Chapter 5 Fiber Plants and Their Cultivation

This document has so far mainly discussed fiber products. This chapter reviews fiber plants, which are raw materials, and summarizes the characteristics and the growing environment/cultivation environment needed to conduct sustainable economic activities. This chapter summarizes the use of fibers as general information, not limited to the scope Africa only.

In addition, the transition to cultivation of rattan as a commercially viable tree species, which is progressively being more and more over harvested, is examined.

5-1 Fiber plants of Africa

5-1-1 Bamboo; Gramineae

1) Bambusa vulgaris Schrad. (*Bambusa vulgaris* Schrad.)

This bamboo grows in areas from Southeast Asia to the Pacific islands and also has been introduced to Africa.

The stems are used as building materials and materials for other bamboo wares including vases, plates, strainers, screens, shakuhachi flutes, bows, bamboo swords, bamboo brooms, and bamboo rakes.

To propagate this bamboo, dig out a first-year underground shoot with a 40 cm to 50 cm in long stem attached, just before the appearance of bamboo shoots, and transplant it. Alternatively, cut a first or second year bamboo into sections (every 3 to 4 joints), insert only 1 to 2 joints into the ground or bury it horizontally about 20 cm deep. After planting, protect the plant from the sun and give it water. After new shoots appear, apply fertilizer, and cut off the stem after 4 to 5 years, leaving the young stems.

5-1-2 Sisal (*Avage sisalana* Perr. et. Engelm; Amaryllidaceae)

Sisal originated in the Yucatan Peninsula of Mexico. As sisal is also suitable for the climate of the savannah region of Africa, it is widely cultivated in East African countries such as Kenya and Tanzania for fiber production.

Fibers are extracted from the thick leaves of sisal to produce strings, ropes, bags, mats, brushes, and rough fabrics. The fibers are also used as raw materials for paper. Fibers need to be extracted from the leaves within 24 hours after they are collected. Fibers that are produced through a fiber processor are dried under the sun and are used as materials for various products after being bleached white. The sap produced from the cut section of a scape is sweet and alcohol (Pluque) is produced by fermenting.

For the propagation of sisal, a bulbil that grows at the tip of a scape or a suction bud that grows from the side of the stem is used. The plant prefers a mild dry climate with an average annual temperature of 23°C or higher and an annual rainfall of 1000 mm or less. It grows in most soils, however, it grows particularly well in an alkaline soil. Bubils and suction buds are kept in a nursery garden for about one

year and then are transplanted into a garden. Crops can be harvested four years after the plants are settled and harvesting is possible for up to 10 years.

5-1-3 Palms: Palmae

1) Rattan (*Calamus rotang* L.)

In English, it is called Common rattan palm or Cane palm. The photograph shown here is one of the typical species. Rattan originated in Tropical Asia in countries such as Bengal, Assam, Sri Lanka, and Malaysia and it is also widely distributed over the tropical zones of Australia and Africa.

The generally thin stem grows up to several tens of meters and attaches itself to other objects with hooks in the same manner as vines. Some long stems reach up to 100 m to 200 m. The stems are torn up or skinned and used for making walking sticks and baskets, or furniture such as chairs and beds. The trees are sometimes planted in gardens and pots as ornamental trees.

In general, wild plants are used and the plants are hardly ever cultivated. Growing from seeds may be a suitable means of propagation. The wisteria family requires lots of sunlight, as insufficient sunlight inhibits the growth. In the jungle, rattan is maintained at a length of up to 30 cm. If it is exposed to sunlight after the top trees are cut down or fall down, it grows rapidly and thrives in the forest, covering the canopy. The stems, which grow up to substantial lengths without branching out, are cut into 10 m pieces, left in the bush until the spiky sheaths are decomposed, and then transported for use.

2) African wild date palm (*Phoenix reclinata* Jacq.)

African wild date palm is a typical palm plant that grows naturally in Tropical Africa and has spread from Tropical Africa to South Africa.

In the production region, leaf fibers are used as the material for fabrics (rabane), bags, and weaving. Alcohol is produced by cutting the flower ears at the middle and collecting the sap.

In general, fibers are collected from wild plants and the plants are not cultivated. For propagation, growing from seeds is suitable. Since it also branches out, the plant may be propagated by inserting a suction bud. Transplantation is not difficult and the plant has high environmental adaptability.

3) Raffia palm (*Raphia ruffia* (Jacq.) Mart.)

Raffia palm originated in the Equatorial regions of East Africa and Madagascar and currently spreads in the swamps and riverbanks of these regions. Raffia palm is a single-trunk palm plant reaching a height

of 2 m to 10 m.

The plant is mainly used for its fibers. The fiber (raffia fiber) collected from the surface skin at the back of the young pinna is flat, soft, strong, and does not stretch or shrink easily. The fibers are used as materials for fabrics (rabane), bags, and weaving (hats, baskets, etc.). The plant is imported to Japan also as a binder for grafting and induction and also as a raw material for paper. The scaly skin of the fruit is used as a craft material. The sap produced from the penduncle is used for sweetened beverages (harafa) and alcohol.

Recently, cultivation of raffia palm is under experimentation; however, in general, wild palms are used. Since the palm forms a single trunk, growing from seeds is a suitable means of propagation. Germination takes several days after the seeds are planted and the germination rate is low. Since the root area must be kept moist, a high moisture retention soil is suitable and sandy soil is unsuitable. The growing temperature is 15°C or higher.

