

FIBRE.

KAPOK.

A SURVEY OF ITS PRODUCTION WITHIN THE EMPIRE, WITH NOTES ON ITS CULTIVATION AND USES.

The fine, cotton-like fibre known as kapok is now familiar to everyone from its wide-spread use as a stuffing material in upholstery. The tree which produces it occurs in all the tropical parts of the British Empire, but practically the entire commercial supply of the fibre is obtained from Java. Efforts have been made at different times to start an export trade in kapok from various British countries, but hitherto the only success obtained, and that on a relatively small scale, has been in Ceylon. The Agricultural Department in Malaya has recently taken up the matter energetically, and there seems every reason to expect that commercial supplies will eventually become available from that country. India exports a certain amount of floss under the name kapok, but this, as will be shown later, is principally derived from a different tree from that furnishing Java kapok and is inferior to the latter in quality. Among foreign countries, other than Java, there is a small export of true kapok from the Philippines and Indo-China. In these countries, and also in Siam, the extended cultivation of the tree is being advocated. A certain amount of floss, of diverse origin, is also shipped from South America.

In view of the interest at present being shown in the material, it has been considered opportune to publish the present article dealing with the prospects of kapok production within the Empire, whilst for the benefit of those desiring to grow the tree for the production of the fibre, information has been given as to methods of cultivation and preparation. Specimens of kapok produced in many countries of the Empire may be inspected at the Imperial Institute by those interested.

As indicating the existing demand for kapok, it may be mentioned that in 1924, Java and Madura exported over 15,000 tons, of a total value exceeding 1½ million pounds sterling. Of this quantity nearly 8,000 tons was shipped to the United States; the Netherlands and Australia each took about 3,000 tons and New Zealand and the United Kingdom 500 and 400 tons respectively. There was also in that year an export of about 1,000 tons from the Outer Possessions of the Dutch East Indies, the bulk of which was consigned to the Netherlands. The imports of Kapok into the United Kingdom during recent years are shown in the following table:—

From	1922		1923		£	
	Tons	£	Tons	£	Tons	1924
India	355	24,578	566	52,486	333	31,783
Other British Possessions	103	7,544	95	10,521	108	9,174
Netherlands	78	7,911	30	3,421	53	7,173
Java	362	36,826	558	69,608	358	44,235
Indo-China	—	32	—	—	113	12,616
Other Foreign Countries	5	470	90	4,697	36	2,617
Total Imports	903	77,361	1,339	140,733	1,001	107,598
Total retained in the United Kingdom	711	58,954	1,113	115,839	690	74,505

The quantities of Indian kapok retained in this country during the three years were 256; 449 and 250 tons, respectively. The corresponding figures for Java kapok were 302; 473 and 288 tons.

In considering the question of extending the production of kapok within the Empire, it is important to bear in mind the possible effect on prices of a large increase in the supplies. In this connection the Imperial Institute is informed by a large firm of kapok merchants that the demand for kapok is increasing, especially in the United States and in certain of the British Dominions, and is likely to continue to do so. They consider that it would be desirable to further the production of the floss within the Empire. Similar views were expressed by an important firm of kapok brokers. As regards the United States it has been stated that mattress manufacturers in that country cannot "boom" kapok, owing to the difficulty of obtaining supplies. On the whole, therefore, it seems probable that, provided properly prepared material equal to or approaching the Java product in quality can be supplied within the Empire, there should be no difficulty in finding a market for it at good prices.

Before the war the market price of Java kapok in London was about 7d. to 9d. per lb. Towards the close of the war the price had risen to as much as 1s. 9d. It has since fallen somewhat and prime Java kapok is now quoted at 1s. 3½d. per lb.

Sources and Uses of Kapok.

In a large number of plants belonging to widely different families the ripe fruits contain a mass of fine hairs, sometimes attached to the seeds, as in the case of cotton, or arising from the wall of the capsule, as in kapok. These hairs are intended by nature to aid in the distribution of the seeds, but man has adopted them in some cases for his own use. In the most notable of these, cotton, it has been possible by hybridisation, selection and suitable cultivation to produce material which in length, colour, yield and other properties shows a vast improvement over the wild forms. The group of fibres to which kapok belongs, known collectively as flosses or silk-cottons, are usually finer than cotton and exhibit a greater lustre, but they are much weaker than cotton and lack the twist which enables the latter to be spun. Their use, therefore, has hitherto been restricted and apart from the careful cultivation and preparation of true kapok little has been done to improve their quality.

