CH_3COOH , KMnO_4 etc.)

4 . Effect of Light: Color changes slightly in presence of sun light. It happens due to presence of lignin in fiber.

5 . Effect of Mildew: Prevention

ability is better than Cotton and Linen.

6 . Dyeing ability: Easy to dyeing. Basic dye is used to color jute fiber.

Chemical Properties:

1 . Effect of Acids: Easily damaged by hot dilute Acids and conc. cold Acid.

2 . Effect of Alkalis: Fibers are damaged by strong alkali. Fibers

Identification of jute fiber:

There are different tests which could be used for the identification of the jute fiber.

There are given below :

Non-technical Test:

1. Feeling test
2. Burning test

Technical Test:

1. Microscope test
2. Density measurement test
3. Staining test

4. Chemical test

Feeling test: Stiff and a harsh hand to human skin, feels bad against skin.

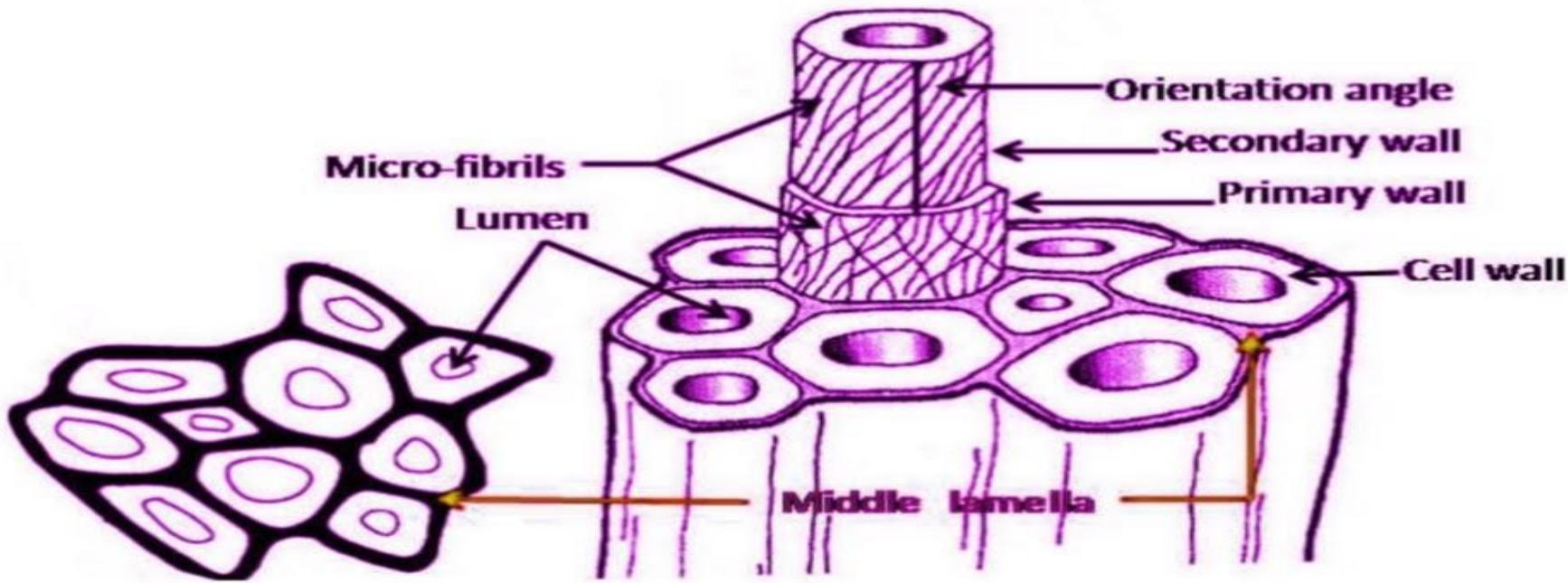
Burning test: Not melt, burn easily, smell like paper burning, because paper is also a cellulosic material.

Microscopic identification:

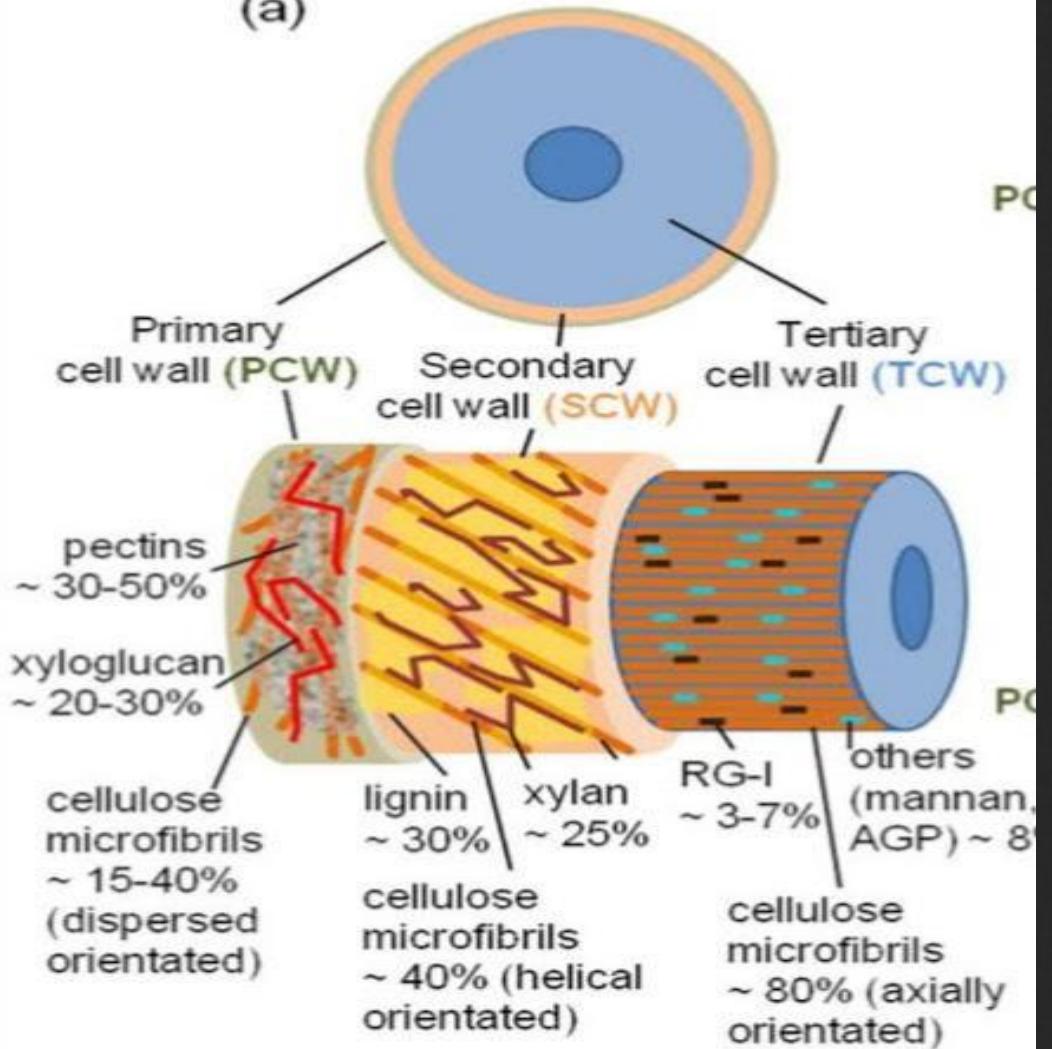
Polygonal shaped cross-section and many ultimate cell of longitudinal view identified jute fiber.

