Forages for Smallholders Project

Technical Report No. 4

# Proceedings of the Third Regional Meeting of the Forages for Smallholders Project held at the Agency for Livestock Services of East Kalimantan, Indonesia.

Samarinda, East Kalimantan, Indonesia

23-26 March 1998

CIAT Working Document No. 188

Edited by W.W. Stür

AusAID

CSIRO

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Centro Internacional de Agricultura Tropical
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# The Forages for Smallholders Project (FSP)

The Forages for Smallholders Project (FSP) is a partnership of the governments of Indonesia, Lao PDR, Philippines, Vietnam, Malaysia, Thailand and P.R. China. A first phase of the FSP from 1995 to 1999 was funded by the Australian Agency for International Development (AusAID) and managed by Centro Internacional de Agricultura Tropical (CIAT) and the Commonwealth Scientific and Industrial Research Organisation of Australia (CSIRO). A second phase of the FSP from 2000 to 2002 has been funded by the Asian Development Bank (ADB) and is coordinated by CIAT.

The objectives of the first phase of the FSP were to increase the availability of adapted forages and the capacity to deliver them to different farming systems, in particular, upland farming systems in Indonesia, Lao PDR, Philippines and Vietnam, and to develop close linkages in forage development activities between these countries and Malaysia, Thailand and tropical areas of P.R. China. The main implementing agencies were:

| | | |
|---|---|---|
| Indonesia | – | Directorate General of Livestock Services (DGLS). |
| Lao P.D.R. | – | Department of Livestock and Fisheries (DLF), Ministry of Agriculture and Forestry. |
| Philippines | – | Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD). |
| Vietnam | – | National Institute of Animal Husbandry (NIAH), Ministry of Agriculture and Rural Development. |
| China P.R. | – | Chinese Academy of Tropical Agricultural Science (CATAS), Hainan. |
| Malaysia | – | Malaysian Agricultural Research and Development Institute (MARDI). |
| Thailand | – | Department of Livestock Development (DLD), Ministry of Agriculture and Cooperatives. |

**For further information**

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|---|---|
| Visit the CIAT-Asia website: | http://www.ciat-asia.org/ |
| Contact the CIAT regional coordinator: | CIAT<br>Regional Coordinator<br>PO Box 783<br>Vientiane, Lao PDR<br>Email: ciat-asia@cgiar.org |
| Visit the CIAT website: | http://www.ciat.cgiar.org/ |

# Contents

# Foreword

Regional meetings of the Forages for Smallholders Project (FSP) are held annually. They serve to summarise the activities and results obtained, and to give partners a voice in formulating the direction of the FSP. It is a forum to review activities, reflect on progress and decide on activities for the coming year. During the first phase of the FSP (1995-1999) the proceedings of the Regional Meetings were published in a Technical Report Series, providing a technical summary of the activities and results obtained in all partner countries. Three Technical Reports have been published so far:

- Technical Report No. 1: Feed Resources for Smallholder Livestock Production in Southeast Asia. Proceedings of the first Regional Meeting of the FSP held in Vientiane, Lao PDR, 16-20 January 1996.

- Technical Report No. 2: Proceedings of the second Regional Meeting of the FSP held at the Chinese Academy of Tropical Agricultural Science, Danzhou, Hainan, P./R. China, 19-24 January 1997.

- Technical Report No. 3: Forage Seed Supply Systems. Proceedings of a workshop held at the Animal Nutrition Research Centre, Tha Pra, Khon Kaen, Thailand, 31 Oct. and 1 Nov. 1996.

This forth Technical Report contains the proceedings of the third Regional Meeting of the FSP held at the Agency of Livestock Services of East Kalimantan, Samarinda, East Kalimantan, Indonesia, 23-26 March 1998. This meeting coincided with the mid-term review of the FSP and provided an excellent opportunity to present the achievements of the FSP, review the process of forage technology development and make plans for the remaining two years of the Project.

# The Forages for Smallholders Project – Where does it fit and what has it achieved?

# The FSP in Indonesia – Where does it fit and what can it achieve?

**Maimunah Tuhulele**[1]

## Introduction

As human population and income per capita increase, the demand for livestock products (meat, milk, and eggs) increases. The demand for ruminant meat (beef, mutton, veal, venison) is second to that for poultry. The ruminant population must increase to satisfy this demand. Consequently, the amount of feed produced for them must also increase.

Naturally occurring forages and crop residues barely satisfy the current demand by ruminant livestock. Additional forage must be produced. During the First Long-term Development Stage (1969 – 94), the Indonesian government, through the Directorate General of Livestock Services (DGLS), has tried to address this problem by introducing improved species of grasses and legumes, multiplying them in government stations, and then distributing these planting materials free to smallholder farmers.

Despite the efforts and budget put into the so-called Forage Intensification Program, there was very little adoption by farmers. The reasons for non-adoption include a shortage of species adapted to smallholder farming systems, low availability of planting materials, and lack of farmer involvement in the forage selection process.

Through a collaboration with the Centro Internacional de Agricultura Tropical (CIAT) and the Commonwealth Scientific and Industrial Research Organisation of Australia (CSIRO), the Southeast Asian Forage Seeds Project was implemented in East and Central Kalimantan, and at BPT-HMT Pelaihari, a government forage multiplication station, from January 1992 to December 1994. The project was funded by the Australian Agency for International Development (AusAID), and aimed to introduce and evaluate new forage germplasm, and distribute adapted varieties to smallholder farmers. Six broadly adapted forage species (*Andropogon gayanus* CIAT 621 or cv. Kent, *Brachiaria brizantha* cv. Marandu, *Brachiaria decumbens* cv. Basilisk, *Brachiaria humidicola* (several lines), *Centrosema pubescens* CIAT 15160, and *Stylosanthes guianensis* CIAT 184) were identified and recommended for on-farm testing.

In January 1995, a follow-on project, the Forages for Smallholders Project (FSP) started, also with funding from AusAID. This project built on the results from the previous project, taking up the challenge to develop forage technologies for smallholder farmers using a farmer participatory approach.

## Organisation and collaborators

The executing agency of the FSP in Indonesia is the Directorate General of Livestock Services (DGLS). The activities in the field are carried out by provincial and district livestock services. The subject matter specialists (Penyuluh Peternakan Spesialis/PPS), field extension workers (Penyuluh Peternakan Lapangan/PPL) and field technicians guide, supervise, and monitor day-to-day activities in the field. The project also collaborates with the Assessment Institutes for Agricultural Technologies (BPTP) in North Sumatra and Nusa Tenggara Timur (NTT) in eastern Indonesia, Udayana University in Bali, and forage multiplication stations of DGLS.

[1] Bina Produksi, Directorate General of Livestock Services, Jalan Harsono RM No. 3, Jakarta Selatan 12550, Indonesia.

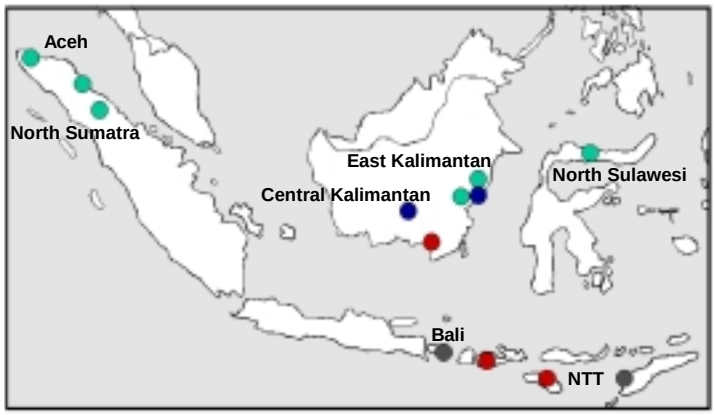



**Fig. 1. FSP sites in Indonesia.**

Sites of the FSP are located in several provinces (Fig. 1). These are in Aceh (grassland), North Sumatra (intensive sedentary upland agriculture and plantation), Central Kalimantan (rainfed lowland agriculture), East Kalimantan (extensive sedentary upland agriculture, rainfed lowland agriculture), and North Sulawesi (plantation and extensive sedentary upland agriculture). Additionally, the FSP collaborates with researchers in Bali and NTT in eastern Indonesia.

An overview of activities carried out at the FSP sites is shown in Table 1. They include regional evaluation of forages, farmer evaluation, multiplication of species, training, and seed production. Following a negative response of farmers during the participatory diagnosis stage, the activities in Central Kalimantan were limited to networking with technicians and PPL. To date, they are involved only in training and information exchange. Farmer evaluation of forages is being conducted at many sites. The local collaborators at each site are shown in Table 2.

Training of local collaborators (extension officers, development workers) in farmer participatory research (FPR) has been conducted in Samarinda and Sungei Putih. Training courses in forage agronomy are planned for Samarinda and Aceh in April/May 1998. Ir. Ibrahim received hands-on training in the Philippines in 1997.

**Table 1. Activities at different FSP sites.**

| Activity | Loa Janan, East Kalimantan | Makroman, East Kalimantan | Sepaku II, East Kalimantan | Kanamit, Central Kalimantan | Gorontalo, North Sulawesi | Marenu, North Sumatra | Pulau Gambar, North Sumatra | Saree, Aceh | Besakih, Bali | Kupang, NTT | BPT-HMT stations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Regional evaluation | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | - | ✔ | - | - | - |
| Participatory diagnosis | - | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | - | - | - |
| Farmer evaluation of forages | - | ✔ | ✔ | - | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | - |
| Farmer training | - | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | - | - | - |
| Expansion to other areas | - | ✔ | ✔ | - | - | - | - | ✔ | - | - | - |
| FPR training for field staff | - | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | - | - | - |
| Government seed production | - | - | - | - | - | - | - | - | - | - | ✔ |

Farmer training in the form of field days, cross visits, provision of planting material, and lectures/discussions have been carried out at all sites where farmers are testing forages.

**Table 2. Activities at different FSP sites.**

| Sites | Collaborators |
|---|---|
| Blang Ubo-ubo, Aceh Besar, Aceh | Ir. T. Bustari, Ir. Mansur, and Mr. Ghozali Zainal (Livestock Services) |
| Marenu and Pulau Gambar, North Sumatra | Dr. Tatang Ibrahim, Ir. Tri Kingkin, and Mr. Rijanto Hutasoit, (BPTP), Mr. Radianto and Mr.Zulkifli Tanjung (Livestock Services) |
| Kuala Kapuas, Central Kalimantan | Dr. M. Taufiq. Ir. Arief Heriadi, and Mr. Said Hasyim (Livestock Services) |
| Loa Janan, Makroman and Sepaku, East Kalimantan | Ir. Ibrahim, Mr. Herianto and Tugiman (Livestock Services) |
| Gorontalo, North Sulawesi | Ir. Susilan and Mr. Idrus Labantu (Livestock Services) |
| Besakih, Bali | Prof. I.K. Rika, Udayana University |
| Kupang, NTT | Dr. Jacob Nulik (BPTP NTT) |
| BPT-HMT Pelaihari, South Kalimantan<br>BPT-HMT Serading, NTB<br>BPT-HMT Kabaru, NTT | Staff of forage multiplication stations of DGLS |

Seed production and multiplication of planting materials must be carried out locally to make access to planting material easy for farmers. Vegetative propagation is often the preferred method by smallholder farmers. National seed production of the best varieties started at BPT-HMT stations in Pelaihari, Serading, and Kabaru. This activity is fully funded by DGLS.

