Anatomy of Fibre Bundles (Filaments) Determines the Yield and Quality of Bast and Leaf Fibres

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Abstract

The paper makes a concise review of research undertaken on anatomy of bast and leaf fibres and its possible relation with yield and quality. The results show a large variability in different anatomical traits among different species and also among genotypes of the same species. In view of the facts that breeders have no direct selection criteria for breeding for yield and quality, the author suggests that this is a potential line of research to use anatomical traits of the bast fibres as selection criteria for possible genetic improvement for yield and quality.

Keywords: Anatomy, bast, genetic improvement, leaf fibre, quality, variations, yield

1. Introduction

Vegetable fibres have great demand in fibre industry and also for various domestic uses. They have to face competition now with synthetic fibres. At present there is diversification of utility of jute and other fibres in the manufacture of materials like hand bags, designed fabrics, curtains, carpets, decorating materials which have great demand in the market.

There exist mainly two groups of vegetable fibres known in the world; bast fibres (long fibres) obtained from the stem such as jute (*Corchorus olitorius*, *C. capsularis)* grown mainly in India and other Asiatic country), kenaf (*Hibiscus cannabinus*), roselle (*Hibiscus sabdariffa*), Sunhemp (*Crotalaria juncea*), *Boehmeria nivea*), flax (*Linum usitatisimum*). Besides, several leaf fibres are available such as *Agave sisalana, A. amanuensis, A. cantala*, most in India and other species such as *Agave lecheguilla*, Nenequen (*Agave fourcoydes*) in Mexico.

Based on nine years of experience of working on Botany and anatomy of bast and leaf fibres in the former Jute Agricultural Institute (at present ICAR-Central Jute and Allied Fibre Institute) located at Barrackpore, India, it has been concluded that quality and yield are two important parameters to the plant breeders for genetic improvement. For example in the case of jute, kenaf and other bast fibres, plant height and basal diameters are used as selection criteria for genetic improvement. They can assess fibre content only after extraction by retting process. With respect to quality the breeders have no selection criteria for breeding. They can assess the quality of fibre after extraction in the technology laboratory, but the quality of fibre is influenced greatly by retting process where over retting or under retting deteriorate fibre quality greatly

The author presents a concise review of extensive studies on anatomy of important bast fibres mentioned above in India and development and structure of *Agave lechequilla*, *A. asperimma* and anatomical structure of *A. fourcroydes* in Mexico. The present paper describes research undertaken on anatomy of bast and leaf fibres and the importance of anatomical structure in determining the quality and yield of the fibre crop species. Literatures on various aspects of different bast and leaf fibres are given in the references.

2. Anatomy of Fibre Bundle (Filament) in Bast Fibre

In the case of bast fibres like jute, kenaf, the fibre filament is composed of fibre cells united end to end by hemicellulose to form fibre filament. Fibre cells are developed near the apical region of stem, then elongatate and grown downwards with the thickening of cell walls with gradual deposition of lignin and cellulose revealing that the fibre filament is young near stem apex but highly matured at the base. Highly lignified fibre is poor in quality.

In transverse section of the stem fibre cells are arranged in the form of bundled of different sized depending on the species. These bundles are arranged in series of pyramidal fibre wedges around central wood cylinder. The number of layers of fibre bundles also varies among species. The fibre bundles are mostly rectangular or square in shape. Fibre bundle surface may be regular or irregular which affect spinning quality. The fibre bundles could be isolated or interconnected which affect spinning quality. In our study large variations are observed in anatomical traits mentioned among different species and among different genotypes of the same species.

In longitudinal section through bark the fibre filaments interconnect in network pattern to form meshy appearance. Too much meshiness is an undesirable trait for carding and spinning process. *Hibiscus vitifolius* and *Malachra capitata* produce fibre fiamments with minimum meshiness having good spinning quality. These two species are growing in wild condition, which need to be domesticated.

The fibre cells of these bast fibre crops are needle shaped with a lumen and cell wall. The length of fibre cells and wall thickness vary largely among species which have direct impact on fibre quality.