Solubility: Jute is dissolved in 58% H_2SO_4 in warm condition.

Fig.2 Cross-sectional view and micro-structure of jute fibre

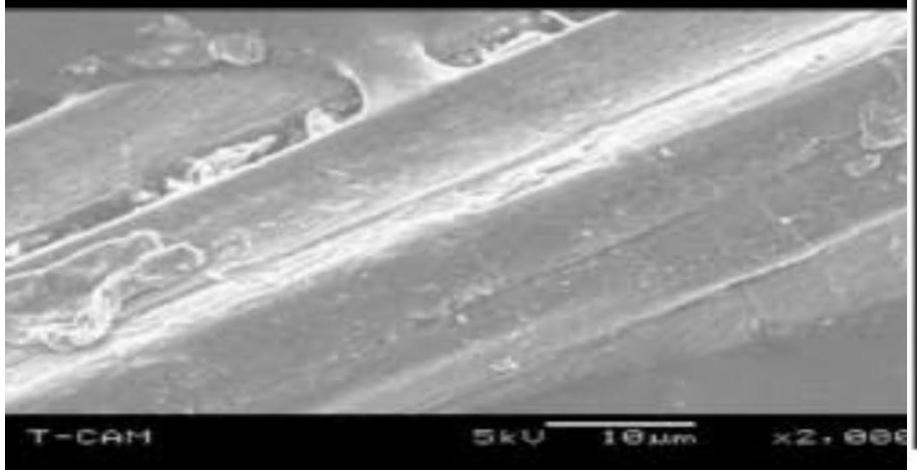


(a)

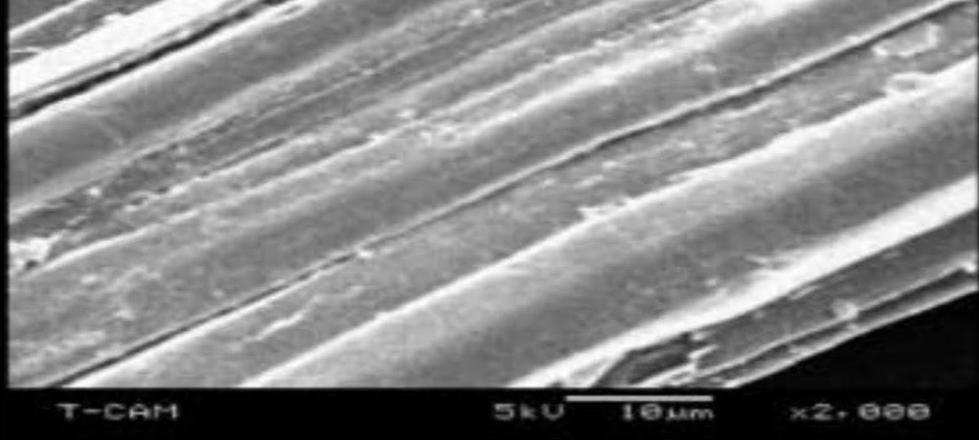


B) Jute Fibre

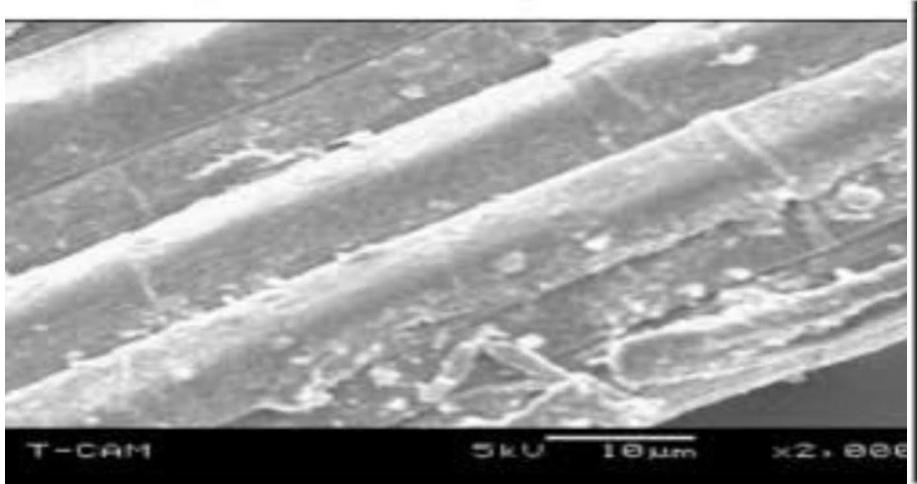
Jute fibres are very long (1 to 4 metres), silky, lustrous and golden brown in colour. In contrast to most textile fibres which consist mainly of cellulose, jute fibres are part cellulose, part lignin. Cellulose is a major component of plant fibres while lignin is a major component of wood fibre; jute is therefore partly a textile fibre and partly wood. Jute fibre has strength, low cost, durability and versatility.



