# EVALUATION OF LEGUMINOUS COVER CROPS AT KERAVAT, NEW BRITAIN

R. MICHAEL BOURKE*

## ABSTRACT

*An evaluation of 23 legume species and one non-legume as cover crops was carried out in a wet tropical lowland environment. Initially fortnightly and then monthly observations were made on crop performance for up to three years. Results of observations on 13 parameters are presented.*

Pueraria phaseoloides *was the best creeping species.* Calopogonium mucunoides *was also satisfactory.* Vigna unguiculata (*cowpea*), Stizolobium deeringianum (*velvet bean*) *and* Lablab purpureus (*lablab*) *were the best of the short-term creeping types. The best erect type was* Stylosanthes guyanensis (*Schofield stylo*). Flemingia congesta, Tephrosia candida, Crotalaria goreensis *and* Cajanus cajan (*pigeon pea*) *were the best of the shrubby types.*

## INTRODUCTION

The purpose of cover cropping is to provide a protective living cover on the soil and also to improve its chemical or physical status. The value of leguminous cover crops is widely known from temperate climates. Bourke (1974) and Kimber (1974) have expressed doubts about their usefulness in maintenance of soil fertility in arable farming systems in Papua New Guinea, although Bourke (1974) points out that leguminous crops have a role as grain crops, as cover and shade crops in plantations, in pastures and perhaps as a rotation crop with paddy rice.

There are currently numerous species and varieties of legumes potentially available for use as cover crops, and this study was commenced in 1970 to evaluate some of them in a wet lowland environment. It was commenced before I had begun to doubt the usefulness of legumes in arable farming systems.

Three recommendations for cover crops in the lowlands have been published previously. DASF (1954) recommended *Pueraria*, *Centrosema*, *Calopogonium* and *Vigna marina* as creeping legumes suitable as cover crops and green manure, and cowpea, mungo bean, *Crotalaria* spp., pigeon pea and *Tephrosia* as suitable erect species. In an evaluation of seven species and varieties as cover crops in the Markham Valley, DASF (1972, pp. 135-6) concluded that *Dolichos lablab* was the most suitable cover crop, with the Aurora variety of cowpea as second choice. In an observation trial with 11 entries in West New Britain, Mendham (1971) found *Pueraria phaseoloides* to be the most suitable legume cover crop for oil palms.

* Agronomist, Lowlands Agricultural Experiment Station, Keravat, East New Britain, Papua New Guinea.

## MATERIALS AND METHODS

The evaluation was conducted in two nearby areas on the Lowlands Agricultural Experiment Station at Keravat on New Britain. The climate is wet lowland tropical with an average annual rainfall of 2760 mm fairly evenly distributed throughout the year, although one or two dry months can be expected each year. The months May to October are on the average drier with more hours of sunshine per month. The soil in the trial area is derived from pumiceous tuff and is a sandy loam overlying sand. The evaluation areas were cleared of vegetation, mainly *Sorghum propinquum*, prior to preparation of plots.

Seed of 11 species used in the evaluation was sent to Mrs J. Hale on New Hanover for an evaluation there. Mrs Hale kindly provided notes on the performance of these and other species on New Hanover. They were grown there on a very sandy soil.

Twenty-three legume species were included, as well as two varieties of two of the species. One non-legume, *Acioa barteri*, was also evaluated. Each species or variety was planted in a single plot six metres square. Seed was broadcast and covered with a few centimetres of soil. Most were planted in November-December, 1970. Performance of some species was checked in later plantings. Planting rate varied with seed size and also availability. High planting rates were used to allow for poor germination and to enable the legumes to

compete with early weed growth. The species and varieties evaluated and planting rates are given in *Table* 1.

Grain producing species that normally would be grown on stakes to maximize grain yield were grown without support as the evaluation was primarily concerned with their performance as covers. It was originally intended not to weed plots, but irregular weeding was required in all plots to prevent the legumes from being overgrown by weeds, mainly *Sorghum propinquum* and *Mimosa invisa.* Despite this, some plantings were overgrown.

