

The Potential of Illipe Nuts (*Shorea* spp.)
as an Agricultural Crop.

J.A.R. Anderson

Introduction. The term 'illipe' is derived from Tamil names for nuts of Bassia spp. (mainly B. longifolia) of the family Sapotaceae produced in South India (5). It was also applied to Mourak nuts (Bassia latifolia) from the same region, and later to other nuts with similar properties, and belonging to the same botanical family, from Sumatra. These included Palaquium oleosum and P. oblongifolium. Dilmy (8) mentions that two other species of Palaquium (P. walsurifolium and P. burckii) produced illipe nuts in Kalimantan (Indonesian Borneo). The term 'illipe' was unfortunately later applied to oil-bearing nuts with similar properties originating in Borneo, and to a much lesser extent in Sumatra, and derived from certain species of Shorea in the family Dipterocarpaceae.

This paper is concerned solely with illipe nuts produced by Shorea species. In recent years in South-East Asia the economic importance of these has completely superseded that of the 'true' illipe nuts derived from species of Sapotaceae.

Illipe nut species. The family Dipterocarpaceae is the main component of the rainforest of the region, and Shorea, the largest genus, produces some of the most valuable timbers. More than 150 species of Shorea occur in Borneo, with 124

in Sarawak alone (3). The genus is conveniently subdivided into four groups based on timber properties, particularly colour. This subdivision more or less corresponds to the botanical sub-division based mainly on flower characters and has wide acceptance. The groups are:

Balau (Bornean name Selangan batu) - Durable heavy hardwoods with dark brown timbers.

Yellow meranti)
White meranti) Mainly light or medium-weight
Red meranti) timbers distinguished on colour.

Illipe nut species mainly belong to the section, Pachycarpae, commonly called the 'Kawang', of the Red merantis, though one species, Shorea seminis (De Vr.) V.Sl., of local importance is a Balau. The vernacular name for illipe nut species in Kalimantan is Kawang or TengKawang, and the former name is also used in Sabah and Brunei; whilst in Sarawak the name is Engkabang.

The following list includes all illipe nut species and is divided into those of primary and secondary importance. Knowledge on the distribution of species in Indonesia, particularly in Kalimantan, is fragmentary and no great reliance should be placed on the notes for this region.

I. PRIMARY SPECIES

Red Merantis

- (1) Shorea macrophylla (De Vr.) Ashton (syn. Shorea

gysbertsiana Burck) Kawang jantung

North and central Borneo, becoming less frequent to the east (Sabah and Kalimantan Timor). Locally abundant on deep clay alluvium, and often riparian in this habitat.

Produces the largest illipe nut and is the most important species in Sarawak. It is estimated (7) that 85-90 per cent of the crop is derived from this species. Timber a Light Red Meranti (479 Kg/m³) (6). Cytology: chromosome count, $2n = 14$ (14).

(2) Shorea beccariana Burck Kawang langgai

Throughout northern Borneo, also widely distributed in Kalimantan.

Scattered, though locally frequent, at low altitude (below 600 m.) on clay ridges and steep hillsides. A medium-sized nut and only collected where trees occur in sufficient abundance. Timber a Light Red Meranti (642 Kg/m³) (6).

(3) Shorea amplexicaulis Ashton Kawang pinang lichen

Throughout northern Borneo to Tarakan in Kalimantan Timor, but apparently absent from southern half of Borneo.

Closely related to, and sometimes difficult to distinguish from, Shorea beccariana. It has a similar sized nut and is often found in the same habitat. Timber a Light Red Meranti (575 Kg/m³) (6).

- (4) Shorea pinanga Scheff. ^a Kwang Langgai bukit
Throughout Borneo, particularly on steep ridges at
medium altitude where it is a conspicuous tree.
Nut of medium size. Timber a Light Red Meranti
(529 Kg/m³) (6). Cytology: chromosone count, $2n = 14$
(14).
- (5) Shorea splendida (De. Vr.) Ashton (syn. Shorea
martiniana Scheff.) Kawang bintang or K. martin
Localized distribution in West Sarawak and Kalimantan
Barat. Closely related to Shorea ^{cr} manophylla, occurs
in the same habitat as that species, and produces a nut
smaller in size. Timber a Light Red Meranti, but speci-
fic gravity not known. Cytology: chromosone count,
 $2n = 14$ (14).
- (6) Shorea stenoptera Burck Kawang rusa
Distributed from Kalimantan Barat to the Saribas valley
in west central Sarawak.
Locally frequent on groundwater podsols in heath
forest, on terraces and plateaux and on periodically
flooded sandy alluvium; but absent from peat swamps.
A medium - to large sized nut. Timber a Light Red
Meranti (687 Kg/m³) (6). Cytology: chromosone count,
 $2n = 14$ (14).

- (7) Shorea macrantha Brandis Kawang bungkus
West Malaysia, west and central Sarawak and Kalimantan Barat.

Locally frequent on deep peats (5-10 m. plus) at inland margins of peat swamps and on poorly drained white sand terraces.

A large wingless nut, rarely collected owing to its local distribution/^{and}nature of the habitat. Timber a Dark Red Meranti (825 Kg/m³) (6).

- (8) Shorea palembanica Miq. Kawang asu
West Malaysia, east Sumatra and western and central Borneo.