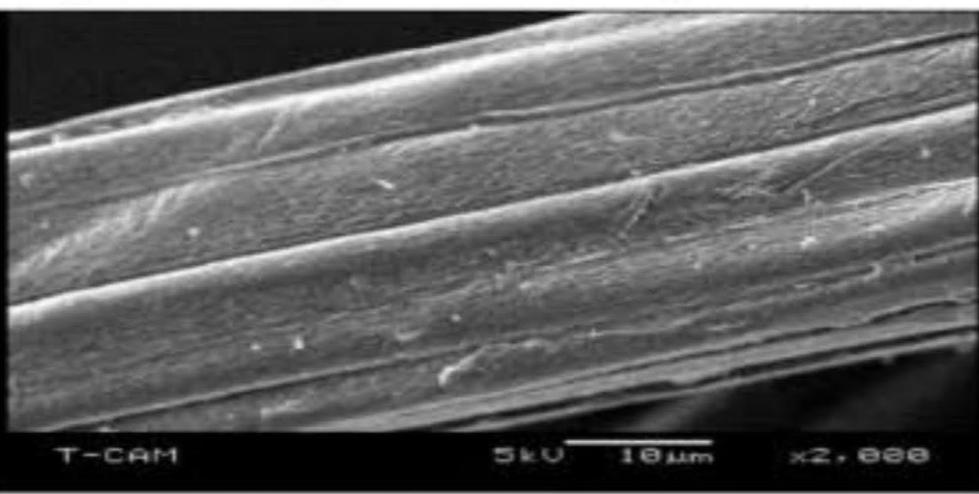
(a) Untreated jute fiber



(b) Detergent washed jute fiber



(c) Ethanol washed jute fiber



(d) Final treated jute fiber

Structure of Fiber

- Commercial jute varies from yellow to brown to greyish in color.
- The bundle of fibers held together by gummy material; **lignin** which plays an important role in structure of plant.
- By contrast with the regular lumen of flax, that of jute is irregular; it becomes narrow in places quite suddenly.

The Chemical Composition of Jute is given below

Components	Percentage (%)
Cellulose	65.2
Hemi-cellulose	22.2
Lignin	10.8
Water soluble	1.5
Fat and wax	0.3