Initially fortnightly and then monthly observations were made on each plot until the death of the crop. Observations are continuing on a few perennial species three and a half years after planting. Crop vigour, ground cover, height of most plants, weed competition, amount of leaf fall, flowering behaviour, seed production and pest and disease problems were noted at each observation.

Growth vigour, ground cover, competition with weeds and leaf fall were classified as either very poor, poor, fair, good or very good. Maximum crop height is the maximum height attained by most plants in the plot. Period to full ground cover, apparent maximum growth, commencement of flowering, commencement of crop decline and death of crop were estimated from observations on ground cover, vigour and flowering behaviour. Full ground cover was taken to have occurred when all of the plot was covered by the species being evaluated.

## RESULTS

Results of the observations are presented in *Tables* 1 and 2 together with common name, whether edible grain is produced, and the planting rate used. Species are grouped according to their growth habit as either creeping, erect or shrub types.

## DISCUSSION

The ideal cover crop would have the following characteristics: It would be a fast grower, rapidly producing a good ground cover. It would be aggressive and able to compete with weed growth. Leaf production and litter fall would be high. It would seed freely producing an edible grain and it would be a perennial. It would not require inoculation with Rhizobium for effective nodulation and, finally, the crop would be resistant to pests and diseases. No one species is likely to fulfil all of these conditions, but some may fulfil most.

In general the faster growing species evaluated were short-lived, and the long-lived species were the slower growers. The creeping and erect species were generally faster growers than the shrubby types. Only amongst shrubby types was complete weed control found. The erect bushy species did not spread much and hence they did not provide such good competition with weeds. The shrubs all set seed freely. They were also less susceptible to disease, possibly because of their more open nature.

Each species is discussed individually below.

### CREEPING TYPES

*Calopogonium mucunoides.* Calopo grew well, formed a dense sward and produced a good quantity of leaf litter. It seeded freely only in dry periods. It is somewhat similar to puero but it is faster growing in the establishment phase and it is not as persistent as puero.

*Centrosema pubescens.* Centro performed very poorly. It was very slow to become established and never really competed with invading weeds. Mendham (1971) in his evaluation in West New Britain also found that it grew poorly and was not vigorous. On New Hanover, Hale found it competed poorly.

*Desmodium intortum.* Green leaf desmodium was slow to become well established and did not flower. Hale reported the same on New Hanover. Hill (1970) states that it is generally not suited to the lowlands.

*Glycine wightii.* The two glycine cultivars differed in the time taken to cover the ground, and flowering behaviour. Cooper covered the ground faster than Tinaroo but it suffered from severe weed competition (mainly from *Mimosa invisa*) and a completely weed-free cover was never established. Cooper glycine flowered but no seed was observed. Tinaroo was slower to establish a ground cover and it did not flower. Mendham (1971) also found that Tinaroo spread slowly and did not set seed. Both cultivars were very susceptible to grey leaf rot (*Rhizoctonia solani*) and at times large gaps appeared in the stands. For this reason they are probably not suitable for wet lowland conditions. Cooper glycine seems the better of the two evaluated as it is a faster grower and sets flowers.

*Plate* I.—A vigorous stand of puero (*Pueraria phaseoloides*)

Photo by author

*Lablab purpureus.* Lablab covered the ground quickly and produced a dense stand. It was not particularly persistent and was susceptible to grey leaf rot. It does not flower in the lowlands except under water stress conditions (Hill, 1967). It could be considered as a suitable short term cover crop. It is not as long-lived as puero, but lives longer than cowpea or velvet bean. In a cover crop evaluation in the Markham Valley (DASF, 1972, p. 135) lablab was the only species to maintain a complete soil cover throughout the duration of the trial. Its dry matter production was also greater than the other species.

*Macroptilium purpureum.* Siratro grew quickly and established a good cover. However it was overgrown by the creeper *Ipomoea bederifolia* after a few months, so its potential is uncertain. Mendham (1971) found that it grew well initially but later became sparse and badly infested with weeds. This would suggest that the Keravat experience was not unusual and that this species is not suited to this environment.

*Psophocarpus tetragonolobus.* Wing bean grown as a cover crop did not produce a good ground cover or much top growth. It is not suitable as a cover crop.