# The FSP in Lao PDR – Where does it fit and what can it achieve?

**Viengsavanh Phimphachanhvongsod**[1]

## Introduction

The vast majority of livestock (cattle and buffalo) in Lao PDR are managed by smallholder farmers using few or no external inputs. Livestock are an important component of upland farming systems in Lao PDR, providing draft power, manure, food, income, and livelihood for resource poor farmers. Locally available inputs (such as rice straw and tree leaves) are sometimes utilized. Animals usually graze on communal land (forests, grasslands, roadsides) and are either kept in pens at night or simply left to roam. In raising livestock, the farmers encounter many problems, including:

- Diseases.
- Lack of feed during the dry season.
- Lack of feed at critical times during the wet season (such as planting and harvesting), when there is not enough labour to care for animals.
- Loss of animals to thieves and predators.
- Damage to other farmers' fields.

The Forage for Smallholders Project (FSP) is working with the Department of Livestock and Fisheries to address these problems. This paper summarises the activities of the FSP in Lao PDR.

## Agro-ecosystems

The project has activities in seven locations (Fig. 1), covering a wide diversity of agro-ecosystems and climate. Soil pH at these sites varies from very acid to neutral. Most soils are moderately to severely infertile. Average annual rainfall ranges from 1000 to 2600 mm, with peak rainfall occurring from June to August (Table 1, Fig. 1). The dry season at all sites lasts for 5 - 6 months, with only 1-4% of total rainfall being received during this period.


**Fig. 1. FSP sites in Lao PDR.**

## Project activities

The activities of the project at each of these sites are summarised in Table 2. In addition to these activities, the following booklets/manuals have been translated into Lao:

- Hacker JB, Simon BK, Phengvichith V. 1996. The pek savannas of the Lao People's Democratic Republic – ecology and floristics. Genetic Resources Communication No. 23. Australian Tropical Forages Genetic Resources Centre, CSIRO

[1] Livestock Development Division, Department of Livestock and Fisheries, Vientiane, Lao PDR.

Tropical Agriculture, Australia.

- Hacker JB, Phimphachanhvongsod V, Novaha S, Kordnavong P, Veldkamp J, Simon BK. 1997. A guide to the grasses of Xieng Khouang province, Lao PDR, and some notes on the ecology of grazing lands in the province. Genetic Resources Communication No. 28. Australian Tropical Forages Genetic Resources Centre, CSIRO Tropical Agriculture, Australia.
- Cheng Y, Horne P. 1997. Field experiments with forages and crops. Practical tips for getting it right the first time. 48 p. Australian Centre for International Agricultural Research, Canberra.
- Developing forage technologies with farmers. A training manual. Forages for Smallholders Project.

**Table 1. Agro-ecosystems for each location.**

| Agro-ecosystems | Louang Namtha | Oudomxay | Louang Phabang | Xieng Khouang | Vientiane | Savannakhet | Champassak |
|---|---|---|---|---|---|---|---|
| Agroforestry | ✔ | ✔ | ✔ | ✔ | - | ✔ | ✔ |
| Upland cropping | ✔ | ✔ | ✔ | ✔ | - | - | - |
| Grassland | - | - | - | ✔ | - | ✔ | ✔ |
| Rainfed lowland rice | - | - | - | - | ✔ | ✔ | ✔ |

## FSP partners

At all sites, we work with provincial and district livestock officers. The FSP has also established links with other development organisations in Lao PDR. Apart from consultative links, active collaboration in on-farm activities is continuing with the GtZ NAWACOP project in Xieng Khouang, the EC Micro Projects in Luang Phabang, and the Lao-IRRI Project in Luang Phabang. Another project with the Norwegian Church Aid in Luang Namtha is about to begin.

## Future activities

The FSP in Lao PDR is planning to expand its activities in on-farm development and evaluation of forage technologies. In 1998, we will start on-farm evaluations in Luang Namtha and Oudomxay and will involve more farmers from Luang Phabang and Xieng Khouang.

To do this, we must learn from our experience during our first year of on-farm work. Because we depend so much on the district rural development officers, we need to spend more time and efforts in developing their skills and motivating them to work with us. This means providing them more training opportunities (both formal and informal), visiting them more often and giving them opportunities to visit other sites to build their confidence in FPR methodologies.

As we expand our on-farm activities we will continue to conduct participatory diagnoses, as these are critical components in planning on-farm trials with farmers.

**Table 2. Project activities in Lao PDR.**

| Activity | Luang Namtha | Oudomxay | Luang Phabang | Xieng Khouang | Vientiane | Savannakhet | Champassak |
|---|---|---|---|---|---|---|---|
| Nursery evaluation | - | ✔ | ✔ | - | ✔ | - | ✔ |
| Regional evaluation | ✔ | - | ✔ | ✔ | - | - | - |
| On-farm evaluation | - | - | ✔ | ✔ | - | - | - |
| FPR training | - | - | ✔ | - | - | - | - |
| Agronomy training | - | - | - | - | ✔ | - | - |
| Evaluation training | - | - | ✔ | - | - | - | - |
| Participatory diagnosis | - | ✔ | ✔ | ✔ | - | - | ✔ |
| Forage multiplication | - | - | - | - | ✔ | - | - |
| Legume tree evaluation | - | - | - | - | ✔ | - | - |
| *Brachiaria* seed experiment. | - | - | - | - | - | - | ✔ |
| Grassland studies | - | - | - | ✔ | - | ✔ | ✔ |

# The FSP in the Philippines – Where does it fit and what can it achieve?

**Ed Magboo[1], Pat Faylon[1] and Francisco Gabunada[2]**

## Forage R & D activities in the country

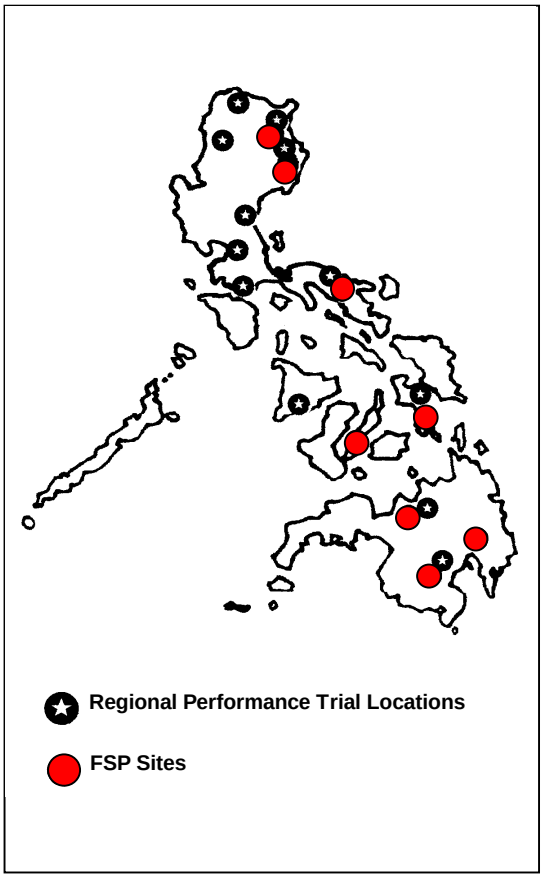
Forage evaluation in the Philippines formally started in 1973 with the creation of the National R & D Team for Forage, Pasture and Grasslands under the coordination of Philippine Council for Agriculture Forestry and Natural Resources Research and Development (PCARRD). Anent to this, a network of R & D stations was established (Fig. 1).

Most of these stations were state colleges and universities (Table 1). The forage evaluation and selection process follows standard procedures:

1. Varietal collection, evaluation, and selection.

*Germplasm collection*. Seeds of different species are collected and planted in plots for seed increase and propagation. In the absence of seeds, root stocks or cuttings are used as planting materials.

*Observational nursery trial*. This unreplicated trial screens a large number of entries. Seed yield potential is determined at this stage.




*Preliminary performance trial*. The entries are those selected in the nursery trials. Exceptions are new introductions with enough seeds and which are known to have performed well in other locations. Each entry is planted in 2 m x 6 m plots, replicated four times. This trial determines which entries will be considered for regional trials.

2. Regional performance trials (on-station).

Entries, which showed high potential from the preliminary performance trials, were distributed to various stations nationwide (Fig. 1). Evaluation based on associative properties, performance under specific environmental conditions, and animal performance is done at this stage.

After this evaluation, the entries that performed better than the existing materials are recommended for distribution and wide-scale adoption.

[1] Livestock Research Division, Philippine Council for Agriculture Forestry and Natural Resources Research and Development (PCARRD), Los Baños, Laguna, Philippines.
[2] Forages for Smallholders Project, CIAT, c/o The International Rice Research Institute, Los Baños, Laguna, Philippines.

**Table 1. Institutions involved in the existing R & D network.**

| | Institution | Location |
|---|---|---|
| 1. | Mariano Marcos State University | Batac, Ilocos Norte |
| 2. | Cagayan State University | Tuguegarao, Cagayan |
| 3. | Isabela State University | Cabagan, Isabela |
| 4. | Abra State Institute of Science and Technology | Lagangilang, Abra |
| 5. | Central Luzon State University | Muñoz, Nueva Ecija |
| 6. | Pampanga Agricultural College | Magalang, Pampanga |
| 7. | University of the Philippines Los Baños | College, Laguna |
| 8. | Bureau of Animal Industry | Diliman, Quezon City |
| 9. | Camarines Sur State College of Agriculture | Pili, Camarines Sur |
| 10. | West Visayas State College | Lambunao, Iloilo |
| 11. | Visayas State College of Agriculture | Baybay, Leyte |
| 12. | Central Mindanao State University | Musuan, Bukidnon |
| 13. | University of Southern Mindanao | Kabacan, North Cotabato |

## The FSP in the Philippines

The Forage for Smallholders Project (FSP) began in 1995. It is guided by the overall objective of the project, that is, to increase the availability of adopted forages and the capacity to deliver them to different farming systems, particularly upland farming systems. In the Philippines, the FSP is coordinated by PCARRD which is part of the Department of Science and Technology. The project has a large number of government and non-government collaborators (Table 2).

