REPORT

ON

THE PREPARATION AND USE

OF

RHEEA FIBRE.

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APPENDIX.

INTRODUCTORY REMARKS.

1. THE present efforts for the utilization of the Rheea plant date from 1869.* In April of that year the Government of India addressed a circular to the Agri-Horticultural Societies in India, with the object of eliciting from them all the information in their possession with regard to the growth and preparation of the Rheea fibre in India. The communications received from the societies, as well as from some gentlemen who had been for years engaged in experiments with the plant, led to the publication of the resolution of 22nd September 1869, in which the Government of India expresses its conviction that the value of the Rheea fibre is undoubted, that all the conditions necessary for its cultivation on a large scale are present in India, and that the only obstacle to the development of an extensive trade in this product was the want of suitable machinery for the separation of the fibre from the stems and bark of the plant in its green or freshly cut state. To encourage the invention and production of such machinery, it was determined to issue prizes, one of 5,000*l.* and one of 2,000*l.* for the two best machines, the merits to be determined at trials to be held in India, and the test of success being the production of fibre worth in the English market at least 50*l.* per ton, at a cost of preparation not exceeding 15*l.* per ton. On the 11th June 1870, the first public advertisement appeared announcing the competition which was to be held in a year's time, and offering one prize of 5,000*l.*, but at the same time holding out a hope that the merits of other inventions, even if not quite successful, would be considered, and certain minor prizes awarded. Owing to the difficulties encountered in the preparatory arrangements for the trials, the period at which they were to be held was postponed, and on 26th January 1871 a second announcement appeared, fixing the trials for April 1872 at Saharunpore, where in the meantime a plantation of Rheea had been established under the superintendence of Dr. Jameson. This advertisement, like the previous one, was extensively circulated both in England and in India, and no fewer than 32

Offer of prizes by the Government of India for machines to prepare fibre from the green Rheea.

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* This is the third time within this century that Rheea has become the subject of official action.

In 1803, Dr. Roxburgh obtained from Bencoolen (Sumatra) a few cuttings for propagation in the Honourable Company's Botanical Garden at Seebpore. He gave the plant the name of Urtica tenacissima, as surpassing in strength all the other fibres he had tested.

In 1810, Dr. Buchanan, who in the meantime had ascertained the plant to be identical with the Khonkhoora grown in the districts of Rungpore and Dinagepore, forwarded to England three bales of Rheea fibre grown in the Botanical Garden. These were referred to the Messrs. Sharpe for examination, and favourably reported on by them, the cord spun from it sustaining a weight of 252 lbs. against the 84 lbs. required by H.M. Dockyard to be borne by Russian hemp of the same size. In 1811, the Society of Arts awarded a gold medal to Capt. Cotton, Director of the East India Company, for bringing the fibre to the notice of English manufacturers. In 1816, the Court of Directors sent out machinery (by James Lees, for preparing flax and hemp,) to be used in the preparation of Rheea, but it failed. The matter then dropped until about 1840, when attention was again directed to it by Col. Jenkins, who discovered the same plant growing wild in Assam, and transmitted a few specimens to the Agri-Horticultural Society in Calcutta. From the cuttings thus obtained, plants were grown in the Botanical Gardens of the Society. Col. Jenkins, Capt. Dalton, Major Hannay, Dr. Campbell of Darjeeling, Mr. T. F. Henley and others, have since contributed to the Agri-Horticultural Society a variety of information on the growth and preparation of this fibre in Northern India, whilst Dr. McGowan, by information and samples sent from China, enabled Dr. Falconer and afterwards Sir Wm. Hooker, to identify Rheea as the same plant from which the Chinese grass cloth is prepared. Several specimens were forwarded to the Exhibition of 1851, and there shown in various stages of preparation: they attracted considerable attention, various experiments having been made for some years by English manufacturers with the view of utilizing the fibre. In 1852 the Government of India forwarded to the Court of Directors a consignment of the Assam fibre, which was examined and experimented upon by Dr. Forbes Royle. Its strength, as compared with other fibres, was again confirmed; its average strength, as compared with Petersburgh hemp, was in the ratio of 280 to 160, while the wild Rheea from Assam was as high as 343. In 1854, the Court of Directors sent to India a memorandum on the fibre prepared by Dr. Royle, with instructions to forward to England 10 tons of the raw fibre. Owing to its limited cultivation, no more than two or three tons could be procured, but Sir Frederick Halliday, then Lieut.-Gov. of Bengal, acting on a suggestion made by Capt. Dalton, Collector of Luckimpore, and also by Dr. Royle, directed the purchase during the ensuing three years of a quantity of fibre up to 10 tons in each year, in order to encourage its cultivation. These purchases were from time to time transmitted to London and sold. In view of the fact that the merits of the fibre were already sufficiently well known in England, and in expectation that its further development might be safely left to private enterprise, the experimental consignments were subsequently discontinued, and no further action on the part of the Government was taken until 1869.

competitors entered their names, but at the last moment only one of them, Mr. Greig of Edinburgh, appeared on the field in India.

Trial at Saharunpore in 1872.

2. The trial of Greig's machine took place in the month of August 1872, under the superintendence of Lieut.-Col. Hyde, the result being that he found himself unable to report in favour of awarding the full prize, as the cost of preparing clean fibre, as calculated from the rate of work of the competing machine, would have amounted to more than 15*l.* per ton. In consideration, however, of the fact that the machine was a bonâ fide and meritorious attempt to meet the requirements of the case, a donation of 1,500*l.* was awarded to the inventor.

The verdict against the machine in India, although founded on the sole ground of costliness of working, would have been arrived at subsequently on account of the defective quality of the fibre produced by it. The samples resulting from the trials, forwarded by the Government of India to the India Office, were submitted to competent authorities. The highest valuation was only 28*l.* per ton, instead of the stipulated 50*l.*, and they were declared suitable only for cordage purposes.†

Reasons for failure.

3. Thus the object aimed at by the Indian Government has not been attained beyond the advantage of attracting greater attention to the importance of discovering methods of preparing the Rheea fibre. This failure is easily accounted for. Col. Hyde in his report makes a few remarks on the difficulty of ever having a real competitive trial in India. This difficulty lies in the fact that the machinists are in one country and the material to be operated upon in another, and that the cost of sending machinery and skilled mechanics out to India is so great, and the time occupied so long, that even a large prize offers no sufficient inducement, especially as the inventors, who in England can only study the dry stems, work in the dark when trying to adapt their machinery to green stems.

Possibility of having trials in England with the dry and the fresh plant.

4. The expediency of testing some machinery for the extraction of the fibre from Rheea in its dry state was shortly afterwards indicated in the despatch of the Government of India of 3rd January 1873, referring to Dr. Collyer's machine for acting on dry Rheea stems, which machine it was requested should be tried in this country. Shortly before the receipt of this despatch, I had received information that the Rheea plant, under the Eastern name of Ramie, was being grown on an estate near Miramas in the south of France. This suggested the possibility of supplying fresh Rheea in this country, and of overcoming the apparently insuperable difficulty, pointed out by Lieut.-Col. Hyde, of bringing the fresh plant to the machinist. Authority was given by the Secretary of State in Council for the purchase of the whole of the crop, which I had in the meantime ascertained from the proprietor of the estate at Miramas would amount to from 20 to 25 tons.

Distribution of specimens of green Rheea to 200 applicants in England in August 1873.

5. A notification was therefore issued on the 4th June 1873, offering to supply any persons wishing to experiment upon the fresh Rheea with a certain quantity of fresh stems, and the prospect was held out that a series of trials would take place in November of the same year, by which time a second crop of cuttings would be ready. The first crop was ready for cutting at the end of July. Preparations were made for the prompt delivery of the plant in London, and a skilled employé was dispatched to superintend the cutting and packing, and to press forward the delivery. The crop however proved, both in point of quantity and quality, far inferior to what I had been led to expect by the report of my evidently "imaginative" correspondent. The total quantity amounted to only about 2½ tons, instead of from 20 to 25 tons, whilst its stunted and branched character gave but a poor idea of the plant when properly grown for textile purposes. This comparatively small quantity of material was burdened with the expenditure incurred for the arrangements made for dealing with the larger quantity, and the upwards of 200 applicants who had responded to the advertisement necessarily received but a small quantity each, and the bulk of this was in a very imperfect condition; but some of the plants forwarded from Miramas were evenly grown and from four to five feet in length,—these proved of use in showing the character of the stems when in the fresh state.

† Extract from memorandum, dated 30th June 1873, referring to valuations of samples produced by Greig's machine.

Second d tribution green Rh in Octobe 1873.

6. Evidence was, however, obtained that Rheea of a much superior quality could be obtained in the neighbouring district of Vaucluse; and the experiments made at the same time, to ascertain the best method of packing the plant, showed that if the stems be stripped of their leaves and tied together in bundles of about 30 lbs., a large proportion of them will arrive at their destination here in good condition. Unstripped Rheea stems, tied in bundles or packed in wrappers of paper or cloth, became heated and altogether spoiled by fermentation. It was likewise ascertained that the second or autumn crop is always superior in quality to that cut in summer. In consequence of the disappointment experienced with the summer crop, it was considered advisable to utilize the autumn one also for distribution to such applicants as wished to continue their experiments, and of these upwards of 100 asked for fresh supplies. The Rheea received in November 1873 was mostly of fair quality; the plants grown in the Vaucluse department being especially fine and well grown. The cool weather at that time of the year was also advantageous, as it diminished the chance of fermentation during transit. Thus the superior quality of the stems and the greater advantages for transmission, both point out the autumn as the most suitable season of the year for the trials; whilst at the same period it is likewise possible to obtain a supply of the plant in this country. In 1873, as well as last year, the Duke of Wellington placed at the disposal of the Department a quantity of green stems, grown at Strathfieldsaye, which proved of considerable use in showing the character of the plant in its perfectly fresh state, and his Grace has kindly arranged to do the same this year should the competitive trials afterwards referred to take place.

POSITION AND PROSPECTS OF RHEEA.

Prospects Rheea fibre in 1870 at the time when the prize was offered.

7. The general aspect of the question has changed since 1870, when the Government Resolution was passed, and the conditions under which the Saharunpore trials were conducted no longer represent the present state of the prospects of Rheea. At that time it was assumed, and quite in accordance with the information and facts then available,—

(*a*.) That Rheea already commands a rapidly increasing market, limited only by the difficulties of supply, for the technical difficulties of manufacture and of the discovery of special uses having been overcome, the only thing needful was to discover machinery by means of which the fibre could be prepared on a large scale fit for the market.

(*b*.) That a price of 50*l*. per ton in the English market for the rough fibre would be sufficiently low to attract a steady demand for it.

(*c*.) That the only possibility of preparing good fibre was by operating on the fresh stems, and simply separating the fibre from them by machinery. Retting and steeping was considered to injure the fibre, and the fibre obtained from dry stems was supposed to be inferior as regards strength and gloss.

Present prospects of Rheea.

8. Each of these conclusions will have to be considerably modified in order to correspond with the present facts.

With regard to the first point, it is true that a few years ago it seemed as if the application of Rheea in manufactures had passed the stage of experiment, and that the fibre had acquired an acknowledged position as the basis of a new textile industry.

The demand for China grass went on at a fairly steady rate till 1872, when the raw fibre supplied through London alone amounted to between 200 and 300 tons; but since then there has been a sudden falling off, from causes which will be hereafter explained. With the exception of one firm, the manufacture of textile fabrics from Rheea seems to have almost stopped; and in London at the present time there is no regular demand for China grass, except in small quantities, for superior twine purposes, and at not more than from 30*l*. to 40*l*. per ton for China grass, and from 19*l*. to 30*l*. per ton for Indian Rheea; and it is a curious fact that even Rheea waste as noils now command a readier sale than the combed fibre.

With regard to the second point, it must be remarked that the price of 50*l*. per ton seemed a reasonable enough limit, when China grass was selling in this country as high as 80*l*. and even more per ton. A variety of considerations seem however to point to the conclusion that the average price of the bulk of Rheea must be permanently lower than 50*l*. per ton in order to tempt manufacturers to introduce it on a large scale.

With regard to the last point, referring to the best mode of preparing the fibre, there is evidence that the process of separating the fibre need not be restricted to the green stems, and that even retting, if carried out under conditions not unlike those in the usual flax or hemp retting, may possibly be employed with advantage.

Comparison of the natural properties of the Rheea fibre with those of other fibres.

9. It remains to be considered how these changed conditions influence the whole question of the prospects of Rheea, of its future application, and of its growth and preparation in India. For this purpose it is necessary to compare it with other fibres with which it may compete, both as regards the inherent and natural qualities of its fibre and its market value, and to consider what influence would be exercised on its future prospects by the discovery of a suitable method of preparing the fibre.

Strength of Rheea fibre.

10. As regards its inherent qualities, it is admitted on all hands that the physical properties of the Rheea fibre give it a high place, and that it is pre-eminent amongst fibres for its strength and lustre. Dr. Roxburgh applied to it the term "tenacissima" from its strength in comparison with other fibres.

Subsequent experiments, more especially those of Dr. Royle, confirmed this estimation, and in certain trials the Rheea proved of more than double the strength of Russian hemp. It would not be safe, however, to infer from these trials the exact extent to which the strength of Rheea fibre is superior to that of other fibres. None of those experiments were carried out with a sufficient variety of samples, nor under sufficiently uniform conditions. But there can be no doubt that Rheea fibre is considerably stronger than either flax or hemp.

Resistance to the action of high pressure steam.

11. Rheea has also a high resisting power of another order. The resisting power of fibres under the influence of moisture and various atmospheric conditions may be to some extent tested by the action of high-pressure steam on them. With the exception of "Himalayan hemp," there is no fibre which suffers so little from the action of high-pressure steam as Rheea. In the subjoined experiments the fibres were first exposed for two hours to steam of about two atmospheres pressure, and then boiled in water for three hours, and the loss in weight ascertained. Subsequently they were again exposed to the action of steam at the same pressure for four hours, and the loss in weight again ascertained. The per-centage loss of a specimen of Chinese Rheea amounted only to 0·89, and of Assam Rheea to 1·51, whilst flax lost 3·50 per cent., Italian hemp 6·18, Russian hemp 8·44, and jute even 21·39 per cent.

The details of the experiments will be found in the subjoined table.

TABLE showing the Comparative Resisting Power of various Indian and some other Fibres under the Action of High-Pressure Steam and Boiling Water.

(Fibres arranged in order of effect produced, commencing with those least influenced.)

Experiment No. I.			Experiment No. II.			Fibres arranged in Order of Total Loss produced by both Experiments.		
No.	Name.	Loss per Cent. after Exposure for Two Hours in Steam, at 15 lbs. Extra Pressure, followed by Boiling in Water (212°) for Three Hours.	No.	Name.	Loss per Cent. after further Exposure, for Four Hours, to Steam and Water at 15 lbs. Extra Pressure.*	No.	Name.	Total Loss per Cent.
1	Himalayan Hemp† (*Cannabis sativa?*)	0·58	1	China Nettle	None.	1	Himalayan Hemp†	0·77
2	Rheea (*Boehmeria nivea*)	0·81	2	Neilgherry Nettle	None.	2	China Nettle	0·89
3	China Grass (*Boehmeria nivea*)	0·89	3	Sunn	None.	3	Rheea	1·51
4	Ambaree (*Hibiscus cannabinus*)	2·39	4	Himalayan Hemp†	0·19	4	Neilgherry Nettle	2·85
5	Flax (*Linum usitassimum*)	2·47	5	Ejoo	0·61	5	Sunn	2·93
6	Pine Apple (*Ananassa sativa*)	2·47	6	Rheea	0·70	6	Flax	3·50
7	New Zealand Flax (*Phormium tenax*)	2·70	7	Flax	1·03	7	Ambaree	3·63
8	Pita or Agave (*Agave Americana*)	2·72	8	Bedolee Sutta	1·20	8	Ejoo	4·15
9	Sufet Bariala (*Sida rhomboidea*)	2·76	9	Ambaree	1·24	9	Bedolee Sutta	4·26
10	Neilgherry Nettle (*Urtica heterophylla*)	2·85	10	Moorva or Marool	2·03	10	Muddar or Yercum	5·47
11	Sunn (*Crotalaria juncea*)	2·93	11	Dunchee	2·18	11	Pita or Agave	5·55
12	Bedolee Sutta (*Pederia fœtida*)	3·06	12	Jute	2·19	12	Moorva or Marool	5·55
13	Muddar or Yercum (*Calotropis gigantea*)	3·19	13	Muddar or Yercum	2·28	13	Sufet Bariala	6·00
14	Italian Hemp (*Cannabis sativa*)	3·38	14	Coir	2·54	14	Dunchee	6·07
15	Manilla Hemp (*Musa textilis*)	3·38	15	Manilla Hemp	2·69	15	Manilla Hemp	6·07
16	Plantain (*Musa paradisiaca*)	3·40	16	Italian Hemp	2·80	16	New Zealand Flax	6·14
17	Russian Hemp (*Cannabis sativa*)	3·47	17	Pita or Agave	2·83	17	Italian Hemp	6·18
18	Ejoo (*Arenga saccharifera*)	3·55	18	Sufet Bariala	3·24	18	Pine Apple	6·49
19	Moorva or Marool (*Sanseviera zeylandica*)	3·72	19	Plantain	3·34	19	Plantain	6·74
20	Dunchee (*Sesbania aculeata*)	3·89	20	New Zealand Flax	3·44	20	Coir	8·13
21	Yucca or Adam's Needle (*Yucca gloriosa*)	5·30	21	Pine Apple	4·02	21	Russian Hemp	8·44
22	Coir (*Cocos nucifera*)	5·59	22	Russian Hemp	4·97	22	Yucca or Adam's Needle	10·87
23	Pandanus or Screw-pine‡ (*Pandanus odoratissimus*)	6·03	23	Yucca or Adam's Needle	5·57	23	Pandanus or Screw-pine	12·21
24	Jute (*Corchorus olitorius; C, capsularis*)	19·20	24	Pandanus or Screw-pine	6·18	24	Jute	21·39

* In this case the samples were partially immersed in the water, and the operation of boiling afterwards to remove the portions loosened by the steam was not required. In experiment No. I. the fibres were placed entirely in the steam, then removed and boiled for three hours in water.

† Although, after careful examination, this is believed to be true hemp, still, looking to the very high place which it takes as compared with that from Russia and Italy, it is quite possible that this opinion may be wrong. It will be noticed that Sunn fibre, which stands 11th in Experiment No. I., occupies the first rank in No. II. This "Himalayan hemp" is not the produce of a nettle, but it may, as originally suggested by Mr. Henry Cope, be that of the Sunn plant.

‡ This refers to the white comparatively weak fibres furnished by the leaves of the Screw-pine, not to the fibrous material yielded by the aerial-roots which shoot downwards from its stem.

Fineness.

12. Although strong and resisting, the fibres of the Rheea are as fine, if not finer, than those of flax. As will be seen from the subjoined table (p. 6) giving the average diameters of the Indian and some other fibres, determined from a large number of micrometric observations, the mean diameter of the ultimate fibres of flax is about $\frac{1}{2060}$ of an inch, of Rheea (from Assam) about $\frac{1}{2100}$, and of China grass $\frac{1}{2260}$ of an inch. Occasionally, however, samples of prepared Rheea are met with in a state of even greater division, either from a more complete disintegration, or perhaps even from the greater original tenuity of the ultimate fibre. Thus the fibre in specimen No. 56 of the accompanying collection of specimens ranges as low as $\frac{1}{6000}$ of an inch in diameter, and compares, as regards fineness, with the most finely divided fibre recorded in the table, viz., that of the pine apple.

TABLE showing the Mean Diameter (Micrometric) of Indian and some other Fibres.

	Classification, Names, &c.		Diameter of Fibres. Ordinary. Min. Decimals.	Ordinary. Max. Decimals.	Ordinary. Mean. Decimals.	Ordinary. Mean. Vul. Frs.	Ultimate. Min. Decimals.	Ultimate. Max. Decimals.	Ultimate. Mean. Decimals.	Ultimate. Mean. Vul. Frs.
EXOGENS.	Class I. For spinning and manufacturing.	Flax. TISI, ULSEE; ATEES, MUSINA, *Hind.* ALLEVERAY; *Tamil.* (*Linum usitatissimum*)	·00278	·00573	·00425	1/240	·000340	·000630	·000485	1/2000
		Rheea.* KUNKHOONA; RAMIE; CALOE, *Sumatra.* CHU-MÂ, *China.* (*Boehmeria* (*Urtica*) *nivea*)	·00302	·00562	·00432	1/230	·000356	·000566	·000461	1/2100
		Pooah from *Sikkim* (*Boehmeria puya*); (*B. frutescens*)	·00095	·00445	·00270	1/370	·000390	·000630	·000510	1/1900
		China Grass. Same as RHEA. Called CHU, or TCHU-MA, in China. (*Boehmeria* (*Urtica*) *nivea*)	·00067	·00160	·00114	1/870	·000343	·000540	·000442	1/2200
		Neilgherry-nettle. ANA-SCHORINEGAM; *Md.* (*Urtica* (*Girardinia*) *heterophylla*)	·00150	·00385	·00267	1/370	·000390	·000680	·000535	1/1800
		Mudar. AK,* *Hindee.* YERCUM; TELLA JILLADOO; *Madras.* (*Calotropis* (*asclepias*) *gigantea*)	·00250	·00530	·00390	1/250	·000325	·000663	·000494	1/2000
		Bedolee Sutta. (*Pederia fœtida*)	†	†	†	†	·000615	·001725	·001170	1/850
	Class II. For spinning and manufacturing purposes, but of inferior durability.	Jute (*Corchorus olitorius*; *C. Capsularis*)	·00142	·00374	·00258	1/380	·000420	·000647	·000533	1/1900
		Sufet Bariala. (*Sida rhomboidea*)	·00115	·00290	·00203	1/490	·000290	·000540	·000415	1/2400
		Ambaree of Western India. MAESTA PAUT; *Bengal.* PALUNGOO; *Madras.* (*Hibiscus cannabinus*)	·00167	·00364	·00265	1/380	·000303	·000529	·000416	1/2400
	Class III. For the manufacture of cordage, twine, &c.	Hemp. (*Cannabis sativa*)	·00302	·00586	·00444	1/220	·000342	·000613	·000478	1/2100
		Sunn. JANAPA-NAR; *Madras.* (*Crotalaria juncea*)	·00391	·00799	·00595	1/170	·000304	·000597	·000450	1/2200
		Dunchee. (*Sesbania aculeata* (*Æschynomene Cannabina*), Roxb.)	·00550	·01500	·01025	1/97	·000300	·000520	·000410	1/2400
		Jetee; "Rajmahl Bow-string creeper." (*Marsdenia* (*Asclepias*) *tenacissima*)	·00260	·00520	·00390	1/250	·000220	·000400	·000310	1/3200
ENDOGENS.	Class IV. For miscellaneous purposes. Chiefly adapted for twine, cordage, and paper-making. Occasionally capable of being manufactured into fabrics suited for women's dresses, imitation horse-hair cloth, &c.	Pine Apple.‡ ANANAS. ANASA. (*Ananassa sativa*)	·00237	·00427	·00332	1/300	·000157	·000227	·000192	1/5200
		Moorva. MAROOL; *Madras.* MOORVA and MOORGAVEE; *Bengal.* (*Sanseviera Zeylanica*)	·00142	·00287	·00215	1/465	·000350	·001000	·000675	1/1500
		Agave or Pita. (*Agave Americana* and also *A. Vivipera*, now called *Fourcroya gigantea*)	·00383	·00676	·00530	1/180	·000400	·000750	·000575	1/1700
		Yucca or Adam's Needle. (*Yucca gloriosa*; also *Y. Aloefolia*)	·00308	·00581	·00445	1/220	·000550	·000966	·000758	1/1300
		Plantain. (*Musa paradisiaca*)	·00250	·00487	·00369	1/270	·000550	·001000	·000775	1/1300
		Manilla Hemp. (*Musa textilis*)	·00366	·00600	·00483	1/200	·000570	·001050	·000810	1/1200
		New Zealand Flax. (*Phormium tenax*)	·00165	·00358	·00262	1/380	·000450	·000716	·000588	1/1700
	Class V. Suited for the manufacture of mats, brushes, coarse cordage, imitation horse-hair for stuffing purposes, &c.	Coir. TENNAM-NAR; *Madras.* (*Cocos nucifera*)	·00350	·01000	·00675	1/150	—	—	—	—
		Ejoo or Gomuto Fibre. EJOO; SEJEE; *Malay.* ANOU; *Sumatra.* (*Arenga Saccharifera*)	·00250	·00775	·00513	1/195	—	—	—	—
		Palmetto Fibre, from the *Chamærops Ritchiana*, called Pfees in Sind	Diameter of fibres about the same as those of Coir different samples vary considerably in this respect.							
		Pandanus or Screw-pine (fibre from aerial roots); KALDERA BUSH. (*Pandanus odoratissimus*)								
		Moonj. *Sind.* (*Saccharum Munja*)								

* *Calotropis Hamiltonii*, a smaller species, commonly found in the northern parts of India.
† As prepared in Assam, already in state of ultimate filaments.
‡ Of Endogenous fibres the Pine Apple is probably the only one capable of being spun and manufactured similarly to flax; and even then the fabrics formed from it are not likely to wear well. All Endogenous fibres are comparatively brittle.