*Pueraria phaseoloides.* Puero was slow to become established, but once established it grew fast to produce a very good ground cover. It is a perennial. It is capable of climbing other species and is aggressive. It did not seed in this evaluation but it is known from other plantings at Keravat that it only seeds under very dry conditions. The crop is attacked by grey leaf rot, but is not particularly susceptible. In this evaluation it was the best of the creeping species.

*Stizolobium deeringianum.* Velvet bean grew rapidly and produced a good stand. It was a good competitor with weeds and climbed over taller species. Hale found it to be a slow starter

*Table* 1.—Observations on characteristics and behaviour of species

| Species | Common name | Edible grain produced | Planting rate kg/ha | Growth vigour | Ground cover | Competition with weeds | Leaf fall |
|---|---|---|---|---|---|---|---|
| *Creeping Types* | | | | | | | |
| Calopogonium mucunoides | calopo | no | 30 | good | very good | good | good |
| Centrosema pubescens | centro | no | 30 | poor | fair | poor | fair |
| Desmodium intortum | green leaf desmodium | no | 5 | fair | good | fair | good |
| Glycine wightii (syn. G. javanica) cv. cooper | cooper glycine | no | 30 | good | good | fair | good |
| Glycine wightii cv. tinaroo | tinaroo glycine | no | 15 | good | good | good | good |
| Lablab purpureus (syn. Dolichos lablab) cv. Rongai | lablab | no | 60 | good | very good | good | very good |
| Macroptilium purpureum (syn. Phaseolus atropurpureus) | siratro | no | 23 | very good | good | very poor (1) | good |
| Psophocarpus tetragonolobus | wing bean | yes | 60 | (2) | fair | poor | poor |
| Pueraria phaseoloides | puero | no | 30 | good | very good | good | very good |
| Stizolobium deeringianum (syn. Mucuna pruriens) | velvet bean | yes | 120 | very good | very good | good | fair |
| Vigna unguiculata (syn. V. sinensis) | cowpea | yes | 30 | very good | good | good | good |
| Vigna unguiculata sesquipedalis (syn. V. sesquipedalis) | yardlong bean | yes | 15 | very good | fair | poor | poor |
| *Erect Types* | | | | | | | |
| Glycine max | soya bean | yes | 30 | very good | good | fair | poor |
| Macroptilium bractearum (syn. Phaseolus lathyroides) | phasey bean | no | 30 | very good | good | good | fair |
| Stylosanthes guyanensis (syn. S. gracilis) | Schofield stylo | no | 30 | good | very good | fair | fair |
| Vigna radiata (syn. Phaseolus radiatus) | green gram | yes | 15 | very good | good | fair | poor |
| Vigna unguiculata (syn. V. sinensis) | poona pea | yes | 30 | very good | fair | fair | poor |
| *Shrub Types* | | | | | | | |
| Acioa barteri | — | no | (3) | very poor | good | poor | poor |
| Cajanus cajan | pigeon pea | yes | 60 | very good | good | good | fair |
| Crotalaria anagyroides | — | no | 30 | good | good | good | fair |
| Crotalaria goreensis | — | no | 30 | very good | very good | good | good |
| Flemingia congesta | flemingia | no | 50 | initially poor then good | very good | very good | good |
| Leucaena leucocephala (syn. L. glauca) cv. Niugini | leucaena | no | 15 | good | fair | good | poor |
| Sesbania punctata | — | no | 30 | good | very poor | very poor | very poor |
| Tephrosia candida | — | no | 30 | poor | very good | very good | fair |
| Tephrosia noctiflora | — | no | 30 | poor | good | fair | fair |

(1) Plot overgrown by the creeper *Ipomoea bederifolia.*
(2) Cowpea grew in plot and evaluation incomplete.
(3) Seedlings 3½ months old planted at 18 300 per hectare.