**Table 2. FSP collaborators in the Philippines.**

| Agency | Focal person | Project site | Farming system | On-going activities |
|---|---|---|---|---|
| Department of Agriculture | V. Pardinez / S. Darang | Gamu, Isabela | Upland | On-station trials |
| | C. Cabaccan / R. Pascua | Aglipay, Quirino | Upland | On-station trials |
| | R. Jamola / A. Cosep | Argao, Cebu | Upland | On-station trials |
| | A. Castillo | Camalig, Albay | Coconut plantation | On-farm trials |
| FARMI, Visayas State College of Agriculture | E. Balbarino / A.Obusa | Matalom, Leyte | Upland | On-farm trials |
| Mag-uugmad Foundation Inc. (NGO) | T. Llena / L. Moneva | Guba, Cebu | Upland | On-farm trials |
| Local government unit | P. Asis | Cagayan de Oro City | Upland | On-farm trials |
| | W. Nacalaban | Malitbog, Bukidnon | Upland | On-farm trials |
| Philippine Coconut Authority | J. Mantiquilla / C. Albacite | Davao City | Coconut plantation | On-station/ On-farm trials |
| Philippine Carabao Centre at University of Southern Mindanao | C.P. Subsuban / O. Arganas | Aroman, Carina, North Cotabato | Upland | On-farm trials |
| | | M'lang, North Cotabato | Rainfed lowland | On-farm trials |

While the regional performance trials (RPT) are conducted on-station, the FSP works with farmers to evaluate forages on farms. At FSP sites, various activities were carried out: Regional evaluation, seed production, farmer evaluation of forages,

multiplication of forages, training courses in participatory diagnosis (for technicians and farmers), planning and evaluation of forages, forage agronomy, and seed production (Table 3).

As part of the staff development program of FSP, 15 local staff (mostly present and prospective collaborators) were trained on Forage Agronomy at IRRI, Los Baños, Laguna from 4-15 August 1997.

**Table 3. Activities being carried out at FSP sites.**

| Activity | Sites | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Isabela | Quirino | Albay | Leyte | Cebu | CDO | Bukidnon | Davao | USM |
| Regional evaluation | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | - | ✔ | ✔ |
| Participatory diagnosis | - | - | - | ✔ | - | ✔ | ✔ | ✔ | ✔ |
| On-farm evaluation | - | - | | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| Participatory evaluation | - | - | - | ✔ | - | ✔ | ✔ | - | - |
| Multiplication of forages | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| Seed production | ✔ | ✔ | - | - | ✔ | - | - | - | - |
| Training of technicians | ✔ | ✔ | - | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| Training of farmers | ✔ | ✔ | - | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |

## Continued collaboration with the FSP – a must for the Philippines

### Access to germplasm

This is a vital area where FSP can help national R & D programs. With the continued program of the Centro Internacional de Agricultural Tropical (CIAT) and with appropriate funding from AusAID, continued access to forage germplasm is assured. The existing program on RPT on forages can be accelerated if FSP can provide new germplasm to the trials.

### Staff development

These is a dearth of available manpower, especially for on-farm R & D, FSP should therefore provide short-term courses and study tours and support attendance to regional and international scientific conferences. The cost can be appropriately divided between FSP and the host country.

### Access to information

Information is vital to R & D work. FSP can initiate establishment of facilities to enhance information exchange and access to information technology. The host country shall shoulder the maintenance cost once facilities have been established.

### New approach to technology development and delivery

Participatory approach to R & D is relatively new in the Philippines but this approach is well suited to the Filipino culture. FSP can provide the necessary training for local staff to strengthen their capability to use this new methodology.

# The FSP in Vietnam – Where does it fit and what can it achieve?

**Le Hoa Binh**[1]

## Forage research and development in Vietnam

Vietnam is a small country (332,000 km$^2$) with a population of more than 75 million. The pressure brought about by high population density and the ever-increasing need for cropland has resulted in a decrease in forests and grasslands, which are traditional grazing areas for cattle and buffalo. In recent years, the Vietnamese government has made structural changes in the agricultural economy, giving greater emphasis to livestock production. During a 10-year period from 1985-95, cattle number increased by 40% and buffalo number by 14%. The total contribution of livestock production to the national economy increased 66%.

The depletion of traditional grazing resources and the increase in livestock number imply a rapidly growing demand for alternative feed resources. What is needed are grass species with high yield potential for intensive production systems (such as *Pennisetum purpureum* and *Panicum maximum*), legume species such as *Stylosanthes guianensis* and *Leucaena leucocephala* to provide higher quality feed, and forage species for difficult soils and long dry seasons (such as some *Brachiaria* spp.).

The Forages for Smallholders Project (FSP) is working with partners in Vietnam to develop forage technologies for smallholder farmers. The main approach consists of:

- Introduction and evaluation of many forage species at different sites throughout Vietnam to identify those that are broadly adapted and have potential to solve farmers' problems.
- Use of participatory approaches to identify farmers' needs and to evaluate adapted forage species on-farm.
- Providing information on forage agronomy, management, and utilisation to development workers and farmers.

The National Institute of Animal Husbandry in Hanoi coordinates the FSP in Vietnam. The project is implemented in close collaboration with:

- Tay Nguyen University in M'Drak, Daklak Province.
- Hue College of Agriculture and Forestry in Xuan Loc, Hue Province.
- University of Agriculture and Forestry, Ho Chi Minh City in Binh Thuan and Ninh Thuan Provinces.
- Vietnam-Sweden Mountain Rural Development Project (MRDP) in Phu Tho, Ha Giang, Tuyen Quang, Lao Cai, and Yen Bai Provinces.

The activities carried out at each site are shown in Table 1.

[1] National Institute of Animal Husbandry, Thuy Phuong, Tu Liem, Hanoi, Vietnam.

**Table 1. Activities at FSP sites.**

| Site activity | Ba Vi | MRDP | Xuan Loc | M'Drak | Binh Thuan Ninh Thuan |
|---|---|---|---|---|---|
| Nursery evaluation | ✔ | - | ✔ | ✔ | - |
| Regional forage evaluation | - | ✔ | - | ✔ | - |
| Participatory diagnosis | ✔ | ✔ | ✔ | - | - |
| On-farm evaluation of forage | - | ✔ | ✔ | ✔ | ✔ |
| Multiplication of forage seed | - | - | - | ✔ | - |
| FPR training course | ✔ | - | - | - | - |
| Agronomy training course | - | - | ✔ | - | - |
| *Leucaena* evaluation | - | - | - | ✔ | - |
| Farmer training | ✔ | - | ✔ | ✔ | - |

Note: ✔ = Commenced and/or completed.

## Future activities

The FSP is planning to:

1. Conduct participatory diagnosis in Daklak and Binh Thuan provinces so on-farm work can begin this year.
2. Involve more farmers in testing forages at sites where the project is working.
3. Expand work to nearby villages at FSP sites.
4. Conduct regular participatory evaluation of forages at existing and new sites.
5. Introduce new species for specific purposes and areas (such as Setaria sphacelata cv. Solander for the northern regions, *Chamaecrista rotundifolia* for ground cover in fruit orchards, earlier flowering lines of *Stylosanthes guianensis* for the northern regions, and *Flemingia macrophylla* for fish feed).
6. Provide farmer training on forage production, management, and utilisation in Hue, M'Drak, and MRDP.

# The FSP in China – Where does it fit and what can it achieve?

**Liu Guodao, Zhuo Jiasuo, Bai Changjun and Wei Jiashao**[1]

In China the Tropical Pasture Research Centre, Chinese Academy of Tropical Agricultural Science (CATAS), coordinates the Forages for Smallholders Project (FSP). The main activities carried out are forage evaluation on station, farmer training, publications and networking.

## Forage Evaluation

### Selection of forages for leaf meal production

The main legume used for leaf meal production in southern China is *Stylosanthes guianensis* CIAT 184. Experiments are being conducted to find alternative accessions of *S. guianensis* with broad resistance to the fungal disease *Anthracnose* in case that the resistance of CIAT 184 breaks down.

Twenty-five accessions of *Stylosanthes* spp. were introduced from CSIRO (Australia) and CIAT (Philippines and Colombia). Together with four CATAS-released varieties, these accessions were included in the experiments to evaluate anthracnose disease resistance. The trials commenced at CATAS in August 1996 and results are described in detail in another paper in these proceedings.

### Selection of *Arachis*

Five accessions of *Arachis pintoi,* (CIAT 17434, 18744, 18748, 18750, 22160) and two accessions of *A. glabrata* (IRFL 3019, CPI 93483) were introduced from CIAT, Philippines and, together with one accession of *A. glabrata* introduced from Guangxi Province, were evaluated to assess forage yield. This experiment was planted in September 1996 and is ongoing.

Two experiments are being conducted to improve the persistence *of Stylosanthes guianensis* CIAT 184 in leaf meal production. Treatments designed to improve branching include time of first cutting, cutting height and frequency. These experiments are ongoing and results are not yet available.

### Selection of *Brachiaria* spp.

Four accessions of *Brachiaria brizantha* introduced from CIAT Philippines*, B. ruziziensis* from Thailand, *Brachiaria decumbens* CIAT 606, and another accession of *B. brizantha* are being evaluated in terms of adaptation and forage yield.

## Farmer training

Thirty farmers participated in a one-week training course in Lingshui County. They learned about cultivation and utilization of Stylo for leaf meal production, using a Stylo booklet (see publications) as the main training material.

[1] Tropical Pasture Research Centre, Chinese Academy of Tropical Agriculture Sciences, Hainan, P.R. China.

## Publications

CATAS researchers have written and edited a booklet on cultivation, management and utilization of Stylo. 1000 copies were printed in Chinese and more than half of these have already been distributed to farmers and extension agents. A draft of the booklet in English has also been finished.

CATAS also produced a comprehensive handbook on the cultivation and utilization of important varieties of tropical forages released in South China. Publication is expected in 1998.

CATAS also distributed the SEAFRAD newsletter.

## Future Activities

- Continue selection trials of forages for leaf meal production. Prepare seed of promising accessions for further evaluation.
- Continue the cutting management experiments of CIAT 184 Stylo.
- Continue selection trial of *Arachis*.
- Continue selection trial of *Brachiaria* spp. for grazing purposes.
- Set up a selection trial of *Panicum* spp.
- Set up a selection trial of *Setaria* spp.
- Publish the handbook on cultivation and utilization of tropical forages.
- Set up two or three FPR sites by using 4-5 promising forage species for cut-and-carry for farmer evaluation of forages.
- Farmer training in forage management in cut-and-carry forage systems.
- Share Farmer Participatory Research techniques learned with other projects at CATAS and the CIAT

# The FSP in Malaysia – Where does it fit and what can it achieve?

**Wong Choi Chee**[1]

## Introduction

The Malaysian Agricultural Research and Development Institute (MARDI) is the implementing agency of the Forages for Smallholders Project (FSP) in Malaysia. The overall objective is to increase the availability of adapted forages and the capacity to deliver them to smallholder farming systems, in particular, to agroforestry and other upland systems in Southeast Asia.

The four specific objectives are to:

1. Identify forages for different ecoregions in agroforestry, upland cropping, and plantation systems.
2. Integrate forages into these different farming systems through participatory research and development (R&D).
3. Increase the capability of national staff through training.
4. Improve the effectiveness of regional R & D activities through networking.

