Tropical Pasture Seed Production for Village Farmers in South-East Asia

M.D. Hare
Tropical Pasture Seed Production
for Village Farmers
in South-East Asia

M.D. Hare

Herbage Seed Scientist,
Grasslands Division,
Department of Scientific and Industrial Research,
Palmerston North,
New Zealand.
Contents

Contents 3
Preface 5
Acknowledgments 6
Introduction 7

Part 1  General Management Principles
1. Site selection for seed production 9
2. Seed crop establishment 11
3. Seed crop management 14
4. Harvesting the seed crop 16
5. Seed drying and cleaning 19
6. Seed storage 19
7. Moisture content and germination tests 25

Part 2  Grasses
1. Panicum maximum 27
2. Cenchrus ciliaris 28
3. Chloris gayana 29
4. Urochloa mosambicensis cv. Nixon 30
5. Paspalum plicatum 31

Part 3  Legumes
1. Stylosanthes hamata cv. Verano 33
2. Stylosanthes scabra cv. Seca 34
3. Stylosanthes guianensis 35
4. Macroptilium atropurpureum cv. Siratro 37
5. Centrosema pubescens 39
6. Leucaena leucocephala 40

References 43
Preface

With the wider use of tropical grasses and legumes by village farmers in South-east Asia, seed production has increased dramatically in importance. The successful Thailand seed production project, where 200 tonnes of tropical pasture seed were produced in 1981, made government organizations aware that large quantities of high quality seed could be produced by village farmers using manual techniques of harvesting and cleaning. Similar projects have been implemented, with varying degrees of success, in Laos, Burma and Indonesia.

In 1980 a manual for tropical pasture seed production in North-east Thailand was written (Hare and Waranyurut, 1980). This manual in Thai and English, was requested from many parts of the world, and in Australia and New Zealand it has been used for teaching courses on tropical pasture seed production to certificate and diploma students. With only a few copies left in print, it was decided to rewrite another manual, but this time to broaden it to include principles of general seed production management covering most of South-east Asia.

The first part of the manual covers the general management principles of tropical pasture seed production. Emphasis has been given on simple labour intensive techniques, methods of planting, harvesting, drying and cleaning. The second and third parts of the manual cover in more detail the main grasses and legumes grown for seed production in the region.

The manual is for use by extension workers and research officers who intend to establish pasture seed production programmes in their provinces. It is also intended for use by students from South-east Asia studying seed technology and seed production at the Seed Technology Centre at Massey University, Palmerston North. This manual will give them a basic introduction to tropical pasture seed production and be a valuable adjunct to more scientific books on the subject (Humphreys, 1979).

Species sections have been written, almost as complete basic recipes, so that translation into local languages can easily be written as extension pamphlets for village farmers. Other species, not mentioned in this manual, are also grown in South-east Asia and it is hoped that the management principles in part one and the local experience of research officers will enable extension pamphlets to be written on these species as well.

Michael D. Hare,
Grasslands Division,
DSIR,
Private Bag,
Palmerston North.
November 1985.
Acknowledgements

The Ministry of Foreign Affairs, Wellington, for financing the typing and printing of this publication is gratefully acknowledged. The Ministry also financed the first manual on Thailand seed production and to again finance a similar publication, is indeed appreciated.

Encouragement by Dr M.J. Hill, Seed Technology Centre, Massey University, to write the manual, Mr W.J. Anderson, Massey University, for supplying the photographs for plate 15, and Dr H.M. Shelton, Queensland University, for supplying the photographs for plates 13, 14 and 16 is appreciated.

The Author

Michael Hare worked in Thailand from 1974 to 1980 on tropical pasture seed production and pasture management. From 1974 to 1976 he developed seed production programmes and seed harvesting and cleaning machinery at the Borabu Land Development Centre in North-east Thailand. As pasture seed adviser on the World Bank/North-east Thailand Livestock Development project from 1977 to 1980, he implemented village pasture and seed production programmes throughout North-east Thailand.

Michael Hare is currently employed by Grasslands Division, Department of Scientific and Industrial Research, Palmerston North, New Zealand, as a herbage seed scientist.
Introduction

The concept of improved pastures is new for many village farmers in parts of South-east Asia. Pasture establishment and management have not been thought of, as grass is a plant which grows when the monsoon rains come and dies when the rains stop. Rice straw and other crop residues, often of poor quality, are fed to livestock during the dry season. When the grass does grow, farmers collect it from around plantation trees, from forest areas and from along roadsides. Farmers can be seen driving carts or cycling, with large bags of grass to feed their livestock, which in many cases, are tethered beside or under their houses.

In places where pastures have been established, grasses have been mainly planted by vegetative propagation. This method is only suitable on small areas with some grass species — e.g. Elephant grass (*Pennisetum purpureum*) and Guinea grass (*Panicum maximum*). Vegetative propagation also gives the small village farmer an additional heavy labour burden to that spent on rice or crop planting, as they have peak labour requirements at the same time. Most grass species and legumes are best established by sowing seed.

Livestock production, especially dairy production, is rapidly increasing in importance in Thailand, Malaysia (sheep, beef and dairy), Philippines and Indonesia. In order to implement pasture improvement programmes in these countries, cheap seed must be readily available. To import seed from countries where large scale commercial tropical pasture seed production has been established, Australia, Kenya and Brazil, is expensive and beyond the cash resources of the village farmers. It is cheaper, if possible, for each country to produce their own seeds.

It is often argued that village farmers neither have the cash nor the mobility to buy pasture seeds, even though rice and cash crop seeds are frequently traded. However, small farm and village pasture seed production schemes have been established in Thailand and the Philippines. The Thailand village scheme has been most successful and in 1981, 187 tonnes of Verano stylo seed was produced by 1131 village farmers at an average yield of 910 kg/ha (Anon. 1981). Parts of the Thailand scheme have been copied to produce seed in Laos, Burma and Indonesia in recent years. By establishing seed production in villages, modest farm-to-farm and village-to-village seed trading can commence, if the demand for pasture improvement is there.

The emphasis in this manual will be on the strategy of small scale seed production for village farmers, employing largely manual methods. Simple mechanical methods which can be employed by larger farmers and government research stations will also be mentioned.
Part 1. General Management Principles

1. Site selection for seed production

1.1 Climate

In the tropics, successful long term seed production is only possible within a very narrow range of climatic conditions. Each particular grass and legume cultivar has its own niche and no one locality is ideal for them all.

Daylength

Most of the tropical grasses and legumes are short-day plants. (They flower if the days are shorter than a critical length). A few species are day neutral and a few flower in long days (Table 1). Flowering responses may be qualitative (obligate) or quantitative. A qualitative response is one in which plants will not flower unless a critical daylength is reached — for example, 12-12.5 hours for *Stylosanthes guianensis* cv. Endeavour. A quantitative short day response is one in which plants flower in a wide range of photoperiods but flower faster and more strongly when critical daylengths are reached — for example, *Macroptilium atropurpureum* cv. Siratro.

Further than 10° (latitude) from the equator the short day cultivars have clearly defined phases of vegetative and reproductive development and the transition occurs at a reasonably predictable time. The closer one gets to the Equator the more difficult it is to separate these two phases. In such circumstances heavy seed yields are impossible and, in general, tropical pasture seed production should not be established within 10° of the equator.

Temperature

The short day grasses and legumes can be severely restricted in their flowering and seed setting by low temperatures. For the majority of these species the mean temperature of the coolest month must be above 17°C.

In most cases high day temperatures do not limit seed production of the short day plants during the periods of short days. However, at the low latitudes flowering and seed production can be enhanced at cooler, high altitude sites. In Papua New Guinea *Lablab purpureus* cv. Rongai does not flower on the coast at sea level (23°C night temperature, latitude 6°S). At high altitude sites (600 metres a.s.l. latitude 7°S) the night temperatures are 6°C cooler averaging 17°C and Rongai flowers well (Hill, 1967).

Frost

Nearly all the tropical legumes and grasses are susceptible to frost; a frost before the completion of seed ripening results in total loss of the seed crop for that year. *Pueraria phaseoloides* may suffer inflorescence bud and shoot death without a recorded ground frost. *Lotononis bainesii*, *Trifolium semi-pilosum*,

| TABLE 1. Daylength flowering responses of some common tropical pasture species. |
|-----------------------------|----------------|
| Day length*                 |
| 1. Tropical grasses         |
| *Andropogon gayanus*        | SD             |
| *Brachiaria decumbens*      | SD             |
| *Brachiaria mutica*         | SD             |
| *Cenchrus ciliaris*         | DN             |
| *Chloris gayana*            | QSD            |
| *Digitaria decumbens*       | QSD            |
| *Hyparrhenia rufa*          | QSD            |
| *Panicum coloratum*         | QLD            |
| *P. maximum*                | QSD            |
| *P. maximum var. trichogline* | QSD        |
| *Passalum dilatatum*        | QLD            |
| *P. plicatum*               | SD             |
| *Setaria anceps*            | QLD            |
| *Urochloa mosambicensis*    | DN             |
| 2. Tropical legumes         |
| *Calopogonium mucunoides*   | SD             |
| *Centrosema pubescens*      | SD             |
| *Desmodium heterophyllum*   | QSD            |
| *Lotonomis bainesii*        | DN             |
| *Macroptilium atropurpureum*| QSD            |
| *Macrotyloma axillare*      | SD             |
| *Neonotonia wightii*        | SD             |
| *Pueraria phaseoloides*     | SD             |
| *Stylosanthes guianensis*   | SD             |
| *S. guianensis var. intermedia* | LD         |
| *S. hamata cv. Verano*      | QSD            |
| *S. humilis*                | SD             |
| *S. scabra*                 | QSD            |
| *Trifolium semi-pilosum*    | QSD            |

Daylength* DN, day neutral; QSD, quantitative short day; SD, obligate short day; QLD quantitative long day; LD obligate long day.
Chloris gayana and Setaria anceps will tolerate some frost.

Because frost risk varies so much with topography, site selection must rely on local experience; records in many cases are not available. Generally if a ground frost is observed more often than once in two years and an air frost is recorded once in ten years, that area should be excluded from tropical pasture seed production. Areas further than 23°N or S of the equator are generally not suitable for tropical seed production because of low temperatures and frost.

Moisture stress

An element of moisture stress is often necessary to promote vigorous reproductive activity, especially in the day neutral and quantitative short day plants.

Macropigillium atropurpureum depends on water stress to produce worthwhile flushes of flowers; Centrosema pubescens behaves in the same way. Both crops will revert to vegetative growth if too much moisture is received during flowering.

Any dry spells during the wet season will promote flowering and make harvesting easier of day neutral Chenchus ciliaris and Urochloa mosambicensis. Often these dry spells occur in the transition period between monsoons.

The timing of flowering of some crops is influenced by the time at which the wet season ends. Flowering of Stylosanthes hamata cv. Verano, which is a QSD plant, is dominated by the wet-dry season periods.

In general, all tropical seed crops perform best in a climate in which wet and dry seasons are reliably and clearly separated.

Rainfall

For most tropical pasture seed crops a wet season of about four months duration is needed for optimum seed production. A longer wet season makes it difficult to curtail vegetative growth and stimulate flowering.

An extended wet season, or the occurrence of rain during the dry season, introduces disease problems. Rhizoctonia in M. atropurpureum, anthracnose (Colletotrichum gloeosporioides) on Stylosanthes spp., and Botrytis head blight in Stylosanthes spp. are encouraged by rain and overcast weather.

Having settled periods during the dry season makes harvesting easier. Many species are ground harvested with the seed swept up from the ground. Dry weather is necessary for these operations to recover maximum yields of seed.

How much total annual rainfall should there be and how much should fall during the dry season?

A lower limit for an average annual rainfall should be about 800 mm; regions receiving less than this do not have reliable enough wet seasons to provide a secure income from seed production. With irrigation, provided it is economic, a lower rainfall region could be selected. An upper limit would be about 2000 mm. Above this figure, the heavy prolonged wet season causes disease problems in legumes and makes grass seed harvesting very difficult.

During the dry season the rainfall should not exceed 300-400 mm. This is very important for DN and QSD crops, as too much dry season rainfall will not promote vigorous flowering.

With tropical grasses, species that flower throughout the growing season and seed freely without special management grow well under dry conditions (700 mm average annual rainfall). These species are either DN or QSD plants — for example Cenchrus ciliaris, Chloris gayana cv. Pioneer, Paniwm maximum cv. Gattoa, P. maximum var. trichogline and Urochloa mosambicensis. Other species which are obligate short day plants need moisture during their longer flowering period. They therefore require sites receiving an average annual rainfall of above 1200 mm. For example Callide and Samford rhodes grass, Brachiaria decumbens, B. mutica, Panicum maximum cv. Hamil, Paspalum plicatulum, and Setaria anceps.

Radiation

Crops grown in regions with high radiation have greater potential for seed production. Flower opening is more intense in bright sunlight. Equatorial regions, besides having unsuitable daylength requirements, receive less total radiation than intermediate latitudes of between 10° to 23° N or S. Parts of Malaysia and Indonesia are unsuitable for seed production because of high rainfall, low radiation and unsuitable daylengths.

Seed yields per hectare from cover crops under oil palms, rubber trees and coconut trees are usually very low because of shading effects.

The main indices to identify sites or regions suitable for tropical pasture seed production are summarised in Table 2.

There is seldom a sharp boundary between regions of suitable and unsuitable climate. Further complications arise when there are insufficient climatic records available to help
TABLE 2. Main climatic indices for successful tropical pasture seed production. (Adapted from Hopkinson and Reid, 1979).