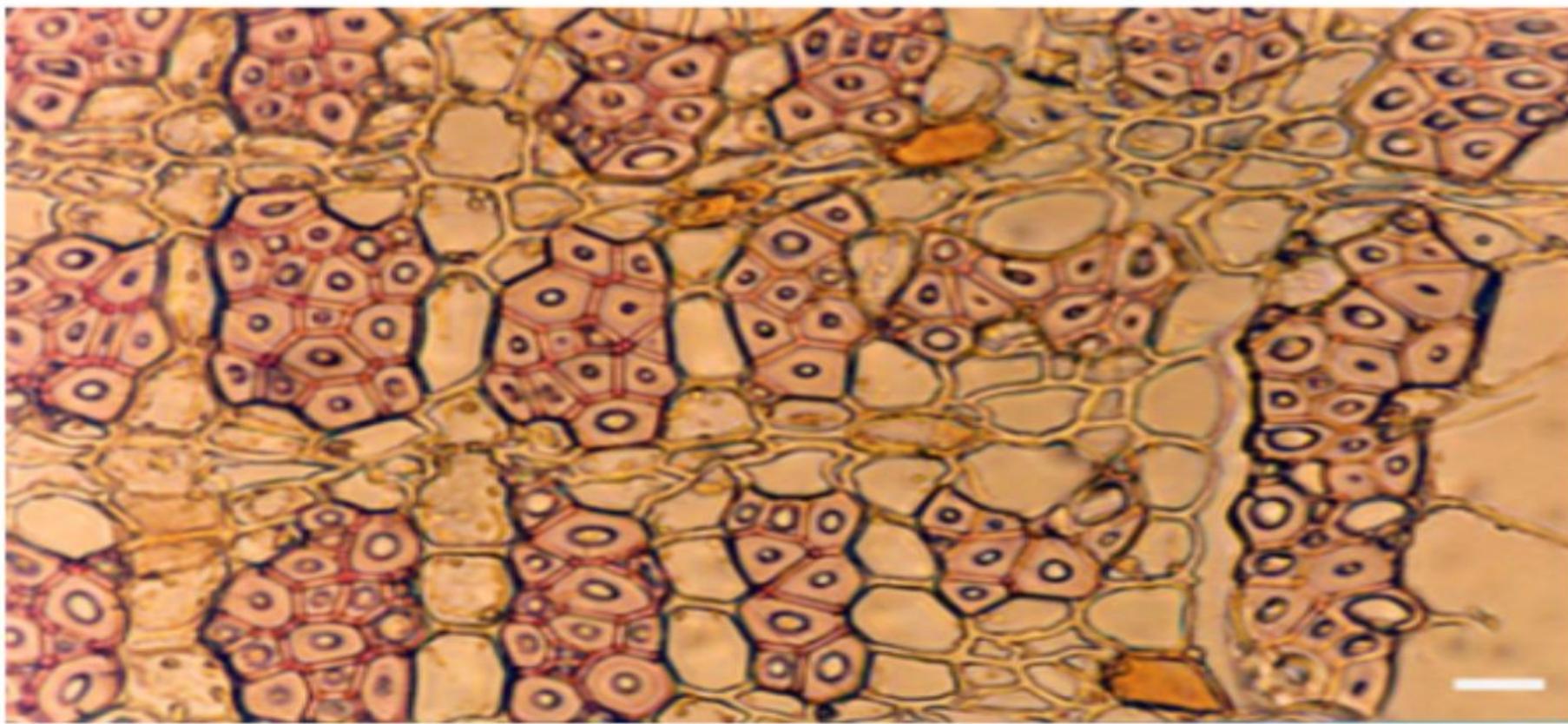
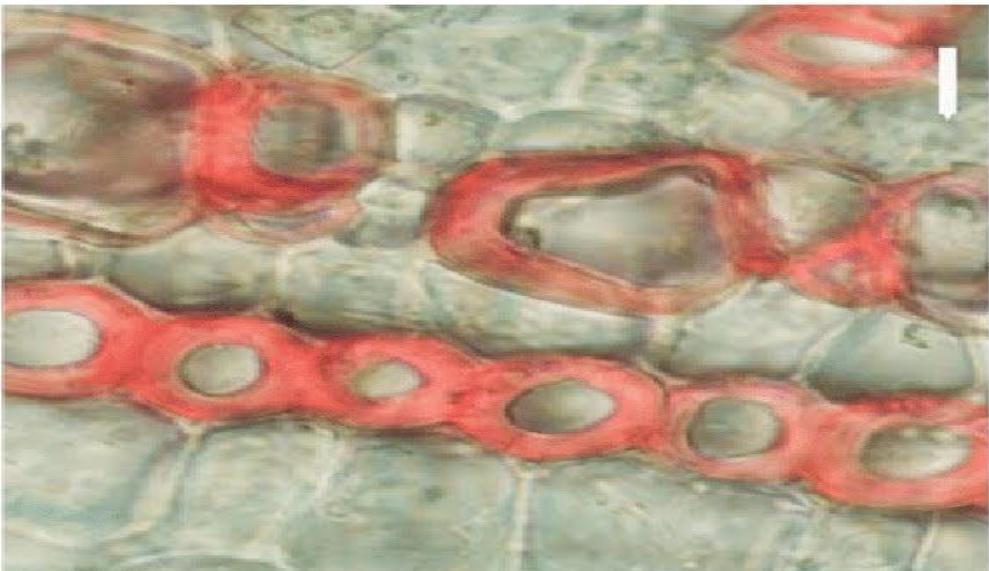
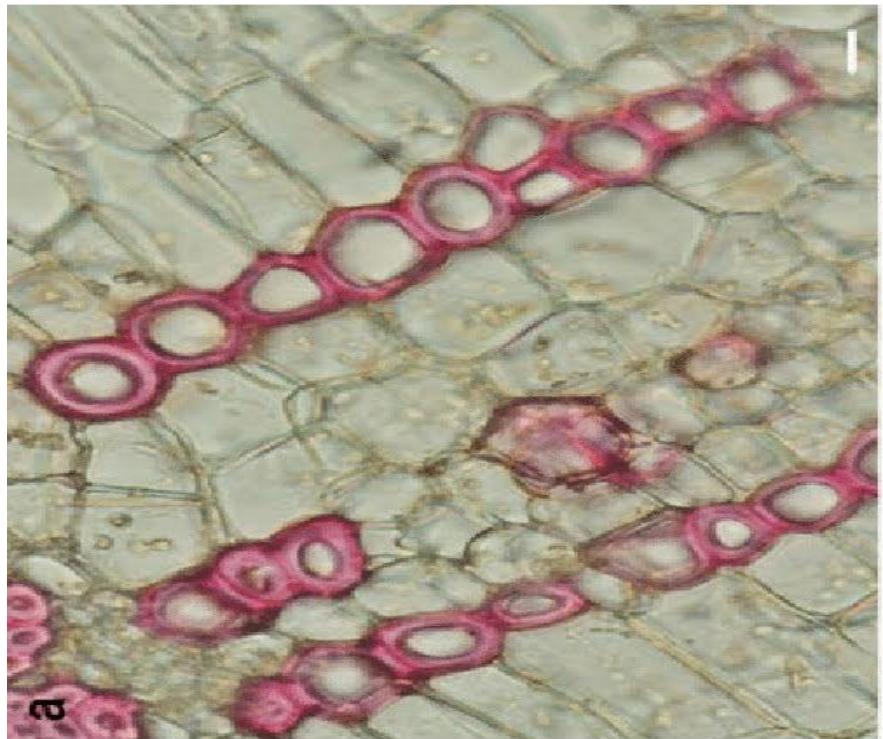


Fig. 1 Variation in shape and size of fibre bundles in a single fibre wedge. *Scale bar* 50 μm

On the contrary, the higher the lignin content in the fibre, the greater the linear density (g/km) or tex of the fibre will be (Fig. 6); consequently, more lignin in the fibre would lead to less fine fibre.