The term "kapok" has been used for the product of a number of trees, but it should be restricted to the floss of *Eriodendron anfractuosum* (*E. orientale*, *Ceiba pentandra*), the source of Java kapok. This tree, which belongs to the natural order Bombacaceae, reaches a great size under natural conditions, but in cultivation is usually seen as a slender tree not exceeding 50 feet in height. It has a very characteristic appearance, producing horizontal branches arranged in tiers. It sheds its leaves in the dry season; the flowers appear just before or at the same time as the new leaves. The fruit is a more or less oblong capsule or pod, about 6 in. long and 2 in. in diameter at its greatest width. As already mentioned the hairs spring from the inner wall of the capsule and are not attached to the seed itself, as in the case of cotton. This is of some importance in connection with the commercial

preparation of the floss, as it renders the separation of the seed much more easy, the hairs not having to be forcibly removed from the seed as is necessary in the ginning of cotton.

Flosses allied to true kapok are yielded by many other plants of the Bombacaceae, the chief of which are species of *Bombax*. The floss exported from India is mainly derived from *B. malabaricum*, and this, when properly prepared, is of good quality, but is not so resilient as good Java kapok. Several species of the genus occur in West Africa, where their floss is used locally, the chief of these, perhaps, being *B. buonopozense*. Other members of the family yielding flosses include *B. Ceiba* and *Chorisia* spp. of South America, *Eriodendron Samauma* of Brazil and *Ochroma Lagopus* of tropical America and the West Indies. Amongst other plants producing silk cottons may be mentioned species of *Asclepias*, *Calotropis gigantea*, *C. procera* and *Gomphocarpus brasiliensis* belonging to the Asclepiadaceae, *Cochlospermum*, *Gossypium* (Bixaceae) and the West African rubber tree, *Funtumia elastica* (Apocynaceae). All these flosses are inferior to true kapok and are unlikely to compete with it in European markets.

The hairs of kapok are cylindrical, from 0.6 to 1.2 in. in length, with very thin cell walls. The cells are full of air and are very light; they also possess the property of being impermeable to moisture, and on this account are extremely buoyant. For this reason kapok is now used throughout the world for the manufacture of buoys, life-belts and life-saving jackets.

The chief use for kapok is for stuffing cushions, pillows, mattresses and similar articles. It is well adapted for this purpose on account of its lightness, its springy or resilient nature and its non-hygroscopic and non-absorbent characters. It is in their resiliency that most other flosses are inferior to kapok and therefore of less value for stuffing purposes.

Many attempts have been made to employ kapok as a textile material, but considerable difficulty has been experienced due chiefly to the fact that the fibres have a smooth, slippery surface and, therefore, lack cohesive force. Moreover, kapok is very weak, and yarns made from it are not strong enough for use where any strain is likely to occur. It is stated that the difficulty of spinning the fibre has been surmounted by roughening the surface by chemical treatment, and so enabling it to exert the necessary grip. By a special arrangement and adaptation of the spinning machinery the roughened fibres can be spun either alone or in admixture with cotton. The yarns so produced are said to be suitable for the manufacture of plushes, lace and other materials. Kapok textiles cannot possess such good wearing properties as those made of cotton, but owing to their non-conducting character they might find a special use as an interlining in warm clothing.

Kapok Seed.

In the course of preparing kapok for the market large quantities of seed are obtained. The seed is rich in oil, and in many countries where the floss is prepared for local use the oil is expressed from the seeds and employed for cooking and other purposes. In the Dutch East Indies the seed now forms an important source of revenue; in 1924 about 14,000 tons, valued at £ 97,500, were exported from Java and Madura, of which all but 1,000 tons were consigned to the United Kingdom.

Samples of kapok seed from Travancore, the Federated Malay States, Gold Coast and Zanzibar have been examined at the Imperial Institute. The results are shown in the following table which includes for comparison the figures for Java kapok seed and oil and for cotton seed and oil.

	Kapok Seed and Oil					Cotton Seed and Oil	
	Travancore	Federated Malay States		Gold Coast	Zanzibar	Usual Range	
<i>Seed.</i>		1.	11.			Usual Range	
Moisture <i>per cent.</i>	11·4	13·8	12·9	13·2	12·7	—	—
Yield of oil <i>per cent.</i>	24·3	20·0	18·8	24·7	21·0	22-25	20-24
Yield of oil (moisture-free seeds) <i>per cent.</i>	27·4	23·2	21·6	28·4	24·0	—	—
<i>Oil.</i>							
Specific gravity at 15°/15° C.	0·9217	—	—	0·9226	0·914	0·921-0·933	0·922-0·925
Acid value	30·9	54·1	61·0	6·1	26·0	variable	variable
Saponification value	192·2	—	—	193·5	194·2	189-195	192-195
Iodine value (Hub 1, 17 hours) <i>per cent.</i>	90·4	—	—	89·6	101·5	85-94	105-115
Unsaponifiable matter <i>per cent.</i>	1·2	—	—	—	—	—	0·8-1·8
Refractive index at 40° C.	1·463	—	—	—	—	1·4605-1·4657	1·4646-1·4653
Solidifying point of fatty acids	29·8° C.	—	—	—	—	27-32° C.	33-37° C.