The specific terms of reference give MARDI the mandate to support the FSP by assigning one staff member of MARDI as the Malaysian coordinator (part-time) for the FSP project, providing reports of the progress of collaboration, and expediting project activities in Malaysia.

The FSP agreed to provide training in participatory R & D methods for two scientists from Malaysia, send one collaborator from Malaysia to attend annual project meetings and a regional conference at the conclusion of the project, and support the publication of a regional newsletter to foster linkages between forage R & D workers in Southeast Asia.

## The role of FSP in Malaysian Forage R & D

Based on the terms of reference, the FSP provided adequate opportunities for its Malaysian partners to attend meetings and training courses. We have learned a lot from our involvement in the FSP (on areas such as germplasm supply, seed supply, training in participatory research, and training in forage agronomy and seed production), and we were able to share our experiences and technologies with colleagues from other Southeast Asian nations, particularly on the forage technologies we have developed for plantation systems.

However, our contribution to the project could have been greater had Malaysia been included as full partner and recipient of assistance in the overall program. The demand for forages and forage R & D in Malaysia is continuing. There are frequent requests for better forages for exotic animal species, such as deer and ostrich. There is interest in creeping grasses that can persist in mango plantations to allow integration with ostrich. In this case, we have little to offer that can be established from seed apart from the *Brachiaria* species. We also receive requests for shade-tolerant grasses and legumes, but only a few productive species are available for commercialisation. Creeping grasses

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are also popular for soil erosion control on hill slopes, for terracing and for turfing. These and many other possible uses of grasses and tropical legumes have not been adequately exploited in Malaysia. In this regard, FSP can do more than limit its mandate on participatory research and development.

## Possible future role of FSP in Malaysia

The FSP could assist in forming the national livestock policy of Malaysia. The agricultural sector is still an important contributor to the national economy, both as a producer of export-oriented commodities and as a supplier of food and resources to the food-based industries. The livestock and livestock product industry was the fastest growing industry in the agricultural sector during the period of the Sixth Malaysian Plan. In 1995, the ex-farm value of the livestock production sub-sector was estimated at RM 4.2 billion and has registered an average growth rate of 7 % per annum since 1990. The poultry and swine industries continue to be major contributors, with poultry contributing 69% and swine 26% of the total ex-farm value. The balance of 5% total ex-farm value is contributed mainly by beef, mutton, and dairy. To further develop agriculture, the Seventh Malaysian Plan outlined the following policies:

1. Encourage greater participation of the private sector in agriculture on a large-scale basis, particularly in the production of food commodities and high-value produce, with the government providing the required support services.
2. Reorient production methods to improve competitiveness in the context of a more liberal market environment.
3. Consolidate the areas planted to rubber, oil palm, and cocoa with the end in view of reorienting production to meet the needs of the local agro-based industry.
4. Integrate and maximize agriculture and forestry land use.
5. Use modern technology.
6. Motivate plantation companies to explore new activities, particularly food production which has high value and can be produced on a large scale.

Modernization in livestock production means a deviation from current practices toward mechanization and increasing livestock density per unit area. We need to adopt a scientific and progressive R & D approach to achieve these objectives.

The more recent livestock production systems in Malaysia involved plantation-livestock integration, crop-livestock integration, and intensive feed lots. These systems of production have contributed to an increase in beef production from 12,200 t in 1990 to 15,600 t in 1995. Several plantation companies are actively involved in livestock production — cattle and sheep are reared in plantations to maximize land utilization and promote more sustainable farming. The feedlot system is widely adopted among commercial farmers. However, most of the raw materials and ingredients for feed production are still being imported. Private sector involvement in livestock production is being encouraged and the privatisation of livestock farms and abattoirs in the public sector is continuing.

To provide and promote livestock production as an attractive medium for long-term investment, the livestock production sub-sector will be developed into an efficient business enterprise, capable of providing enough supply for domestic and export markets and overcoming pollution and environmental problems. In the short term, there are proposals to designate specific zones for livestock production and ensure more effective implementation of regulations and standards, and promote large-scale cattle and sheep integration under plantation crops.

Based on this new agricultural policy, there is scope for forage development to serve the needs of the livestock industry. The following aspects need attention:

1. Forages (including fodder shrubs or leguminous trees) with high nutritive value need to be identified for cattle, sheep, deer, ostrich, and equine enterprises.
2. New forage ecotypes which are adapted to acidic soils, need to be tested in agronomic trials; forage species must be evaluated as conserved fodders in animal feeding trials.
3. Planting materials derived from selected germplasm of the genera *Brachiaria*, *Stylosanthes* and *Arachis* need to be made available to livestock producers. The species provided should match the ecological niches of the different production systems.
4. Many research activities on forages were done in the past. There is enough information compiled to develop a tropical forage database. The data could be used to develop systems and simulation models. At present, we tend to repeat work done elsewhere under similar conditions. A database for use in computing and simulation studies would save a lot of time and money.
5. There is a need to develop efficient seed production technology to meet domestic requirements.
6. Better cover crop legumes must be identified for the plantation environment. Little has been done to screen new materials for such environments.

## Conclusions

Under the terms and conditions of the MOU with Malaysia, the achievements and progress of the project have been satisfactory. However, much more could be achieved with greater cooperation between MARDI and the FSP. By definition, the FSP focus on smallholders has actually marginalized Malaysia's forage needs. The FSP is promoting participatory research and development and is applying the concept of 'participation' in planning its activities.

However, the FSP must recognise the uniqueness of each of its member country and it should try to help meet their diversified needs. The scope of the FSP can be broadened to include a variety of R & D activities that focus on the specific needs of the feed resource in each country and region. In this way, a stronger linkage between member countries could be fostered in the longer term.

# The FSP in Thailand – Where does it fit and what can it achieve ?

**Chaisang Phaikaew**[1]

## Forage R&D activities in Thailand

From 1994 to 1996, the Government of Thailand launched the Reformed Agricultural System Project which aimed to increase farmers' income. Under this project, rice and cassava areas were replaced with livestock farms. At the same time, the Department of Livestock Development (DLD) actively promoted dairy production. This expansion of beef and dairy production has increased the demand for improved forages which, in turn, has led to new research on forage species and methods of establishment, management, and utilisation. The research and development (R&D) efforts are spearheaded by the DLD and several Universities. The Division of Animal Nutrition in the DLD has a Forage Research Section, which is responsible for forage R&D for the whole country. In 1997, there were 45 forage research projects being conducted in eight animal nutrition research centres (Fig. 1).

### Selection of species

Most forage species being evaluated were introduced from other countries. Regional evaluations of 40 of the most promising grasses and legumes are being conducted at 25 forage stations and 8 animal nutrition research centres to identify the species best adapted to local environments. To date, three grasses (*Brachiaria ruziziensis, Panicum maximum* TD58, and *Pennisetum purpureum*) and three legumes (*Stylosanthes hamata* cv. Verano, *Stylosanthes guianensis* CIAT 184, and *Desmanthus virgatus*) have been identified as most promising. Other forage species that show promise but need to be evaluated further for their potential forage are *Paspalum atratum* BRA 9610, *Setaria sphacelata, Brachiaria brizantha, Brachiaria decumbens, Arachis pintoi* cv. Amarillo, *Centrosema pascuorum* cv. Cavalcade and Bundy, *Chamaecrista rotundifolia* cv. Wynn, *Aeschynomene americana* cv. Lee and Glenn and *Macroptilium gracile* cv. Maldonado.

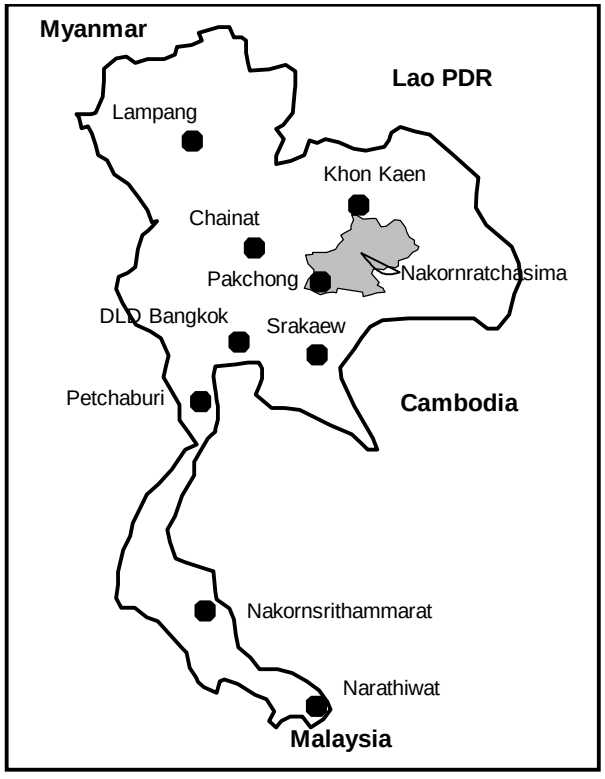


**Fig. 1. Location of animal nutrition research centres in Thailand.**

### Establishment, management, and utilisation of forage crops

Successful establishment of grasses and legumes lies in the choice of appropriate species and appropriate methods of establishment, including land preparation, sowing rate, and seed treatment. Many trials have been (and are continuing to be) conducted in Thailand to determine the best methods of establishment for promising species mentioned earlier (Thinnakorn and Wittayanuparpyuenyong 1992, Egara and Kodpat 1992).

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DLD's research on forage management provides a better understanding of the nutrient requirements of each species (Khemsawat et al. 1993, Suksaran et al. 1997) and the role of cutting in crop management (Punyavirocha et al. 1994, Nakamanee et al. 1995, Phaikaew et al. 1984).

Research is also continuing to assess the potential of these species for improving animal production. For example, we have known for some time that Ruzi grass is reasonably palatable when mature and provides good roughage for cattle and buffalo in the rainy season. However, the quality of Ruzi straw (after seed harvesting) is low, so it should be used in conjunction with a high-quality feed supplement (Kodpat et al. 1991, Chuenpreecha et al. 1992, Phaikaew et al. 1987). Dried *Desmanthus* leaf can be used to provide a protein supplement to improve the quality of feed for cattle in the dry season (Nakamanee et al. 1993, 1995).

### Seed production and processing technology

Unavailability of seed is frequently a major limitation in forage development programs. To address this problem, the DLD has developed considerable practical information on forage seed crop management, especially on *B. ruziziensis* and *P. maximum* TD58. As a result, Thailand was able to produce more than 1200 t of forage seed in 1995 (Phaikaew et al. 1997). Recent trials on new seed harvesting techniques have shown that excellent quantity and quality of seed can be obtained by shaking seed heads rather than cutting them (Phaikaew et al. 1995). Research on seed production of new promising species (*Stylosanthes guianensis* CIAT184 and *Brachiaria* spp.) is continuing.

