

On the Value of Some Legumes

BY

W. R. C. PAUL

PERADENIYA

FROM earliest times leguminous plants have played an important role in agriculture. They have long been recognised as of value in providing the three essential requirements of food, forage and fertility maintenance. Two of the oldest crops in the world are lucerne, a forage legume which was first grown in South-Western Asia and soya beans, a pulse of great antiquity in China. In the West, the establishment of a rotation with the introduction of a leguminous crop at regular intervals laid the foundation for intensive agriculture and in the tropics legumes formed a useful component of mixed cropping. During the present century legumes have been introduced to aid soil conservation and to provide protection against insolation and wind for permanent crops like tea and cacao though the practice in coffee is quite old (11). Individual species are also grown for particular purposes, e.g., sunnhemp for fibre and groundnuts for oil.

In the monsoon tropics, high temperatures and heavy rains bring about considerable losses of soil nitrogen through denitrification and leaching when the vegetational cover—the forest climax—is removed, and permanent or annual crops are grown in succession. On undulating and high lands where drainage is unimpeded, further losses take place as a result of the lateral movement of water and soil when no restriction is offered.

Nitrogen can, however, be regained through the agency of leguminous plants. Following on the discovery in 1886 that nitrogen from the air within the soil can be fixed by the symbiotic bacteria (*Rhizobium* species) which exist in the nodules on the roots of most legumes, methods are being investigated by which greater use can be made of this important family of plants in different agricultural systems. There is a greater preponderance of legumes in the tropics and there are many species of forage and green manure value whose suitability for cultivation under various methods in different tropical countries has not been fully explored.

All leguminous species do not form nodules and therefore do not produce nitrogen. Two commonly occurring species on waste land, chiefly in the dry zone areas of Ceylon are *Cassia occidentalis* Linn. (Singh. *peni tora*, Tam. *ponnantakarai*) and *C. tora* Linn. (Singh. *peti tora*, Tam. *vadda* or *pandi takarai*) and in these nodules are not formed. On the other hand, *C. absus* Linn. (Singh. *bin tora*) a species of similar habitat but of much less frequency and *C. leschenaultiana* D. C. a weed which occurs on waste places in the wet zone nodulates freely. Species also vary in the efficiency of nodulation.

The quantity of nitrogen added to the soil in the case of the large majority of nodule forming legumes is quite considerable and may vary between 100 and 150 lb. of nitrogen and even more, depending on the degree of nodulation, the quantity of foliage and the density of the stand. Half the nitrogen in the plant is assumed to come from the soil and the other half from the air though the relative amounts taken up from the soil and the air vary with the legumes. The percentage of nitrogen in the roots is 1.4 to 2.3 and in the leaves 2.10 to 4.84 based on the dry matter at 100° C. The leaves contain about 4 to 5 times the quantity in the stem. As pointed out by McKee (12) since about one third of the total nitrogen of most legumes is in the roots over half the nitrogen added to the soil would be taken from the air in the case of those crops which are used for forage and for seed, where part of the tops would be returned to the soil. Legumes which are to be grown for forage and as green manures should be leafy and should be utilised before the stems become woody.

There are two morphological types of leguminous plants which are grown for the improvement of soil fertility as well as for checking soil erosion. These are the trailing or ground covers and the erect or bush covers. Forage legumes as well as those grown as beans or pulses in mixture with arable crops may also be trailing or erect types.

Trailing Covers.—This type of cover is mostly herbaceous and it protects the soil from the impact of heavy rain and insolation by the close growth produced along the surface of the soil. Weeds are smothered and leaching prevented. Humus is added to the soil by the decomposition of the roots, leaves and stems, microbial activity is encouraged and crumb structure improved. These covers are useful on sloping land under permanent crops especially during the early period in the establishment of the latter. Their value lies in their ability to form a complete cover quickly and to remain on the land without dying out either in patches or altogether. Resistance to pests and diseases is desirable, particularly to eelworm disease caused by the root knot nematode (*Heterodera marioni*) (Cornu) Goodey and to attacks of aphides, bugs and the flea beetle (*Longitarsus* sp.) on the leaves.