It will be seen that in general characters the oil resembles cotton-seed oil. After refining it can be employed as an edible oil, and it is also suitable for soap-making and other purposes to which cotton-seed oil is applied. There is a steady market in the United Kingdom for kapok seed, and a small consignment received at the Imperial Institute from the Federated Malay States was sold in Liverpool in March, 1925, at the rate ruling for Java kapok seed, viz., £ 11 15s. per ton, c.i.f. As regards the marketing of the seed the Institute is informed that it is the custom in this country to allow 25 per cent. of damaged seed in a consignment without any reduction being made in the price, notwithstanding the fact that the seed obtained from kapok plantations in Java contains, as a rule, only a little over 4 per cent. of defective seed.

The residual cake, left after the expression of the oil, forms a fairly good feeding-stuff for live-stock; it is somewhat inferior to cotton-seed cake, and is believed to be used principally as an ingredient in compound feeding-

cakes. The composition of the meal obtained from Travancore seed at the Imperial Institute is shown in the following table, in comparison with commercial kapok-seed cake and undecorticated cotton-seed cake.

	Kapok meal from Travancore Seed		Commercial kapok-seed cake *	Undecorticated cotton-seed cake English make *
	As prepared at the Imperial Institute	Calculated to contain 7 per cent. of fat		
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Moisture	13·8	12·9	13·8	13·8
Crude proteins	32·7	30·6	26·2	24·6
Fat	0·5	7·0	7·5	6·5
Carbohydrates, etc. (by difference)	19·8	18·4	23·2	29·3
Crude fibre	26·8	25·1	23·2	21·2
Ash	6·4	6·0	6·1	4·6
Nutrient ratio	1:0·6	1:1·1	1:1·5	1:1·67
Food units	103	112	107	107

The cake is rich in constituents of manurial value, the percentage (expressed on dry matter) in the case of cake prepared in Indo-China being as follows (*Bull. Econ. Indo-china*, 1925, 28, No. 174, p. 459)—

Nitrogen	4·5
Phosphoric Acid (P ₂ O ₅)	1·6
Potash (K ₂ O)	1·5

Indian kapok seed (*Bombax malabaricum*) yields an oil similar to that obtained from true kapok seed, but of slightly better quality (see Bulletin of the Imperial Institute, 1920, 18, 335). The residual cake is rich in proteins and would form a more valuable feeding-stuff than kapok-seed cake.

Other By-Products.

The wood of the true kapok tree is light and soft and little used, even by the natives. It has been suggested that the wood might be suitable for paper-making, but experiments conducted some years ago by a firm of paper manufacturers in this country were not very satisfactory, and it was not considered that the production of pulp from the material would be a commercial success. More recent experiments in France showed that the wood yields 30 per cent. of bleached pulp (expressed on the dry material), which furnishes a paper of ordinary quality (*cf.* Bulletin of the Imperial Institute, 1924, 22, 501).

The young leaves and the roots are used in native medicine, whilst the bark contains a reddish-coloured fibre sometimes used by the natives for tying purposes.

* Smetham, *Journ. Roy. Lancs. Agric. Soc.*, 1914.

Production of Kapok in the Empire.

Asia.

True kapok grows in the hot moist tracts of Western and South India and in Burma, but it is nowhere systematically planted. The internal trade in the floss is stated to have developed considerably, but the quantity shipped is small, most of the so-called kapok exported from India consisting, as already mentioned, principally of the floss of *Bombax malabaricum*. So far as can be judged from material examined at the Imperial Institute, the true kapok produced in India is of good quality. A sample from Madras examined in 1906 was considered by brokers to be fully equal to good Java kapok (see Bulletin of the Imperial Institute, 1909, 7, 13), and a sample from Travancore recently received at the Institute was also favourably reported on.

The exports of Indian kapok, chiefly from Bengal and Bombay, in 1923-4 amounted to 1,692 tons, of total value of £ 136,000. Of this quantity 443 tons were shipped to the United Kingdom, 277 tons to the Netherlands, 210 tons to Germany, 196 tons to France, 140 tons to Italy, 110 tons to the United States and 73 tons to Australia.

