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MADRAS RECORD OFFICE

GOVERNMENT OF MADRAS

Rev DEPARTMENT

G.O. No. / B.P. No.	1179.	Press / Mis.
Dated 5. R. 1875		196 .

Not to be folded or roughly handled

Proceedings of the Madras Go[illegible]ent, Revenue Department,
5th Au[illegible]s 1875.

No. 43. Read the following despatch fr[illegible] the Right Honorable the Secretary of State for India :—

Statistics and Commerce,
No. 10.

INDIA OFFICE, LONDON,
24th June 1875.

SIR,—I transmit, for the information of your Excellency, a copy of a despatch No. 57, dated 24th June 1875. which has been addressed to the Governmnt of India on the subject of the testing of machinery for the extraction of [illegible] fibre. Fifty copies of the printed memorandum therein mentioned will be fo[illegible]d to your Government.

I have, &c.,
(Signed) SALISBURY.

To His Excellency the Honorable
The Governor in Council, Fort [illegible] George.

ENCLOSURE No. 1.

Despatch from the Right Honorable the Secretary of State for India (Statistics and Commerce), to His Excellency the Right Honorable the Governor-General of India in Council, dated India Office, London, 24t[illegible] June 1875, No. 57.

Your Excellency's letters noted in the margin on the subject of Rhea fibre have been under my consideration, and I have to express my regret that through inadvertence the arrangements sanctioned by the Duke of Argyll in 1873 for conducting certain experiments to test the machinery best suited for the extraction of the fibre were not communicated to your Goverment at the time.

13th Dec. 1872, No. 9 (Fibres and Silk)
3rd Jan. 1873, „ 1 („ „).
11th Aug. „ „ 7 („ „).
25th „ „ „ 8 („ „).
13th Feb. 1874, „ 1 („ „).

2. In the accompanying printed memorandum by the Reporter on Products (of which 200 copies will be forwarded to your Government, as well as 50 to each of the other Presidencies,) you will find a summary of the information existing on the subject at the present time. For the reasons given by Dr. Forbes Watson, it appears to me desirable that further experiments should be conducted in November next to ascertain the most suitable machine, and that they should be carried on in London, where a much larger competition may be anticipated than in India; but I do not think it necessary, in the altered circumstances of the case, to repeat the offer of a prize.

3. In accordance with the suggestion contained in your letter of the 3rd of January 1873, I have associated with Dr. Watson in the intended inquiry Major-General F. C. Cotton, C.S.I. (formerly of the Madras Army), who, as your Excellency is aware, has for many years acted occasionally as Referee of the India Office on questions of agriculture, and Mr. E. C. Amos, C.E., who for twenty years has been employed as the Engineer for testing the machines of the Royal Agricultural Society. Both these gentlemen have rendered assistance to Dr. Watson in the experiments recently conducted at Manchester for testing the gins best adapted to the cotton of India, of which I trust that the report will be ready in the course of this summer, with the result of the calculations now being worked out.

4. I have requested to be furnished [illegible]early date with a report on the measures which seem best adapted for the purpose of cond[illegible]the experiments on Rhea fibres; but, in order not to lose time, I begged your Excellency, [illegible]y telegram of the 22nd instant, to cause about 30 tons of the dried Rhea stems to be sen[illegible] to this country, so as to arrive not later than the middle of October next.

5. I would further direct your Excellency's attention to that portion of the report which refers to the cultivation of the Rhea plant with a view to the proper officers of your Government being instructed to endeavor to collect precise information as to the variations in the quantity and quality of the produce, due to differences of season and growth, age of plant, soil and system of cultivation, and so forth. The great importance of giving proper attention to these matters, and to the most economical system of cultivation generally, will be obvious, and they may very usefully be made subjects of enquiry, while the further experiments as to the best methods of treating the fibre are being carried out.

No. 44. ORDER THEREON, 5 August 1875, No. 1,179.

Miscellaneous.

ORDERED to be communicated to the Board of Revenue, Chamber of Commerce, and Agri-Horticultural Society, Madras.

(True Extract.)

(Signed) A. MACGREGOR,
Acting Secretary to Government.

To the Board of Revenue, with thirty copies of Dr. Forbes Watson's Memorandum.
„ Chamber of Commerce, with five do. do.
„ Agri-Horticultural Society, Madras, with five do. do.