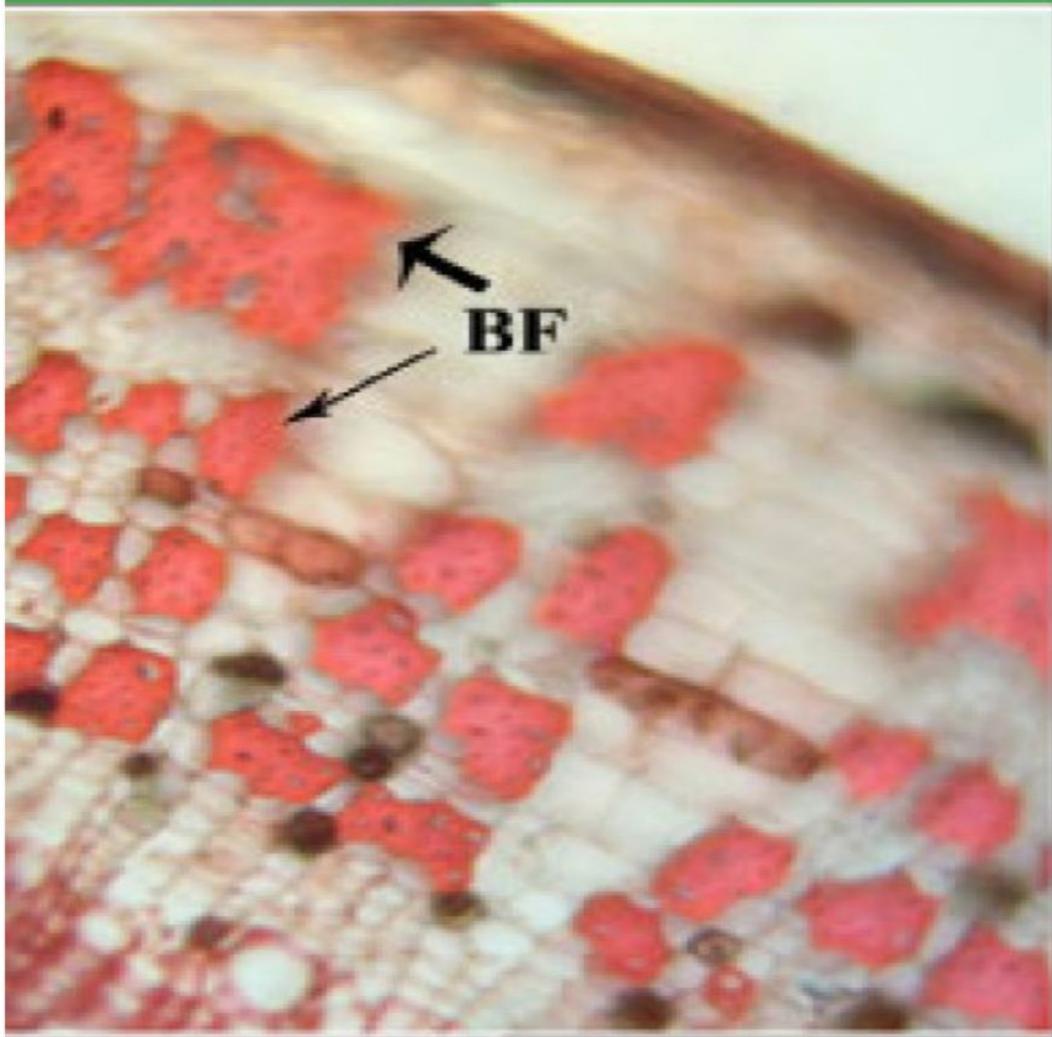


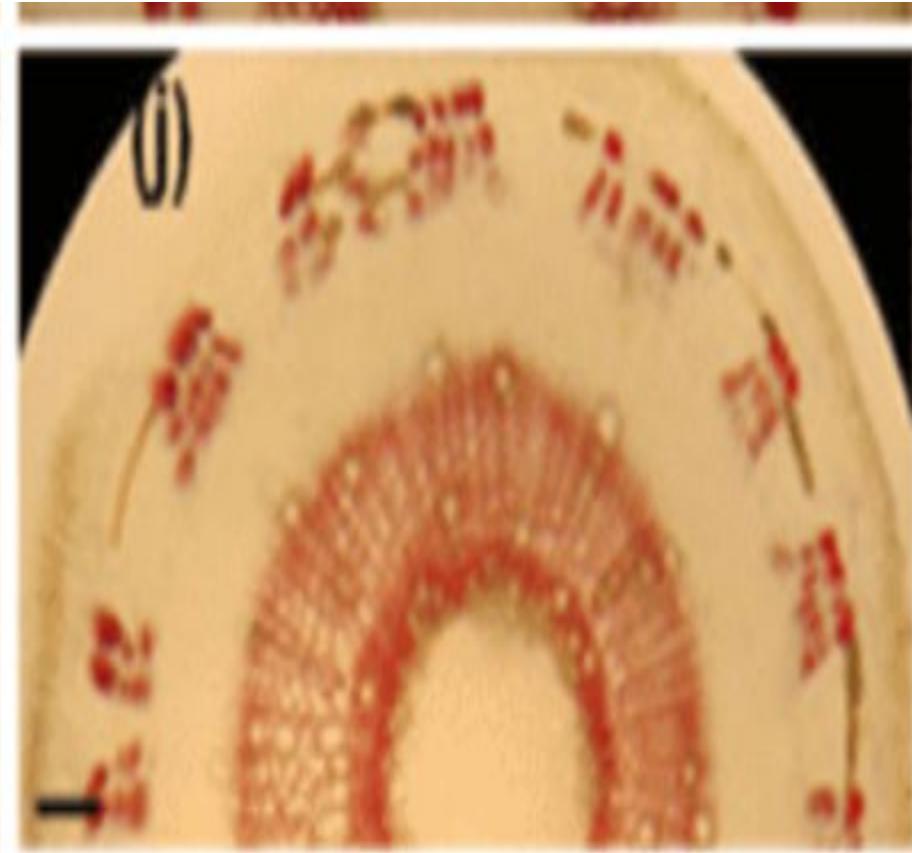
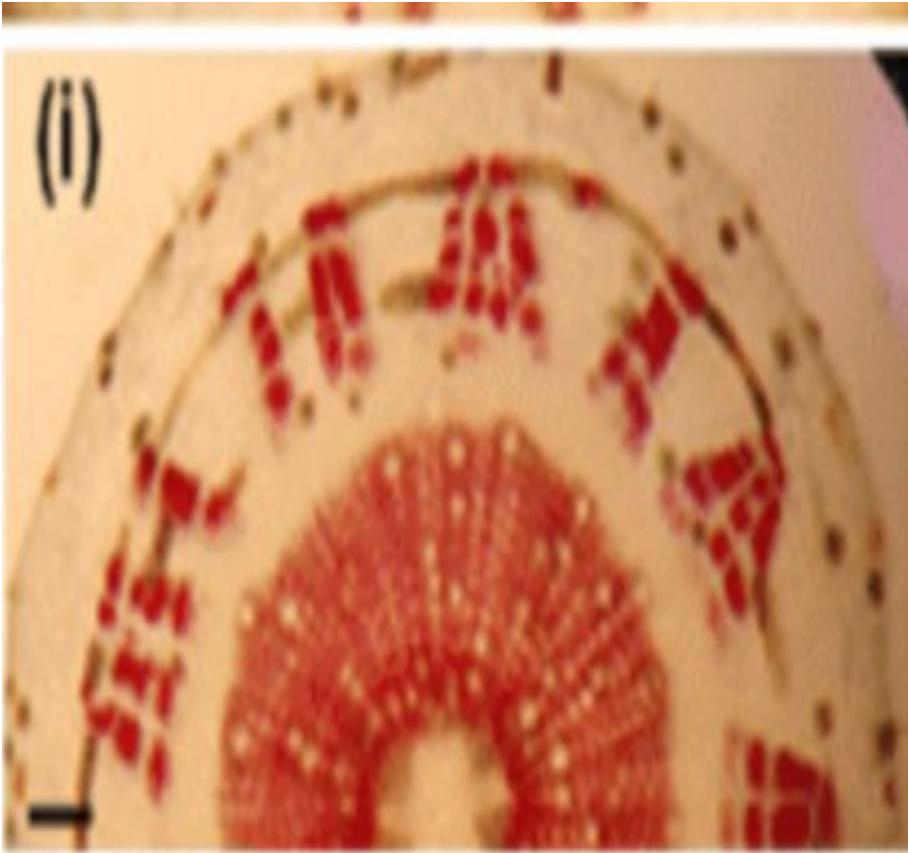
Lignified secondary phloem fibre cells of dlpf are stained reddish with phloroglucinol-HCl