The popular perennial species are *Calopogonium mucunoides* Desv. and *Pueraria phaseoloides* (Roxb.) Benth. (tropical kudzu) for coconut plantations and *Desmodium ovalifolium* Wall for rubber. *Indigofera endecaphylla* Jacq. was regarded some years ago (2, 3, 5) as a promising cover for tea but it did not subsequently fulfil this expectation partly because the shoots tend to grow through the tea bushes and the cover itself could not survive under the low shade obtained under well-established tea. So far no satisfactory leguminous ground cover has been found for tea nor indeed is it necessary with a close stand of bushes. In the observation plots at the Experiment Station, Peradeniya, a strain of *Pueraria phaseoloides* received some years ago from South India is markedly superior to one received from the Philippines and to the local variety as well as to *Calopogonium mucunoides* in vigour of growth, size of leaves and quantity of green material produced. Under the conditions of greater shade provided by rubber, *Desmodium ovalifolium* is a more satisfactory crop.

In arable cropping, certain annual trailing varieties of cowpea (*Vigna sinensis* Linn.) which grow rapidly and produce a dense leafy growth are



PHOTO 1.—Plants of *Crotalaria brownei* Bertol.



FIG. 1.—*Crotalaria brownei* Bertol showing leaves, flowers and pods.

of value as a green manure and forage crop to be grown in rotation with other crops. The leaves and vines make good roughage but unfortunately this legume is susceptible in certain seasons to attacks of the bean fly (*Agromyza phaseoli* Coq.), to aphides and to wilt disease caused by *Sclerotium rolfsii* Sacc. A variety which is reported to produce much green material received from the Council of Scientific and Industrial Research, Australia, is under trial at the Experiment Station, Peradeniya. Other legumes used in this way in the tropics and also as a cover crop in orchards are *Mucuna aterrima* Holland (*Stizolobium aterrimum* Piper and Tracy) or the Bengal bean, *M. deeringiana* (Bort.) Holland (*S. deeringianum* Bort.) or the Florida velvet bean and *Canavallia ensiformis* D. C., the trailing variety of the sword bean, there is the likelihood from preliminary trials that the first species will be superior to cowpeas in vigour of growth and resistance to pests and diseases.

Erect Covers.—The erect types are woody or semi-woody when a few months old and are mainly grown in contour strips in young plantations of permanent crops. They are used as green manures by periodically lopping the tops and turning these into the soil between the rows of the crops. They provide temporary shade for newly planted permanent crops and afford protection against the lateral movement of soil by serving as a barrier which acts as a sort of filter for the excess water. The species included in this category reach a height of 4-10 feet and generally become woody or semi-woody after about 4 months' growth. When the base of the stems tend to be woody or the plants die back after several loppings they should be uprooted. Sunnhemp (*Crotalaria juncea* Linn.) is a popular green manure in rotational cropping and is the least woody of the *Crotalaria*s. It is short-lived, sheds its leaves and dies down after the formation of its pods. It is quick growing, but being a small plant a close stand is necessary and consequently a high seed rate—40 lb. per acre for seed production and 60 lb. per acre for green material (7). This legume is badly attacked by the bug (*Ragmus importunitas* Dist.) which causes scarring and discolouration of the leaves to such an extent as to reduce considerably the yield of green material and seed production under conditions at Peradeniya.

There are several other species of *Crotalaria* which produce a large quantity of leafy material but are not as quick growing in the early stages. The two popular species for plantation crops are *Crotalaria usaramoensis* Baker and *C. anagyroides* H.B.K. In observation plots at the Experiment Station, Peradeniya, these two species were grown along with a number of other species of *Crotalaria*, *Tephrosia* and *Desmodium*. Amongst the *Crotalaria*s under study, the species which gave the heaviest foliage and showed marked resistance to attack of the leaves by the bug *Ragmus importunitas* Dist. and the flea beetle (*Longitarsus* sp.) was *C. Brownei* Bertol. The other species which are listed in order of decreasing susceptibility to *Ragmus* are *C. juncea* Linn., *C. grahamiana*, W. and A., *C. anagyroides* H. B. K., *C. usaramoensis* Baker, and *C. striata* D. C. (= *C. mucronata* Desv. of American authors).

