SELECTED ARTICLES.

COVER CROPS AND GREEN MANURES.*

ONE of the most important problems which have to be dealt with by Malayan agriculturists is undoubtedly that of soil erosion and it is satisfactory to record that the employment of cover crops on both rubber and coconut estates throughout Malaya is now receiving much greater attention than formerly. This clearly indicates that the majority of planters are beginning to appreciate the numerous advantages which may be gained by growing one or other of the more suitable types of cover plants, both as a means of maintaining the fertility of rich soils and improving poor soils.

The necessity for taking every possible precaution to prevent the loss of valuable surface soil on either hilly or undulating land cannot be too strongly emphasised, since any neglect in this connection must eventually result in a serious loss in crop production and may even do so much permanent damage as to render the cultivation of a crop unremunerative.

The cultivation of one or more of the low-growing types of cover plants in combination with silt-pitting is one of the most satisfactory means of dealing with this particular problem.

The question of soil improvement, however, is an entirely different problem and generally consists in growing one of the erect types of cover plants with the object of digging the fresh prunings or, in some cases, the whole plant into the soil, thus enriching the latter by the addition of large quantities of organic matter. When a cover plant is grown solely for this purpose it is generally referred to as a green manure crop.

Green manure crops may to a certain extent serve as cover crops, and vice versa, but the erect types are naturally much less effective than the low-growing types for the purpose of arresting soil erosion on hilly or undulating land.

USES OF COVER CROPS.

The principal benefits which are derived from the cultivation of cover plants may be briefly described as follows :—

(1) The prevention of loss of surface soil on both undulating and hilly land liable to wash.

(2) The reduction of weeding costs, especially on newly-opened areas.

(3) The addition of humus to the soil by falling leaves and decaying stems.

(4) The aeration of the soil is improved by the roots of the cover plants tending to open up the soil and make it more friable.

(5) The protection of the soil and of the roots of crops from the excessive heat of the sun.

(6) The conservation of the fertility of the soil by taking up available plant food which might otherwise be washed away.

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* By B. Bunting and J. N. Milsum in *The Malayan Agricultural Journal.* Vol. XVI, No. 7, July, 1928.

(7) The appropriation of additional nitrogen from the atmosphere in the case of leguminous plants.

The question of nitrogen fixation by leguminous plants by means of the nodules on their roots is probably of much less importance than the beneficial effect of decaying plant residues added to the soil by periodically turning the cover plant into the land, more particularly so in the case of soil deficient in organic matter. The probable reason for this is that the acid nature of most tropical soils is not so favourable for nitrogen fixation as that of soils in temperate regions. Investigations on this point are in progress at the Department.

Further, it is frequently asserted that cover plants by covering up the ground check the loss of soil moisture by evaporation. This is an entirely erroneous idea and may possibly have originated from the fact that the surface of the soil beneath a low-growing cover crop is always moist, owing to the fact that the cover plant prevents the drying of the surface layer of soil by evaporation. Such a condition, however, is purely artificial and it is now well recognised by scientific workers that a leafy crop is capable of evaporating three or four times as much water as the bare surface of soil on land lying under fallow, since the roots of the cover crop absorb an excess of water from below. This phenomenon is naturally not of such great importance in countries with a plentiful and regularly distributed rainfall as in those which are liable to long periods of drought.

OBJECTIONS TO COVER CROPS.

It might be mentioned that there are several objections to the use of certain cover crops such as (a) twining plants damaging the permanent crop (most twiners), (b) the risk or fire (*Mimosa invisa*), (c) the danger of harbouring diseases (*Tephrosia* spp.), and (d) the danger of harbouring insects (*Mimosa invisa*), and these factors must always be taken into consideration when selecting a cover plant.

SELECTION OF A COVER PLANT.

The essential characteristics of a good cover plant may be described as follows :—

(1) A perennial plant is always to be preferred to an annual on account of its greater permanency.

(2) A plant with a creeping habit, which will creep out to open spaces and root at the nodes, is preferable to the erect type that does not spread.

(3) A plant with a twining habit, which will entwine itself round even the thinnest shoots of grass and weeds, thus smothering them out.

(4) It should have a fairly well developed root system, so that its fibrous roots will assist in binding the surface soil together as much as possible.

(5) It should be a plant which makes rapid growth, so that it will soon form an effective cover.

(6) Plants which are easily raised from seed are usually to be preferred to those which can only be propagated from cuttings.

(7) Those which grow best in the open are the most suitable for young clearings.

(8) Those which grow best under shade are more suitable for mature areas of rubber or coconuts.

(9) It should not be subject to either diseases or pests liable to cause damage to the permanent crop.

(10) A leguminous plant is preferable to a non-leguminous one.

METHODS OF PLANTING.

It is most important that the cover plant should be planted as soon as possible after the land has been opened up so that the cover may become well established before any of the surface soil is lost, and while the land is free from weeds.

The method of planting depends on whether the plant is propagated from seed or cuttings, but the first essential is to see that the area to be planted is cleaned up and free from weeds.