*Table* 2.—Observations on characteristics and behaviour of species

| Species | Maximum crop height | Seed Production | | Period from planting to: | | | | | Pest and disease problems |
|---|---|---|---|---|---|---|---|---|---|
| | | Frequency | Quantity | Full ground cover | Apparent max. growth | Flowering | Commencement of crop decline | Death of crop | |
| *Creeping Types* | | | | | | | | | |
| Calopogonium mucunoides | 30 cm | occasional | fair | 7 weeks | 2½ months | 6 months | 12 months | 20 months | |
| Centrosema pubescens | 10 cm | (6) | none | 6 months (4) | 6 months | 7 months | 10 months | 20 months | Infected by *Rhizoctonia solani* |
| Desmodium intortum | 50 cm | (5) | none | 3½ months | 5 months | (5) | 14 months | 24 months | Infected by *R. solani* |
| Glycine wightii cv cooper | 40 cm | (6) | none | 2 months | 4 months | 8 months | 7 months | 13 months | Very susceptible to *R. solani* |
| Glycine wightii cv tinaroo | 40 cm | (5) | none | 3 months | 4 months | (5) | — | 13 months | Very susceptible to *R. solani* |
| Lablab purpureus | 60 cm | (5) | none | 7 weeks | 3 months | (5) | 12-14 mths | 17 months | Susceptible to *R. solani* |
| Macroptilium purpureum | 30 cm | (6) | none | 5 weeks | 3 months | 9 weeks | 4 months | 5 months (1) | |
| P. tetragonolobus | 30 cm | (2) | fair | 9 weeks | (2) | 5 months | 5 months | 11 months | Susceptible to *R. solani* |
| Pueraria phaseoloides | 60 cm | (5) | none | 10 weeks | 3 months | (5) | 22 months | (7) | Infected by *R. solani* |
| S. deeringianum | 1 m | continuous | fair | 4 weeks | 2 months | 3½ months | 7 months | 12 months | Infected by *R. solani* |
| Vigna unguiculata | 60 cm | continuous | good | 7 weeks | 2 months | 2 months | 8 months | 15 months | Infected by *R. solani* |
| Vigna unguiculata sesquipedalis | 50 cm | continuous | fair | 5 weeks | 7 weeks | 2 months | 5 months | 10 months | Beans attacked by a bug. Susceptible to *R. solani* |
| *Erect Types* | | | | | | | | | |
| Glycine max | 60 cm | one seed crop | good | 4 weeks | 6 weeks | 2 months | 3 months | 5 months | |
| Macroptilium bractearum | 1.2 m | continuous | good | 5 weeks | 2 months | 2 months | 7 months | 11 months | Infected by *R. solani* |
| Stylosanthes guyanensis | 60 cm | (6) | none | 10 weeks | 3½ months | 4½ months | — | 24 months | |
| Vigna radiata | 60 cm | continuous | fair | 5 weeks | 2 months | 7 weeks | 2½ months | 6 months | |
| Vigna unguiculata cv poona pea | 60 cm | one seed crop | fair | 5 weeks | 7 weeks | 6 weeks | 2½ months | 3½ months | |
| *Shrub Types* | | | | | | | | | |
| Acioa barteri | 2 m | occasional | fair | 12 months | (8) | 20 months | (8) | (8) | |
| Cajanus cajan | 4 m | continuous | good | 7 weeks | 6 months | 6 months | 12 months | 20 months | Grain severely attacked by insects |
| Crotalaria anagyroides | 4.2 m | continuous | good | 3 months | 8 months | 4 months | 11 months | 23 months | |
| Crotalaria goreensis | 1.5 m | continuous | good | 3 months | 5 months | 3 months | 7 months | 12 months | |
| Flemingia congesta | 4 m (9) | continuous | v. good | 4 months | 12 mths (10) | 5½ months | (11) | (11) | |
| Leucaena leucocephala | 6 m (9) | continuous | v. good | 9 weeks | 3 months | 3 months | (11) | (11) | |
| Sesbania punctata | 3.5 m | continuous | fair | not achieved | 4 months | 4 months | 6 months | 7 months | |
| Tephrosia candida | 4 m | continuous | good | 4 months | 24 months | 9 months | (11) | (11) | |
| Tephrosia noctiflora | 3.5 m | continuous | good | 5 months | 14 months | 3 months | 16 months | 23 months | |

(4) Plots slashed at 1 month. Severe weed competition.
(5) Crop did not flower.
(6) Crop flowered but did not set seed.
(7) Crop still present 2½ years after planting.
(8) Crop still growing 3½ years after planting.
(9) Height at 3½ years after planting. Maximum height not yet attained.
(10) By 12 months most of growth had occurred.
(11) Crop still vigorous 3½ years after planting.

on New Hanover, but this is not the usual experience on the Gazelle Peninsula. It was not as long-lived as cowpea, nor did it seed as well. The seed is edible.