Lustre.

13. Whilst, therefore, as regards strength, resistance, and fineness, Rheea is either equal or superior to the best known fibres, it has the additional advantage of possessing in a considerable degree a silky lustre. Jute, the only other fibre which can compete with it in this respect, is far inferior to it in strength and durability, as well as in its capability for bleaching and dyeing.

Hairy nature.

14. A very characteristic, and in some respects unfavourable quality of the Rheea is the comparative stiffness and brittleness of the fibre, and most of the difficulties which in spinning and manufacture it has to overcome are due to this circumstance. The hairy nature of the Rheea is well exemplified in sample No. 51, although all the samples exhibit to some extent the same characteristic. It is this stiffness which prevents Rheea, although so strong in its usual condition, from sustaining as easily as other fibres the effect of a sharp bend or kink. Thus if a knot be tied with a small bundle of fibres, the Rheea will break very readily, much more so than flax, for instance, although all fibres will break more readily under such conditions. Another consequence of this stiffness is that the fibre does not twist readily, and that the yarn spun from Rheea is often very rough notwithstanding the smoothness and silkiness of the individual filaments. This roughness is due to the projecting ends of the filaments turned outside by the twist which the yarn receives in spinning. On the other hand, the stiffness or hairiness has also certain advantages, as in consequence of it Rheea readily combines with wool.

15. Thus Rheea, in virtue of its quality, has a wide range of affinity with other fibres, though it is not perfectly similar to any of them. This explains why its experimental applications cover such a wide field. It has been actually tried as a substitute for cotton, hemp, flax, wool, and silk.

Rheea and cotton.

16. With regard to cotton, attention was directed to it among other fibres during the years of the cotton famine produced by the American war. In 1862, Dickson prepared in this country cottonised Rheea, and sometime afterwards, in France, Messrs. Mallard and Bonneaud, by cutting the fibre into lengths of two inches and treating it with alkalies and oil, produced from China grass a material suitable for admixture with cotton. This cottonised Rheea was the subject of various experiments carried out during the year 1864 by the Rouen Chamber of Commerce. In the present state of the cotton trade it is not very likely that Rheea will ever be used for such a purpose, as, apart from considerations of price, cottonised Rheea hardly permits advantage to be taken of the peculiar and prominent qualities of the fibre,—its length, strength, smoothness, and lustre. Nevertheless, the Rouen experiments are interesting as throwing some light on its manufacturing qualities. Under Messrs. Bertel and Cordier, of Rouen, the cottonised Rheea was spun, and the yarn woven into different fabrics, and dyed and printed; in the first experiment it was mixed with an equal weight of Egyptian cotton, and in the second and larger one (on 220 lbs. of cottonised Rheea) with an equal proportion of Indian cotton. The fabrics, as compared with those of pure cotton, are reported to have gained in strength, and to have acquired a certain amount of gloss, rendering them more similar to linen fabrics. Neither the spinning nor the dyeing gave rise to any difficulties. The mixed fabrics are reported to have dyed as well as those of Egyptian or American cotton, and better than fabrics of Indian cotton. Only with a few colours was it necessary to modify the mordant or the strength of the dyeing bath, in order to obtain the same shade of colour as with unmixed cotton.

17. Rheea will, however, always remain too valuable a material to be used merely as an admixture with or even as a complete substitute for cotton. With Indian cotton at 6*d*. per lb. and American cotton at 9*d*. per lb. the competition is very difficult. Calculated per ton, the market value of the above kinds of cotton amounts at the present time to 56*l*. and 84*l*. respectively. In comparing this price with the prices of Rheea or China grass, two points must be kept in view. Firstly, that Rheea being a considerably heavier material than cotton, yarn of the same apparent size will require a larger weight of raw material. Secondly, that China grass or Rheea as brought into the market has first to undergo a mechanical and chemical treatment, in the course of which, according to Messrs. Mallard and Bonneaud's statements, a loss of 25 per cent. in weight takes place, so that only 75 per cent of actual cottonised Rheea is obtained. The price of the China grass must be increased, therefore, by one third, in order to obtain the price at which the utilizable portion of the rough fibre is bought, and to this must be added the cost of preparation. Rheea taken at the standard price of 50*l*. fixed by the Government of India as the limit to be attained at the Saharunpore trials, would therefore come in its cottonised form to 67*l*. per ton, exclusive of the costs of preparation. Messrs. Mallard and Bonneaud's statement, that the cottonised Rheea may be supplied at 7*d*. per lb. or 65*l*. per ton, could only be verified with very low prices of the raw material.

Rheea and flax.

18. Whilst, however, no future can be held out to cottonised Rheea, there seems to be a fair probability of its becoming a formidable rival to flax, especially to the finer varieties. There are, however, technical difficulties to be overcome before Rheea can be spun successfully on flax machinery. Owing to the stiffness of the fibre, the yarn produced is frequently very rough. Soon after 1851 Messrs. Marshall of Leeds spun Rheea on flax machinery, and on a larger scale than had then or probably has since been attempted, but the yarn produced was unsaleable, owing to its roughness. There are, however, grounds for believing that this obstacle is not insurmountable. Moerman, in his pamphlet on the cultivation and preparation of Rheea, states that he had occasion to examine specimens spun in some French and Belgian mills on flax machinery on cold water frames, and that they were quite smooth, although less glossy than Rheea usually is. He observes, however, that the gloss is restored by passing the fabric between

cylinders. Mr. Horsman, who has for many years been in the employment of Messrs. Marshall of Leeds, and who continued the experiments with Rheea after Messrs. Marshall had given up the subject, writes, in 1873, that he had succeeded in producing from it perfect yarn, and proposes to use it on account of its great strength as warp for very fine linens.

19. If, as seems probable, Rheea could be worked up on the same machinery as flax, the development of the Rheea trade would be immensely facilitated, inasmuch as there would then be an immediate and practically unlimited field for its consumption. It must be noted here that this may be to a considerable extent a question of a suitable preparation of the fibre. In fact, some of the inventors claim as a special merit of their processes that the fibre which they produce can be worked on flax machinery, whereas that usually produced cannot. That hitherto the experiments, however successful, have not resulted in establishing the use of Rheea for the manufacture of articles now produced from flax, is not astonishing, considering the prices which have been ruling for China grass during the last 10 or 15 years. The imported rough China grass sold in 1860 at 40*l.* to 45*l.* per ton, but a comparatively small demand for it in subsequent years raised the price to 70*l.*, 80*l.*, and even occasionally to 100*l.* and 120*l.* per ton, and although now the price has fallen to about 35*l.* per ton, yet with the smallest demand, in the present inelastic state of supply, the prices would be sure to rise rapidly.

20. Moreover, in comparing these prices with those of flax, the remark made when comparing cottonised Rheea with cotton is here also applicable, that is, that the rough Rheea or China grass as it now comes into the market contains a very large proportion of its natural gum, causing the fibres to stick together, and in order to get it ready for combing and spinning it must first undergo a chemical treatment involving a considerable expenditure for chemicals and labour, as also a certain loss in weight. The rough or undressed flax, on the other hand, consists almost entirely of pure fibre, the gum having to a large extent been destroyed by retting.

21. The loss in weight involved by the chemical treatment will, of course, vary according to the quality of the China grass and the nature of the process adopted. In the cottonization experiments already mentioned the loss amounted to 25 per cent. M. Moerman quotes a letter from Mr. Bonsor, manager of the Wakefield China Grass Company, in which the latter estimates the loss in his operations as between 23 and 38 per cent., the remainder consisting of either combed fibre or tow. The average yield of fibre from good specimens of China grass amounted to 76 per cent. French experiments, reported on by the Lyons Chamber of Commerce, estimate the loss at from 30 to 34 per cent. From the above data it seems, therefore, that the proportion of available fibre in the rough Rheea cannot be estimated at more than three fourths of the whole weight, whilst probably it is nearer to two thirds only of the quantity.

22. It must, however, be taken into account that in all these latter experiments the loss determined includes the dead loss incurred in combing the prepared Rheea, though it does not include the tow, the latter, as well as the combed Rheea, being counted as fibre. Now flax will also suffer a certain dead loss during combing, but it has to undergo no chemical treatment. In the better kinds this loss will be from one to two per cent., in inferior kinds about five per cent. This amount is therefore a mere fraction of the loss suffered by Rheea. So that in comparing flax with Rheea, the result already arrived at would not have to be materially modified, that is, that the rough Rheea does not represent more than three quarters to two thirds of its weight of fibre comparable with the undressed flax, and that in consequence, before comparing its price with the price of flax, the price of the rough Rheea must be increased by from 33 to 50 per cent., in addition to the cost of the chemical treatment.

23. If Rheea as imported were to sell at 50*l.* per ton, the fibre available in it would be practically paid at the rate of from 67*l.* to 75*l.* per ton, to which price will have to be added the cost of chemicals and of labour used in its preliminary preparation. But the bulk of the flax imported at the present moment into the

United Kingdom cannot be valued at more than 45*l.* per ton, whilst the finer varieties imported from Holland and Belgium sell at from 60*l.* to 70*l.* per ton, and only the very finest Courtray flax commands higher rates, say, 120*l.* to 140*l.* per ton. Under such conditions it is clear that the range of prices would prevent Rheea from entering into competition with any but the finest kinds of flax, and that even with the raw material as low as 35*l.* per ton (which means the available fibre at a minimum of 47*l.* to 53*l.* per ton, in addition to the cost of chemicals, &c.), it would not be possible for Rheea to replace the commoner descriptions of flax, whilst in the present state of the market, when a small demand might send up the price of raw China grass to 80*l.*, such a price would be prohibitory to its competing with almost any description of flax. The bearing of these facts on the future prospects of Rheea will be considered subsequently. There can be no doubt, however, that if the spinning difficulties were once overcome, the valuable qualities of Rheea would render it eminently fitted for successful competition with the finer varieties of flax.

24. The application of Rheea which has hitherto attracted most attention, and which for a time achieved the greatest share of success, is its use as a substitute for long-stapled wools. Both the nature of the fibre and the higher prices of the materials for which it acted as a substitute have hitherto favoured experiments in this direction. The hairy nature of the fibre has already been noticed. The cells of which the fibre consists are from 3 to 18 inches long. Under chemical treatment these cells are separated from each other, and the long fibre falls naturally into lengths of from 4 to 9 inches, and in that state bears a striking similarity, when not too closely viewed, to some long-stapled hairs and wools. Combing produces long fibre and tow or noils in about equal proportions. The average yield from rough China grass may be taken as one-third combed fibre, one-third noils, one-third loss by chemical treatment, dust, &c. But good qualities of China grass yield about 40 per cent., and sometimes even 44 per cent., of combed fibre. Rheea and wool.

25. The prepared Rheea, or China grass, cut up into suitable lengths, has, in fact, been found capable of being spun on worsted machinery, and then used like mohair or other long-stapled wools, for the manufacture of certain kinds of fabrics which depend for their effect on the gloss of the material. These fabrics were made, as a rule, with cotton warps, Rheea yarn of comparatively little twist being used as weft. The use was mainly for ladies dresses, and at first it seemed as if the success was complete. More than 20 years ago Mr. Lister and Mr. Sangster, and subsequently Messrs. Wade and Sons and Mr. Whitaker of Bradford, the China Grass Company at Wakefield, and other manufacturers, devoted many years and many efforts to the development of this industry; and as early as 1860, at a lecture delivered to the Society of Arts, I was enabled to exhibit some 40 specimens made from fibre prepared by Dickson's processes. But after a certain time the inferiority of the new fabrics for ladies dresses became manifest. Although everything that could be desired as regarded appearance and finish, there was the fatal objection that in wear they became easily creased, as the vegetable Rheea fibre is wanting in the great elasticity possessed by wool. In view of such an inferiority, the prices then ruling for Rheea made its use for this purpose no longer remunerative. The new trade collapsed as rapidly as it had sprung up, and since 1872 the matter is again one of experiment. The creasing, however, is to be got over by mixture with wool, or by the use of very thick cotton warps, and fabrics of a new kind have been manufactured on a small scale, and have found a ready sale.

26. There is also sufficient evidence that at prices of the raw material permanently lowered there would be a larger field for the use of Rheea as a substitute for long-stapled wool. Even if its use for ladies dresses were not again resumed, there are hangings, carriage linings, carpets, and other manufactures for which the suitability of Rheea has been established, and for which its application continues to engage the attention of some of our most eminent manufacturers. There are several circumstances favouring the use of Rheea in this line rather than in competition with flax. The material competed with is higher priced than flax, the better classes of wool varying from 130*l.* to 280*l.* per ton, whilst those which in their raw state are lower priced contain such a propor-

tion of dirt that the price for the really available fibre is, here also, in reality, not much lower. Thus the technical difficulties in the way of spinning and weaving Rheea on worsted machinery have been much better overcome than similar difficulties encountered in using it as a substitute for flax. There is also the circumstance that the Rheea combing waste, or noils, has been found very suitable for mixture in bulk with rough kinds of wool, and capable of being used for blankets, as also, possibly, for giving strength to shoddy, and for a variety of other rough purposes.

Rheea and silk.

27. Ever since the Exhibition of 1851 brought Rheea prominently into notice, a great number of experiments have been tried with regard to its suitability for being used as a substitute for silk, or even as an admixture with it. The glossiness of the finely-prepared Rheea naturally suggested this use. Both in England and in Lyons the subject has been taken up repeatedly; and though by the application of Rheea it is possible to imitate to a certain extent the effects of silk in certain mixed fabrics, the special use of Rheea for this object has never acquired any real footing apart from the fabrics relying on very similar effects which have been prepared from it on worsted machinery, and already noticed. As regards mixture with silk also, Rheea has a formidable rival in the much cheaper jute, now largely used for this purpose.

Rheea and hemp.

28. In the cases in which Rheea is used as a substitute for flax, wool, and silk, it is made to compete with high-class fibres, in the preparation of high-class fabrics, for which it must be rendered fit by means of a complicated manipulation, and it is put essentially to a new use different from those to which it is applied in the countries of its original growth, such as China and the East Indies, because the fine grass-cloth fabrics produced in China, and woven not from Rheea yarn but from untwisted bundles of fibres joined end to end, either by the gum naturally contained in the fibre or by a special kind of knot, cannot be compared with any fabrics produced in this country. On the other hand, the use of Rheea for purposes for which hemp is used in this country is generally practised in Assam, in parts of Bengal, and in the East Indian Archipelago. It is used for nets,* fishing lines, and other purposes for which strength, lightness, and power of resisting water are essential.

29. The question of price, which is so serious for the future of Rheea, even in comparison with such high-priced fibres as fine flax, wool, and silk, seems to be even more formidable when Rheea is compared with such a comparatively low-priced material as hemp, the best varieties of which only range at 43*l.* per ton, while commoner varieties do not much exceed 30*l.* per ton. It must, however, be remembered that hemp suffers a greater loss in weight in the process of heckling, and the rough Rheea in the manipulation required in making it available for the purposes of hemp need hardly experience such a great diminution in weight as that already mentioned as taking place in the process of converting it into fine fibre, viz., one third to one fourth of the whole weight, nor, probably, will the expense of chemicals, &c., should such be required, be so considerable in this case. It follows that in comparing the undressed hemp as it comes into the market with the available fibre contained in the rough Rheea or China grass, a much smaller addition will have to be made to the price of the latter than was necessary in comparing the relative prices of Rheea and flax.

30. Another point of great importance is the superiority of Rheea to hemp as regards strength and resistance to water. The greater strength of Rheea may make it possible to replace hempen cordage by lighter Rheea ones. For many purposes, such as ships rigging, the increase in lightness is in itself an important consideration, apart from the saving of the material. It is this circumstance which has rendered Manilla hemp so valuable as

* Nets in India are almost invariably tanned with decoctions of one or other of the many substances there available for such purposes. In this country "cutch" (Catechu) is chiefly employed for a similar purpose, although the Scotch fishermen prefer Highland birch bark when it can be obtained. Nets, in this country, are made of hemp, as it is found that flax does not retain the tannic acid, or, as it is called, does not "bark" well. Even old weakened lines when retanned resume their strength. In India ordinary cordage is frequently subjected to this process, and the subject is one deserving of more attention in this country than it has yet received.

compared with the ordinary hemp. On all these grounds Rheea may be substituted with advantage for hemp, even if it be at a considerably higher price than hemp. The same may be said of its cognate use for canvas and sailcloth instead of flax. In that case also the superior strength of Rheea results in the double advantage of a saving in material and of greater lightness, and would enable it to compete successfully with flax, even if this latter were considerably cheaper per ton.

Rheea as a paper material.

31. The use of Rheea fibre as a paper material is, of course, not likely to be of any primary importance. Some of the waste, however, may very well come in for this purpose, although the following table, which embraces the results of a series of experiments made at the Haverstoke Mills under the direction of Mr. Wyndham Portal, upon the paper-making qualities of samples of Indian fibres supplied from the India Museum, shows that Rheea offers no special advantages as a paper material when compared with some other Indian fibres of far inferior value for the other important purposes for which Rheea is adapted. I must remark, however, that since the above experiments I have had communications from experienced paper manufacturers with respect to the use of Rheea as a paper material, all speaking in a hopeful tone, and considering that a certain admixture of Rheea is sufficient to impart strength and cohesion to very inferior materials.

TABLE indicating the Strength and Quality of Papers made from Indian Fibres, and from "Bank Note" and "Bill" Pulps.

Division.	No	Name and Condition.	Average Weight sustained by Slips of Paper in the "Water-leaf," or unsized Condition, each weighing 39 Grs.	Average Weight sustained by Slips of Paper of 39 Grs., after being sized.	REMARKS.
			lbs.	lbs.	
EXOGENS.	1	Sunn (*Crotalaria juncea*) in "raw" state	57	63¾	Makes a nice clean smooth paper, of good colour, but does not take ink well.
	2	" " "	55	65¾	During pulping, worked what is technically called "wet." This sample bears ink well.
	3	Bun-kra (Bengal) (*Urena lobata*) "	69	75	Worked "woody" and "hairy." Bears ink well.
	4	Ambaree (*Hibiscus cannabinus*) "	64	71	Worked well, and bears ink well.
	5	Rheea (*Boehmeria nivea*) "	—	60	Very stubborn and lumpy when pulping. Makes a smooth good-looking paper.
	6	Bon or Jungle Rheea from Assam* "	49	54	Very stubborn and lumpy when pulping. Makes a smooth good-looking paper. Does not bear ink well.
	7	Jute (*Corchorus olitorius*) "	51	60	Washed and worked satisfactorily. Makes a firm paper. Bears ink well.
	8	Gunny-bag material - - - -	—	53	Makes a very superior paper.
	9	¼th Sunn (*Crotalaria*) and ¾ths linen rags	39	59	Does not bear ink well.
ENDOGENS.	10	Agave (*Agave Americana*) in "raw" state	87	89	Most approved of. Makes a strong, tough, smooth paper, which appears to possess some peculiar qualities. It feels like oiled-paper, and can be written upon, although unsized, without the ink running.
	11	" " "	45	49	Worked very freely, and takes ink well.
	12	Plantain (*Musa paradisiaca*) "	74½	78	Originally badly cleaned; would otherwise have made a good paper. Bears ink, although unsized.
	13	Pine Apple (*Ananassa sativa*) "	71	74½	Worked very "wet" in pulping. Makes a good and very strong paper. Bears ink well.
					NOTE.—Each of the above 13 specimens has been treated alike, viz., boiled for several hours in alkaline solution; then washed bleached, and pulped. The fibre was, as nearly as could be made, of the same length in each specimen.
	14	"Indian Bill" pulp "	51	78	Composed of linen, with a certain proportion of cotton.
	15	New India Note pulp (long fibre) "	50	65	
	16	" (ordinary) "	36	52	
	17	Bank of England Note pulp "	32½	47	
					NOTE.—The materials from which the bank-note and bill-papers (Nos. 14, 15, 16, and 17) were made, were, for the sake of colour and appearance, more highly prepared than the above samples, and their strength consequently diminished.

* Bon or Jungle Rheea, called also Wild Rheea, is very common in Assam. It is still undecided whether botanically it is different from the *Boehmeria nivea*, which furnishes the cultivated Rheea of Assam and other places. As imported into this country, it is of a dark colour, and although not difficult to bleach, all attempts to extract a fair proportion of its fibre in a state fit for spinning and manufacturing purposes have hitherto failed.