When the cover is propagated from seed it is usual to sow the seeds in rows from 2 to 5 feet apart, the distance varying according to the habit of the plant. By this means it is possible to give more attention to weeding until the cover plant has completely covered the ground. The amount of seed required to plant up a definite area naturally varies with different types of cover plants and depends principally upon the distance of planting and on the size of the seed, the small-seeded types usually having a lower seed rate than the large-seeded ones.

Before planting the seed, the rows are lightly forked or changkolled and a quantity of good surface soil is placed in the rows to form a slight mound. The seed is then distributed on the loose surface, covered with a thin layer of soil and pressed well down in order to attract sufficient moisture from below to cause germination.

As a rule the seed of most cover plants germinates fairly rapidly without any treatment, but in the case of those types having a hard seed coat, which retards germination, it is sometimes advisable to place the seed in water heated to a temperature of about 45°C., where it should remain for a period of about 24 hours. Seed which has been treated in this way should on no account be allowed to get dry before sowing.

When it is necessary to propagate the plant from cuttings, the latter may be spaced roughly at distances of 2 or 3 feet apart or they may be placed in rows as in the case of planting from seed. Whichever system is adopted, great care should be taken to see that only mature cuttings are used and that when planted they are pressed well down; otherwise they may dry out.

In order to ensure success, planting operations should only be carried out at the beginning of one or other of the recognised wet seasons. Further, on soils where a certain amount of erosion has already taken place the addition of a small quantity of artificial manure may materially assist in establishing the cover plant.

Once the cover plant is established it should be kept some distance away from the main crop, particularly while the latter is in the early stages of development; otherwise there will be serious competition between the two crops for both water and plant food.

After planting, it is absolutely necessary to pay special attention to weeding until the young plants have formed an effective cover. Even then periodical weeding should be carried out systematically, if noxious weeds are to be kept under control.

It should be stated that, for some reason not understood, several of the cover plants described in this article are very shy seeders in Malaya, but fortunately they can all be propagated from cuttings, provided suitable weather conditions are selected for transplanting. Seed of such cover plants, although somewhat expensive, can invariably be obtained from Java and Sumatra in order to form a nursery from which future supplies of planting materials, in the form of cuttings, can be obtained.

DIFFERENT TYPES OF COVER PLANTS.

There are a large number of different species of cover plants at present under cultivation in this country and for practical purposes they may be divided into two distinct groups as follows :—

(a) Low-growing types more suitable for the prevention of soil wash.

(b) Erect-growing types more suitable for green-manuring.

Although the Department has from time to time had over fifty different species of cover plants under trial, principally at the Government Experimental Plantations, Kuala Lumpur and Serdang, only the more important ones are described in this article.

(A). LOW-GROWING TYPES SUITABLE AS COVER CROPS.

The low-growing or creeping types of cover plants are generally cultivated for the purpose of protecting the surface soil from wash and the roots of crops from the excessive heat of the sun and when such plants are used primarily for this purpose they are known as cover crops.

In this connection the following six cover plants have been selected as representative of the group in question and a few details as to their origin and methods of cultivation, together with their suitability under different conditions, are given below :—

(1) *Calopogonium mucunoides* (N. O. *Leguminosae.*)
(2) *Centrosema pubescens* (N. O. *Leguminosae*).
(3) *Dolichos Hosei* (N. O. *Leguminosae*).
(4) *Indigofera endecaphylla* (N. O. *Leguminosae*).
(5) *Pueraria phaseoloides* (N. O. *Leguminosae*).
(6) *Mikania scandens* (N.O. *Compositae.*)

CALOPOGONIUM MUCUNOIDES.

Description.—A vigorous creeping herb forming a mat of foliage, one to two feet high. The tendrils have a twining tendency, climbing in an anti-clockwise direction. Length of stems 3 to 10 feet, forming roots adjacent to each node. Stems succulent and entirely covered with short brown hairs. Leaves trifoliate, leaflets 1 to 4 inches long, 1 to 4 inches broad, hairy on both sides, oval with round or wedge-shaped base and blunt apex, having a small nerve point. The stipules are small and triangular. Flowers in racemes 1 to 4·5 inches long, flowers small, pale blue, from 4 to 12 on a raceme. Pod 0·75 to 1 inch long, about 0·2 inches broad, densely covered with brown hairs, containing 4 to 8 seeds. Seeds small, flattened and brown in colour, about 2·12 inches long and 0·1 inch broad. The number of seeds per pound is about 34,000.

Habitat.—The plant is a native of tropical America, but was discovered recently growing wild on the East Coast of Sumatra and in various parts of Java. This legume was introduced into Malaya about four years ago and its value as a cover plant was soon recognised .

Soil Conditions.—Calopogonium will thrive on a wide range of soils, but attains its maximum growth on newly-opened land which is well drained. Although it is a moisture-loving plant and on this account suitable for employment in ravines and other damp places, this cover cannot withstand stagnant water around its roots.

Good results are obtained on undulating land, recently silt-pitted or bunded, by sowing the seeds in lines on the "spoil" thrown out from the pits or from the sides of the bunds.

Propagation.—The most satisfactory method of establishing this cover plant is by sowing the seeds fairly thickly in rows from 3 to 5 feet apart according to the fertility of the land. The soil in the rows should be lightly forked or changkolled and, if the land has previously suffered from wash, any loose surface soil or wood-ashes from burnt timber may be added so as to form a suitable medium for establishing the plant.

