Mesta Plant—A potential papermaking raw material

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Mesta plant, which has recently gained considerable importance in U.S.A. etc., can be a potential paper making raw material in India, where shortage of Bamboo is posing a problem to the growth of the industry. In this article, authors have discussed the availability, agronomical aspects of Mesta and extensive experiments carried out in the Laboratory.

To meet the ever increasing demand of paper in our country, there had been a constant effort to search out new raw materials, as Bamboo which has been almost the exclusive raw material so far, will not be able to meet the future raw material requirement. By the end of this decade the total raw material requirement is expected to be about 5.0 million tonnes/year whereas the bamboo's availability is estimated at about 1.5 million tonnes. To meet this gap, several raw materials other than bamboo are being tried e.g. bagasse, straws, hard woods and jute sticks etc. though they have their own limitations.

Mesta, a fast growing annual crop, has in recent years drawn considerable attention as a fibrous raw material for Pulp and Paper making. It is believed that the plantation of Mesta originated from India but today it is being cultivated in many parts of the world. Extensive research has been carried out in U.S.A. and certain other advanced countries on this raw material as a source of paper making, but unfortunately in India it has not found its due place so far. The authors have made an effort to study the various aspects of this raw material, which could be a potential source for paper making in the years to come.

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Mesta and its Availability :

Mesta Plant's common botanical species are Hibiscus cannabinus and Hibiscus sabdariffa. Internationally, they are known as Kenaf and Roselle. However, in India, Mesta name is used commonly for both the species, though in Andhra Pradesh and Madras, it is known as Bhimli and Pulchi respectively. The Mesta (Genus Hibiscus), an annual plant growing from 2.4 to 3.5 meters height, consists of central woody portion i.e., stem and its branches covered with bark constituting mainly of bast fibres. The broad proportion of different parts of the plant are given below :

Particulars	Ton/ Acre	On % Basis
Green weight of the plant	20 T.	100%
A. Weight of the leaves	4 T.	20%
B. Weight of the green sticks without leaves	16 T.	80%
(a) Green ribbon (fibre plus other matter)	6 T.	30%
(b) Wet wood stem	10 T.	50%

Mesta has been put to several uses since long. Its bast fibres, after extraction from the plant, are used mainly for ropes, nets, chairbackings, carpets, mats, sacks, hessian cloth etc. due to their similarity to jute in their fibre properties. It is used as a substitute for Jute and there has been great demand for this fibre by the Jute Mills. The Mesta stick so far, has found no other use except as a fuel and a fencing material. The bast fibres alone or whole plant as such without leaves, can be considered a good raw material for paper making.

In India, it is mainly grown in Bihar, Assam, Orissa, Andhra Pradesh, Madhya Pradesh and Tamilnadu. The climate of South India, being most suited for its growth, a part of Andhra Pradesh depends upon this crop only. The available data indicate that about 2 lakh acres of land is under cultivation in Srikakulam and Vizag districts of Andhra Pradesh yielding about 10/12 lac tonnes of A.D. (with 15% moisture) Mesta plant without leaves.

Agronomical Aspects

(Cultivation, Harvesting and Collection)

Mesta, being a hardy and versatile crop of less exacting nature than jute in its edaphic requirements, can grow on poor soil with less moisture content. It grows in soils ranging from clay to sandy looms and acidic to

alkaline but a good drainage, specially in the seeding stage, is essential. A pH of 6 to 8 is considered to be ideal.

The crop being highly photosensitive, limits its cultivation to particular latitude. Data available reveal an optimum day length of about 12 hours confining the cultivation season to certain periods of the year where day length is more than 12 hours. This helps in maximum growth resulting in higher yield. Once the night length exceeds the critical period, flowering sets in, ceasing the growth of the plant.

The plant can tolerate certain amount of drought too but it needs evenly distributed rainfall of about 100 mms/month in the initial stages. Due to its ability to stand prolonged drought it is generally preferred to other crops in certain regions. Though the plants can be grown in temperate/tropical climates, generally warm and humid conditions are found to encourage the growth as compared to cold and dry conditions. The choice of a particular variety falls on the planter and the consumer depending upon the soil and climatic conditions and the quality of the fibre in view of the following :

Hibiscus cannabinus

Fibre quality better; shorter duration for growth; can grow in region where uniform rainfall is available; sufficient plant protective measures to save it from insects etc. necessary ;

Hibiscus sabdariffa

Coarser fibre; longer duration for growth; more resistant to drought; less susceptible to pests and diseases thus less protective measures; better yield due to longer duration required for its growth ;

The crop can be sown in April/June, the main season and January/April, the off-season. The main-season crop is harvested in the month of October/November and the off-season crop from August to September to enable the transplantation of paddy crop. However, the off-season crop is not considered to be a good paper making raw material for its comparatively poor yield and quality of fibres. The most appropriate time for harvesting is at 50% flowering stage, in case of Hibiscus Sabdariffa and 50% pod stage in case of Hibiscus Cannabinus as the fibre gets fully grown and matured at this time. Usually, it takes 200 days from the day of sowing to reach this stage. The harvested plants are dried in the sun for 20/25 days in the fields itself and bundled after removal of the leaves. The moisture after sun drying is about 15/20% thus reducing the bulk or economic transportation.