How to stain a plant section to show lignin?

A good stain for showing lignin is phloroglucinol. Phloroglucinol is usually supplied as an alcoholic solution from suppliers. Treat the sections with this stain and then acidify the preparation with a drop of concentrated hydrochloric acid. The lignin in the cell walls stains red. Alternatively, you could use pre-mixed acidified phloroglucinol, in which case it will be a single step procedure, but old preparations of the combined stains may lose their HCl component and thus be less effective.

Jute stem section stained with phloroglucinol. a. *C. olitorius* var.





Phloroglucinol stained transverse sections of *C. capsularis* stems at different developmental stages

- Both phloroglucinol and hydrochloric acid are corrosive, and phloroglucinol is also harmful, so avoid contact with skin. Work quickly and cleanly, and avoid inhaling fumes from the bottles. You would also be advised to wear gloves when handling your preparations. Once sections are stained,  they can be mounted in glycerine or similar mounting fluids, which are safer than leaving them in the acidic stain.

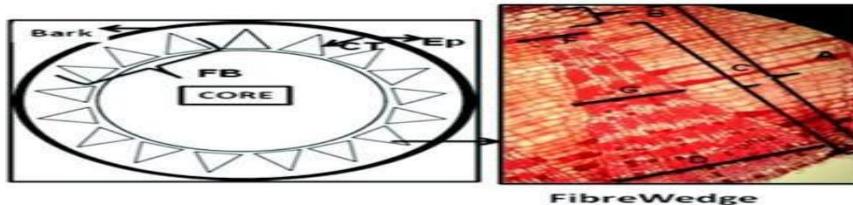


Fig. 1: Exhibits the pattern of distribution of cells in cross section of jute fibre

FB = Fiber Bundle **Ep** = Epidermis **CT** = Cortex **A** = Total bark diameter **B** = Difference between fiber wedge tip and base **C** = Average length of fiber cell wedge **D** = Average width of fiber wedge at base **F** = Average width of fiber wedge at top **G** = Average width of fiber wedge at middle

Distribution of fibre cells in cross section of different genotypes

Stage-1(30 Days)



Fig.2: JRO 204

Stage-2(60 Days)



Stage-3(90 Days)



Stage-4(120 Days)