A related species, Wine raffia-palm (Bamboo palm, *R. vinifera* Bauv.), originated in Nigeria and grows wild in the coastal region of Tropical West Africa. The stem is shorter than *R. ruffia*, however, the leaf stem is longer. The leaf fiber (piassaba fiber) is used for industrial art and handicraft products, as is the raffia palm. The hard vegetable ivory is used as the material for buttons. As alcohol (toddy and bourbon) is produced using the sap collected from the shank of the flower ear, the palm is also called wine-raffia palm.

4) Fan palm (palmyra palm, *Borassus flabellifer*)

Fan palm that originated in Tropical Africa is cultivated in India, Sri Lanka, Myanmar, Malaysia, and Thailand.

The leaves are used for the raw material for paper, roofing material, mats, baskets, ladles, and ethnic musical instruments. Fibers are collected from the leaf stems also. The timbers are used as building materials and decoration materials (the timber is hard and insect-resistant). Fibers are collected from the inside of the timber also. Fibers are also collected from the exterior skins of nuts. The sweet sap, which is produced from the cut section of the flower ear, is used for making sugar, alcohol, and vinegar. The core of a young bud is used in soup and palmito salad.

In general, the plant is propagated from seeds and it takes about 10 years to bear any fruit. A related species is *B. aethiopum* Mart., which grows in Tropical West Africa. Although it is not clear if the plant is used for fibers, however, it is likely to be used as a similar plant. The fruit turns a yellow orange color when it ripens and is eaten raw. The albumen of an immature seed is also eaten raw.

5) Oil palm (*Elaeis guineensis* Jacq.)

Oil palm originated in Tropical Africa and is cultivated in tropical areas worldwide.

The leaves are used as materials for roof thatching and mats. For oil extraction, the palm is cultivated commercially on a large scale in the tropical zones worldwide.

Although many leaves sprout and grow, in general, about 40 to 50 leaves are kept and the remaining old leaves are removed. The plant is a monoecious plant; however, as the flowering timings of stamen and pistil do not match, pollination within the same plant hardly ever occurs and pollination relies on insects or wind under natural conditions. Normally, in commercial cultivation, artificial pollination is applied. The seeds have a latent period and it takes three to six months or more for the seeds to germinate under natural conditions so that germination occurs unevenly. The desirable cultivation environment is an average annual temperature of 24°C to 30°C, rainfall of about 3000 mm, sunny, and well-drained rich soil.

6) Coconut palm (*Cocos nucifera* L.)

Coconut palms grow in tropical seashore areas worldwide.

Fibers (coir) of the seed vessel of the fruit are used for ropes, scrubbing pads, and coir yarns. The fibers are light and strong, and to collect high quality fibers, fruits are harvested for use one month prior to full maturity. The shells of the inner seed vessels are processed for containers, buttons, and figurines as well as fuel and palm shell activated coal. The activated coal is also popular for use in factories due to its high gas absorbability. It is also used for refrigerator air fresheners. Rice is cooked by wrapping it with a basket of undeveloped leaves, and dried young leaves are used for mats and baskets. Matured leaves are used as the material for thatching. The trunks have a high water-proof feature and are used for posts and bridge piers. By chipping the hard material, in particular, the dense outer section, various cooking utensils and figurines are produced.

For cultivation, in general a fruit (seed) is collected from the plant that bears high-quality fruits and the seeds are used for propagation. Seeds are planted sideways in a nursery field. The seeds germinate in around one month from micropyles without having any latent period, and take root in about 40 days. The plants are settled in the main field in around 10 months. The planting interval is 9 m to 10 m. The palm bears fruit after three years. The maximum commercially viable tree age is about 50 years. The palm prefers alluvial soil with rich organic matter and lime. It requires an average annual temperature of 20°C or higher. It requires rainfall of 1500 mm to 2000 mm and prefers conditions of strong sunlight and the seashore, estuaries, and riversides with a constant gentle breeze.

5-1-4 Cyperaceae

1) Jointed flatsedge (*Cyperus articulatus* L.)

Jointed flatsedge, which is a Cyperaceae plant, originated in Tropical Asia and grows in tropical areas worldwide, North and South America, Central and South America, Asia, Africa, and Australia. The perennial grass grows in freshwater wetlands such as swamps, lakes, and channels.

Dried stems are used as the materials for mats, and split stems are used for baskets and bags.

The plant can be propagated by division; however, in general, the ones that grow wildly in wetlands are used. A similar plant is Scirpus tabernaemontani (*Schoenoplectus lacustris* (L.) Palla subsp. *Validus* (Vahl) T. Koyama) of Cyperaceae.

2) Papyrus (*Cyperus papyrus* L.)

This famous plant known as papyrus originated in the areas from Egypt to Palestine and grows in wetlands and swamps in Tropical Africa, Middle and Near East, and Southern Europe.

In the era of ancient Egyptian culture, the stems were used for reed boats and fibers were used for paper. In general, the plant is used very widely and not only as the material for ropes and weaving. It is also used for walls, mats, baskets, simple houses, and fences for livestock barns.

Although papyrus is not artificially cultivated, the plants growing in swamplands are harvested, dried, and used. It can be propagated by division.