Two grades of Indian kapok are recognised on the London market, viz., Calcutta and Bombay. Double-cleaned Calcutta kapok was recently quoted at 1s. to 1s. 0½d. per lb., or 3d. less than prime Java.

Eriodendron is a common tree in Ceylon and is widely distributed. It grows from sea-level to 2,500 feet or more, but gives the best results at low and intermediate elevations. It is planted in village gardens and on some estates as a boundary tree. There is a small export of kapok from the island, the quantity in recent years amounting to about 300 tons, most of which has been consigned to the Netherlands. The quality is usually intermediate between Indian and Java kapok.

In parts of Malaya the kapok tree is grown in considerable numbers by the peasants, but hitherto little use has been made of the product except for domestic purposes. The Agricultural Department have recently made an exhaustive study of the possibility of establishing an export trade and have initiated a scheme for collecting the pods from existing trees and selling the floss and seed. Further, they definitely assert that Malaya is suitable for the profitable production of kapok under plantation conditions (*Malayan Agric. Journal*, 1923, 11, 1).

It is estimated that at the present time there are about 100,000 trees in Malaya, of which 7,500 are in Selangor (mainly in Kuala Selangor); 3,800 are scattered in Pahang; 62,000 are in Perak (of which 40,000 are near Perak River and 20,000 in Krian); 7,000 are scattered in Malacca; and 6,100 are in Penang (4,000 of which are in Balik Pulau). Of the trees now in bearing nearly three-quarters are to be found in the four definite workable areas mentioned in brackets above. It is in these districts that endeavours will be made to teach the Malays to harvest the pods and prepare the floss for the market. Collecting centres will be established at which kapok brought in by the natives will be purchased for cash. In certain districts arrangements have already been made, under European management, for the purchase of kapok and its preparation for the market.

Kapok of fairly good quality has been produced in Mauritius, but, owing to the ravages of a beetle, the cultivation of the tree had to be given up. A sample of floss from trees grown at the Botanic Gardens, Pamplemousses, was examined at the Imperial Institute in 1906. It was slightly darker than ordinary Java kapok, more uneven in colour and somewhat inferior in lustre. Similar material would find a market in this country at prices a little below that of the Java product.

Africa.

The kapok tree reaches a very large size in the West African forests, being only exceeded by a few mahoganies. It occurs in all the British Colonies of West Africa and is found in both the evergreen and mixed deciduous forests. No systematic attempt seems to have been made to collect the floss, except in Togoland. Here kapok received special attention under the German regime and seed was distributed in large quantities to the natives. The tree occurs throughout the whole of the Mangu-Jendi District in Northern Togoland, part of which is now included within the British sphere, but it is considered that the establishment of any extensive export trade from this district would have to await the provision of railway transport. Before the war there was a small export from Togoland, 9 tons being shipped in 1913. This is stated to have been derived mainly from wild trees. A small bale of kapok from Togoland was received at the Imperial Institute from the Chief Commissioner, Northern Territories, Gold Coast, in 1916. It was similar in all respects to the kapok of commerce and was sold at a satisfactory price, considering the small quantity available (see Bulletin of the Imperial Institute, 1917, 15, 19). It would certainly be worth while to encourage the natives to collect and clean the material for export, both in this district and in other parts of British West Africa. It will be necessary, however, to insist on the systematic picking of the pods in order to maintain the quality of the floss, and not to allow the natives merely to gather the fallen pods, as they at present do for their own use. The results of examination of material received in recent years at the Institute from the Gold Coast and Gambia indicate that kapok of good quality could be produced in those countries if due care were taken in the preparation.

In East Africa the systematic cultivation of kapok has been undertaken in Tanganyika. Before the war the industry was increasing, the area under cultivation in 1910, 1911 and 1912 being 1,735, 3,458 and 6,580 acres respectively, and the exports in those years being 12, 28 and 52 tons. No information appears to be available as to the present area under kapok in the Territory, but it has been stated that the plantations suffered damage by elephants, both during and since the war. There are signs, however, that the industry is reviving, and during the four years ending 1924, quantities of 6, 30, 32 and 52 tons respectively were exported. The local Department of Agriculture do not seem to favour any extension of the cultivation, as the kapok trees are liable to harbour insect pests which may spread to the cotton-fields.

Kapok is stated to grow well in the coastal region of Kenya, and it is planted commonly as a boundary tree in Zanzibar. Floss produced in Government plantations in the latter country is stated to have been exported to the United Kingdom.

The tree thrives well in the Sudan, and floss obtained from trees planted at Mongalla was examined at the Imperial Institute in 1917. It proved to be of excellent quality, and similar material, if produced in commercial quantity, should realise the market price of good Java kapok (see Bulletin of the Imperial Institute, 1917, 15, 19).

