A Comparative Study of Yield Components and Quality of Common Indian Bast Fibres

R. K. Maiti [1] and K. Chakravarty [2]

Vegetable fibres are in great demand today not only for textile purposes but also for diverse uses like paper making, hard- and soft-board manufacture, insulation, fillers, etc.

India provides a diversity of climate, land, and people to make possible the growing of fibre crops other than jute and cotton. Among bast (stem) fibres, jute is commercially the most important one required for preparation of burlap, gunny, and many other articles. Since jute cultivation is restricted to eastern parts of India and Bangladesh because of its peculiar edapho-climatic requirements, we consider it necessary to study other fibre-yielding crops that can be grown profitably and with less care under varied conditions. A number of workers have studied sundry bast fibre crops to assess the feasibility of growing them commercially (Basu and Chakravarty, 1968; Betrabet, 1956; Ergle *et al.,* 1945; Kundu *et al.,* 1959; Wilson, 1967).

Plant height (P.H.), diameter of stem at the base (B.D.), fibre percentage, and fibre: wood ratio are generally considered dependable yield components of a bast fibre crop. The present paper deals with the study of these yield components and general quality characters of some promising fibre plants to explore their possible utilization in different industries.

Twenty-three different species of bast fibre crops, listed below, were sown 25 April 1967 in a replicated randomized block design at the Jute Agricultural Research Institute farm. Plot size was maintained at 240 cm × 90 cm.

TILIACEAE

1. Tossa Jute *(Corchorus olitorius* L.) (Var. JRO 632)
2. White Jute *(C. capsularis* L.) (Var. JRC 212)

MALVACEAE

3. Mesta *(Hibiscus cannabinus* L.) (Var. HC 583)
4. Roselle *(H. sabdariffa* L. var. *altissima)* (Var. HS 4288)
5. *H. radiatus* Wild.
6. *H. acetosella* L.
7. *H. vitifolius* L.
8. *H. tetraphyllus* Roxb.
9. *H. penduraeformis* Burm.
10. *H. surattensis* L.
11. *Abelmoschus esculentus* W. & A.
12. *Abelmoschus* sp.
13. *Urena lobata* L.
14. *Urena sinuata* L.
15. *Malachra capitata* L.
16. *Sida rhombifolia* L.
17. *S. cordifolia* L.
18. *Abutilon indicum* G. Don

STERCULIACEAE

19. *Abroma augusta* L.
20. *Pentapetes phoenicea* L.
21. *Helicteres isora* L.

PAPILIONACEAE

22. Sunnhemp *(Crotalaria juncea* L.)
23. *Sesbania aculeata* L.

These plants were nursed under identical conditions to ensure good vegetative

[1] Present address: International Crops Research Institute for Semi-Arid Tropics (ICRISAT), 1-11-256, Begumpet, Hyderabad 500016, India.

[2] Jute Agricultural Research Institute, Indian Council of Agricultural Research, Barrackpore, West Bengal.

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growth. Yield components, as defined by Basu and Chakraborty (1968), Ergle *et al.* (1945), Ghosh and Patel (1945), Roy (1962), Sukhla and Singh (1969), and Wilson (1967), were measured on the basis of 10 plants selected at random from each of four replications of 19 species. Plants were harvested separately by species at 50% flowering stage. Stripped weight, plant height, and basal diameter were recorded plant by plant immediately after harvest. Weight of single plant fibre and also single plant wood were taken separately after proper extraction and thorough drying of both fibre and wood. The yield components of 19 of the species were statistically analyzed. The general features of quality of all 23 fibres were studied in terms of current trade practices.

The yield components of the 19 fibre species and their vegetative phases are represented in Table I.

Vegetative phase. From germination to the date of the first flower may be defined as the period required for maturity in bast fibre crops. It is evident from Table I that this period differs from species to species. Although it is known that temperature and relative humidity influence the change from the vegetative to the reproductive phase, a photoperiodic effect is known to be most profound on the tiliaceous, malvaceous, and papilionaceous bast fibre crops sown in late spring or early summer (Kar, 1959).