In the case of ramie (*Boehmeria nivea*), each fibre cell traverse from the base of the stem to the tip representing longesr cellulose fibre of fibre of vegetable origin. In transverse section the fibre cells are oval in shape arranged in bands in the cortex of the stem showing large variability among genotypes. In the case of Sunhemp (*Crotalaria juncea*) and flax (*Linum usitatisimum*) the fibre cells are arranged in patches which unite together to form fibre fiament unlike that in ramie. In the case of ramie each fibre cell forms one filament. The fibres of ramie cannot not be extracted by normal retting process owing to the presence of large amount of gum, favourable for microbial growth affecting directly fibre. The fibre of ramie is extracted by series of chemical degumming process.

In the case of leaf fibre like *Agave sisalana*, *Agave lecheguilla*, the fibrecells initials re derived by the cell division at the base of leaf which elongate and increase in cell wall thickness by the deposition of lignin and hemicellulos, grow upwards and unite with other fibre cells to form a filament and finally join with other neighbouring filament to form a strong spine at the leaf apex. Therefore, the fibre filament near the leaf base is the youngest to that near the leaf apex which reflects the variation if fibre strength between the fibre filament at the base to that at the apex. Unlike that of bast fibre, each filament represents one fibre while in the case of jute and other bast fibre the fibre filaments join forming reticulated meshy structure. The fibre filament is very thick. In the case of leaf fibres the leaves present at the basal region are hghly lignified while the fibres obtained from the central leaf are thin walled, producing better quality fibre, may be for paper pulp,

It should be noted here that in transverse section of the leaves of a leaf fibre species like *A. sisaana*, the fibre bundles are more less half-mmon like in shape located in the meshophyll tissue in few layers, isolated. Each fibre bundle produces one fibre filament. The fibres are extracted from the leaves by a shredding machine.

The results reveal that there exist large variations among different bast fibres and among different genotypes of the same species such as *C. olitorius*, *C. capsularis*, *H. cannabinus, H. sabdarrifa.* Few papers are published cited in references.

3. Anatomy of Fibre Bundles and Its Possible Relation with Fibre Yield

As mentioned earlier, breeders have no direct selection criteria for genetic improvement of yield because they can assess yield of jute and allied fibre only after extraction anatomical parameters of fibre after retting process. In my opinion, anatomicalparameters such the number and layers of fibre bundles in a fibre wedge and also number of cells in fibre bundle could be related to yield. This can be assessed by cutting a small portion of the bark near the base of stem and then cutting section with sharp razor.

In the case of ramie and flax, the number of fibre cells in fibre patch, number per unit area could be related to fibre yield. We observed also variation among the genotypes of ramie in the number of bundles in fibre patch (Figure 1). This could be used as selection criteria for genetic improvement of yield in ramie. This is a potential line of research.

4. Fibre Quality Parameters and Its Possible Relation with Anatomical Structure

Fibre tenacity (strength), fineness, rigidity and surface regularity, meshiness are considered are the main quality parameters in the case of bast fibres. It is reported that length of fibre cells, its length/breadth (L/B) ratio contributes to fibre tenacity. Similarity, the cross section area of bundle is related to fineness. It is desirable that fibre bundle surface should be regular, smooth, while fibre filament with irregular surface affects spinning quality. Therefore, the variation in anatomical structure of fibre bundles could be related to quality determination of a particular of fibre crop species. Therefore, the merits and demerits of fibres with respect to fibre quality could be assessed on the basis of anatomical structure.

It is well documented that there exists a large variability in anatomical structure among different bast fibres and also among genotypes of the same species.

In the case of *Hibiscus vitifolius* and *Malachra capitata*, it is reported that the fibre bundles are uniform in shape with less irregularity; most isolated and not interconnected revealing no meshy structure which is desirable for good spinning quality. These fibres have god tenacity also.

In our study, the fibre bundles are more or less smooth in surface showing less interconnection compared to that of *C. capsularis* for which the fibre quality of *C. olitorius* is superior to that of *C. capsularis* where fibre bundles are very irregular and more interconnected showing more meshiness. More meshiness is undesirable for spinning quality. Similarly the fibres of *H. cannabinus* are superior in these traits compared to that of *H. sabdariffa*.

