LEGUME COVER-CROPS FOR OIL PALMS IN WEST NEW BRITAIN

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ABSTRACT

Results are reported from an observation trial of different legume cover-crop species at Dami Oil Palm Research Station, in West New Britain. Experience with legumes, mainly Pueraria phaseoloides, *on other trials and commercial oil palm plantings in the district is also summarized. Pueraria has been the most vigorous legume, and is well adapted to the local environment of high rainfall and volcanic ash soils. It forms a dense cover with much less effort expended on establishment and maintenance than is needed in Malaysia, thus having an important weed control function, and reducing field costs. The effect on the palms appears highly beneficial, high leaf nitrogen levels and good growth being achieved.*

Other creeping legumes with promise are the Cooper and Tinaroo strains of Glycine javanica, Stylosanthes guyanensis, *and probably* Calopogonium caeruleum *and* Psophocarpus palustris. *The last two, being more shade-tolerant, may be useful after the palm canopy has closed. Seven other creeping legumes tried either did not establish a good cover at all, or failed to maintain themselves against competition from Pueraria and weeds.* Flemingia congesta *was the best of the bushy legumes tried.*

INTRODUCTION

Leguminous cover-crops have been generally grown in most oil palm areas of the world, with more emphasis in some countries than others. In Malaysia their cultivation is a standard practice in the early years of the life of the palms. The reasons put forward for this, and the species generally used, have been discussed in an earlier article (Mendham 1967). Control of weeds, and the effect on soil erosion and fertility are the most important aspects. Considerable effort is expended in establishing a cover (Bevan, Fleming and Gray 1966) with complete clean-weeding initially, then sowing seed in drills over the whole area except near the palms. A high standard of weeding for the first two years is required to keep the legumes free of undesirable plants, particularly *Imperata cylindrica,* known as kunai in Papua New Guinea. The main species used have been *Pueraria phaseoloides,* which is slow to establish, the faster-growing but less permanent *Calopogonium mucunoides,* and *Centrosema pubescens,* a useful addition to Pueraria in the longer term. These creeping legumes have generally given beneficial effects to palm yields, compared with natural regrowth and grass. Bushy legumes, particularly *Flemingia congesta,* are also sometimes used, and have an additional value in restricting the flight, and hence damage to palms, of rhinoceros beetles (*Oryctes rhinoceros).* In Africa there is less emphasis on establishing cover-crops (Hartley 1967), although Pueraria often forms a volunteer cover, and seems to establish much more readily than in Malaysia. The soils in Malaysia are generally acid, and often low in nutrients, and it seems that none of the legumes normally used are really well adapted (B. S. Gray, personal communication), hence the difficulty in establishment and maintenance. For this reason a cover-crop is not as useful there for controlling weeds as it is in some other countries.

Since Pueraria has normally been one of the best legumes in other countries for oil palms, and has been used with some success with other crops in Papua New Guinea, it was decided to standardize on it for commerial oil palm planting in West New Britain. It normally establishes fairly readily on fertile soils, forming a good cover under coconuts.

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OBSERVATIONS AND EXPERIMENTS

Nahavio Observation Plots

Small plots of various species of legume were established at Nahavio Agricultural Extension Station in West New Britain in early 1967, for observation and possible seed production. The species used were *Pueraria phaseoloides, Centrosema pubescens, Calopogonium mucunoides, Glycine javanica, Phaseolus lathyroides, Phaseolus atropurpureus* (cv. Siratro) and *Flemingia congesta.* The last species established poorly and needed replanting several times to get a good stand, but the others established quite well. No records of growth were kept, but observations by the author indicated that *Phaseolus lathyroides* only lasted a few months before dying off. Centrosema did not seem to be vigorous. The others formed good covers. Observations on all plots in January, 1969 ($1\frac{1}{2}$ to 2 years after planting) showed that Pueraria had maintained a good cover and was spreading well. Glycine and Siratro were also quite good, with however, more grass and vines in evidence than in the Pueraria plot. Calopogonium did not appear vigorous, and many parts of the plot were covered with grass and weeds. Much of the Calopogonium was yellowish, resembling sulphur deficiency. The Centrosema plot was even poorer, and had been partly taken over by Pueraria. After the slow establishment, Flemingia grew well, and formed a dense high cover in most parts of the plot.