Widespread but only locally abundant on clay rich alluvium and low undulating land.

A medium-sized nut. Timber a Light Red Meranti (677 Kg/m³) (96).

- (9) Shorea mecistopteryx Ridl. Kawang burong
Northern Borneo from Kalimantan Barat to the Kinabatangan area of Sabah.

Rather rare on gently undulating low hills and sandy clay soils.

A medium-sized nut with long wings. Timber a Light Red Meranti (567 Kg/m³) (6).

Rare to very rare in Borneo on leached sandy soils and shallow swamps, but not in peat swamps.

Nut medium-sized, but owing to rarity of species is rarely collected. Timber a Dark Red Meranti, but density not known.

- (14) Shorea parvistipulata Heim Kawang pinang bersisek
Northern Borneo, from west Sarawak to Crocker Range in Sabah.

Scattered on clay rich soils.

Timber a Red Meranti (729 Kg/m³) (6).

- (15) Shorea pilosa Ashton Kawang bulu
Confined to north central Borneo, including Brunei, 5th Division of Sarawak and west Sabah, and probably neighbouring areas in Kalimantan.

Rare and localized at low altitude. Timber a Light Red Meranti (519 Kg/m³) (6).

- (16) Shorea smithiana Sym. Kawang rambai
Probably throughout Borneo, scattered on low undulating hills.

Timber a Light Red Meranti (567 Kg/m³) (6). Cytology: chromosome count $n = 7$ (13).

An undescribed species (Shorea sp. No. 63 in the Red

Merantis of Ashton (3)) deserves mention as it is apparently a true 'Kawang' and related to the principal illipe nut species, Shorea macrophylla. The fruit is at present unknown to science. The species has a limited and localized distribution on steep ridge terrain in the middle reaches of the Rejang river in central Sarawak.

Certain other species have been recorded (4, 17) in Sarawak as illipe nut producers, including Shorea atrinervosa Sym. (Engkabang tukul), Shorea ferruginea Dyer ex Brandis (Engkabang Keli), Shorea havilandii Brandis (Engkabang pinang) and Shorea pauciflora (Engkabang cheriek or Nemesu). These are mainly species that produce only smallish nuts and may be disregarded. Dilmy (8) mentions, among others, Shorea leprosula Miq. as an illipe nut species in Kalimantan, but this widespread species produces a very small nut and is unlikely to be ever collected for marketing.

Properties of illipe nuts. Marketed illipe nuts consist of the kernel which comprises the two large cotyledons without the wings or shell. It may also include the 'germ' (the radicle and plumule) but this is often broken off and discarded during processing. Analyses of nuts of Shorea macrophylla, from plantations at the Forest Research Institute, Kepong (original material from Sarawak), and Shorea seminis from Sarawak were undertaken at the

Colonial Plant and Animal Products Laboratory (forerunner of the Tropical Products Institute) in London in 1956 (15), and the results are shown in tables 1 and 2.

Table 1. A comparison between the composition of illipe nuts yielded from Shorea macrophylla & Shorea seminis

| <u>Composition of Kernels</u> | <u>Shorea macrophylla</u> | <u>Shorea seminis</u> |
|--------------------------------------|---------------------------|-----------------------|
| Fat (moisture-free basis), % | 51.6 | 51.6 |
| Protein (N x 6.25), % | 5.4 | 6.5 |
| Ash, % | 1.2 | 0.8 |
| Crude fibre, % | 0.8 | 1.2 |
| Nitrogen-free extract, by difference | 37.6 | 37.8 |

Table 2. A comparison between the constants of fats yielded from Shorea macrophylla & Shorea seminis

| <u>Composition of fats</u> | <u>Shorea macrophylla</u> | <u>Shorea seminis</u> |
|------------------------------------|---------------------------|-----------------------|
| Specific gravity at 15.5 degrees C | 0.967 | 0.965 |
| Melting point, degrees C | 37 | 35 |
| Refractive index, nD 40 degrees C | 1.455 | 1.456 |
| Iodine value (Wijs, 1 hr), % | 31.4 | 30.4 |
| Thiocyanogen value, % | 30.5 | 28.5 |
| Saponification value, mg KOH/g oil | 188.8 | 189.2 |
| Acid value, mg KOH/g oil | 1.1 | 1.7 |
| Unsaponifiable matter | 0.8 | 1.0 |

Further analyses of nuts of six species were under-

taken by the Research Branch of the Department of Agriculture, Sarawak and reported in the annual report (9) of that branch for 1970. All the material originated from the Forest Department plantations in the Semengoh Forest Reserve. The results (mean values only), extracted from the annual report, are shown in Table 3.

Table 3. Composition of the kernels of six species of illipe nuts

| Species | Av. weight of single fruit (gms) | Composition of Kernels | | % ash |
|--------------------|--|------------------------|--------------------------------------|-------|
| | | % fat (O.D. basis) | % free-fatty acid (as oleic acid) | |
| <u>stenoptera</u> | 13 | 46.4 | 2.32 | 1.98 |
| <u>seminis</u> | 5 | 46.7 | 2.13 | 1.93 |
| <u>macrophylla</u> | 52 | 48.2 | 2.35 | 2.41 |
| <u>splendida</u> | 24 | 47.7 | 2.39 | 2.27 |
| <u>palembanica</u> | 6 | 34.1 | 2.92 | 2.77 |
| <u>pinanga</u> | 19 | 50.7 | 1.85 | 1.95 |

It will be noted that the percentage fat is slightly less than in the samples analysed previously in London. However Connell (7) reports that on samples collected during his study Shorea seminis had the highest fat value (61.8%), whilst Shorea macrophylla had 55.9%; most of the other species with small nuts had a low value, Shorea palembanica having only 41.4%.