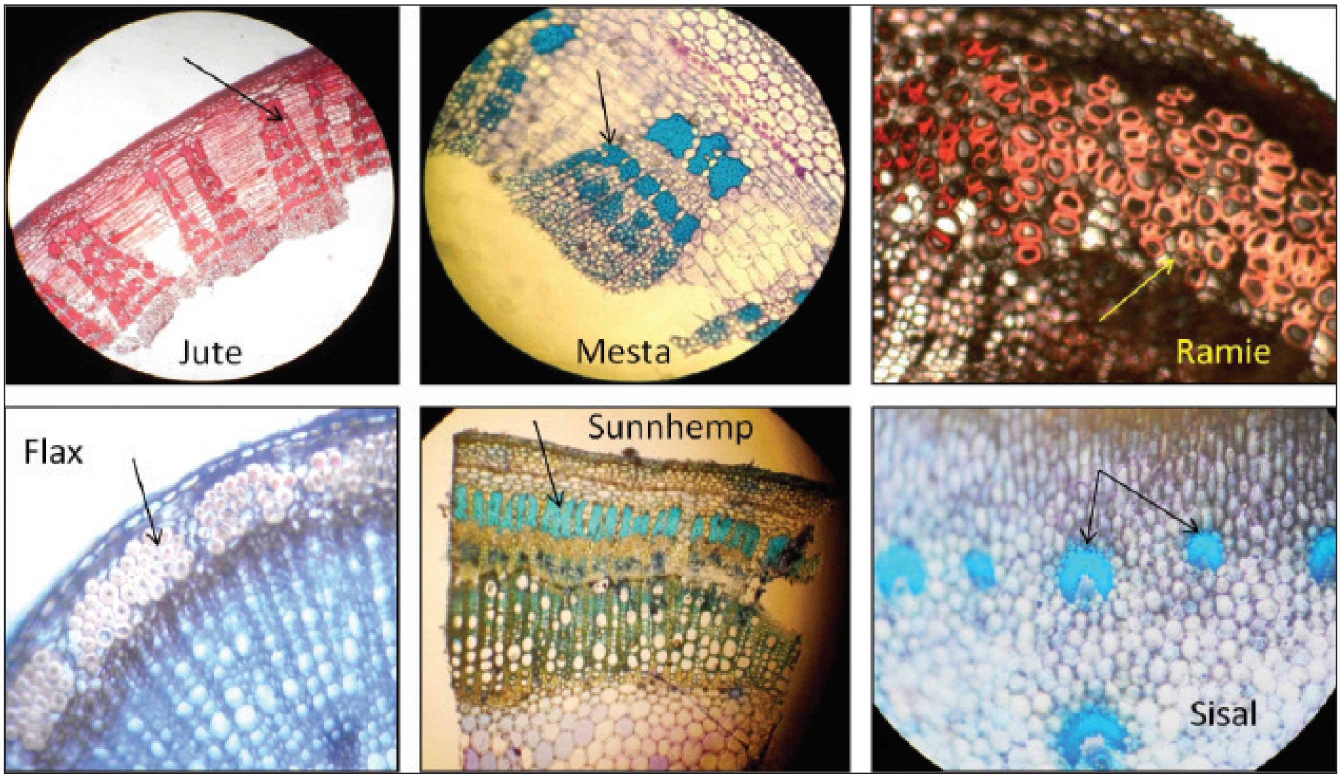

Figure 1: Anatomy of fibre bundles of various fibre yielding plants

In the case of *C. olitorius*, it has been observed that the fibre bundle of the genotype Funduk is thick but uniform. This will definitely give strong but it will produce coarse fibre. On the other hand, in the case of Sudan, the fibre bundle is low in cross sectional area which will produce finer fibres compared to that of Funduk. We studied anatomy of few jute mutants showing interesting results. Soft stem mutant have more parenchymatous tissue and scanty fibre bundles leading to the softness of the stem, while the hard stem mutant has more thick walled fibre cells thereby leading to hard stem. There is a necessity to study the genetic of the species. Therefore in the case of *O. olitorius* and *C. capsularis* there is necessity for genetic improvement for improving fineness (low crossectional area).