*Vigna unguiculata.* Cowpea quickly produced a ground cover and the resulting sward was dense and a good competitor with weeds. It was short-lived and was attacked by grey leaf rot. It seeds well and its pod is edible. Hale considered cowpea to be the best legume in her evaluation.

*Vigna unguiculata sesquipedalis.* Yardlong bean grew quickly and was short-lived. Ground cover, competition with weeds and leaf production were not good and the crop cannot be considered as a cover crop.

ERECT TYPES

*Glycine max.* Soya bean grew quickly, produced a good ground cover and set a heavy seed crop. However it was short-lived and produced little leaf matter. For these reasons it is not suitable as a cover crop.

*Macroptilium bractearum.* Phasey bean produced a good ground cover quickly, and provided an adequate although not a dense cover. It was short-lived. Overall it was satisfactory as a cover crop but not as good as some of the creeping short term covers.

*Stylosanthes guyanensis.* Schofield stylo produced an impressive dense cover although it was unable to compete with invading *Sorghum propinquum.* Flowering was recorded at one observation but no seed was observed. At Dami, Mendham (1971) found that stylo grew well but did not spread well from the planting strips. It maintained a high proportion of planted legume. It did not flower. Hale also recorded no flowering on New Hanover.

The crop is not as long-lived as puero nor does it compete with weeds as well because of its upright habit. However it could be considered as an alternative to puero.

*Vigna radiata.* Green gram grew rapidly and produced a reasonable cover. The crop started to die back after only two and a half months.

*Vigna unguiculata.* The Poona pea variety of cowpea grew rapidly and produced a seed crop. Ground cover was only fair and the crop was short-lived.

***Plate* II.—Schofield stylo (*Stylosanthes guyanensis*). The stand is being invaded by "karapau" (*Sorghum propinquum*)** Photo by author

SHRUB TYPES.

*Acioa barteri.* This Rocaceous tree is planted as a fallow crop in Southern Nigeria and is almost the only satisfactory fallow cover which can be established on the leached impoverished acid soils in that region (Newton, 1960).

Growth rate was extremely slow in this evaluation and the crop provided very little competition with vigorous weed growth. It is not worth further consideration for this environment.

*Cajanus cajan.* Pigeon pea provided a ground cover quickly, particularly for a shrubby legume. It also produces an edible seed, although this is rarely eaten in Papua New Guinea. It is difficult to obtain a seed crop because of insect attack. Henderson (1954) states that pigeon pea is extremely susceptible to insect attack and to pinks disease (*Corticium salmonicolor*). Leaf production was not especially good and the crop was short-lived for a shrub type.

*Crotalaria anagyroides.* This shrub grew well, although it did not produce a lot of leaf litter nor was it very long-lived. Henderson (1954) states that it is susceptible to pinks disease. Other shrubs performed better than *C. anagyroides.*

*Crotalaria goreensis.* This short shrub produced a dense ground cover reasonably quickly. It was short-lived.

*Flemingia congesta.* Flemingia grew very slowly initially, but after four months growth rate was satisfactory. It produced an excellent cover and remained almost weed-free with a good quantity of leaf litter being produced. The crop is still vigorous three and a half years after planting. Other plantings at Keravat have persisted for at least ten years and probably longer. Flemingia suckers and seedlings come up under the crop. It would be difficult to eradicate the crop at the end of the cover cropping phase.

*Leucaena leucocephala.* Leucaena grew rapidly and produced a good ground cover initially. Leaf production was poor. When the crop is planted densely, the leucaena stems tend to bend after a few years. This allows more light penetration and weed growth occurs under the crop.