Apart from the infra-specific variation, which is probably small, the main cause of the variation in the fat content

is dependent on the method of processing the nuts after harvesting, and to a lesser extent on the conditions of their subsequent transport and storage before analysis. This will be discussed in a later para.

It is probable that the fat content is about 50 per cent for most of the important species, though apparently lower in Shorea palembanica and that this fat (or oil) has a relatively high melting point (about 36 degrees C).

Harvesting and processing for export. Illipe nuts have been, and still are, essentially a jungle crop. The main species, particularly Shorea macrophylla, occur on alluvial strips and in riverain forest deep into the interior of west and central Borneo. Flowering usually occurs in September or early October, with fruiting about three months later in January, February or early March. The indigenous peoples tend to concentrate on the collection of this windfall crop often to the detriment of their hill rice, and disputes over collecting rights are not infrequent.

Fruits require to be collected as soon as they fall. Collection from the trees - frequently hazardous owing to their height - is discouraged, and the lighting of fires beneath trees to encourage the fruit to fall and

the lopping of branches is prohibited in Sarawak. Germination of the single-seeded fruit is rapid in the moist conditions prevailing, usually within two to three days. The oil content of cotyledons of developing seedlings inevitably decreases rapidly and 'spent' cotyledons, which may sometimes be collected, have little value.

After collection the nuts are dewinged by means of a blunt instrument and then either kiln dried or packed in crates made on the spot from bamboo or rotan and immersed in neighbouring rivers or streams. The later method produces the 'black' nuts which have a better reputation on the market (16). Complete immersion besides killing off insects allows the cotyledons to swell thus facilitating the shelling of the nuts. The kernels are then sun dried for about five to seven days. In the kiln-drying method the nuts, after being dewinged, are placed on a simply constructed platform and roasted over a slow-burning fire until dry when they are easily shelled. This method produces the less favoured 'brown' nuts.

Connell (7) undertook a comparative processing trial of Shorea macrophylla nuts in Sarawak. Analyses were undertaken at the Agriculture Research Centre, Sarawak

and/or at the Tropical Products Institute, London. A summary of some of the analytical results are shown in Table 4.

Table 4. Summary of analytical results of processing trial of illipe nuts. (Mean results only)

| Sample description | % Moisture content | % Oil content (moisture free) | % Free fatty acid (as oleic acid) |
|--------------------------------|--------------------|-------------------------------|-----------------------------------|
| a) Control oven dried | 6.25 | 53.05 | 0.31 |
| b) Sun dried | 6.85 | 51.25 | 0.33 |
| c) Kiln dried kernels in shell | 6.50 | 50.40 | 0.36 |
| d) Soaked/sun dried | 11.15 | 55.00 | 1.33 |
| e) Soaked/kiln dried | 7.60 | 55.70 | 0.99 |
| f) Kiln dried, 70-80 degrees C | 4.50 | 51.20 | 1.24 |
| (g) High temperature trial | 7.20 | 52.20 | 1.76 |

The results tend to confirm that nuts which are immersed before drying (either naturally or artificially) produce a higher oil content, though the reasons for this are not at present understood.

Infection by micro-organisms and infestation by insects. The fruit as soon as it falls to the ground is liable to be attacked by micro-organisms and insects. Connell (7) reported that in two samples of nuts examined on the day of collection 27.9 and 20% of the kernels were infected

by micro-organisms and 50 and 25% infested with insects. Heavily affected nuts should of course be discarded but this is not always done.

Inadequate drying or inefficient processing of the nuts is liable to cause severe attacks later during transport and storage in the country and during shipment to an overseas market. Under present conditions the processing of nuts from Sarawak, and almost certainly from Kalimantan Barat as well, is inefficient and could be greatly improved. Records of the Infestation Control of the Ministry of Agriculture and Fisheries of Great Britain, as reported by Connell (7), show that 96 species of insects have been found in illipe nut cargoes entering the United Kingdom during the period 1947 to 1963, and that four species were present in 50% or more of the cargoes. During the period 1953 to 1963 only one cargo of 95 investigated was certified as clear of infestation.

This infection and infestation of the processed nuts results in a quality deterioration (breakdown of the oil into free fatty acid) in addition to a phytosanitary hazard. Problems relating to the processing, storage, packaging and transport of the nuts have been closely investigated by Connell, where^{ose} main recommendations are:

- (i) That the nuts should be processed as soon

as possible after harvesting.

- (ii) That the moisture content should be reduced to and retained at not more than seven per cent.
- (iii) That shipments should be fumigated before export.