Erd. J. W. Fischer.

1120

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India Office,
London, 24th June 1875.

Statistics and Commerce,
No. 57.

To His Excellency The Right Honourable The Governor General of India in Council.

My Lord,

Para. 1. Your Excellency's letters noted in the margin*, on the subject of Rheea fibre, have been under my consideration, and I have to express my regret that, through inadvertence, the arrangements sanctioned by the Duke of Argyll in 1873, for conducting certain experiments to test the machinery best suited for the extraction of the fibre, were not communicated to your Government at the time.

* 13th December 1872, No. 9 (Fibres and Silk).
3rd January 1873, No. 1 " "
11th August 1873, No. 7 " "
25th August 1873, No. 8 " "
13th February 1874, No. 1 " "

2. In the accompanying printed memorandum by the Reporter on Products (of which 200 copies will be forwarded to your Government, as well as 50 to each of the other Presidencies), you will find a summary of the information existing on the subject at the present time. For the reasons given by Dr. Forbes Watson, it appears to me desirable that further experiments should be conducted in November next to ascertain the most suitable machine, and that they should be carried on in London, where a much larger competition may be anticipated than in India; but I do not think it necessary, in the altered circumstances of the case, to repeat the offer of a prize.

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4. I have requested to be furnished at an early date with a report on the measures which seem best adapted for the purpose of conducting the experiments on Rheea fibres; but, in order not to lose time, I begged your Excellency, in my telegram of the 22nd instant, to cause about 30 tons of the dried Rheea stems to be sent to this country, so as to arrive not later than the middle of October next.

Govt. of Madras
1875
REVENUE.
To
The BOARD OF REVENUE,
&c., &c., &c.
Dated August, 5th.
Read.
P. C. 6th August 1875, No. 1,179.
AUGUST
Nos. 43-44.

Machinery for the extraction of Rhea Fibre.—Communicating to the Board of Revenue, Chamber of Commerce, and Agri-Horticultural Society, Madras, despatch from the Secretary of State transmitting copy of one addressed to the Government of India regarding the testing of —, and intimating that fifty copies of the memorandum therein mentioned will be forwarded.

5. I would further direct your Excellency's attention to that portion of the report which refers to the cultivation of the Rheea plant, with a view to the proper officers of your Government being instructed to endeavour to collect precise information as to the variations in the quantity and quality of the produce, due to differences of season and growth, age of plant, soil and system of cultivation, and so forth. The great importance of giving proper attention to these matters, and to the most economical system of cultivation generally, will be obvious, and they may very usefully be made subjects of inquiry, while the further experiments as to the best methods of treating the fibre are being carried out.

I have the honour to be,

My Lord,

Your Lordship's most obedient humble Servant,

(Signed) SALISBURY.

No. 8.

Copy Statistics & Commerce Despatch to the Govt. of India, No 57, dated 24th June 1875.

Refered to in Statistics & Commerce Letter to Madras, No. 10, dated 24th June 1875.

Proof

5/1179

REPORT ON THE PREPARATION AND USES OF RHEA FIBRE.

1. The present efforts for the utilization of the Rhea 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 Rhea 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 Rhea 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 Rhea 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 Rhea.

* This is the third time within this century that Rhea 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 Rhea 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 Rhea, 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 Rhea 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 Rhea 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 Rhea 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 Rhea 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 Rhea 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 Rhea 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 Rhea 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 Rhea 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 Rhea 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.

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Second distribution of green Rhea in October 1873.

6. Evidence was, however, obtained that Rhea 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 Rhea 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 Rhea 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 has proved of considerable use in showing the character of the plant in its perfectly fresh state.

POSITION AND PROSPECTS OF RHEA.

Prospects of Rhea 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 Rhea. At that time it was assumed, and quite in accordance with the information and facts then available,—

(*a.*) That Rhea 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 Rhea.

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 Rhea 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 Rhea 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 Rhea; and it is a curious fact that even Rhea waste as knoils 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 Rhea 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 Rhea fibre with those of other fibres.

9. It remains to be considered how these changed conditions influence the whole question of the prospects of Rhea, 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 Rhea fibre.

10. As regards its inherent qualities, it is admitted on all hands that the physical properties of the Rhea 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 Rhea 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 Rhea 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 Rhea fibre is considerably stronger than either flax or hemp.

Resistance to the action of high pressure steam.