<table>
<thead>
<tr>
<th>Latitude</th>
<th>Between 10° and 23° N or S. Below 10° daylength is too similar with insufficient short daylengths, and radiation cover is too low. Above 23° frosts occur too frequently during short days of flowering.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frost</td>
<td>If sites have any frost they should be excluded for legume seed production and most grass seed production. The frequency of frosts is the important factor.</td>
</tr>
<tr>
<td>Average daily mean temperature</td>
<td>Less than 17°C during coolest month is not suitable for legume flowering.</td>
</tr>
</tbody>
</table>
| Rainfall       | Average annual rainfall  
|                | Lower limit 800 mm  
|                | Upper limit 2000 mm  
|                | Dry season rainfall should not exceed 3-400 mm.                                                                                                                                                  |

one to make site selection decisions. Local knowledge and experience must be used in many cases to compensate for a lack of climatic data.

1.2 Soils

Tropical grasses and legumes will grow on a range of soils, but for seed production good agricultural soils are preferred. Acid, saline, waterlogged soils are not suitable.

For the obligate short day plants, soils with good water-holding capacity are necessary to prevent moisture stress during the short days of the dry season.

Species which are ground harvested, e.g. *Stylosanthes* spp., need soils which are easily screened out during harvesting or cleaning. Laterite soils, which are common in the tropics, are not suitable at all.

1.3 Isolation

Only a few of the tropical grass species are cross pollinated and require isolation. These include cultivars of *Chloris gayana*, *Setaria anceps*, *Cynodon dactylon*, some *Paspalum* spp., *Desmodium* spp., and *Trifolium semi-pilosum*. The degree of isolation will depend on the grade of seed involved, but minimum distances are 200 m for areas two hectares or less and 100 m for areas larger than two hectares.

If the seed grower chooses the right site and then with good management makes efficient use of the environment, that grower has every prospect of a successful seed harvest at the end.

2. Seed crop establishment

2.1 Time of establishment

The highest seed yields will come from crops sown at the beginning of the growing season (the wet season in most cases). Some annual species, e.g. *S. humilis*, may be planted later in the wet season.

Early sown crops can be prone to lodging but this can be controlled by grazing or cutting.

2.2 Seed bed preparation

Full land preparation, with ploughing and shallower cultivations, is necessary to produce an even seed bed.

Sites which have relatively few weeds should be chosen for cultivation. Weeds which have seeds which are difficult to remove during seed harvesting and cleaning are of prime

TABLE 3. Tolerance of legumes to various chemicals for weed control. (Adapted from Hawton and Johnson, 1980).

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Desmodium</th>
<th>Glycines</th>
<th>Centros</th>
<th>Siratro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-plant incorporated chemicals</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trifluralin</td>
<td>Unsafe</td>
<td>Safe</td>
<td>Safe</td>
<td>Safe</td>
</tr>
<tr>
<td>Benfluralin</td>
<td>Safe</td>
<td>Safe</td>
<td>Safe</td>
<td>Safe</td>
</tr>
<tr>
<td>Pre-emergence chemicals</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alachlor</td>
<td>Unsafe</td>
<td>Unsafe</td>
<td>Safe</td>
<td>Safe</td>
</tr>
<tr>
<td>Post-emergence chemicals</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2,4-D</td>
<td>Safe</td>
<td>Safe</td>
<td>Unsafe</td>
<td>Unsafe</td>
</tr>
<tr>
<td>Dinosel</td>
<td>Safe</td>
<td>Probably safe</td>
<td>Safe</td>
<td>Moderately safe</td>
</tr>
<tr>
<td>Bentazon</td>
<td>Safe</td>
<td>Probably safe</td>
<td>Safe</td>
<td>Safe</td>
</tr>
</tbody>
</table>

11
TABLE 4. Tolerance of grasses to various chemicals for weed control. (Adapted from Veenstra and Boonman, 1974).

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Chloris gayana</th>
<th>Setaria spp.</th>
<th>Barchia spp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atrazine</td>
<td>Safe</td>
<td>Safe</td>
<td>Safe</td>
</tr>
<tr>
<td>Bentazon</td>
<td>Safe</td>
<td>Safe</td>
<td>Probably safe</td>
</tr>
<tr>
<td>Bromacil</td>
<td>Safe</td>
<td>Safe</td>
<td>Moderately safe</td>
</tr>
<tr>
<td>Bromophenoxyim</td>
<td>Safe</td>
<td>Safe</td>
<td>Probably safe</td>
</tr>
<tr>
<td>Bromoxynil</td>
<td>Safe</td>
<td>Safe</td>
<td>Safe</td>
</tr>
<tr>
<td>Butetril M</td>
<td>Safe</td>
<td>Probably safe</td>
<td>Probably safe</td>
</tr>
<tr>
<td>2,4-D amine</td>
<td>Safe</td>
<td>Safe</td>
<td>Probably safe</td>
</tr>
<tr>
<td>2,4-D and dicamba</td>
<td>Safe</td>
<td>Safe</td>
<td>Probably safe</td>
</tr>
<tr>
<td>2,4-D ester</td>
<td>Safe</td>
<td>Probably safe</td>
<td>Probably safe</td>
</tr>
<tr>
<td>I oxyxyl/bromoxynil</td>
<td>Safe</td>
<td>Safe</td>
<td>Safe</td>
</tr>
<tr>
<td>MCPP salt</td>
<td>Probably safe</td>
<td>Probably safe</td>
<td>Probably safe</td>
</tr>
<tr>
<td>MCPP + dicamba</td>
<td>Probably safe</td>
<td>Probably safe</td>
<td>Probably safe</td>
</tr>
<tr>
<td>Methabenzthiazuron</td>
<td>Probably safe</td>
<td>Probably safe</td>
<td>Unsafe</td>
</tr>
<tr>
<td>Terbacil</td>
<td>Moderately safe</td>
<td>Moderately safe</td>
<td>Moderately safe</td>
</tr>
<tr>
<td>Terbutryne</td>
<td>Moderately safe</td>
<td>Moderately safe</td>
<td>Moderately safe</td>
</tr>
</tbody>
</table>

importance; weeds which reduce crop growth especially in legume seed crops (Figure 1). In through competition are of secondary general, annual species will give optimum seed importance. Sida spp. and Crotalaria spp. must yields at higher rate densities than perennial be removed from sites which are to grow species.

Stylosanthes spp. The legumes are more prone to weed invasion than the grasses.

In Queensland applying trifluralin three weeks before sowing and then rotary hoeing the herbicide into the soil is used successfully on most legume seed crops except Desmodium spp. Tolerances to various chemicals are listed in Tables 3 and 4.

2.3 Sowing

Sowing rate

High plant densities may depress yields especially in legume seed crops (Figure 1). In general, annual species will give optimum seed yields at higher rate densities than perennial species.

Recommended sowing rates for tropical grasses and legumes are shown in Tables 5 and 6.

Row spacing

Sowing in rows (Plates 1 & 2) has several advantages.

1. A lower seeding rate is used. This is important when seed from overseas is imported to establish seed production areas, and when village farmers first move into seed production.

TABLE 5. Recommended sowing rates for tropical grass species.

<table>
<thead>
<tr>
<th>Tropical grasses</th>
<th>Common name</th>
<th>Cultivar</th>
<th>Minimum* % purity</th>
<th>% germination</th>
<th>Sowing rate (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brachiaria decumbens</td>
<td>signal grass</td>
<td>Basilisk</td>
<td>50</td>
<td>15</td>
<td>3-6</td>
</tr>
<tr>
<td>B. mutica</td>
<td>para grass</td>
<td>—</td>
<td>40</td>
<td>15</td>
<td>2-3</td>
</tr>
<tr>
<td>Cenecrus ciliaris</td>
<td>buffel grass</td>
<td>—</td>
<td>90</td>
<td>20</td>
<td>1-4</td>
</tr>
<tr>
<td>C. setigerus</td>
<td>birdwood grass</td>
<td>—</td>
<td>90</td>
<td>20</td>
<td>1-4</td>
</tr>
<tr>
<td>Chloris gayana</td>
<td>Rhodes grass</td>
<td>Pioneer, Katambora,</td>
<td>90</td>
<td>20</td>
<td>1-6</td>
</tr>
<tr>
<td>Cyphon utile</td>
<td>Bermuda couch</td>
<td>—</td>
<td>90</td>
<td>20</td>
<td>1-6</td>
</tr>
<tr>
<td>Melinis minutiflora</td>
<td>molasses grass</td>
<td>—</td>
<td>97</td>
<td>60</td>
<td>1-3</td>
</tr>
<tr>
<td>Panicum coloratum</td>
<td>Makarikari grass</td>
<td>—</td>
<td>40</td>
<td>30</td>
<td>1-4</td>
</tr>
<tr>
<td>P. maximum</td>
<td>guinea grass</td>
<td>—</td>
<td>80</td>
<td>20</td>
<td>2-3</td>
</tr>
<tr>
<td>P. maximum</td>
<td>—</td>
<td>—</td>
<td>40</td>
<td>25</td>
<td>2-6</td>
</tr>
<tr>
<td>Paspalum dilatatum</td>
<td>green panic var,</td>
<td>Petrie</td>
<td>70</td>
<td>20</td>
<td>1-6</td>
</tr>
<tr>
<td>P. maximus</td>
<td>trichoglume</td>
<td>—</td>
<td>60</td>
<td>60</td>
<td>6-10</td>
</tr>
<tr>
<td>Paspalum notatum</td>
<td>bahia grass</td>
<td>—</td>
<td>60</td>
<td>60</td>
<td>2-5</td>
</tr>
<tr>
<td>P. plicatulum</td>
<td>plicatulum</td>
<td>—</td>
<td>60</td>
<td>40</td>
<td>2-4</td>
</tr>
<tr>
<td>Pennisetum clandestinum</td>
<td>kikuyu</td>
<td>—</td>
<td>93</td>
<td>60</td>
<td>1-2</td>
</tr>
<tr>
<td>Setaria anceps</td>
<td>setaria</td>
<td>—</td>
<td>60</td>
<td>20</td>
<td>2-5</td>
</tr>
<tr>
<td>Sorghum alimun</td>
<td>cumbulus grass</td>
<td>—</td>
<td>97.3</td>
<td>65</td>
<td>1-10</td>
</tr>
<tr>
<td>Urochloa mosambicensis</td>
<td>sabi grass</td>
<td>—</td>
<td>60</td>
<td>3</td>
<td>1-6</td>
</tr>
</tbody>
</table>

*The minimum purity and germination values are the standards defined in the Queensland Government Seed Regulations.
### TABLE 6. Recommended sowing rates for tropical legume species.

<table>
<thead>
<tr>
<th>Tropical legume</th>
<th>Common name</th>
<th>Cultivar</th>
<th>Minimum*&lt;br&gt;</th>
<th>Sowing rate&lt;br&gt;(kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calopogonium mucunoides</td>
<td>calopo</td>
<td>—</td>
<td>93.5</td>
<td>60</td>
</tr>
<tr>
<td>Centrosema pubescens</td>
<td>centro</td>
<td>Common, Belalbo</td>
<td>93.8</td>
<td>50</td>
</tr>
<tr>
<td>Desmodium heterophyllum</td>
<td>hetero</td>
<td>Johnstone</td>
<td>94.5</td>
<td>70</td>
</tr>
<tr>
<td>D. intortium</td>
<td>desmodium</td>
<td>Greenleaf</td>
<td>94.5</td>
<td>70</td>
</tr>
<tr>
<td>D. uncinatum</td>
<td>desmodium</td>
<td>Silverleaf</td>
<td>94.5</td>
<td>70</td>
</tr>
<tr>
<td>Glycine wightii</td>
<td>glycine</td>
<td>Tinaroo, Cooper, Clarence, Malawi</td>
<td>97.5</td>
<td>60</td>
</tr>
<tr>
<td>Lablab purpureus</td>
<td>lablab</td>
<td>Rongai, Highworth</td>
<td>98.6</td>
<td>75</td>
</tr>
<tr>
<td>Leucaena leucocephala</td>
<td>leucaena</td>
<td>Peru, El Salvador</td>
<td>97.5</td>
<td>60</td>
</tr>
<tr>
<td>Lottotonis</td>
<td>lototonis</td>
<td>Miles</td>
<td>93</td>
<td>50</td>
</tr>
<tr>
<td>Macroptilium atropurpureum</td>
<td>siratro</td>
<td>Siratro</td>
<td>97.5</td>
<td>70</td>
</tr>
<tr>
<td>M. lathyroides</td>
<td>phasey bean</td>
<td>Murray</td>
<td>98</td>
<td>70</td>
</tr>
<tr>
<td>Macroptilum axillare</td>
<td>axillaris</td>
<td>Archer</td>
<td>97.5</td>
<td>60</td>
</tr>
<tr>
<td>Macroptilum uniflora</td>
<td>uniflorus</td>
<td>Liechhardt</td>
<td>97.5</td>
<td>60</td>
</tr>
<tr>
<td>Pueraria phaseoloides</td>
<td>puero</td>
<td>—</td>
<td>93.5</td>
<td>50</td>
</tr>
<tr>
<td>Stylosanthes guianensis</td>
<td>stylo</td>
<td>Schofield, Cook, Endeavour</td>
<td>90</td>
<td>40</td>
</tr>
<tr>
<td>S. humilis</td>
<td>Townsville stylo</td>
<td>Common, Patterson, Lawson, Gordon</td>
<td>90</td>
<td>40</td>
</tr>
<tr>
<td>S. hamata</td>
<td>caribbean</td>
<td>Verano</td>
<td>90</td>
<td>40</td>
</tr>
<tr>
<td>S. acabra</td>
<td>shrubby stylo</td>
<td>Seca</td>
<td>90</td>
<td>40</td>
</tr>
<tr>
<td>Trifolium semipilosum</td>
<td>Kenya white</td>
<td>Safari</td>
<td>93.5</td>
<td>75</td>
</tr>
</tbody>
</table>

*The minimum purity and germination values are the standards defined in the Queensland Government Seed Regulations.