Under ordinary conditions, if planted in rows 3 feet apart, about 5 lbs. of seed is required to plant up an acre, but where the soil is poor the seed rate may be increased to about 8 lb. per acre. On exceptionally rich land, where the rows are spaced 5 feet apart, 3 to 4 lb. of seed per acre will be sufficient. After the seed is sown in the rows it should be lightly covered with fine soil and well pressed down in order to maintain a sufficient supply of moisture near the surface.

Seed may also be broadcast on land which has been previously forked or changkolled, but this system has many disadvantages and is not recommended. Another method which is sometimes adopted is to dibble the seed into the soil at distances of about 3 feet apart each way. This is more economical as regards the quantity of seed required per acre but presents difficulties with regard to weeding until the plants have become established.

The plant may also be successfully propagated from cuttings but this method is not usually practised, since in planting out in the field a large percentage of failures occurs owing to drying out of the succulent cuttings.

Although the seed may be sown at practically any period of the year the best time for planting appears to be at the commencement of the wet seasons, March/April and September/October. It is most important that land should be in a friable condition and free from weeds when germination takes place, otherwise the young plants will be retarded in growth and weeding costs will be considerably increased.

Under average conditions the seeds commence to germinate within about 5 days from sowing and in about 4 months the growth of the plants is sufficient to cover the land.

As the plants develop the twining shoots spread outwards and the new shoots become attached to the soil by means of the roots thrown out at the nodes.

Flowering usually commences after 3 months from sowing and 3 months later the seeds are produced. *Calopogonium* is a very profuse seeder and natural reproduction takes place freely where there is sufficient space for the seedlings to thrive, more especially if the whole plant is dug under as a green manure.

On flat land where the growth of the cover has become very dense, it is frequently a matter of considerable difficulty to harvest seed in any quantity. The collection of seed is facilitated if there is any timber on the land over which the plants can climb.

General.—The plant is a perennial and when once established is of a fairly permanent nature, but during very dry seasons the older plants have a tendency to die off, thus leaving open spaces on the land. Natural regeneration, however, usually results in the land becoming recovered with a fresh supply of seedlings.

As previously stated, this plant has a twining habit and it is therefore necessary, particularly in young clearings, to prevent any climbing plants from damaging the permanent crop.

Although it is frequently stated that *Calopogonium* grows well under the dense shade of mature rubber this has not been observed in Malaya, where under such conditions the plants usually show weak growth and in

time tend to die out. The value of this plant lies in its employment as a soil cover and wash preventive in newly-opened areas and for these purposes *Calopogonium* is probably superior to most cover plants at present cultivated in this country.

CENTROSEMA PUBESCENS.

Description.—A twining herb ascending any supports with which it comes in contact, but on open land forming a loose mat about 18 inches deep. Stems hairy and inclined to be somewhat wiry. Leaves 4·5 inches long, petiole 1·5 to 2 inches long, trifoliate. Leaflets 1·5 to 2 inches long and 1 inch broad. Stipules minute. Racemes 1·5 inches long, 3 to 5 flowers on short stems 0·75 inch long. Flowers pale mauve with purple lines in the centre. Pod 4 inches long and 0·2 inches broad containing 12 to 15 seeds. Seeds 0·20 to 0·25 inches long and 0·12 inch broad, brownish-green with streaked and mottled dark-green markings, somewhat flattened. The number of seeds per pound is about 16,000.

Habitat.—This plant is stated to have originated in South America, but in 1921 was discovered growing wild in a few places in Java. It has been extensively cutivated as a cover plant in the Netherlands East Indies and to a smaller extent in this counrty.

Soil Contitions.—*Centrosema pubescens* reouirs a fairly good soil and consequently some difficulty is usually experienced in establishing this plant. Further, like the allied species *C. Plumieri,* it will not grow under wet soil conditions.

Although at first comparativelv slow growth is made, once the plant becomes established it forms an excellent cover and in 5 or 6 months the ground is completely covered with a mass of dense foliage.

Propagation.—As in the case of *Calopogonium,* the most satisfactory means of establishing this cover is to sow the seed in rows 3 feet apart, but since the seed is comparatively large it is not sown so thickly, only about 5 lb. of seed being required to plant up an acre. If, however, the seed is dibbled in at distances of 3 feet apart in the rows, allowing two or three seeds to a hole, about 1 lb. of seed will be sufficient for an acre.

The land having been cleaned of weeds and the rows lightly forked, in order to bring the soil to a friable condition, the seeds should be sown about half an inch deep and the soil highly pressed down on top.

Germination usually takes olace within 10 to 14 days from time of sowing, but the growth of seedlings is at first somewhat slow and it takes at least 5 to 6 months before the plant forms an effective cover.

At this stage the plant begins to throw out a large number of twining stems, which are able to curve round even the thinnest shoots of grass and weeds, the latter being bent down by the increased weight of the young stems when forming leaves. Consequently this cover plant has a marked habit of choking out all other plants under its heavy foliage.