Fig.3: JRO 524



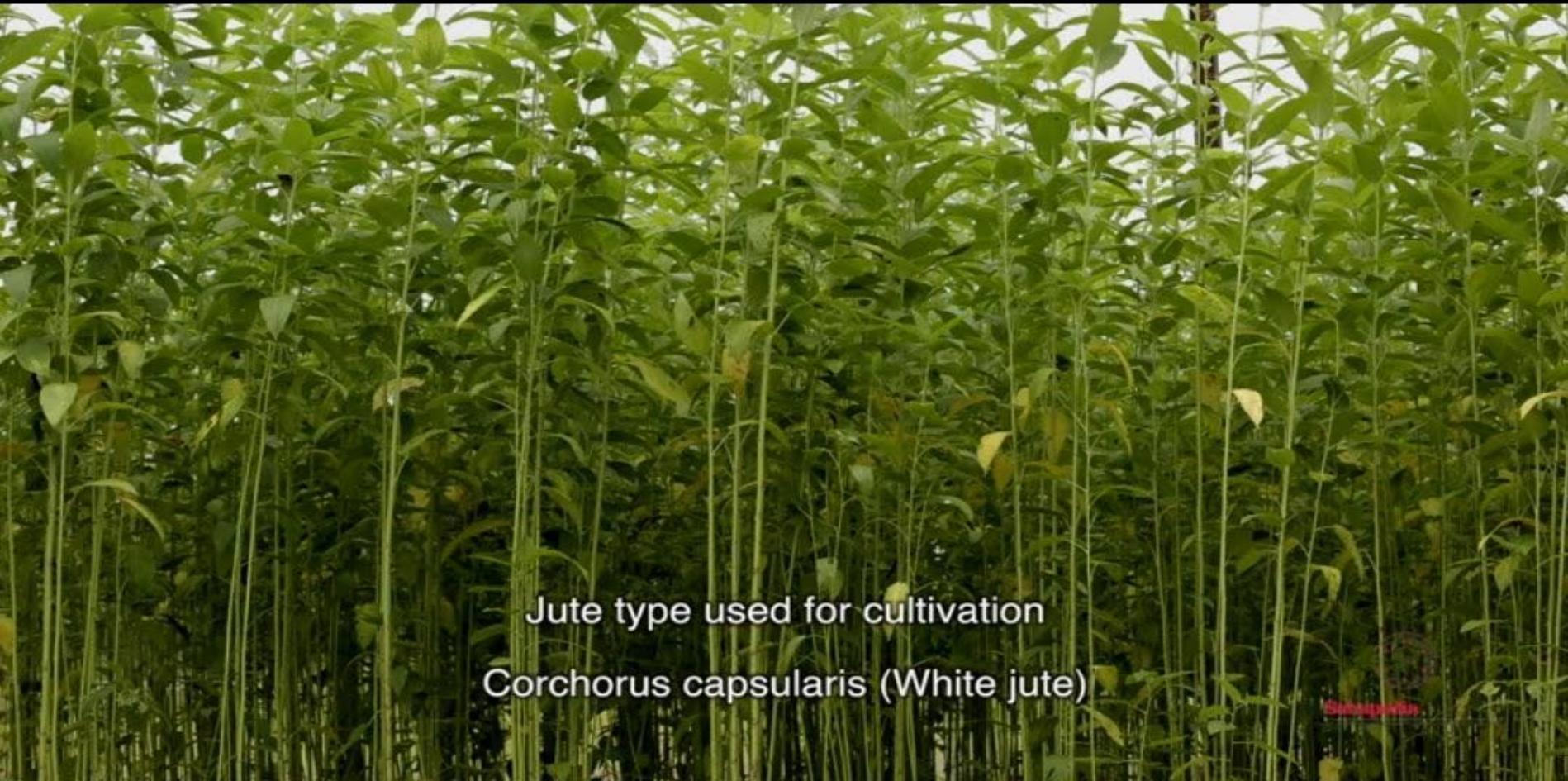
Fig.4: JRO 8432



Fig.5: OMU 09



Processing cycle of Jute



Jute type used for cultivation

Cochchorus capsularis (White jute)



Harvesting of jute

SaiSapdu







7.3 SEPARATION OF BAST FIBER FROM CORE

The historical removal of the bark and the separation of bast fiber from the core is done by biological retting. Jute has been retted in India and Bangladesh for several hundreds of years by placing the entire plant in a pond and letting the natural decay process remove the bark and separate the long bast fiber from the core or stick. The process takes from 2 to 3 weeks and requires large quantities of water. Since the water contains a mixture of organisms, many biological reactions take place other than retting. The quality of the bast fiber coming from this process is often reduced due to the mixture of organisms and the dirty water. The core is then used for fuel or for fence posts and the bast is sold for use in textiles.

One of the difficulties in the retting procedure is that the thicker parts of the stem take longer to ret than the thinner parts, and, consequently, if the butt ends of the stem are full) retted, the top ends are over-retted and damaged. This can be avoided by stacking the bundles of stems upright with the butt ends in water for a few days, before immersing the whole stem. However, with the fiber intended for export, it is usual to cut off the partly retted butt ends and sell these separately as "cuttings."

Correct retting is an essential first step in the production of good-quality fiber. A comprehensive account of the techniques used, and their effect on fiber quality, has been given by Jarman [9]. Controlling the quality of water along with improving microorganisms used in the process are the keys to improve fiber quality. The use of clean water and specific microorganisms has been shown to greatly improve both the efficiency of the retting process and the quality of the bast fiber.

Extensive research has been done on the mechanical separation of the bast from the core on kenaf. The U.S. Department on Agriculture sponsored a research in mechanical "retting" at the Mississippi State University [10] and with a private firm in Bakersfield, California [11]. Chopped whole stock was used in a process involving a spiked cylinder and an airline cleaner [12]. Separation efficiencies of 42 to 48% were achieved. It was found that the moisture content was a critical factor in the separation efficiencies and, if controlled, the separation was cleaner and quicker. Fisher [11] used a modified cotton gin and found separation efficiencies of more than 90%.



Low extensibility

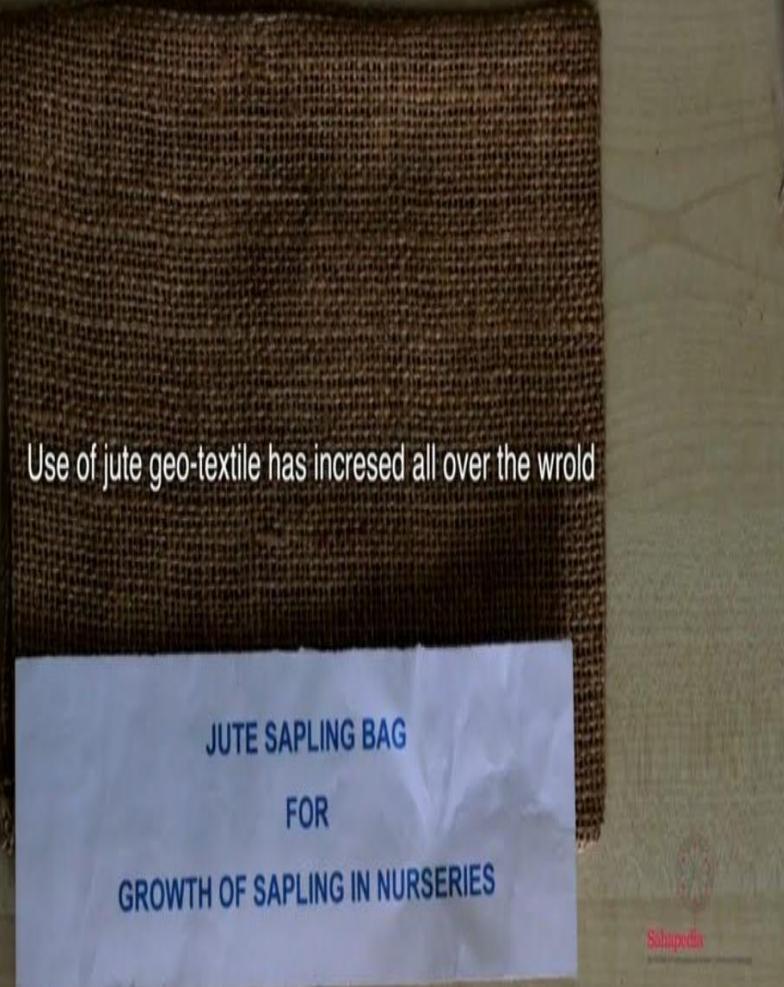


After stripping the fibre jute stalks are dried in open air



Familiar uses:

1. Packaging: bags, sacks, wrapping material i.e. cotton packs and wool packs.
2. Geotextiles – landfill covering, embankment reinforcement.
3. Braids and webbing
4. Cable filler
5. Rope
6. Furniture
7. Camp beds
8. Filter cloths
9. Hand bags
10. Covering fabrics