Pilot Blocks

The first oil palm plantings in the area were two pilot blocks at Mosa and Siki in December, 1967 (Mendham 1971). At Siki a cover was obtained by the following simple method. After felling of the rainforest and a superficial burn, Pueraria seed was broadcast at about 1 kg per hectare. Forest regrowth then occurred as well as Pueraria establishment, and about a year later this was cut back ready for lining and planting. Pueraria then rapidly (about three months) formed a good cover with little assistance, and has since been easily maintained by periodic cutting back of any growth that emerges through it. At Mosa the Pueraria was planted along the palm lines, on a cleared strip about 2 metres wide, and at the same time as the palms, using about 2 kg of seed per hectare. This was then weeded regularly for about three months until the Pueraria established itself. After this the legume spread rapidly over the interline, which had been slashed several times, and by six months a complete cover had been achieved. Maintenance has since involved only ring-weeding of the palms plus cutting back the small amount of regrowth that emerges through the cover.

Commercial plantings on smallholder and plantation areas have had good covers established relatively easily using methods similar to that used on the Mosa pilot block. It seems that in this area, with the initially fertile volcanic soils, cleared from forest, Pueraria can be much more easily established than in Malaysia, and it can be maintained as a nearly pure stand with very little effort. Small areas that had been felled previously, such as old village garden areas, are harder to establish cover-crops on. This is probably partly due to the reduced soil fertility, and partly to the presence of more competitive grass and other regrowth. However, even here, with adequate planting of legume and attention to weeding during establishment, a cover will be formed quickly, although it usually takes about two to three months longer than in forest areas.

Legume Observation Plots, Dami

Observation plots were set up at Dami Oil Palm Research Station in 1969, to compare Pueraria with other possibly useful species of legumes. Dami soils were described by Aland (unpublished report), and have developed on volcanic effluvium, which has been conditioned by alluvial deposition. The sandy loam topsoil is derived from recent volcanic ash. The climate is equatorial lowland, with usually no marked dry spells, and a heavy rainfall maximum in January to April. Annual rainfall is approximately 3500 mm.

The main planting, in March, 1969, consisted of unreplicated 28-palm (0.2 hectare) plots of 12 legume species and varieties. These legumes are listed in *Table* 1, with the approximate seeding rate used, and estimates of the growth and spread of the legumes after four months from germination. Also included are estimates of the percentage of good legume and other types of cover on the plots in April, 1970, 13 months from planting.

Table 1. — Main planting, Dami legume observation plots. Seeding rate, early growth and persistence.

	March, 1969	Observations July, 1969*		Estimated Percentage Cover April, 1970				
	Seed Rate kg/ha	Growth	Spread	Good Legume	Legume with Grass and Weeds	Legume with Pueraria	Pueraria	Weeds and Grass
Pueraria phaseoloides	4	4	4	96	4			
Centrosema pubescens	4	2	2	8	34	8	50	
Phaseolus calcaratus	8	3	1	13	11	26	50	
Glycine javanica cv. Tinaroo	4	3	1	46		42	12	
Cooper	4	3	3	54	8	13	25	
Clarence	4	1	0		13	12	68	17
Stylosanthes guyanensis	4	4	2	54		46		
Phaseolus atropurpureus cv Siratro	4	4	3		29	25	34	12
Dolichos lablab	9	3	3		8	12	68	12
Dolichos axillaris	3	4	3		25	25	42	8
Vigna luteola	3	4	3			25	75	
Flemingia congesta	8	3	0			83	17	

* Early growth scores (July, 1969): growth 1-5 (5 = very vigorous growth)

spread 0-5 (5 = full cover of planting strips and interlines)

Establishment. — Planting strips 2 metres wide were cleared and legumes and palms planted along these, the palms being at a 9-metre triangular spacing. All legumes were inoculated with the appropriate Rhizobium strain, except for a small patch in each plot kept as a control. Establishment of legumes was good, except for Flemingia, the seed of which was of poor quality giving a patchy stand. Birds ate some of the *Dolichos lablab* seed, and a sparse stand also resulted, although the remaining plants grew well and formed quite a good cover. Observations of root nodules and plant vigour of the 12 legumes showed little difference between inoculated and uninoculated plants, all plants being healthy and with a fair number of nodules. It appears that inoculation may not be required at Dami, although observations of commercial planting in other nearby areas indicated poor growth and nodulation if this was not done.