Similar study needs to be directed in the case of Kenaf and roselle. In case of *H. cannabinus* the fibre bundles thinner with less surface irregularity compared to that of *H. sabdariffa*. There is a necessity to select genotype with less cross sectional area, and less irregularity. There is necessity of the selection of genotype with low cross sectional area of fibre bundle and less surface irregurity. Very little attention is directed in this direction.

There is a necessity of selection of species in jute and allied fibre for higher fibre cell length and high L/B ratio which contribute to tenacity.

5. Conclusion

Intensive researches have been undertaken by Maiti on anatomy of several bast fibre and few leaf fibres revealing that there exist large variation among species and genotypes of the same species in few anatomical traits. Anatomical research on fibre crops is a potential line of research which is neglected. It is suggested that these anatomical traits could be effectively used by plant breeders as selection criteria for the genetic improvement both for yield and quality. Breeders should work hand in hand with anatomist to fulfill this objective.

6. References

Maiti, R.K., 1979. A study of the microscopic structure of the fiber strands of common Indian Bast Fibers and its economic implications. Economic Botany 33(1), 78−87.

Maiti, R.K., 1973. Comparative study of morphological characters of fibres from various pulps and plants. Jute Bulletin 1&2, 1−8.

Maiti, R.K., 1973. Fibre microscopy of ramie (*Boehmeria nivea* Gaud.) with special reference to its response to histo-chemical reactions and microscopic determination of kindred fibres. Bulletin of Botabical Society of Bengal 27, 59−64.

Maiti, R.K., 1973. Relationship of cross sectional area and perimeter with the number of cells in the fibre bundles of jute and mesta. Journal of Textile Association 34(4), 202−203.

Maiti, R.K., Ghose, K.L., 1974. Comparative microscopy of fibre strands of some ramie varieties (*Boehmeria nivea* Gaud.) with special reference to its relation to yield and quality. Jute Bulletin 37(5&6)

Maiti, R.K., Basu, N.C., 1968. Fiber anatomy of *Malachra capitata* L. with special reference to its ultimate fibre and fibre tenacity. Indian Journal of Agricultural Sciences 38(4), 724−729.

Maiti, R.K., Chakravarty, K., 1977. Comparative study on yield components and quality of common Indian bastfibres. Economic Botany 31, 55−60.

Maiti, R.K., Mitra, G.C., 1972. Cambial activity in relation to production of fibre bundles at different phases of growth in white jute (*Corchorus capsularis* L.). Bulletin of Botanical Society of Bengal 26(1), 79−85.

Maiti, R.K., 1969. Prediction of quality of jute and some related bastfibre form microscopic study. Textile Digest 30, (2&3), 99−103.

Maiti, R.K.,1970. Hibiscus vitifolius a new fibre crop. Economic Botany 23(2),141−147.

Maiti, R.K., 1970. Fibre microscopy for the study of performance of fibre crops in the different fields of research. Bulletin Botanical Society of Bengal 24(1&2), 37−44.

Maiti, R.K., 1970. Microscopic standardization of fiber quality of jute and jute supplements and its potentiality in utilization research in the field of textile science. 27th All India Textile Conference, 161−172.

Maiti, R.K., 1971. Quality of jute and allied fibres as revealed from anatomical stand point. Souv. 21st Annual Session, Text. Assoc. (India) West Bengal Branch, 11-16.

Villarreal, R.L., Maiti, R.K., 1991. Caracteristicas morfoanatomicas y productividad de fibra en Agave lecheguilla Torr., en Nuevo Leon, Mexico. Turrialba 41(3), 423−429.

Villarreal, R.L., Maiti, R.K., 1991. Caracteristicas morfo-anatomicas de la hoja y fibra en Yuccacarnerosana (Trel) McKelvey. Publicaciones Biologicas 5(1), 32−35.

Villarreal, R.L., Maiti, R.K., 1991. Estudio anatomico de la fibra de henequen (*Agave fourcroydes* Lemaire). Biotam 3(3), 9−14.

Villarreal, R.L., Maiti, R.K., 1991. Estudio cuantitativo de las caracteristicas morfológicas y anatomicas de la hoja en Agave asperrima Jacobi. Pubicaciones Biologicas 5(1), 36−38.