West Indies.

The kapok tree is found in most of the West Indian islands; one, at Nassau, Bahamas, has reached a very large size and is familiar to all visitors to that island. There seems little hope, however, of the floss from existing trees in the West Indies being collected for export, owing to their very scattered distribution. Moreover, it is unlikely that the tree will be planted specially for the production of floss, on account of its harbouring a cotton stainer; indeed, for this reason it has been made compulsory in St. Vincent that all kapok trees should be destroyed.

An attempt was made some years ago to introduce the cultivation of the tree into British Guiana, and a number of plants were raised for distribution; but no development appears to have been recorded.

Australasia.

The tropical parts of Australia seem suitable for the cultivation of kapok, and a few trees already exist round some of the towns in Northern Queensland. The Agricultural Department in Queensland have drawn attention to the possibility of producing the floss for the Australian market, at present supplied by Java, and point out that the tree can be grown practically along the whole of the Queensland coastal belt from Brisbane northwards. They suggest that the most profitable method in that area would probably be to plant the trees as wind-breaks or shade trees, rather than in the form of pure plantations.

In New Guinea, under the German regime, kapok trees were regularly planted for several years and the crop was collected and exported. The produce was of good quality and realised satisfactory prices, but the cultivation was stated to be unprofitable, chiefly on account of the high cost of transport, and was, therefore, abandoned.

The kapok tree is cultivated by natives in all parts of North Borneo, but the industry has made little progress, as the floss has mostly been shipped in the uncleaned state. The cleaned floss, however, is of excellent quality, and has been sold in the London market at the price of the best Java kapok. In 1919 a concession was granted to a London company giving them the sole right to export kapok from the territory, and in return they agreed to purchase at a fixed minimum price all kapok offered to them. The company also undertook to install cleaning machinery and to export a minimum quantity of cleaned floss per annum. In the event of the supply of kapok being insufficient the company will themselves undertake planting operations. During the first year (up to July 1920), the company had purchased from producers 38 tons of kapok, most of which was shipped to London, and small quantities have continued to be exported each year since.

Attention is also being devoted to kapok in Samoa. The tree grows practically wild throughout the islands, and is at present chiefly used as a wind-break in cacao plantations.

CULTIVATION.

Climate.

A suitable climate is the first essential to the successful cultivation of the kapok tree. Although found in a wild or semi-wild state from the sea-level up to an altitude of 3,000 or even 4,000 feet and more, the tree gives the best yield and quality of fibre when grown at elevations less than 1,500 feet above the sea. It will withstand slight frost, but low temperatures hinder the growth of the tree and the development of the fibre, and from a commercial point of view cultivation should be attempted only in the tropics or in certain parts of semi-tropical countries. As regards rainfall, the tree flourishes under a wide range of conditions. It reaches its greatest size in the tropical rain forests of West Africa, but at the same time, owing to its deciduous habit, it can resist long periods of drought. The ideal conditions are abundant rain during the growing season and a dry period from the time the flowers are setting until the pods are harvested. As in the case of cotton, a long spell of wet or even damp weather during the later stages of pod formation will greatly reduce the quality of the fibre.

The quick-growing branches are easily broken or damaged by high winds, and exposed situations should therefore be avoided in fixing the site of plantations.

Soil.

A well-drained soil is necessary for the proper growth of kapok. It flourishes well on a deep, porous, sandy loam, such as is frequently found on alluvial flats along streams, but the finest kinds of Java kapok are produced on well-weathered volcanic soil. It is not always advisable to plant the better land exclusively with kapok, since this can often be more profitably used for other crops. Nevertheless, a soil of fairly high fertility is required since the returns from kapok are relatively low, and a high yield is therefore essential.

Land infested with white ants should not be used for kapok since the tree is very susceptible to the attack of these insects.

Propagation.

The tree is easily propagated from either seed or cuttings. The merits of the two methods have been a matter of dispute. Plants raised from cuttings come into bearing somewhat earlier, but, on the whole, the general opinion is in favour of propagation by seed. Advantages of the latter method are that a deep-growing tap-root develops which renders the plant less liable to be uprooted by high winds, and the plants remain longer in bearing. Where a form notable for its high yield or other specially favourable character is to be reproduced, cuttings should be employed.