C. Brownei is an indigenous species which has a good branching habit and grows to a height of 6-8 ft. before flowering especially on soils which have been treated with phosphates (Photo 1). It has large trifoliate leaves, dark bluish green in colour, the terminal leaflets being slightly larger than the other two (Fig. 1). The leaflets are oblong-acute in shape, 8-11 cm. long and 4-7 cm. broad, with a mucronate tip. The flowers are yellow without

any striations on the standard petal, and are borne on moderately dense racemes. The pods are slender, light brown and glabrous. Flowering commences in 4 months' time and seed can be collected about a month later. Nodulation is efficient. The plants can be lopped several times. The *Crotalaria*s are with the exception of *C. juncea* Linn. known to be resistant to eelworm attack and are able to grow according to McKee (12) on poor acid soils.

Two other bush legumes which produce a large quantity of leafy material are *Desmodium gyroides* D. C. and *Tephrosia vogelii* Hook.

D. gyroides is an indigenous plant which can grow to a height of 9 ft. before flowering on good soils (Photo 2). It has large trifoliate leaves, the terminal leaflets being much larger than the other two (Figs. 2 and 3). The leaflets are ovate-elliptic, obtuse, the terminal leaflets measuring 5.5-7.5 cm. long and 3.8-4.5 cm. broad. In the young plant the leaves, are simple. A characteristic red blotch appears on the stipules. In the early stages, growth is slow. Flowering commences in about 5½ months' time, the flowers being pale blue in colour. A heavy foliage is produced which is quite free from any pest attack. It has so far not been found to be susceptible to eelworm disease. A long tap root is produced even in the young plants. Nodulation is not vigorous through it takes place quite early. Some stems tend to grow outwards from the base in the young plants and these develop adventitious roots at the nodes where they touch the soil. The plant can be propagated both from seed and cuttings. It is palatable to stock.

T. vogelii was introduced in 1921 and is found to be the most satisfactory species amongst the *Tephrosias* examined. Its leaves are imparipinnately compound, the leaflets being narrowly oblong-elliptic, obtuse, 5.5-8.5 cm. long and 1.5-2.5 cm. broad (Fig. 4 and Photo 3). They are thick but soft in texture and soon decay on falling to the ground. The stems and leaves are covered with brown hairs. The plants grow more rapidly than *D. gyroides* and on good soils reach a height of 10 ft. before flowering. Large white flowers (Photo 4) are produced in about 5 months' time. This species provides a much larger quantity of green material than any of the other *Tephrosias* under observation, viz., *T. candida* D. C., *T. noctiflora* Boj. ex. Baker, *T. toxicaria* Pers., *T. villosa* Pers. and *T. purpurea* Pers. The pods of *T. vogelii* are much larger than those of *T. candida* and unlike the latter are free from insect attack. The roots are, however, susceptible to eelworm disease.

These three bush legumes, *Crotalaria Brownei*, *Desmodium gyroides* and *Tephrosia vogelii* are recommended for planting in contour hedges in the wet zone up to an elevation of about 2,000 ft. in tea, coconuts and young rubber and on arable land and home gardens.

Forage and Pasture Legumes.—The stems and leaves of legumes have a much higher protein content than grasses. They are also rich in calcium and are fairly well supplied with phosphorus and the vitamins A and D. Species which are palatable to stock and have no toxic effect are used either on the soiling system whereby they are cut as green fodder and fed direct or after turning into hay or silage to livestock or are grown mixed with grasses in pastures which are subject to intermittent grazing. Lucerne is the most valuable forage crop in western countries and in Australia. It is capable



PHOTO 2.—Plants of *desmodium gyroides* D. C.