Early growth. — The figures for growth and spread (i.e. cover of the interline vegetation) four months after planting (*Table* 1) show that Pueraria formed the best and quickest cover. A nearly complete cover was attained by this time. Siratro, *Dolichos axillaris* and *Vigna luteola* had formed almost as good a cover, with slightly poorer weed exclusion. *Dolichos lablab* and Cooper Glycine were not so good as these. Stylosanthes grew well, but did not spread so rapidly away from the planting strips. Tinaroo Glycine and *Phaseolus calcaratus* were similar, although less vigorous in growth. Centrosema grew poorly, and Clarence Glycine hardly at all, in surprising contrast to the other Glycines. Flemingia, a bushy legume, grew well. Pueraria was planted with it, and this grew out to cover the interlines.

Persistence after one year. — The percentage ground cover given in *Table* 1 after 13 months was largely influenced by the degree to which Pueraria had taken over. This invaded from adjacent areas of palms planted with a normal Pueraria cover. A small amount had also been planted on the trial site before it was decided to use it for the other legumes, and, in spite of attempts to eradicate it by hand-weeding, still persisted. The amount of the original legume still remaining is generally a good indication of its competitive ability against Pueraria and, to a lesser extent, other growth such as grass, vines and tree regrowth from stumps. At this stage, Pueraria formed an almost complete cover. The only others with a high proportion of planted legume were Stylosanthes, and the Tinaroo and Cooper strains of Glycine. The remainder of these plots were mainly a mixture of Pueraria and the planted legume.

On the other plots, no legumes are maintaining dense covers. *Dolichos axillaris,* Siratro and Centrosema seem to reach a balance with grasses and weeds as would be expected for pasture species. The first is a twining type and is unlikely to form a thick mat needed for a cover-crop. Siratro, although initially growing well, later became sparse and badly infested with weeds. *Phaseolus calcaratus* is an annual and went through about three cycles in the first 18 months. Each time it seeded and died off, Pueraria and weeds invaded further. Neither *Dolichos lablab* nor *Vigna luteola* have persisted in spite of early good growth, and both are probably out of their environmental range. Clarence Glycine at no stage grew well. Flemingia remained in balance with Pueraria although Pueraria tended to climb over it.

Pests and disease. — Continuous attack by a ladybug, *Henosepilachna signatipennis,* contributed to the weakness of *Vigna luteola.* The only other legume attacked, Siratro, was not as severely infested. In May and June, 1970, heavy infestations of a leaf-rolling caterpillar, *Hedylepta diemenalis,* were recorded on all plantings of Pueraria at Dami, destroying an appreciable proportion of the leaf area. Most of the other legumes had some damage also. This came in three waves, approximately three weeks apart. The amount of damage decreased after the second wave, and since then there have been no significant numbers of the insects. Some damage also occurred at that time on Pueraria on other oil palm plantings in the district, although none appeared as serious as this. Pueraria recovered rapidly and produced new leaves after the infestation ceased, and the vigour of this legume is such that even sporadic heavy attacks should not cause it to die out. This pest species, synonymous with *Lamprosema diemenalis,* is a recognized pest of legume cover-crops in Malaysia (Bevan, Fleming and Gray 1966), occurring mostly in dry weather.

A leaf-rot occurred in patches on the Glycines, Siratro, *Dolichos axillaris* and to a small extent on Pueraria in the 1970 wet season. The

pale brown fungal hypha associated with this rot was identified as *Rhizoctonia solani.* This is reported from Malaysia (Bevan, Fleming and Gray 1966) as the only significant disease on Pueraria and Calopogonium, occurring in wet weather.

Flowering. — Legumes which flowered and set seed in the first six months were *Phaseolus calcaratus, Vigna luteola,* Siratro, Centrosema and Flemingia. The latter has continued to produce abundant seed since then. In the 1970 dry season between June and September, Pueraria, Cooper Glycine and *Dolichos lablab* also flowered and set seed, although subsequent wet weather spoiled much of it. The only legumes which have not flowered are *Dolichos axillaris,* Stylo and Tinaroo Glycine.

Effects on palms. — No effect of any of the legumes on palm growth has been noticed, and as the trial is unreplicated, only a large effect would be apparent. Leaf length measurements after 13 months indicated that palms on all plots were similar, except for Flemingia, where the bushy habit of the legume caused an increase in leaf length and hence palm height. presumably by competition for light. Third leaf samples taken for chemical analysis showed no important differences except that in plots where a lot of grass had invaded, such as Clarence Glycine and Centrosema, nitrogen levels tended to be lower.