Seed for sowing should, whenever possible, be specially obtained from the largest pods of old high-yielding trees, instead of using purchased seed of unknown parentage produced in the course of cleaning the floss. About 6 lb. of seed should be sufficient for planting up 100 acres. The seed is sown in nurseries, sometimes in rows 10 to 12 in. apart in raised beds, or, as recommended in the Philippines, in "hills" about 6 in. apart. The nursery must be carefully prepared, the soil manured beforehand, if poor, and kept well weeded. In dry weather watering may be necessary. As soon as the

seed has germinated, which takes only a few days, the seedlings are shaded until they are about 5 or 6 in. high, when they must be exposed to the sun. If the plants do not obtain plenty of sunshine they grow thin and lanky. At this stage the seedlings should be thinned out to 6 or 9 in. apart; when sown in hills only one seedling should be allowed to each hill. The young plants grow very quickly, and when from 6 to 12 months old they should be planted in their permanent quarters.

Owing to the readiness with which kapok cuttings take root, this method of propagation has hitherto been that most commonly used by the natives of Ceylon and the Philippines. The cutting, which should never be of the current year's growth, varies in size from about $\frac{3}{4}$ to 2 in. or more in diameter and from 18 in. to 6 feet or more in length. Experiments conducted in the Philippines with cuttings ranging in length from 1 to 10 feet and $\frac{1}{2}$ to 5 in. in diameter at the base, showed that the larger cuttings gave the best results, 100 per cent. of those 6 feet, or more in length and $3\frac{1}{2}$ in. or more in diameter striking root, as against from 15 to 70 per cent. in the case of the smaller cuttings. The cuttings should be inserted as soon as they are cut, about 12 to 18 in. deep according to their size, and this work should be done, if possible, at the beginning of the rainy season. The cuttings must be inserted in the place they are to occupy permanently.

Planting Out and After-cultivation.

In Java, and indeed in most countries where the natives cultivate kapok, the trees are most commonly planted irregularly, as boundary trees and fences, along the sides of roads, or with other trees in the gardens. It is from such indiscriminately planted trees that most of the kapok produced is still obtained. In Java the tree is sometimes planted between other crops, such as coffee, cacao, pepper and vanilla, whilst in the Philippines it has been suggested that fibre crops like maguey, sisal and Mauritius hemp, might be interplanted with kapok. The most suitable crop to be grown in this way will vary with local conditions, and from observations made in Malaya it is thought that roselle fibre, sunn hemp, tuba, limes and tobacco should prove successful. In quite recent years the practice has been commenced in Java and the Philippines of growing kapok as the sole plantation crop; but this method will probably only give profitable results where the conditions are specially favourable to the production of high yields.

When grown as the only crop in plantations the seedlings or cuttings should be placed about 18 feet apart, but in mixed plantations the distance will vary with the nature of the accompanying crops. The seedlings, when removed from the nursery, should be topped and all leaves removed. In lifting the plants, the roots must be damaged as little as possible, and planting out should be done immediately. If possible, transplanting should be performed during showery weather.

Little cultivation of the soil is required in kapok plantations. For a few months after planting the soil should be kept loose round the plants, and if kapok is the sole crop it is only necessary to keep the ground clean for a short distance from the tree to facilitate the collection of the pods. The remainder of the plantation is preferably planted with a leguminous cover crop, so that the cost of weeding is reduced to a minimum.

Harvesting and Yield.

Where, as in Java, the pods ripen during a dry season, they are often collected each day as they fall to the ground, but if rains are liable to occur during the harvesting period, the pods must be picked from the tree as they mature; otherwise the floss may suffer considerable damage. As the pods ripen their colour changes from a light green to a light brown and the surface, at first smooth, becomes somewhat wrinkled. It is at this stage, and before the pods open at the end, that they should be picked. It is no economy to harvest the whole crop at once, since this will result in a mixture of unripe, ripe and over-ripe pods, which will give a product of low value. The ease with which the branches break precludes the gathering of the pods from tall trees by climbing, and they are best gathered by means of knives or small hooks attached to long poles. The harvesting season usually extends over a period of about 3 months. The pods must be spread out on a dry floor in the sun to ripen thoroughly and the floss removed as soon as possible. If it is necessary to store the pods for a time, they must be thoroughly dried, so as to avoid fermentation and discolouration of the floss.

Kapok trees usually begin to bear after 3 or 4 years, but the yield at first is small. Seven-year old trees will yield 350 to 400 pods, and 10-year old trees 600 pods or more. The yield of cleaned floss from the pods varies somewhat, but on the average it may be taken that 100 pods furnish 1 lb. of cleaned floss. On this basis an acre planted with 132 trees (18 by 18 ft.) would yield about 800 lb. of floss.

Preparation of the Fibre.