32. Amongst minor uses of Rheea may be mentioned that for packings of steam engines. As seen from the foregoing table, it is extremely difficult to reduce Rheea to the state of pulp, and consequently, for the above purpose, it would be likely to last much longer than flax, which is far inferior in point of tenacity. The small effect of high-pressure steam on Rheea, as compared with almost all other fibres, bears likewise on this point. As a curiosity, it deserves to be mentioned that Rheea fibre is now in use for polishing ivory, such as billiard balls, &c.

CONCLUSIONS WITH REGARD TO THE FUTURE PROSPECTS OF RHEEA.

The foregoing short account of the physical properties of the Rheea fibre, and of the various uses to which it has hitherto been put, gives an idea of the wide range of its applications, and leads to several clearly defined conclusions.

Rheea has the widest range of possible applications of any fibre.

33. It appears that there hardly exists a fibre which, in virtue of its own inherent properties, can be applied to so many different uses. Amongst the fibres which already enter largely into textile manufactures, flax is perhaps the one which possesses the most extended range of applications—from the roughest canvas and cordage to the finest lace; yet the range of Rheea is even greater still. This is due partly to the superlative degree in which it possesses certain qualities, such as fineness, strength, and lustre, not usually associated in the same perfection in any single fibre, and partly to the curious intermediate position which it holds between the usual vegetable and the animal fibres. Although a vegetable fibre, its hairiness assimilates it to wool, and its gloss and fineness to silk. The resemblance to wool Rheea shows in common with other nettles, the Neilgherry nettle, for instance, which is, however, so very rough and hairy that it could never compete with smooth fibres such as flax, whereas Rheea can be rendered fit for either use. Thus Rheea combines the whole range of applications of hemp, to which it is superior in almost every respect, with almost the whole range of the uses of flax, excepting perhaps its use for body linen, together with certain other uses for which only the animal fibres, wool and silk, have hitherto been employed.

Price the principal obstacle to its rapid development.

34. If, therefore, the extensive introduction of Rheea into manufactures depended upon its own inherent qualities, there would be hardly a fibre which had ever better chances of success. The obstacles in the way of such a successful result are the technical difficulties experienced in spinning and weaving, and the high price of the raw material. It may, however, be stated that the price is the only serious obstacle, since most of the technical difficulties have either already been overcome, or are sure to be so if once a lower price should render its use sufficiently remunerative.

Comparative progress of Rheea and jute.

35. It is the high price of the raw material which explains the fact that Rheea, although brought to notice in this country only about 15 years later than jute (introduced into England in the last decade of the past century), is still, notwithstanding its superior qualities, in very much the same position as it was in 1816, when the Court of Directors considered it as proved that it could be used for the finest Brussels lace, and when they sent out to India machinery for the preparation of the fibre, whilst jute, in the meantime, has become one of the leading Indian staples, the value of the exports of jute and jute manufactures from Calcutta in the year 1872–73 amounting to more than 5,000,000*l.*

Jute has always been the cheapest of fibres.

36. But from the very beginning jute took its stand at the bottom of the price list as the cheapest of fibres, its price about the year 1830, before it had yet received any extended application, being between 10*l.* and 12*l.* per ton, and for many years subsequently it never, except for short periods, rose beyond 15*l.* or 16*l.* per ton. This low range of prices supplied the stimulus which led the manufacturers to incessant experiments with it until about 1850, when, after an experimental period of almost 20 years, all the mechanical difficulties of its working had been surmounted, its special uses ascertained, and the new manufacture established on a firm basis.

Long period of experiments with jute.

37. It must be remembered also, that even with the stimulus of low prices, 43 years passed between 1796, when it was first imported into this country, and 1839, when it was first utilized on a large scale, that is to say, not merely as an occasional adulterant of other fibres, but for the manufacture of fabrics *sui generis*. It was only in that year that Mr. Rowan of Dundee succeeded in persuading the Dutch Government to employ bagging made from jute as a substitute for that made from flax tow for the use of the Dutch coffee plantations in the East Indies.

Whilst jute owed its success to cheapness, Rheea will owe it to its high qualities once that the price has ceased to be prohibitive.

38. The stimulus which, in the case of jute, was afforded by low prices, will, in the case of Rheea, be sufficiently supplied by its own high qualities, if only the prices do not become prohibitive. Rheea possesses qualities which will always make it a comparatively high priced fibre, standing as it does between the vegetable fibres, hemp and flax, ranging from 30*l.* to 70*l.* per ton, and the usually much higher priced animal fibres, wool and silk, ranging from 130*l.* per ton upwards. It is only in competition with these latter that Rheea will have to rely on its cheapness, since as regards the other vegetable fibres it has already been noticed that at equal or even superior prices it may yet in many cases be used with advantage instead of hemp and flax. The details supplied in the previous section satisfactorily prove, however, that the prices of the raw material have in reality been hitherto prohibitive. On any greater demand for it, the prices of the raw fibre rose at once to 70*l.* or 80*l.* per ton, which corresponds to 100*l.* or 120*l.* per ton of available fibre, exclusive of costs of preparation. Prepared or combed fibre was usually sold at 2*s.* 6*d.*, sometimes 3*s.* 6*d.* per lb., or 280*l.* to 392*l.* per ton, prices such as, with the exception of the best kinds of Sea Island cotton and of some superfine kinds of flax, which may almost be called fancy varieties, no vegetable fibre commands. The combing waste or noils of Rheea even now find a ready sale at from 80*l.* to 100*l.* per ton, a price which, with the present prices of rough China grass, might make it remunerative to convert its whole quantity into combing waste, if so be that this could be practically carried out. Under such conditions, it is a striking acknowledgment of its value that it should ever have been considered as having any chance at all, and have come so near to actual success as it has done.

39. In considering what range of prices would be sufficient to secure a large demand for this material in the present state of the market, several circumstances must be taken into account.

Differences in the quality of Rheea arising from the nature of the plant.

It is important to bear in mind that, like all other fibres, Rheea exhibits remarkable differences in quality. In China, where alone it is used for any fine purposes, a difference is even remarked between the various layers of fibre on the same stem: the outside layer close to the bark being stronger and rougher, whilst the inner layer is glossier and finer, and more suitable for high class fabrics. It is also highly probable that, as in flax, the fibre at the base of the stem is rougher than that at the top. Well-marked differences arise from the season of cultivation and the time of cutting. The first crop of the plant is usually shorter and more woody and branched, and yields inferior fibre to the second or third crop, which, in turn, appear to differ from each other. It seems also certain that, like jute, the early-cut stems yield a finer fibre, but in proportionably small quantities, whilst in the perfectly ripe stems, the fibre increases in weight and strength, but diminishes in fineness and lustre. If the Rheea stems be worked up in their fresh state, and if the time of cutting should have extended over four or six weeks, this in itself would be sufficient to produce fibre of different qualities, even from the same plantation.

Differences in the quality of fibre produced by modes of cultivation.

40. A difference in the soil or mode of cultivation is as sure to produce remarkable differences in the qualities of the fibre as it does in the case of flax or jute. In the Rheea stems obtained from France there was a proportion of strong, branched, knotty sticks, more than half an inch in diameter at the bottom, whilst there was also a considerable proportion of thin shoots hardly a quarter of an inch thick, and straight and smooth, although as high as the former, and containing a much finer fibre. The difference arose obviously from the former growing as central stems with a number of lateral branches, while the latter grew as parallel shoots thrown out from the same root,—a difference which the mode of planting and cultivation would produce.

Advisability of not letting the plant grow beyond 3 to 4 feet for fine purposes.

41. On the part of several correspondents who have long given their attention to this fibre, it has been suggested that, for very fine purposes, this plant should not be grown to a greater height than three or four feet, the superior value of the fibre compensating for the diminished out-turn per acre, although even the out-turn might be increased, or at least remain unchanged, if the smaller height to which the plant is grown should allow of planting it closer together, or of obtaining more crops per annum than when the plant is grown to its usual

height of six or eight feet. The fibre from the smaller stems is likely not only to be finer, but it is also likely to suffer less loss in combing. Although the bark peeled off the six to seven foot stems may be of the same length as the stems, yet the fibres do not run the whole length. At each joint a certain proportion of the fibres stops, so that along with the full length fibre there is always a certain proportion of short lengths, which in scutching and combing mostly run to tow. With stems of less height this difficulty is likely to be lessened.

Differences in the quality of the fibre arising from the mode of preparation.

42. All these are differences in the natural properties of the fibre itself, and independent of variations produced by a different mode of preparation. The latter, which will be superadded to those inherent in the fibre as grown, will be hardly less considerable. There is the difference between the fibre obtained from the green stems and that from the dry stems. The subsequent chemical treatment may result in a greater or less disaggregation of the original fibre, and materially influence its character. On all these grounds it appears that the Rheea brought into the market will, under any circumstances, even with the most perfect methods of cultivation and preparation, manifest considerable differences in its quality and properties,—differences greater than is the case with other fibres. As before explained, it is quite likely that, even from the same plantation, some of the produce may be remarkable for strength, but deficient in fineness and gloss; another portion, fine and glossy, but less strong; another, by its roughness and hairiness, approaching wool in its character.

Influence of the differences in the quality of the fibre on its introduction for manufacturing purposes.

43. Ultimately, this very range in the quality may prove an advantage; but at first, in the experimental stage, it is a decided disadvantage; and it can be easily shown that this is, in itself, a sufficient reason why it is impossible to expect that Rheea should, from the first, command such high prices as its good qualities are likely to ensure to it after its cultivation and preparation have become more developed. A high price of necessity restricts the application of the fibre to the very finest purposes. Now, it is the invariable characteristic of high-class manufacture to require perfect uniformity in the quality of the material used in it. Not only must each bale of fibre used for fine purposes be as nearly as possible uniform in its quality, but it is likewise necessary to ensure the steady supply of other bales as uniform and of the very same quality. It is an established fact, that in the case of any inequality in the material, the whole quantity will sink almost to the value of the lowest quality contained in the mixture, and that no high-class expensive machinery will ever be established unless there are grounds for expecting that the quality of the raw material will be uniformly maintained. In any other case, the fibre can only be used for rougher purposes, and worked on simpler machinery, in which such variations in quality are of no moment.

Probability that only a portion of the crop will be suitable for fine purposes.

44. As before explained, there will be in the case of Rheea even greater difficulties than in the case of other fibres in ensuring this perfect equality in condition, as a considerable amount of variation in the character of the fibre is unavoidably connected with the very nature of the growth of the plant. It will require a perfect knowledge of the nature of the plant and of the fibre and its working, and a perfect mutual understanding between the agriculturalist growing it, the machinist cleaning it, and the manufacturer spinning it. This can only be the slow result of time, and will only have been attained when cultivation, being more extended, and trade conducted on a larger scale, it will be possible to carry out a complete subdivision of the crop according to its various qualities, and when the best practical uses of each quality will have been ascertained. Moreover, in any case, even with the agricultural and mechanical treatment, it is likely that only a certain part of the crop will be suitable for fine uses, whilst a considerable proportion will only be available for rougher purposes. So that, unless the method of preparation allows of utilizing this rougher portion of the crop also, the remaining portion suitable for fine purposes will always be disproportionately dear.

A large trade in Rheea can only spring up if the bulk of the fibre is supplied at prices which make it possible to introduce it into the manufacture of common goods of wide consumption.

45. It is clear, therefore, that a rapid development of the Rheea trade cannot be expected until the bulk of the raw fibre can be supplied at a price much below that which it will eventually attain when its higher qualities have been more fully developed, and below that which the finer portion of the crop is likely to

command even now. It may finally come to be applied to the manufacture of damask, cambric, and lace, but for some years to come, even if its use for such purposes should prove successful, it will have to be worked up by manufacturers only gradually discovering its properties, and on machinery with processes imitated from those used with other fibres, and therefore not specially adapted to Rheea. The consumption of the fibre for fine purposes, during that experimental stage will be necessarily small, and restricted only to the best qualities. No real outlet therefore will have been obtained for Rheea unless it be applied for purposes for which, in the opinion of some of its sanguine advocates, it is far too good, such as for cordage, as also for canvas, mixture with rough wools, lower kinds of carpets, hangings, linings, certain kinds of linen, &c. It is also to be remembered that only by becoming suitable for the manufacture of comparatively cheap articles produced in large quantity, is there any hope of its becoming a great staple. If it were able to compete with only the Courtrai flax, and no cheaper fibres, however successful it might be in this respect, it would never develop into a large trade.

For successful competition with other fibres the price of Rheea for all but fancy qualities should not be beyond the limits of from 25*l.* to 40*l.* per ton.

46. It will appear clearly from this discussion that in all probability the standard price of 50*l.* per ton for machine prepared Rheea in the London market, which was considered sufficiently low five years ago to ensure its extensive introduction, is in the present condition of the market too high to effect this object, especially if it be also considered that the machine prepared Rheea is not likely to be equal to the hand prepared China grass. Such a price of raw material for fibre available for spinning would correspond, as already calculated, to a price per ton of 75*l.*, with the addition of the cost of chemicals, a price which would amount to rather more than that of the finest varieties of flax, which enter extensively into the commerce of this country. If Rheea, with all the disadvantages attending the introduction of a new staple, is to compete successfully with the fibres which already have possession of the market, there must be some likelihood of obtaining steady supplies of the rough fibre at prices which correspond more nearly with the prices of the other vegetable fibres, such as flax and hemp, that is, at an average price of at the outside from 30*l.* to 40*l.* per ton for the better, and from 20*l.* to 25*l.* per ton for the lower, qualities. Even with such prices, the fibre, freed from gum and in a condition similar to that of undressed flax, could not be prepared at less than from 35*l.* to 60*l.* per ton, plus cost of chemicals. Considering its superior qualities, however, such a price would seem sufficiently low to bring Rheea into competition with flax and hemp, even if the latter were somewhat cheaper. It has also to be considered that the limits of price for Rheea will, of course, always depend on the state of the market with regard to fibres generally, and that at present the values of all the fibres are much lower than they were some years ago. With a recovery in the value of other fibres, the limits of price here indicated for Rheea would have to be proportionately increased.

PREPARATION OF THE FIBRE FOR THE MARKET.

Having thus determined the limit of price at which the Rheea fibre may compete successfully with other fibres, it remains for us to consider what probability there is of preparing it at that price for the market. The problem is partly agricultural and partly mechanical; that is, its conditions are an improved growth of the fibre and the discovery of improved processes for its separation from the stems, instead of the tedious and expensive hand labour hitherto employed. It is this latter portion of the problem which has given rise to the action of the Government of India, and which to this day remains unsolved.

Comparison of Rheea with flax and hemp.

47. A short description of the plant, as compared with flax and hemp, will be the best introduction to the discussion of the various methods which have been proposed or tried for the preparation of the fibre. In its general character, as in the length, thickness, and woody nature of the stems, the Rheea stems appear at first sight to resemble hemp, so that it seems as if the same processes and the same machinery which are suitable for the preparation of the hemp fibre for the market ought likewise to be suitable for Rheea. There is, however, one important difference; the Rheea stems are much more succulent than hemp. The green Rheea stems lose on drying from 75 to 83 per cent. of moisture, whilst hemp only loses from 45 to 60 per cent., and flax from 50 to 70 per cent. The difference between the three plants appears even more striking if the amounts of dry stems obtained from 100 lbs. of fresh stems are compared with each other.

100 lbs. fresh hemp	will yield	40 to 55	lbs. dry stems.
,, flax	,,	30 to 50	,,
,, Rheea	,,	17 to 25	,,

The quantity of dry stems obtained from the same quantity of green stems is thus less by more than one half in the case of Rheea than it is in that of hemp; and even flax, though more succulent, yields almost double the weight of dry straw that Rheea does.

Proportion of fibre in dried stems.

48. The per-centage of fibre contained in the dry stems of the three plants does not differ very much:

100 lbs. dry hemp stems	yield about	17	lbs. raw fibre.
,, flax straw	,,	15	,,
,, Rheea stems	,,	20 to 28	,,

The yield of Rheea appears to be larger than that of hemp or flax, but this is mainly due to the fact that, as already explained, what is called raw fibre in the case of Rheea contains from 25 to 30 per cent. of gum, whilst the raw flax and hemp have already been freed from gum by the process of retting. By deducting from the yield of Rheea 25 or 30 per cent., the yield of fibre is reduced to about 15 per cent., or to about the same yield as that of hemp or of flax.

Proportion of fibre in fresh stems.

49. Calculated on the green however, the proportionate yield of fibre from Rheea will appear much smaller than the yield from hemp or flax:

100 lbs. green hemp stems	yield about	9 to 12	lbs. raw fibre.
,, flax straw	,,	5 to 7	,,
,, Rheea stems	,,	4 to 6	,, corresponding to from 3 to $4\frac{1}{2}$ lbs. of fibre freed from gum.

Thus, on an average, 100 lbs. of green Rheea cannot be expected to yield more than about 5 lbs. of raw fibre in the state in which it is now sold in the market, corresponding to about $3\frac{1}{2}$ or 4 lbs. of fibre freed from gum.

The proportion of moisture and of fibre here adopted for flax and hemp are as fair averages as can be obtained, and the greatest number of recorded observations agrees with them. When occasionally a much higher out-turn of fibre from the green straw is mentioned, this is due to a confusion of language, the air-dried but unretted straw being still called green straw. In the air-dried condition the proportion of fibre is, of course, more than double with reference to the weight of straw than it is in the fresh straw as taken from the field.

All the data, in so far as they refer to Rheea, have been obtained from recent experiments carried out in London; the per-centage of fibre yielded by the dry stems being obtained by repeated trials on large quantities of Indian stems, and the per-centage of moisture contained in the green stems, by several experiments on French and Algerian stems. No other reliable data on these points have been forthcoming. At the Saharunpore trials, Greig's machine obtained only $2\frac{3}{4}$ lbs. of fibre from 100 lbs. of fresh stems, but there is no evidence that the whole of the fibre was removed by its action.

In fact, judging from the action of the machine and from the account of the trial, it is likely that a considerable portion of the fibre was either left on the stems, or else got lost and broken up during the process. So that $2\frac{3}{4}$ per cent. appears to be a much lower proportion than that actually contained in the stems. On the other hand, Col. Hyde states that according to all obtainable data the amount of fibre obtained by stripping the stems by hand amounts to about 200 lbs. of fibre for each ton of stems, or about 9 per cent. Such a yield appears rather high. It might be explained if the plants were cut rather late, and with the moisture reduced to about 60 per cent., or perhaps the weight may apply to the stripped bark, before the scraping which removes the outer cuticle as well as a large quantity of gum. At any rate there are no detailed experiments to show that so large a proportion of marketable fibre as 9 per cent. has ever been obtained.

50. Another characteristic of the green Rheea stems is the presence of a considerable amount of gummy and resinous, or what is called extractive matter. In fact, the two characteristics, moisture and extractive matter, as a rule, go together. The more moisture, the more extractive matter is contained in solution in the juices of the plant, and as a rule the more gummy, resinous, glutenous, and other such proximate constituents deposited in the cells and vessels. Hemp with about 50 per cent. of moisture, on the average contains gum to the extent of about 25 per cent. of the weight of the dry stems. One half of this gum is soluble in water, the other half insoluble in water, though soluble in alkalies. Flax, which contains on the average about 60 per cent. of moisture, contains also a larger proportion of gum, to the extent of about 35 per cent. of the weight of the dry straw. Of this gum also one half is soluble in water, the other half only in alkalies. The succulent Rheea stems, which contain so much more moisture than either of the two preceding plants, on the average no less than 80 per cent., are likely on that account to contain an even larger proportion of extractive matters than is the case with flax. There are no exact experiments bearing on this point, but we know that the raw China grass, although the scraping and washing has already removed a considerable portion of the gum, still contains from 25 to 30 per cent. of it; and we know that all who have ever experimented with the green stems are unanimous in declaring that the great quantity and somewhat acrid nature of the gum contained in the Rheea is the greatest obstacle in the way of the successful preparation of its fibre. This gum, moreover, seems to be rapidly affected by exposure to air; apparently it coagulates, becomes insoluble in water, and appears as a reddish brown shellac kind of substance. In the Saharunpore trials all the iron rollers and other exposed parts of the machinery were covered with a resinous coating consisting of this substance, and it was noticed that when the fibre stripped from the stems was allowed to lie over night, without being at once scutched and cleaned, it was rendered useless for all further purposes, the gum or mucilage having become thickened, binding all the fibrous threads strongly together.

Retting of the Rheea plant and its difficulty.

51. In the case of flax and hemp, the method usually employed for the removal or destruction of the gum consists in retting, during the process of which the gum is destroyed by fermentation, flax losing in weight between 25 and 30 per cent., and hemp from 20 to 25 per cent. The more succulent the plant, and the larger the proportion of gum, the more difficult is it to control the process of fermentation in such a manner that the fibre shall not be injured by over-retting. Accordingly flax retting is a more difficult and delicate operation than hemp retting, and from the presence of the large quantity of gum in the Rheea plant, one can conclude at once that retting will be a difficult operation. It is easy to account, therefore, for the opinion usually entertained, that the process of retting is inapplicable to Rheea. The fermentation

will of necessity be rapid and energetic, and will easily become destructive. In any usual crop of Rheea full grown, woody sticks and slender succulent stems are almost invariably found together; and, besides, the top part of the stems is always much more tender than the lower part. Consequently there is always a chance of a large proportion of stems being over retted and the fibre entirely spoilt, whilst the thicker woody sticks will hardly have been attacked by the fermentation; besides, the top part of the stem may have already become rotten, while the lower part still contains a large proportion of undestroyed gums.

Possibility of regulating the process of retting the Rheea stems.

52. In India and China, therefore, retting is considered injurious, but although the fibre is not retted, yet it is steeped for various periods from 12 hours to 3 days; and in Sumatra it is stated to undergo a complete retting process without apparently losing any of its strength. It appears, therefore, that although difficult to regulate, retting need not necessarily be considered impossible. It will be noticed subsequently that the preparation of the fibre by retting has attracted the attention of a number of experimenters. The operation will have to be conducted very carefully, and will require thorough sorting of the stems according to their thickness, length, and dryness, and a preliminary crushing between rollers might help to equalize the action of the fermentation on the more fleshy and the more woody portions. There is another point to be taken into consideration. The process of fermentation becomes much slower and consequently more manageable if the plants have been dried before retting. In the case of flax the straw is almost invariably stacked in the field and dried before retting; only in a few Belgian districts is the contrary practice followed, that of retting the green straw. Hemp, likewise, is mostly retted in the dry state. In India, however, in the case of jute and sunn, retting, as a rule, follows immediately after the cutting, although in some localities the practice prevails of stacking the stems and leaving them exposed for two or three days to the sun. It is the Indian habit of performing the retting on the green stems, which may account for the failure of all retting operations in the case of Rheea. At all events retting cannot be condemned finally until it has been thoroughly tried on the dried stems.