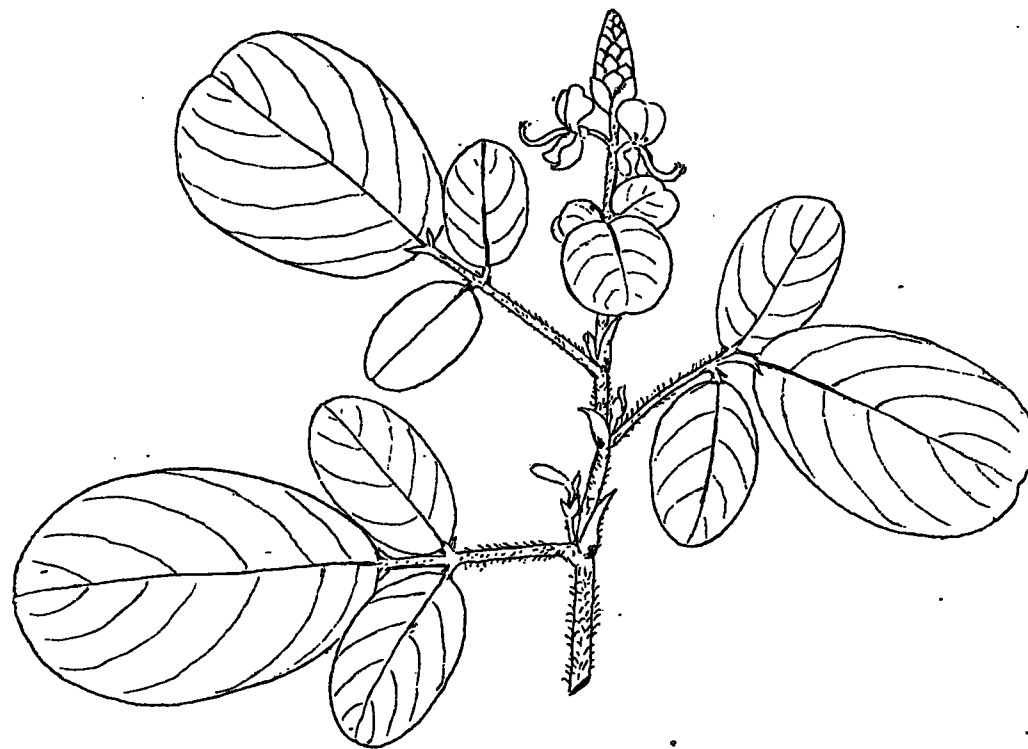


FIG. 2.—*Desmodium gyroides* D. C. showing leaves and terminal inflorescence.

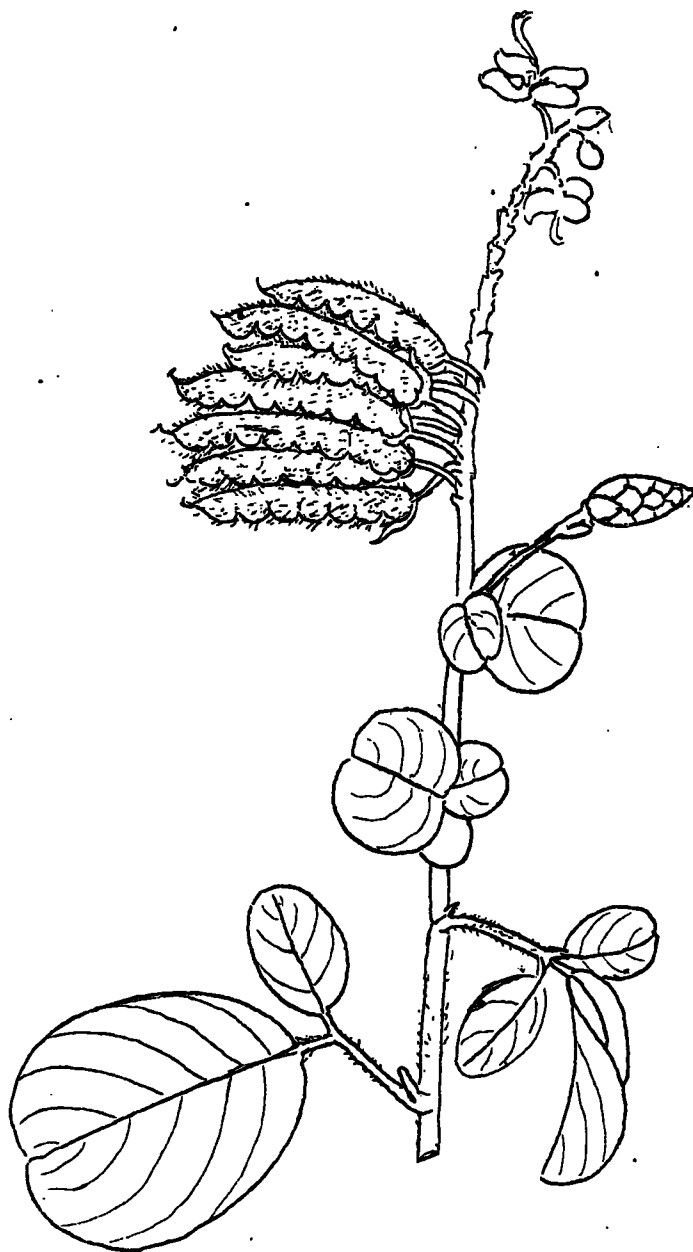


FIG. 3.—*Desmodium gyroides* D. C. showing development of pods.