5-1-5 Trees

1) Baobab (*Adansonia digitata* L.): Bombacaceae

Baobab, which is a giant deciduous tree, originated in the savannah region of Tropical Central Africa and grows in Africa, Madagascar, India, Sri Lanka, and South America.

Fibers are collected by peeling off the bark and are used for bags and strings. The fruits are eaten raw and consumed as drinks. The young leaves are edible. The leaves are also used as medicine. Cooked seeds are used as food or medicine. The green fruit is used as floats for fishnets.

The tree is propagated from seeds. Propagation by cutting is also possible. Seeds germinate quickly soon after planting. The tree grows quickly. Baobab prefers a dry land with good sunlight and drainage in the subtropical and tropical zones.

2) Kapok (*Ceiba pentandara* (L.) Gaertn.); Bombacaceae

The origin of Kapok is unknown; however, the tall deciduous tree may have originated in Africa or tropical America. The tree mainly grows in those regions as well as the tropical regions of Asia and the islands of the Pacific Ocean.

Young fruits are used as food (vegetable) and seed oil is used as food or soap material. The fibers surrounding the seed are long and have high durability and resiliency. Kapok is used for cushions, pillows, mattresses, filling of chair cushions, soundproofing, insulation material, and raw cotton. By combining with other fibers such as cotton, the fibers are also used for silk cotton, velvet, rugs, lace, and felt hats. The timber, which is light and strong, is used for dugout canoes, furniture, wood carving dolls, and bodies of drums and violins. The fibers that are collected from the bark are used as materials for paper and ropes.

Kapok, which is cultivated in various areas of the tropical zone, prefers mild rich soil. Kapok prefers the areas with a definitive dry season and a rainy season with low rainfall during the harvesting period. Kapok is propagated using seeds or by cutting. The tree reaches a fruit bearing stage in five to six years. When the outer skin of a green fruit becomes brown and shows wrinkles, the crop is harvested and the fibers are extracted.

3) Bark cloth fig (*Ficus natalensis* Hochst.): Moraceae

The origin of bark cloth fig is assumed to be the South African region. This medium-height evergreen tree grows in wide areas of the tropical African region.

Bark fabrics are produced from this plant by peeling off the bark and the fabrics are used for religious garments and for wrapping dead bodies. Recently, the bark is also used as the material for bags and pouches. The body of the tree is used for shading and as a windbreak.

Propagation is achieved by cutting. Bark cloth fig is often used for producing fabrics by peeling the bark while using it as a mixed windbreak to protect the banana trees in banana plantations.

4) Kyenkyen (*Antiaris Africana* Hengl.): Moraceae

Kyenkyen originated in tropical Africa. The tall evergreen tree grows in the areas from Senegal to Sudan, and Nigeria, and areas from Cameroon to Tanzania.

Bark fabrics are produced from the bark tissues that are carefully peeled off. The timber is used for plywood boards as well as for interiors, boxes, and woodwork. The white yellowish timber is soft and does not have high durability or strength. In Africa, it is used for doors, benches, and the handles of daggers used by locals. The timber is useful for general joinery work.

Kyenkyen can be propagated from seeds. However, as it is a Moraceae plant, it can also be propagated by cutting.

The related family is Upastree (*A. toxicaria* Lesch.). Upastree is not originally from Africa and grows in

India, New Guinea, and Southern China. The tree exceeds 50 m in height. The bark is used for producing bark cloth, which is used as a fabric in the same way as Kyenkyen.

5-1-5 Gramineae herbs

1) Guineagrass (*Panicum maximum* Jacq.)

Guineagrass originated in Tropical Africa. Currently, Guineagrass is cultivated in the tropical and subtropical zones worldwide as feed crop and some escaped plants grow wildly. The perennial herb grows to a height of about 2 m.

The leaves and canes are dried and used for feed and fuel. Guineagrass is mostly cultivated as a feed crop. In Africa, the canes are used for weaving material. The entire grass is used in the same way as for leaves. Spikes with a long elliptical shape with a length of about 3.5 mm grow sparsely.

The plant is propagated from seeds, by division, and shallow planting of the stems. Guineagrass grows in open grass fields such as along rivers where tropical trees and shrubs grow. The grass field is maintained for a long time if it is a fertilized pasture. Guineagrass can be cultivated in bushes as it can be adapted to shady environments to some extent. Guineagrass can be adapted to a wide range of soils and has high adaptability to draining conditions and a change of fertile soils.

2) Elephantgrass (*Pennisetum purpureum* Schum.)

Elephantgrass originated in Tropical Africa and has been widely naturalized in North and South America, Australia, and South East Asia as a feed crop. The perennial grass grows up to 3 m in height.

The canes are dried and used as the materials for thatching, fencing, and weaving. The leaves are dried together with canes and are used for feed and fuel. The entire grass is cultivated as a feed crop as well as for soil erosion prevention of sloping lands and as a windbreak.

The grass propagates by division or planting stems that are cut into 3 to 4 joint units from the base section. Although the grass can be propagated from seeds, seed collection may be difficult as ear emergence occurs in warm places only. In warm places, once the grass is planted, it can be used as feed for five to six years.

Pearl millet (*P. typhoides* (Burm.f.) Stapf & Hubbard) that originated in Sudan is a related species. In Africa, this plant was used as an important staple together with Sorghum and the stems and leaves are used as feed and thatching material.