Yield

The average yield of the A.D. (15% moisture) plant without leaves is about 6 tonnes/acre but with fertilizer application even 10/12 tonnes/acre can be achieved. The reports from advanced countries like U.S.A. and Japan confirm the same. With respect to the yield of the seed, it ranges from 100/150 Kg/acre and can be used for oil extraction, if need be.

EXPERIMENTS :

Laboratory Experiments

Raw Material :

The Mesta plants from off season crop were procured from Srikakulam distrct in A.P. and sun dried for 20 days. The leaves were manually removed and stems along with branches chopped manually into 5/6 cms. pieces. The chips were analysed for its chemical constituents as per Tappi Standards. Results are given in Table I.

Digestion :

1.5 to 2 Kgs. of the chopped material was digested in any indirectly heated stainless steel stationery autoclove of 20 litres capacity with circulation arrangement under varying conditions as per the details given in Table-2(a). For comparative study, the screened bamboo and Euclyptus chips obtained from the Mills's chipper house were also digested in the same autoclove. The pulp was washed free of chemicals, Yields & K. No. were determined. The pulp (with traces of screenings) was beaten in the Laboratory valley beater at a consisting of 1.5% to a final freeness of 40°SR Standard sheets were made and tested for their physical properties at 27°C. and 80/99 % RH. The results are summarised in table 2 (A).

Bleaching :

The unbleached pulp was bleached with Calcium hypochlorite in single stage maintaining a PH of 6.5/7.0 by Alkali buffering at room temp. but with constant agitation with varying chemical additions with the objective to get a brightness of 78/80 °PV. Under the similar conditions, Bamboo and Euclyptus unbleached pulps were also bleached. The Pulps were washed, yield determined and evaluated for physical properties.

Conclusions :

(i) The yield of unbleached Mesta pulps comes to 49% when compared

to 44.0 & 40 of Bamboo & Eucalyptus respectively with almost similar cooking conditions except the bath ratio which is higher i.e. 1:6 in case of Mesta. The breaking length & double folds are quite high while B.F. remains practically some. Tear factor is lower than Bamboo but higher than Euclyptus hybrid.

(ii) A bleached pulp with 78/80 °PV brightness can easily be obtained. The yield comes to 42.4 when compared to 39.7 of Bamboo & 37.5 of Euclyptus. The strength prop. in general are slightly higher than bamboo & Euclyptus. However the chlorine consumption is high by about 2/3 % when compared to other raw material because of its slightly higher K. No.

(iii) The beating times in case of bleached & unbleached Pulps are less.

An average fibre length 1.4 mm. is lower than bamboo but higher than Euclyptus but it does not effect the strength properties.

(iv) The plants under investigation were taken from offseason crop which is of comparatively poorer quality rank. The main season crop results are expected to be better.

In view of the above it is concluded that Mesta plant can find a place as a substitute of bamboo for manufacturing writing & printing papers.

The authors have undertaken further experimentations to study the pulping of main season crop and also the multi-stage bleahing.

Problems Related with Mesta Crop :

(1) Mesta is an annual crop. Which depends to some extent on the rains whereas bamboo is a long term crop unaffected by monsoons. However, the rains affect the Mesta Plant yield only by 15/20 %. In case of poor rains/draught, the availability of Mesta might get reduced by 15/20%.

(2) **Total area required for cultivation :**

For a 100 tonnes/day paper plant the total raw material requirement will be about 75,000 Tonnes/year. Taking the yield of the plant as 5/6 T/Acre (moisture-15%) the total cultivation area should be about 15000 Acres and since the Mesta is an annual crop which depends to some extent on the rains, the actual acreage should be 20% more than the required i.e. about 20,000 Acres.