Shipping. Port facilities in Sarawak, and probably also in Kalimantan, are inadequate to handle the cargo and ensure that the moisture content is reduced to an acceptable level for ocean carriers. Excessively moist nuts are liable to spontaneous heating and pose a hazard to shippers. Initial shipment by coastal vessels is therefore to Singapore where adequate facilities for handling, storage, drying and inspection of the cargo are available. However in view of the levels of infestation of the cargo on arrival at European ports, mentioned in the previous section, it is doubtful whether the treatment in Singapore is entirely satisfactory. Port facilities in Borneo could, and possibly would, be improved to enable complete handling of the cargo and direct shipment on ocean carriers if regular (annual) crops became available.

Marketing and processing and uses. Despite the generally low quality of the product on arrival in overseas ports, and the irregular and sporadic nature of the crop, illipe nuts have always been marketable at a price high enough to induce the indigenous people to collect the crop. The principal markets have been the United Kingdom and

Holland, though in recent years Japan has bought considerable quantities. The main use is in the confectionary industry, especially in chocolate manufacture (the high melting point of illipe oil is said to be particularly suitable for use in chocolates to be exported to hot climates). In this industry illipe nuts are used as an alternative to cocoa butter. They also find a market in soap manufacture, in the cosmetic industry and to a small extent for medicinal purposes.

Processing requires relatively expensive and sophisticated apparatus and machinery, and there is no likelihood under present circumstances of processing plants being established in Borneo or even Singapore. This once again would depend on regular crops of adequate quantity becoming available. After processing and the extraction of the oil (or 'illipe butter' as it is sometimes known) the remainder of the kernel or husk can be used as food for livestock though apparently it compares unfavourably with linseed and groundnut meal on account of its lower protein content (9.4 to 12.5 per cent).

Small quantities of the harvest are processed locally in the forest or at longhouses. Simple methods are used either by applying heat or a combination of heat and pressure to extract the oil which is allowed to harden in

bamboo tubes and then eaten as a flavouring with rice. Engkabang terendak (Shorea seminis) is particularly sought after for this purpose.

Value of the illipe nut crop. An indication of the value of the illipe nut crop is provided by the export statistics from Sarawak. Data for the period 1947 to 1973 are shown in Table 5. In terms of volumes of illipe nuts exported there were nine major crops (a major crop being arbitrarily defined as one exceeding 5,000 tons) during this twenty-seven year period, and it is notable that the largest crop of 28,061 tons was exported in 1973 despite the comparatively low price per ton. In recent years the collection of the harvest has been facilitated by better communications and by the increased ownership of outboard engines by the indigenous people which enables them to penetrate into less accessible areas upstream.

The total value of the exports, shown in column (iii), provides, for years of major crops, a major contribution to the net exports of the State: in 1954 and 1959 the value exceeded that of the total exports of round timber. The revenue to Government, which is charged at 10 per cent ad valorem, is also not insignificant.

The price per ton (column iv) shows considerable varia-

tion, similar to that of other primary agricultural products from the region, but this variation is less than for rubber or pepper - the two main agricultural products of Sarawak. Since 1958 the price has varied from a minimum of \$M40.44 per ton in 1966 to a maximum of \$768.12 in 1958. The latter high price probably coincided with a shortage on the world markets of cocoa and cocoa butter owing to the deprecations of disease in cocoa crops in West Africa. It is indeed the price of cocoa butter on world markets that mainly determines the price offered for the illipe nut crop.

In column (v) the price per pikul is shown: the pikul (= 133 pounds = 60.33 Kg) being the standard unit of weight used for measuring the harvest before shipment. The values given are at time of shipment, but about three-quarters of this value is paid to the collectors of the illipe nuts. Connell (7) mentions that exceptionally a collector may gather three to four pikuls of fresh nuts in a day but on the average the collection may only be 30 to 40 katies (.3 to .4 pikuls), which appears to be an exceptionally low figure. Possibly a fairer estimate would be to take the family unit, as the children assist with collection of nuts and the womenfolk with the drying, especially in the longhouses. A family unit may collect and process and sell ten pikuls of dried nuts during the

Table 5. Volume, value and periodicity of illipe nut harvests
in Sarawak, Malaysia, based on export figures for
period 1947 to 1973.

| Year (i) | Volume Tons exported (ii) | Total (iii) | Value in Malaysian dollars | | |
|-------------|---------------------------------|----------------|----------------------------|------------------|--------------------|
| | | | Per ton British (iv) | per pikul (v) | per 100 Kg (vi) |
| 1947 | 7,658 | 1,897,248 | 247.75 | 14.71 | 24.38 |
| 8 | 22 | 5,061 | 230.05 | 13.66 | 22.64 |
| 9 | 752 | 444,970 | 591.72 | 35.13 | 58.23 |
| 1950 | - | - | - | - | - |
| 1 | 22 | 9,272 | 421.45 | 25.02 | 41.47 |
| 2 | 30 | 15,465 | 515.50 | 30.60 | 50.72 |
| 3 | 2,807 | 2,141,873 | 763.05 | 45.31 | 75.11 |
| 4 | 16,047 | 12,631,295 | 787.14 | 46.74 | 77.48 |
| 5 | 1,452 | 873,213 | 601.39 | 35.71 | 59.19 |
| 6 | 158 | 92,198 | 583.53 | 34.65 | 57.44 |
| 7 | - | - | - | - | - |
| 8 | 6,205 | 7,119,738 | 1,147.42 | 68.12 | 112.92 |
| 9 | 22,006 | 19,976,395 | 907.77 | 53.90 | 89.34 |
| 1960 | - | - | - | - | - |
| 1 | 15 | 14,101 | 940.07 | 55.82 | 92.53 |
| 2 | 19,883 | 16,011,630 | 805.29 | 47.81 | 79.25 |
| 3 | - | - | - | - | - |
| 4 | - | - | - | - | - |
| 5 | 502 | 371,797 | 740.63 | 43.97 | 72.88 |
| 6 | 6,761 | 4,605,240 | 681.15 | 40.44 | 67.03 |
| 7 | - | - | - | - | - |
| 8 | 16,032 | 12,769,085 | 796.47 | 47.29 | 78.39 |
| 9 | - | - | - | - | - |
| 1970 | 16,554 | 17,263,776 | 1,042.88 | 61.92 | 102.64 |
| 1 | - | - | - | - | - |
| 2 | - | - | - | - | - |
| 3 | 28,061 | 20,158,938 | 718.40 | 42.65 | 70.70 |