3) Sorghum (*Sorghum bicolor* Moench)

Sorghum originated in the savannah region called Sahel at the edge of the Southern side of the Sahara desert of Africa. This annual plant of 2 m high or more is cultivated in the areas from the temperate zone to the tropical zone worldwide as a staple food and for feed.

The seeds are used as food as sorghum flour and stems and leaves are generally dried and used for livestock feed as silage. In some developing countries, the dried stems and leaves are used for starting fires and for fibers.

The plant is propagated from seeds. Sorghum, which withstands dry weather, grows in most soil conditions; however, the plant grows better in the areas with a period of long sunlight. This is a short-day plant and in a long day of 14 hours or more, flower bud differential does not occur in most varieties. The optimum soil acidity is about pH 6; however, the plant endures alkaline soils. In a mild climate, seeds are generally planted in March, June, and October.

For hoki sorghum (*S. bicolor* Moench var. *hoki*), which is a related species, the fruit spikes that remain after the berry drops are used for the brush section of a broom. Sudan grass (*S. sudanense* (Piper) Stapf) is also used as a fiber material in Africa.

4) Vetiver (*Vetiveria zizanioides* Stapf)

Vetiver originated in India, Sri Lanka, and Myanmar and is cultivated in India, Myanmar, Sri Lanka, South East Asia, and the Seychelles. Vetiver also grows on the Gold Coast of Africa. Vetiver is a perennial plant of about 2 m in height and belongs to the Gramineae family.

The foliage is used as material for thatching and paper manufacturing. The plant is also used for producing rugs, chick blinds, mats, and fans. Vetiver oil is collected from the roots by distillation and is used for incense and perfumes, cosmetics, and soaps. Roots are also used as the filling for mats after being washed and dried. It is also used as insect deterrent incense for garments and for medicinal purposes. Oil extracted from seeds is used as a medicine. The grass is used for prevention of soil runoff or soil erosion of sloping farm fields.

Vetiver propagates by division. Propagation should be carried out in a rainy season. To improve root development, the above ground section should be cut occasionally. In tropical flat lands, the plant can be cut twice a year.

The related species is *V. nigritana* (Benth.) Stpf and is used in a similar way.

5) *Phragmites Karka* (Rez.) Trin.

It is assumed that Phragmites Karka originated in the Asian region and grows in wide areas from the temperate belt to India, Malaysia, and Australia. It is similar to reed; however, the perennial plant Gramineae grows larger. The cane diameter is about 2 cm.

The canes are dried and are used as the materials for reed blinds, reed screens, and baskets. The canes may be used as raw materials for manufacturing paper as pulp.

In general, the plant is not cultivated and it propagates by division.

Reedgrass (*P. communis* Trinius) and *P. Japonica* Steeud are related species.

5-1-6 Other herbaceous species

1) Kenaf (*Hibiscus cannabinus* L.); Malvaceae

Kenaf originated in Africa and grows wild mainly in the tropical zone and subtropical regions of Africa. Kenaf is also cultivated in tropical zones and subtropical regions worldwide as a fiber crop. Kenaf is a straight annual plant that grows to 2.5 m to 4 m in height.

The surface skins are peeled off from the stem and the fibers are used as the material for ropes, mats, and jute bags. Recently, the fibers are also used as the material for paper, electrical insulation, and filters. The fibers are also used as roofing material binding strings, harnesses, fishnets, and joint filling material for boats. Leaves are eaten as vegetables and the seeds, which contain about 20% of linoleic acid, are used as edible oil. The oil is also used as a lubricant, lamp oil, material for linoleum, paints, and varnish.

Kenaf propagates from seeds. Kenaf grows wild and is also cultivated in the tropical and subtropical zones. The suitable temperature for the growing period is 16°C to 27°C and an average rainfall of 500 mm to 750 mm. As Kenaf is a short-day plant, it is important to accelerate growth by nourishing under long hours of daylight until flowering. The plant does not require a special soil condition; however, cultivation in lowland swamps is not suitable as it has low moisture resistance. Seeds need to be planted in May to June. After the stem has grown sufficiently, the plant is removed and dried under the sunlight. The surface skins are peeled off after soaking them in water for 10 to 20 days, and the fibers are extracted.

2) Upland cotton (*Gossypium hirsutum* L.); Malvaceae

There are many species other than this species. Upland cotton is assumed to have originated in Central America or South America and the plant is cultivated in tropical and subtropical zones worldwide. This annual plant grows to 1 m to 15 m in height.

Flosses are removed from the seeds with a cotton-ginning machine and cottonseed oil is extracted from the seeds. The semi-dried cottonseed oil is also used as food. Flosses around the seeds are also used. The residue of the expressed oil is used as feed and fibers surrounding the seeds are widely use as fiber

materials.

Upland cotton propagates from seeds. Adequate rainfall is necessary during the growing period before flowering. After flowering, the plant is cultivated in the dry areas until harvesting or such an environment is selected for cultivation. The plant does not grow well in acidic soils. As Upland cotton can grow in areas of comparatively high saline concentration, it can be cultivated in reclaimed lands also.