Mosa Fertilizer Trial

The effect of a Pueraria cover-crop on oil palm leaf nitrogen levels is shown clearly by early results from a fertilizer trial at Mosa Plantation. The trial has 64 plots, of 16 palms each. Cover-crop establishment was uneven, the majority of plots having good cover when treatments started, but some having grass and vines, and varying amounts of legume. A sample was taken from the third leaf of all palms in each plot in December, 1969, one year after the palms were planted and four months after the fertilizer treatments commenced. There was no effect of any of the fertilizers on leaf levels, but there was a close relation between the type of ground cover, estimated in August, 1969, and leaf nitrogen levels, analysed by the Oil Palm Research Station, Banting, Malaysia. The results are given in *Table* 2.

The generally used "critical level" for palms of this age in Malaysia is 2.8 per cent nitrogen, and only the plots with mainly Pueraria exceeded this. The main reason for this effect is probably the removal of competition for nitrogen by the ground cover. It is not likely that the legume is returning significant quantities of nitrogen to the soil for use by the palms at this age, as measurements on the palms showed a significant response in leaf growth (measured by increase in leaf length) to nitrogen fertilizer, and the response was similar for both good and poor cover plots. The palm measurements showed a small difference in growth of the palms on good and poor cover-crop plots, in favour of the former, again probably due to removal of competition for nutrients.

Additional Plots

Bushy legumes. — Plots of the following were established adjacent to the trial at Dami:

Crotolaria anagyroides 16-palm plot (0.1 hectare) planted May, 1969.

C. laburnifolia 16-palm plot (0.1 hectare) planted September, 1969.

C. striata 16-palm plot (0.1 hectare), planted September, 1969.

Tephrosia candida 16-palm plot (0.1 hectare) planted May, 1969.

T. noctiflora 0.8-hectare plot, planted September, 1969.

All species established well. The Crotolarias grew to between 2 and 4 metres in height (*Crotolaria anagyroides* being the tallest species) and then seeded heavily and have since died back, about 12 to 18 months from planting. They would thus only be useful as

Table 2. — Relation between ground cover and leaf nitrogen levels, Mosa fertilizer trial.

Cover	No. of Plots	% N Mean	% N Range
Mainly grass	4	2.51	2.36-2.66
Grass and vines	10	2.56	2.43-2.70
Mainly vines	7	2.61	2.51-2.78
Vary amount Pueraria	6	2.76	2.62-2.91
Good Pueraria	37	2.91	2.74-3.07

a temporary cover, for example if cocoa was to be interplanted with the oil palms. The Tephrosias are rather more permanent, although *Tephrosia candida* had mostly died out by 18 months, possibly due to a root rot. It had flowered after about six months, at a height of 2 metres. *Tephrosia noctiflora,* which formed a dense stand, flowered heavily at a height of 1 to 1.5 metres after four months. It has since increased slowly in height, flowering continuously, and it has become rather spindly.

Calopogonium caeruleum. — Seed of this could not be obtained in time for the main planting. It has shown great promise in Malaysia and has grown well in the Sogeri area of Papua. A 0.8-hectare plot was planted at Dami in October, 1969. It established well, and by about 7 months had formed a good cover, although not excluding weeds in the interlines. By 13 months about a third of the plot had been taken over by Pueraria. The rest was maintaining a fair cover, although with more weeds than the Pueraria plot at that age, and probably not as good as the Glycines or Stylosanthes. This species has not flowered yet.

Psophocarpus palustris. — This African species has grown exceptionally well as an oil palm cover-crop on certain soils in Sumatra, but poorly on other soils, and in Malaysia (T. Fleming, personal communication). A 0.4-hectare plot was planted at Dami in February, 1970 with seed from Sumatra. The normal Rhizobium strain used for Pueraria, CB756, was used. The plants mostly appeared yellowish, and grew very poorly for two or three months. However, after this they came away well to form a good cover in most parts of the plot by about 8 months. Studies of inoculated and uninoculated plants at 5 months showed that both had nodulated well, and were healthy dark green. By about 12 months the plot had suffered the usual Pueraria invasion, but the remaining Psophocarpus was growing strongly forming an effective cover on most of the plot. A small number of flowers, which set seed, were seen in the 1970 dry season.