As the twining stems assume an upright position they do not form too compact a mass, thus allowing air to penetrate into the soil.

When the stems come in contact with the soil they produce roots from below the leaf stalks and therefore assist materially in maintaining vigorous growth, as in the case of *Calopogonium.*

The plant usually commences to flower about nine months from time of sowing and seeding follows about three months later. In order to encourage the production of seed the plants should be allowed to climb supports prior to the commencement of the dry season.

General.—A marked characteristic of *Centrosema pubescens* is its ability to withstand severe drought, the density of foliage remaining unchanged even during the driest weather.

As in the case of the majority of other cover plants this species is difficult to establish under heavy shade, but in those cases where it is firmly established before the shade is produced it continues to show fair growth under the altered conditions for some considerable time.

Undoubtedly this plant forms a very satisfactory cover crop under the light shade produced by coconuts and oil palm. Further, in new clearings, provided the soil conditions are suitable and the plant becomes well established, *Centrosema pubescens* is equal to, if not better than, *Calopogonium.*

Centrosema pubescens forms a much denser and more permanent form of cover than *C. Plumieri* and is far superior to the latter from every point of view.

DOLICHOS HOSEI.

Description.—A low, creeping perennial herb. Leaves trifoliate and slightly hairy, leaflets 1·5 inches long, stipules small and narrow. Stems wiry. Flowering racemes produced from the axils of the leaves on a stalk 1 to 2 inches in length. Flowers 3 to 4 in number, 0·25 inch long and pale yellow with orange keel. Pods about 0·7 inch long, few seeded. The seed is 0·2 inch long and 0·15 inch broad, colour brown, blotched chocolate. The number of seeds per pound is about 18,000.

This legume, referred to in the Netherlands East Indies under the synonyms of *Vigna oligosperma* and *Vigna Hosei,* should according to a recent determination by the authorities at Kew be known by the name of *Dolichos Hosei,* as originally described by Prof. Craib in the *Kew Bulletin of Miscellaneous Information,* No. 2 of 1914.

Habitat.—This plant is recorded as being indigenous to Sarawak, from where it was introduced to this country by the Department of Agriculture, Federated Malay States, as far back as 1913. under the name of the Sarawak bean, vide *Agricultural Bulletin, F. M. S.,* Vol. 1, p. 276.

About 5 to 6 years ago considerable interest was taken in this plant, under the name of *Vigna oligosperma,* as a cover crop for mature rubber areas.

Soil Conditions.—The Sarawak bean grows vigorously on a loose porous soil, especially where a mulch has been allowed to accumulate. It makes equally good growth on the lighter types of alluvial clay soils in the coastal districts provided that the land is not liable to flooding, but it is difficult to establish on the heavier types of clay or on hilly land which has suffered from surface wash.

Propagation.—The plant may be propagated either by seed or cuttings, but owing to the paucity and expense of seed it is in the first instance advisable to establish the plants in nursery beds. Once these beds have become established a plentiful supply of cuttings will be available for transferring to the field.

When the seed is sown in nursery beds the soil should be cleaned of weeds and lightly forked to form a good tilth. The seeds are then sown about half an inch deep at distances of 9 to 12 inches at the rate of two seeds per hole, which is equivalent to about 5 lb. of seed per acre. Under normal conditions the seeds will germinate in about ten days from sowing and all that is necessary is periodical weeding while the plants are young.

Within about three months the nursery beds should be entirely covered by the plants and a commencement may then be made to take cuttings for planting out in the field. The older the cuttings the better they will stand transplanting. In taking cuttings, portions of the stem about 1 foot long, with three internodes, should be selected.

On young clearings the cuttings may be planted in the field in rows 3 feet apart and about 2 feet in the rows, requiring approximately eight sacks of cuttings to plant up one acre.

An alternative method for mature rubber areas is to make holes a changkol deep in rows about 6 feet apart, the holes being spaced 3 feet apart in the rows. A small quantity of cattle manure is mixed with the soil removed from the hole; two cuttings are then laid crosswise on the surface and the loose earth replaced, the cuttings being firmly pressed into the soil with two internodes below the surface.

With rubber planted at distances of 20 feet by 20 feet apart, the planting of two or three rows of Sarawak bean between each row of trees will cost from $2·50 to $3 per acre. This cost includes the collection and preparation of cuttings, supply of cattle manure and planting.

In suitable weather the growth is rapid and the land will be well covered to a depth of 4 to 6 inches within a period of six months.

After the cuttings have been removed from the nursery beds a new flush of growth will take place with the result that further cuttings will become available within about three months.

Although the plants flower fairly freely in this country, it is only rarely that seed is produced, and even then in such small quantities as to make its collection impracticable. Supplies of seeds, however, are obtainable in quantity from Sumatra, thus overcoming this difficutly.

General.—It should be stated that the plant has a very shallow rooting system compared with other cover plants and in view of this it is probably of greater use as a cover on flat and undulating land rather than for the prevention of surface wash on steep hilly land. It is a moisture-loving plant and appears to thrive best in low situations.

The Sarawak bean is specially valuable owing to the fact that it thrives well under the dense shade of old rubber areas, where most other cover plants usually fail.