A related species, *G. arboreum* L., which originated in India, is a woody plant and grows up to 4 m to 6 m in height. Some breeds diverged from the elementary species. *G. herbaceum* Oliver are assumed to have originated in the areas from Asia Minor (region enclosed by the Mediterranean Sea and Aegean Sea/Black Sea) to the Northern part of the Arabian peninsular. This plant is also called old world cotton and many breeds grow in areas from the Middle Near East to India and Africa. *G. barbadense* L., which originated in South America, is called new world cotton and is cultivated in Brazil, West Indies, and the East Coast of America. There are many other divergent species and breeds as they have been used for a long time and these species and breeds are widely cultivated as fiber crops.

5-1 Transformation from gathering from the wild to cultivation - Using rattan as an example

Rattan is a collective term for the palmae plants across 13 genera and about 550 species that spread[1] over tropical and subtropical regions of the old world centering around South East Asia, Southern China, Oceania, India, and Africa. About 20% of them are commercially viable. Tree species[2] that are classified as rattan normally have long joint intervals, are not self-reliant unlike other palmae plants, and grow by creeping around other trees. Rattan can be considered a vine plant of the palmae family[3].

Figure 5-2-1 General morphology of rattan: A. Old trunk that lost its leaf sheath, B. Young bud, C. Spiky leaf sheath, D. Runner in lash shape (sourced from Tropical Palms, FAO)

In Africa, four genera and 22 species are known and in Ghana, the following three genera and nine species are known. All of them grow in humid evergreen forests and semi-humid deciduous forests with comparatively high rainfall.

- *Calamus deërratus* G.Mann
- *Eremospatha dransfieldii* Sunderl.
- *Eremospatha hookeri* (G.Mann & H.Wendl.) H.Wendl.
- *Eremospatha laurentii* De Wild.
- *Eremospatha macrocarpa* H.Wendl.
- *Laccosperma acutiflorum* (Becc.) J.Dransf.
- *Laccosperma laeve* (G.Mann & H.Wendl.) Kuntze
- *Laccosperma opacum* Drude
- *Laccosperma secundiflorum* (P.Beauv.) Kuntze

Among those, *E. macrocarpa* (trunk diameter: 10 mm to 18 mm) and *L. secundiflorum* (trunk diameter

[1] In the new world, plants related to the Chamaedorea genus and the Desmoncus genus are known.

[2] As there are many species, rattan plants of many different morphologies and ecologies are available. In this section, rattan that is normally used is described in general terms.

[3] The plant climbs by clinging to a tree rather than coiling like other vines.

30 mm to 35 mm) have the highest commercial viability followed by *E. hookeri* and *C. deërrtaus*.

5-2-1 Transformation from gathering from the wild to cultivation

In many countries, rattan has traditionally been used as a secondary income source[4] such as for savings for unexpected expenses and has been regarded as a native forestry product that can be collected from forests, much like medical herbs and mushrooms[5]. In terms of criteria for growth, rattan is a very unique plant. In general, rattan is extremely susceptible to strong sunlight and dry conditions during the initial growth period and requires the environment conditions of sufficient shade such as a forest, and suitable amounts of humidity and water. As the plant is not self-reliant, it requires trees for its support and when it reaches the canopy, the plant transforms into a sun tree and grows rapidly. In other words, rattan requires a forest at every growing stage and cannot survive without a forest. Due to the recent transformation from forests to agricultural lands, and thus the reduction and deterioration of suitable habitation areas, the quantity has decreased. With the increase of the demand for rattan materials, shortage of the resource supply is accelerating. Under the circumstances, three measures can be suggested for securing materials and resources for the rattan industry; ① increase of rattan resources by appropriate management of native forests, ② introduction of cultivation, and ③ material importation.

1) The limits to gathering from the wild in natural forests

In general, rattan productivity is low in natural forests that are protected to some extent such as a protected forest area[6]. In terms of ecology, the productivity of rattan is basically high under a high light interception environment such as at the edge or in a gap of a forest, so that the two objectives of conservation of a dense primary forest and expansion of rattan resources are incompatible.

2) Necessity for cultivation

Transformation to cultivation cannot be avoided if the stable supply of products and materials is to be maintained in sufficient volumes. To realize this, it is necessary to promote rattan forestation in suitable cultivation areas and secure a resource increase of rattan and its products. Therefore, there needs to be a fundamental transformation of the mentalities of rattan producers and local residents from the present exploitation of forests to cultivation and harvesting. The Government should also implement some reinforcement measures as described later.

5-2-2 Actual conditions and issues of the rattan forestry industry

1) Propagation of and raising seedlings

In this section, mainly Asian precedents are discussed. Although some descriptions may not be applicable to specific plant species, the rattan forestation techniques are commonly applied in general.

In order to cultivate rattan, the first necessary steps are the collection of seeds and nursing of seedlings.

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[4] In some regions, the young buds are used as food.

[5] It is reported that in the areas where clear traditional ownership is available, selected harvesting has been exercised.

[6] In a region where the wild animals that assist rattan distribution are scarce, this tendency is more prominent.

Although tissue culture is being attempted, it is still a long way from commercial feasibility. A direct seeding is not recommended unless a large quantity of seeds can be secured due to the high probability of artisan pressure. Transplantation of natural seedlings is comparatively easy and is effective for farmers who carry out small-scale planting. However, the quantity that is secured is limited and it is necessary to ensure that the seedlings are definitely the right ones.