FIG. 4.—*Tephrosia vogelii* Hook showing leaflets, flowers and pods.



PHOTO 3.—Plants of *Tephrosia vogelii* Hook.



PHOTO. 4.—*Tephrosia vogelii* Hook with terminal inflorescence



FIG. 5.—*Indigofera endecaphylla* Jacq. showing leaves, inflorescence and pods.

of rapid growth and gives several cuts of highly nutritious fodder a year. It makes a good hay crop and is also used as silage as well as, more recently, in pastures. But it is a heavy feeder and requires liberal applications of lime, phosphate and potash. Lucerne has been successfully grown in observation plots at the Experiment Station, Peradeniya, and has produced seed. Trials are in progress to compare the total quantity of green fodder as well as of hay that can be produced a year in comparison with other legumes which grow well at this Station and are palatable to stock such as *Stylosanthes gracilis* H. B. K., *Desmodium ovalifolium* Wall and *D. gyroides* D. C. Stylo is a legume which grows remarkably well even on poor laterite soils and a considerable improvement in the structure of the soils can be observed after this legume has occupied the land for a number of years. It is a useful pasture legume (9) but it can also be cut and fed as green fodder. *Lespedeza* has been tried and though it seeds and germinates satisfactorily it does not grow much above a height of 4 in. and therefore is of little use.

When the tall fodder grasses such as Guinea (*Panicum maximum* Jacq.) and Napier (*Pennisetum purpureum* Schum.) are grown for soiling purposes the nutritive value of the forage can be greatly improved by interplanting perennial legumes which are palatable to stock and can withstand periodic cutting. The soil as well as the grass will benefit by the association. The legumes previously recommended for pastures in the wet lowlands (9) are also suitable for planting between the rows of fodder grasses. Another legume *Indigofera endecaphylla* Jacq. (creeping indigo) (Fig. 5) has been found valuable both in mixture with fodder as well as pasture grasses. This legume was observed growing in swards along the banks and edges of the arable fields and roadside verges at the Experiment Station, Peradeniya, in mixture with the local grasses such as *Axonopus compressus* (Swartz) Beauv., *Digitaria sanguinalis* (L) Scop., *Cynodon dactylon* Pers., *Eleusine indica* Gaertn., and *Dactyloctenium aegyptium* (L) Richt. These strips have been frequently slashed as well as grazed and the *Indigofera* has persisted. It was, therefore, selected for planting in pasture blocks both in the open and under coconuts as well as in poultry runs in mixture with the grasses *Melinis minutiflora* Beauv. (Molasses grass) *Paspalum dilatatum* Poir, *Brachiaria distachya* Stapf. and *B. miliiformis* Chase, the other legumes being *Alysicarpus vaginalis* D. C. (Sinh. *Aswenna*) and *Stylosanthes gracilis* H. B. K. These pastures were subject to rotational grazing and the runs on which these grasses and legumes were established were maintained on the intensive system with fixed night houses as well as movable fold units. *Indigofera* has proved palatable to cattle, poultry, and pigs and it combines well with grasses and other legumes. No toxic effects were observed but according to a communication dated November 8, 1949, from O. R. Younge, Associate Agronomist in Hawaii, some toxicity was observed there in preliminary feeding and pasture trials with this legume when used as the sole or major source of roughage. It is possible that the variety grown in Ceylon belongs to a non-toxic strain. It is a common legume in grasslands in East Africa and in observations carried out on the palatability of some of the indigenous legumes there it was found to be wholly relished by cattle and sheep (1).