(Note: 1 pikul = 133 pounds = 60.33 Kg)

period of the harvest. At the price paid in 1973 this would yield \$M320, not a large amount by world standards but a very significant contribution to a family that has little other means of earning cash. On this basis the 1973 harvest benefitted about 47,000 family units in Sarawak (population c.1,000,000), a high proportion of the rural people.

Periodicity of flowering and fruiting. In addition to the evidence of periodic harvests shown in Table 5, data on exports of illipe nuts from Sarawak are available for the period since 1908, excluding the war years, 1941 to 1946, for which there are no records. During this thirty-three-year period there were nine harvests (quantities exported at this time were generally less than the 'major crops' as defined previously) which works out at a harvest every 3.6 years. A major crop can therefore be expected on the average every three to four years. It is significant perhaps that if suitable conditions prevail good harvests can occur in two years running, as in 1914/1915 and again in 1958/1959.

This periodicity of flowering and fruiting, which is very typical amongst the Dipterocarpaceae and also occurs in many other species of the tropical rain forest, is not fully understood. It is however, related to the climatic

conditions prevailing: an abnormal period of dry weather in July and August stimulates the trees to flower in September and October. After a heavy flowering there is no absolute certainty of a good harvest. Early and severe monsoon storms may destroy the flowers or young fruit, as occurred in 1927, 1952 and 1957.

Plantations. Plantations of illipe nut species have been established at the Forest Research Institute, Kepong, West Malaysia; near Kuching, Sarawak, East Malaysia; and at Haubentes in West Java, Indonesia. It must be admitted that these plantations were designed and managed mainly to study the growth of the species rather than to investigate the fruiting. They do however provide valuable material on which further research may be based.

(i) West Malaysia. A plantation of Shorea macrophylla, from fruit originating from Sarawak, was established in 1935 at Kepong and covers an area of 0.8 acres (0.324 ha). It fruited heavily in 1952 and then again in 1955. This second harvest was processed, providing the following results (12):

No. of trees: 37; Age: 20 years

Fresh weight of fruit (including wings and shell):
2709 lbs (1228.8 Kg)

Loss on dewinging and shelling: 58 per cent

Loss on drying of kernels to c.10 per cent
moisture content: 12 per cent.

Net weight of dried kernels: 813 lbs (368.8 Kg)

The harvest therefore was equivalent to 1015 lbs (7.63 pikuls) per acre (1138 Kg per ha). At a value of \$40 per pikul the harvest would realize \$M313 per acre (\$M773 per ha).

In comparison with data from Sarawak the loss of 58 per cent on dewinging and shelling and a net loss of 70 per cent, including drying, appears to be excessive.

(ii) Sarawak, East Malaysia. The Forest Department, Sarawak has established and maintained the following plantations in the Semengoh Forest Reserve, ten miles from Kuching:-

| Species | Area acres & ha | Year of establishment | Mode of establishment |
|-----------------------|--------------------|--------------------------|--|
| <u>S. macrophylla</u> | 4 (1.62 ha) | 1936 | Planted under shelter with belian. (<u>Eusideroxylon zwageri</u>) sown in alternate rows |
| <u>S. splendida</u> | 0.27 (0.11) | 1926 | Not known |
| <u>S. splendida</u> | 3.3 (1.34) | 1936 | Planted under secondary forest |
| <u>S. splendida</u> | 2.0 (0.81) | 1940 | ditto |
| <u>S. hemsleyana</u> | 5.4 (2.19) | 1935 | Sown under secondary forest |
| <u>S. pinanga</u> | 2.0 (0.81) | 1935 | Planted under secondary forest |
| <u>S. palembanica</u> | 2.0 (0.81) | 1940 | ditto |
| <u>S. stenoptera</u> | 2.4 (0.97) | 1940 | ditto |

These plantations were neglected during the war years and inevitably there was some mortality among the then young trees, but survivals have been adequate to obtain some data on growth rates and, more recently, on yields of illipe nuts. Two heavy thinnings have been made in the Shorea macrophylla plantation and a single thinning in 1976 in the other plantations. Girth increment data for these plantations are shown in Table 6.