According to the data provided in Table I, one may classify these 19 crops into (1) short, (2) medium, and (3) long vegetative phase crops.

1. *Short vegetative phase (40 to 120 days).* The plants of this class include *Abelmoschus esculentus, Hibiscus vitifolius, Urena lobata,* and *Pentapetes phoenicea.* They are long-day plants. The average day length required for initiation of flowering is about 13 hours 29 minutes during the period of June to August.

2. *Medium vegetative phase (121 to 160 days).* The fibre species falling in this class flower in the period when day length decreases gradually from 12 hours 20 minutes to 11 hours 30 minutes in the month of September. They are *Abutilon indicum,* tossa jute, white jute, *Hibiscus tetraphyllus, Malachra capitata, Abelmoschus* sp., and sunnhemp *(Crotalaria juncea).*

3. *Long vegetative phase (161 to 210 days).* These plants start flowering from the first week of October to the last week of November as day length decreases gradually from 11 hours 50 minutes to approximately 10 hours. They are mesta, *Hibiscus acetosella, H. radiatus,* roselle, *Sida rhombifolia, Abroma augusta,* and *Urena sinuata.* These are short-day plants.

The data on time required for the different fibre species to reach harvest stage (50% flowering) indicate that *Urena sinuata* took the longest period (215 days), occupying the field from 25 April to 25 November. *Abelmoschus esculentus* took the least time to mature. The time of maturity differs, depending upon the photoperiodic response and genetic make-up of respective fibre species.

Plant height and basal diameter, which result from the respective activity of apical growth and intercalary growth, are considered by breeders of fibre crops as important criteria for selection. Physiological efficiency of particular fibre species is manifested in the increment of plant height and increase in basal diameter. These two factors are highly influenced by environmental conditions. The rate of increment of each factor is controlled by the genetic make-up of a particular species. As there is no direct method for assessing the fibre yield from a standing crop, plant height and basal diameter may be considered general guiding criteria for efficient production of fibre in a particular species. Another criterion, the length of the vegetative period as indicated by initiation of flowering, may show whether a particular plant will be economic or not. So it is a complicated issue. The breeder must look into it from various angles while assessing the value of the different fibre crops. He must consider the following problems. *(a)* A particular fibre crop may be high yielding when it is very tall and has a large basal diameter; but if it takes a longer time to mature, it may be uneconomic in areas where mono-cropping is not practised. *(b)* A question to be considered by the plant breeder is whether he is selecting a fibre crop to fit in the specific

TABLE I

YIELD COMPONENTS AND VEGETATIVE PHASES OF 19 FIBRE SPECIES[a]

Fibre Species	Date of First Flowering	Day Length Preceding Date of First Flower (in hours-minutes)	Date of Harvest	Plant Height (in cm)	Basal Diameter (in cm)	Fibre Yield per Plant (in gm)	Fibre % Stripped Weight Basis	Fibre:Wood Ratio
Tossa jute	15 Sept.	12–17	27 Sept.	395.7	1.66	19.97	7.22	0.41
White jute	13 Sept.	12–17	27 Sept.	309.8	1.74	12.92	8.10	0.49
Mesta	4 Oct.	11–48	23 Oct.	462.7	2.62	46.88	66.57	0.36
Roselle	14 Nov.	10–37	25 Nov.	395.6	1.56	32.86	7.81[b]	0.42
Hibisuc radiatus	12 Oct.	11–48	23 Oct.	317.5	1.55	13.26	5.24	0.35
H. acetosella	13 Nov.	11–7	13 Nov.	266.4	1.31	7.77	4.47	0.34
H. vitifolius	10 July	13–12	7 Aug.	73.2	1.25	1.92	2.58	0.16
H. tetraphyllus	14 Sept.	13–19	27 Sept.	199.4	1.43	14.10	6.09	0.46
Abelmoschus Esculentus	1 June	13	19 June	209.8	1.93	12.58	5.57	0.49
Abelmoschus sp.	28 Aug.	11–36	7 Sept.	54.5	1.16	0.73	1.66	0.35
Urena lobata	6 July	13–21	7 Aug.	103.6	0.96	2.09	4.43	0.27
U. sinuata	23 Nov.	10–47	25 Nov.	233.5	1.38	8.59	6.97	0.26
M. capitata	13 Sept.	12–17	30 Nov.	221.2	2.19	13.49	4.83	0.24
Abutilon	10 Sept.	12–21	19 Sept.	194.6	0.89	4.79	6.58	0.26
Sida	20 Oct.	11–27	15 Nov.	219.8	1.18	3.71	4.53	0.18
Abroma	1 Oct.	11–52	3 Mar.	139.2	1.94	6.84	5.31	0.32
Pentapetes	25 Aug.	12–43	13 Nov.	177.8	1.61	3.85	3.57	0.36
Sunnhemp	1 Oct.	11–52	23 Nov.	361.7	1.88	13.54	4.48	0.12
Sesbania	9 Sept.	12–22	13 Nov.	312.9	1.64	6.31	2.64	0.09