During the rainy seasons, especially after heavy showers, the foliage sometimes dies off in small patches, but in such cases fresh growth is made with the advent of dry weather.

Owing to its prostrate habit, the plant has not that tendency to climb the trees exhibited by several of the more vigorous types of cover plants.

The plant is of a permanent nature and once it is established it will remain in a vigorous condition for a number of years, even under heavy shade.

INDIGOFERA ENDECAPHYLLA.

Description.—A low creeping herb. Leaves pinnate, with an odd terminal leaflet. Leaflets 7 to 13, side leaflets alternate, up to 1 inch long. Stipules narrow and membranous. Racemes up to 4 inches long, many flowered. Flowers in spikes, small, under 0·3 inch long, purple pink. Pod 0·75 to 1 inch long, four-sided, 6 to 10 seeded. Seed minute measuring 0·06 to 0·07 inch long, light brown in colour. The number of seeds per pound is about 220,000.

Habitat.—This plant is a native of Southern India, where it occurs at an elevation of 3,000 feet, though it is known to thrive well from sea level up to 6,000 feet.

It was originally employed on the tea plantations in Ceylon and South India from where it was introduced to the Netherland East Indies and Malaya.

Soil Conditions.—It thrives best on land which has not suffered from wash and appears to require a moist soil containing a fair amount of humus. It was formerly suggested as a possible cover plant for old rubber areas for use in a similar manner to the Sarawak bean, but it has not proved a success under such conditions in Malaya.

Propagation.—The plant may be raised readily from seed, but as the latter is somewhat difficult to obtain, it is, at least in this country, usually propagated from stem cuttings. The cuttings, which should be about 9 inches long, are dibbled into the land at distances of about 2 feet apart each way, approximately three sacks of cuttings being required to plant up one acre.

After about six months from planting, the cuttings form a low compact cover about 6 inches deep over the land.

Seed may be obtained from both Sumatra and Java, but, since it is somewhat expensive, seed should only be used for establishing small plots of this plant. Owing to the small size of the seed it should be mixed with sand previous to sowing, thus allowing for a better distribution. If planted in rows three feet apart, the seed rate will be about 3 lb. per acre.

The plants send out trailers, which under suitable conditions may attain a length of 5 feet, and these produce numerous adventitious roots, thus assisting the cover in becoming more firmly attached to the soil.

In the first instance the cuttings apread all over the land and growth remains very low, the cover rarely exceeding 4 inches in height. As the plants mature, they become somewhat taller and at two years old are usually about 12 inches high.

The plants flower within about one year from planting and the seed matures in a further three months' time.

General.—Indigofera endecaphylla is being used in South India and Ceylon as a cover plant with young rubber and has recently been extensively planted in the Netherland East Indies for this purpose.

The plant unfortunately has a tendency to die back in dry weather, but it puts out vigorous fresh growth at the commencement of the rains. It is also liable to attacks from the larvae of a small moth, probably *Lamprosema diemenalis,* but the damage is not permanent.

PUERARIA PHASEOLOIDES.

This plant is often referred to under the synonym of *Pueraria javanica.*

Description.—A strong twining herb attaining a length, in the wild state, of over 20 feet. Stems hairy. Leaves 6 to 8 inches long, 4 to 5 inches broad, trifoliate. Flowers in racemes, 12 inches long in scattered pairs, mauve in colour. Pod smooth, narrow and flat, 3·5 inches long and 0·2 inch wide. Seeds dark brown, 0·15 inch and 0·1 inch broad. The number of seeds per pound is about 37,000.

Habitat.—This plant which is distributed troughout Indo-Malaya, occurs occasionally on the plains in Malaya growing over low shrubs in open situations. Although indigenous in this country it has only comparatively recently been cultivated.

Soil Conditions.—This cover plant appears to be best suited to the heavier types of soil and will not thrive in dry sandy situations. It is specially adapted to the alluvial clay types of land found in the coastal districts and is likely to prove a valuable legume for use on coconut estates.

Propagation.—There is every indication that this plant is a shy seeder and for this reason seed is not only expensive but difficult to obtain. The plant, however, roots rapidly from cuttings and may be propagated by this means.

Stem cuttings, about 2 feet long, should be taken from mature shoots and planted at distances of about 3 feet apart each way on clean land. It requires approximately ten sacks of cuttings to plant up an acre. The cuttings root very readily and in about three or four months a very fair cover about 6 to 9 inches deep is formed.

Although growth is somewhat slow at first a thick dense cover is eventually formed.

General.—As previously mentioned, this cover plant has only recently received attention, but it thrives exceedingly well under shade and should be of considerable value on this account.

This cover plant has been recently observed growing under the dense shade of old rubber on a clayey type of soil where the Sarawak bean failed to become established. In this instance a system of selective weeding was previously adopted and resulted in the *Pueraria* entering the area, eventually forming a very effective cover.

MIKANIA SCANDENS.

Description.—A twining herb belonging to the Natural Order *Compositae.* Leaves opposite, 1 to 2 inches long. Flowers whitish, small and inconspicuous, produced in heads 2 inches wide. Seeds extremely minute and so light that it is almost impossible to collect them.