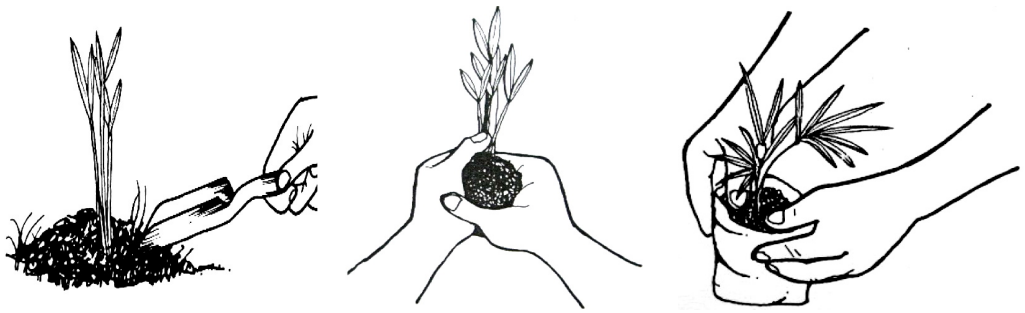

Figure 5-2-2 Method of raising natural seedlings (transplant the seedling to a pot while keeping the soil surrounding the root)

At the initial stage of raising seedlings, it may be difficult to secure the seeds. A sufficient quantity must be secured by collecting a small amount of seeds at a time and cultivating them. As rattan is a recalcitrant type of plant, the germination rate decreases quickly within one and half months and the seeds must be kept moist to avoid dryness during storage, long-term storage is not practical. Therefore, in principle, immediate planting is recommended and by closely watching the timing of flowering and fruit bearing, raising seedlings needs to be considered according to the timing.

Although no special seed processing is required other than thoroughly washing off and removing scale-patterned shells and flesh before planting the seeds, it is important that the seeds do not become dry during the period from collection to planting. Normally, the seeds are planted after thoroughly soaking in water (flowing water is desirable) for 24 to 28 hours. When the seed is fresh and very likely to germinate, it can be planted directly in a pot. However, it is recommended that planting beds be prepared to ensure germination. Plant each seed at a depth of 2 cm to 3 cm according to the size. As rattan seedlings are susceptible to dryness, the nursery field is often prepared in the middle of a forest such as a plantation. When preparing a nursery field in fallow land, it is important to provide an adequate sunshield constantly using palm leaves and so on. Germination occurs within 2 to 3 weeks. The germination rate is 70% to 80% for fresh seeds.

Photograph 5-2-1 Box of seedlings and transplanted seedlings (Seedling bed in a farm of East Kalimantan, Indonesia)

When a seed is germinated and the first leaf fully opens, the seedling is to be transplanted to a pot of a suitable size. After transplanting, rear the plant by providing a sufficient sunshield. A sunshield of 50% is assumed to be ideal for rearing rattan seedlings. Seedling rearing management is the same as that for normal plant species, except for ensuring sufficient moisture and prevention of dryness. As the seedlings are susceptible to dryness, it is safe to rear the seedlings in pots. When the pots cannot be obtained easily or the farmer directly plants seeds near the farmer's residence in a wet climate, seedlings can be reared as bare seedlings if the transportation period is short. In this case, divide the seedlings into the required quantity and transport them directly to the planting location keeping the roots surrounded by soil.

Photograph 5-2-2 Seedlings with soil attached

Cultivating comparatively larger rattan seedlings is recommended to increase the survival rate, prevent artisan pressure, and delay weeding. Therefore, the suitable pot size of the general tree species is 8 x 10 inches[7]. For a tree species with an extremely large trunk diameter, a pot of 16 x 20 inches that can be used for oil palms may be suitable. In any case, when the seedlings grow to 40 cm to 50 cm high, this is the suitable time for transplanting them to a larger space. Normally, it takes about 12 months for a seedling to reach this height. If seedlings are too small, the failure rate after planting becomes high. However, if small seedlings of 5 cm to 10 cm are preferable, it is possible to plant them. In this case, it is recommended to set a rearing period to match the suitable planting timing, which is the beginning of the rainy season.

Photograph 5-2-3 Rattan seedling cultivation state in the middle of the forest (Nursery for business in the Sabah State, Malaysia)

2) Rattan forestation model

As described above, rattan requires trees and adequate water and humidity in the forest floor for support, and an existing forest is required for its cultivation. The reason for most failures in rattan cultivation is the failure in securing the adequate water and humidity required for growing the plants due to the exposure to direct sunlight at the initial stage of cultivation. The following three practical patterns can be assumed for rattan forestation, although it depends on the condition of the existing forest of the target area.

- Planting using the edge of a primary forest
- Introduction by upgrading of secondary forest configuration
- Introduction into an artificial forest

Rattan is classified into three types descriptively based on the propagation morphology; a single trunk type, a bushy type, and a running bush type. Rattan with a large trunk of a single trunk type represented by *Clamaus manan* Miq. (Manau) of South East Asia is most difficult to conserve and propagate as it does not propagate by division. Only one plant grows from one seedling and its life ends if it suffers from insect damage or is harvested once. Such a tree species is under a highest risk of extinction and its

[7] Size in a flat state without spreading.

protection and cultivation must be implemented urgently. On the other hand, bushy type rattan, which is represented by *Calamus caesius* Blume. (Sega) and has multiple trunks, can be harvested many times and propagates by sprouting from a stump; these crops can be harvested continuously in three-year cycles. Running bush type rattan, which is represented by *Calamus trachycoleus* Becc. (Jahab/Irt) propagates most vigorously. However, this type of rattan is not grown in Africa. The forestation method such as rattan planning interval varies according to the morphology also.