[a] Date of sowing, 25 April 1967; plot size, 240 cm × 90 cm; replication, 4.
[b] Includes barky fibre.

crop sequence for multiple cropping. *(c)* Plant population in the field is also an important factor affecting the final yield of fibre. *(d)* A fibre crop otherwise unsuitable may prove to be useful under certain climatic conditions. *(e)* A fibre plant may be a high yielder, but if its fibre be of inferior quality and fetches a lower price, it may not be economic.

Studies on plant height and basal diameter (Table I) indicate that these two yield components are highest in mesta. Next to mesta is tossa jute in plant height. *Abelmoschus* sp. shows minimum plant height. The plant height of different species may be arranged in descending order as mesta, tossa jute, roselle, sunnhemp, *Hibiscus radiatus,* etc. Mesta shows the highest basal diameter, followed by *Malachra capitata, Abelmoschus esculentus, Abroma augusta,* and *Crotalaria juncea.*

Fibre percentage indicates the efficiency of particular species in the production of fibre (dry weight) per unit weight of green stem. The fibre percentage is variable according to the tissue constituents of different species. Higher percentage does not always mean higher yield. For example, white jute shows the highest fibre percentage (8.10), but the yield of fibre per plant is lower than mesta, roselle, tossa jute, etc.

Plant height, basal diameter, and green weight are governing factors for fibre yield. Green weight is again dependent on density of the tissue system of a particular species.

In respect to fibre yield per plant, mesta (46.88 gm) tops the list; next in descending sequence are roselle (32.83), tossa jute (198.97), sunnhemp (13.54), *Malachra* (13.49), *Hibiscus radiatus* (13.26), white jute (12.92), and so on. The fibre yield per plant indicates the comparative efficiency in production of fibre amongst the different species. However, the spacing and stands per unit area are also to be considered while making comparison between species.

Fibre:wood ratio is suitable for consideration as a selection index. These two components are direct derivatives of secondary cambium. This activity in the production of fibre and wood is controlled by the genetic make-up of a particular variety. A higher fibre:wood ratio indicates the plant's efficiency in the production of higher yield of fibre than of wood. A lower ratio indicates a higher yield of wood in comparison to fibre. These criteria may be utilized as a measuring stick in the production of fibres of different species or varieties. Although the respective fibre:wood, as well as the yield per plant, is more or less the same in both *Abelmoschus esculentus* and white jute, the fibre percentage is higher in white jute. On the other hand, though the fibre: wood ratio in case of mesta, roselle, and tossa jute is much lower, the yield of fibre per plant is much higher compared to white jute. Consequently, the fibre percentage is more or less the same in *Hibiscus cannabinus* and *Urena sinuata,* yet the yield in mesta is more than five times greater.

The results of analysis of variance for different yield components presented in Table II reveal that the differences among means for five characteristics are highly significant.

Analysis on correlation coefficient indicates that fibre yield is highly positively correlated with plant height ($r = +\ 0.812$) and basal diameter ($r = +\ 0.745$).