*Sesbania punctata.* This quick-growing, short-lived shrub did not even cover the ground, so it afforded very poor competition with weeds. Top growth production was very poor and it is not worth considering as a cover crop.

*Tephrosia candida.* This shrub was slow to produce a ground cover, but once it did so it formed a very good weed-free cover. Leaf production was fair. It is long-lived. Henderson (1954) states that it persists for up to three years. In this evaluation it is still growing vigorously three and a half years since planting. On New Hanover, Hale also recorded four months to establish a good ground cover and nine months to flowering.

Ground cover and leaf fall were not as good as flemingia, but it would be easier to remove because it does not sucker.

*Tephrosia noctiflora.* This was very slow to produce a ground cover, although it was hindered by poor germination. Once established ground cover was satisfactory. Competition with weeds was only fair. The crop started to decline after sixteen months. It is not as good a cover crop as *T. candida.*

FOOD CROPS

A number of the species in the evaluation produce an edible grain. Because of the grain's high protein content and storage ability, grain legumes are most useful and hence it would be valuable if a cover crop also produced an edible grain. Species that produce edible grain in this evaluation were *Cajanus cajan* (pigeon pea), *Glycine max* (soya bean), *Psophocarpus tetragonolobus* (wing bean), *Stizolobium deeringianum* (velvet bean), *Vigna radiata* (green gram), *Vigna unguiculata* (cowpea), and *V. unguiculata sesquipedalis* (yardlong bean).

Of this group the creeping cowpea and velvet bean are the best covers for reasons discussed earlier. The seed of cowpea can be eaten green or dry. Velvet bean did not produce much grain and its use as a food crop is much less widespread than cowpea. Of the others, only pigeon pea was satisfactory as a cover crop and its seed production was poor because of insect attack.

OTHER SPECIES

Two other cover crops were not included in the evaluation because they were known from other plantings to be unsuitable. These were *Mimosa invisa* and *Phaseolus calcaratus.* Notes on these two covers are given below.

*Mimosa invisa* produces an excellent cover and a good bulk of green material fairly rapidly. However it is difficult to deal with and its aggressive nature, prolific seeding ability and thorny nature make it a weed in garden areas. It is very susceptible to root knot nematodes (*Meloidogyne* spp.) and stands are often killed by nematodes, although they quickly regenerate.

*Phaseolus calcaratus.* Rice bean was used as a cover crop in the Keravat rotation trial for some years. However it was sometimes killed by nematode attack before it reached maturity (Newton and Jamieson, 1968) and for this reason was replaced by cowpea which at Keravat has been found more resistant to the root knot nematodes.