- ii. Weeds can be easily controlled by spraying, mechanical grubbing or hand weeding.
- iii. Harvesting is usually a lot easier.

With climbing legumes such as *Macroptilium atropurpureum* better yields are harvested from row spaced trellises (Table 7; Plate 1).

### TABLE 7. The effect of sward and trellis plantings on siratro seed production (kg/ha). (Wickham, 1976).

| 1. Trellis                          | 993          |
| spacing 1 metre apart              | 660          |
| 2 metre                            | 354          |
| 3 metre                            | 354          |

2. Sward 533

In countries with seed certification schemes 30 cm row spacings are obligatory for many of the tropical pasture species (Boonman, 1979).


<table>
<thead>
<tr>
<th>Nitrogen level</th>
<th>Pure live seed yield kg/ha Width between rows (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>7.6 11.7 13.1</td>
</tr>
<tr>
<td>medium</td>
<td>19.5 18.9 14.9</td>
</tr>
<tr>
<td>high</td>
<td>19.0 14.0 11.0</td>
</tr>
</tbody>
</table>

In arid areas row spacings of up to 2.4 metres are commonly used in order to improve the moisture status of plants and increase seed yields. Under good rainfall and high fertility conditions narrower row spacings are preferred (Table 8).

![Figure 1](image1.png)  
**FIGURE 1.** Effect of plant density on seed yield and its components in *Stylosanthes humilis* (after Shelton and Humphreys, 1971).
TABLE 9. Examples of the effects of different treatments on various hard seeds.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Species</th>
<th>% Permeable</th>
<th>Author</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot air or heating</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90°C, 12 hours</td>
<td><em>Stylosanthes hamata</em></td>
<td>0</td>
<td>Gilbert &amp; Shaw</td>
<td>1979</td>
</tr>
<tr>
<td>155°C, 15 secs</td>
<td><em>S. hamata</em></td>
<td>8</td>
<td>Mott &amp; McKeon</td>
<td>1982</td>
</tr>
<tr>
<td>140°C, 10 secs</td>
<td><em>Macroptilium atropurpureum</em></td>
<td>20</td>
<td>Mott et al.</td>
<td>1982</td>
</tr>
<tr>
<td>160°C, 60 secs</td>
<td><em>Ornithopus compressus</em></td>
<td>10</td>
<td>Mott et al.</td>
<td>1982</td>
</tr>
<tr>
<td>140°C, 15 secs</td>
<td><em>Neonotonia wightii</em></td>
<td>14</td>
<td>Mott et al.</td>
<td>1982</td>
</tr>
<tr>
<td>75°C, 12 hours</td>
<td><em>Stylosanthes scabra</em> cv. Seca</td>
<td>3</td>
<td>Gilbert &amp; Shaw</td>
<td>1979</td>
</tr>
<tr>
<td>Hot water</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>75°C, 5 min.</td>
<td><em>Stylosanthes scabra</em> cv. Seca</td>
<td>3</td>
<td>Gilbert &amp; Shaw</td>
<td>1979</td>
</tr>
<tr>
<td>65°C, 5 min.</td>
<td><em>S. viscosa</em></td>
<td>29</td>
<td>Gilbert &amp; Shaw</td>
<td>1979</td>
</tr>
<tr>
<td>Scarification</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical</td>
<td><em>Centrosema pubescens</em></td>
<td>28</td>
<td>Win Pe et al.</td>
<td>1975</td>
</tr>
<tr>
<td>Acid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H₂SO₄, 15 min.</td>
<td><em>Centrosema pubescens</em></td>
<td>28</td>
<td>Win Pe et al.</td>
<td>1975</td>
</tr>
</tbody>
</table>

Sowing in swards (Plates 3 & 4) does, however, have some advantages.

i. In wet weather (often when harvesting grass seed) there are better conditions for machinery to travel.

ii. There is more forage for livestock.

iii. There is less vulnerability to erosion. Erosion can be a major problem in tropical areas. Heavy monsoon rains can wash soil from between rows on even gentle sloping land.

Seed treatment

Many of the tropical legumes have hard seeds. For seed crop establishment rapid even germination is required. Various scarification treatments are employed prior to sowing to improve permeability (Table 9).

TABLE 10. Rhizobium requirements of common tropical pasture legumes.

<table>
<thead>
<tr>
<th>Tropical legumes</th>
<th>Rhizobium requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Calopogonium mucunoides</em></td>
<td>cowpea</td>
</tr>
<tr>
<td><em>Centrosema pubescens</em></td>
<td>specific CB 1103</td>
</tr>
<tr>
<td><em>Desmodium heterophyllum</em></td>
<td>specific CB 627</td>
</tr>
<tr>
<td><em>D. intortum</em></td>
<td>specific CB 627</td>
</tr>
<tr>
<td><em>Glycinum wightii</em></td>
<td>cowpea</td>
</tr>
<tr>
<td><em>Lablab purpureus</em></td>
<td>cowpea</td>
</tr>
<tr>
<td><em>Leucaena leucocephala</em></td>
<td>specific CB 81 — acid soils</td>
</tr>
<tr>
<td></td>
<td>NGR-8 — alkaline soils</td>
</tr>
<tr>
<td><em>Lorojsonis bainesii</em></td>
<td>cowpea</td>
</tr>
<tr>
<td><em>Macroptilium atropurpureum</em></td>
<td>cowpea</td>
</tr>
<tr>
<td><em>M. latifolius</em></td>
<td>cowpea</td>
</tr>
<tr>
<td><em>Macrotiloma axillare</em></td>
<td>cowpea</td>
</tr>
<tr>
<td><em>Macrotiloma uniflorum</em></td>
<td>cowpea</td>
</tr>
<tr>
<td><em>Pueraria phaseoloides</em></td>
<td>cowpea</td>
</tr>
<tr>
<td><em>Stylosanthes guianensis</em></td>
<td>cowpea</td>
</tr>
<tr>
<td><em>S. humata</em></td>
<td>cowpea</td>
</tr>
<tr>
<td><em>S. scabra</em></td>
<td>cowpea</td>
</tr>
<tr>
<td><em>Trifolium semipilosum</em></td>
<td>cowpea</td>
</tr>
</tbody>
</table>

Seeds often have to be protected against insect attacks, e.g. *Macroptilium atropurpureum* cv. Siratro seeds must be coated with a dieldrin slurry to control bean fly (*Melanagromyzidaeae*).

*Cenchrus ciliaris* seeds dusted with BHC dust will repel seed harvesting ants.

Inoculation of legumes prior to sowing is recommended when introducing new species into new areas. Many legumes are specific in their *Rhizobium* requirements and special inoculum is required (Table 10). If the specific *Rhizobium* inoculum is not available, then soil from around established nodulating plants of the same species should be mixed with the seed.

3. Seed crop management

3.1 Fertiliser

Nitrogen is the main nutritional determinant of grass seed yield and optimum levels in the range of 100 — 200 kg N/ha per year are required to maximise seed yields. Inflorescence density is the main yield component which responds to nitrogen and, to promote inflorescence development, nitrogen should be applied straight after the cleaning cut and/or closing date. If two or three seed crops are taken in one season this nitrogen should be applied after each cleaning cut.

In many South-east Asian countries phosphorus and sulphur are limiting and applications of both will increase seed yields (Table 11). Potassium has also been reported as limiting seed yields particularly in second year perennial legume seed crops (L.R. Humphreys pers. comm.). This is more so, if the removal of plant residues from the field after harvest is practised.
TABLE 11. Townsville stylo seed production on a red latosol soil at different levels of phosphorus and sulphur (kg/ha). (Source: Wickham et al., 1977).

<table>
<thead>
<tr>
<th>Phosphorus level (kg/ha)</th>
<th>Sulphur level (kg/ha)</th>
<th>0</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>840</td>
<td>1420</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>910</td>
<td>1400</td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>1020</td>
<td>1440</td>
<td></td>
</tr>
<tr>
<td>162</td>
<td>1230</td>
<td>1400</td>
<td></td>
</tr>
<tr>
<td>LSD (p&lt;0.05) = 65</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Some tropical legumes are tolerant of low soil pH (e.g. Lotononis bainesii grows well at pH 4.5), and of high levels of manganese or aluminium.

Seed producers must discover all the mineral deficiencies in their soils and study the needs of each particular seed crop. Yearly soil tests may have to be made in areas of high leaching.

3.2 Weed control

As seed crops age, weeds can invade, particularly legume crops. 2,4-D amine can be applied to *S. guianensis* crops, but it can be harmful to *Centrosema pubescens*. Dichotyledonous weeds can be controlled with 2,4-D and MCPA depending on the species involved (Tables 3 and 4).

3.3 Insect control

Siratro must be regularly sprayed to protect the pods from aphids and thrips. In Uganda thrips cause damage to *Chloris gayana*, *Setaria anceps* and *Cenchrus ciliaris*. Stem borers damage *Stylosanthes guianensis* in South America and *Crotalaria juncea* in Thailand.

Each locality has its own insect pests and growers must always be on the alert for them.

3.4 Disease control

Some cultivars of a particular species are more resistant to disease. For example *Setaria anceps* cv. Kazungula is more resistant to leaf spot (*Periclum trisca*) than cv. Nandi or cv. Narok. *Centrosema pubescens* cv. Belalto is more resistant to *Cercospora* leaf spot than common centro.

Rhizoctonia solani can badly affect siratro; no economic controls are found at the moment. Likewise ergot (*Claviceps paspali*) can not be controlled in *Paspalum dilatatum* except by moving to ergot free areas. However, *P. notatum* cv. Pensacola is immune. Ergots also occur on *Panicum maximum* and *Cenchrus ciliaris* in Kenya, along with Bunt (Tilletia erichinosperma). In humid weather *Botrytis cinerea* can destroy *S. guianensis* seed crops, but it can be controlled with two applications of benomyl at 0.5 kg/ha at or just before flowering. *Stylosanthes* spp. have now been bred which are tolerant of anthracnose which previously devastated seed crops of *S. humilis* in Australia and in Thailand.

3.5 Irrigation

Irrigation in the dry tropics with high radiation levels can increase seed yields of most seed crops. With grass seed crops, two or three harvests can be taken in a season with irrigation; under rainfed conditions only one might have been possible.

By manipulating the water supply and subjecting siratro crops to wet and dry conditions high seed yields can be obtained (Hopkinson, 1977).

Normal irrigation practice is to water a seed crop during the vegetative period and terminate it at floral initiation or flower appearance. As mentioned earlier, in QSD and DN plants a period of moisture stress is beneficial for flowering and seed setting. The problem of extended flowering is, therefore, overcome to a certain extent.

3.6 Grazing or cutting

Grazing or cutting seed crops before floral initiation or flower appearance generally does not decrease seed yields and may increase seed yields in some crops. Later defoliation which removes flowering parts is usually harmful.

In *S. guianensis* cv. Cook, cutting six weeks before floral initiation facilitates harvest as a more compact canopy results. *S. hamata* cv. Verano can withstand heavy grazing up to the early flowering stage without any loss in seed yield.

Defoliation can delay flowering times. This may be beneficial in providing a longer sequence of harvest operations, but it may be detrimental in delaying flowering when droughts or very cool nights occur. Defoliation does not appear to induce more concentrated flowering of tropical pasture seed crops.

Lodging of well grown grass seed crops can be prevented by grazing or cutting. Also, if mechanical harvesting is carried out there is less bulk to dry and to be handled in the header. This is especially beneficial with twinning legumes such as *Glycine wightii*, *Macroptilium atropurpureum* cv. Siratro and *Macrotyloma axillare*; a heavy grazing 12 weeks before harvest makes them easier to cut and thresh.
FIGURE 2. Flowering patterns of tillers 1, 2, 3, and 4 of Guinea grass (adapted from Kowithayakorn and Kannasoot, 1978).

4. Harvesting the seed crop

4.1 Problems of harvesting tropical pasture seeds

Grasses
1. Most of the grasses have very poor synchronisation of seed maturity; flowering proceeds over a very long period with inflorescences being continuously produced.
2. There is a constant turnover of spikelets and mature seeds shed very easily. Usually a crop at any particular time will contain a very high proportion of immature seeds. Most harvest methods used are destructive so that regardless of harvest time a high proportion of immature seeds will be harvested. This is illustrated in Figures 2 and 3. A normal Guinea grass plant has about four reproductive tillers. The flowering of each tiller varies (Figure 2), so that tillers 2, 3 and 4 commenced flowering 2, 2½ and 6 weeks respectively after the first tiller.

Seed maturity in Guinea grass is reached about 22 days after anthesis (Figure 3), yet shedding can occur at a very early age. Seed only 10 days old showed 23% seed shattering (Figure 3).

Therefore, with the possible exceptions of some species where selected harvesting can be done (beating or plucking Cenchrus ciliaris seed) and obligate plants with better synchronisation of maturity (Paspalum plicatulum and Melinis minutiflora), tropical grass seeds are harvested in an extremely immature state.

FIGURE 3. Changes in some physiological and seed quality components during seed development in Guinea grass (adapted from Kowithayakorn and Kannasoot, 1978).