Use of jute geo-textile has increased all over the world

JUTE SAPLING BAG
FOR
GROWTH OF SAPLING IN NURSERIES

Silagpedia



Prefab. Jute Drain
for
Consolidation of Soft Soil

Till now 270 cases of jute geo-textile use can be seen in India

Silagpedia

500 gsm Non-Woven Jute Geotextile
for
Drainage & Agromulching

SPECIFICATION OF WOVEN JGT- 20kN/m

Weight: 627 gsm, Ends x Picks/ dm: 86 x 32, Thickness (at 2 kPa): 1.79, Width (cm): 100, Tensile Strength (kN/m, MD x CD): 22.2x22.8, Elongation at break (%- MD x CD): 9 x 6 Porometry (micron) (0₉₅): 280, Permeability at 50 mm constant head (s⁻¹): 1.10

7.17.2 GEOTEXTILES

The long bast or leaf fibers can be formed into flexible fiber mats, which can be made by physical entanglement, nonwoven needling, or thermoplastic fiber melt matrix technologies. The two most common types are carded and needle-punched mats. In carding, the fibers are combed, mixed, and physically entangled into a felted mat. These are usually of high density, but can be made at almost any density. In the mid-1960s, a mechanical system was developed to process long synthetic fibers for use in medium density fiberboard (Figure 7.7). Section A in Figure 7.1 is where the kenaf or jute bast fiber is fed into the system. Section B is a fiber opener where fiber bundles are separated and can be mixed with other fibers. Between 4 and

Work has been done that demonstrates how additives, such as super absorbent powders and binders, can be added to the web during the forming process. In the case of super absorbents, one advantage of this approach is that the super absorbent powder when near the area of maximum void space in the web can absorb liquids faster and in greater quantity than if added to a finished web as part of a laminate in an off-line process. Also, because of their uniform dispersion, powdered binders can perform in much the same manner to insure maximum strength with a minimum add-on. Medium- to high-density fiber mats can be used in several ways. One is for the use as a geotextile. Geotextiles derive their name from the two words geo and textile and, therefore, mean the use of fabrics in association with the earth.

Geotextiles have a large variety of uses. These can be used for mulch around newly planted seedlings (Figure 7.9). The mats provide the benefits of natural mulch; in addition, controlled-release fertilizers, repellents, insecticides, and herbicides can be added to the mats

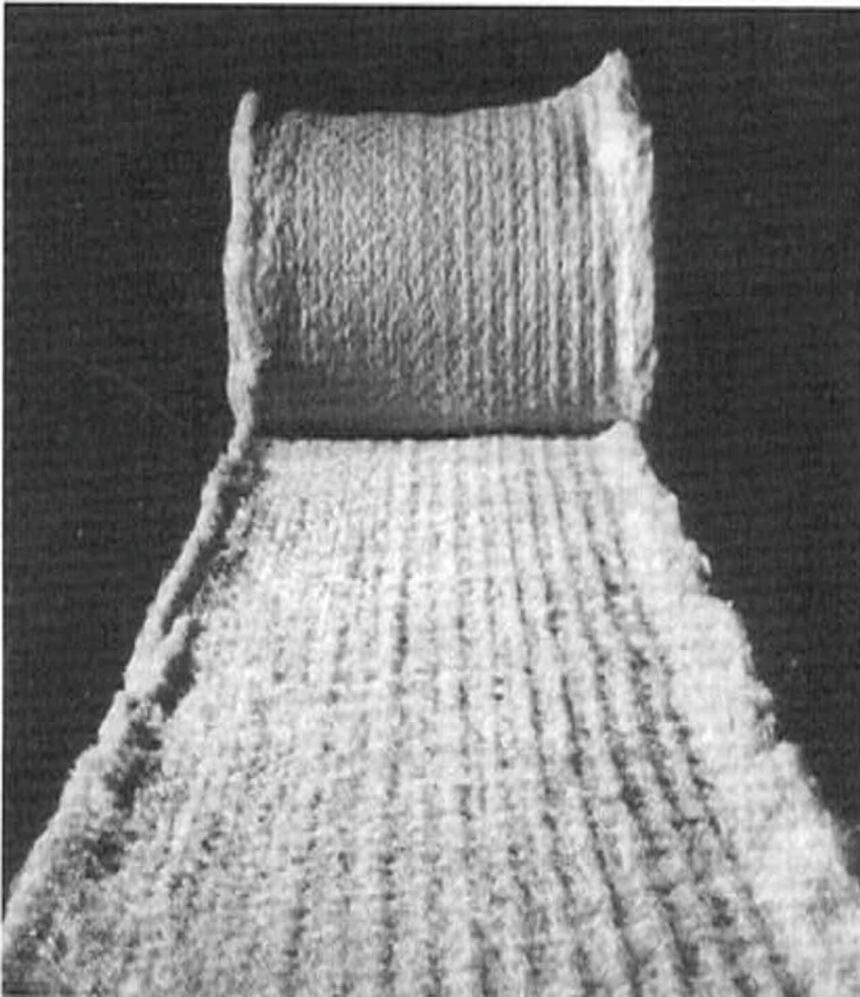
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The addition of such chemicals could be based on silvicultural prescriptions to ensure seedling survival and early development on planting sites where severe nutritional deficiencies, animal damage, insect attack, and weed problems are anticipated. Medium-density fiber mats can also be used to replace dirt or sod for grass seeding around new homesites or along highway embankments (Figure 7.10). Grass or other type of seed can be incorporated in the fiber mat. Fiber mats promote seed germination and good moisture retention. Low- and medium-density fiber mats can be used for soil stabilization around new or existing construction sites. Steep slopes, without root stabilization, lead to erosion and loss of top soil. Medium- and high-density fiber mats can also be used below the ground in road and other types of construction as a natural separator between different materials in the layering of the back fill. It is important to restrain slippage and mixing of the different layers by placing





FIGURE 7.10 Geotextile used to stabilize a steep slope (USDA).



8 Fiber web (USDA).

separators between the various layers. Jute and kenaf geotextiles have been shown to work very well in these applications, but the potential exists for any of the long jute and kenaf fibers.



Wall coverings



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Ropes

Gunny bags

Handicrafts

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