Indigofera endecaphylla produces long, slender, and slightly reddish stems which creep as well as climb on to other plants growing in proximity

to it. A deep tap root is developed and there are numerous adventitious roots at the nodes wherever the stems come in contact with the soil. The leaves are imparipinnately compound, the leaflets being 1.2-5 cm. long and .75-1.0 cm. wide numbering 7-9, arranged alternately. The flowers are small, purplish pink and are borne on a long stalk and the pods which are slender, cylindrical, and brown in colour are produced in clusters, each containing 6-9 seeds. The plant can be propagated both from seed as well as cuttings. Nodule formation is good. In an observation plot in which this was the sole species growing for a number of years, eelworm disease was detected but so far no attack has been observed in the plots growing in mixtures with grasses and other legumes. In view of the recent discovery by Timson in Southern Rhodesia and others that where the organic matter content of the soil is high, the nematode does not thrive because of the presence of predatory organisms and that dressings of green material, cattle manure or compost can effectively reduce the population of *Heterodera* it is unlikely that on pastures subject to grazing this disease will occur.

Intercalary Cultivation.—Certain legumes can be grown with advantage between the rows of a main annual crop. There are numerous instances of mixed cropping with legumes and non-legumes in peasant agriculture of tropical countries. The subject has been discussed by several writers (6, 11). In fact, with the exception of paddy, continuous monoculture does not obtain in peasant agriculture. The important claim now sponsored for mixed cropping with legumes is the availability of readily assimilable nitrogen provided by the legume to the non-legume growing in close association with each other. Nicol (6) has in addition pointed out the value of the biological contribution made by the legume to the soil. Amongst food crops, well-known mixtures are cereals and pulses. In the case of the intercalary cultivation of kurakkan (*Eleusine coracana* Gaerth) and green gram, a better total yield was obtained from the mixture than from the sum of the separate crops grown on the same unit of land (8).

Apart from these important considerations, intercalary cropping will result in a better cover of the soil, especially in the early stages of growth of the main crop. Protection is thus afforded to the soil against erosion, insolation and leaching and also microbial activity is encouraged. With the quick growing species weed growth can be kept down. It is desirable that the legume should germinate quickly and grow rapidly so as to form a cover which will effectively keep down weeds. If the legume is to be planted primarily for the protection of the soil then it should be sown broadcast between the rows but if the production of beans is the main consideration then it is best drilled in rows at a suitable spacing depending on the distance between the rows of the main crop. In the case of erect legumes if the plants grow too tall and tend to interfere with the growth of the main crop then they can be cut down to ground level and the loppings used as a mulch between the rows. In this way continued protection can be given to the soil and weeds suppressed. In addition, a mulch of green material will be effective in dry weather in retaining moisture below it. The more resistant the material to decay, the more valuable it becomes from this point of view. It was found that a mulch of bamboo leaves spread between the rows of crops like chillies and brinjals considerably extended their growth periods and the production of

fruits. Legumes differ in the rate of decay of their leaves, e.g., *Desmodium gyroides* has leaves which are much more resistant to decay than *Tephrosia vogelii*.

The study of a number of legumes was taken up for their suitability for intercalary cultivation between the rows of such arable crops as cereals, chillies, brinjals, manioc, and the large-leaved yams (*Colocasia esculenta* (L) Schott and *Xanthosoma sagittifolium* (L) Schott. The legumes include bean and green manure trailing and erect crops. Those which are most promising are soya beans and the erect varieties of cowpeas amongst the bean crops, *Crotalaria Brownei* and *Tephrosia vogelii* amongst the erect green manure crops. It was found that the large seeded bean crops grow more rapidly in the early stages than the green manures. This is an important consideration in weed control, but the bean crops mature early and then die down while the late maturing green manures form a more effective cover in the later stages. It is possible that a mixture of the early maturing and late maturing legumes may give better results. There is much work to be done on this subject of intercalary cropping. The choice of suitable legumes, the method of sowing, the time of sowing, and the method of treatment are questions that have to be determined for each main crop. It should be stressed that the protection of the soil for as long a period as possible by legumes which will not interfere with the growth of the main crop but which will benefit it by contributing to the fertility of the soil should be the main objective in intercalary cropping. Fallow periods between two main crops in a rotation should be avoided or reduced to a minimum. When one main crop is over the intercalary legume can cover the ground or form with it a stubble mulch. In this way, the legumes function as protective crops. Preparatory tillage operations for the next season can be confined to disc harrowing the stubble, ploughing being omitted altogether. This system has been adopted at the Experiment Station, Peradeniya, and is held to be valuable in maintaining soil fertility.