3. Many of the seeds have awns, bristles and hooks which can interfere with harvesting and cleaning.
4. Grasses are usually harvested during the later stages of the wet season. Heavy monsoon rains can quickly cause seed shedding and plant lodging.

Legumes
1. Seed pods shatter readily when ripe, throwing the seed over a wide area. With pods forming over a long period (e.g. M. atropurpureum cv. Siratro), at any one time there is a large percentage of the seed on the ground unless daily hand harvesting is carried out.
2. Vegetative and reproductive stems, especially with twinning legumes, can intermingle making seed harvesting and cleaning difficult.
4.2 Time of harvesting

With grass seeds one must try to judge the stage when the rate of increase of ripe seeds from young inflorescences balances the loss of good seed from older inflorescences. Usually the first formed inflorescences produce more, and better quality, larger seeds than later-formed inflorescences. In the Philippines it was found that the largest quantity of high quality seed is produced from a Guinea grass panicle when the panicle has shed 40-60 percent of its spikelets (Javier and Mendoza, 1976). This is supported by work from Thailand (Figure 3) and from Kenya (Boonman, 1979) with other grass species.

Some techniques can be used to judge the time to harvest:
1. Seed hardness. Rub the seed in the palm of the hand and if a gritty, sandy noise is heard and the seed feels hard, then usually it is mature.
2. If the seed can be pinched out of the spikelets then it is ready to harvest.
3. Chenopodium cineraria seed plucks easily off the seed head when mature.
4. Paspalum plicatulum seeds change from green to brown at maturity.

Many legume seed pods change from green to brown at seed maturity e.g. Siratro and Leucaena. If ground harvesting is practised, then wait until nearly all the seed has fallen to the ground before commencing harvesting operations. Time of ground harvesting will often depend on periods of fine weather.

4.3 Methods of harvesting

Machine harvesting

Most tropical pasture grass seed crops in Australia are direct headed with conventional combine harvesters. This is a wasteful operation, as Roe (1972) demonstrated with Panicum coloratum (Table 12).

<table>
<thead>
<tr>
<th>Method</th>
<th>Seed yield recovered (kg/ha)</th>
<th>Seed size (mg)</th>
<th>Germination (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total collection (seed fell into bags below the plants)</td>
<td>410</td>
<td>0.98</td>
<td>54</td>
</tr>
<tr>
<td>Cutting and field drying</td>
<td>104</td>
<td>0.96</td>
<td>39</td>
</tr>
<tr>
<td>Hand shaking</td>
<td>256</td>
<td>1.03</td>
<td>53</td>
</tr>
<tr>
<td>Reaper and binder</td>
<td>31</td>
<td>0.76</td>
<td>29</td>
</tr>
<tr>
<td>Direct heading</td>
<td>123</td>
<td>0.74</td>
<td>35</td>
</tr>
</tbody>
</table>

Hopkinson and English (1982) found in studies on P. maximum cv. Gatton and Brachiaria decumbens cv. Basilisk that seed was lost in substantial quantities in direct heading at two main points: where the machine failed to gather it, and where it failed to thresh it. The bulk of green vegetation presented to combine harvesters in direct heading makes gathering losses high. However, even though losses were high, actual yields were 58% and 82% of the standing seed for Gatton panic and Basilisk signal grass respectively; these yields are an improvement on the 30% yield Roe (1972) got from direct heading P. coloratum (Table 10).

Direct-headed grass seed is usually of a high moisture content, 50-65%, and must be slowly dried at 35°C until a moisture content of below 14% is reached before seed cleaning. Farmers machine harvesting grass seeds must have drying facilities on their properties.

Some grass seed crops are harvested using a beating or rubbing technique. Only the ripe seeds are harvested leaving the immature seed attached to the plant for subsequent harvest. Humphreys (1979) describes various techniques. Rotating beaters in front of a gauze cage mounted on a tractor has successfully harvested Buffel grass and Green panic grass seed in Thailand and Australia (Plate 5).

Legume seeds in most cases are below 14% moisture at harvest. In Australia the legume seed crops are harvested in two ways.

1. Cut, dried and combine harvested and then, depending on the price of the seed and the amount of seed on the ground, vacuum harvested. Before vacuum harvesting the residue of the crop is baled, the stubble cut and windrowed with a side delivery rake, and the exposed ground surface vacuumed. Siratro seed crops often are combine harvested twice (July and November) and vacuum harvested after the final seed crop is combine harvested.

2. Cut, raked and vacuum harvested only. This method requires only one end of season total harvest of fallen seed on the ground. Styllosanthes hamata cv. Verano and S. humilis cultivars have been successively harvested by this method in Thailand and Australia (Plate 6).

Vacuum harvesting is slow (0.05 ha per hour) and soil particles are often difficult to separate during seed cleaning. While the speed of harvesting can not be improved the design and construction of a continuous-flow flotation cleaner using a heavy solvent (perchloroethylene) solved siratro cleaning problems in Australia (Hopkinson, 1977).

In North-east Thailand a successful
method was developed locally to harvest *Stylosanthes humilis* seed (Wickham et al., 1977). A conventional flail-type forage harvester operating from the pto of a tractor delivers the chopped seed crop into a large inclined rotating cylinder. The fine mesh of the screens allows the seed to fall into the bottom of the cylinder while the coarse material falls back into the field (Figure 4; Plate 7). Rice winnowers pre-clean the seed and a final cleaning is done by a rotating cylinder of steel straps which picks the *S. humilis* seed up by its hooks (Figure 4; Plate 8).

**Hand harvesting**

**Grass seed**

Hand harvested tropical grass seed is usually of a higher quality than machine harvested seed. Depending on the grass species, several methods of hand harvesting can be employed.

1. **Sweating**

*Panicum* species will produce high yields of high quality seed if the freshly cut seed heads are placed in a stack and then sweated for two to three days before threshing and drying (Plate

---

**FIGURE 4.** Diagramatic representation of harvesting and cleaning operation for Townsville stylo seed (from Wickham et al., 1977).
9). The main aims of sweating are to detach the seed from the heads and to allow marginally mature seed to mature fully.

Method of sweating
(a) Ripe seed heads are cut in the field, tied into loose bundles and taken to a shed. Long stems and leaves should be removed as their high moisture content can spoil the seed during sweating.

(b) The bundles should be stacked no more than one metre high with the heads turned inwards. The inside temperature of the stack may rise to over 50°C, CO₂ levels may reach 20%, oxygen may become virtually exhausted, and moulds will develop. The high moisture content inside the stack prevents the seed from losing water and the immature harvested seed completes its maturation process.

(c) When the stack is opened after two to three days most of the mature seed has undergone abscission. A light threshing on the floor will loosen more mature seed.

(d) Sweated seed should then be dried slowly over several days to the required storage moisture content (8-10%).

2. Stooking
Brachiaria decumbens, Chloris gayana and Paspalum plicatulum seed heads can be tied into bundles and stooked, heads upright, in a shed. The seeds must be allowed to dry out slowly over seven to ten days before threshing. The bundles can be placed on racks and allowed to dry and drop mature seed on to the floor, from where it is collected and cleaned.

3. Plucking
Cenchrus ciliaris and Chloris gayana seeds can be gently plucked by hand from the seed heads. Those seeds which can not be plucked should be left until they mature further.

4. Shaking
Mature seed of many species can be shaken out of their seed heads into bags in the field (Plate 10). Good, high quality, mature seed can be harvested two or three times a week using this method.

Legume seed
Mature seed pods of Macroptilium atropurpureum, Centrosema pubescens, Leucaena leucocephala, Crotalaria juncea, Pueraria phaseoloides, and Desmodium spp. can be hand picked every two or three days. Yields are higher if some of these species are grown on trellises rather than in swards, as yields are higher and the pods are more easily hand picked (Plate 1).

Seeds of Stylosanthes spp. can be ground harvested. At the end of the season the standing herbage is cut with machetes and rolled away, the seeds and residual debris swept into heaps and transported to a cleaning area. By using simple sieves and bamboo pans the seed can be cleaned to over 90% purity (Plates 13-16).

5. Seed drying and cleaning
Grass seeds are harvested at moisture contents above 50%. They must be dried slowly at temperatures not above 35°C, otherwise seed quality can be affected. Drying slowly on tarpaulins in the shade over several days is the best method. Drying on concrete pads is also effective, but temperatures can easily reach 45°C and destroy a moist seed lot very quickly. Seed dryers must be used if large areas of grass seed are machine harvested. Legume seeds are usually harvested at low moisture contents and do not require further drying after cleaning prior to storage.

Cleaning of the grass seeds can be difficult because of awns, bristles and hairs. Special machines have been developed to cope with these seeds (Linnert, 1977). Sweated seed can be threshed out, in the field (Plate 11) and cleaned using rice winnowers (Plate 12).

Recent developments include threshing Chloris gayana and other chaffy seeds in a cone thresher and burning the hairs off Cenchrus ciliaris seed.

Hand harvested legume seeds from pods usually require very little cleaning. Mention has been made already of Townsville stylo seed cleaners and floating siratro seed off heavy solvents. The heavy solvents do not affect seed germination.

6. Seed storage
There have always been problems with storing tropical seeds, especially grass seeds, and transporting them from country to country. There have been numerous instances of seed deterioration and failure to germinate.

Moisture proof bags and insulated containers are needed when transporting seed. Seed stored within countries should be in properly insulated cool rooms maintained at about 10°C with a relative humidity of 40%.
If farmers produce their own seed then storage and transport problems can be overcome to a certain extent. Home-grown seed may only have to be stored for a few weeks after harvest before being sown.

7. Moisture content and germination tests

7.1 Determination of moisture content

Two methods to determine content of seeds can be used (ISTA, 1985).

1. Low constant temperature oven method. Duplicate samples must be placed in containers and the container placed on top of its cover in an oven maintained at a temperature of 103 ± 2°C and dried for 17 ± 1 hours. The containers and their covers must be weighed before and after filling. The drying period begins at the time the oven reaches the required temperature. At the end of the prescribed period cover the container and place in a desiccator to cool for 30-45 minutes. After cooling weigh the container with its cover and contents. The relative humidity of the ambient air in the laboratory must be less than 70% when the determination is carried out.

2. High constant temperature oven method. The procedure is the same as above, except that oven is maintained at a temperature of 130-133°C, and the sample is dried for one hour. No special requirement pertains to the relative humidity of the ambient air in the laboratory during determination.

Calculation of results

Weighing shall be in grams to three decimal places. The moisture content as a percentage by weight shall be calculated to one decimal place by means of the following formula:

\[ \frac{(M_2 - M_1) \times 100}{M_2 - M_1} \]

where:

- \( M_1 \) — is the weight in grams of the container and its cover
- \( M_2 \) — is the weight in grams of the container, its cover and its contents before drying
- \( M_1 \) — is the weight in grams of the container, cover and contents after drying.

With the duplicate samples, the difference between the two moisture determinations must not exceed 0.2%. Otherwise, repeat the determination in duplicate.

7.2 Germination tests

Methods, substrates, temperatures, light conditions and special treatments are described in Table 13. For further details refer to ISTA (1985).
PLATE 1. Siratro establishing under trellises, Ubon forage station, Ubon, Thailand.

PLATE 2. Leucaena growing in 3 m spaced rows, Lamphyaklang livestock station, Saraburi, Thailand.

PLATE 3. Verano stylo growing in a sward, Ban Tum, Khon Kaen, Thailand.

PLATE 5. Harvesting Green panic grass using a rotating beater and gauze cage, Borabu seed research centre, Mahasarakham, Thailand.

PLATE 6. Bagging vacuum harvested Verano stylo seed, Swang Dan Din forage station, Sakhon Nakon, Thailand.

PLATE 7. Rotating cylinder and forage harvester, harvesting Townsville stylo seed, Huai Luang pasture centre, Udorn, Thailand.

PLATE 8. Cleaning Townsville stylo seed using rice winnowers and a rotating cylinder of steel straps, Borabu seed research centre, Mahasarakham, Thailand.
PLATE 9. Sweating Hamil guinea grass seed, Walkamin, North Queensland, Australia.

PLATE 10. Sabi grass seed harvesting, Lamphyaklang livestock station, Saraburi, Thailand.

PLATE 11. Threshing Green panic seed after sweating, Borabu seed research centre, Mahasarakham, Thailand.

PLATE 12. Cleaning Green panic seed using a hand driven rice winnower, Borabu seed research centre, Mahasarakham, Thailand.
PLATE 13. Cutting back Townsville stylo with a machete.

PLATE 14. Sweeping Townsville stylo seed sand, soil and debris into rows.

PLATE 15. Screening Verano stylo seed with fine debris falling through the 0.1 mm screen and seed remaining on top.

PLATE 16. Winnowing Townsville stylo seed in a rice winnowing pan.