Separation of fibre from bark and stem.

53. The separation of the retted flax and hemp fibre from the woody stem and from the outside bark is a very simple operation, as in consequence of the destruction of the gum during the retting the fibre is already in a perfectly loosened condition, and both the wood and the bark have become brittle, and are easily crushed, broken up, and shaken out from the fibre in the processes of heckling and scutching. The operation is, of course, performed only on the dry stems. If Rheea could be retted the same results would follow, and even in the dried unretted Rheea a somewhat similar effect has been obtained. In the case, however, of the fresh Rheea the fibre not only adheres strongly to the woody stem, but even more so to the bark, and can only be separated from the latter by a process of scraping. The bark consists of an outer brown skin, and below it there is a thickish green fleshy layer in which a large proportion of the fibres are as it were imbedded. The complete removal of this outer brown bark is the great difficulty in the case of all the machines which have been devised for operating on the green stems of the Rheea plant.

Out-turn of fibre per acre.

54. It is more difficult to obtain reliable data of out-turn for the different fibres. The differences in different localities and in different seasons appear to be almost greater in the case of fibres than in the case of any other crops.

The following numbers may be taken as approximately correct. The weights given refer in all cases to clean marketable fibre.

Out-turn of cotton in India, about	70	lbs. per acre.
" " the United States	2–300	"
" flax	5–600	"
" hemp	7–900	"
" jute	12–1500	"
" Rheea—		
250 lbs. of fibre for each crop. Thus with 3 crops in the year	750	"
With 4 crops in the year	1,000	"

The numbers inserted above with regard to flax and hemp represent nearly enough the average out-turn in England, France, and Germany. The out-turn of

jute has been calculated from the data contained in the report by Hem Chunder Kerr, of the Commission appointed by Sir George Campbell on the cultivation of jute in Bengal, recently published. It may be mentioned that this out-turn more than doubles that of the numbers previously accepted. The average crop of jute was formerly estimated at from 400 to 700 lbs. per acre, though most people who had any special acquaintance with the trade held that estimate to be much under the mark.

With regard to Rheea, there are extraordinary discrepancies between the various statements referring to out-turn per acre. In a discussion on the subject of Indian fibres at the Society of Arts (7/5/1869), Mr. Bainbridge mentioned that notwithstanding the use of manure, he could not obtain a larger crop of green stems than 720 lbs. per acre, yielding 45 lbs. of fibre. Thus with three crops in the year, the out-turn would be 135 lbs. per acre per annum. On the contrary, some published data of experimental cultivation of Rheea in the United States estimate the out-turn of clean fibre at from 700 to 800 lbs. for each crop, and calculating on three crops in the year, an out-turn of one ton of fibre per acre is anticipated. The plantation at Saharunpore seems, however, to afford a safer basis for calculation than any of the other published data. On the occasion of the trials in 1872, $1\frac{1}{2}$ acres yielded a crop of $3\frac{1}{2}$ tons of fresh stems, or at the rate of 5,200 lbs. per acre. As the fresh stems contain from four to six per cent. of fibre, such a crop ought to yield from 208 to 312 lbs. of clean fibre, or on the average about 250 lbs. As it may not be safe to count on more than three crops in the year, the out-turn per annum is brought to 750 lbs. But four or even five crops are sometimes obtained, and this, of course, proportionately increases the out-turn per annum. In confirmation of the above number of 750 lbs. per acre, the experience of the only other plantation of any size the results from which have been published may be adduced. Mr. Montgomery estimates the possible out-turn of fibre from the Rheea grown on his Rambagh estate, near Kangra, at the same figure.

Comparison of cultivation of Rheea with that of jute and cotton.

55. It appears, from the numbers quoted in the previous paragraph, that the out-turn per acre of the different fibres is almost exactly in an inverse ration to their values, and that jute, which is the cheapest, yields also the heaviest crop of all the known fibres. As compared with Rheea, it is seen that the out-turn per acre is almost double, being 1,200 to 1,500 lbs. per acre against 750 lbs. Moreover, this out-turn is obtained at one crop, whilst three crops and all the attendant manual labour are required to obtain the 750 lbs. of Rheea. The question occurs,—Is it possible to expect that the cultivation of Rheea could be rendered profitable under such conditions? To this it may be answered that, in the first place, we do not know whether, by the use of irrigation, the out-turn of Rheea may not be considerably increased. Secondly, it is likely that the part of India which will be most adapted for the growth of Rheea will not be the part in which jute is now cultivated. Thirdly, there is the great difference in price. Jute is now sold in London at from 12*l*. to 20*l*. per ton. If Rheea came to be sold at the prices already indicated, viz., 25*l*. to 40*l*. per ton, low as these would be in comparison with prices paid in former years, they would still range at about double the prices of jute. As the freight and shipping charges from Calcutta to London will not differ very much in either case, and will thus bear heavily on the cheaper material, the price of Rheea at Calcutta would be, perhaps, treble the price of jute, and in the districts more than treble; so that the difference in price is likely to compensate and more than compensate for the inferiority in out-turn, as well as to supply a certain margin for an increased cost of preparation as compared with the jute. As regards the cultivation of cotton, Rheea is not likely to enter into any competition with it. The parts of India in which the cultivation of Rheea offers the greatest chances of success are not those which grow cotton to any extent, and, moreover, quite a different soil would be appropriated to Rheea than that now under cotton, so that the cultivation of the one fibre would not agriculturally displace the other, though as regards profit, the heavier out-turn of Rheea is likely to tell in its favour.

Review of the various systems tried for the preparation of the Rheea fibre.

56. The usual way of obtaining the fibre from the Rheea stems is to strip by hand the unretted green stems, an operation at which a day's work is variously estimated to yield from $\frac{1}{2}$ to $2\frac{1}{2}$ lbs. of fibre. Retting, as before mentioned, is considered injurious, and drying the stems is likewise held to spoil the fibre. Adopting the experience of the countries in which the plant is grown as con-

clusive, the Government of India limited the competition to machines for extracting the fibre from the green stems.

Yet this experience hardly seems conclusive, nor is the experience of the Rheea-growing countries, with regard even to retting, by any means conclusive.

As regards the preparation of the fibre from the dried stems, the experience of countries in which skilled chemical treatment is hardly known is no proof that the fibre from the dried stems is necessarily worthless.

For the last four years a very large number of persons both in this country and on the continent have been supplied with samples of Indian-grown dried Rheea stems, and during the last year also with specimens of fresh Rheea grown in southern France. A large number of specimens of the produced fibre has been received at this office, and most of them accompany this report. The methods used for the preparation of the fibre appear to have been very varied. Moerman in Belgium uses a patent system of retting in warm water in presence of a small proportion of alkaline sulphurets, which according to him prevent putrid fermentation, and never lets the retting proceed to the extent of injuring the fibre. He claims, moreover, that the fibre prepared by his method of retting (No. 50) is fit to be spun on flax machinery. Mr. Bevan subjects the entire sticks to some chemical treatment which extracts the gum and leaves the fibre but loosely adhering to the stem, from which it can afterwards be separated by a simple mechanical operation (No. 62). These two processes have been mentioned first, as in both the resulting fibre is free of gum, and can be used at once for combing and spinning. All the other processes, in the first stage, effect only the separation of the fibre from the wooden stem, and the outer brown bark, leaving in it the greater portion of the gum. Thus the condition is about similar to that of the rough China grass as imported into this country, and also contains a large proportion of gum, which is subsequently removed by chemical treatment. Numerous specimens are, however, given of the subsequent stages of chemical treatment, as well as of the first stage. Specimens No. 1, No. 2, and No. 7 illustrate the condition of raw China grass, while Nos. 3–6 and 8–9 represent the same in its various stages of chemical preparation and bleaching. Specimens Nos. 10 and 11 are samples of the Rheea prepared by Greig's machine at the Saharunpore trials. Nos. 23 and 24, received from Mr. Green, are samples of freshly prepared Rheea, grown in the Southern States, and said to be produced by a new machine brought out in New Orleans. Other specimens of fibre from the green stems have been received from Mr. T. Watson, Nos. 12, 13; Mr. T. Gray, Nos. 34–37; Mr. Deininger, Nos. 42, 43; Mr. Houghton, Nos. 45–76. Most of the other samples have all been prepared from the dry stems, such as Mr. T. Watson's, Nos. 14–19; Mr. C. F. Dennet's, Nos. 20–22; Mr. Hill Dickson's, Nos. 27–30, Mr. G. Gibbs', Nos. 31–33; Mr. T. Gray's, Nos. 38–41; Mr. Deininger's, No. 44; Mr. F. B. Houghton's, Nos. 47–49; Capt. Wundt's, No. 51; Mr. Graham's, No. 52; Mr. J. Marshall's, No. 53 and Nos. 66–75; Messrs. W. Pope & Sons, Nos. 54, 55; Dr. Collyer's, No. 56; Mr. Lagergreen's, No. 60; as also several others, not included in the series, sent as a sample prepared by M. Labiche from Mulhouse, and there are some others also.

Probable success of trials with dried stems.

57. With regard to the comparative merits of the fibre as extracted from the green and from the dry stems, there seems to be an almost unanimous concourse of opinion in favour of the dry stems. However much this opinion may have been influenced by the greater facility with which the dry stems are worked as compared with the green, and by the inferior quality of the first French crop distributed in July 1873, still the prevalence of this opinion is a fact of some importance. Moreover, samples of the raw fibre produced from the dry stems have been valued at 35*l.* per ton, or a good deal higher than the fibre produced at the Saharunpore trials from the fresh Rheea, and which has been reported to be not worth more than 25*l.* to 28*l.* per ton. Numerous experiments seem also to show that the fine fibre prepared from the dry Rheea does not possess less strength or lustre than that prepared from the green Rheea, as some of the specimens accompanying this report may confirm. It must be also kept in mind that both in the case of flax and of hemp all the operations are conducted on the dry sticks, and that all existing machinery is adapted only to dry stems.

Probable advantages of dealing with dried stems in preference to green stems.

58. From all this it appears that the question of preparing the fibre from the dried stems deserves to be taken into consideration, especially as there are many

other circumstances which would make it advantageous to use dried stems, if only the quality of the fibre were not too inferior.

The advantages of using dried stems may be briefly enumerated as follows:—

(*a.*) The greater facility in designing machinery, and the probable simplicity of its working when compared with that intended to work the green stems. As a matter of course, it is easier to break up and to remove the wooden core of the stem if the latter is perfectly dry and broken, than if it is moist and flexible. Then, as regards the important point of removing the outer brown cuticle of the bark, if the dry stems are operated upon, this cuticle is very friable and easily reduced to dust and shaken out, whilst on the green it requires a scraping action to remove it, an action of all the most difficult to obtain by mechanical means.

(*b.*) Possibility of keeping the machinery going all the year round, while that for green Rheea is dependent upon the supply of fresh stems; and even by extending each of the four crops to about six weeks, the machinery cannot be utilized during more than about six months in the year; moreover, as already pointed out, if the cutting of the crop is spread over say six weeks, the quality of the produced fibre is likely to change considerably during that time.

(*c.*) Possibility of dissociating the working of the cleaning mill from the work of a plantation. If the Rheea is to be cleaned in its fresh state, the supply of stems must always be close at hand, partly on account of the heavy freight for the fresh stems, 20 tons of which are required to produce one ton of fibre, as also on account of the necessity of a regular daily supply of fresh stems, which cannot be obtained unless the mill and the plantation work completely hand in hand, one day's supplies only arriving at the factory each day, and only the smallest possible stock being kept. On the other hand, if the dried stems are worked, any agriculturist, even not in the immediate vicinity of the factory, may grow the plant, cut it and stack it according to his own convenience, and then sell the dried stems to the factory. Freight is much reduced in the dried stems, every four tons yielding one ton of fibre, and no special regularity in the supplies are needed, as the dried stems can remain in stock for any time. Under these conditions the plant could be grown by the Indian ryot, whilst the fibre would be prepared at central establishments.

(*d.*) Probable increase in yield of fibre. As before stated, the fibre obtained from the dried stems amounts to about 20 to 28 per cent. of the weight of dry stems, which corresponds to about 4 to 6 per cent. on the weight of fresh stems. But the yield from Greig's machine at the Saharunpore trials amounted to no more than $2\frac{3}{4}$ per cent. of the weight of the fresh stems, or not much more than one half of the fibre which was presumably contained in them. The difference is at any rate considerable, and proves how necessary it is to take into account not only the working expenses and the quality of the produced fibre, but also the proportionate yield compared with the weight of fresh stems; and, however much the machines for working the fresh stems may be improved, it seems, from the whole of the conditions under which the work takes place, that the yield of machinery using dry stems is never likely to be reached. Under such circumstances, even a certain inferiority in quality would hardly counter-balance the increased yield. This is a matter in which the agriculturist will be interested. At the Saharunpore trials, the yield per acre amounted to 138 lbs. of rough fibre as separated by Greig's machine. If, however, an average yield of 5 per cent. of fibre had been obtained, instead of the $2\frac{3}{4}$ per cent., then the yield would have amounted to about 250 lbs. per acre. With three crops in the year, this would represent 750 lbs. of fibre per acre per annum; and with four crops the yearly production would rise to 1,000 lbs. per acre. The preparation of Rheea from the dried stems seems thus to be intimately connected with the problem already indicated,—how to produce cheap Rheea in large quantities.

Possible disadvantage of dealing with the dried stems.

59. Against the preparation of fibre from the dried stems stands first the possibly higher quality in the Rheea prepared from the green stems. In this respect one thing may be stated, viz., that the fibre prepared from the green stems and carefully washed and scraped is likely to contain less gum than that prepared from the dry. It is likewise doubtful whether any fibre can be prepared from the dried stems of as high immediate value as the hand-prepared China grass. But inferior value in this first stage need not necessarily bring with it inferior value of the final cleaned fibre as prepared for spinning.

Moreover, it is to be taken into account, that if the crop is cut in large quantities for drying, a much better opportunity is afforded for a thorough sorting of the plant according to length and thickness than can be afforded with the small quantities which would have to be cut from day to day to supply a machine working on the green. Therefore, by using dried sticks, there is a much greater probability of producing a uniform quality of fibre.

The other difficulty will be that of drying the stems, a difficulty which, in some parts of India, will be experienced during the rainy season. Dr. Campbell, who forwarded to the India Office some years ago a certain quantity of Pooah fibre from Darjeeling, had great difficulties in this respect, and was obliged to make use of artificial heat. But it is probable that in parts like the N.W. Provinces no serious difficulty need be anticipated on this account. It is likewise possible that the difficulty of drying may be overcome by the following expedient. It seems likely that stems of a long growth, tall and thick, will contain a much rougher, but also much stronger, fibre than the small slender stems of shorter growth. The first may produce fibre suitable for hemp purposes, cordage and such like. The thin and short stems may give a fibre suitable for fine or textile manufacturing purposes. But during the rainy season, in order to avoid the difficulty of drying the stems, it might answer to let the plant grow to its full height, sacrificing quality to a certain extent, but still obtaining fibre which will be very marketable. On the other hand, during the remaining part of the year it might be advisable never to let the plant exceed three or four feet, and thus obtain the finer qualities of fibre.

Importance of fairly examining and testing all the systems, several of which may prove equally good, from preparing a fibre suitable for different purposes.

60. From this review of the processes used for extracting the fibre, it appears that at present there are no sufficient grounds for deciding which are really superior to others, and that there are grounds for believing that good fibre may be prepared in any of the several ways,—by retting, by chemical treatment of the stems, or by a mechanical separation of the fibre from either the dry or green stems. The points to be considered are the cost of the necessary machinery or chemicals, the greater or smaller simplicity of manipulation, and the yield of clean fibre per ton of fresh stems. In investigating, therefore, this question, the utmost latitude ought to be allowed to the inventors, every process and every machine being placed on equal terms, and only compared as regards quality of the fibre, cost of production, and yield per ton of stems,—difference, of course, being made between processes and machines producing only raw fibre still containing its gum, and processes and machines producing fibre at once available for spinning; because if, say, four per cent of fibre are obtained by a retting process, the amount of fibre available for spinning will be as large as if, say, six per cent. had been obtained by a mechanical separation of the fibre from the stem.

It is likewise possible that there will be two or more successful machines or processes. The advantage which one machine may afford by the high quality of the fibre turned out, the other may secure by cheapness of operation, producing an increased quantity of fibre, though of smaller value. Some machines may be more suitable for the treatment of the full-grown stems, others for the fine stems; the one producing Rheea for cordage purposes, the other Rheea competing with the finest flax and alpaca. It is only by testing and searching in this manner the whole field of the possible applications of Rheea that a speedy development of this invaluable plant can be secured.

Advisability of having agricultural experiments going on hand in hand with mechanical trials.

61. The Agricultural part of the problem must likewise be briefly adverted to. The discovery of the best machinery and the best processes for the separation of the fibre from the stems will not prove of much use unless the agriculturists know how to grow fibre suitable for the purposes for which Rheea will have to be applied. The experiment previously suggested of growing the plant only to a height of

three or four feet, planting it thickly, and cropping at short intervals, appears a very important one, and is considered by competent judges to be at the root of supplying fibre of a uniform quality suitable from its silkiness and fineness for high class purposes. There are too other questions to be investigated,—the influence of age, of the season of growth, of irrigation; the practicability of effecting the sorting of the plants at the time of cutting, and many others which will readily suggest themselves to agriculturists accustomed to the cultivation of high class fibres. In fact some of the properties of the fibre which are most important for success, such as uniform quality, the production of a certain amount of strength, or of silkiness according to requirements, and others, depend mainly on the action of the agriculturist.

PROPOSED MEASURES.

Question of the prize.

62. As it seems desirable that some fresh steps should now be taken by Government, the first question to be decided is whether a new reward should be offered similar to that of 5,000*l.* five years ago. The solution of this question will mainly depend upon the decision arrived at with regard to the place in which the new trials, if sanctioned, are to be carried out. The prize of 5,000*l.* was avowedly offered in order to tempt the inventors to incur the considerable risk and expense of sending out their machines and their agents to India, where alone the trials with fresh stems were supposed possible. But if the trials were to take place in England no such reasons would apply. The expense and risk to which the competitors would be put would be insignificant in comparison with what would be necessary with trials held in India. All that seems necessary is that Government should provide the space and the driving power, as also the supply of dried and fresh stems. To win in a fair competition would be a sufficient prize, as the successful machine is likely to prove a more valuable property than any prize which the Government could be expected to offer.

Trials in England.

63. Trials in England even without a prize are likely to attract a good many more competitors than trials in India with a prize. The difficulty hitherto has been to supply the raw Rheea stems. This difficulty has, however, been overcome. In the first place, as already pointed out, trials with dried stems are likely to prove as important, if not more so, than trials with green stems; and, moreover, experience has shown that green stems may be obtained from France, and even from Algiers, in a state perfectly fit for working. There is, therefore, no difficulty in arranging for a perfectly fair trial both of machines operating on dry and machines operating on fresh stems.

Object of trials.

64. The purpose of the trials ought to be to test all the principal methods of extracting the fibre from the Rheea stems, especially with the view of settling the comparative value of the fibre obtained from the dry and from the green stems. Retting, both of dry and of green stems, should likewise be tested, and there is no reason why it should be impossible to test also some of the other methods of treatment in which steam under pressure and chemicals are used for the disintegration of the stems.

As regards the cost of preparing one ton of fibre, competent mechanical referees, whose decision could be accepted with confidence, would have to be appointed. As there would be no prize, it will be unnecessary to fix any specific limit for the cost of preparation or for the value of the fibre. It will be quite sufficient to ascertain fairly in the case of each machine or of each process, what these values are. And, with regard to this point, the experience of the cotton gin trials held at Manchester proves satisfactorily that there is no difficulty in devising such arrangements, that not only all machines are in reality tested fairly against each other, but that even it is impossible to impugn the fairness of the operations. The same programme of arrangements as then adopted will, with small modifications, hold good for the Rheea trials likewise.

Preliminary trials in July or beginning of August, and final trials in October or November.

65. With regard to the time of the year most suitable for the trials, this depends mainly upon the facilities for obtaining fresh Rheea stems. In the south of France, from which the supplies will have to be obtained, there are two crops, one gathered about the middle of July and the other about the end of October. The first crop is very inferior in quality to the second. Moreover, the transport of large quantities of fresh stems at that season of the year is very difficult, as there is considerable danger of heating and fermentation on the one part, and of drying on the other. These two considerations thus point to Autumn as the best period for the trials with fresh stems. A sufficient supply of dry stems from India could be likewise obtained by that time.

Experiments to be carried out in India.

66. The mechanical portion of the problem of preparing Rheea for the market can thus be solved in England. But the no less important agricultural problems can only be solved in India. The Government plantation at Saharunpore ought to afford ample opportunities for an experimental investigation of the b

methods of growing Rheea of the quality required for the various purposes to which it might be applied. The marked success which accompanied the efforts of Dr. Jamieson, the able superintendent of the Botanical Gardens there, in the case of the cultivation of tea, makes it possible to anticipate a similar success in the case of Rheea. The principal points to be investigated are the following:—

(*a.*) Influence of irrigation and manuring, especially with regard to the effects of returning to the soil the leaves and branches of the plant as well as the ashes of the sticks after decortication:

(*b.*) Influence of seasons. The experiments of Mr. Sandys referred to at page 38. in the Appendix ought to be repeated. They consisted in cutting a certain portion of the crops during each successive month throughout the year, and forwarding the produce of each month for valuation and report:

(*c.*) Influence of height to which grown. The point of comparing the quality of the fibre contained in short stems of only three feet height with that obtained from full grown stems is the one of most importance to be decided. Of course if the plant is only grown to this small height it should be planted closer than it is at present:

(*d.*) In fact independently of the height, it is important to ascertain the effects of the different spacing of the plants on the thickness, straightness, and branchiness of the stems. As before pointed out, it is quite possible that by growing the plant only three feet high, a much larger out-turn per acre may be obtained, partly in consequence of the denser growth, and partly from the greater number of crops during the year.

(*e.*) Cost and arrangement of the gathering and drying. Two things have to be considered in gathering: 1st, the stripping of the leaves; and 2nd, the sorting of the stems according to length and thickness. In the course of the operations carried out by this department in Southern France for the supply of fresh stems, it was found very convenient to strip the branches and leaves before cutting the stem by simply passing the hand from the bottom of the stem upwards. This could be done more readily than after cutting. The sorting of the stems is of the greatest importance and should be done directly on the field. As regards drying, different plans of stacking in the field ought to be tried, noting the time required to effect complete drying. It is of course advisable to avoid as far as possible the drying in sheds and the cartage of the fresh stems. Retting experiments with dried stems might likewise be instituted, though in this matter a considerable amount of practical experience is required in order to have any chance of success.