### Transfer of forage technology

Each animal nutrition research centre and forage station in Thailand has been involved in transferring forage technologies to farmers in the vicinity. In the future, one village near each centre and station will be identified for dissemination of forage technologies.

## How does the FSP fit into these forage R&D activities?

A wider range of species that are better adapted to particular conditions in Thailand, such as lowlands, waterlogged soils, saline soils, and areas with long dry seasons is needed. The capability of local staff in forage agronomy and technology transfer should also be increased. The Forages for Smallholders Project (FSP) plays an important role in these forage R&D activities, especially in the selection of adapted species (see Fig. 2). The FSP has already provided new tropical forage germplasm and technical support for species evaluation, including the design, implementation, analysis, and interpretation of on-farm trials.

The FSP has also provided two training courses on participatory R&D methodology and forage agronomy, seed production and supply systems. It has funded one in-country course on participatory R&D, which was so successful that DLD funded additional courses for 54 forage officers from 8 centres and 25 stations during 1996-97.

Through FSP regional meetings and training courses, forage researchers from different countries in Southeast Asia now cooperate and share their ideas in forage development. This active networking alone is a good indicator of the success of the project.

# FSP activities in Thailand (1997)

The FSP in Thailand is a cooperative program involving the DLD and CIAT/CSIRO. Local staff and facilities have been mostly provided by DLD. The staff directly involved in the work are the country coordinator (Chaisang Phaikeaw) and two counterparts, Mr. Kiatisak Klum-em from the Division of Animal Nutrition and Mrs. Ganda Nakamanee from the Pakchong Animal Nutrition Research Centre.

### Regional evaluation

Seed production potential of 33 accessions of *Brachiaria* spp. introduced from CIAT by Dr. Werner Stür, has been evaluated in 1996-97 at the Pakchong Animal Nutrition Research Centre, Nakorn-ratchasima (Fig. 1). Nine accessions were selected for further testing in 1998.

### Seed multiplication

From the 1996 trial, five accessions of *Brachiaria* sp. demonstrated tolerance for dry conditions and potential to produce seed. *Brachiaria brizantha* CIAT 6780, 16835, 6387, 26110 and *B. decumbens* CIAT 26297. Seed of these 5 accessions has been multiplied at the Pakchong Animal Nutrition Research Centre. Plots were planted with seedlings in July 1997. Because the plots were planted late and there was a long dry season in 1997, seed yields were very low (Table 1).

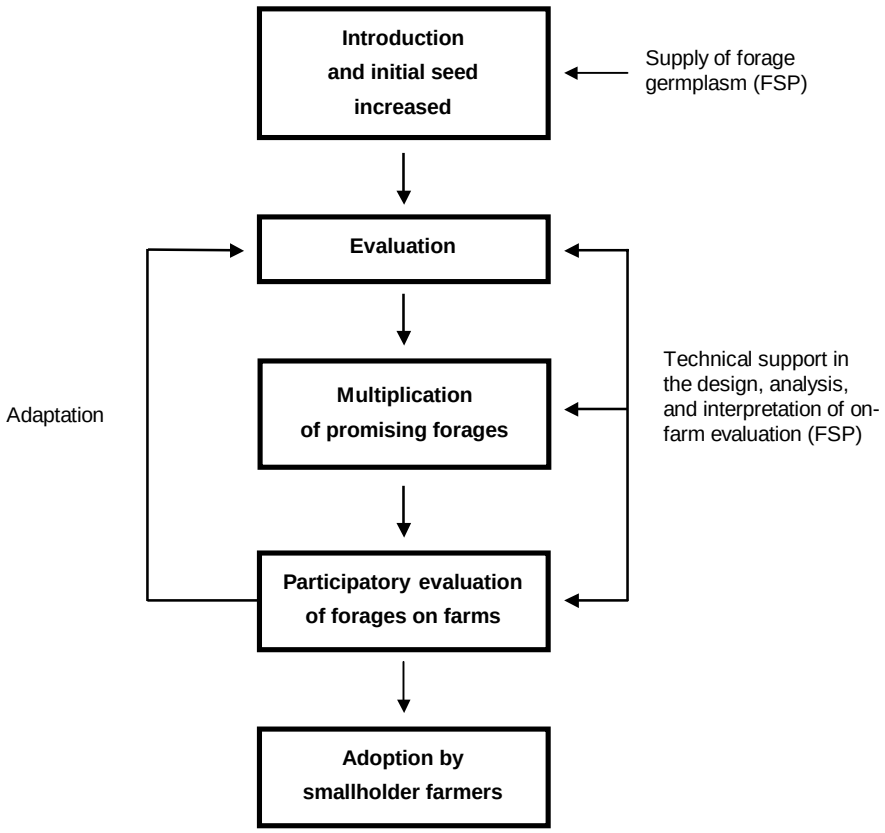


**Fig. 2. Integration of the FSP into forage R & D activities in Thailand.**

**Table 1. Seed yield of five *Brachiaria* spp. at Pakchong Animal Nutrition Research Centre.**

| Species | Area planted ($m^2$) | Seed yield (kg) | Seed yield (kg/ha) |
|---|---|---|---|
| *B. brizantha* CIAT 6780 | 325 | 4.8 | 148 |
| *B. brizantha* CIAT 26110 | 133 | 0.8 | 60 |
| *B. brizantha* CIAT 16835 | 300 | 2.8 | 93 |
| *B. brizantha* CIAT 6387 | 400 | 3.8 | 95 |
| *B. decumbens* CIAT 26297 | 100 | 2.6 | 260 |

### Farmer evaluation of new forage grasses for small dairy farms in Nakornratchasima

The grasses in Table 1 will be introduced to dairy farmers in Nakornratchasima Province in 1998 to get feedback on their performance. Dairy farmers from two villages in Sung Nern District were selected, being members of a farmers' group who were keen to participate and who had insufficient feed in the dry season for their cattle. This district has an average annual rainfall of 805 mm. Twenty farmers were selected to participate in the program. The farmers and district livestock officer will make plans to implement forage evaluations in April 1998.

### Distribution of SEAFRAD Newsletter and FSP books

Two issues of the 1997 *SEAFRAD Newsletter* were distributed to forage workers in animal nutrition research centres, stations and universities, and to others who were interested in forages. The FSP booklet, '*Field experiment with forages and crops. Practical tips for getting it right the first time*' and the proceedings of the FSP regional meeting held in Vientiane in 1996 *('Feed Resources for Smallholder Livestock Production in Southeast Asia')* were distributed to DLD and university researchers.

The FSP also facilitated better information exchange between regional forage workers by setting up an electronic mail system at DLD.

### IGC Participation

The FSP co-supported the attendance of Chaisang Phaikaew to the 18th International Grassland Congress (IGC) in Winnipeg and Saskatoon, Canada, on 8-19 Jun 1997. She presented a paper on *'Tropical Forage Seed Production in Southeast Asia: Current Status and Prospects'.*

## Acknowledgement

The author would like to thank all parties involved in the Forage for Smallholders Project for all their support and hard work, especially Dr. Werner Stür, Dr. Peter Horne, Dr. Peter Kerridge, Dr. Bryan Hacker, Mr. Chirawat Khemsawat (Director of Animal Nutrition Division), and Mr. Somchit Intaramanee (Director of the Pakchong Animal Nutrition Research Centre).

## References

Chuenpreecha. T., Jenkollop, D., Boonpakdee, W. 1992. Cassava meal or rice bran as a supplement to Ruzi hay for feeding buffaloes. In: Proceedings of the 11th Annual Livestock Conference, Department of Livestock Development, Ministry of Agriculture and Cooperatives, Thailand. p 342-351.

Egara, K., Kodpat, W. 1992. Method of establishment of Ruzi sward. Final report of the Technology for Pasture Establishment in Thailand. Department of Livestock Development, Ministry of Agriculture and Cooperatives, Thailand. p. 72-76.

Khemsawat, J., Punyavirocha, T., Nakamanee, G. 1993. Yield and chemical composition of hedge Lucerne (*Desmanthus virgatus)* at different P rates under irrigation. In: Proceedings of the 13th Annual Livestock Conference, Department of Livestock Development, Ministry of Agriculture and Cooperatives, Thailand. p 129-134.

Kodpat, W., Sanitwong, C., Padungsak, P. 1991. Utilization of corn and corn meal as a feed supplement for beef cattle. Annual report of the division of Animal Nutrition, Department of Livestock Development , Ministry of Agriculture and Cooperatives, Thailand. p 1-7.

Nakamanee, G., Khemsawat, J., Punyavirocha, T., Punpipat, W. 1995. Effect of cutting interval on yield and chemical composition of Napier grass (*Pennisetum pupureum*) dwarf elephant grass (*Pennisetum pupureum* cv. Mott) and King Grass (*Pennisetum pupureum Pennisetum americanum)* under irrigation. Annual report of the Division of Animal Nutrition, Department of Livestock Development, Ministry of Agriculture and Cooperatives, Thailand. p 122-128.

Nakamanee, G., Punpipat, W., Ponbamroong, T. 1993. Dried *Desmanthus* (*Desmanthus virgatus)* as a protein supplement for feeding cattle in dry season. Annual report of the Division of Animal Nutrition, Department of Livestock Development, Ministry of Agriculture and Cooperatives, Thailand. p 29-39.

Phaikaew, C., Suriyachantrathong, W., Indraramanee, S., Senagasp, U., Kawitsarasai, P., Nakamanee, G. and Phonboon, P. 1984. Yield and nutritive value of Verano Stylo (*Stylosanthes hamata* cv. Verano ) at different cutting intervals. In: Proceedings of the 3rd Annual Livestock Conference, Department of Livestock Development, Ministry of Agriculture and Cooperatives, Thailand. p 62-77.

Phaikaew, C., Devahudee, P. and Boonpahdee, W. 1987. Effect of defoliation and harvesting times on seed yield and quality of Ruzi grass (*Brachiaria ruziziensis ).* In: Proceedings of the 6th Annual Livestock Conference, Department of Livestock Development, Ministry of Agriculture and Cooperatives, Thailand. p 442-459.

Phaikaew, C., Pholsen, P. and Chinosang, W. 1995. Effect of harvesting methods on seed yield and quality of purple Guinea Grass (*Panicum maximum* TD58*)* produced by small farmers in Khon Kaen. Annual Report – Division of Animal Nutrition, DLD,, Ministry of Agriculture and Cooperatives, Thailand. p 102-107.

Phaikaew, C., Guodao, L., Abdullah, A., Tuhulele, M., Magboo, E., Bouahom, B. and Stür, W.W. 1997. Tropical forage seed production in southeast Asia: current status and prospects. In: Proceedings 18th Inter. Grasslands Congress, Canada, June, 1997.

Punyavirocha, T., Khemsawat, C., Nakamanee, G., Kanjanapibul, N. and Punpipat, W. 1994. Yield and nutritive value of hedge Lucerne ( *Desmanthus virgatus*) at different cutting intervals under irrigation. In: Proceedings of the 13th Annual Livestock Conference, Department of Livestock Development ,Ministry of Agriculture and Cooperatives, Thailand. p 176-182.