PLATES 13-16. Harvesting and cleaning Townsville and Verano stylo seed, Ban Tum, Khon Kaen, Thailand.
<table>
<thead>
<tr>
<th>Species</th>
<th>Prescriptions for: Substrate Temperature °C</th>
<th>First count (days)</th>
<th>Final count (days)</th>
<th>Additional directions including recommendations for breaking dormancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alysicarpus vaginaeisis</td>
<td>BP</td>
<td>35</td>
<td>4</td>
<td>21 Pierce seed coat of swollen seed at 21 days and continue test until 35 days. Swollen seeds may be placed at 20°C for two days and then at 35°C for three more days.</td>
</tr>
<tr>
<td>Brachiaria humidicola</td>
<td>TP</td>
<td>20-35</td>
<td>7</td>
<td>21 KNO₃</td>
</tr>
<tr>
<td>Brachiaria mutica</td>
<td>TP</td>
<td>20-35</td>
<td>7</td>
<td>21 H₂SO₄; KNO₃</td>
</tr>
<tr>
<td>Brachiaria ruzizensis</td>
<td>TP</td>
<td>20-35</td>
<td>7</td>
<td>21 H₂SO₄; KNO₃</td>
</tr>
<tr>
<td>Cenchrus ciliaris</td>
<td>TP; S</td>
<td>20-35; 20-30; 30</td>
<td>7</td>
<td>28 Preheat; Prechill; KNO₃</td>
</tr>
<tr>
<td>Centrosera pubescens</td>
<td>TP</td>
<td>20-35</td>
<td>4</td>
<td>10 —</td>
</tr>
<tr>
<td>Chlorella gayana</td>
<td>TP</td>
<td>20-35; 20-30</td>
<td>7</td>
<td>14 KNO₃; Light</td>
</tr>
<tr>
<td>Crotalaria juncea</td>
<td>BP; S</td>
<td>20-30</td>
<td>4</td>
<td>10 —</td>
</tr>
<tr>
<td>Cyamopsis decaryon</td>
<td>TP</td>
<td>20-35; 20-30</td>
<td>7</td>
<td>21 Prechill; KNO₃; Light</td>
</tr>
<tr>
<td>Desmodium intortum</td>
<td>TP</td>
<td>20-30</td>
<td>4</td>
<td>10 H₂SO₄</td>
</tr>
<tr>
<td>Desmodium uncinatum</td>
<td>TP</td>
<td>20-30</td>
<td>4</td>
<td>10 H₂SO₄</td>
</tr>
<tr>
<td>Dolichos lablab</td>
<td>BP; S</td>
<td>20-30; 25</td>
<td>4</td>
<td>10 —</td>
</tr>
<tr>
<td>Glycine javanica</td>
<td>TP</td>
<td>20-30; 10-35</td>
<td>4</td>
<td>10 —</td>
</tr>
<tr>
<td>Leucaena leucocephala</td>
<td>TP; BP</td>
<td>25</td>
<td>4</td>
<td>10 —</td>
</tr>
<tr>
<td>Lonotis bainsil</td>
<td>TP</td>
<td>20-30</td>
<td>7</td>
<td>21 —</td>
</tr>
<tr>
<td>Macroptilium atropurpureum</td>
<td>TP</td>
<td>25</td>
<td>4</td>
<td>10 H₂SO₄</td>
</tr>
<tr>
<td>Macroptilium ianthroides</td>
<td>TP</td>
<td>25</td>
<td>4</td>
<td>10 H₂SO₄</td>
</tr>
<tr>
<td>Macrotylloma axilure</td>
<td>BP</td>
<td>25</td>
<td>4</td>
<td>10 H₂SO₄</td>
</tr>
<tr>
<td>Macrotylloma uniflorum</td>
<td>TP; S</td>
<td>20-30; 25</td>
<td>4</td>
<td>10 —</td>
</tr>
<tr>
<td>Melinis minutiflora</td>
<td>TP</td>
<td>20-30</td>
<td>7</td>
<td>21 Prechill; KNO₃</td>
</tr>
<tr>
<td>Panicum antidote</td>
<td>TP</td>
<td>20-30</td>
<td>7</td>
<td>28 —</td>
</tr>
<tr>
<td>Panicum coloratum</td>
<td>TP</td>
<td>20-35</td>
<td>7</td>
<td>28 —</td>
</tr>
<tr>
<td>Panicum maximum</td>
<td>TP</td>
<td>15-35; 20-30</td>
<td>10</td>
<td>28 Prechill; KNO₃</td>
</tr>
<tr>
<td>Panicum milaceum</td>
<td>TP; BP</td>
<td>20-30; 25</td>
<td>3</td>
<td>7 —</td>
</tr>
<tr>
<td>Panicum ramosum</td>
<td>BP</td>
<td>20-30</td>
<td>4</td>
<td>14 Preheat; KNO₃</td>
</tr>
<tr>
<td>Panicum virgatum</td>
<td>TP</td>
<td>15-30</td>
<td>7</td>
<td>28 Prechill; KNO₃</td>
</tr>
<tr>
<td>Paspalum dilatatum</td>
<td>TP</td>
<td>20-35</td>
<td>7</td>
<td>28 KNO₃; Light</td>
</tr>
<tr>
<td>Paspalum notatum</td>
<td>TP</td>
<td>20-35; 20-30</td>
<td>7</td>
<td>28 KNO₃</td>
</tr>
<tr>
<td>Paspalum plicatum</td>
<td>TP</td>
<td>20-35</td>
<td>7</td>
<td>28 KNO₃; Light</td>
</tr>
<tr>
<td>Paspalum scrobiculatum</td>
<td>TP</td>
<td>20-30</td>
<td>7</td>
<td>20 KNO₃</td>
</tr>
<tr>
<td>Paspalum urvillei</td>
<td>TP</td>
<td>20-35</td>
<td>7</td>
<td>21 KNO₃</td>
</tr>
<tr>
<td>Paspalum wettsteinii</td>
<td>TP</td>
<td>20-35</td>
<td>7</td>
<td>28 KNO₃</td>
</tr>
<tr>
<td>Psoraria phascoloides</td>
<td>TP</td>
<td>25</td>
<td>4</td>
<td>10 H₂SO₄</td>
</tr>
<tr>
<td>Setaria anceps</td>
<td>TP</td>
<td>20-35</td>
<td>7</td>
<td>21 KNO₃;</td>
</tr>
<tr>
<td>Setaria italica</td>
<td>TP; BP</td>
<td>20-30</td>
<td>4</td>
<td>10 —</td>
</tr>
<tr>
<td>Setaria sphacelata</td>
<td>TP</td>
<td>20-35</td>
<td>7</td>
<td>21 KNO₃</td>
</tr>
<tr>
<td>Stylosanthes guianensis</td>
<td>TP</td>
<td>20-35; 20-30</td>
<td>4</td>
<td>10 H₂SO₄</td>
</tr>
<tr>
<td>Stylosanthes humata</td>
<td>TP</td>
<td>20-35; 10-35</td>
<td>4</td>
<td>10 —</td>
</tr>
<tr>
<td>Stylosanthes humilis</td>
<td>TP</td>
<td>20-35; 10-35</td>
<td>2</td>
<td>5 Cut seed</td>
</tr>
<tr>
<td>Stylosanthes scabra</td>
<td>TP</td>
<td>20-35</td>
<td>4</td>
<td>10 —</td>
</tr>
<tr>
<td>Trifolium semifilum</td>
<td>BP; S</td>
<td>20; 15</td>
<td>3</td>
<td>7 —</td>
</tr>
<tr>
<td>Urochloa mosambicensis</td>
<td>TP</td>
<td>20-35</td>
<td>7</td>
<td>21 —</td>
</tr>
</tbody>
</table>

The abbreviations have the following meanings:
TP = top of paper
BP = between paper
S = sand
KNO₃ = Use solution of 0.2% potassium nitrate instead of water
H₂SO₄ = Soak seeds in concentrated sulphuric acid prior to the germination test.
Part 2. Grasses

1. *Panicum maximum*

1.1 Climate

There are a number of cultivars grown in South-east Asia.

1. *P. maximum* cv. Common

Tall growing perennial forming dense tussocks which enlarge by short root-stocks. Leaves are long and broad with flowering stalks 1.5 to 2.5 m tall. The seed is in the form of a spikelet with a single caryopsis. They are enclosed in smooth, hairless glumes. The green or purplish spikelets are 3-4 mm long.

2. *P. maximum* cv. Hamil

Hamil is taller than common guinea and can reach heights of 2.4-3.0 m. It has short creeping rhizomes and roots freely from root nodes. The green spikelets are 3.0-4.5 mm long enclosed in smooth glumes.

3. *P. maximum* cv. Gatton

Gatton panic is of medium height, 1.5 to 1.8 m, and has smooth stem nodes. The green or purplish spikelets are 2.5 to 3.0 mm long enclosed in smooth glumes. The leaves are finer than Common and Hamil. The leaves are darker green than Green panic in colour and the leaf sheaths are purple at the base.

4. *P. maximum*. var trichoglume cv. Petrie

Green panic is smaller than common guinea, with slender stems, fine soft leaves and it reaches a height of 1.5 to 1.8 m. It has an extensive root system which is finely branched and concentrated in the surface layers of the soil. The green purplish spikelets are 2.5 mm — 3.2 mm long enclosed in hairy glumes. The leaf sheaths are also hairy.

1.2 Establishment of the seed crop

Seed of *Panicum maximum* cultivars must be sown on to the surface of a very well prepared seed-bed. The seeds are very small (Green panic 1.9 million/kg, common guinea 1.1 million/kg) and so require a fine seed-bed for good establishment. Avoid covering the seeds to deeply with soil.

3 kg/ha of *Panicum maximum* cultivars and 6 kg/ha of Green panic seed must be sown at the beginning of the wet season, May/June.

1.3 Management of the seed crop

Grazing and cutting

All established seed crops must be grazed and the old stalks cut down to 30 cm at the beginning of the wet season.

Usually two crops of the seed can be harvested per season. The first in July/August and the second in September/October. After each harvest the field should be grazed and then the old stalks cut to 30 cm to allow fresh vegetative growth. Also, more reproductive tillers will form if the crop is grazed and cut after harvesting.

If the crop is producing too much vegetative material and growing too tall, it should be cut back to 50 cm or lightly grazed. A crop that is too tall, as is often the case with Hamil guinea, is very difficult to hand harvest.

Maintenance fertiliser

After the first harvest and subsequent grazing and cutting, ammonium sulphate or urea should be applied. Green panic, especially, has a high nitrogen requirement in North-east Thailand.

Weeds

All weeds must be hand grubbed especially *Chromolaena odorata* and *Pennisetum polystachion*.

1.4 Harvesting

Time of harvesting

Green panic and Gatton panic respond very well to early season rains and seed can be harvested in June and July. Common guinea and Hamil guinea set seed from late July onwards. Two harvests per season are usual for all *Panicum maximum* cultivars, the first between June and August and the second between September and October. In some seasons where there is good prolonged rainfall, three harvests of Green panic seed can be taken.

When 60-70% of the inflorescences have fully emerged, and some seed shedding has commenced, the seed should be examined for seed hardness and maturity. Gently shake the inflorescences and if the seed falls off easily, then the seed is mature. Rub this seed in the palm of the hand and if the seeds are hard and fully mature, a gritty, sandy noise will be heard. The crop should then be quickly harvested
before the good, hard, mature seed falls to the ground.

Method of harvesting

All the *Panicum maximum* cultivars are hand harvested. The quickest method that gives the maximum amount of seed is to cut the seed heads with a sickle, tie the seed heads together into a bundle, and then 'sweat' the bundles in a shed for two to three days (Plate 9). Often it is not necessary to cut the stalk as the stalk can be pulled out easily from the leaf sheath. This is better than cutting, because if a lot of leaves are left on the stalk, during 'sweating' the high moisture content of the leaves can cause mould and fungus to form. If sweating is not done, cut seed heads can be threshed in the field (Plate 11) and the seed cleaned in a rice winnower (Plate 12).

In small seed crops, the mature seed can be shaken into a bag two or three times a week. High quality seed can be harvested this way. However, this method is very slow and yields are usually low.

When harvesting begins, the seed must be harvested as quickly as possible. Seed of *Panicum maximum* cultivars shed very easily and rain storms during the wet season can destroy the whole seed crop. Therefore, dry periods during the wet season should be used to harvest as much seed as possible if the seed is ready to harvest. If rain storms are likely to come, it is often better to harvest the seed before the seed has reached full maturity rather than take the risk and wait for the optimum time of seed maturity.

1.5 Drying, cleaning and storage

Follow the same procedure for drying, cleaning and storage as outlined in Part 1.

1.6 Seed yields

From experience a yield of 25-50 kg/ha of pure clean seed can be expected.

2. *Cenchrus ciliaris*

Common name Buffel grass

2.1 Description

Tufted or rhizomatous perennial. Tall varieties grow to about 1.5 m in height, and medium varieties grow to about 1 m in height. Leaves are glabrous or hairy, 7-30 cm long and 2.5 mm wide, green or bluish in colour. The panicle is in the form of a single cylindrical spike, 3-15 cm long and 8-20 mm wide, pale or purplish in colour, bearing numerous clusters of spikelets, each cluster being surrounded by a ring of bristles. The spikelets can be solitary or in clusters, 3.5-5 mm long with a caryopsis 2-2.3 mm long.

1. Tall varieties

These varieties grow to about 1.5 m in height, and have straw coloured spikelets. The leaves are large and bluish green.

Cultivar Nunbank is similar to Biloela, but has higher seed production.

Cultivar Molopo is taller than both Biloela and Nunbank and it forms a sparser, more rhizomatous seed. Seed production is low.

2. Medium height varieties

These varieties grow to one metre in height, are leafier, more prostrate and have a greater number of tillers and do not develop rhizomes.

Cultivar Gayndah is very leafy with straw coloured spikelets.

Cultivar American has finer stems than Gayndah and is a lot denser. The spikelets are purple in colour.

3. Short Varieties

Cultivar West Australian grows to about 0.70 m in height, has dense fine-leafed tillers.

2.2 Establishment of the seed crop

Buffel grass seed should be broadcast at 2 kg/ha on to a well prepared seed-bed. The light fluffy seed is often very difficult to spread unless it is mixed with fine soil or sand, which facilitates spreading.

Buffel grass should be sown at the beginning of the wet season in May or June.

Ammonium sulphate and superphosphate should be spread at the time of establishment.

All weeds especially *Pennisetum polystachion* should be cleared from the site before establishment.