Although machinery is now largely employed for cleaning kapok in Java, the initial process of opening the pods and removing the floss and seeds from the husk and core is always done by hand, chiefly by women and children. The subsequent separation of the floss from the seed is the most important process in its preparation. A common native method is to place a quantity of floss and seeds on a perforated platform and beat it with bamboo sticks, wielded in a horizontal direction, so that the seeds are loosened and fall through the holes in the platform. This is continued until the floss is beaten up into a snow-like mass. The top layer is then removed and given a further beating on another platform, when the floss is ready for baling. In an improved method, which has come into use in Java, the floss as it comes from the pods is placed in a bamboo basket or hollow cylinder with a perforated base, and the mass stirred up by a paddle-like arrangement revolved within it by means of a handle. These hand methods are only of use where kapok is produced on a comparatively small scale. On a large scale machine-cleaning is essential. Most of the machines hitherto employed consist of a horizontal chamber with a perforated bottom, in which the floss is beaten up by a series of blades revolving close to fixed blades on the sides of the chamber. The blades are so arranged that the floss moves along to the end of the chamber, where it is either blown out by fans or falls into receptacles. The Bley machine, invented by a Java planter, is claimed to be able to clean 217 kilos of floss per hour. This could only be used profitably on a very large scale. A smaller machine, of British manufacture, capable of cleaning 120 to 130 kilos of floss per day of 10 hours, has been used in the Philippines.

Kapok should always be graded carefully before baling for export. As a rule, four grades of cleaned Java kapok are recognised: (1) Superior or extra, containing less than 0.5 per cent. of seed; (2) prime, containing not more than 2 per cent. of seed; (3) fair average, with not more than $3\frac{1}{2}$ per cent. of seed; and (4) damaged.

Owing to the bulky nature of the material, the floss is pressed into bales for export. The pressure applied will depend on the size of the bale, but too much must be avoided, particularly with the finest quality, otherwise the elasticity of the fibre will be destroyed. Machine-cleaned, very dry fibre requires more pressure than hand-cleaned, but on the average the pressure should not exceed 140 lb. per sq. in. Thus a bale 2 ft. wide by 2 ft. long will require a pressure of 80,640 lb. The bales are generally packed in gunny cloth or matting and are bound with galvanised iron hoops, cane or fibre. The weight of the Java bales ranges from 80 to 120 lb. and the size from 8 to 16 cubic feet.

Pests and Diseases.

So far few insect pests and fungoid diseases have been recorded as causing any great damage to the kapok tree or floss. This may be due to the custom, most frequently followed at present, of growing the tree in isolated positions. If large plantations are made it will be necessary to keep careful observation to prevent the spread of harmful insects and diseases, just as is the case with other plantation crops.

In Malaya and certain other countries white ants are the most serious pests, especially to young plants, and the usual precautions against these insects must be taken. An insect (*Dysdercus cingulatus*) allied to the cotton stainer, sometimes attacks the pods, but the damage is said to be slight. A related species has also been reported on kapok in San Thome. It is sometimes considered inadvisable to grow kapok in the vicinity of cotton, owing to the danger of stainers spreading to the latter crop and, as already stated, in St. Vincent all kapok trees have to be destroyed. There is little risk, however, if the trees are properly tended and care is taken not to allow old pods to lie on the ground. In the Belgian Congo, kapok trees in the neighbourhood of cacao plantations are cut down, owing to the fact that they serve as host-plants for a serious cacao pest, *Sahlbergella singularis*. Caterpillars of several kinds of moths do a certain amount of damage, and one of them (*Mudaria variabilis*) in certain years has been known to destroy a large proportion of the crop in Java; in 1914, for example, it is recorded that 30 per cent. of the pods were attacked. The caterpillar feeds on the undeveloped fibre and seeds of the green pods, and even if any fibre should mature it is usually badly stained, whilst birds in their search for the caterpillars often complete the destruction of the pods. Other caterpillars bore into the stem and twigs, and some feed on the leaves. Boaring beetles of the genus *Batocera* also attack the tree, and one of them (*B. rubra*) is so partial to it in Mauritius that kapok cultivation has had to be given up in that island.

Bats, monkeys and squirrels sometimes do considerable damage by eating the green pods or growing shoots.

Among the worst enemies of kapok in Java and Malaya are parasitic flowering plants of the genus *Loranthus*, which send out suckers into the bast and wood of the tree and absorb the nutriment required by the growing shoot. In bad cases the whole tree becomes weakened by the loss of the necessary nourishment and great damage may thus be caused. The trouble is not difficult to control if the plantation is properly inspected at regular intervals and all parasites removed as soon as they make their appearance.

Among the few fungoid pests of kapok, pink disease (*Corticium salmonicolor*) has been known to attack the plant, and leaf spot (*Ramularia eriodendri*) and an unidentified disease causing bleeding at the base of the trunk have occasionally been reported.

Bibliography.