India Office, June 1875.

Department of the Reporter on the Products of India.

APPENDIX.

I. REPORT BY LIEUT.-COLONEL HYDE ON THE TRIAL OF GREIG'S MACHINE.

No. 782.

From Lieut.-Colonel H. HYDE, R.E., Master of Her Majesty's Mint, Calcutta, to the SECRETARY to the GOVERNMENT OF INDIA, Department of Revenue, Agriculture, and Commerce, dated 4th October 1872.

SIR,

IN obedience to the instructions contained in your letter No. 150 of the 24th July 1872, I proceeded to Saharunpore to examine certain machines for the preparation of rhea fibre, and I have the honor to submit herewith a report on the same.

Machines present.

2. One machine only was presented to compete for the prize offered by Government in the advertisement of 26th January 1871.

3. There was, on the ground, a machine brought over from America, but it was the property of Government and did not compete.

Rhea crop.

4. The whole of the first crop of rhea plant had been cut early in the season, and the crop now ready was the second. It was large and sufficient to have supplied the wants of many competitors. The plant was stated by the Superintendent of the Botanical Gardens to be of an average full growth, and as near as possible as would be found in an estate producing fibre for the market; the stems being, as far as the present knowledge of the subject enables a judgment to be formed, in the state when they would produce the best fibre. There were, of course, small patches of the plant both somewhat more forward and somewhat more backward than the mass; but the crop seemed on inspection to be very uniform.

5. The cutting the stems began on the 7th August and ceased only on the 20th, a period of fourteen days, which, at this season of the year (August), of necessity rendered so quick growing a plant uniformly somewhat older at the end of the trial than it was at the commencement.

Competing machine.

6. The machine that was presented to compete for the prize was the property of, and designed by, Mr. John Greig, junior. It had been made in the factory of Mr. Greig, senior, of Edinburgh, and was patented in England in 1870. The Patent Office specification No. 1690 of 11th June 1870 is annexed, and added to the specification is a statement of the alterations and additions subsequently made.

Appendices 1 and 2.

7. The machine is constructed for working up green stems, and its action is described in the specification. The speeds of the several parts are—

First motion, number of revolutions		$a = 65$	per min.
Fluted roller	,,	$\frac{1}{6} a = 10\frac{5}{6}$	,,
Scraping cylinders	,,	$8\,a = 520$	,,
Blower	,,	$8\,a = 520$	,,

The travelling webs, both feed and delivery, have a speed of one foot for three revolutions of a, equal to 21⅔rd feet per minute.

8. The weight of the machine is 1¾ tons; the weight of the heaviest part, viz., the fly-wheel, is 4 cwt.

9. The Patent Office specification leads the reader to understand that the machine patented was intended to turn out fibre clean and fit for sale in one operation. The machine does not succeed in effecting this, and there is, attached to the machine, but not included in the patent, a scutcher (of the ordinary construction used in flax mills) of 5 feet diameter, having five blades and making 260 revolutions per minute.

10. All the fibre, after having passed through the patented machine, has also to be cleaned by the scutcher to remove the small portions of the stalk and green bark not taken off by the first process and found adhering to the fibre after it has left the first machine. The fibre is turned out very wet from the machine, and it is necessary to dry it in a free current of air. If the fibre is scutched wet, a second scutching becomes necessary when it is dried.

Arrangements.

11. The machine was fixed in the new masonry stables belonging to the stud. It was worked from a shaft which was driven by a portable engine (two cylinders 8 inch diameter and 12 inch stroke) belonging to Government.

12. A portion of the rhea crop was pointed out to me by the Superintendent of the Botanical Gardens as being a fair average of the whole plantation, and in the best condition for cutting. Thereon I requested that the cutting should be confined to this portion, and that it should be cut regularly through as requisitions for stems were made.

13. The following is the diary of the trial:—

Trial.

6th August. The machine was started to enable an estimate to be formed of its capabilities, to exhibit its working, and to admit of its revolving parts being examined in motion. A small quantity of rhea stems was worked up to enable the fibre to be traced and followed through the machine.

14. The exhibitor was then requested to prepare for the trial of the machine on the head of out-turn, and to be ready to start at 6.30 a.m. on the following morning.*

Quantity of out-turn. 15. *7th August.*—Trial for out-turn.

Hour.	Steam. lbs.	Revolutions of shaft per minute.	Number of minutes standing.	Remarks.
A.M.				
6.40	30	—	—	Started.
7.12	—	—	3″	Stopt } To fill water tank and clean machine.
7.15	—	—		Started }
7.30	39	75		
7.50	—	—	8″	Stopt } Ditto.
7.58	41	75		Started }
8.30	37	76		
8.47	—	—	11″	Stopt } Ditto.
8.58	37	75		Started }
9.1	—	—	4″	Stopt } Ditto.
9.5	40	—		Started }
9.30	37	72		
10.0	37	72		
10.25	—	—	9″	Stopt } Ditto.
10.34	—	—		Started }
10.44	—	—	44″	Stopt } Ditto.
11.28	—	—		Started }
12.0	33	75		
12.13	—	—	—	Stopt. Machine broke down.
H. M. Total 5 33	—	—	H. M. 1 19	
Average say	37	74$\frac{2}{7}$		Total time - - 5 H. 33 M.; Do. time standing - 1 19; Actual time at work - 4 14; Say 4¼ hours. The exhibitor himself and four natives working.

Break down.

16. The break down was caused by the fracture of the flange of the left plummer block that carried the lower scraping cylinder. This put the wheel on the cylinder spindle out of gear, and caused the stripping of a total of twelve teeth, out of the several wheels working in connection with the one displaced. In some places three teeth, and in others only one, were stripped; two spindles were bent. The plummer block had evidently been cast from an old pattern; it was weak in the flange by reason of a bolt hole. There was also a bad flaw in the iron at the bolt hole where it parted. The trial was of necessity stopped, and the exhibitor set to work to repair the machine. The wet fibre produce was set out to dry.

17. The exhibitor having inserted new teeth into all the broken wheels, and, on the 14th August, the repairs being sufficiently advanced to admit of the scutcher being used, the trial was resumed, and the following is the diary:

Trial continued.

14th August.—The fibre turned out of the machine on the 7th August was scutched by the exhibitor himself, which operation completed, and the fibre declared finished, it was weighed, and found to produce—

Out-turn dry.

Good fibre	- -	45¾ lbs.
Somewhat shorter	-	3 ,,
Waste	- -	10½ ,,

* The stems of the rhea plant were cut and sent on to the ground by the Superintendent, Botanical Gardens. They were stacked close to the machine. Water carriers were supplied to give water to the machine, as the well was at some distance from the stable. Sweepers were provided for cleaning away all refuse.

The proper complement of men and sufficient fuel were provided for the engine, the speed of which was regulated, as the exhibitor gave instructions.

I admitted 48¾ lbs. in 4¼ hours, giving, say, 11¼ lbs. per hour.

Waste.

The large amount, 10½ lbs. of waste, is due to the bad form of the scutcher which tears away the fibre. If the scuther had not torn the fibre, the out-turn would most probably have been 13 lbs. or more per hour.

Production of sample.

15th August.—The machine having been repaired throughout, the exhibitor was requested to produce 2 cwt. of fibre for sample for valuation.

The supply—in amount about two tons—of rhea stems that remained on the ground when the machine broke down had dried somewhat. The exhibitor made an objection to these stems. I admitted the objection. Fresh stems were supplied, and the machine was started. Number of hours' work—5.

16th August.—The machine was worked from 6.28 a.m. to 5.55 p.m., with an interval of one and a half hour for breakfast. Number of hours' work—say 10.

Spoiled fibre.

17th August.—The machine was worked from 6.30 a.m. to 6.30 p.m., with an interval of one and a half hour for breakfast. Number of hours' work—10½. Some fibre remained unscutched at the close of this day's work, the exhibitor, who scutched all the fibre with his own hands, being unable to complete the task. This fibre was left inside the building till Monday, when it was found spoiled, the mucilage having become thickened and glutinous, binding all the fibrous shreds very strongly together.*

18th August.—Sunday.

Spoiled fibre.

19th August.—The machine was worked from 6.30 a.m. to 6.30 p.m., with one and a half hours' interval for breakfast; a small quantity of fibre was (as on Saturday 17th), left unscutched inside the house for the night. In the morning it was found spoiled as before. Number of hours' work—10½.

20th August.—The machine was worked from 6.30 a.m. till 7.30 a.m., one hour's work, by which time sufficient fibre had been turned out to produce 2 cwt. dry.

Labour supplied by Superintendent, Botanical Gardens.

During this trial, the exhibitor, Mr. Greig, scutched with his own hands all the fibre as it came from the machine. Two men were employed feeding stems, one collecting fibre. In addition the Superintendent supplied the following labour:—

Water-carriers to supply water to the machine and engine.

Two sweepers to clear up and carry away refuse.

Two or more men to sort stems.

Scutchers.

After 7.30 a.m. the machine was stopped and the scutcher was driven alone. The exhibitor, Mr. Greig, commenced the final scutching out of the dry fibre of the previous four days' work. The work was continued till 6.30, with an interval of one and a half hours for breakfast. Number of hours' work on scutching—9 hours.

21st August.—The scutcher was worked from 6.30 a.m. till 6.30 p.m., with an interval of one and a half hours for breakfast. Number of hours' work on scutching—10½.

22nd August.—The scutcher was worked from 6.30 a.m. till 4 p.m., with an interval of one and a half hours for breakfast. At this hour—4 p.m.—all the fibre was finished. Number of hours' work on scutching—8 hours.

Abstract. The abstract of this is in round numbers—

On 15th August	- -	5 hours	Working up the fibre.
,, 16th ,,	- -	10 ,,	
,, 17th ,,	- -	10½ ,,	
,, 19th ,,	- -	10½ ,,	
,, 20th ,,	- -	1 ,,	
Total	-	37 hours.	
On 20th August	- -	9 hours	Additional working on scutching.
,, 21st ,,	- -	10½ ,,	
,, 22nd ,,	- -	8 ,,	

Out-turn per acre and ton.

18. The quantity of rhea stems sent to the ground subsequent to the 14th was 3½ tons and was the produce of 1½ acres of land. Of this 3½ tons, 480 lbs. of short stems were left unworked as refuse, reducing the worked up stems to 7,360 lbs.=3·28 tons. The fibre, when clean and dry, weighed 207 lbs., the result being 1½ acres of land produced 7,360 lbs., or 3·28 tons of stalk fit to be worked up by the exhibitor's machine, which machine turned out from that amount 207 lbs. of fibre, which gives—

About	- -	63 lbs. per ton.
Or	- - -	138 ,, ,, acre.

Exhibitor selected an hou for work.

19. On the 17th the exhibitor suddenly desired to have a special trial of out-turn for quantity for one hour, *viz.*, the hour he was then commencing, as he was not satisfied with the trial of the 7th. I permitted him to keep the quantity turned out in the selected hour separate, solely for his own satisfaction. It produced 15½ lbs. of dry fibre, but I in no way bound myself by it, because the trial of the 7th was a much more extended trial, *viz.*, over five hours' duration, and the stems were of average growth and size. I therefore informed the exhibitor that though I granted his request, the hour's result would not supersede the trial of five and a half hours on the 7th.*

Trial closed.

20. This closed the trial. I was present at the machine during all the hours it was at work, and saw all the fibre turned out. Two parcels of one cwt. each were separated, and after having been dried in a room in the muséum of the Botanical Gardens, were, on 24th August, packed in two boxes lined with tin. One was deposited with the Superintendent of the Botanical Gardens on the 24th August, and the other delivered into the Office of the Secretary to the Government of India, Department of Agriculture, Revenue, and Commerce, on the 4th September 1872.

Quality of the machine.

21. The machine, as a piece of mechanism, is good; it is well made and well proportioned, the relative strength of the various parts having been well considered. It is calculated to wear well, and deserves commendation as far as being a good substantial piece of work.

Break down local.

22. The break down, of which I have stated the cause, was entirely local, and cannot be considered as affecting the general quality of the workmanship.

Machine imperfect.

23. The machine, however, as must always be the case with machines of this kind, *i.e.*, contrived to do a work of which there is little or no experience available, and without means of obtaining the natural material to work upon, is far from matured. Few, if any, of such machines are ever constructed at once able to do the work for which they are intended, most are generally perfected by degrees through numerous partial failures. Experienced gained in the process of working, alone enabling many defects to be seen and remedied, and a perfect machine to be produced, and such appears to be the case with this mill; for, independent of whether it is or is not the best description of machine for preparing the fibre, it is, on the one hand, in many points very deficient in the work the exhibitor sets it forward to perform, while, on the other hand, it is certain that it can be improved in much that is faulty.

Machine designed for smaller stems.

24. The exhibitor states that he designed the machine for a smaller stalk than that supplied; hence the pins fastening the fluted rollers to the spindles being too weak, gave, and the spindles were found to spring; for this reason, and on account of the temporary nature of the repairs, he was, during the latter portion of the trial, obliged to limit the machine in speed and quantity of stem fed. It will be easy to insert a larger spindle, and all the other parts being sufficiently strong, the machne will then work up any size of stem.

Supply of water.

25. The trials showed that a much larger supply than was provided for of water is desirable. The tank on the top of the machine has a capacity of 33¾ gallons, and it was obviously desirable to fill it every ⅘ths of an hour, giving 41 gallons per hour. As a fact, however, during the trial, it was not quite so often filled, the supply was irregular; hence at times the fibre wound round the rollers, and showed that 41 gallons per hour was too little, for the more freely the water is supplied, the better the machine works. This, of course, is a matter quite within control.

Brushes and scrapers.

26. The brushes had been removed, the fixed scrapers all gave way or were removed as being too slight or of little use. All have to be altered; these are, however, adjuncts, and do not affect the main machine.

Action of machine.

27. In working, the machine breaks up the stems well without injuring the fibre, and the action of the fluted rollers seems good. On the other hand, the action

* If the fibre of these two days had been placed outside, as was suggested, in the free circulating air, it would have remained good.

* See extract from letter, Enclosure 2, showing time of most approved stems to hand was selected.

of the cylindrical scrapers is deficient; when there is a plentiful supply of water, the fibre is to a certain extent cleaned, but always irregularly and never thoroughly freed from bark and stem.

Action of scraping cylinders.

28. It is necessary here to explain the construction and working of the scraping cylinders, which is as follows:—On the cylinders are inserted radial blades running the whole length of the cylinder and in the line of its axis. They run in pairs, and in revolving, work into one another after the manner of ordinary cog wheels, the blades in these cylinders taking the place of the cogs in the gearing. Each cylinder is driven, and the steel blade of the one cylinder alternately travels through the flute between the blades of the other cylinder. The inventor explained that the curves of these flutes are intended to be so accurately struck, and the blades and cylinders so accurately adjusted, that each blade shall clear the opposite flute by the bare thickness of the fibre, and that the action is similar to the action of cleaning the fibre on a board with a knife that each flute taking the place of the board affords an unyielding support to the fibre during the period that the opposite blade scrapes its surface. Now, I have carefully measured a number of ribbons of fibre cleaned by the hand, and I find the average thickness to be—

1. Measurement near root - ·0046 of an inch.
2, „ middle - ·004 „
3. „ upper end ·0025 „

If then the scrapers act as the inventor states they do, the curves of the flutes must be struck, and the cylinders geared and set to the $\frac{5}{1000}$ of an inch. It is needless to say that in such a machine this is not practicable, and that the scrapers cannot act in the manner described.

29. In the machine exhibited, the flutes are alternately wood and iron, the iron flutes being part of the cylinder, the wooden flutes removable for the purpose of inserting and holding in the knives. These flutes are wedge shape, having the apex towards the centre, while the knives, which are also wedge-shaped, have their base towards the centre. Hence in forcing home the wooden flutes with screws, the knives are retained in their place, but the construction must insure a far greater variation than $\frac{1}{200}$ in the surface of the wooden flutes. The upper scrapers then act simply on the fibre in a certain state of tension, and are not very efficient in their action. When the ends fall, there seems to be an inefficient action also in the blower, forthe fibre is very often doubled up, and in that state delivered on to the travelling web, and only a few of the ends even reach the lower scraper. This will easily be understood, for if the blower is efficient in driving the first falling end of the fibre between the delivering rolls, it must, of necessity, interfere with the direct fall of the last end into the lower scrapers.

Imperfect action.

30. The separation of the broken wood stem and green bark from the fibre is imperfectly effected. The main portions of the wood and some fragments of the bark fall out at the bottom of the machine, but a very noticeable portion of the wood and an injurious amount of the green bark and refuse pass out with the fibre. The operation is imperfect in every way and much of the green bark remains unremoved from the fibre. The amount of this, however, though always considerable, is perceptibly affected by the supply of water under which the machine is worked. Much of the detached bark passes over the upper roller, from whence it either falls among the fibre on the travelling web or has to be removed by hand, an awkward arrangement.

Conditions adverse to good work.

Machine not matured.

31. The working of the machine is irregular and uncertain, but in the trial there were so many affecting conditions, as hereafter noted, which could not be removed, that it is difficult to say if this fault can or cannot be entirely obviated. As far as I can judge the machine is in its infancy, and the result of its working on this trial is certainly much below what it could even now be made to do both in quality and quantity, properly worked and superintended, at the same time it did not do its work well or clean.

Reasons for bad work.

32. The reasons for the inferior and irregular work and quality of the fibre turned out are—

First,—The exhibitor had not ready an organized complete crew drilled to work the machine; he stated that his best men were sick and had left him, and that he was obliged to take any he could get. The result was that the machine was worked under great disadvantage throughout the entire trial.

Secondly.—The exhibitor had not any scutcher on the ground, the one man he had trained being sick. He therefore scutched the whole of the fibre with his own hands, and as the occupation not only demanded the whole of his attention, but was also exceedingly laborious, he was entirely unable to superintend the working, or to look to the machine, for which superintendence there was the greater necessity on account of the raw hands employed.

Thirdly.—The exhibitor's arrangements for water supply was absolutely *nil.* The tank placed on the top of the machine was some eight feet from the ground, and had to be filled by hand (sometimes stopping the machine, sometimes not) from water brought by bheesties.

Fourthly.—The exhibitor had not made any arrangement for drying the fibre. To assist him, men were sent from the Botanical Gardens by the Superintendent, and lines of bamboo rails were put up for him as the trial proceeded, so that he might not be disturbed in his work or his attention taken from it. The drying and turning of the fibre on these rails was to a great extent similarly done for him.

Exhibitor solely responsible.

33. For all these difficulties the exhibitor was entirely and solely responsible; but seeing that the difficulties did exist, every legitimate assistance was given.

Reason for small out-turn.

34. In the first four and a quarter hours the machine turned out 11¼ lbs. per hour. This trial was very carefully carried out, and was fair in all conditions except those dependent on the exhibitor himself, viz., that he worked with too few men and with his own hands instead of with his intelligence in directing his men. If the exhibitor had provided a properly drilled crew, and had confined his exertions to directing in the place of working, the out-turn would have been much more.

In the exhibitor's own trial of one hour, he turned out 15½ lbs. of fibre, but the trial was too short, exceptional, and not admitted.

In the work of producing the 2 cwt. of fibre, 207 lbs. were turned out in 37 hours, which gives 5½ per hour. But this cannot be taken into account as to time, because the machine was obviously and of necessity, by reason of the repairs having only been temporarily made, and for other reasons before given, only worked at very partial power. It can, however, be taken into account under the head of quantity per ton and acre. This trial gave as before stated—

63 lbs. per ton,
138 „ „ acre,

while all available information gives the out-turn by hand to be 200 lbs. per ton.

Loss from scutcher.

35. Some of the reasons for the deficiency of out-turn in this trial are the rejection of 480 lbs. of short stems, all of which could have been worked up; by rejecting this amount, the quantity of fibre produced was less, but an advantage was gained in quality. The machine, as before stated, was worked very imperfectly, and the waste of fibre was very large. Many hours' work was spoiled on the night of the 17th. There was in every case a great loss from the scutcher, the blades of which did not extend far enough in towards the centre, having been cut off short close to a ring put on to strengthen the arms that were too weak without it.

The fibre was caught in this and torn to shreds.* The scutcher is only an attempt to apply a machine found to answer to a certain extent with flax, which might also, if it were properly constructed, answer with rhea. But it was not properly constructed; on the contrary it was badly made, and a loss of fibre was the consequence.

36. *Exhibitor's method of treating the fibre.*—I have before pointed out that a very large quantity of water is required to be poured on the stems at the time of breaking them up; first, to keep the fibre free from the parts of the machine, secondly, to clean it, and it was palpable from first to last, that the more freely the water was supplied, the better the fibre turned out.

No settled system.

37. The exhibitor was not only labouring under the disadvantage of an undrilled set of workmen entertained for the day, but he did not, as far as I could see, appear to have worked on any settled system. Part of the fibre he scutched dry and part wet.† This he explained by stating, he had not time to scutch it all wet. There is, however, the fact, though he personally declares to give the wet fibre as it comes from the machine a preliminary scutching, that he did not carry out this practice throughout the trial, and whatever his own ideas may be, his action seemed to me to be very undecided, and he did not exhibit throughout the trial a definite and systematic process. On the contrary, his proceeding rather took the character of an anxious and sanguine inquirer endeavouring to find the best method, of which there was still a large amount of uncertainty.

* This deficiency in this machine is well known, and many attempts have been made to provide a remedy; the extent of the evil, of course, depends much on the make of the scutcher.

† This wet scutching seems necessary to remove the green bark that remains on the fibre after it has left the machine, for if it is not so scutched, the bark dries on it.

Irregular quality of fibre.

38. The other result of this kind of working was that the fibre turned out was of several different qualities, one portion differing very much in appearance from another. Some of it was spoiled and some of it injured, which might easily have been duly worked up by making proper arrangements.

Complaint by exhibitor.

39. After the 17th, the exhibitor complained that the stems are old* and knotty, and wanted to select portions in the plantation to be cut for him. I decided against this, because, first, the stems generally were not old and knotty, now and then a stalk with a small bud turned up, but generally the stems were good; and, secondly, what was necessary, was not a trial on stems selected from a large plantation, but a trial on a fair average cutting, and having seen that the area proposed by the Superintendent of the Botanical Gardens was a fair average, I determined that without very good cause, all the stems for the trial should be cut fairly from one end to the other of this area, and the crop was so cut.

Fibre colored.

40. A portion of the fibre turned out of a brown color stained by the bark of older growth. This was not necessary, as some of the same lot of stems turned out of the ordinary tint, but it was entirely due to the irregular way in which the fibre was treated. When water was plentifully supplied, and the fibre worked and set out to dry quickly, the color was ordinary. When the water-supply was insufficient, and when there was delay in putting the fibre out to dry, it was tinged brown.