(1) Planting using the edge of a primary forest

When the forest is conserved in good condition (assumed tree height is 15 m to 20 m or higher), approximately 10 m around the edge of the forest can be set as a rattan garden and rattan can be planted and cultivated by weeding the forest floor. Several weeding sessions may be necessary until the rattan reaches the upper layer to adjust to the amount of light interception at the suitable level.

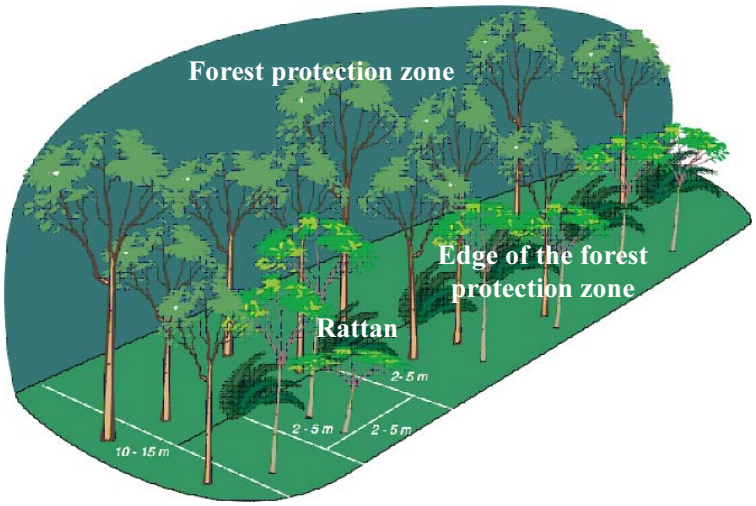

Figure 5-2-3 Example of rattan planting at the edge of a primary forest

(2) Introduction by upgrading of secondary forest configuration

For a primary forest that has been degraded by erosion due to excessive harvesting or transformation to an agricultural land, or a secondary forest after a certain fallow period or in a conservative state (assumed tree height of 10 m to 15 m), an open belt space is created inside of the forest, and rattan is planted after weeding. Creation of an open belt space is intended for work efficiency and if rattan is planted by an individual farmer or on a small scale, rattan can be planted in a gap in the forest or a degraded section at the edge of the forest. This way saves labor and achieves higher forest conservation effects.

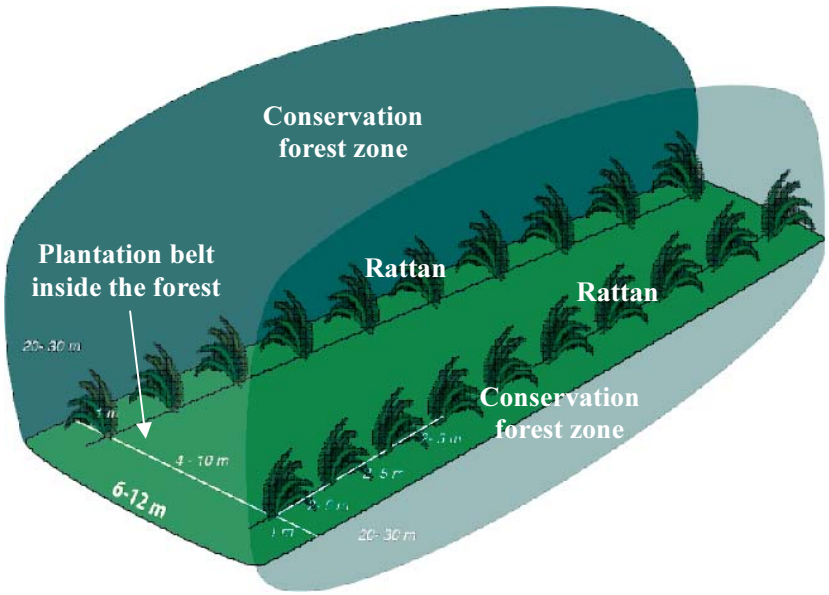

Figure 5-2-4 Example of rattan planting on the secondary forest configuration upgrading belt

Photograph 5-2-4 Planting belt by opening and preparing the inside of a secondary forest

Photograph 5-2-5 Suitable rattan planting area prepared using the gap inside the forest

As the economical value of the secondary forest itself such as this is generally low, the forest can be managed as a permanent rattan garden without harvesting its timbers.

(3) Introduction to an artificial forest

Rattan can be cultivated between established artificial forests. However, forests that have not reached the adequate height may be affected by rattan, suppressing the growth of the main forest, and damage suffered at the time of harvesting also needs to be taken into consideration. Therefore, introduction of rattan is restricted only for an established forest of a long-term-harvesting species or a low-value artificial forest. For instance, in Malaysia, rattan is introduced into rubber plantations whose values have decreased and rattan is managed and produced in the forest as a rattan garden. In this case, although the planting interval is restricted by the plantation that already exists, the recommended planting densities are 400 plants per hectare for the very large species and about 600 plants for the small species. A forest of young trees that still has a gap in the forest canopy is preferable for the growth of rattan rather than the inside of a dense forest.