The following list includes the most important publications dealing with kapok issued in recent years. Most of them may be consulted in the library of the Imperial Institute, where further information is available regarding the various points dealt with in this article. Those marked with an asterisk have been largely consulted in compiling the notes on cultivation.

- Bley, G. E. J.—“ De Kapokcultuur op Java ” (Soerabaia, 1911).
- Crevost, C. and Lemarie, C.—“ Plantes et Produits Filamenteux et Textiles de l'Indochine. Ouatiers.” *Bull. Econ. Indochine* (1919, 22, No. 137, pp. 553-591).
- * Grist, D. H.—“ Kapok,” *Malayan Agric. Journal* (1923, II, 3-27).
- Houard, A.—“ L'exploitation du Kapok en Afrique occidentale française,” in Henry's “ Matieres Premieres Africaines,” Tome I, pp. 154-218. (Paris, 1918).
- * Mathieu, E.—“ Kapok.” A Lecture given at Kuala Kangsar, Aug. 16, 1922. (Singapore, 1922).
- * Saleemy, M. M.—“ The Kapok Industry.” Bull. No. 26 (revised ed.), *Philippine Bur. Agric.* (Manila, 1925).
- Schaefer, H.—“ Die Produktion von Kapok und dessen Stellung in der Weltwirtschaft.” *Beiheft zum Tropenpflanzer* (1925, 22, No. 1, pp. 1—54).
- Zimmermann, A.—“ Der Kapokbaum (*Ceiba pentandra*.” *Der Pflanzer* (1914, 10, 123-133).
- Warbung, O.—“ Baumwolle-Ersatzstoffe.” *Verhandlungen der Baumwolle-Kommission der Kol. Wiri. Kom.* (1911, No. 2, pp. 62-80).
- Bulletin of the Imperial Institute, Vol. XXIV, No. 1, 1926.

COTTON CULTIVATION AT EMBILIPITIYA.

Cotton cultivation was tried at Embilipitiya by the Department of Agriculture for the first time in 1923 under the supervision of the Agricultural Instructor, Godakawala, and 1½ acres were planted up with Cambodia variety of cotton.

Low jungle land was selected for cultivation upon where the soil was of a light loamy character, and work was started during the latter part of the year, and everything was ready for sowing of seed, which was done during the middle of October, 1923, seeds being planted 3 ft. by 2 ft. apart. During the early stages of planting there was a spell of dry weather, with the result that some trouble was experienced from field mice and squirrels; vacancies were then filled up, when the rains commenced; with the rains, weeds began to appear, making it necessary to keep them down. Weeding of the plots was done twice, and the weeds so collected were placed in rows so as to serve as a mulch during the dry months. It was also found to be very necessary to have proper drainage.

In November caterpillars were noticed on the young leaves, and this pest was checked at the outset by hand-picking, and also by the removal of the plants which were more severely attacked.

During the third week of February, 1924, *i.e.*, about 4 months after planting, the first picking commenced and continued until the following May; this plot gave a yield of 813 lb., the average being 542 lb. to the acre.

SECOND YEAR OF CULTIVATION.

The same plot was used for a second cultivation during August, 1924, when the area was prepared by uprooting the stumps of cotton plants, and the same procedure followed. The officer-in-charge encountered the same difficulties as in the previous year, *e.g.*, pests such as squirrels and field mice and the caterpillar: absence of rain was also a handicap. The second year's yield was poor in comparison, the total cotton gathered being 339 lb. being an average yield of 226 lb. to the acre.

THIRD YEAR OF CULTIVATION.

Once more the plot was planted upon with Cambodia cotton, operations commencing in August, 1925, the conditions being the same as during the previous two cultivations. The yield during this year was far in excess of the previous years, and as much as 1,354 lb. of cotton were collected from the plot of $1\frac{1}{2}$ acres cultivated, showing an average of 902 lb. to the acre which is greater than the average of 1924 and 1925 put together.

COTTON CULTIVATION BY VILLAGERS.

Encouraged by the success of these experiments village cultivators have undertaken cotton cultivation and applied for chenas, but only 6 were given lands on lease at the rate of 3 acres for each applicant, half of which was to be cultivated with cotton.

Instructions were obtained by the villagers from the Agricultural Instructor. Their endeavours may be said to have been successful as the 9 acres under cotton yielded 30 cwt.

The villagers' cotton crop was bought up by the Agricultural Instructor at the rate of Rs. 21 50 per cwt. All cotton was disposed of to the Spinning and Weaving Mills, Wellawatta, in terms of the undertaking they had given to purchase all cotton grown under the direction of the Department.

A. B. ATTYGALLE,
Agricultural Instructor,