(3) **HIGHER BULK OF MESTA:**

(A) **Higher Storage Area :**

The density of the Kenaf (Mesta Plant) storage being 150 Kg/ m^3, it can be stacked upto 5 meters height. (For Bamboo density 200 Kg/ m^3 and stacking height 9 meters). Thus for 1,000 tonnes of Mesta, the area required for storage is 1110 m^2 which is practically double to the storage area required by Bamboo (about 560 m^2). Since Mesta is an annual crop, the total requirement of the year has to be stored at a time. To give an idea, for a 100 tonnes/day plant requiring 75,000 tonnes of Mesta Plant, a total storage area required would be about 82,250 m^2 and taking into consideration the space for movement loading, unloading and handling the total space required would be about 16, 5000M^2

(B) The density of chopped Mesta and Bamboo chips are 0.17/ 0.19 MT/M^3 and 0.25 MT/M^3 and solid to liquor ratio 1:6 and 1:3 respectively. This would mean an increase in the capital cost due to additional digesters and auxiliary equipments with increased capacity.

The above would result in an increase in cost of production of pulp from Mesta due to more capital investment, depreciation and overheads etc.

(4) **Cost of Raw Material and Production :**

(i) Taking into consideration the present cost of Mesta fibre, the cost of Mesta Plant per tonne would work out about Rs. 140/tonne at site for a mill located at a place where average rail and truck or bullock cart transport distance is 150 and 10/12 kms. respectively. Due to bulky nature of the material, in order to keep the transportation cost low, the distance between the field and the mill should not exceed 140/160 Kms.

(ii) With respect to yield and cooking chemicals on the basis of O.D. raw-material, it is similar to bamboo. Thus these costs will be same as that of bamboo, but due to more auxilaries and equipments needed the cost for Mesta Plant pulps will be high.

(iii) Assuming a minimum vield of 42% which is certain to be achieved, 2.8 tonnes of Mesta with 15% moisture will be needed for one tonne of bleached pulp. Hence cost of kenaf for one tonne of bleached pulp will be about Rs. 392/- (@ Rs. 140/- tonne at site (A.D.)) against the cost of Bamboo of Rs. 350/- (Rs. 140/-tonne at site (O.D.)) with an vield of 40.0%.

(iv) Due to increase in steam consumption on account of high solids: Liquor ratio and chlorine consumption by 2/3 %, the cost of production would approx. be Rs. 50/60 more in case of bleached pulp from Mesta crop. The cost of Evaporation too may be slightly increased due to low concentration of Black liquor.

In view of the above, the cost of bleached pulp from Mesta Plant is likely to be about Rs. 120/125 more than the bamboo pulp. (which is about Rs. 1000/tonne)

Conclusion :

Based on the studies and results obtained it can be concluded that:

(i) Mesta Plant is a suitable raw-material for paper making and can be used for producing writing and printing papers.

(ii) Since it is an annual crop the storage area requirement is very high and the cost of the Pulp will be about 10/15% higher than that of Bamboo Pulp.

(iii) The cost of Raw-material could be brought down, so that the Pulp cost be substantially reduced, if total or partial cultivation is taken up by the Mills and scientific methods of cultivation are adopted to increase the yield by using proper fertilizers and manures.

(iv) The transportation cost and the digester loading capacity etc. can be improved by introducing bailing arrangements.

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TABLE 1

Physical & Chemical Characteristics of Kenaf Bamboo & Eucalyptus (Hybrid)

Sl. No.	Particulars	Unit	Kenaf	BAMBOO (Dendracalamus Strictus)	Eucalyptus
1.	**Physical Characteristics:**				
	a. Fibre Length Average	mm.	1.38	1.97	0.83
	b. Fibre width Average	Gsm.	30.30	47.5	100
	c. Fibre length/diameter ratio.		45	41	83
2.	**Chemical Characteristics:**				
	(i) Holo Cellulose	%	69.90	65.89	60.25
	(ii) Lignin	%	17.50	28.00	28.26
	(iii) Pentasons	%	21.50	19.56	13.30
	(iv) Ash	%	3.0	2.30	0.51
	(v) Alcohol Bengene solubility	%	3.8	2.31	0.10
	(vi) 1% NaOH Solubility	%	31.0	24.50	16.4
	(vii) Cold Water Solubility	%	5.20	4.50	1.8
	(viii) Hot Water Solubility	%	7.70	8.64	13.8
	(ix) Silica	%	2.50	1.52	0.35

All analysis as per TAPPI PROCEDURE. The Fibre length and diameter is the average of 75/100 readings.