DISCUSSION AND CONCLUSIONS

Pueraria phaseoloides has shown itself to be very vigorous and well adapted to conditions in West New Britain, and its choice as the legume for commercial oil palm growing is well justified. It can be established by a number of methods, but the principle seems to be to establish it in clean-weeded areas, either planting strips or patches, which are approximately a quarter of the area to be covered. One effective method is to clear 2-metre wide planting strips along the palm lines, and sow two or three drills of Pueraria along these. An additional narrow strip cleared in the middle of the interline and sown with a single drill encourages an even quicker cover. If these are then weeded several times until the legume is established and starting to run, it will spread over the rest of the area and form a good cover in four to six months. The area can then be maintained by ring-weeding the palms, and slashing any regrowth that appears through the Pueraria. The cover takes longer to establish if smaller areas are sown, or if grass or other strongly competing species are present. At Dami, an observation block of about one hectare was planted in 1970 with a single drill line of Pueraria along the palm lines on a narrow planting strip less than 1 metre wide. Seven to ten months were needed before a good cover was established, and some parts of the plot with grass were not covered even after one year.

The ease of establishment and maintenance of Pueraria in West New Britain contrasts strongly with Malaysia, and this has a marked effect on reducing field costs in the early years of a palm planting. The exclusion of grasses and other weeds which compete for nutrients, especially nitrogen, probably has a beneficial effect on palm growth, and certainly a good Pueraria cover gives high leaf nitrogen levels. The longer-term effect of the legume should be to build up soil nitrogen and reduce the need for fertilizers, although moderate dressings of nitrogen should be beneficial to palm growth in the early years.

Of the other creeping legumes tried, the Cooper and Tinaroo strains of *Glycine javanica, Stylosanthes guyanensis* and possibly *Calopogonium caeruleum* and *Psophocarpus palustris* are the only ones with any promise. Tinaroo Glycine and Stylosanthes spread fairly slowly, and hence would not be of such value in giving a quick cover. The Glycines are apparently more susceptible than Pueraria to attack by *Rhizoctonia solani,* and this would be a factor against their use. Cooper Glycine will apparently flower and set seed whereas Tinaroo and

Stylosanthes probably do not, under West New Britain conditions.

Psophocarpus palustris may prove to be a useful species, if the initial establishment problem can be overcome. Another strain of inoculum may be required. Further observations are needed, as this species was planted much later than the others. *Calopogonium caeruleum* does not appear superior to Pueraria in growth or weed suppression, but has grown well enough to warrant further study. It does not appear to flower under these conditions.

The fact that some of these legumes are less vigorous than Pueraria may not necessarily be a disadvantage. Very regular and thorough ring-weeding of the oil palms is needed with Pueraria, as otherwise it climbs into the palms and, on neglected areas, causes a marked check in growth. During dry weather Pueraria competes strongly with palms for soil moisture, and in Africa cutting back of Pueraria before the dry season can be highly beneficial to palm growth. Dry weather of this intensity is not likely in West New Britain, although on light sandy soils there may be an effect with even a short dry spell. It may be worthwhile considering some of these other legumes, as the effect on growth may more than compensate for the extra effort needed to establish and maintain them. To achieve a quick cover as with Pueraria, a higher seeding rate, greater coverage and better early weeding standards than are used for Pueraria would probably be required. These points would need careful checking, however, before a recommendation could be made.

If a bushy legume is required, there would be no need to go past *Flemingia congesta* unless a temporary cover only was required, in which case *Crotolaria anagyroides,* for a short period, or *Tephrosia noctiflora* for a longer period would be satisfactory. While a bushy legume has been shown in Malaysia to reduce palm damage by *Oryctes rhinoceros,* it does not follow that it will reduce damage by *Scapanes* sp. in West New Britain, as the two probably have different habits. Oryctes has not been found in West New Britain yet. Any of these bushy legumes grown in association with Pueraria may have a short life, since Pueraria would probably take over if they were slashed back to reduce palm shading. This occurred at Dami with the *Crotolaria anagyroides* plot.

The trials and observations reported here do not consider the legume cover after the palm canopy has closed. Observations on the better grown pilot blocks show that a nearly closed canopy is reached at about three years from planting and that much of the Pueraria rapidly dies out after this, presumably from lack of light. The main function of the cover has been fulfilled by then, but it may be useful to have a more shade-tolerant legume such as Centrosema to plant then. If this was planted when the palms and Pueraria were planted, it would probably not survive until the canopy closed, although small amounts of Centrosema have persisted under the shade of a few young palms in the Centrosema plot at Dami. *Psophocarpus palustris* and *Calopogonium caeruleum* are both more shade-tolerant than Pueraria, and may be more useful than Centrosema for mature palms.

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