Habitat.—The plant is indigenous to Malaya, where it is commonly found twining over shrubs and low-growing trees on the edges of jungle up to an elevation of 4,000 feet.

It is known in this country under the following native names :– "Akar lupang", "Cheroma" and "Akar ulam tikus."

Soil Conditions.—This possible cover plant will grow successfully on almost any type of soil and is frequently met with as a weed on estates. Its advantage lies in the fact that it can often be established on comparatively poor soils on which other cover plants have failed.

Propagation.—Owing to the great difficutly in collecting seed the plant is always propagated from cuttings, which are taken from the mature stems. The cuttings should be about 1 foot in length and planted at distances of from 5 to 10 feet apart, requiring approximately one sack of cuttings per acre when planted at the former distance.

Providing the weather conditions are suitable, the rooted cuttings spread with extraordinary rapidity and within three to four months from planting the plants will have completely covered the land to a depth of about 1 foot. On account of its rapid growth it has been described as "the mile-a-minute plant".

General.—Owing to the twining nature of the plant all weed growth is entirely checked. If employed as a cover among crops which branch near the ground, care should be taken to prevent it climbing over the young plants.

The plant is capable of withstanding long periods of drought and will thrive well under light shade.

In view of its remarkably rapid growth and the very close mat of cover which it quickly forms over the surface of the ground, *Mikania scandens* will suppress all weeds, a factor to be considered when the reduction of weeding costs is one of the main objects. When the plant is cultivated on young clearings great care should be taken to keep it well away from the roots of the main crop; otherwise it may enter into serious competition with the latter for available supplies of plant food. Although *Mikania* is so strong growing it can be very easily eradicated at comparatively little cost, if desired.

This cover plant is a non-leguminus one and therefore has not the power attributed to leguminous plants of collecting nitrogen from the atmosphere, but its dense growth produces a large quantity of organic matter, which will prove useful in enriching soils deficient in humus.

MIXTURES OF COVER PLANTS.

Having described the merits of the respective cover plants when grown singly, attention should be drawn to the possible advantages of planting a combination of two or more cover plants.

In practice, it will be found that certain cover crops produce comparatively rapid growth at first, but gradually die off, while others which show somewhat slow growth at the commencement eventually produce a more permanent form of cover, thus taking the place of the less permanent one. An example of this is to be found in the case of a mixture of *Calopogonium mucunoides* with *Centrosema pubescens*, the latter gradually replacing the former. Further, plants such as *Calopogonium mucunoides* and *Centrosema pubescens*, which are not tolerant of dense shade, make excellent growth in the open, while such plants as *Pueraria phaseoloides* and *Dolichos Hosei* will thrive almost as well in the shade as in the open.

Excellent results have been obtained on young oil palm clearings with a mixture of *Calopogonium mucunoides*, *Centrosema pubescens* and *Pueraria phaseoloides*. In such a mixture the seeds of *Calopogonium mucunoides* and *Pueraria phaseoloides*, being about the same size, might be mixed together before sowing, but the larger-seeded *Centrosema pubescens* should be sown separately in order to ensure a more even distribution of the different cover plants comprising the mixture.

(B). ERECT-GROWING TYPES SUITABLE AS GREEN MANURES.

The erect-growing or bushy types of leguminous plants are cultivated principally for the purpose of providing large quantities of organic matter and when the plants are periodically cut back and the fresh prunings dug into the soil they are known as green manure crops.

When the green material is turned into the soil it not only increases the amount of humus, but in the process of decomposition has the effect of liberating the dormant mineral constituents of plant food, such as phosphoric acid and potash already present in the soil, and rendering them more readily available for the main crop.

Although there is a wide range of leguminous cover plants which can be employed for this purpose, details are given below of the origin and method of cultivation of the two more permanent types which have proved most satisfactory for cultivation in Malaya :—

(1) *Tephrosia candida* (N. O. *Leguminosae*).

(2) *Crotalaria anagyroides* (N. O. *Leguminosae*.)

TEPHROSIA CANDIDA.

Description.—A bushy erect shrub attaining a height of 8 to 10 feet. Stems branching and covered with short hairs. Leaves pinnate, about 6 inches long, leaflets 1·5 to 2 inches long, 0·5 inch broad, hairy on the underside only, oblong with a small nerve point at the apex. Stipules small, narrow. Flowers in racemes, 4 inches long, flowers large, 1 inch long, colour white, numerous on the raceme. Pod 3·6 inches long, 0·3 inch broad, hairy, narrow, 10 to 12-seeded. Seeds small, flattened, olive green in colour, about 0·2 inch long and 0·15 inch broad. The number of seeds per pound is about 26,000.

Habitat.—This shrub is a native of tropical Asia, and is commonly known by the name of "Boga medaloa". It has been a favourite green manure in India and Ceylon for many years and is also well known in Malaya. The plant is very robust and thrives well at all elevations from sea level up to about 5,000 feet.

Soil Conditions.—Tephrosia candida grows well on almost all types of soil, but is liable to die out prematurely on very dry land. It is well suited to the alluvial soils of the coast, where it forms dense growth. On inland soil, however, its habit is less vigorous and in exposed positions on poor land it dies out within three years, especially if pruned periodically.