Uniformity of stems required.

41. I noticed that out of 3½ tons there were left 480 lbs. of short stems. The reason of this was, that the exhibitor stated his machine ought to be supplied during any given time with stems of uniform length, that is, either short or long, and not mixed short and long. Hence all the long stems were first worked off and the short stems from time to time rejected to accumulate. This was equivalent to a certain extent to giving selected stems, and was an advantage towards improving the fibre which could not be afforded in actual practice. But I admitted it, because it was evident that, on the whole, the sample turned out was in quality below what ought to have been and could have been, and for this reason I further permitted the exhibitor to withdraw from the total quantity turned out the inferior portion that was surplus over the 2 cwt. required as a sample.

Season against the trial.

Want of arrangements by exhibitor.

42. With the sole exception of the difficulties of drying the fibre in the rainy season (and even this difficulty could have been met by a little forethought and arrangement), all the difficulties in the way of turning out good fibre were of the exhibitor's creating, by his neglecting to make the obvious necessary arrangements and by his non-realization of the task he had to perform. Every possible assistance, even more than he was entitled to, was given him by the Superintendent of the Botanical Gardens, because it was palpable that he did not meet the call upon him, and that he did not in any way obtain so good a result from his machine as it would certainly have given under proper management.

43. The engine consumed on an average 1,370 lbs. of good wood per diem throughout the trial. The power required to drive the machine was a little under 6-horse power indicated.

Estimate of the cost of working.

Appendix No. 4.

44. The original specification did not make any provision for a scutcher. One, however, was provided with the machine. During the progress of the trial, it became evident that even with the limited out-turn obtained, one scutcher was unequal to the work, and that to work the machine effectively, several would be required. I therefore called on the exhibitor for an estimate of his complete machine and of the cost of working it. This I annex.

Scutchers.

It provides for one scutcher attached to the machine, and for four scutchers on a shaft independent from the machine.

* All the plant was, as before noted, older on the 20th than on the 7th, and this was solely due to the extent to which the trial was delayed by the reason of the break down.

Period of work.

45. The first question that arises is, for what portion of the year will the machines work, and for what portion will they stand idle. The plant yields from three to four crops during the year; say four crops. During the four cold months there will be little growth in the plants. It is necessary, therefore, that each crop should be quickly cut, for the purpose of enabling that succeeding it to spring; and it seems certain that six weeks must be the maximum allowed for cutting any crop.* The mills will then work for 24 weeks, or 144 working days, which may be roundly set down as half the working year; and the entire expenses of the twelve months will have to be charged on the work turned out during this number of days.

46. Daily labour will not be affected by this. For such labourers as it may be desired to retain on the factory can be employed on the plantation work, but the interest chargeable for the money invested and calculated on the year will have to be doubled as a daily charge. The engine and machine will not be subject to wear and tear during the half year of standing idle, but the rates I have taken in the table below are English rates, and must be doubled when applied to India, on account of inferior labour, the extra cost and inferiority of repairs, &c. I have, therefore, calculated the cost for depreciation and wear and tear on English rates for the six months, as in the case of interest.

Estimate of single mill.

47. The estimate for a single mill to be fitted with the exhibitor's machine and scutcher, with four detached scutchers, will be:—

Permanent building:

Shed for one mill and scutcher, with four detached scutchers -	Rs. 3,000	0	0
Well - - - - -	„ 250	0	0
Drying ground and shed fitted with rails - - -	„ 1,000	0	0
Shed for engine - - -	„ 1,000	0	0
Total cost of building for one mill - - -	Rs. 5,250	0	0

Engine power required to drive one mill with scutcher and four scutchers detached,—8 horse-power in place, with shafting, pump, &c., to draw water from wells and to supply machine, boilers, &c.

Cost of boiler - - -	Rs. 2,000	0	0
Engine, shafting, pumps, &c. -	„ 1,450	0	0
Mill with scutcher and four detached scutchers - -	„ 2,000	0	0
Bands for driving - - -	„ 100	0	0

The charge for interest for wear and tear, and for allowance for depreciation in value by English rates, will then be—

Description.	Value.	Depreciation per Cent.	Wear and Tear per Cent.	Interest per Cent.	Total per Cent.	Charge per Annum.	REMARKS.
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	
Permanent building -	5,250	2½	—	5	7½	394	144 being the number of working days, Rs. $\frac{1164}{144}$ = say Rs. 8 will be the amount chargeable per day on each mill.
Boiler - -	2,000	7	3	5	15	300	
Engine - -	1,450	3	3	5	11	160	
Mill - -	2,000	5	3	5	13	260	
Bands - -	100	—	45	5	50	50	
Total charge per annum	—	—	—	—	—	1,164	

The cost of 8 horse-power indicated by steam is, from Roorkee data, Rs. 3 10 0 per day of 10 hours.

The labour required to work the machine and four detached scutchers will be—

4 men to scutch, at 6 annas each per day - - - -	Rs. 1	8	0
4 men to tend machine, at 4 annas each per day - - -	„ 1	0	0
4 men to carry dry fibre and to clean up, at 3 annas per day -	„ 0	12	0
12 men, costing per day - -	Rs. 3	4	0
1 native overlooker, at 8 annas per day - - -	„ 0	8	0

* The first of the crop in this case will be half grown by the time the cutting is finished.

In estimating the superintendence, I propose to take a factory of 300 acres to yield two tons of stems per acre; this would give 600 tons of stem for a crop. Six weeks being allowed for working up, this would give 100 tons per week of six working days, or, say 17 tons per day. I estimate that two machines, if properly worked, could consume three tons of stem per day, or, say 10 machines for the 17 tons. The salary of a superintendent could not be less than Rs. 400 per mensem, which, on 25 working days in the month, would give say Rs. 1 9 0 per machine per day. This supposes that his services for the period the mills stand idle will be charged to the cultivation of the crop.

Superintendence.

The estimate will then be, if the mills only run for six months during the year—

For charges on house and machinery	Rs.	8	0	0
„ steam power -	„	3	10	0
„ oil, &c. - -	„	0	2	0
„ labour - -	„	3	4	0
„ native overlooker -	„	0	8	0
„ superintendence -	„	1	9	0
„ office expenses -	„	0	6	0
Total cost of working one mill for 10 hours - -	Rs.	17	7	0

Rs. 17 7 0 = £1 14*s.* 10*d.*

The trial gives an out-turn of dry fibre 11¼ lbs. per hour = to 112½ lbs. per day of 10 hours.

	£	s.	d.
Thus, say 112 lbs. of fibre cost -	1	14	10
* Or one ton - - - - -	34	16	8
The limit being - - - -	15	0	0
There is a difference in excess over the advertised limit of - - -	19	16	8

48. The cost of working the machine for a day of 10 hours being Rs. 17 7, the out-turn should be 260·7 lbs. during that period, or at the rate of 26 lbs.† per hour.

49. The machine consuming 1½ tons of stem should (on the known out-turn by hand of 224 lbs. per ton) yield 336 lbs. of fibre per day of 10 hours, or at the rate of 33½ lbs. per hour.

50. If it be proposed to work the machines in temporary buildings, the estimate will be for the building about Rs. 1,300 per mill, and the charges for interest, wear and tear, and for allowance for depreciation in value, by English rates, will be—

Temporary building.

Description.	Value.	Depreciation per Cent.	Wear and Tear per Cent.	Interest per Cent.	Total per Cent.	Charge per Annum.	REMARKS.
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	
Temporary building -	1,300	5	5	5	15	195	144 being the number of working days, Rs. $\frac{965}{144}$ = say Rs. 6-11 will be the amount chargeable on each mill.
Boilers - -	2,000	7	3	5	15	300	
Engine - -	1,450	3	3	5	11	160	
Mill - -	2,000	5	3	5	13	260	
Bands - -	100	—	45	5	50	50	
Total charge per annum	—	—	—	—	—	965	

All other charges would remain the same, and the estimate would be—

For charges on house and machinery	Rs.	6	11	0
„ steam power - -	„	3	10	0
„ oil, &c. - -	„	0	2	0
„ labour, &c. - -	„	3	4	0
„ native overlooker -	„	0	8	0
„ superintendence -	„	1	9	0
„ office expenses -	„	0	6	0
Total cost of working one mill for 10 hours -	Rs.	16	2	0

Rs. 16·2 = 1*l.* 12*s.* 3*d.*

	£	s.	d.
And 112 lbs. of fibre would cost -	1	12	3
‡Or one ton - - - - -	32	5	0
The limit being - - - -	15	0	0
There is a difference in excess over the advertised limit of - - -	17	5	0

* Taking out-turn at 15½ lbs. per hour, cost per ton would be 25*l.* 3*s.* 5*d.*
† Mr. Greig's special hour of 15½ lbs. did not come near this.
‡ Taking out-turn of 15½ lbs. per hour, the cost per ton would be 23*l.* 6*s.*

51. In this estimate the cost of the building and engines &c., is calculated on the data of one mill. In erecting a factory for a number of mills there would be a saving both in the first cost of construction and in the labour for working. It is difficult to estimate what this would be, but in order to give the exhibitor the fullest advantage, say, deduct 25 per cent., which will far exceed any possible saving that could be effected, from the cost of turning out a ton of fibre, this will bring the cost to the following :—

Prize not awarded.

	£	s.	d.
One ton per estimate in permanent building - - - - -	34	16	8
Deduct 25 per cent. - - - -	8	14	2
*Reduced cost of one ton - - -	26	2	6
Temporary buildings one ton per estimate - - - - -	32	5	0
Deduct 25 per cent. - - - -	8	1	3
†Reduced cost of one ton - -	24	3	9

and I am therefore unable to award the prize.

52. I have now to deal with the machine under the second part of paragraph 2 of your letter No. 150 of 24th July 1872.

Mr. Greig, in designing this machine for the rhea plant, has apparently followed to some extent the type of certain machines used in the preparation of flax. Thus grooved rollers, all driven, with an arrangement of weights or springs on the spindle to ensure the requisite uniform pressure, have long been in use in flax mills, the flutes of such rollers gearing into one another at fixed distances (vide Plummer's patent) as do those on Mr. Greig's machine. The four scutchers of five blades, each on one spindle, are exact copies of the arrangement of scutchers in Mr. MacAdam's flax machinery. I do not know if the scraping cylinders are a new application, but I am quite certain that they do not act as the exhibitor personally explained they were intended to. The machine, however, is a bonâ fide meritorious attempt to meet the want that the Government has set forth as existing. The amount of success it has achieved cannot be definitely determined until the fibre produced has been valued, but, as far as is in my province, I consider it entitled to a certain amount of reward.

Flax machines of similar character.

Scutcher for flax.

53. I estimate that the inventor must have expended on it in money and time fully one thousand pounds. I do not think the machine is successful, or that it will continue in its present shape, but I believe that its construction and working cannot fail to advance the question and to prove a considerable step towards solving the difficulty of producing a machine that will prepare the rhea fibre.

Estimate of expense incurred by exhibitor.

54. I would point out that few can be aware of the difficulties and expenses an inventor has to encounter in producing a machine of this kind in this country, and fewer still can know the amount of courage and determination that is required to face all difficulties and to bring it to a trial like the one now undertaken, and it therefore has been a matter of great regret both to the Superintendent of the Botanical Gardens and to me to see that Mr. Greig failed in exhibiting his machine to the best advantage.

Difficulties attendant.

55. Considering then the outlay and the decided advance that the exhibitor has made in the work, also the fact that he alone has had the perseverance to come to trial, I would propose, for the consideration of Government, an award of 1,500*l.* (one thousand and five hundred), leaving for further consideration any additional award Government may feel disposed to make on the receipt from England of the report on the quality of the fibre.

Award.

56. I have now to enter on the general question of the machines and process for the preparation of the rhea fibre.

57. Mr. Greig's machine is of a character more suited to a large Spinning Factory than to such an establishment as would prove economical at a rhea plantation. Independent of the first cost of such a machine (which is itself an objection) and the power required to drive it, the

General question of machine.

* Taking out-turn at 15½ lbs. per hour, cost per ton would be 18*l.* 17*s.* 7*d.*
† Taking out-turn at 15½ lbs. per hour, cost per ton would be 17*l.* 9*s.* 6*d.*

working and maintaining such machines in order would necessitate the establishment of a workshop far more extensive than is desirable. Hence, if it be possible to do the work required by a less expensive and more simple process, Mr. Greig's mill will certainly not be adopted.

58. I hold that the main object to be kept in view is simplicity in construction, and that all endeavours should tend towards working out a process in which the most simple machines can be worked by the unskilled labour of the country on the minimum outlay.

59. Mr. Greig's machine gives useful information on the action of the rollers on the stems, as well as in the failure in the action of the scrapers.

60. The American machine bearing the name of Roessel is simply an iron drum with knives and breaking bars arranged on its surface. The stems are delivered by hand against the drum, which revolves at about 100 revolutions per minute. The woody stems are broken by the breaking bars into short pieces which fall out below; while the fibre is separated into shreds by the knives. The separation of the fibre from the stem is effectual, and the machine turns out far more in quantity than Mr. Greig's machine does, but the work is done dry, and the fibre is not cleaned from the bark.*

Roessel's machine.

61. The woody stem of the rhea plant being remarkably brittle and the fibre exceedingly tough, the machine, which acts with great violence on the stems, is able to effect the separation without apparent injury to the fibre. There can be no doubt, however, that such violent action should be avoided, and that if an equal result can be effected in a less violent manner, it would be better both for the machine and for the fibre, and I am therefore inclined to think that the method of first breaking up the stems by rollers under water, as adopted by Mr. Greig, will stand, but that no other part of the machine will. From what I have observed, it appears to me that the action of the scutcher (even if it were properly made) is far too violent, and that it breaks up and injures the fibre to a very great extent. I do not think that any such violent action is necessary, but, on the contrary, that if the fibre is kept from the commencement of the process in an extended and unentangled condition (which is not the case in Mr. Greig's machine, see paragraph 32), it may be much more easily dealt with, and may be cleaned with less violence, and it seems very probable that the Roessel machine (the breaker being removed and some other modification effected) when driven at a less speed, may be effectually applied with water to clear out the broken wood and to clean the bark from the fibre softened by some process for dissolving the gum as hereafter treated of.

Violent action to be avoided.

Fibre to be kept extended throughout process.

62. After Mr. Greig's machine had ceased to work, all the rollers, scrapers, &c., were found coated with a strong brown varnish, which entirely protected the iron it covered from rust. This varnish was the dried insoluble portion of the juice of the plant, and when scraped off, it had somewhat the appearance of fine shell-lac.

Juice of the rhea plant.

63. One of the difficulties† encountered in the preparation of the rhea fibre is this gum, and a knowledge of the constituent of the rhea juice is evidently necessary before any process can be entered on for its treatment. I therefore forwarded some of the gum, and afterwards some fresh stems of the plant, to Dr. Macnamara, Chemical Examiner to Government, and I solicited an analysis, with a view to ascertain if there were any solvents that could be practically applied to the plant to dissolve the gum out of the fibre.

64. The Chemical Examiner has replied :—" The juice contains 62 per cent. by weight of oxalate of lime, and besides this some alumina, oxide of iron, and other mineral matters which dissolve in hydrochloric acid. The residue, insoluble in dilute hydrochloric acid, consists of colouring and resinous matter, and forms 9·5 per cent. by weight of the juice dry."

Chemical examiner's report.

65. The Chemical Examiner also pointed out that dilute hydrochloric acid would dissolve the gum, and suggested a trial of sea-water. Thereon some dilute‡ sea-water was procured, and the fibre steeped in it for twelve hours was found to have been deprived of its gum to a great extent.

* There is no waste whatever with this machine.
† I pointed out in para. 17 how the juice of some fibre left for the night glued the whole mass of the bundles of fibre together, so that it appeared like shreds in thick isinglass.
‡ The water procurable at the mouth of the Hooghly at this season is not very salt.

66. The Chemical Examiner still has the matter under consideration, and it seems advisable that the process should be fully experimented on at leisure ;* meanwhile, it appears desirable to draw attention to the article on oxalate of lime, first in Watts' Chemical Dictionary, in Storer's Dictionary of Solubilities of Chemical Substances, and in Fresenius's Quantitative Analysis.

Watts' Chemical Dictionary—Oxalate of Calcium.

" Oxalate of Calcium, $C^2 Ca'' O^4$. This salt is very widely diffused in the vegetable kingdom, being found in the juice of most plants, whence it is deposited on the vascular tissue, towards the end of the growing season, in microscopic crystals having the form of a square-based octahedron (P : P in the terminal edges of the primary octahedron 46° 28′; in a more obtuse octahedron modifying the first = 119° 34′). According to Braconnot (Ann. Ch. Phys. [2] xxviii, 318), it often constitutes about half the weight of lichens growing on calcareous stones. The marble of the Parthenon at Athens is encrusted in some parts with a greyish, warty, and somewhat opaline coating of calcic oxalate about a line thick, called *Thierschite* by Liebig, which is supposed to have been deposited by lichens growing on the stone. Calcic oxalate has also been found by Schmidt (Ann. Ch. Pharm., lxi, 304,) in beer-yeast. It is also of frequent occurrence in the animal body (p. 250).

" Calcic oxalate is precipitated as a white powder whenever a soluble calcium-salt is mixed with oxalic acid or an alkaline oxalate, provided there be no strong mineral acid present in large excess. It is insoluble in water, acetic acid, and solution of salammoniac, nearly insoluble in free oxalic acid, and sparingly soluble in lactic acid, but it dissolves with tolerable facility in hydrochloric or nitric acid, whence it is precipitated by caustic alkalis or alkaline carbonates. Chloride of magnesium also renders it slightly soluble in water (Turner, Pogg. Ann., xix, 148).

" Oxalate of calcium is insoluble in hot concentrated solutions of the chlorides of potassium, sodium, ammonium, barium, strontium and calcium, but soluble to a considerable extent in hot solutions of the salts of the metals belonging to the magnesian group, and is precipitated from these solutions by an excess of alkaline oxalate (Souchay and Lenssen)."

It does not seem to be necessary to quote from the other two authorities, but the knowledge that oxalate of lime is so largely found in plants growing on calcareous soils, and is developed at the time of their maturity, may perhaps be deserving the attention of the grower with reference to the soil and manure necessary for the plant, and as affecting the time most suitable for cutting.

67. Regarding the mechanical part of any process for preparing the fibre, the difficulty in the way of perfecting a good machine seems to lie in the fact that the mechanics are in one country and the rhea fibre in another. The very first requisite for designing any machine is an accurate knowledge of the work required to be done. In the present case the work to be done is the preparation of the fibre from the fresh rhea stem. A mechanic cannot, therefore, enter on the task of designing a machine till he has the fresh rhea stems at hand to work upon. There must be many mechanics in England who would doubtless have been glad to have competed for the prize, but it was not in their power to do so, from the simple fact that as there were no fresh rhea stems in England, there was no means of knowing what character of work was required to be done. In India, where there are rhea stems, the mechanical ability necessary to design such a machine can rarely be found : hence the failure of the trial ; and as the growing plant cannot be supplied to the mechanic in England, the only alternative left is to bring the mechanic to the plant.

Reasons for only one machine coming to trial.

68. I would then submit for consideration whether it would not be advisable to grow a few acres of the plant near Calcutta, and to send out a mechanic skilled in designing such machines, first to see what is required, and then to work out and construct a machine in the dockyard factory.

Suggestion.

69. At the same time, I would also suggest that Government should, as there may be mechanics in the Calcutta mills who would like to turn their attention to the subject, sell at cost price the rhea plant to all such applicants as may ask for it, and who can show that there is a reasonable prospect of their being able to perfect some kind of machine for the purpose.

* It will be advisable to send one of the Roessel's machines to Calcutta to assist in this.

70. I do not think more facilities are required, because, if a good process be patented, the profit therefrom will sufficiently pay any successful man.

I have, &c.,
H. Hyde,
Master of Her Majesty's Mint.

Enclosure 1.

Memo. of Alterations made in J. Greig's Rhea Fibre Machine before sealing of the British Patent, reference being made to the drawings accompanying specification. The alterations are only in detail, for the sake of simplicity and cheapness, the whole principle of the Machine remaining the same, dated Saharunpore, the 23rd August 1872.

1st.—The oblique shaft K, with its level wheels for giving motion to the delivery rollers Ct I, is substituted by an endless pitch chain.

2nd.—The revolving brush or fan H, at first having boar bristles (which caught the fibre), is replaced with leather flaps, which serves the purpose of blowing the small ends of the fibre between delivery rollers, and also keeps the knives of scraping cylinder above it free from the mucilaginous matter which adhere to them.

3rd.—The revolving brushes N N, intended for keeping clean the knives of lower scraping cylinders M M, have been taken away, as it is found they are not required, the centrifugal force being sufficient to throw off any matter.

4th.—The upper revolving brush N, which worked in contact with upper scraping cylinder G, and also in contact with rubber roller I (as this revolving brush caught the fibre and twined round it as it was delivered on travelling web J); this was abandoned, and substituted by a stationary brush attached to light steel springs thus ×, and to keep rubber delivery roller I clean, a scraper, having leather inserted at its edge, has been fixed in front of it.

5th.—The travelling table E and the delivery table J are shown on plan, having strips of thin wood fixed on bands of leather; this, being certain to stretch with the water employed, catch the fibre, and to foul itself, very strong ⅛ inch thick canvass (interlaid and covered with vulcanized Indian-rubber), endless and seamless webs, have been substituted.

6th.—A heavy fly-wheel and brake attached is present on machine not shown on drawings; also a clutch and handle for stopping travelling feed web at pleasure; also lever handle and stricker gear for starting or stopping machine —all within easy reach of the boy who feeds.

7th.—The scraping cylinders G G and M M are shown on drawing, side elevation, having eight knives in each. At present there are 16 knives, and are tapered at the bottom edges, held firmly between eight cast-iron flutes or spaces, into each of which two knives are fixed by means of long hard wood wedges, and which are held in their tapered seat in body of cylinder by means of screws. The edges, outer, of these wedges are fluted (of a shape found by experiments) for the knives of the opposite cylinder to scrape into as they rotate together, and between which the flattened stems are caught, and both sides scraped clean at the same moment.

Enclosure 2.

Extract from a Letter from Mr. J. Greig, junior, dated Saharunpore, the 24th August 1872.

The only matter of which I have to complain, and justly so for a fair trial of the machine, is the over-ripe state or age of the stems employed, and which consequently have not shown the machine to the best advantage, and I have not had an opportunity of showing a much greater out-turn; and besides better, *i.e.*, more valuable quantity of fibre, which is got from soft green stems cut at their proper age, before they become brown, neither knotty, and their cores hard and dry.