11. Rhea 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 Rhea. 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 Rhea amounted only to 0·89, and of Assam Rhea 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 to Steam, at 15 lbs. Excess Pressure, followed by Boiling in Water for Three Hours.	No.	Name.	Loss per Cent. after four Hours' Exposure to Steam, at 15 lbs. Excess Pressure, followed by Boiling in Water for Three Hours.	No.	Name.	Total Loss per Cent.
1	Himalayan Hemp† (*Cannabis sativa?*)	0·58	1	China Nettle	None.	1	Himalayan Hemp†	0·77
2	Rhea (*Boehmeria nivea*)	0·81	2	Neilgherry Nettle	None.	2	China Nettle	0·89
3	China Grass (*Boehmeria nivea*)	0·89	3	Sunn	None.	3	Rhea	1·51
4	Ambaree (*Hibiscus cannabinus*)	2·39	4	Himalayan Hemp†	0·19	4	Neilgherry Nettle	2·85
5	Flax (*Linum usitatissimum*)	2·47	5	Ejoo	0·61	5	Sunn	2·98
6	Pine Apple (*Ananassa sativa*)	2·47	6	Rhea	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 Suttа	1·20	8	Ejoo	4·15
9	Sufet Barials (*Sida rhomboidea*)	2·76	9	Ambaree	1·24	9	Bedolee Suttа	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 Suttа (*Pederia fœtida*)	3·06	12	Jute	2·19	12	Moorva or Marool	5·56
13	Muddar or Yercum (*Calotropis gigantea*)	3·19	13	Muddar or Yercum	2·28	13	Sufet Barials	6·00
14	Italian Hemp (*Cannabis sativa*)	3·33	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*)	3·49	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 Barials	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*)	5·20	21	Pine Apple	4·03	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*)	6·05	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 Rhea 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 $\frac{1}{2056}$ of an inch, of Rhea (from Assam) about $\frac{1}{2160}$, and of China grass $\frac{1}{2260}$ of an inch. Occasionally, however, samples of prepared Rhea 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.	·00278	·00573	·00425	1/23	·000340	·000950	·000488	1/205
		·00302	·00562	·00432	1/23	·000356	·000566	·000461	1/216
		·00095	·00445	·00270	1/37	·000390	·000630	·000510	1/196
		·00067	·00160	·00114	1/87	·000343	·000540	·000442	1/226
		·00150	·00385	·00267	1/37	·000290	·000690	·000535	1/186
		·00250	·00530	·00390	1/25	·000325	·000663	·000494	1/202
		†	†	†	†	·000615	·001725	·001170	1/85
	Class II. For spinning and manufacturing purposes, but of inferior durability.	·00142	·00374	·00258	1/39	·000420	·000647	·000533	1/188
		·00115	·00290	·00203	1/49	·000290	·000540	·000415	1/240
		·00167	·00364	·00265	1/38	·000303	·000529	·000416	1/240
	Class III. For the manufacture of cordage, twine, &c.	·00302	·00586	·00444	1/23	·000543	·000618	·000478	1/209
		·00091	·00799	·00595	1/17	·000594	·000597	·000450	1/222
		·00550	·01500	·01025	1/97	·000300	·000520	·000410	1/244
		·00200	·00520	·00390	1/25	·000229	·000469	·000319	1/313
	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.	·00237	·00487	·00332	1/30	·000157	·000227	·000192	1/521
		·00142	·00287	·00215	1/47	·000350	·001000	·000675	1/148
		·00388	·00676	·00530	1/19	·000402	·000750	·000575	1/174
		·00308	·00581	·00445	1/22	·000550	·000966	·000758	1/132
		·00250	·00487	·00369	1/27	·000550	·001000	·000775	1/129
		·00165	·00358	·00262	1/38	·000450	·000716	·000533	1/188
	Class V. Suited for the manufacture of mats, brushes, coarse cordage, imitation horse-hair for stuffing purposes, &c.	·00380	·01800	·00675	1/15	—	—	—	—
		·00250	·00775	·00513	1/19	—	—	—	—

Diameter of fibres about the same as those of Coir; different samples vary considerably in this respect.

* *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, Rhea 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 Rhea 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 Rhea is well exemplified in sample No. 51, although all the samples exhibit it to some extent the same characteristic. It is this stiffness which prevents Rhea, 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 Rhea 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 Rhea 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 Rhea readily combines with wool.