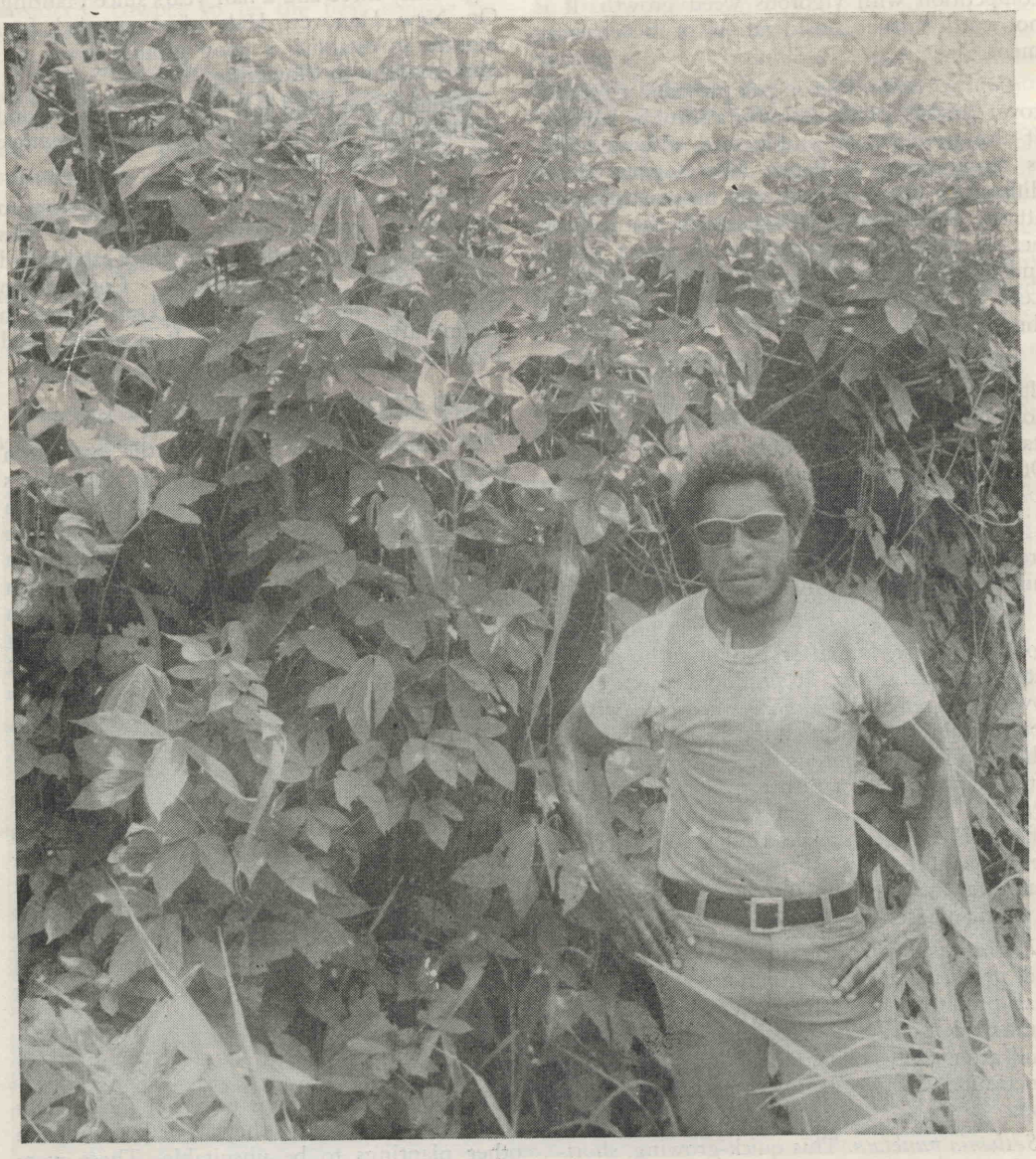

*Plate* III.—*Flemingia congesta.* Flemingia produced a dense weed-free cover
Photo by author

Some of the limitations of the evaluation should be pointed out. There was, for most species, no replication in time or space. However, comparison of results with those from West New Britain, New Hanover, other plantings at Keravat and the literature (Whyte *et al.*, (1953) and *Queensland Country Life* (1967) ) has provided a check on the results. In most cases the observations were in agreement with those from the other sources.

With the exception of two species only one variety of each was examined. Other varieties may have performed differently. Flowering of several of the legumes is affected by day length, temperature or moisture stress, so flowering behaviour at Keravat may not be the same at different altitudes or at latitudes further south.

Competition from weeds was fairly severe. This however is probably a realistic situation, for the legume crop would be following a food crop in a rotation and at this stage weeds would be becoming a problem.

## CONCLUSIONS

Amongst the creeping types puero was the best species as it fulfils most of the requirements listed earlier for a cover crop. Calopo could also be considered if a faster growing species with a shorter life was required. Of the short-lived creeping type species, cowpea, velvet bean and lablab performed well. Each species has some advantages and disadvantages compared with the others. For example velvet bean covers the ground faster than cowpea, but is not as long-lived nor does it seed as well. Lablab persists better than the other two but is more susceptible to grey leaf rot and it seeds in the lowlands only in periods of water stress.

Schofield stylo was the only erect type to perform well and this species could be considered as an alternative to puero.

Both flemingia and *Tephrosia candida* would be excellent long term shrub type cover crops, provided they could be removed effectively when required. Flemingia provided better cover and leaf fall than *T. candida*, but the latter would be easier to remove. *Crotalaria goreensis* would be the best species where a quick-growing short-lived shrub was required. Pigeon pea would also be suitable as a fast-growing, relatively short-lived shrub.

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