Seed of different varieties of Buffel grass can be easily mixed up so there should be a 20 metre spacing between varieties if they are sown at the same place.

2.3 Management of the seed crop

After each harvest, Buffel grass seed crops should be grazed and then cut by rotary slasher to 20 cm in height.

Old stands can be burnt prior to the wet season. Buffel grows extremely well after burning and will often produce good seed one month after burning if good rain falls.
After each harvest, except the end of season harvest, ammonium sulphate should be applied. The seed crop must be kept weed free by hand grubbing.

2.4 Harvesting

If climatic conditions are right, Buffel grass will produce seed all year round. Usually Buffel grass produces seed from May to November. However, early rains can cause seed to be produced in March and April. Some control over seed production is achieved if old crops are grazed, cut and fertilised with ammonium sulphate at the beginning of the wet season, and if the same is done after each harvest for both old and new crops. Harvests can then be taken every two months during the wet season.

When the spikelets with the seed inside are mature, they can be easily hand plucked from the spike-like panicle and put into bags in the field. Seed that is not ripe cannot be easily plucked from the panicle and should be left for later harvesting.

2.5 Drying and storage

Buffel seed is usually dry enough at harvesting time to make it unnecessary for any further drying. Cleaning of hand harvested Buffel seed is usually not necessary for local trading.

Buffel seed exhibits a post-harvest dormancy and so must be stored for at least six months before sowing. Seed harvested during the wet season can be stored over the dry season and sown the following wet season.

2.6 Seed yields

It is expected that an average yield of 30 kg/ha per season of pure clean seed could be harvested.

3. Chloris gayana

Common name Rhodes grass

3.1 Description

Cultivar Pioneer

Tufted perennial with strong stolons which root readily at the nodes. Leaves are glabrous, 15-50 cm long and 2-20 mm wide. Flowering stems grow to between 0.5 and 1.5 m in height with 10-12 brownish-green spike-like racemes, 4-15 cm long, per stem. The spikelets consist of two florets. The lowest floret is fertile, 2.5 mm long with an awn 1-10 mm long. The top floret is infertile with shorter awns. There are 3.9 million seeds per kg. Pioneer will flower all through the wet season. Pioneer is a diploid.

Cultivar Callide

It is much taller than Pioneer (up to 2.5 m), coarser, with thick stolons and stems, broad leaves, long racemes, and long awns on the spikelets. Callide is a tetraploid.

3.2 Establishment of the seed crop

Sowing

Rhodes grass seed must be sown at the rate of 3 kg/ha at the beginning of the wet season (May/June) into a thoroughly cultivated seed bed.

Broadcast the very small seeds on to the seed-bed surface. Do not bury the seed at all. Sand may have to be mixed with the seed to facilitate spreading.

Weeding

Rhodes grass seed is very difficult to clean, hence, all weeds must be removed from the site before establishment. During the growing season, Rhodes grass seed crops must be carefully hand weeded. The seedlings are often very small and weak and, therefore, do not like competition from other plant species, particularly weeds.

3.3 Management of the seed crops

Fertiliser

Apply ammonium sulphate at establishment.

Pioneer Rhodes grass should receive ammonium sulphate after each harvest during the season. Callide Rhodes grass flowers late in the season, therefore, only one application of ammonium sulphate is required.

Grazing and cutting

After seed harvesting, Rhodes grass seed crops are very rank and stemmy. They should be grazed or cut down and ammonium sulphate applied before closing up the field for the next seed crop.

Burning

In established seed crops, burning the old, rank, stemmy material before the wet season (March/April) is recommended. Rhodes grass responds well to burning, and lush green growth will result after the first rains, following burning.
3.4 Harvesting

Ripeness of the seed can be recognized by a change in seed colour which changes the field colour from dark brown to a rich tan. The crop is ready to harvest after there has been some shedding of the early maturing spikelets. When the crop is ready to harvest, the ripe seed can be squeezed out of the spikelets by pinching the base. Pioneer Rhodes will produce seed almost continuously throughout the wet season. Through grazing, cutting and nitrogen application, some control over seed harvesting periods can be achieved. Two to three harvests of Pioneer Rhodes can be taken in one season. Flowering of Callide Rhodes usually coincides with short-days and so occurs later on in the wet season.

The best method is to cut the seed heads off the stem at the top of the leaf canopy, bind them into bundles and the stook the bundles in a shed. The bundles are stooked for about one to two weeks and then threshed to release the seed. The stooking dries the seed out making it suitable for threshing. The bundles should be handled as gently as possible to avoid seed shattering.

3.5 Drying and cleaning

Rhodes grass seed must be dried down to 6-9% moisture content. The seed is very difficult to clean. A light winnowing, using cane pans after threshing and drying is usually all that is necessary to clean the seed in South-east Asia. Seed can be sown almost immediately after harvest, but germination improves in the first few months of storage, reaching its maximum in 6-12 months.

3.6 Seed yields

An average yield for both Callide and Pioneer of between 20-40 kg/ha can be expected in South-east Asia.

4. Urochloa mosambicensis

4.1 Description

A perennial creeping stoloniferous plant with a very flat crown and a low habit of growth. The stems are smooth with short silky hairs around the nodes. Leaves are 10-15 mm broad and 15-25 cm long with dense hairs on the upper and lower surfaces. Panicles have three to nine, one-sided, spike-like racemes 5-9 cm long. The spikelets are 3-4 mm long and 1.5-3 mm wide.

4.2 Establishment of the seed crop

For seed production, Sabi grass must be sown on to well-drained upland areas. The seed-bed must be very well cultivated so that the small seeds (one million per kg) can establish. Broadcast 3 kg/ha of seed on to a moist well prepared seed-bed. Do not bury the seeds as the rain will cover the seeds with soil. Apply ammonium sulphate and superphosphate at establishment.

The site must be completely weed-free prior to establishment.

4.3 Management of the seed crop

Sabi grass responds very well to rain and so comes away early in the wet season.

Three to four seed harvests can be taken in one season. After each harvest the seed crop should be grazed and ammonium sulphate fertiliser applied. Cutting after grazing is only necessary if a lot of old stems remain. Grazing removes the old foliage and enables fresh tillers to form.

4.4 Harvesting

Three to four harvests per season can be taken from June until October. The mature seed can be knocked into bags two or three times a week (Plate 10). High quality seed results from this method, but yields are low.

The seed crop is especially vulnerable to shattering during rain storms and so the seed should be harvested as quickly as possible when the seed is ripe. This is best done by having labourers cut the ripe seed heads with sickles and then stook the seed heads in bundles in a shed to dry out for seven to ten days. The seed is then threshed out of the seed heads, by beating on a screen or on to the floor. The seed heads can also be sweated for one to two days instead of stooking. Sweated seed falls out of the seed head very easily when threshed.

4.5 Drying and cleaning

The threshed seed must be dried slowly over three to four days, in the shade, to a moisture content of between 10-12%. Once this moisture percentage is reached further drying down to between 6-9% can be done in the sun.

Freshly harvested seed has very low germination and so must be stored for between nine and twelve months to overcome this post-harvest dormancy.
4.6 Seed yields
An average yield of about 30 kg/ha over one season would be expected.

5. Paspalum plicatum
Common name Plicatum

5.1 Description
Tufted perennial growing up to 1.2 m high. Long broad leaves which are slightly hairy. Panicle has 8-13 spike-like racemes, each 2-6 cm long containing a double row of spikelets. The glumes are hairy and the seed dark brown and shiny.

Cultivars grown in South-east Asia
Cultivar Bryan
In Bryan there is a distinct collar of short hairs at the junction of the sheath and blade. From this dense collar, a zone of fairly dense hairs extends for at least two cm down the sheath, tapering towards the midrib.

Cultivar Rodd's Bay
In Rodd's Bay the hairy collar is absent and the sheath is almost entirely hairless or, very occasionally, has just a few hairs on the upper portion.

5.2 Establishment of the seed crop
Plicatum will grow on relatively poor soil and will tolerate low-lying, damp, waterlogged soils. For maximum seed production, however, good heavy soils should be selected. The small seeds, 0.8 to 1.2 million seeds per kg, must be sown on to a very well cultivated seed-bed at the rate of 3 kg/ha. Ammonium sulphate and superphosphate should be applied at establishment.

If the two cultivars, Rodd's Bay and Bryan, are planted at same place, they must be separated by at least 50 metres from one another, in case seed is mixed up at harvesting time.

5.3 Management of the seed crop
Nitrogen fertiliser will increase seed yields and so ammonium sulphate should be applied 6-8 weeks after sowing. Plicatum sown in May should receive ammonium sulphate in late July or early August.

In second year or older seed crops, the stand should be slashed to 20 cm at the beginning of the wet season and ammonium sulphate applied. Ammonium sulphate should be applied again in July or August.

Established crops (two years old or more) can be grazed through the wet season until the end of July. The crop should then receive ammonium sulphate and be closed for seed production. Do not overgraze the crop to below 20 cm in height.

5.4 Harvesting

Time of harvesting
Seed production of plicatum is better synchronized than most of the other tropical grasses as it requires short days for flowering. Panicles will emerge in September and October, four to five months after establishment. Seed is usually ready to harvest three to four weeks after panicle emergence. However, in established crops flowering will occur earlier in the wet season, so that two harvests can be taken.

Plicatum seeds will change from green to brown at maturity. However, seed hardness (press with a pen-knife) is a better indication of maturity. Better quality seed and a higher yield of viable seed results from delaying the seed harvest until the early formed seed has shed. This delay will depend on suitable weather conditions. If the weather is doubtful, harvest before any seed has shed.

Method of harvesting
The mature inflorescences must be cut with a sickle, tied into bundles and then taken to a shed for stocking. The bundles are stood, heads upright, so that the seeds can dry out. Avoid stocking the bundles close together in case sweating and heating occurs. The purpose is to dry the seeds out on the panicles making threshing easy. Stook the bundles for seven to ten days before threshing.

5.5 Drying and cleaning
Plicatum seed must be dried to between 6-9% moisture content before storage. Seed harvested in one wet season can be sown the following wet season if it is kept in good sealed storage.

Hand harvested seed is easily cleaned by winnowing in cane pans.

5.6 Seed yields
An average yield of 80-100 kg/ha can be expected.
6. Brachiaria decumbens
cv. Basilisk
Common name Signal grass

6.1 Description
Vigorous, trailing, stoloniferous plant which forms erect stems, 30-100 cm high. Leaves are short, dark green, hairy and taper to a sharp point. The inflorescence is a panicle with two to three spike-like racemes attached at right angles to the panicle. The racemes are 2-5 cm long with double row of hairy spikelets 4-5 mm long. The seeds are 3.5-4 mm long enclosed in the floret. The seeds are larger than most grass seeds, 250,000-300,000 seeds per kg.

6.2 Establishment
For seed production, signal grass should be sown at the beginning of the wet season (May/June) at a rate of 5 kg/ha on to a very well prepared seed-bed.

Signal grass produces good seed crops on fertile sandy loam soils. Signal grass can be established vegetatively by planting cuttings on a square grid pattern, 30 cm apart.

Signal responds very well to nitrogen; ammonium sulphate and superphosphate must be applied at establishment.

6.3 Management of the seed crop
Fertiliser
Ammonium sulphate should be applied four to six weeks after establishment and again after the first seed harvest.

Grazing and cutting
After the first seed harvest in July or August the seed crop should be grazed and then the coarse rank stems slashed to encourage fresh tillers to form.

6.4 Harvesting
Time of harvesting
Signal grass can be harvested twice a season in South-east Asia; the first harvest is taken in July or August and the second harvest in September or October. The spikelets should be rubbed in the palm of the hand and if there is hard seed inside, a sandy, gritty sound will be heard. The spikelets can be pressed with a penknife (or between the teeth) to determine whether there is hard seed inside.

Methods of harvesting
1. The mature seed can be harvested by pulling the inflorescences down into a bag and shaking hard.
2. The inflorescences can be cut with sickle, tied into bundles and then taken to a shed and stacked. After seven to ten days when the seed has dried out, the seed heads must be threshed on the floor or over a wire screen.

6.5 Drying, cleaning and storage
Signal grass seed must be dried slowly over three to four days to between 6-9% moisture content. The hand-harvested seed is easily cleaned by hand winnowing, using can pans.

Seed of signal grass is usually of low germination, mainly because of the impermeability of the hard floral scales firmly enclosing the seed (caryopsis).

Post harvest dormancy is overcome by storing the seed in good sealed storage for nine to twelve months. Germination of freshly harvested seed can be improved by dipping the seed in concentrated sulphuric acid for 10-15 minutes, followed by a thorough washing in cold water before the seed is dried.

6.6 Seed yields
An average yield of 20-40 kg/ha can be expected.
Part 3. Legumes

1. *Stylosanthes hamata*
cv. *Verano*
Common Name Carribean stylo

1.1 Description
A short lived perennial with a semi-erect branching habit. The stems have short white hairs down one side. Leaves are trifoliate, acute and glabrous. The inflorescence is a spike, with 8-14 flowers on long stem. Each flower has two articulations, the upper is a hooked glabrous pod and the lower a hookless pubescent pod. Approximately 50% of the pods are hookless. The hookless pods are lighter in weight than the hooked pods. The seeds are medium to dark brown in colour and 2-2.5 mm long.

1.2 Site selection for seed production
For seed production *S. hamata* must be grown on free draining, upland sandy loam soils. *S. hamata* must not be sown on sites that are prone to drought and flooding. It only has a moderate tolerance of salinity and generally, saline soils should be avoided.