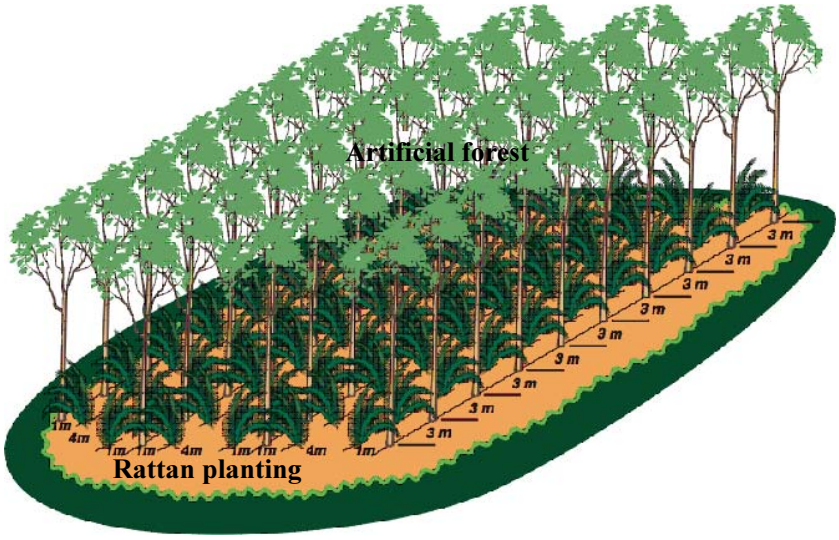

Figure 5-2-5 Example of rattan planting inside an artificial forest

Photograph 5-2-9 Planting rattan between forests of an abandoned rubber plantation (Sabah State, Malaysia)

4) Cultivation management

Covering must be provided to prevent the plants from drying during the initial stage. When the plants are planted at the edge of a forest, weeding is necessary to prevent artisan pressure. During the initial growth period, damage by wild animals such as rats and elephants that eat apical buds has been reported[8].

When the plant reaches the sufficient height (5 m or higher), the forest canopy must be exposed to the sunlight by gradual thinning. There are many cases where growth is compromised due to insufficient sunlight caused by neglect of thinning during the latter period of cultivation. The species of thin trunks can be harvested after seven to eight years and the normal species can be harvested after 10 to 15 years.

5-2-3 Measures for promoting the rattan forest industry and issues on the institution

In the promotion of the rattan forest industry, the improvement of the institutional framework is more important than the technical issues. As described previously, rattan requires a "forest" for its growth and it is difficult for it to grow in areas other than a forest. If forests need to be left undisturbed for conservation purposes, establishment of a rattan forest industry is difficult. To cultivate rattan, an intermediate area called a rattan garden, which is neither a pure native bush nor a field, must be secured. Therefore, a complex vantage point for actively cultivating resource-rich forests that foster forestry products while conserving existing forests is essential. For instance, in the Sabah State of Malaysia, which is known as the advanced rattan forest industry region, rattan was introduced into a large area by upgrading the forest configuration of the secondary forest in the nature reserve and large profits were successfully gained from the barely productive forest.

The issues to be examined here are the institutional matters such as ownership of the forest and the right of use. The essential issues for the community residents to implement such a rattan forest industry by using the existing forest region include the guarantee of the long-term right of use and the permission of

[8] In South East Asia, serious damage is caused by elephant beetles also.

forestry management for cultivation, such as the opening and thinning of the forest canopy, maintenance thinning, weeding, and product harvesting. Otherwise, although the residents can harvest rattan as a forestry product, they cannot actively cultivate and grow it. Comprehensive agreements and contracts that satisfy the above-mentioned cultivation conditions over the long term must be concluded between Government organizations and the local residents as the recognized users. The rattan forest industry will surely take root in the region if the Forestry Bureau and Forestry Government Corporation clearly position rattan cultivation as a livelihood improvement activity for the local community with the community participation type forestry management contract, prepare the necessary institutional framework, and support the production and planning guidance for seedlings.

For instance, the Government zones a 10 m swath around the edge of a forest reserve as a rattan garden, leases the rattan garden to the local residents, and provides guidance on cultivation methods. The residents acquire cash income from the cultivation and production of rattan. An institutional framework needs to be created that enables the establishment of such a cooperative relationship. As an example, the author believes that the distribution of the burden and profit as shown below is a reasonable contract for both the Forestry Bureau and the local residents.

Table 5-2-1 Example of a rattan cultivation contract between the Forestry Bureau and the residents

Forestry Bureau	Local residents
Long-term lease (15 years or longer) of the rattan garden forest	Compliance with the contract and obligation of conservation of the main forest
Permission for thinning/opening the forest canopy in a certain range, maintenance thinning, and weeding	Implementation of maintenance thinning and weeding and compliance with the usage range and purposes
Raising and providing rattan seedlings	Rattan planting and cultivation management
Permission for harvesting management	Harvesting and use of products

Once the high income from rattan cultivation becomes certain, the residents' focus must switch to forest conservation. This is because rattan cannot be harvested without the forest and thus no income can be obtained if this forest is not protected. In this way, release of a secondary forest or an edge of the forest to the local residents, permission for certain maintenance thinning, and establishment of an institutional framework that enables rattan cultivation all contribute to the policies for sustainable conservation of forests.

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