Suksaran, W., Vongpipatana, C. and Nonthanawong, T. 1997. Response of *Panicum maximum* TD58 to nitrogen and phosphorus fertilisers on Ubon soil series in Thung Kula Ronghai. Annual report of the Division of Animal Nutrition, Department of Livestock Development, Ministry of Agriculture and Cooperatives. p 99-117.

Thinnakorn, S. and Wittayanuparyuenyong, S. 1992. Quality improving of Ruzi pasture by using different seed rates of Verano and Graham stylo. Proceedings of the 11th Annual Livestock Conference. Department of Livestock Development, Ministry of Agriculture and Cooperatives. p 260-287.

# Livestock development in Indonesia

# Policy on livestock development in Indonesia

**Erwin Soetirto**[1]

## Introduction

Indonesia is one of the countries in Asia with an agricultural base. It consists of more than 17,500 islands, extending along 5110 km from east to west and 1888 km from north to south. The country covers a land area of 1.9 million km$^2$. Indonesia has 27 provinces, 243 districts, 62 municipalities, 3625 subdistricts, and about 65,852 villages. The human population is about 201 million, 63% of whom live in rural areas. About 54% of the labour force is engaged in agriculture.

Agriculture (forestry, food crops, fisheries, estate crops, and livestock) is the most important sector of the Indonesian economy, and livestock is an integral part of agriculture development. During the first phase of the long-term development plan (1969-93), the livestock sub-sector has contributed significantly to the development of agriculture. Although the share of the agriculture sector to national gross domestic product (GDP) decreased from 42% in 1969 to 18% in 1993, the contribution of the livestock sub-sector to agriculture GDP increased from 6% to 10.5% in the same period. For the second phase (1993-2018), the livestock sub-sector is estimated to grow 6.4% annually which compares to food crops 2.5%, estate crops 4.2%, and fisheries 5.2%.

## Role of livestock in national development

The role of livestock in national development covers the following areas:

### Livestock as a source of food supply

The supply of meat from ruminant and non-ruminant livestock increased from 309 t in 1969 to 1749 t in 1997. Of this amount, poultry meat was the largest contributor (59% or 1024 t) followed by ruminant meat (30% or 527 t). Egg production was 58 t in 1969, and this increased to 818 t in 1997. The purebred chicken egg is the largest contributor at 66%, followed by duck egg 19%, egg and free-range chicken egg 16%. Domestic dairy products increased from 29 t in 1969 to 447 t in 1997.

### Livestock as a source of income and labour absorption

At the farmer level, livestock and their products are a source of cash income as well as a reserve and a way of savings. Livestock minimize the risks of harvest failure.

At the national level, livestock contribute 11.5% to agricultural GDP or 2% to the national GDP. Livestock is a new growth source in the agricultural sector – its growth rate of 6.4% per year is higher than that of other sub-sectors. It can create job opportunities and the 6$^{th}$ Five-Year Plan has targeted an increase of 456,000 new jobs.

### Livestock for sustaining agriculture and environmental conservation

Research and experience show that mixed crop-livestock farming is profitable. Livestock complement other farm activities and the interaction between farm animals and farmland can improve soil fertility. Research shows that manure can be an alternative to lime for reclamation of acid farmland. Livestock can serve both as a source of power for

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ploughing paddy fields and as a means of rural transportation. In 1992, an ADB study suggested that distribution of beef cattle was conducive to expansion of paddy field and non-irrigated field, by 23% and 26%, respectively. Farm animals can be used for conservation of farmland, particularly in the prevention of erosion. Most conservation-related government programs include livestock as one of its components.

**Livestock for poverty alleviation**

Many smallholders own livestock and depend on it for income. A 1975 study by the University Gajah Mada indicated that farmers with less than 0.4 ha of land generate 34% of their income from livestock. The corresponding figure for farmers owning 0.4 - 0.8 ha is 22%, and from 0.8 upwards, 16%. Another study shows that a farmer who received a cattle loan (IFAD Project) earns 63% higher income than a farmer who did not. In a survey in Indonesia, 40-50% of respondents identified livestock as an important component of the poverty alleviation program.

**Livestock for industries**

Livestock also has the important role of providing raw materials to industries, either food or non-food. For the food industry, livestock provides raw materials such as meat, egg, and milk. For the non-food industries, livestock is good source of leather/skin, bone, horn, or other animal waste products.

## Policy of livestock development in the 6th five-year development plan (1994-1999)

The goal of livestock development is to:

- Increase income from livestock through optimising production capabilities, use of advanced technology, and increasing business efficiency.
- Increase livestock production to fulfil domestic demand, provide raw materials to industry and to enable export and import substitution.
- Improve quality of food and community nutrition through diversification.
- Develop agribusiness to encourage livestock development as an effort to increase income, create jobs and develop the rural economy.
- Optimise the use of natural resources for the benefit of livestock production and encourage environmental conservation by means of recycling waste.

**Strategies**

The attainment of this goal requires a strategy using three development approaches:

*Technical approach*

The main target is to increase livestock population. The approach is to increase livestock birth rate by means of artificial insemination and embryo transfer. To minimize mortality, animal health programs should be conducted: quarantine, vaccination, controlling slaughtered of productive female livestock, and importation of high-quality breeding stock.

*Integrated approach*

The target is to increase production through intensification. This means solving problems by integrating production, economic, and social aspects of technology development.

*Agribusiness approach*

The target is to optimise utilization of resources. With this approach, the smallholder farmers and livestock enterprises cooperate in farm supply, production, processing, and marketing.

**Problems**

- Scale of business ownership is relatively low.
- Operationalisation of livestock production and productivity has not been achieved yet.
- Animal disease outbreaks often occur.
- Dependence on provision of raw material for feed.
- Discrepancy between technology development and application at the farmer level.
- Farmer institutional needs to be improved through cooperatives.
- Inadequate infrastructure.

**Targets**

- 6.4% livestock growth to support 3.4% growth in agriculture.
- Absorption of 456,000 additional labour.
- Increase in production of meat from 1.3 million t to 1.6 million t (5.5% increase); egg from 636,000 t to 784,000 t (5.4% increase); and milk from 425,000 t to 530,000 t (5.7% increase).
- Increase in population of 11 species of livestock from 33.9 million units to 48 million units (8% annual increase).
- Increase in animal protein intake from 3.6 g/capita/day to 4.5 g/capita/day. At the end of the 6th Five-Year Plan, it is hoped that an average annual per capita consumption of 7.6 kg of meat, 3.0 kg of egg, and 6.2 kg of milk will be reached (3-4% increase).
- Investment in livestock development during the 6th Five-Year Plan of Rp. 5.5 - 7.9 trillion (or Rp. 1.1 - 1.6 trillion per annum).
- Import substitution to reduce the negative trade balance.

## Programs and projects

**Under government support programs**

*Integrated Smallholder Agricultural Development Program*

This program aims to increase the role of small-scale farm business by providing guidance to farmer groups and cooperatives. It is hoped that farmer will be independent and will take steps leading to farm industrialization based on a model developed by the Applied Centre for Agribusiness Development of Superior Farm Commodities.

*Agriculture Business Development Program*

It is hoped that this program will accelerate rural economic growth by intensifying capital, technology, management, and market access. Participation of BUMN (state-owned corporation) and BUMD (regional government-owned corporation) and cooperatives will be sought, as well as the private sector, and the farmers themselves to bring about a mutually profitable integrated agribusiness or agroindustry. This will require a climate conducive to private sector investment and must involve small-scale farmers.

*Food and Nutrition Diversification Program*

This program aims to consolidate the twin objectives of food self-sufficiency and improved nutrition through food diversification.

*Agriculture Resources, Input Supply, and Infrastructure Development Program*

This program aims to improve the quality of human resources and maximize the use of natural and agricultural resources and supply. The construction and development of facilities and infrastructure, in addition to the development of farmer institutions are intended to ensure efficient and effective use of all development resources.

*Support Programs*
This is divided into a program for effective use of system implementation and control, and a program of statistical improvement and development.

## Private programs and projects

**Development of beef cattle industries**

Three models are being followed:
- Fattening nucleus scheme.
- Feeder cattle nucleus scheme.
- Feed stuff nucleus scheme.

**Development of dairy cattle industries**

Integrated efforts have been made to consolidate this type of agribusiness covering improvements in breed and feed, and animal health and reproduction. Farmers' organizations are also improved.

**Development of poultry industries**

The development of a purebred chicken industry will be pursued in close partnership.

## Functional policies

There are five main functional policy elements in national livestock development: (1) animal health system, (2) livestock breeding system, (3) livestock production and farming system, (4) livestock distribution and development system, and (5) livestock agribusiness system.

**National Animal Health System**

*Animal health status*
Of a total of 226 kinds of animal diseases that exist in the world, 87 (40%) occur in Indonesia. Of the 44 sporadic diseases, 11 have been declared eliminated (as declared by the Minister of Agriculture's Decree of 31 January 1994) and two have been stated as case free (i.e. Malleus and Blue Tongue on serologic testing prior to be stated as a free disease). Since October 1990, Indonesia has been declared free of food and mouth disease. Without adequate and appropriate control of endemic and epidemic diseases , it is estimated that there would be annual losses of about Rp.100 billion. With the current control system, the losses can be minimized to 50%.

*Animal health approach*
The animal health approach consists of five components: animal protection, animal disease surveillance, prevention and control, veterinary public health, and veterinary drug control.

*Animal health operation*
The national animal health operation consists of four activities: integrated animal health services, protection of breeding environment, protection of natural resources, and protection of livestock products.

*Animal health infrastructure*
The main units of animal health consist of 7 Diagnostic Centres, 24 type-B and 51 type-C animal health laboratories, 1 veterinary drug assay laboratory, and 1 residue assay laboratory.

### National livestock breeding system

*Beef cattle breeding*

The national livestock breeding system aims to ensure adequate and good-quality breeding animal. There are three priority commodities in Indonesia's breeding development: beef cattle, dairy cattle, and poultry.

*Dairy cattle breeding*

Although the dairy cattle population increased significantly, there are problems of productivity, efficiency, and farm management facing the industry:

- Feeding management, particularly in feed quality.
- Reproduction and long calving interval.
- Mastitis, particularly subclinical symptoms.
- Poor milk quality caused by inadequate quality and quantity of feed as well as poor hygiene and sanitation.
- Poor farm management resulting in higher cost and lower productivity.

*Poultry breeding*

The 'native' chicken development was carried out with intensification of vaccination and mass guidance program. The breeding of commercial improved chicken is conducted by a number of breeding farms scattered throughout the country. In 1997, there were 116 chicken breeding farmers, operating in pure line farms, 16 grand parent stock farms, and 120 parent stock farms with 1.5 trillion day-old-chick production capacity and 195 million layers.