Propagation.—As this plant is usually employed as a green manure amongst such crops as rubber, coconuts, oil palms, tea and coffee, it is obvious that the distance of sowing will vary according to the permanent crop. At the Government Plantation, Serdang, this green manure has been extensively used amongst a variety of crops. On an area of limes, planted 20 feet by 20 feet triangular, two rows were sown between the limes, requiring 5 lb. of seed per acre. On an area of oil palms, planted 28 feet by 28 feet triangular, seed of this legume was sown in rows of 3 feet apart there being seven rows between the rows of palms. From 9 to 10 lb. of seed were sown per acre in this instance. When used as a green manure amongst coffee, planted 10 feet by 10 feet apart, one row between the coffee was found sufficient. On open land, when sown thinly in rows 5 feet apart, about 6 to 7 lb. of seed are required per acre and under favourable conditions germination may be expected within about one week. The most suitable time for establishing this plant is at the commencement of the rainy period when the land is usually free from weeds.

Within about four months from sowing the seed, the plants average 3 to 5 feet high and begin to shade the land. The plants commence to flower at six months and, when in full bloom, they should be pruned to within 1½ feet from the ground. If pruned too low they are liable to die back. The plant is at all times very impatient of severe treatment. Pruning should not be undertaken during the dry seasons for this reason. Further pruning may be done as the plants increase in size, preferably when they commence again to flower freely. The reason for this is that in formation of seeds there is a heavy drain on the food meterials absorbed and manufactured by the plant. On average land the plants will live for four years or so and should be pruned at least twice a year.

General.—In most districts it is a difficult matter to collect seed of *Tephrosia candida,* though large quantities are formed. This is due to the depredations of a small Platyrrhinid beetle (*Araecerus fasciculatus*), which lays its eggs in the immature pods. The eggs hatch in the pods and the larvae feed on the seeds causing, in most instances, destruction of the entire contents of the pod.

A possible objection to the use of this legume on young rubber clearings is that on account of its woody habit of growth the plant is liable to harbour pink disease (*Corticium salmonicolor*), particularly if the development of the plant is not restricted by periodical pruning.

Tephrosia candida attains its maxium development in full sunshine, but will thrive well under light shade. This is specially so when grown with coconuts and oil palms. Under rubber, the plants rapidly weaken as the overhead shade increases. It is in much favour in Sumatra as a light shade and green manure for tea. When employed for this purpose the plants are grown as standards and allowed to spread out when about seven feet high so as to form overhead shade. When grown as a hedge plant between rows of young coffee it forms an excellent windscreen.

This legume is a valuable plant on account of the large amount of green matter added to the soil both from prunings and from decaying leaves. The leaves which continually fall from the plant during its growth take a long time to decay, so that they form an excellent soil cover, thereby restricting the growth of weeds.

Experiments were carried out at the Government Experimental Plantation, Serdang, with *Tephrosia candida* planted as a green manure on two one-acre plots of oil-palms. The first pruning was made at 6 months and two subsequent prunings at intervals of three months and on each occasion the plants were cut back to within about two feet from the ground. The result of this trial showed that the average yield of freshly cut prunings of *Tephrosia* per plot was 14,380 lb. during the first year of growth, *i.e.*, from the date of sowing the seed.

In another set of trials conducted at Serdang, with *Tephrosia candida* grown as a sole crop on a smaller area and under better soil conditions, the plants were cut back to within three feet of the ground at intervals of six, nine and twelve months respectively. The total yield of fresh prunings in this experiment was 26,880 lb., per acre during the first year of growth.

In order to obtain the full benefit of this plant, or any other green manure, the fresh prunings should be dug into the soil. When the operation is being performed a small quantity of air-slaked lime added to the soil will often give beneficial results.

Tephrosia candida is a robust plant which can withstand fairly frequent pruning and is therefore capable of adding large quantities of organic matter to the soil. These excellent qualities, combined with the fact that the plant is comparatively long-lived, make it one of the most suitable for use as a green manure.

CROTALARIA ANAGYROIDES.

Description.—A tall, bushy, erect shrub reaching a height of 12 to 14 feet. Stems woody at the base, branching above, covered with minute hairs. Leaves trifoliate, leaflets 3 to 3·5 inches long, 1·25 inches broad, slightly hairy on the undersides, smooth on the upper, oblong with a small nerve point at the apex. Stipules minute. Flowers in racemes, 10 to 12 inches long, flowers 0·75 inch long, colour pale yellow with a few black streaks on the standard, numerous on the raceme forming an oblong head. Pod 1·50 inches long, 0·60 inch broad, flattened with a point at the apex, covered with short pale hairs, containing about 16 seeds. Seeds flattened, 0·20 inch long, 0·15 inch broad, brown in colour. The number of seeds per pound is about 24,000.

Habitat.—This shrub is a native of Central and South America, and is of comparatively recent introduction to the East Indies. A supply of seed of this plant was obtained from the Department of Agriculture, Buitenzorg,

at the beginning of 1924 for trial at Serdang. The results of this trial showed that it thrives well in Malaya and is the most luxuriant of the shrubby leguminous cover plants so far introduced. Although the plant is more suited to the plains it can be grown successfully at elevations up to 5,000 feet above sea level.