15. Thus Rhea, 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.

Rhea an 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 Rhea, 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 Rhea 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 Rhea will ever be used for such a purpose, as, apart from considerations of price, cottonised Rhea 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 Rhea 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 Rhea) 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. Rhea 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 Rhea or China grass, two points must be kept in view. Firstly, that Rhea 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 Rhea 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 Rhea 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. Rhea 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 Rhea 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.

Rhea and flax.

18. Whilst, however, no future can be held out to cottonised Rhea, 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 Rhea 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 Rhea 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 Rhea, 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 Rhea 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 Rhea 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, Rhea could be worked up on the same machinery as flax, the development of the Rhea 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 Rhea 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 Rhea with cotton is here also applicable, that is, that the rough Rhea 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. Bontor, manager of the Yorkshire 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 Rhea 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 Rhea, though it does not include the tow, the latter, as well as the combed Rhea, 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 Rhea. So that in comparing flax with Rhea, the result already arrived at would not have to be materially modified, that is, that the rough Rhea 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 Rhea must be increased by from 33 to 50 per cent., in addition to the cost of the chemical treatment.

23. If Rhea 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

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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 Rhea 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 Rhea 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 Rhea will be considered subsequently. There can be no doubt, however, that if the spinning difficulties were once overcome, the valuable qualities of Rhea would render it eminently fitted for successful competition with the finer varieties of flax.

Rhea and wool.

24. The application of Rhea 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 12 to 17 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.

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25. The prepared Rhea, 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, Rhea 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. 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 Rhea fibre is wanting in the great elasticity possessed by wool. In view of such an inferiority, the prices then ruling for Rhea 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 Rhea 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 Rhea 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 Rhea 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 Rhea on woollen 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 Rhea 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.

Rhea and silk.

27. Ever since the Exhibition of 1851 brought Rhea 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 Rhea naturally suggested this use. Both in England and in Lyons the subject has been taken up repeatedly; and though by the application of Rhea it is possible to imitate to a certain extent the effects of silk in certain mixed fabrics, the special use of Rhea 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, Rhea has a formidable rival in the much cheaper jute, now largely used for this purpose.

Rhea and hemp.

28. In the cases in which Rhea 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 Rhea 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 Rhea 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 Rhea, even in comparison with such high-priced fibres as fine flax, wool, and silk, seems to be even more formidable when Rhea 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 Rhea 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. 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 Rhea 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 Rhea and flax.

30. Another point of great importance is the undoubted superiority of Rhea to hemp as regards strength and resistance to water. The greater strength and the lesser density of Rhea may make it possible to replace hempen cordage by considerably lighter Rhea 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

* 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.

as compared with the ordinary hemp. On all these grounds Rhea 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 Rhea 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.

Rhea as a paper material.

31. The use of Rhea 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 Mill under the direction of Mr. Wyndham Portal, upon the paper-making qualities of samples of Indian fibres supplied from the India Museum, shows that Rhea 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 Rhea 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 Rhea as a paper material, all speaking in a hopeful tone, and considering that a certain admixture of Rhea 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 35 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	64½	Makes a nice clean smooth paper, of good colour,
	2	" " "	58	65½	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	Rhea (*Boehmeria nivea*) "	—	60	Very stubborn and lumpy when pulping. Makes a smooth good-looking paper.
	6	Bon or Jungle Rhea 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	4th Sunn (*Crotalaria*) and ¾ths linen rags	39	39	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	76	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	73	
	15	New India Note pulp (long fibre) "	50	65	Composed of linen, with a certain proportion of cotton.
	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 Rhea, called also Wild Rhea, is very common in Assam. It is still undecided whether botanically it is different from the *Boehmeria nivea*, which furnishes the cultivated Rhea 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.

Minor uses of Rhea.

32. Amongst minor uses of Rhea may be mentioned that for packings of steam engines. As seen from the foregoing table, it is extremely difficult to reduce Rhea 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 Rhea, as compared with almost all other fibres, bears likewise on this point. As a curiosity, it deserves to be mentioned that Rhea fibre is now in use for polishing ivory, such as billiard balls, &c.

CONCLUSIONS WITH REGARI TO THE FUTURE PROSPECTS OF HEA.

The foregoing short account of the physical properties of the Rhea 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.