Table 6. Girth increment data of illipe nut plantations
In Sarawak

| Species | Age | No. of trees | Mean Annual Increment | | | | Largest tree | |
|-----------------------|-----|--------------|-----------------------|-----|---------------------|-----|--------------|-------|
| | | | All trees | | 10% largest (girth) | | (girth) | |
| | | | in. | cm. | in. | cm. | in. | cm. |
| <u>S. macrophylla</u> | 37 | 125 | 1.58 | 4.0 | 2.42 | 6.1 | 102.3 | 259.8 |
| <u>S. splendida</u> | 47 | 30 | 0.90 | 2.3 | 1.21 | 3.1 | 59.6 | 151.4 |
| <u>S. splendida</u> | 37 | 120 | 1.05 | 2.7 | 1.54 | 3.9 | 81.4 | 206.8 |
| <u>S. splendida</u> | 33 | 111 | 1.25 | 3.2 | 1.71 | 4.3 | 61.4 | 156.0 |
| <u>S. hemsleyana</u> | 38 | 85 | 1.05 | 2.7 | 1.40 | 3.6 | 60.4 | 153.4 |
| <u>S. pinanga</u> | 38 | 96 | 0.99 | 2.5 | 1.42 | 3.6 | 62.0 | 157.5 |
| <u>S. palembanica</u> | 33 | 61 | 1.16 | 2.9 | 1.71 | 4.3 | 62.5 | 158.8 |
| <u>S. stenoptera</u> | 33 | 132 | 1.07 | 2.7 | 1.37 | 3.5 | 54.1 | 137.4 |

The growth rates for these Light Red Merantis is moderately high (for Dipterocarps!), about 1 in (2.54 cm) to 1.5 in. (3.81 cm) girth per annum; and that of Shorea macrophylla is exceptional: the twelve largest trees having a mean annual increment of 2.42 in. (6.15 cm).

Shorea hemsleyana, the only Dark Red Meranti, has a slightly slower growth rate.

Although illipe nut species have perhaps their greatest potential when grown as an agricultural crop the possible utilization of the timber should also be borne in mind. The density of the timber for each species has been shown earlier. Of the eleven primary species all are Light Red Merantis, except Shorea macrantha, which is a Dark Red Meranti and the Balau, Shorea seminis. The Light Red Merantis are one of the best-known commercial timbers of the region. As a general utility timber they are widely used locally, though being non-durable they should not be used in exposed situations. Large quantities are also exported particularly for the veneer and plywood industry. If fast-growing plantations of these low-density Light Red Merantis, especially Shorea macrophylla, were established the incidence of brittle heart in the timber would need to be investigated.

Fruiting of plantations. The Shorea macrophylla plantation fruited first in 1962 at the age of 26 years, and again in the years 1968, 1970 and 1973. Like many other forest trees if Shorea macrophylla is grown under moderately dense plantation conditions flowering and fruiting is delayed until the trees are mature. Much earlier

flowering and fruiting may be stimulated by open conditions and no overhead shade. A few trees of Shorea macrophylla (fruit originating from the 1962 harvest on the plantation) planted under these conditions flowered in 1967 and set fruit in early 1968. Local Ibans report that the period may be reduced to five or even four years. Plantations of the other illipe nut species fruited for the first time in 1968, and then in 1973.

Yields. The 1968 harvest of Shorea macrophylla yielded approximately thirty pikuls of dried nuts which is equivalent to 7.5 pikuls per acre (1118 Kg per ha), a yield closely proximating that from the West Malaysia plantation.

Fruit of five species from the plantations, and one, Shorea seminis, from the Semengoh Forest Reserve but not grown as a plantation, was sent after the 1970 harvest to the Agricultural Research Centre for analysis. The published results (1) include a table, included here as Table 7, showing the percentage by weight of the components of the fruit in both fresh and dry states.

The Forest Department (II) undertook a comprehensive investigation of the yields from the plantations following

Table 8. Yield from five species of illipe nuts grown in plantations in Sarawak

| No. | Species (ii) | Area acres (iii) | No. of trees (iv) | No. of fruits coll. (v) | Av. No. of fruit p. tree (vi) | Total dry wt. of kernels lb (vii) | Av. dry wt. of single kernel oz (viii) | Av. yield Per tree lb (ix) | Kg (x) | Pikuls p acre (xi) | Kg per ha (xii) |
|-------|-----------------------|------------------------|-------------------------|----------------------------------|--|--|---|----------------------------------|-----------|--------------------------|-----------------------|
| 1 | <u>S. macrophylla</u> | 4.0 (1.62 ha) | 125 | 142,006 | 1,136 | 6292 2854 | 0.709 20.10 | 50.34 22.83 | | 11.83 | 1762 |
| 2,3,4 | <u>S. splendida</u> | 5.57 (2.26) | 259 | 130,686 | 505 | 2858 1397 | 0.377 10.69 | 11.90 5.40 | | 3.86 | 618 |
| 6 | <u>S. pinanga</u> | 2.0 (0.81) | 96 | 198,160 | 2,064 | 4071 1847 | 0.328 9.32 | 42.31 19.24 | | 15.31 | 2280 |
| 7 | <u>S. palembanica</u> | 2.0 (0.81) | 35 | 33,408 | 955 | 289 131 | 0.138 3.92 | 8.24 3.74 | | 1.09 | 162 |
| 8 | <u>S. stenoptera</u> | 2.4 (0.97) | 132 | 102,328 | 775 | 1728 784 | 0.270 7.66 | 13.08 5.94 | | 5.41 | 808 |

were weighed inclusive of the shell, some extrapolation has been required using the percentage dry weight of components of fruit (Table 7) as a basis.