SUMMARY

There are in the tropics numerous legumes whose value for forage and green manure purposes has still to be studied. The perennial trailing varieties are useful as ground covers for certain permanent crops. A strain of *Pueraria phaseoloides* (Roxb.) Benth. from India was found superior to one received from the Philippines and the local variety. Under the conditions of greater shade provided by rubber, *Desmodium ovalifolium* D. C. is more satisfactory. No suitable legume as a ground cover has been found nor is considered necessary in well-established tea. In arable cropping, annual trailing crops are of value to be grown in rotation with other crops. So far, the cowpea is the most satisfactory although it is susceptible in certain seasons to attacks of the bean fly (*Agromyza phaseoli* Coq.), to aphides and wilt caused by *Sclerotium rolfsii*.

Amongst the erect legumes, Sunnhemp (*Crotalaria juncea* Linn.) is the most satisfactory in rotational cropping but at Peradeniya it is badly attacked by the bug (*Ragmus importunitas* Dist.). For planting in contour strips the later maturing but more woody species which have been found most suitable are *Crotalaria Brownei* Bertol., *Tephrosia vogelii* Hook, and

Desmodium gyroides D. C. The first two are efficient in nodulation and are quick growing but the last produces a large quantity of leafy material which is more resistant to decay.

As regards forage legumes, *Indigofera endecaphylla* Jacq. has given evidence of being the most satisfactory. It can be grown in pastures as well as interplanted with fodder grasses. It is palatable to cattle, poultry and pigs and no toxic effects were observed.

The intercalary cultivation of a legume between the rows of a main annual crop is desirable in the tropics. Apart from the contribution of nitrogen by the legume to the associated crop, protection is afforded to the soil against erosion, insolation and leaching. Microbial activity is encouraged and with quick growing legumes which produce a dense growth weeds can be suppressed in the early stages. In the case of erect legumes, if the plants grow too tall and tend to interfere with the growth of the latter they can be cut down and the loppings used as a mulch between the rows. There is much work to be done in this subject. For the present it can be stated that amongst the early maturing legumes soya beans and cowpeas are suitable and for the late maturing species *Crotalaria Brownei* and *Tephrosia vogelii* are the most promising.

LITERATURE

1. Bogdan, A. V.—Observations on palatability of some leguminous plants of Kenya. The East African Journal, Vol. 15, No. 1, 1949.
2. Holland, T. H.—A trial of *Indigofera endecaphylla* in tea at Peradeniya. The Tropical Agriculturist, Vol. 79, No. 9, 1932.
3. Holland, T. H.—Experience in the use of creeping crops in tea cultivation with special reference to *Indigofera endecaphylla*. The Tropical Agriculturist, Vol. 70, No. 5, 1928.
4. Hosaka, E. G. and Ripperton J. C.—Legumes of the Hawaiian ranges. Hawaii Agric. Experiment Stn. Bulletin No. 93, 1944.
5. Joachim, A. W. R.—*Indigofera endecaphylla* as a conserver of the fertility of tea soils at Peradeniya. The Tropical Agriculturist, Vol. 79, No. 9, 1932.
6. Nicol, H.—Mixed cropping in primitive agriculture. Empire Journal of Experimental Agriculture, Vol. 3, No. 10, 1935.
7. Paul, W. R. C.—A comparison of different seed rates of sunnhemp on the yield of green material and seed. The Tropical Agriculturist, Vol. 91, No. 12, 1938.
8. Paul, W. R. C. and Joachim, A. W. R.—Experiments on associated growth of leguminous and non-leguminous crops. The Tropical Agriculturist, Vol. 97, No. 5, 1941.
9. Paul, W. R. C.—Progress in pasture work in the humid lowland region. The Tropical Agriculturist, Vol. 104, No. 3, 1948.
10. A manual of green manuring. Department of Agriculture, Ceylon, 1931.
11. Leguminous plants in the tropics. International Institute of Agriculture, Rome, 1936.
12. Grasses. U. S. Department of Agriculture, Yearbook, 1949.