Rhea 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 Rhea 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 Rhea 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 Rhea can be rendered fit for either use. Thus Rhea 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 Rhea into manufactures depended upon its own inherent qualities, there would be hardly a fibre which had ever better chances of success. The obstacle 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 Rhea and jute.

35. It is the high price of the raw material which explains the fact that Rhea, 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, Rhea 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 Rhea, be sufficiently supplied by its own high qualities, if only the prices do not become prohibitive. Rhea 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 Rhea 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 Rhea 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 Rhea arising from the nature of the plant.

It is important to bear in mind that, like all other fibres, Rhea 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 Rhea 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 Rhea 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 fom the smaller stems is likely not only to be finer, but it is also likely to suer 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 whle length. At each joint a certain proportion of the fibres stops, so that alon; with the full length fibre there is always a certain proportion of short lengths, vhich in scutching and combing mostly run to tow. With stems of less heightthis 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 he natural properties of the fibre itself, and independent of variations produced by a different mode of preparation. The latter, which will be superaded to those inherent in the fibre as grown, will be hardly less considerable. There is the difference between the fibre obtained from the green stms and that from the dry stems. The subsequent chemical treatment may reult in a greater or less disaggregation of the original fibre, and materially influence its character. On all these grounds it appears that the Rhea brought into th 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; anotherportion, 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 eason why it is impossible to expect that Rhea should, from the first, command uch high prices as its good-qualities are likely to ensure to it after its cultivaion 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 uniformty 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 s likewise necessary to ensure the steady supply of other bales as uniform and of he 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 wil 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 Rhea even greater difficulties than in the case of other fibre 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 vill 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 Rhea can only spring up if the bulk of the

45. It is clear, therefore, that a rapid development of the Rhea 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 Rhea. 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 Rhea 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, a 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.

fibre is supplied at prices which make it possible to introduce it into the manufacture of common goods of wide consumption.

For successful competition with other fibres the price of Rhea 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 Rhea 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 Rhea 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 tha: of the finest varieties of flax, which enter extensively into the commerce of this country. If Rhea, 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 from 30*l.* to 40*l.* per ton for the better, and of about 25*l.* per ton for the ower, 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 Rhea into competition with flax and hemp, even if the latter were somewhat cheaper. It has aso to be considered that the limits of price for Rhea 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 Rhea would have to be proportionately increased.

PREPARATION OF THE FIBRE FOR THE MARKET.

Having thus determined the limit of price at which the Rhea 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 Rhea 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 Rhea 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 Rhea. There is, however, one important difference; the Rhea stems are much more succulent than hemp. The green Rhea 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 "
" Rhea " 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 Rhea than it is in that of hemp; and even flax, though more succulent, yields almost double the weight of dry straw that Rhea 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 "
" Rhea stems " 20 to 28 "

The yield of Rhea 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 Rhea 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 Rhea 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 Rhea 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 "
" Rhea stems " 4 to 6 "
corresponding to from 3 to 4½ lbs. of fibre freed from gum.

Thus, on an average, 100 lbs. of green Rhea 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 3½ 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.

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All the data, in so far as they refer to Rhea, 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 2¾ 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 2¾ 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 stem, 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 scaping 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 Rhea 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 Rhea 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 Rhea 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 Rhea 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 Rhea 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 Rhea. The fermentation

will of necessity be rapid and energetic and will easily become destructive. In any usual crop of Rhea full grown, wood 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 Rhea stems.

52. In India and China, therefore, reting 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 Rhea. 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 Rhea could be retted the same result would follow, and even in the dried unretted Rhea a somewhat similar effect has been obtained. In the case, however, of the fresh Rhea 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 Rhea 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 clear 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	„
„ Rhea—		
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 Rhea, 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 Rhea 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, 1½ acres yielded a crop of 3½ 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 may be adduced. Mr. Montgomery estimates the possible out-turn of fibre from the Rhea grown on his Rambagh estate, near Kangra, at the same figure.

Comparison of cultivation of Rhea 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 Rhea, 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 Rhea. The question occurs,—Is it possible to expect that the cultivation of Rhea 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 Rhea may not be considerably increased. Secondly, it is likely that the part of India which will be most adapted for the growth of Rhea 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 Rhea 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 Rhea 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, Rhea is not likely to enter into any competition with it. The parts of India in which the cultivation of Rhea 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 Rhea 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 Rhea is likely to tell in its favour.