Shorea macrophylla, which has a nut almost twice as heavy as any other species, produced the greatest yield per tree, 50.34 lb (22.83 Kg), but Shorea pinanga, which fruited extremely heavily (average 2,064 fruit per tree), produced the highest yield per acre, 15.31 pikuls (2,280 Kg/ha). The species with the smallest nut, Shorea palembanica, did not fruit very heavily and the yield was much less than that for other species. This species, as noted earlier, also has the lowest oil content of those species analysed.

(iii) Haurbentes, West Java. Haurbentes lies about 60 Km west of Bogor in an area with a typical equatorial climate, having about 4,000 mm (157 in.) annual rainfall and no pronounced dry season. The driest month is July when on the average approximately 200 mm (7.9 in.) rain falls. The most extensive plantations are those of Shorea stenoptera. Other illipe nut species represented, some by only a few trees, include Shorea pinanga, Shorea palembanica, Shorea compressa (considered by Ashton to be a synonym of Shorea pinanga), Shorea splendida (in plantations named S. martiniana), Shorea mecistopteryx,

Shorea macrophylla (syn. S. gysbertiana) and Shorea seminis. The fruit of all species originated from Kalimantan and the plantations were mostly established in 1940.

Sudiono and Ardikusumah (18) have published results on an investigation of the Shorea stenoptera plantations and include data on flowering and fruiting, diameter height and volume increment, and a description of the stand. The plantation initially flowered in September 1949 and fruited in December. Further fruiting occurred in the years 1957, 1961 and 1963. Diameter increment (mean annual increment) for thirty years is 1.72 cm (0.68 in.), equivalent to a girth increment of 5.4 cm. (2.1 in.), which is somewhat greater than that for the species grown in Sarawak. This investigation concerned only the true Shorea stenoptera which has the typical form with a straight bole and high branding.

The main interest in the plantations, however, is centred on a form of Shorea stenoptera which has the reputation of flowering and fruiting annually. The original fruit was collected by a Dutch Forest Officer in 1940 from a single tree located in a village near Palai Kerangan in the Kapuas drainage of Kalimantan Barat. About 15 to 20 of the original trees comprise a small planta-

tion, with numerous smaller trees that have developed from fallen fruit. The average girth is somewhat smaller than that of the neighbouring true Shorea stenoptera, planted also in 1940, and the trees have poor form with low branding, giving them the appearance more of fruit trees than timber trees. The author visited this plantation in September 1972 and was informed that it flowered and fruited annually, and that progeny of the plantation retained this characteristic. Flowering occurs at a young age. At the time of visit trees planted in 1970 (2½ years old) were in full flower when 4 to 6 m. in height, and a few trees planted in 1971 were in flower, at a height of 2 to 3 m.

The Indonesian Forest Department appreciate the value of this form of Shorea stenoptera and have extended the plantations by about 400 ha. The planting distance is 6 x 6 m and light shade is usually provided by Albizia falcataria. Ardikusumah (person com.) stated in 1973 that he had recently revisited the area in Kalimantan Barat where the original fruit was collected and found that this form of Shorea stenoptera was widespread in the locality, being extensively planted by the indigenous people.

It has been suggested that the more frequent fruiting

might be the result of the conditions prevailing in West Java. This, however, seems unlikely especially as the true Shorea stenoptera, and other Shoreas, follow the usual pattern of irregular and spasmodic flowering and fruiting.

Current Research. Current research on illipe nuts is mainly centred on the Department of Agriculture, Sarawak. The results of a study on the inorganic nutrient composition (including both major and minor nutrients) has been completed by Md. Iqbal Ahmed and E.S. Sim (I). On the basis of this a manurial programme for illipe nut species in cultivation is recommended. Further research includes fertilizer experiments, and hormonal experiments to observe the effects of seven substances on growth rates and time of flowering and fruiting of Shorea macrophylla. Pruning and ringing, and grafting research is also being undertaken.

The Science Faculty of the University of Aberdeen through its Institute for S.E. Asian Biology is undertaking an investigation of the population genetics and ecology of rain forest trees in the region. The scientific objective is to investigate the process of diversification in a tropical rain forest through a study of the genetics, embryology, cytology, and pollination biology

of selected species; and the practical objective is to provide the genetical knowledge essential both to future exploitation and cultivation of potentially economic rain forest tree species and to the ecological management of nature reserves and national parks. One of the groups selected for particular study is the Pachycarpae (Kawang) section of Shorea. Active research under this programme is now being undertaken in the region. Some results (13, 14) of cytological investigations (chromosome counts) have been included here under the species descriptions.

Discussion. A discussion on the potential of illipe nuts as an agricultural crop is perhaps best considered by listing, and discussing, the advantages and disadvantages.