TABLE No. 2(A)

Digestion Experiments

Sl. No.	Cooking process	Percentage of chemicals added as Na_2O %	Sulphidity	Bath ratio	Steaming time Hrs.	Cooking time Hrs.	Temp. °C	K.No.	Yield (on O.D. basis)	Initial freeness °SR	Final freeness °SR	Beating time Mts	Breaking length Mts.	Burst Factor	Double fold	Tear factor
1.	Sulfate	16	23.5	1:6	2	2	160	—	Remains Uncooked—Knots %—20							
2.	-do-	16	23.5	1:6	2	2	166	—								
3.	-do-	16	23	1:6	2	2	170	19.2	49.5	19	40	28	5900	45	800	124
4.	-do-	18	23	1:6	2	2	160	18.1	48.8	20	40	25	6200	46	900	126
5.	-do-	18	23	1:6	2	2	166	17.5	48.0	21	40	23	5950	46	823	125
6.	-do-	18	23	1:6	2	2	170	17.5	46.5	22	40	20	5900	45	727	120
7.	-do-	18	23	1:6	2	1.5	170	17.1	47.0	22	40	19	5850	44	725	120
8.	-do-	20	23	1:6	2	2	160	17.0	46.5	20	40.5	23	5800	44	700	118
9.	-do-	20	23	1:6	2	2	166	17.0	46.5	21.5	40.5	21	5600	43	600	115
10.	-do-	20	23	1:6	2	1.5	166	16.5	46.0	21.5	40.0	22	5600	42	600	115
11.	-do-	22	23	1:6	2	2	160	16.5	46.3	22.0	40.0	22	5600	40	500	108
12.	-do-	22	23	1:6	2	1.5	160	16.5	44.0							
13.	Soda	14	—	1:6	2	2	160	—	Remained uncooked							
14.	Soda	15.6	—	1:6	2	2	160									
15.	Soda	15.6	—	1:6	2	2	170	17.2	45.5	19	40	25	5750	39	380	98
16.	Soda	18.7	—	1:6	2	1.5	170	17.2	45.0	18	40	27	5700	41	400	100
17*.	Sulfate	16	23	1:3	2	2	160	17.5	46.0	11	40	52	5800	45	670	160
18*.	-do-	18	23	1:3	2	2	160	16.8	44.0	11.5	40	48	5600	45	690	150
19**.	-do-	15	23	1:3	2	2	166	16.8	48.5	16.0	40	37	5600	43	525	93
20**.	-do-	17	23	1:3	2	2	170	13.7	40.0	16.0	40	39	5100	40	295	100
21**.	-do-	19	23	1:3	2	2	170	9.9	38.03	16.5	41	37	5000	40	303	96

*Bamboo (Dendracalanus strictus) grown in Orissa

**Euclyptus—The sample received from Orissa Forest.

TABLE No. 2(B)
BLEACHING EXPERIMENTS

S. No.	NK. corresponding to table No. 2A)	BLEACHING CONDITIONS					YIELD	STRENGTH PROPERTIES						
	Av. Cl_2 in Hypo	NaOH addition as buffer	End PH	Retention time	Consistency	Brightness	On the basis of OD fibrous raw material	Initial Freeness	Final Freeness	Beating Time	Breaking length	Burst Factor	Double Fold	Tear Factor
								°SR	°SR	Mts.	Mts.	—	Nos.	—
3	17.0	2.5	6.5/7.0	4	10	78/80	43.0	19.5	40	24	5100	33	190	98
4	15.0	2.0	6.5/7.0	4	10	78/80	42.4	20	40	20	5600	36	220	110
5	13.0	1.5	6.5/7.0	4	10	78/80	42.0	22.0	40.5	19	5400	36	190	108
6	13.0	1.5	6.5/7.0	4	10	78/80	41.3	22.5	40	18	5200	33	150	93
7	13.0	1.5	6.5/7.0	4	10	78/80	42.0	22.5	40.5	19	5200	33	160	98
8	13.0	1.5	6.5/7.0	4	10	78/80	42.0	21.0	40	19	5300	33	140	94
9	13.0	1.5	6.5/7.0	4	10	78/80	41.7	22.0	40	18	5250	30	160	96
10	13.0	1.5	6.5/7.0	4	10	78/80	41.7	22.0	40	20	5250	31	120	98
11	11.5	1.5	6.5/7.0	4	10	78/80	40.80	22.5	40	20	5000	30	99	93
12														
13		Remains uncooked												
14														
15	14.0	1.0	6.5/7.0	4	10	78/80	41.60	20	40.5	20	5000	30	100	90
16*	14.0	1.0	6.5/7.0	4	10	78/80	41.10	19	40	22	5200	30	110	88
17**	10.5	1.0	6.5/7.0	4	10	78/80	41.20	12	40	43	5450	35	180	120
18**	10.0	1.0	6.5/7.0	4	10	78/80	39.70	13	40	40	5200	33	160	110
19**	10.0	1.0	6.5/7.0	4	10	78/80	43.50	16	40.5	38	5100	28	95	93
20**	9.0	1.0	6.5/7.0	4	10	78/80	39.00	17	40	36	4700	30	90	93
21**	8.5	1.0	6.5/7.0	4	10	78/80	38.80	17	40	32	4500	30	75	96

*Bamboo (Dendracala us strictus) grown in Orissa.

**Eculyptus—The sample received from Orissa forest.