This fact was amply proved by the greater out-turn and better quality of fibre from the ordinary trial of an hour's work at the rate of nearly-within 8 lbs. of 1½ cwt. per 10 hours from rather younger stems (than the usual run) cut the night before, but not sorted or selected in any way whatever; simply lifted from the floor, and placed on the table as they came from the cart in bundles; even although these same stems were much too old (by three weeks), such was the result.

Even at the rate of 1½ cwt. per day (by present machine), I think it quite certain success, for the enterprize will pay well, and come within the conditions laid down by Government for the prize, both as to cost of cleaning and value of fibre when working on green stems, which is also one of the Government conditions.

Enclosure 3.

Approximate Cost of cleaning one ton of Rhea Fibre by J. Greig's Machine from soft green stems, cut when they attain an average height of four or five feet, and being of the age of five or six weeks' growth, the same producing (1½ cwt. per day of 10 hours) workable long fibre and waste of an average value of 50*l.* per ton in the English market. Dated Saharunpore, N.W.P., the 24th August 1872.

	Rs. A. P.	Rs. A. P.
To—Wages of 3 coolies, 1 feeder, deliverer—and scutcher, present wages 3 annas, say 4 annas per day each - -	0 12 0	
2 inferior coolies handling stems and fibre at 2½ each - - - -	0 5 0	
14 days—allowing for stoppages—to produce a ton, total, 5 coolies, wages for 14 days at above rates - - -	- - -	14 14 0
14 days' wages of native mistree to take charge of, say, 2 machines at Rs. 15 per month - - - - - -	- - -	3 8 0
17 maunds per day of knot-wood fuel at 4 maunds per rupee—14 days' fuel at above rate, Rs. 4-4 per day - -	59 8 0	
But as two or more machines may be driven by the same quantity of fuel, a deduction should be made, say one half, for actual working one machine -	- - -	29 12 0
Oil for 1 machine and 1 scutcher for 14 days - - - - - -	- - -	2 0 0
Net price of Rhea fibre mills without scutcher - - - - - -	1,000 0 0	
Net price of long independent scutcher shaft, having fitted on it 4 scutchers specially adapted for long fibre, also stocks, wall-brackets, fly-wheel, and pullies for the same - - -	400 0 0	
1 scutcher to act with one mill—actual cost - - - - - -	100 0 0	
Packing cases and freight to Bombay -	256 0 0	
Total cost of Rhea mill and 1 scutcher, including freight, &c. - - -	1,356 0 0	
Interest at 5 per cent. on capital expended, Rs. 1,356 - - - -	- - -	68 0 0
Wear and tear on machine and scutcher, say 2 per cent. on out-turn of fibre -	- - -	20 0 0
Total cost of working a ton of fibre, not including interest on price of engine -	- - -	138 2 0

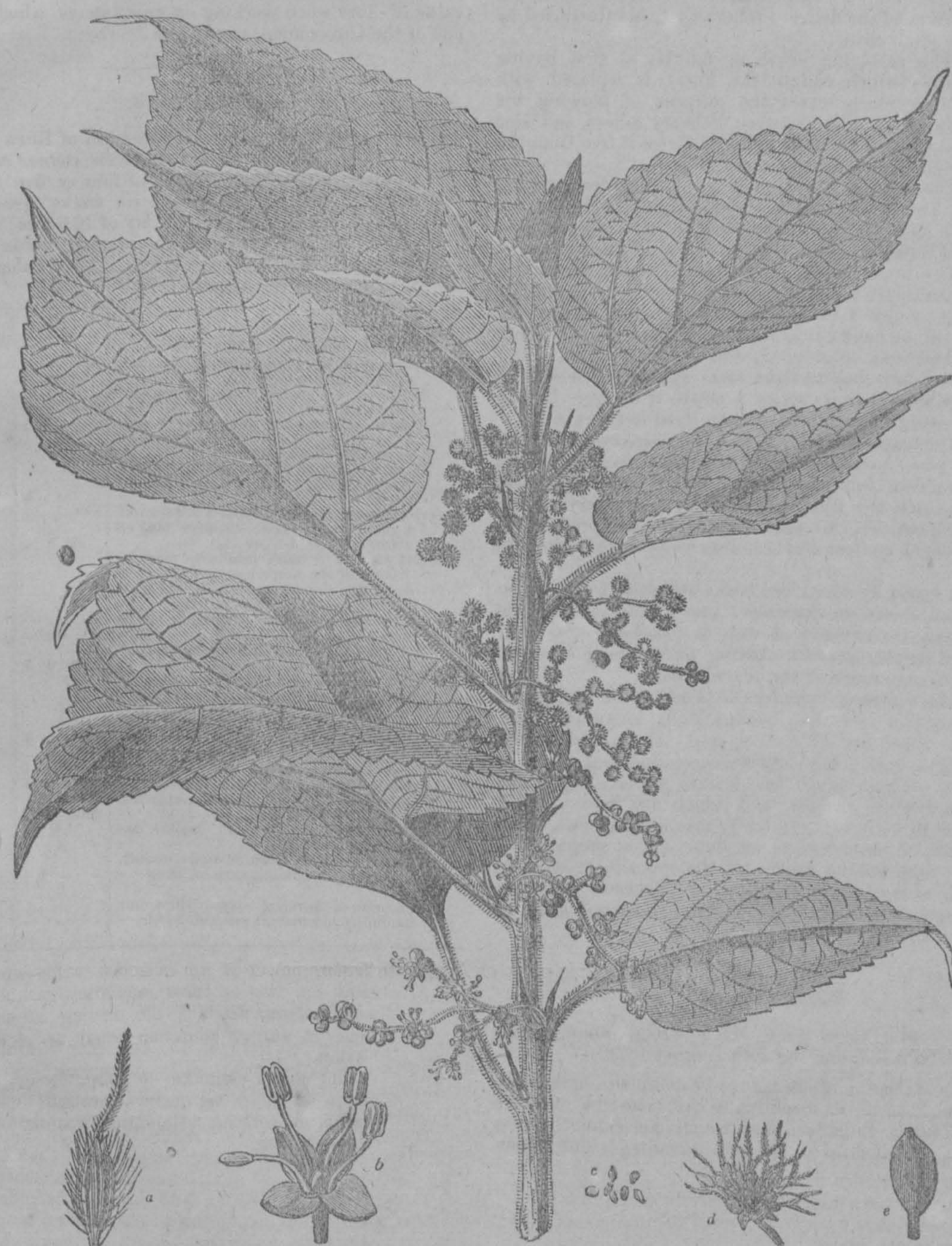
N.B.—If driving power be an overshot water-wheel, sufficient for two or three machines, prime cost of which about Rs. 500, the driving expenses will then be almost nominal—such as is found in Ceylon.

The above estimate by John Greig, junior, is taken as on a regularly organised factory and plantation working systematically under favourable circumstances.

II.—DESCRIPTION OF THE RHEEA PLANT.

The following plates (from "Hooker's Journal of Botany and Kew Garden Miscellany," vol. 3. plates vii. and viii. represent the species best known in India.

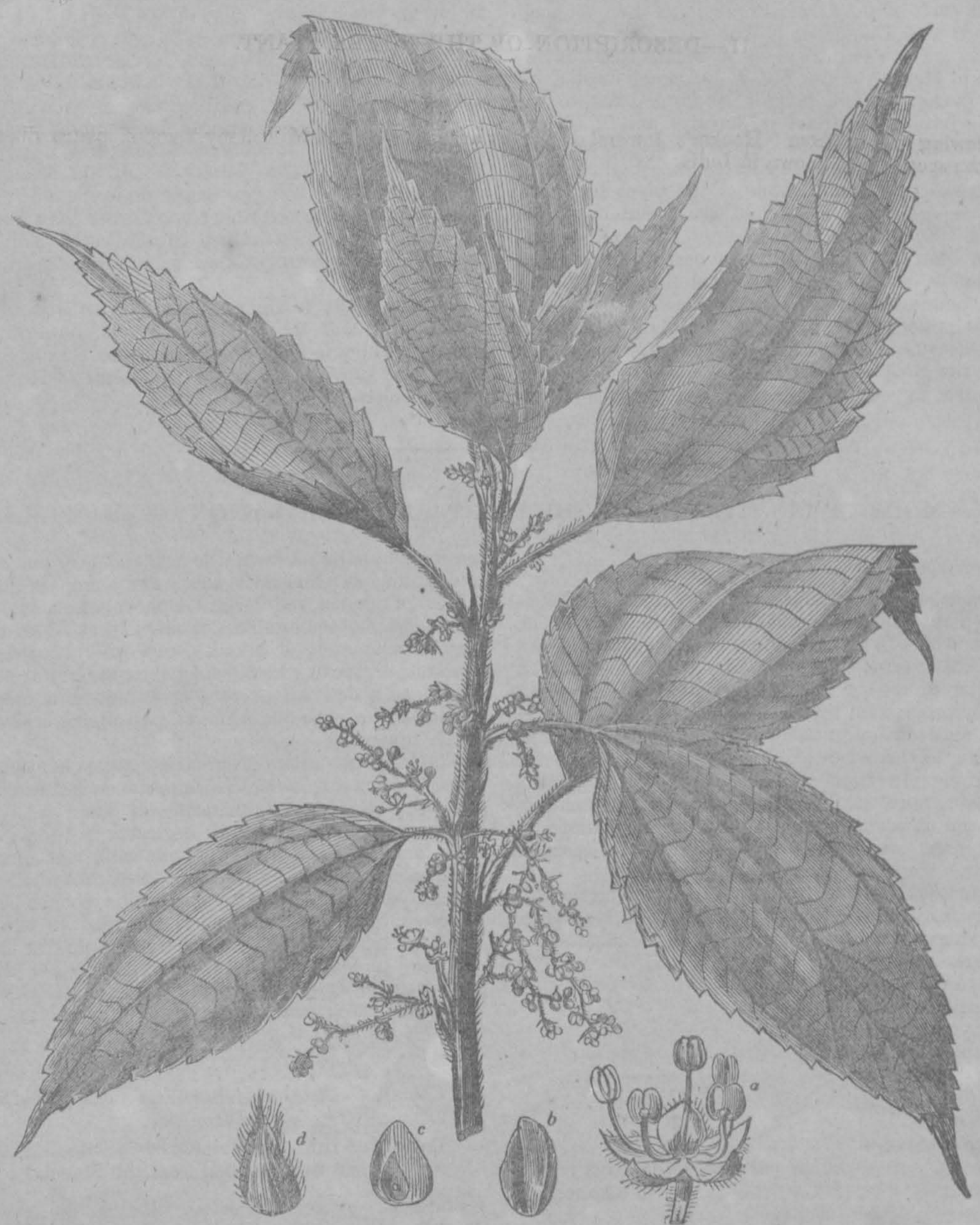
Fig. 1.



Rheea (*Boehmeria nivea*).

The first is the *Boehmeria nivea* (Fig. 1), called also *Urtica nivea* and *Urtica tenacissima*. The *Boehmeria nivea* is known by the native names of Rheea, in Assam; Kunkhoora, in Rungpore; Ramie, amongst the Malays; Caloee, in Sumatra; Isjo Karao, in Japan; and Chu, or Tchou ma, in China. Dr. Roxburgh described it as growing luxuriantly in the Botanical Gardens of Calcutta, and states that it may be grown from cuttings as readily as the willow. In habit it is a shrub, varying in height from five to eight feet. The branches are covered with short spreading hairs; the leaves, on long, hairy leaf-stems, broadly-caudate, with serrate margins, terminating suddenly in a fine point, the under-leaf is covered with a dense-white down; peduncles hairy, usually two together, carrying nearly sessile clustres of flowers; *a* represents a female flower; *d* a cluster of them; *b* a male flower; *c* the seeds of natural size; *e* magnified.

FIG. 2.



POOAH (*Boehmeria puya*, or *Boehmeria frutescens*).

Boehmeria puya, Fig. 2, called Pooah, flourishes near Darjeeling, and at other places in the North. The leaves, differ from those of the *B. nivea*. The male flowers, *a*, are like those of the former species. The seeds also differ; *b* and *c* represent the denuded seed, much magnified; *d* the seed in its envelope or perianth.

Of these two varieties it is the first, or the *Boehmeria nivea*, which has been almost exclusively the subject of experiments; and it is usually supposed to produce a finer fibre than the Pooah plant.

Dr. Falconer and Sir William Hooker consider the Indian specimens of the *Boehmeria nivea* here represented as identical with the Chinese plant from which the China-grass is prepared. The Dutch botanists, however, are inclined to distinguish between the two plants, and consider them as belonging to two different species. Haskarll gives to the Chinese variety the name of *Boehmeria sanguinea*, and to the Indian variety, which is the same as that grown in the Indian Archipelago, the name of *Boehmeria candicans*. The name *Sanguinea* of the Chinese variety is derived from the dark blood-red colour which the stems assume on ripening. In addition to the colour of the stems, the distinction between the Indian and the Chinese variety is said to be that the underside of the leaf is in the Indian variety green, slightly reticulated in white, whereas in the Chinese variety the underside of the leaf is white, reticulated in green.

III.—GEOGRAPHICAL DISTRIBUTION OF THE BOEHMERIA NIVEA.

The range of growth of the *Boehmeria nivea* is very extensive. It is indigenous in China, Japan, the Philippine Islands, Java, Sumatra, and the other islands of the Indian Archipelago, as also in Siam, Burmah, Singapore, and Penang. In India it is indigenous, in Assam, Nepal, and in some parts of the Lower Provinces of Bengal, such as Rungpore and Dinagepore. The plant has been acclimatised in various countries. Don Benito Roezl introduced it into Mexico, whilst Mr. J. Bruckner started its cultivation in the southern part of the United States. It has likewise been acclimatised in Jamaica, and it thrives in Natal, where an indigenous variety is said to attain a height of 24 feet. Through the efforts of the Paris Society of Acclimatisation, the cultivation of the plant has been introduced experimentally into Southern France as well as into Algeria. Even within the limits of England its cultivation has been attempted. It has been grown in the Channel islands. Good specimens exist in the Botanical Gardens in London, and considerable quantities have been raised in the gardens of his Grace the Duke of Wellington at Strathfieldsaye.

Though the profitable cultivation of *Boehmeria nivea* in our climate is out of the question, yet the possibility of growing it here shows the hardy nature of the plant. In India itself the cultivation of Rheea has been successfully attempted in various parts of the country. Messrs. Morrell report that the Rheea grows most luxuriantly in the Sunderbunds, and Mr. Montgomery started a plantation in the Kangra Valley in the Punjab. It is grown extensively at the Government Botanical Gardens at Saharunpore, as also near Mussoori, in the North-western Provinces, as also in Oudh, in the Nilagiri hills, as also in almost every part of India where its growth has been attempted. It may be noticed incidentally that both in India, as well as in America, France, and Algeria, it appears to be the Indian variety which has been used for cultivation. The Kangra plantation is the only exception. Mr. Montgomery,—strongly convinced of the superiority of the Chinese plant,—obtained in 1867 seed from Canton, and stocked his farm exclusively from plants grown from that seed.

Whether there is any real difference in quality between the Chinese and the Indian variety is, however, a moot question, though it is not improbable that the Chinese plant may prove superior, as the result of its long and careful cultivation in that country.

IV.—MODE OF CULTIVATION OF THE PLANT, AND PREPARATION OF THE FIBRE.

1. *General agricultural character of the Rheea plant.*

The extracts subsequently inserted describe the cultivation of the plant and the preparation of the fibre in the countries in which it is indigenous,*—China, Assam, and the Indian Archipelago. The mode of cultivation employed is very similar in all the countries referred to, the plant being mainly propagated by roots, cuttings, or suckers, and requiring a good deal of moisture for its full development, and appearing to thrive best in shade.

It is distinguished from all other textile plants of the same character, such as flax, hemp, jute, &c., by being a perennial, and it seems even that the crops obtained in subsequent years are superior in quality to the crops of the first year.

The exhaustive nature of the plant is shown by the following analysis of dry Rheea stems by Dr. T. K. Hornidge. The Rheea stems were found to contain, in 100 parts,—

Carbon - - - -	47·28
Hydrogen - - -	6·26
Nitrogen - - -	0·09
Oxygen - - - -	42·23
Ash - - - -	4·14
	100·00

The ash consists of—

Potash - -	32·37	per cent.	48·76 per cent. of alkalies.
Soda - -	16·39	„	
Lime - -	8·40	„	
Magnesia - -	5·39	„	
Peroxide of iron -	—	„	
Chloride of sodium	9·13	„	
Phosphoric acid -	9·61	„	
Sulphuric acid -	3·11	„	
Carbonic acid -	8·90	„	
Silicic acid (with a little charcoal and sand) -	6·60	„	
	99·90		

It will be noticed that the alkalies contribute almost one half, and the phosphoric acid about one tenth of the ash. As from the results of the Saharunpore trials previously quoted, the weight of dry stems obtained at one crop may be taken at about 1,000 lbs. per acre, this gives, with three crops in the year, a yield of about 3,000 lbs. of dry stems per acre per annum. The quantity of ash in that quantity will amount, according to the foregoing analysis, to 124 lbs., and the quantity of alkalies subtracted from one acre in the course of the year will be about 60 lbs., and of phosphoric acid about 12 lbs. In England, a crop of wheat is usually assumed to subtract from the soil about 30 lbs. of alkalies and 28 lbs. of phosphoric acid; and a crop of flax, about 50 lbs. of alkalies and 24 lbs. of phosphoric acid. In comparison with these numbers it seems that Rheea requires a very large amount of alkalies, especially of potash, more than either flax or wheat, whilst the quantity of phosphoric acid is only one half of that contained in a crop of flax owing to the large quantities of phosphoric acid contained in the linseed.

The large quantities of mineral matters contained in the Rheea stems explains the importance attached by the Chinese to the careful manuring of the plant. This is a point which ought not to be neglected in India; and even if it should be difficult to provide sufficient quantities of manure, the dry sticks, after the separation of the fibre, and all the refuse during its preparation, should be carefully collected, burnt, and the ashes returned to the soil. If this is systematically done there need be no fear that Rheea as a crop should prove very exhaustive to the soil, as the proportion of valuable mineral constituents taken away in the fibre itself is quite small.

2. *Chinese Cultivation of Bohmeria nivea, called in China Tchou-ma.*

(Translated from the Chinese by M. Stanislas Julien, and re-translated from the French.)

Cultivation of the Tchou-ma, Urtica nivea. Imperial Treaties of Chinese Agriculture, Book or Vol. 78, p. 3.

For the purpose of sowing the *tchou-ma* in the third or fourth month a light sandy soil is preferred. The seeds are sown in a garden, or, where there is no garden, in a piece of ground near a river or a well. The ground is dug once or twice, then beds one foot broad and four feet long are made; and after that the earth is again dug. The ground is then pressed down, either with the foot or the back of a spade. When it is a little firm, its surface is raked smooth. The next night the beds are watered, and on the following morning the earth is loosened with a small-toothed rake, and then again levelled.

After that half a *ching*, four pints and a half, of moist earth and a *ho* (a pint) of seeds are taken and well mixed together. One ounce of seeds is enough for six or seven beds. After having sown the seeds, it is not necessary that they should be covered with earth; indeed, if that were done, they would not germinate.

The next thing to be done is, to procure four sticks, sharp at one end, and to place them in the ground in a slanting position, two on one side of the bed, and two on the opposite side. They are for the purpose of supporting a sort of little roof two or three feet high, and covered with a thin mat.

In the fifth or sixth month, when the rays of the sun are powerful, this light mat is covered with a thick layer of straw. If this precaution were not adopted, the young plants would be destroyed by the heat.

* The best book for reference with regard to the cultivation of Rheea in India is still Dr. Forbes Royie's "Fibrous Plants of India," 1856, pp. 344 to 376. As regards other countries more details can be obtained in the following French publications:—
La Ramie, &c.; par Theophile Moerman. 112 pp. Gand. 1871.
Culture et Emploi de l'Ortie de la Chine; par Paul Madinier. 16 pp. in the Journal de l'Agriculture des Pays Chauds. Paris. Nov. 1865.

Before the seeds begin to germinate, or when the young leaves first appear, the beds must not be watered. By means of a broom dipped in water the roof of matting is wetted so as to keep the ground underneath moist. At night the roof is removed in order that the young plants may catch the dew.

As soon as the first leaves have appeared, if parasitical plants appear, they must be immediately pulled up. When the plant is an inch or two high, the roof may be laid aside. If the earth is rather dry, it must be slightly moistened to the depth of about three inches.

A stiffer soil is now chosen and thrown into beds, to which the young plants are to be transferred. The following night, the first beds in which the young plants are are to be watered; the next morning the new beds are to be watered also. The young plants are then dug up with a spade, care being taken to keep a small ball of earth round their roots, and are pricked out at a distance of four inches the one from the other. The ground is often hoed.

At the end of three or five days the earth must be watered, and again at the end of ten days, fifteen days, and twenty days.

(Extract from the General Treaties on Agriculture, entitled Nong-tching tsiouenchou.)

When the *tchou-ma* is cultivated for the first time it is raised from seed. The roots of the seedling plants give of themselves new shoots. At the end of a few years, the roots cross each other and intertwine, when the stems must be separated and replanted.

At the present day, it is very common in the countries of 'An king and Kien-ning to disentangle the roots with a knife, and to replant them. Those who cannot procure seeds follow the plan adopted for obtaining young mulberry trees from layers. This plan is a very quick one.

In those countries, however, where there are no roots of the *tchou-ma*, and where it is not easy to procure them from other places, the seed is had recourse to.

As soon as the young plants are a few inches high, they are watered with a mixture of equal quantities of water and liquid manure. Immediately after the stems are cut, the ground must be watered, and this ought to be done at night or on a cloudy day; for if the plants were watered in the sunshine they would rust. Great care must be taken not to make use of pigs' dung.

The *tchou-ma* may be planted every month; but it is necessary that *the ground be moist*.

Transplantation and Propagation of the Tchou-ma.

When the tufts of the *tchou-ma* are strong enough, the earth around is dug, and new stocks are detached and transplanted elsewhere. The principal stock then grows more vigorously. At the end of four or five years, the old stocks becoming excessively strong, they are divided and replanted in other beds.

Some persons are satisfied with bending the long stems down and obtaining layers in the ordinary way.

When a bed becomes too crowded, another must be formed, and then another. In this way the plants may be propagated to any extent.

A stiff soil that has been well worked in autumn is chosen and manured with fine muck. In the following spring the plants are transplanted. The best time for carrying on this operation is when the stems have attained a considerable size.

The new plants are placed a foot and a half from each other, and when they have been well surrounded with earth they are watered.

In summer as well as in autumn, advantage must be taken of the time when the earth has just been moistened by rain. The off-sets can be transplanted to places near at hand; but it is essential to have a ball of earth around each plant.