Advantages:

1. Arboreal crop indigenous to the region. Throughout South East Asia severe soil degradation and erosion is taking place under non-arboreal crops. An arboreal crop that is likely to maintain the fertility of the soil, especially if fertilizer is applied, and generally prevent degradation and erosion has much to recommend it. At low altitude within the region of tropical rain forest illipe nut species should grow well if planted under suitable conditions. Though most species, including Shorea macrophylla

occur naturally on deep alluvial soils, it is notable that Shorea stenoptera is found on infertile, sometimes podsolized, heath soils.

2. Provides a 'hard' oil which is likely to maintain its value, without wide fluctuations in price, on world markets. Long-term projections on its value are required before any large-scale plantings are considered.
3. After planting little or no cultivation is required. In the first year, or two years at the most, cleaning and weeding of the plantations may be required to ensure that the young trees are not suppressed but later no cultivation is absolutely necessary though research might indicate that some cultivation is beneficial.
4. Can be processed locally, for export as dried nuts, without the necessity of expensive machinery and equipment. Though the quality of the product at present leaves much to be desired Connell (7) has indicated that improvements can be brought about by better techniques only.
5. Provides a cash crop, of which a high proportion of

the export value is paid to the collector or producer.

6. If grown as a smallholder crop it may provide a measure of stability in areas where primitive (shifting cultivation) is practised.
7. Can provide a small addition to the diet, though the value of this in dietetic terms requires further investigation.
8. The timber is of value. If the crop is grown solely for the production of nuts the timber is likely to be of much less value as fruit-tree-type growth will be encouraged, but even this timber can be utilized locally for general purposes and firewood. It might also be possible to grow some trees closely spaced to provide more valuable timber, and illipe nuts, when trees are mature.

Disadvantages.

1. Irregular and spasmodic flowering and fruiting. This has been and still is the main stumbling block to the development, or interest in the development, of the crop. In the past it has to some extent been assumed that Dipterocarps must have a resting period, covering two or three years, before they will flower

and fruit again. But this is not necessarily the case (the extremely interesting material of the form of Shorea stenoptera at Haurbentes is an example). It is possible that within Borneo there are other untapped genetical resources in the Kawangs that will assist with solving this problem. Yields from trees that fruit more regularly, preferably annually, can probably be maintained if not increased by the application of fertilizers. With an adequate range of genetical material plant-breeding research may be able to solve this problem.

2. Low yields per unit area. In comparison with many cultivated crops the yields obtained so far are low, but this is perhaps not a fair comparison: one is comparing a basically jungle crop against one that in many cases has been selected for higher yields over many years (centuries or millenia in some instances). It is well known in Borneo that illipe nuts of any one species may vary considerably in size: Connell (7) mentions that though the average size of nuts of Shorea macrophylla is 4.5 cm (major axis) x 3.0 cm (breadth or diameter) he saw some nuts that were 7 x 5 cm. Once again it is a matter of tapping the genetical resources to obtain both material that will produce maximum yields in weight

and genotypes with particularly high oil content. There are of course many other characters for which selection might be made.

3. Difficulty in storage and transport of viable fruit. This can be considered a secondary disadvantage as research on fresh material will probably to a large extent overcome it. Furthermore if clones of regular-fruiting, high-yielding material are eventually developed vegetative propagation may well become the normal practice. Mist cultivation would appear to offer good prospects in this respect.

Conclusion. The potential of illipe nuts deserves serious investigation. Current research should be intensified, particularly on tree-breeding to obtain or develop material that fruits more regularly and/or to develop means of stimulating flowering and fruiting. For the benefit of both countries, and the region as a whole, research in Indonesia and Malaysia should be closely coordinated and material freely distributed. When the next illipe nut crop occurs intensive collecting in Borneo should be organised to obtain both a wide range of species and selected genotypes for further research.

REFERENCES

1. Ahmed, Md. Iqbal and Sim, E.S. Inorganic nutrient composition of Sarawak illipe nuts. Mal. Agric. Journ 50, 1973.
2. Ashton, P.S. Manual of the Dipterocarp trees of Brunei State. Oxford Univ. Press, 1964.
3. Ashton, P.S. Manual of the Dipterocarp trees of Brunei State and Sarawak, Supplement. Borneo Lit. Bur. 1968.
4. Browne, F.G. Forest trees of Sarawak and Brunei. Gov. Print. Office, Kuching, 1955.
5. Burkill, I.H. Dictionary of the economic products of the Malay Peninsula, 1935.
6. Chu, F. Fei-Tan. Anatomical features of the Dipterocarp timbers of Sarawak. Gardens' Bulletin, Singapore 27 (1), 1974.
7. Connell, M. Sarawak illipe nut trade, a post-harvest study. Tropical Products Instit. Rep. R42, London, 1968.
8. Dilmy, A. Natural Products of the Lowland tropical forests, mainly of Indonesian Borneo. Proceedings of symposium on the planned utilization of lowland tropical forests, Bogor, 1971 (1973).
9. Department of Agriculture, Sarawak, Malaysia. Ann. Rep. of Research Branch, 1970.
10. Forest Department, Sarawak, Malaysia. Research Branch, unpub. rep., 1973.
11. Forest Department, Sarawak, Malaysia. Annual Reports 1947 - 1973.
12. Forest Research Institute, Kepong, Malaysia. Unpub. report, 1955.