Soil Conditions.—This plant grows well on the majority of soils, but makes most vigorous growth on sandy loams of a good depth. Where drainage is deficient growth is retarded and the plants gradually die out. It is particularly valuable on account of its deep-rooting habit, which assists materially in breaking up the lower layers of subsoil.

Propagation.—As in the case of *Tephrosia candida* the distance of sowing depends on the permanent crop under cultivation. On open land the seeds may be sown thinly in rows five feet apart, requiring 5 to 6 lb. of seed per acre. This plant is being used at the Experimental Plantation, Serdang, as a green manure amongst coffee, planted 10 feet by 10 feet square, one row of the legume being planted between each row of coffee.

The plant makes very rapid growth and attains a height of 6 feet at the end of three months, while flowering usually commences within a period of three to four months from germination of the seed. Pruning should be undertaken when the plants are in full bloom, but before the first pods begin to form and again as often as the plants become sufficiently dense, which may take from three to four months according to the season. Although this *Crotalaria* is frequently stated to be of superior constitution to *Tephrosia candida* it appears to die out more readily than the latter when the plants are heavily pruned.

General.—Though the seeds are often attacked by insect pests considerable quantities of sound seed are produced and there is usually no difficulty in securing a sufficient supply of seed in this country. The plant produces seed most abundantly when grown in full sunlight; consequently when seed production is the main object it should be planted on open land. Under such conditions, the plant will commence to produce seed within about six months from the time of sowing. After the plants have been allowed to seed freely for a period of about three to four months they should be cut back to within 2 feet from the ground, preferably at the beginning of a wet season. If this practice is followed a good supply of seed may be harvested from plants up to at least two years old.

Experiments were conducted at the Experimental Plantation, Serdang, with *Crotalaria anagyroides* planted as a green manure on two one-acre plots of oil palms. The first pruning was made at three months and three subsequent prunings at intervals of three months, on each occasion the plants being pruned back to within about 2 feet from the ground. The result of this trial showed that the average yield of fresh prunings was 27,156 lb. per plot during the first year of growth, *i.e.*, from the date of sowing the seed.

It is interesting to note that in this particular trial *Crotalaria anagyroides* was ready for pruning within a period of three months from sowing the seed, whereas the slower growing *Tephrosia candida* was not ready for pruning until six months old. On the other hand *Crotalaria* was beginning to suffer from the effects of the excessive pruning at the end of a year, while *Tephrosia* was still growing vigorously.

In further trials carried out at Serdang with *Crotalaria anagyroides* grown as a sole crop on a smaller area and under slightly better soil conditions, when the crop was cut back to within 3 feet from the ground at intervals of six, nine and twelve months respectively, the total yield of fresh prunings was 33,120 lb. per acre during the first year of growth.

Allowing for 75 per cent. of moisture in the fresh prunings the above yield would be equivalent to 8,280 lb. of dry matter per acre per annum.

The principal advantages of *Crotalaria anagyroides* are that it grows remarkably well under varying conditions of both soil and climate and can withstand comparatively long periods of drought. Further, it grows very rapidly and produces large quantities of organic matter, which when periodically dug into the ground not only serves to improve the physical condition of the soil but materially to increase its nitrogen content, thereby benefiting the permanent crop.

CONCLUSIONS.

Although the low-growing or creeping types of cover plants are cultivated primarily for the prevention of soil erosion, the additional advantages which may be derived from periodically digging such plants into the soil as a green manure should not be overlooked. The main object is, however, the first consideration, so that on steep land liable to soil wash only alternate strips of the cover plant should be treated for the purpose of green manuring. A few weeks later the areas so treated should either be replanted with the same or, better still, another species of cover plant.

The cultivation of the erect types of cover plants with the periodical digging of the prunings into the soil with the object of improving its fertility is an entirely different matter. By this means several tons of dry matter are added to the soil at each pruning, thereby increasing the amount of plant food in the soil and at the same time improving its physical condition by supplying large quantities of organic matter. In order to obtain the full advantage of a green manure crop it is essential that it should be pruned and dug into the ground when in full bloom and before the seed pods begin to form.

The seed rates as recommended in this article represent the minimum quantities which are required to plant up an acre when the shortage of seed necessitates a certain amount of economy in this connection, but, in cases where a plentiful supply of seed is available at a comparatively low cost, a cover will be formed more quickly by increasing the seed rate per acre.

Considerable difficulty is frequently experienced in establishing a cover plant under the dense shade of old rubber and this is generally due to the fact that the surface feeding roots of the rubber trees are in serious competition with the young cover plant for available supplies of plant food. This difficulty can sometimes be overcome by the addition of small quantities of either cattle manure or artificial fertilizers at the time of planting.

It should be pointed out that it is quite impossible to make any definite recommendations as to the most suitable cover plant for the varying conditions of types of soil which are to be found on different estates. What will suit one particular estate may not suit another; consequently the selection of a cover plant is a matter which can only be decided by establishing small experimental areas of the more promising cover plants on the individual estate.