### National livestock production and farming system

The objectives of the system are to:

1. Achieve the projected production target.
2. Increase farmer's income and welfare.
3. Provide job and business opportunities mainly in the rural areas.
4. Assist in the formation of farmer groups, cooperatives and rural economic institutions.
5. Promote cooperation (partnership) between farmers and enterprises to increase added value adding.
6. Improve efficiency, productivity, and product quality to meet consumer's demand.

The system has four subsystems – namely ruminant production development, non-ruminant production development, poultry production development, and minor animal production development.

### Livestock distribution and development system

The livestock distribution and development system aims to optimise the use of under-utilised land to increase livestock production, to increase farmer's income and welfare, to alleviate poverty, and to fill the gap between regions and groups.

The system consists of four subsystems – the humid areas, the arid areas, the critical areas, and the border areas.

### Livestock agribusiness system

In the 6$^{th}$ Five-Year Development Plan, livestock agribusiness and agroindustry is targeted to:

1. Enhance the growth of livestock GDP to 6.4% per annum.
2. Support the investment to Rp 5.5-7.7 trillion.

3. Increase job opportunity in the livestock sub-sector to 3.5% per annum and labour absorption to 456,000 people.
4. Increase labour productivity by 2.9% per annum.
5. Create a conducive situation for investment in agribusiness.
6. Fill the gap between regions by enhancing development of the eastern part to the country.
7. Alleviate poverty.
8. Substitute import commodities and promote export of livestock commodities.

**National forage production system**

As the ruminant population increases, the demand for forages increases accordingly. It is calculated that the demand for 1998 alone is equivalent to 37 million tonnes of dry matter. To meet this demand, several programs on forage development have been launched. These efforts could be divided into four categories:

1. Intensification, through a program of planting improved species such as Napier, King grass, and legumes.
2. Extensification through establishment of grazing lands and forage multiplication stations.
3. Rehabilitation of critical lands.
4. Diversification, through increased use of agricultural and industrial by products.

*Constraints to forage development*

Forage development programs in Indonesia face several constraints. The major ones are as follows:

- The average land owned by a farmer in Java is very small. It is difficult to expect farmers to plant forages on this limited area, which is mainly planted to food crops. In the outer islands, farmers do not consider forage supply a serious problem, since a vast area of natural grassland is available, and herd size per family is small in this region.
- Investments to improve natural pasture and cultivated pasture are high. The shortage of seeds (due to low seed production), the price of fertiliser and the high cost of transportation of vegetative planting materials limit improvement efforts.
- Forage production technologies are still new to farmers. The lack of knowledgeable and experienced technicians and extension workers results in low rates of adoption.

*The prospects for increasing forage production*

Prospects for increasing forage production in Indonesia depend on the development of the ruminant industry. With increasing demand for meat and milk, the ruminant population should increase to meet this demand. Hence, the need for forages will also increase. Also, with pressure from population growth and with the establishment of new economic areas, existing natural pastures will be converted into cropping areas and construction projects, further reducing the feed base.

There is a tendency to involve forage development in new development programs, such as reclamation of critical lands, watershed management, and reforestation, which are aimed at improving the welfare of farmers in the surrounding areas.

Some grasses and legume species suitable for different agro-ecosystems have been identified through, among others, the forage seeds project. These species are being integrated into upland farming systems through the Forages for Smallholders Project. To assist farmers, technicians and extension workers have been trained in forage agronomy and in the participatory approach. Soon more staff will undergo similar training.

## Livestock towards an international free trade

The major force that influences the livestock industry in Indonesia is the continued movement toward open and free trade and investment at the global and regional levels in the face of the implementation of the Uruguay Round of GATT and the evolution of regional trade groups such as the EC, NAFTA, AFTA, and the emerging APEC forum.

In anticipation of these situations, the government has formulated several policies to strengthen livestock development in the country:

**Beef cattle**

The following principles will be followed: increase beef cattle population; balance supply and demand; decrease on import; value added; and people participation. Application of a non-tariff policy through a 'technical barrier on trade' in the short-term:

1. Import cattle should be feeder steers, 2.5 years, maximum weight 350 kg; go through a feedlot system for at least 60 days; and 10% of imported cattle should be pregnant heifers to increase livestock population.
2. Since the importer/private company do not want to cooperate with farmers, they have to buy 20% of the local feeder steers.
3. As per the decision of the Working Group on Agriculture and Food Cooperation of Indonesia-Australia, feedlot operators are called upon to set aside 1% of their profit for purchasing cattle for farmers.

Implementation of technical policy through

- Beef cattle intensification (INSAPP)
- Development of village breeding centre (Gerbang Serba Bisa)
- Development of priority commodity (SPAKU)
- Development of livestock in transmigration areas
- Strengthening of beef cattle breeding (Inpres Perbibitan)
- Eradication and control of brucellosis.

**Poultry**

Trends in poultry development show that supply is greater than demand. The oversupply of poultry would be exported. The government policy is directed at increasing efficiency and productivity, to enable poultry producers to compete in the market through better quality products, competitive prices and good delivery systems.

**Dairy Cattle**

Continue the consolidation program using the agribusiness approach through the cooperation between GKSI (Union of Indonesian Dairy Cooperatives) and the IPS (Milk Processing Plant).

## Conclusions

Considering the achievements of the 1st Long-Term Development Plan, the livestock sub-sector has good potential as a source of growth and is considered a new development source within the agricultural sector.

Livestock development in Indonesia can give great opportunities for use of resources, employment, and marketing expansion. The recent deregulation imposed by the government has encouraged investment efforts, particularly to promote export and to provide more job opportunities.

In spite of the success in livestock development, some problems and constraints remain such as lack of standardization of livestock products, lack of an efficient marketing system, low level of animal protein intake, lack of knowledge transfer, and animal disease problems. Therefore, livestock development in each operational activity shall focus on harnessing the existing potential of natural and human resources.

# Trends in ruminant livestock development in East Kalimantan

**Erik Nursahramdani**[1]

The East Kalimantan Province in Indonesia has an area of about 211,440 km$^2$ (1.5 times larger than Java and Madura) and, in 1997, had a population of 2.2 million. It occupies an important position in the Indonesian economy because of its rich natural resources.

Many of the soils are acid and infertile and not well suited for crop production. The topography is hilly and only partly used for upland farms, the rest is *Imperata* grasslands which have not been fully utilized. There are about 15 million ha of this type of land which is suitable for livestock development. Under a framework which aims to promote the well being of smallholders, these lands may be used as the basis of livestock development, especially when planted to forages.

In 1996, the amount of ruminant meat consumed (cattle, buffalo, goat, and sheep) was 29% of the total consumption of meat. Ruminants from other provinces were used (which average 40,110 head per year or 70%) and even the feeder cattle have to be imported from Australia. Local supply was only 30%.

## Ruminant development

### Cattle

Looking at East Kalimantan's land potential and relatively low cattle population (Table 1) the province has good prospects for increasing cattle production.

**Table 1. Population of ruminant livestock (animal units) in East Kalimantan, 1994-1997.**

| Species | 1994 | 1995 | 1996 | 1997 | Annual increase (%) |
|---|---|---|---|---|---|
| Cattle | 58,556 | 61,216 | 62,604 | 66,460 | 4.3 |
| Dairy | 52 | 56 | 56 | 58 | 3.5 |
| Buffalo | 20,165 | 20,646 | 21,201 | 21,727 | 2.5 |
| Goat | 7,070 | 7,656 | 9,420 | 9,749 | 11.3 |
| Sheep | 402 | 378 | 333 | 338 | -5.7 |
| Deer | 9 | 11 | 13 | 15 | 18.7 |
| Total | 86,254 | 89,963 | 93,626 | 98,347 | 4.5 |

The East Kalimantan Province is a fast developing region. Pelita I has been getting feeder cattle from several regions in Indonesia and from other countries. The government, through its 'Departemen Transmigrasi dan Pemukiman Perambah Hutan', plans to bring 200,000 heads to East Kalimantan during a 20-year period, starting in 1997/1998.

### Buffalo

As with cattle, the government supports buffalo development by importing feeder steer through the ADB II and Banpres Projects. In 1997, 1200 buffaloes from the Banpres Project were distributed to farmers in Pasir and Kutai districts.

[1] Head, East Kalimantan Livestock Services, Samarinda, East Kalimantan, Indonesia.

The potential of buffalo raising is high in East Kalimantan. Good indigenous germplasm resources are Kalang and Krayan buffaloes. The Kalang buffalo, a swamp buffalo, is found near the Mahakam river. During the dry season, they roam in the forest. During the wet season, when their habitats are flooded, they return to animal pens with a raised wooden floor (= Kalang) where they are kept during the flooding period and fed cut grasses.

Another kind of buffalo that has thrived well in northeast Kalimantan is the Krayan buffalo. The largest population is concentrated in Krayan District, Kabupaten Bulungan, numbering about 9,700 animal units or 45% of the buffalo population in East Kalimantan.

### Goats

During the 6th National Development Plan the population of goats in East Kalimantan has risen at an average of 11% per year. Goats have been distributed to farmers through several projects.

Goats are popular among smallholder farmers as they are a small ruminant and good source of ready extra income. Goat raising is one of the poverty alleviation methods espoused by the government.

### Sheep

The sheep population in East Kalimantan is very small. Population is only 340 animal units. One reason, why sheep are not popular in East Kalimantan is their link with the infectious MCF disease, which can infect Bali cattle and cause an epidemic.

### Deer

Another ruminant group being developed in East Kalimantan, is Sambar deer (*Cervus unicolor brookei*). Classified as a small ruminant, they live in the forests and savannas in East Kalimantan. They number about 50,000 but are threatened by excessive hunting activities – about 5,000 animals are lost every year.

The East Kalimantan Livestock Services was mandated to oversee deer breeding. For the past 7 years, deer breeding has been conducted on 1000-ha government land at Desa Api-api, Kecamatan Waru, Kabupaten Pasir. Captive breeding of deer has been proven possible and the deer population now stands at 78, with average annual increase of 19% during the last four years.

## Forage development

The opportunities for developing ruminant production are good. At the end of 7$^{th}$ Five-Year National Development Plan (Pelita VII), ruminant population is expected to grow to 132,775 animal units at an annual growth rate of 5.2% (Table 2).

**Table 2. Projections of ruminant population (animal units) in East Kalimantan under Pelita VII.**

| Species | 1999 | 2000 | 2001 | 2002 | 2003 | Annual increase (%) |
|---|---|---|---|---|---|---|
| Cattle | 74,900 | 79,514 | 84,412 | 89,612 | 95,132 | 6.2 |
| Dairy | 62 | 64 | 66 | 68 | 70 | 3.3 |
| Buffalo | 22,818 | 23,384 | 23,963 | 24,558 | 25,167 | 2.5 |
| Goat | 10,444 | 10,809 | 11,187 | 11,579 | 11,984 | 3.5 |
| Sheep | 347 | 351 | 356 | 361 | 366 | 1.3 |
| Deer | 24 | 29 | 36 | 45 | 56 | 23.9 |
| Total | 108,594 | 114,151 | 120,021 | 126,223 | 132,775 | 5.2 |

Ruminants must eat 10-15% of their body weight of fresh forages each day. It is projected that about 40% of forage requirement will come from natural grass and agricultural by-products; the remaining 60% must come from planted forage (grass and legume). At the beginning of Pelita VII, the need for planted forages is 951,000 t, rising to 1,163,000 t by the end of the period (Table 3).