Quality. The quality of bast fibres is a complex function involving sundry quality parameters like strength, fineness, meshiness, surface structure of fibre strands, colour, lustre, amount of cuttings, etc. All these quality indices do not go together. There are different methods for determination of quality. Mechanical methods with the help of specific instruments are important; hand-and-eye methods are also employed. It is generally accepted that fibre of best quality cadre should have sufficiently long reed length, soft feel, good lustre and colour, less meshiness, fewer specks and roots, and less knotty structure. All these criteria are taken into consideration in "hand-and-eye methods" of determination of quality. An expert can distinguish strong and fine fibre strands from weak and coarse ones by simple hand testing. Good lustre and colour are associated with stronger fibre. Meshiness, specks, roots, and knotty structure cause hindrance in carding and spinning, thereby reducing the quality of yarn.

A study on quality of different bast fibres

TABLE II

ANALYSIS OF VARIANCE FOR FIVE CHARACTERISTICS OF BAST FIBRES

	Mean Sum of Squares				
	Plant Height (cm)	Basal Diameter (cm)	Fibre Yield (gm)	Fibre % Stripped Weight Basis	Fibre:Wood Ratio
Culture 18	49538.8[a]	0.7106[a]	517.401[a]	12.2475[a]	0.05538[a]
Error 54	515.0	0.0580	12.057	0.0811	0.00064
C.D. at 5%	32.16	0.34	9.29	17.42	0.03
C.D. at 1%	42.86	0.45	12.38	23.22	0.04

[a] Significant at 1% level.

by visual and customary hand-and-eye methods reveals that all these differ markedly in different quality parameters.

On the basis of these general characteristics of fibre quality of different species, and also taking into account the structure of fibre strands (Maiti, unpublished data), and various fibres may roughly be graded into three groups: *(a)* Best quality-em-Tossa jute, white jute, *Malachra capitata, Hibiscus vitifolius, Urena lobata,* and *U. sinuata; (b)* Medium quality-em-Mesta, roselle, *Sida, Pentapetes, Hibiscus radiatus, H. acetosella, H. tetraphyllus, Abutilon, Abroma,* and *Crotalaria juncea,* and *(c)* Poor quality-em-*Abelmoschus* sp., *A. esculentus, Hibiscus ficulneus, H. pungens, H. suratteneis, Helicteres,* and *Sesbania.*

A thorough and critical examination reveals the structural peculiarities of different bast fibres. The fibres of *Hibiscus vitifolous, Malachra capitata,* and *Abutilon* are showy, because of their excellent lustre. Meshiness is a great drawback in bast fibres; less meshy structure is good for quality. In this respect *Hibiscus vitifolius* and *Malachra capitata* are ideal. Their fibres can easily be separated into individual strands. On the other hand, the meshiness of the fibres of *Helicteres, Abroma,* and *Abutilon* is extreme. It is very difficult to separate the fibres into individual strands. Other peculiarities of fibres of *Helicteres, Abutilon,* and *Abroma* are that the fibres are in the form of flat ribbons. These fibres will definitely hinder the carding process. The fibres of *Pentapetes* and *Sida,* though short, are of good quality for their fineness, soft feel, and much less meshy structure. The fibres of *Hibiscus panduraeformis, H. pungens, H. surattensis,* and *Sesbania aculeata* are of extremely poor quality and are not suitable for spinning, because they are highly brittle during extraction and break into masses of short strands. The fibres of *Urena lobata* and *Urena sinuata* are good for soft feel, fineness, good colour, and lustre. Those of sunnhemp are highly lustrous, very strong, and easily separated into individual strands.

SUMMARY

A study of vegetative phase, yield components, and general quality of a variety of bast fibre crops indicates that under similar conditions these crops show differences in growth and quality parameters. Knowledge of these differences may be useful in proper selection, breeding, and improvement of any fibre crop and may also help in selecting a particular fibre crop to suit a multiple cropping programme. Some newer fibre crops have been described which may prove useful as a source of fibre outside the jute belt. Admixture of suitable bast fibres with jute may be experimented to meet the shortfall in raw jute for the industry.

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