To propagate the *tchou-ma*, portions of its roots two or three inches long are detached by a knife, and are placed by twos and threes in little trenches that are about a foot and a half from each other. The roots are then surrounded with good earth and watered; the watering is renewed three or five days afterwards. When the new stems have attained a certain height, the earth must be often hoed.

If the earth is dry it must be watered. If the plants have to be carried to a distance, their roots ought to be surrounded by the soil in which they have been growing, well enveloped in leaves of the reed. They are placed, in addition to this, in a mat, folded so as to exclude them from air and light. They may then be carried without danger to a distance of many hundred miles.

The first year, when the plants are a foot high, they are gathered; and again in the second year the fibres of the cut stems are fit for spinning.

In the tenth month of every year, before cutting the off-sets which pass beyond the roots, the earth is covered with a thick layer of cow or horse dung. In the second month the manure is raked off in order to allow the new plants to come up freely. At the end of three years the roots become excessively strong. If part of the plants which come up in close tufts were not removed, the others would be smothered.

Gathering the Tchou-ma.

The *tchou-ma* may be gathered three times a year. When the stems are cut, the little shoots springing from the root-stock should be about half an inch high. As soon as the large stems are cut, the suckers spring up with more vigour, and soon furnish a second crop. If the young shoots be too long, the large stems ougnt not to be cut, but the ground shoots would not become vigorous, and would be prejudicial to the development of the larger stems.

The first crop is got in towards the commencement of the fifth month; the second, in the middle of the sixth month or at the beginning of the seventh month; and the third and last, in the middle of the eighth or beginning of the ninth month. The stems of the second crop grow much faster than the others, and are by far the best.

After the crop, the stocks of *tchou-ma* are covered with manure and immediately watered.

Peeling the fibres of the Tchou-ma.

When the stems are all got in, they are split longitudinally with knives of iron or of bamboo. The bark is first removed, then the lower layer (which is white, and covered with a shrivelled pellicle which comes off by itself) is scraped off with a knife. The interior fibres are then seen; they are to be removed and softened in boiling water. If the *tchou-ma* be peeled in winter, the stems must be previously steeped in tepid water in order that they may be more easily split.

The first layer of *tchou-ma* is course and hard, and is only good for making common materials; the second is a little more supple and fine; the third, which is the best, is used for making extremely fine light articles.

Steeping and bleaching the Tchou-ma.

The stems are tied up in little sheaves, and placed on the roof of a house in order that they may be moistened by the dew at night, and dried again by the sun in the day. In the course of from five to seven days they become perfectly white. If the weather be cloudy or rainy the stems are placed under cover in a current of air. If they are wetted by the rain they immediately turn black.

Another author says, after peeling the fibres they are tied in skeins arranged in a circle and steeped for a night in a pan of water; they are then spun on a wheel. This done, they are again steeped in water containing the ashes of burnt mulberry wood.

Having taken them from the pans they are divided into packets of 5 ozs. weight each; the packets are placed for a night in a tub of a mixture consisting of a cup of pure water and an equal quantity of powdered chalk to each packet.

The next day the chalk is got rid of, and the fibres are boiled in water containing straw ashes, by which process they become white and supple. Being now dried in the sun they are again boiled in pure water; they are then stirred about in more water, which finishes the cleansing process, and, lastly, they are dried in the sun.

This done, the fibres are joined end to end on the wheel so as to make long threads, which form the warp and the woof, and are manufactured into stuff in the usual way.

Another author says, after having spun the fibres of *tchou-ma*, they are boiled in lime water, and, when cool, carefully washed in pure water, then, by means of a bamboo sieve, placed on the surface of the water, they are spread out in equal layers in order that they may be as it were half wetted below, and half dried above. As night approaches, they are taken out, strained and dried: the same process is repeated the next and following days until the threads are perfectly white. They are then, but not before, fit for being made up.

According to another process, the *tchou-ma* is first soaked, then spun and made up, instead of being soaked after the spinning.

Other persons again take the fresh fibres, expose them at night to the dew, and in the day to the sun; then spin and weave, bleaching last of all.

Others, lastly, following those who employ the plant *ko*, cut the stems, soften the fibres in the steam of boiling water, then weave, and do not bleach at all. Fibres thus prepared give a material that is more supple and fibrous.

Mode of gathering the best seeds of Tchou-ma.

When seeds of *tchou-ma* are wanted for the purpose of sowing, those which are found on the main shoots are to be preferred. In the ninth month, after the period *choangkiang* (after the 2nd of October) the seeds are collected and dried in the sun; they are then mixed with damp sand, and put in a bamboo basket, carefully covered with straw. This precaution is needed, for if the seeds are frozen they will not grow. The seeds of the lateral shoots are not fit for sowing. Before sowing the seeds are thrown into water, and those that sink are used, while the others are of no use.

The seeds are sown before the first half of the first month. The best seeds are those which are spotted black. After they are sown, they are covered with ashes. If they are sown thick, the plants coming from them will be weak and sickly; they will be strong and healthy, on the contrary, if the seeds are thinly sown. As soon as the leaves appear the plants are watered with liquid manure. In the seventh month, the seeds are collected, put on canvas, and hung in a strong current of air; this aids and hastens germination. (Journal of the Horticultural Society of London, vol. 4th, part 4th.)

(3.) *Cultivation of Rheea in Assam.*

With respect to the cultivation of the Rheea plant and the preparation of its fibre in Assam, I cannot do better than quote from Colonel Hannay's published observations, as well as from a communication received from that gentleman in 1859.

" The sole cultivators of this plant are the dooms or fishermen, who use it chiefly in making their nets; they cultivate it in very small quantity however; and as the fourth crop is that which bears seed, and they cut it down before the seed is formed, the plant is propagated entirely by dividing the roots. The ground is a small plot close to their huts, which they have great opportunities of attending to, and manuring well with ashes and cow-dung, a quantity of which is essential to the proper growth of the plant.

" I have mentioned four crops, but as I have now a crop, the fifth, since planting, fit for cutting in February, and I see others belonging to the dooms in the same state, there will be five crops since planting, or six crops from April to April; the last or cold-weather crops, cut in February, being considered to produce the strongest fibre. However, as moisture seems so essential to the quick growth of the plant, generally speaking, after the early November or fourth crop, the dooms allow the cattle free ingress into their plots, and it is thus kept down till February, when some pains are taken in opening out the roots, heaping up the earth, and manuring them, as well as enclosing afresh the plot of ground. The soil, from repeated manuring, is of course rich; and on this, and a good degeee of shade and protection from storms, depends the luxuriance of the crop, which I have seen here eight feet high, and the extracted fibre six feet long. So much attention, indeed, is given to length of stalk amongst the Kakoos of the Chinese frontier, that the gardens are walled in (with wattling) like a *Pan* [*Piper Betle*] garden.

" From the roots thus dressed up in February, a crop will be cut in April, another in June, another in August, and another early in November; the most luxuriant crops being those of June and August, as naturally receiving the greatest quantity of moisture. The fifth crop takes from early in November to February to come to maturity. Between the cuttings, all that seems necessary is a fresh opening up of the ground around the roots, which in a regular plantation is best done by hoeing between the rows with a spade-shaped hoe set in a long handle; the person, as he performs this, going backwards, so as not to step over his work;—in fact, nothing can be more simple than the cultivation of this plant: all that is required being a loose rich soil, and protection to the crop by a good strong fence. The roots throw up at least 12 shoots when in full bearing; should they increase, and the crops get too thick, the roots require to be separated; and by this means of planting out fresh ground, and new plants from seed, the cultivation can be carried to any extent."

The separation of the fibre from the stalk is a difficult and expensive operation. It is thus described :—

" The stalks are considered fit for cutting when they have become of a brown colour for about six inches above the roots. To cut them, the doom seizes the leaves at the upper end with his left hand, and passing the right hand down to the root, strips off the leaves. He then cuts the stem two or three inches from the ground. As the stalks are made up into bundles, they are either carried home, or, on the spot, taken separately by an expert hand, broken through the middle, and then, after a smart movement of the right hand to either side, the thumb is passed up, and the fibre ripped off with its adherent bark. The fibre is then steeped in water for a few hours, and thus much discoloured refuse matter is withdrawn; but such a steeping does not appear to be absolutely necessary. The fibre with the bark is then fastened by one end to a hook. The operator takes one strand at a time, and holding the thicker end in his left hand, with slight tension passes the thumb of his right hand along the inside of the strand, which at once disengages the bark. This falls down, and whatever feculent matter may remain in the fibre is dexterously forced out by pressure with a blunt knife held in the right hand. When the bundle is finished, it is put out to dry, if there is sun; if not, it is spread out in an exposed building When thoroughly dry it can be put aside.

The drying requires great care to prevent mould or blight afterwards."

Another process of removing the fibre, somewhat different from that described above, is likewise practised. Instead of at once stripping the fibre, with the bark attached, the latter is scraped from the individual stems with a blunt-edged knife, leaving the fibre on the woody part of the stalks, which are then exposed to a hot sun for two or three days to dry. The third morning, after having been exposed to the dew for several hours, the fibre is removed by breaking the woody stalk right through towards the thicker end, and then separating it therefrom by drawing it off slowly towards the small end—some care being required in giving it a peculiar twist so as to draw off as much as possible. Having finished with the smaller end, what remains on the thick one is pulled off in the same manner. With respect to this mode of extracting the fibre, Colonel Hannay remarks, that it leaves probably one-fifth still adherent to the stem.

(4.) *Notes on the cultivation of Rheea in India; by W. King, Officiating Superintendent, Botanical Gardens, Saharumpore.* 1869.

Limit of Growth.—The garden in Dehra Doon is about 2,500 feet above the sea level, and the plantations in the Kangra Valley are probably higher. There are no exact records known to me showing the height at which the Chinese nettle thrives best. It grows, however, freely in the plains at very low elevations. At Saharumpore, which is about 1,000 feet above the sea, the plants are very green and healthy, and reach a height of 5 to 7 feet.

Soil and Shade.—The Chinese prefer a rather stiff soil; but I gather from a communication in the journal of the Agri-Horticultural Society, that in Assam a loose rich soil is considered the best. That in the Dehra Doon Gardens is of the former description, whereas the patch of ground planted with Rheea at Saharumpore is rather light and sandy. My own experience, which, however, is but limited, leads me to think moderate shade is an advantage. The finest plants in the garden at Saharumpore are a few grown under trees; and shade appears to be the only condition of growth in which these differ from less vigorous plants near them.

Moisture and Manure.—A good supply of moisture is undoubtedly required and regular irrigation would be necessary in the plains. But of all the requisites for successful cultivation, I believe the first to be manure, and this is the one least recognised in Indian Agriculture. The Chinese manure extensively. They plant out in soil which has been carefully prepared and richly manured. They also use liquid manure, and in the cold season give a top dressing of stable litter.

Propagation and Cultivation.—The plant being one of those in which the male and female flowers are separate, and situated on different parts of the stem, the production of seed is uncertain in localities where the insects by which fecundation is probably accomplished are not indigenous. In districts where Rheea has been *introduced*, propagation has therefore not been conducted by seed but by cuttings, and by division of the roots of old plants. By cuttings it may be propagated very easily, as scarcely one fails to strike. During damp weather roots of old plants may be freely broken up into smaller ones, and these, if planted out into well manured nurseries, thrive well. This is the favourite mode of propagation in China. Both cuttings and fragments of root should be planted about $1\frac{1}{2}$ feet apart. The soil between the plants should be frequently broken up so as to keep it loose, and should, of course, be kept free from weeds. Top dressing with manure is strongly insisted on by Chinese cultivators.

(5.) *Experiments in Rheea Cultivation, by Mr. J. Sandys, Bhangulpore.* 1869.

(Letter dated 30th June 1869, in enclosure to despatch of the Government of India, No. 86, of 11th October 1869.)

After several years' study of the plant, extraction of its fibre, no end of experiments, including one patent, now useless as too expensive and inefficient, and oftentimes inclined to throw the matter up in despair, I have arrived at the conclusion that the greatest Rheea difficulty would be overcome if its produce grown during all seasons of the year was marketable, Dr. Forbes Royle's opinion being that the character of the fibre was affected by the different seasons. Accordingly, in April last, I forwarded to England a large quantity of fibre, the produce of each month of the year up to March 1869, with the exception of that for April last, which I have now in store, thereby completed produce for each month of the year. As far as I can judge, the produce is far superior to that already reported on for May and June 1868. The fibre is shortest during the extremes of heat and cold. Still none of it is shorter than the English manufacturer's minimum, viz., two feet. Moreover, under a peculiar cultivation, I have succeeded in raising a three and a half feet fibre during the past month of May. If the year's produce now in England is accepted, then the same principle by which it has been obtained monthly can be equally extended to a daily operation. Rheea can then be planted, harvested, and the fibre extracted daily, cultivation and manufacture thereby working hand in hand together economically under a properly organized system.

(6.) *Extract from a Report of the Dutch Botanist Bluma on the Cultivation of Boehmeria Nivea in Java and Sumatra.*

(Translation from the French in Moerman's "La Ramie," pp. 98–102.)

The inhabitants of the Indian Archipelago have used this plant from time immemorial for their fishing nets, which are considered stronger and more resisting to the action of moisture than those made from usual hemp. Formerly the fibre was manufactured into cloth of all kinds, and used for various articles of dress, remarkable for their lasting qualities. But this industry has disappeared before the low-priced European calicoes now universally used.

The Boehmeria Nivea under the Malay name of Ramie is spread all over the Indian Archipelago. The plant thrives best in shade, in a moist and fertile soil, conditions such as are usually found in abandoned coffee plantations. . . The plant thrives best in the hilly parts of the country in which rain is frequent. In the plains it would require irrigation. Experiments undertaken by the Dutch Government in Java have mostly failed from the inappropriateness of the ground selected for its cultivation. Rice fields were used which, from their open situation, were not suitable for the Boehmeria, which requires shade.

The mode of cultivation is very simple. The propagation takes place by dividing the roots and planting them separately at from three to four feet distance. The plant soon grows to the height of five to seven feet. As soon as the stems begin to get brown at the bottom they are cut. Experimental cultivation has shown that four crops may be obtained in the year, and that already in the first year the plant yields four stems at the first crop, six to eight stems at the second crop, 10 or 12 at the third, and from 16 to 20 at the fourth crop. A still larger number is obtained in the following years. . . . . It is advisable to hasten the time of the first cutting without waiting until the stems have become ripe, especially as the fibre from the first cutting is considered so inferior that it is altogether rejected by the natives.

The mode of extracting the fibre usually employed in Java is very tedious, and, as described by Dr. Blume, resembles the Chinese and Assamese methods. In Borneo and Sumatra, however, the stems are tied into bundles, and left for five or six days in water before being stripped. Information from other sources shows that this retting is sometimes continued in Sumatra up to 14 days.

V.—STATISTICS OF RHEEA AND CHINA GRASS.

The Customs in England do not return China grass under separate headings, so there are no official data with regard to the amount of Rheea or China grass imported into England, and all the other data available on the subject must be taken with a considerable amount of reservation.

From inquiries made in 1860, it appears that the whole quantity imported into England up to that time during the previous 30 years amounted to about only 60 tons. The export of China grass from China was always very fluctuating. The largest exports took place in the years 1863–4–5.

M. Moerman, in his work on Ramie, quotes the following figures from the report of the Belgian consul in Shangai referring to those years. The quantities given seem, however, much larger than one would be led to expect from any of the facts obtainable in this country.

Export of—			Piculs.	Piculs.	Tons.
White China grass	1863	-	28,784	33,265	2,000
Green ,,	,,	-	4,481		
White ,,	1864	-	33,026	49,485	3,000
Green ,,	,,	-	16,439		
White ,,	1865	-	38,453	57,475	3,500
Green ,,	,,		19,022		

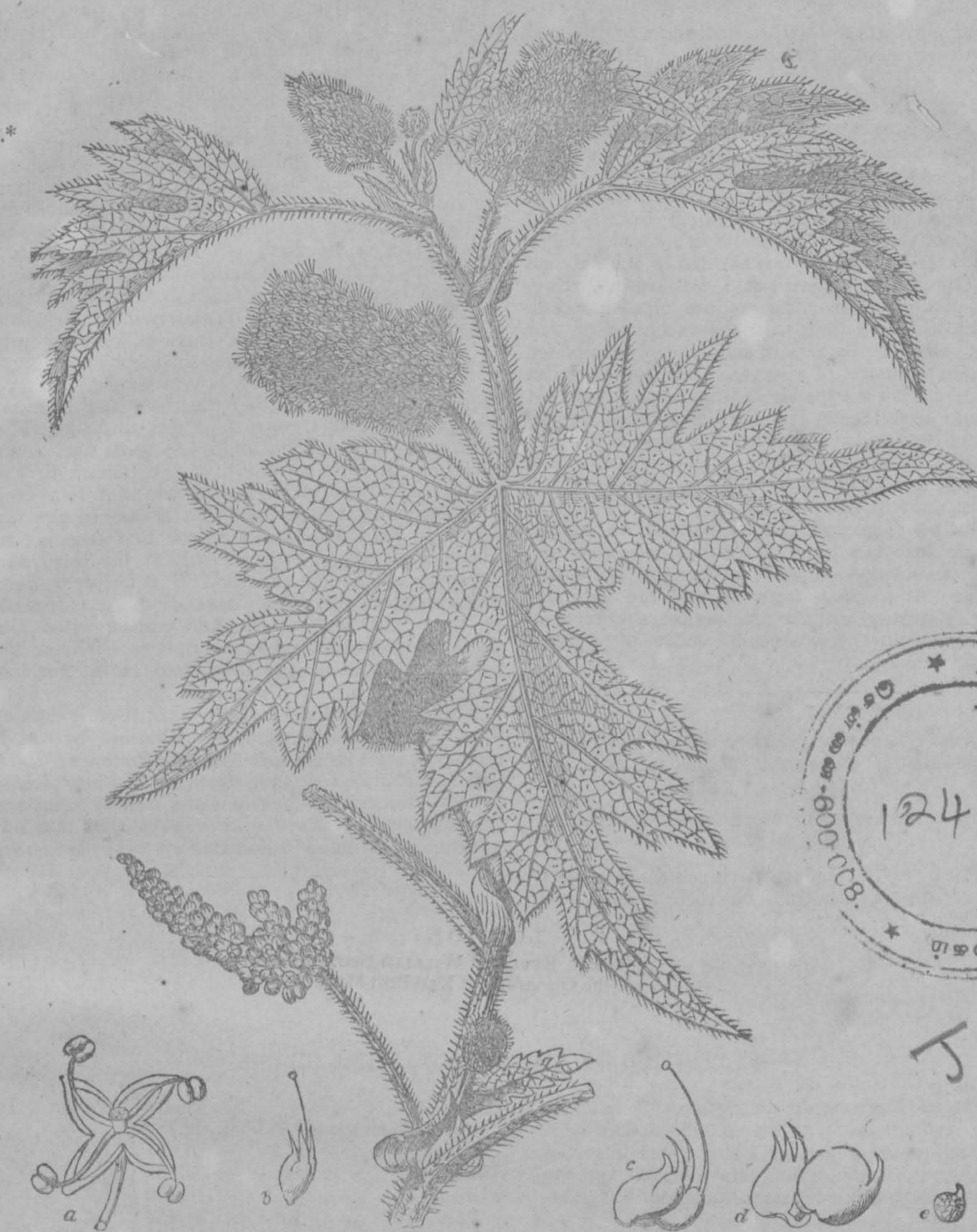
From a communication by Messrs. Manning and Collyer, the London brokers, through whose hands most of the China grass recently imported into this country has come, I learn that in the years 1866–7–8 there were scarcely any exports from China. The quantities for the following years are given as follows:—

Export of China grass to the United Kingdom in—

	Piculs.		Tons.
1869 - - -	1,438	or	86
1870 - - -	4,200	,,	252
1871 - - -	2,384	,,	143
1872 - - -	2,317	,,	139

VI. NILAGIRI NETTLE.

FIG. 3.*



NILAGIRI NETTLE (*Urtica heterophylla*).

A short notice of a fibre similar in character to the Rheea may find a place here.

It is the *Urtica heterophylla* of Roxburgh, commonly known by the name of "Nilagiri nettle," although one of the most widely diffused of the tribe to which it belongs. It is not only found in Southern India, but it also flourishes in Burmah, Assam, and many other places along the foot of the hills. In Assam it is known by the name of *Horoo Surat*—"Surat," according to Colonel Hannay, being the general term employed by the Assamese to designate all the larger nettles.

It is described by Dr. Roxburgh as a "most ferocious-looking plant," and the accompanying cut (fig. 3), showing a portion of it, sufficiently indicates its formidable character. It is an annual: has upright angular stems, covered with small prickles, and is marked with small white specks. The leaves are similarly protected by bristles; they are irregularly serrate, long, variously lobed, petioled, and almost caudate at the base. The seeds are of quick growth, and the cultivation of the plant could be rapidly extended if necessary. From the injuries consequent upon its sting, as also from the character of its stem, there are, however, greater difficulties in manipulating it, so as to obtain its fibre, than in the case of the Rheea or Pooah; and as, in addition, its fibre has hitherto been always valued at a considerably lower figure than that of the Rheea or China grass, the prospects of its becoming a commercial article of any importance are very small, unless some special use were discovered for it. Its fibre is well known and appreciated by the Todawers and Burghers of the Neilgherry Hills, as well as the Bhoteeas to the north of Assam, who are said to use it extensively for the manufacture of cloth. By the former the plant is boiled before the separation of the fibre is attempted. The necessity for machinery, in this case, is even more obvious than in that of the two former—although for all some readier method of separating the fibre is absolutely essential. The remarks made with respect to the rough character of the Rheea fibre are still more applicable to those of the Nilagiri nettle. Indeed, so similar to wool is its fibre that, when cut short and crumpled up or "scribbled," I have known it valued by an experienced broker as wool, and its price stated accordingly. The term "vegetable wool," which it has already reeeived, is therefore very suitable.

The diameters of the fibres of the *Urtica heterophylla* are exhibited in the following table:—

NEILGHERRY NETTLE (*Urtica heterophylla*).

Name and Place of Growth.	Diameter of Fibres. Ordinary. Min.	Ordinary. Max.	Ordinary. Mean.	Ultimate. Min.	Ultimate. Max.	Ultimate. Mean.
	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
Urtica heterophylla, from the Neilgherry Hills	·00160 ·00140	·00420 ·00350	·00290 ·00245	·00040 ·00038	·00070 ·00066	·00055 ·00052
Mean	·00150 $\frac{1}{660}$	·00385 $\frac{1}{260}$	·00267 $\frac{1}{370}$	·000390 $\frac{1}{2600}$	·000680 $\frac{1}{1500}$	·000535 $\frac{1}{1900}$

* From Wight's "Icones Plantarum Indiæ Orientalis." Vol. ii.

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