*S. hamata* must not be sown on the following soils:
1. Laterite, stoney soils
   Seed is collected from the ground and if mixed with stones, the stones are difficult to separate out during cleaning.
2. Heavy wet soils
   These soils will make *S. hamata* continue to produce vegetative growth during flowering, with very little reproductive growth and subsequent seed set.
3. Cracking clay soils
   Seed is very difficult to recover from the cracks of these types of soils.
4. Saline soils
   The plants grow very poorly on saline soils.
5. Waterlogged soils
   Sites that are water logged during the wet season are unsuitable for *S. hamata*.
   Soils that dry out very quickly at the beginning of the dry season are also unsuitable for *S. hamata* seed production. *S. hamata* sets seed over a long period and soils that dry out quickly will cause a lot of immature seeds to form.

1.3 Establishing the seed crop

Land preparation
Tall trees, shrubs and grass must be removed by slashing, hand grubbing, burning and grazing before cultivation. A weed-free site is best. Sites that are covered with the following weeds should be avoided, *Hyptis* spp., *Chromolaena odorata*, *Alysicarpus vaginalis*, *Sida* spp., *Mimosa pudica*, *Tephrosia* spp. and *Pennisetum polystachion*. If these sites cannot be avoided, then the weeds must be completely removed prior to cultivation.

The soil must be thoroughly cultivated. One disc ploughing, two disc harrowing and levelling before seed sowing is necessary. Village farmers who use buffalo must first plough and then harrow twice before seed sowing.

*S. hamata* seed is ground collected and so the site must be free from sticks and stones and very level. A well prepared level seed-bed will give an excellent seed strike, good plant establishment, and make seed harvesting easy.

The site should be prepared in March and April. After the first rains in May, a final harrowing should be given and the seed sown. If the seed is sown in June and July greater attention must be given to cultivation and weed control.

Sowing
Broadcast on the surface at a rate of 4 kg/ha early in the wet season. It is not necessary to cover the seed as the rain will push the seed into the soil. For good establishment the soil should be moist for three to six days after sowing.

Fertiliser
Apply superphosphate and gypsum at establishment. Split dressings of gypsum may be necessary as sulphur is easily leached out of the soil. In some areas with a potassium deficiency it will be necessary to apply potassium sulphate at establishment rather than gypsum. Apply gypsum later.

Re-cultivation
*S. hamata* for seed production should be treated as an annual and the site should be re-
cultivated after seed harvesting in March. Second year crops that are not resown but regenerate themselves, tend to be very dense and low seed yields result.

**Rhizobium requirements**

*S. hamata* does not need inoculation, as it nodulates freely with native rhizobia of the cowpea type in the soil.

### 1.4 Managing the crop

**Weeds**

All weeds must be hand removed from the seed crop during the wet season. *Hyptis* spp., *A. vaginalis*, and *Sida* spp., especially, must be totally removed from the seed crop before they produce seed, as seeds of these weeds are very difficult to separate out from *S. hamata* seed during cleaning. Weeds should be removed, dried, and then burnt outside of the seed field.

*Trifluralin* should be used as a pre-emergence herbicide and 2,4-D for post-emergence (plants must be 5 cm tall) and established crop weed control.

**Grazing and slashing**

*S. hamata* grows very vigorously during the wet season and has a tendency to suffer from moisture stress during the early dry season when the seed is setting. Immature pods can form without any seed inside at all. Moisture stress can be avoided to some extent by preventing *S. hamata* from growing too tall, through grazing or slashing in late July and early August.

Grazing or slashing must take place before flower formation in late August. Do not graze or slash the plants below 20 cm in height.

It may not always be necessary to graze or slash if the crop is growing on good soils that do not lose their moisture and the plants are not over 50 cm in height at the time of flower formation in late August.

### 1.5 Harvesting and cleaning the seed crop

*S. hamata* is a QSD plant so it will start flowering early in the growing season. It will start producing inflorescences with seed in September and October. The seeds ripen unevenly and fall out on to the ground when ripe. By February, when nearly all the seed has ripened and fallen out, harvesting can begin. In some areas due to moisture stress, seeds will ripen earlier. In other area where rain falls during the dry season, seed will keep forming throughout most of the dry season.

*S. hamata* can be successfully hand harvested and cleaned by village farmers (Plates 13-16). The areas to be hand harvested should be no more than 0.5 ha in area, unless a lot of labourers can be employed.

The sward is first cut off at ground level using knives, machetes and hoes. (This herbage should be fed to cattle before it wilts). Leaves, stem material, sand, soil and all of the mature seed form a dense litter on ground. This material must be swept up and gathered into small heaps using stick brooms, rakes and hoes. The material must then be sieved through mesh screens. The first 3 mm round hole mesh screen separates out sand and soil. Soil particles may have to be crushed on the 1.0 mm screen for the particles to pass through. This can be done by rubbing the seed with a rubber sandal. The seed and any remaining material must then be tossed in bamboo winnowing pans.

Mosquito netting, fishing nets, and cane sieves, can be all used to assist with cleaning the seed. The lower articule hookless seed pods in the flower must be pounded in a rice pounding bowl or rubbed vigorously with rubber sandals to remove the glumes from around the seed pods. A final winnowing will clean this seed.

If care is taken with seed-bed preparation, the ground is clean and level before sowing, weeds are removed during the growing season, and the harvesting and cleaning is done thoroughly and carefully, high yields of good clean seed will be produced by hand harvesting.

### 1.6 Seed yields

Yields of up to 900 kg/ha can be reached.

### 1.7 Seed storage

Seed can be stored in hessian bags in an ordinary room for up to six months. Seed harvested during the dry season (February/March) should be sown during the following wet season (May to October).

Seed that is dried and put in sealed plastic bags can be stored for up to one year in an ordinary room.

### 2. *Stylosanthes scabra* cv. Seca

**Common name** Seca stylo or shrubby stylo

#### 2.1 Description

Erect perennial legume up to 1.5 m in height. The stems are hairy, becoming very
woody with age. Leaves are trifoliate, long and wide. Flowers are small and yellow.

Each flower has two articulations; the upper is a pubescent pod with a small hooked beak; the lower a hookless pubescent pod. The seeds are yellow to light brown in colour 1.75 mm to 2 mm long.

2.2 Site selection for seed production
Free-draining, upland soils must be selected for Seca stylo seed production. Seca should not be grown for seed production on saline, laterite, and waterlogged soils.

Seca does not tolerate waterlogging or flooding; low lying areas should be avoided.

Even though Seca is extremely hardy and tolerant to drought, for seed production it should be grown on soils that do not dry out rapidly in the dry season.

2.3 Establishing the seed crop
Land preparation
Weeds such as Hymenaea spp. and Sida spp. must be completely removed from the site. The soil must be thoroughly cultivated by ploughing once and disc harrowing twice in March and April.

After the first rains in May a final harrowing should be given and the seed sown.

Fertiliser
Apply superphosphate and gypsum before sowing. Apply gypsum again two months later.

Sowing
The seed should be broadcast on the surface in rows 50 cm apart at a rate of 3 kg/ha early in the wet season. The rows should be clearly marked before sowing. It is not necessary to bury the seed as the rain will push the seed into the soil. If the seed is planted in a furrow 2 cm deep then seed will not be washed out of the rows during heavy rain.

Seca stylo is very slow growing the first year of its establishment. It is recommended that Seca seed be planted in plastic bags or ‘jiffy pots’ during the dry season and watered. When the wet season begins in May, plants 10-15 cm tall will be available to plant out.

Plant the seedlings 25 cm apart in rows and make the rows 50 cm apart. Seca grown from seedlings will establish very quickly the first year.

Heat treating seed
Germination percentage of Seca seed is improved by soaking the seed in hot water at 75°C for five minutes.

Rhizobium requirements
Seca inoculates freely with native rhizobia in the soil.

2.4 Managing the seed crop
Seca is slower growing than either S. hamata or stylo, therefore it should be sown as early as possible in the wet season or planted as seedlings.

For seed production Seca should not be allowed to grow more than 0.80 m in height. In August it should be cut back to 0.50 m. Seca planted in rows can be easily weeded.

2.5 Harvesting the crop
Seca starts flowering in October and a seeding peak is reached in February.

Seca seed should be gently knocked from the plants on to plastic sheets or cane pans two or three times a week. Seca seed holds very well in the flower head and usually no seed will fall to the ground at all. In March the Seca plants should be cut off at 20 cm, dried and then threshed to remove the remaining seed. Care should be taken not to cut the Seca plants below 20 cm otherwise they will die.

Seca seed is easily cleaned by tossing the seed in cane winnowing pans to remove leaf material. Seca seed should be dried before cleaning and storage.

2.6 Storage
Seca seed should be stored in sealed plastic bags. Seca seed in South-east Asia should be sown the same year it is harvested.

2.7 Seed yields
Yields of between 200-400 kg/ha can be expected.

3. Stylosanthes guianensis
Common name Stylo

3.1 Description
Semi-erect to erect perennial legume with branching upright stems up to 1 m in height, the stems are hairy becoming woody at the base with age. Leaves are trifoliate, long, rather narrow and pointed. Flowers are small and yellow in cv. Schofield and cv. Endeavour, but cv. Cook has orange coloured flowers.

Seed pods are hairy with a very small beak. Seeds are yellowish-brown, averaging 1.75 mm long and tightly enclosed in a brown hull.
Cultivar Schofield
Erect legume which flowers late in February and March setting seed in March.

Cultivar Cook
Leaves are narrower and more pointed than Schofield, and have a blue green colour with bright red stipules around the stem. It flowers six to eight weeks earlier than Schofield and sets seed in December and January.

Cultivar Endeavour
Semi-erect, densely branching, more prostrate type than Cook. Leaves are light green. Stems are thinner than Schofield. It flowers about two to four weeks earlier than Schofield in January and February.

3.2 Site selection for seed production
For seed production, stylo prefers good sandy loam soils that retain their moisture well into the dry season. Even though stylo will tolerate acid soils and poorly drained soils as a pasture plant, these soils are not suitable for stylo seed production. Likewise, free draining soils that S. hamata prefers, generally are not suited to stylo. Stylo prefers heavier soils than S. hamata. This is because stylo is a short-day plant and so does not flower and set seed until well into the dry season (January to March). Soils therefore must be able to retain their moisture for two to three months after the end of the wet season.

3.3 Establishing the seed crop
Land preparation
A weed-free site should be chosen. If such a site cannot be found, then weeds such as Hypitis spp. and Chromolaena spp. must be completely removed from the site, dried and burnt.

The soil must be thoroughly cultivated by ploughing once and disc harrowing twice in March and April. Several harrowings may be necessary if the site has recently been cleared from forest or scrub land. The site must be levelled, and completely cleared of sticks, stones and tree roots before sowing.

After the first rains in May a final harrowing should be given and the seed sown. Stylo requires a finer seed bed than S. hamata.

Fertiliser
Apply superphosphate and gypsum at establishment. Two months later apply gypsum again.

Sowing
Lightly hand sprinkle the seed down on to the surface in rows 50 cm apart at a rate of 3 kg/ha early in the wet season. Always harrow the site the day before or on the day of seed sowing. Do not bury the small stylo seeds, as the rain will push the seed into the soil to a sufficient depth for good germination. Mark out the rows clearly before sowing. For high seed yields the crop must not be too dense.

Rhizobium requirements
Stylo inoculates freely with native rhizobia in the soil, although it nodulates better in the second year of its establishment.

3.4 Managing the seed crop
Stylo is slower growing than S. hamata and therefore should be sown as early as possible in the wet season. The seed site should be well fenced so that livestock are prevented from grazing the young plants.

Once established stylo will grow rapidly. A light grazing or cutting to 40 cm in height in August will promote branching and prevent it from becoming woody. A short plant will also suffer less from moisture stress during the dry season, and set more mature seed than a tall plant. Do not cut the plant close to ground or overgraze stylo. Only graze or cut back the stylo plants if growth is rapid, and the plants look like becoming too tall.

Good weed control can be achieved by planting the stylo in rows. All weeds must be hand removed, dried and burnt away from the seed fields.

3.5 Pests and Diseases
Most perennial stylos are susceptible to anthracose attack and this will affect seed yields. Caterpillars attack flower heads of some cultivars and so stylo must be sprayed.

3.6 Harvesting and cleaning stylo seed
The three main cultivars of perennial stylo grown in South-east Asia all develop flowers and seeds at different times. A timetable of the expected development of stylo seed crops in North-east Thailand is shown in Table 14.

Hand harvesting should commence at the seeding peak for each cultivar.
Stylo seed holds in the flower head longer than S. hamata before falling to the ground. Stylo planted in rows can be harvested by placing plastic sheets or rice winnowing pans underneath the rows or plants to catch the seed.
TABLE 14. Timetable of expected development of perennial stylo seed crops in Northeast Thailand.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Cook</th>
<th>Endeavour</th>
<th>Schofield</th>
</tr>
</thead>
<tbody>
<tr>
<td>First flowers appear</td>
<td>Late September</td>
<td>October</td>
<td>October</td>
</tr>
<tr>
<td>Flowering peak</td>
<td>Mid to late December</td>
<td>Mid to late January</td>
<td>Late January to early February</td>
</tr>
<tr>
<td>Seed peak</td>
<td>Mid to late January</td>
<td>Early to mid February</td>
<td>Late February to mid March</td>
</tr>
</tbody>
</table>

as it falls. Beating the plants two or three times a week will cause good mature seed to fall out on to the sheets or winnowing pans.

Seed that falls to the ground can be swept up from between the rows. A final cutting should be done, the plant dried and then threshed to remove any seed remaining in the flower head. The stylo plants should be cut about 20 cm from the ground. A close cutting will kill the plants. After cutting, there should be a final sweep to collect any seed remaining on the ground.