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

56. The usual way of obtaining the fibre from the Rhea stems is to strip by hand the unretted green stems, an operation at which a day's work is variously estimated to yield from ½ to 2½ 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 dried stems.

Yet this experience hardly seems conclusive, nor is the experience of the Rhea-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 Rhea stems, and during the last year also with specimens of fresh Rhea 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 Rhea prepared by Greig's machine at the Saharunpore trials. Nos. 23 and 24, received from Mr. Green, are samples of freshly prepared Rhea, 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. L. 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 Rhea, 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 Rhea does not possess less strength or lustre than that prepared from the green Rhea, 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

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.

with dried stems in preference to green stems.

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 Rhea 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 Rhea 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 Rhea from the dried stems seems thus to be intimately connected with the problem already indicated,—how to produce cheap Rhea in large quantities.

Possible disadvantage of dealing with the dried stems.

59. Against the preparation of fibe from the dried stems stands first the possibly higher quality in the Rhea 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 likewse doubtful whether any fibre can be prepared from the dried stems of as hgh immediate value as the hand-prepared China grass. But inferior value in his first stage need not necessarily bring with it inferior value of the final cleand 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 anc thickness than can be afforded with the small quantities which would have o be cut from day to day to supply a machine working oa the green. Theefore, 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, wil 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 hea. 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 night 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 sufficien grounds for deciding which are really superior to others, and that there are grunds 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 nvestigating, 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 treatmeat of the full-grown stems, others for the fine stems; the one producing Rhea for cordage purposes, the other Rhea 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 Rhea 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 Rhea 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 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 Rhea 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, repeated 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 Rhea 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 high-pressure steam 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 Rhea 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 Rhea 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.

There are, however, great advantages in having a smaller preliminary trial in Midsummer; at any rate, for machines operating on the dry stems. A certain amount of dry Rhea stems is available for this purpose. In the case of trials with such a difficult and little known fibre as Rhea, it is natural to expect that a first series of trials will be useful mainly in suggesting further improvements in

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the machinery, rather than in deciding the whole question at once. Dealing even with such a well-known fibre as cotton, it was found during the progress of the cotton gin trials at Manchester that a first series of trials gave at once an impetus to further modifications in the cotton cleaning machinery, which was subsequently tested in the second and third series of trials, and which showed the considerable progress effected in the construction of the machinery consequent upon the experience gained during the progress of the trials. The same thing is even more likely to occur in the case of Rhea. As regards dried stems, it is quite possible to carry out a real preliminary trial on a small scale at the time indicated, whilst, in the meantime, arrangements could be made for the distribution of a certain quantity of green stems preliminary to the final trials at the end of October next.

Experiments to be carried out in India.

66. The mechanical portion of the problem of preparing Rhea 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 best methods of growing Rhea 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 Rhea. 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 in the Government despatch of 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.

J. Forbes Watson.

India Office,
May 1875.

An appendix will follow in the copies about to be forwarded for distribution —

Statistics and Commerce.
No 10.

No 57. dated 24th June, 1875.

India Office,
London, 24th June, 1875.

18/1179

Sir,

I transmit, for the information of Your Excellency, a copy of a despatch which has been addressed to the Government of India, on the subject of the testing of machinery for the extraction of Rhea fibre. Fifty copies of the printed memorandum therein mentioned will be forwarded to your Government.

I have the honor to be,
Sir,
Your most obedient,
humble Servant
Salisbury

His Excellency
The Honorable,
The Governor in Council,
Fort St. George.

WHB.

Reg'd Dec

No 7.

Statistics & Commerce
24th June 1875.

The
Letter to Dr K. St George
No. 10.

Rec. 23d July/75

No 1179

Ordered to be communicated to the Board of Revenue, Chamber of Commerce and Agri Horticultural Society Madras

5 August/75.

1 To the Board of Rev with Thirty Copies of Dr Forbes Watts Memorandum
1 Ch. of Chamber of Commerce with four do
1 The Agri Horticultural Society Madras with four do

Transmitting copy of a Despatch addressed to the Govt of India on the subject of the testing of machinery for the extraction of Rhea fibre; and intimating that 50 copies of the printed Memo therein mentioned will be forwarded.

No 1179. 5th August 1875.

With Order