Seed-harvesting ants may be a problem, as they will take some of the seed. They usually store the seed around the entrances to their ant holes from where it is easy to collect and clean. The seed usually has been de-hulled if collected by ants.

Seed that has been collected from the plants is easily cleaned by tossing in rice winnowing pans to separate out leaves and stem material. Ground harvested seed must be sieved through 2 mm diameter round hole screens and 0.5 mm diameter round hole screens. Soil particles the same size as the seed may be a problem but by rubbing the seed with a rubber sandal, these soil particles will be crushed and then can be sieved out.

3.7 Seed storage

Stylo seed does not have to be dried. Seed can be stored in hessian bags for up to six months without deterioration.

Seed harvested during the dry season should be sown the following wet season.

Seed stored longer than six months in South-east Asia should be in sealed plastic bags in an air-conditioned room.

3.8 Seed yields

Yields of 100-200 kg/ha can be expected.

4. *Macroptilium atropurpureum* cv. Siratro

Common name Siratro

4.1 Description

Deep-rooting, twinning perennial with trailing, slightly hairy stems which root readily at the nodes. Leaves are trifoliate, dark green, and slightly hairy on the upper, and silvery and very hairy on the lower surface.

Flowers are dark purple to deep red giving rise to straight pods about 7 to 10 cm long containing 12 to 14 seeds. The seeds are light brown to black, ovoid in shape, 4 x 2.5 x 2 mm.

4.2 Site selection for seed production

Siratro will establish on a wide range of soils. It will even tolerate moderately saline conditions. For seed production however, the following sites should be avoided:

1. Damp low lying sites with heavy soils. Siratro does not tolerate flooding or waterlogging. Heavy soils will cause siratro to produce too much vegetative growth rather than reproductive growth.

2. Free draining laterite soils that dry out quickly. Pods will wilt and immature seeds will form when siratro is grown on laterite soils.

Siratro will give higher seed yields if it is irrigated so it should be planted at a site with easy access to water; next to a dam, stream or pump is an ideal site as siratro can be easily hand watered.

4.3 Weed control

Pre-planting chemicals can be used, but most post-emergence chemicals are harmful (Table 3).

4.4 Establishing the seed crop

Siratro should be planted at 2 kg/ha on to a well-cultivated seed-bed. The seed should be covered with a light cover of top soil 1.5 to 2.5 cm deep. This can be done by harrowing after seed sowing.

If trellises are to be erected the rows should be marked out clearly first and the seed sown in furrows. Trellises can be constructed before or after seed sowing (Plate 1).

Superphosphate and gypsum should be applied at establishment. Gypsum should be applied again two months later.

Trellises

Siratro will give very high yields, 600-900 kg/ha (Table 7) if trellises are constructed for the siratro to climb up. Trellises must be 1.5 m high and 1 m apart (Plate 1). They can be made
of bamboo, sticks, concrete posts and wire depending on the area to be planted and the funds available for their construction. The posts should be two metres apart in the rows and five strands of plain wire used. Concrete posts are better than wooden posts as they are not attacked by termites.

Sward

Lower yields, 500 kg/ha, will be produced if siratro is grown as a sward. The costs are much cheaper than trellises.

Seed treatment

Germination percentage of siratro is improved by using one of the following methods:
1. Soaking the seed in hot water at 70°C for ten minutes.
2. Scarification by rubbing small quantities of seed between two sheets of sandpaper held in the palm of the hand.

Rhizobium requirements

Siratro usually nodulates freely with the native cowpea type in the soil and so the seed does not require inoculation.

4.5 Managing the seed crop

Siratro grows slowly at the beginning of the wet season and then grows rapidly from August onwards.

Flowering is usually advanced by short days and moisture stress, but in South-east Asia siratro will produce flowers and seed pods throughout most of the year if conditions are favourable.

Disease pests

Siratro is attacked by Rhizoctonia solani, a blight which causes the plants to wilt and die. It is only severe during very humid periods and does not affect seed production in South-east Asia. Rust (Uromyces appendiculatus) causes heavy leaf losses.

Aphids and pod borers (Bruchus spp.) will cause damage to young pods and seeds. It is controlled by spraying monthly during November and March with dimethoate. This chemical will give sufficient control of aphids and pod borers once a month.

Sward management

Siratro should be lightly grazed during the wet season from July until September. Livestock will eat the runners back to the crown and then the crown should be protected from overgrazing by closing the field to stock. Do not graze below 15 cm. Rotational grazing every three weeks is best.

Large quantities of vegetative material should be removed by grazing before flowering begins in September and October.

On small specialized seed production swards of siratro, good yields are achieved through irrigation. The sward should be irrigated and subjected to a short interval of moisture stress which stimulates flower and seed pod development. After watering, the seed pods are elevated up above the sward making it very easy for hand harvesting.

Farmers who grow siratro for seed can easily water their plots using watering cans once a week. Overwatering must be avoided otherwise too much vegetative growth will form and very little reproductive growth will take place.

Trellis management

Siratro grows up the trellises during the wet season and by October a dense canopy of siratro will have formed over the trellises.

Reproductive growth should be simulated by subjecting the siratro to water and then a period of moisture stress. Siratro on trellises will require less waterings than siratro grown in a sward.

At the beginning of the next wet season in May, all the old vegetative material should be removed and the runners cut back to 15 cm and new runners allowed to climb up the trellises again. The trellises, if damaged, must be repaired. If the old vegetative growth is not removed, lower seed yields will occur in the second year and two wet seasons cumulative vegetative growth will cause the trellises to collapse.

4.6 Harvesting and cleaning the seed crop

Seed pods are ready to harvest when they change colour from green to brown. Siratro produces seed over a long period, hence the brown pods must be harvested daily from October to April. A lot of seed pods will shatter before they can be picked and the seed will fall to the ground.

From March to April, siratro in the sward between the trellises should be cut, and the seed that is lying on the ground swept up.

The seed pods must be sun dried on tarpaulins or on a concrete pad. Mosquito netting or fine gauze should be spread over the pods to prevent the seed from being widely
scattered. The seed is tossed in cane winnowing pans to remove the pods and other inert material. Ground collected seed should be passed through 2.5 mm slotted screens and over 1.5 mm slotted screens to remove sand, stones and other impurities before winnowing.

4.7 Storage
Siratro seed can be stored in ordinary hessian bags at room temperatures for two to three months during the dry season. One aluminium phosphate fumigation tablet per 100 kg must be added to prevent insect damage during storage. Seed stored for longer periods must be dried, put in sealed plastic bags with phostoxin tablets and stored in an air-conditioned room.

4.8 Seed yields
Trellises, daily harvesting 600-900 kg/ha.
Sward, daily harvesting 400-550 kg/ha.

5. Centrosema pubescens
Common Name Centro

5.1 Description
Centro is a vigorous, trailing, twining and climbing perennial legume. Leaves are trifoliate, dark green, pointed, and slightly hairy on the lower surface. Flowers are bright or pale lilac in colour which develop into straight or slightly twisted dark brown pods about 8 cm to 15 cm long containing up to 20 brownish-black mottled seeds.

5.2 Site selection for seed production
For seed production centro requires better soils and more rain than either siratro or S. hamata. Centro is more suited to the wet tropics but the long dry season in Thailand and parts of the Philippines is ideal for centro seed production.

5.3 Establishment of the seed crop
Centro is best grown on trellises or poles to facilitate hand harvesting.

Trellis construction
Trellises can be made of bamboo, wood, or concrete posts and wire. The trellises should be no more than 1.5 m high and 1 m apart. Trellises are identical to those constructed for siratro seed production (Plate 1).

Sowing rate, time and depth
Seed should be sown at 3 kg/ha to a depth of 2 cm in furrows one metre apart at the beginning of the wet season, May to June.

Seed treatment before planting
To improve seed germination the seed should be treated with boiling water for 15 minutes and then soaked overnight in cold water.

Rhizobium requirements
Centro usually nodulates readily with the indigenous rhizobia of the cowpea type, but seed inoculation with the appropriate culture is advisable because it is beneficial to good rapid establishment. The current Rhizobium culture used in Australia is CB 1103.

Fertiliser requirements
Centro grows well in fertile soils without fertiliser. It is recommended, however, that superphosphate and gypsum be applied at establishment and gypsum applied again two months later.

5.4 Management of the seed crop
Disease and pests
Centro is relatively free of pests and diseases. However, during flowering centro should be watched closely in case pests attack the seed pods.

Irrigation
Watering will stimulate reproductive growth, especially if followed by a period of moisture stress. More irrigation may be necessary if no rain falls during the early part of the dry season.

Grazing
Centro, if grown as a sward, should be very lightly grazed the first year. No grazing should take place after October.

Day Length
Centro is a short day plant so flowering is favoured by short days during the dry season. Pod production is therefore well synchronized, more so than siratro which has an indeterminate pattern. The critical photoperiod is slightly less than 12 hours.
5.5 Harvesting of the seed crop

Time of harvesting
Pod production is well synchronized by short days leading to maximum pod formation during January and February. Most of the seed (90%) is hand harvested during these two months.

The pods change colour from green to brown when the seeds are mature.

Method of harvesting
Hand picking the mature pods using contract labour (paid per kg of clean seed) is the best way of harvesting centro seed.

The pods must be dried on tarpaulins or on concrete pads in order that they split, releasing the seed.

Cleaning
Hand winnowing using can pans gives a satisfactory cleaning of centro seed.

5.6 Seed storage
The seed can be stored in ordinary hessian bags for up to six months.

5.7 Seed yields
Average yield of 200-400 kg/ha can be expected.

6. **Leucaena leucocephala**

Common name Leucaena; Gratin (Thailand); ipil-ipil, lepile and bayani (Philippines); lamtoro (Indonesia).

6.1 Description
Erect perennial shrub with large bipinnate leaves. Flowers are white ball-like clusters. These develop into long, flat, strap-shaped brown pods (11 to 20 cm long and 2 cm wide), containing 12 to 25 bright brown flattened seeds (4-6 mm long).

It has a very deep root system and the roots can reach two metres in one year.

Cultivars

Cultivar Hawaii — a small bushy type. It flowers and seeds heavily throughout the year. It is found throughout South-east Asia.

Cultivar Peru — slightly taller than the Hawaiian cultivar, with larger leaves; flower heads are larger but contain fewer flowers; pods are longer and broader, seeds larger and flatter. Peru grows into a tree and can reach 15 m in height. It is shorter than "El Salvador".

Cultivar El Salvador — an erect tall tree, with very little basal branching and will reach a height of 20 m.

Cultivar Guatemala — a tall sparsely branched tree.

Cultivar Cunningham — a cross between cv. Guatemala and cv Peru. It produces large quantities of forage and has a lot of basal branching.

6.2 Site selection
Leucaena will grow in a wide range of environments, but it prefers alkaline soils. It will grow on acidic soils, but only after a lengthy establishment phase. Leucaena does not tolerate shading and should be grown in the full sunlight.

6.3 Establishment of the seed crop
Leucaena seed must be treated before sowing to get good germination (80% germination in eight days). The seed must be soaked in hot water (80°C) for two to three minutes, the seed dried and if stored will remain viable up to 15 months after treatment.

Leucaena is very slow to establish. It should be grown in plastic bags in a nursery. Seedlings should be planted out when they are 5-10 cm tall and before the roots are breaking out of the plastic bags.

Seedlings must be planted in rows two metres apart with 20 cm between seedlings in the rows (Plate 2). Lime should be lightly spread down each row and mixed with the soil before planting. Lime will raise the pH of acidic soils and facilitate *Rhizobium* inoculation. The seed bed must be very well prepared with two deep ploughings and two discings during the dry season to kill the weeds. Leucaena seedlings will not tolerate competition and shading from other grasses, shrubs and weeds. The site therefore must be cleared of all vegetation and be thoroughly cultivated before the seedlings are planted.

Leucaena has a highly specific *Rhizobium* requirement and therefore needs inoculation with a special Leucaena inoculant. *Rhizobium* strains are available for special soil conditions; CB 81, from Australia for use in acid soils, and NGR — 8 from Papua New Guinea for use in alkaline soils. If the site has grown leucaena before, inoculation will not be necessary, as the *Rhizobium* will be in the soil. If inoculant cannot be obtained, then soil from around the roots of established nodulating leucaena trees should be used to grow the seedlings. This soil will contain the specific *Rhizobium*.
Superphosphate and gypsum should be applied to growing at seedlings. Molybdenum may be necessary for establishing leucaena.

6.4 Managing the seed crop

In the early stages of growth, leucaena will not tolerate competition from weeds or other plants. Weeds and other plants must be removed from around the seedlings.

In villages, fences must be constructed around the young seedlings to prevent poultry eating them.

Once leucaena has grown to 0.5 m in height, guinea grass can be planted between the rows. This has two advantages:
1. Guinea grass will prevent weeds growing.
2. Valuable livestock feed can be cut from between the rows.

In established seed crops the leucaena shrubs should be cut back to 50 cm at the beginning of every wet season to prevent them from becoming too tall. Shorter shrubs make hand harvesting easier.

6.5 Harvesting and cleaning the seed crop

When the seed pods change colour from green to brown they can be hand harvested. The dry pods must be threshed to remove the seed. Some cleaning may be necessary to separate out broken pods and stems.

6.6 Seed storage

Seed can be safely stored in hessian bags at room temperatures for up to six months if the seed is thoroughly dried before storage.

6.7 Seed yields

Yields per ha are unrecorded in South-east Asia.