**Table 3. Planted forage and land requirements under Pelita VII.**

| Item | 1999 | 2000 | 2001 | 2002 | 2003 | Annual increase (%) |
|---|---|---|---|---|---|---|
| Planted forage (t) | 951,000 | 1,000,000 | 1,050,000 | 1,106,000 | 1,163,000 | 5.2 |
| Area required (ha) | 4,800 | 5,000 | 5,300 | 5,500 | 5,800 | 5.2 |

Based on these projections some 4,800 ha of planted forage is needed at the start of Pelita VII and some 5,800 ha at the end, expanding by 200 ha each year. The present area of planted forage is only 137 ha, so more than 4,600 ha will still have to be developed by the beginning of Pelita VII.

By cooperating with the Forages for Smallholder's Project, it is expected that forage species will be identified which are well adapted to the conditions in East Kalimantan and which are easily adopted by farmers.

# Environmental adaptation of forages

# Environmental adaptation of forages in Lao PDR

**Phonepaseuth Phengsavanh[1] and Viengsavanh Phimphachanhvongsod[2]**

In Lao PDR, livestock production is almost totally a smallholder farming practice and is a vital component of livelihood security. Animals generally graze on native forages (grasses, shrubs, legumes, and tree leaves) that are available in forests and grasslands. However, native grass is abundant only during the wet season. Dry season feed shortages are common, resulting in severe animal feeding problems for farmers throughout the country. There are currently few, if any, alternative feed sources.

For many years, some Hmong farmers, who live on the fertile highland soils in Luang Phabang and Xieng Khouang, have fed grazing animals Napier grass (*Pennisetum purpureum*) as a supplement. Some farmers in Xieng Khouang have recently started to use Ruzi grass (*Brachiaria ruziziensis*) for the same purpose. However, in general, very few farmers in Lao PDR plant forages. This does not mean that there is no demand. The severity of feed resource limitations in some provinces (especially Luang Phabang and Xieng Khouang) is creating a huge interest in planted forages among farmers.

To meet this demand, the Department of Livestock and Fisheries, in collaboration with the Forages for Smallholders Project, established forage nurseries at five different agro-ecological sites in four provinces to evaluate forage adaptation for subsequent on-farm testing at Namsuang (Vientiane municipality), Houakhoth and Houaphai (Luang Phabang), Ban Km 32 (Oudomxay), and Khinak (Champassak).

## Site descriptions

The soil pH (1:5 water) at these sites varied from very acid to neutral (Table 1).

**Table 1. Physical characteristics of sites for nursery evaluation.**

| Site | Latitude | Altitude (m) | Annual rainfall (mm) | Wet season | Number of wet months (>50 mm) | Soil characteristics | Farming system |
|---|---|---|---|---|---|---|---|
| Namsuang | 18° N | 150 | 1500 - 2000 | May - Oct | 6 | pH 4.5[1], sandy loam, well drained, infertile | Lowland rice (rainfed and irrigated) |
| Houakhoth | 20° N | 400 | 1600 - 1800 | May - Oct | 6 | pH 5, silty loam, moderately drained, moderately fertile | Shifting cultivation in upland area, irrigated rice and home gardens in valleys |
| Houaphai | 20° N | 428 | 1600 - 1800 | May - Oct | 6 | pH 5.9, loam, well drained, moderately fertile | Shifting cultivation in upland area, irrigated rice and home gardens in valleys |
| Ban km 32 | 21° N | 900 | 1000 - 1600 | Apr - Oct | 7 | pH 4.3, silty loam, moderately drained, moderately fertile | Shifting cultivation (rice), upland cropping (maize, cassava). |
| Khinak | 14° N | 85 | 1300 - 1500 | May - Oct | 6 | pH 6, sandy loam, well drained, infertile | Lowland rainfed rice, lowland crops, and grazing of pek savannah |

[1] pH measurement in 1:5 $H_2O$.

[1] Forages for Smallholders Project, Vientiane, Lao PDR.
[2] Livestock Development Division, Department of Livestock and Fisheries, Vientiane, Lao PDR.

**Table 2. Soil analysis at each experiment site.**

| | Nam Suang | Houakhoth | Houapai | Ban km 32 | Khinak |
|---|---|---|---|---|---|
| Soil texture | Sandy loam | Silty loam | Loam | Silty loam | Sandy loam |
| pH (1:5 water) | 4.6 | 5.0 | 5.9 | 4.3 | 6.0 |
| Organic carbon (%C) | 0.5 | 1.4 | 1.3 | 1.6 | 0.6 |
| Nitrate nitrogen (mg/kg) | 4.2 | 16.6 | 16.9 | 33.0 | 12.4 |
| Sulfur (mg/kg) | 2 | 10 | 11 | 9 | 4 |
| Phosphorus (BSES) (mg/kg) | 7 | 13 | 19 | 7 | 12 |
| Phosphorus (Colwell) (mg/kg) | 3 | 9 | 7 | 7 | 6 |
| Potassium (Amm. Ac.) (meq/100g) | 0.05 | 0.39 | 0.46 | 0.15 | 0.13 |
| Calcium (Amm. Ac. )(meq/100g) | 0.25 | 3.34 | 7.19 | 0.46 | 1.42 |
| Magnesium (Amm. Ac.) (meq/100g) | 0.06 | 2.68 | 4.39 | 0.29 | 0.34 |
| Cation Exch. Cap. (meq/100g) | 1.29 | 7.62 | 12.26 | 4.07 | 2.04 |
| Aluminium saturation % | 71 | 16 | - | 77 | - |

Most soils were moderately to severely infertile (Table 2). Average annual rainfall at the five sites ranges from 1000 to 2600 mm, with peak rainfall from June to August (Fig. 1). The dry season at all five sites ranges from 5-6 months, with only 1-4% of total rainfall being received during this period. The topography of the sites is flat to rolling; with altitude ranging from 85 to 900 m above sea level. The farming systems are quite different and include shifting rice cultivation and intensive upland cultivation of maize and cassava in the mountainous regions and irrigated/rainfed rice and cash crops in the lowland areas (Table 1).

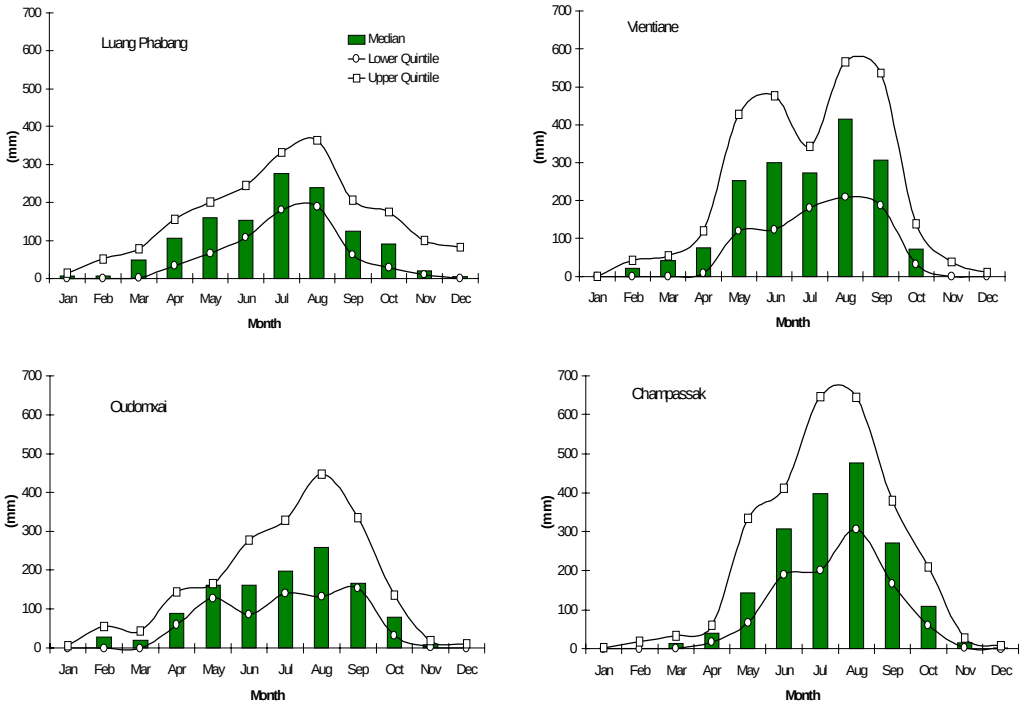


**Fig. 1. Rainfall pattern in the four provinces (1985-95)**

## Results

A large range of forage species was evaluated over 2 years at each of the five sites. Three nurseries (Nam Suang, Houakhoth, and Houaphai) have already been completed and the other two (Ban km 32 and Khinak) are ongoing.

At each nursery, the species were planted in four plots consisting of single rows 3 m long. The forage nurseries were visually evaluated each month and the following information was collected:

*Establishment success*: 0=did not emerge, 1=poor, 2=moderate, 3=good, 4=excellent.
*Yield potential, persistence, and seed production:* 1=poor, 2=moderate, 3=good, 4=excellent.
*Pests and diseases:* 0= no damage, 1=little impact, 2=moderate impact, 3=severe impact, 4=plants killed.
*Maintains green leaf in dry season:* 0=very poor, 1=poor, 2=average, 3=good, 4=excellent.

The number of species evaluated at each site varied, depending on the forage systems in the area and the availability of seeds. A complete list of species evaluated at each site is available from the authors.

Results showed that many grasses and legumes were well adapted.

### Namsuang

Eighty-four forage species (64 legumes and 20 grasses) were planted in the middle of July 1995. The grass species which were well adapted to this site were *Andropogon gayanus* cv. Kent, *Brachiaria brizantha* (all accessions, including CIAT 6780, CIAT 16318 and CIAT 16835, *Brachiaria decumbens* cv. Basilisk, *Brachiaria humidicola* cv. Tully and *Panicum maximum* CIAT 6299. Only a few legumes showed good adaptation and performance to the acid and very infertile soil: *Stylosanthes guianensis* (various accessions but especially CIAT 184), *Chamaecrista rotundifolia* cv. Wynn and, to a lesser extent, *Centrosema acutifolium* CIAT 5277 and *Zornia latifolia* CIAT 728. The details of performance of each species at the Namsuang site are presented in Table 3.

**Table 3. Performance of forage species at Namsuang.**

| Species | Establishment success[1] | Yield potential[2] | Persistence[2] | Seed production[2] | Maintains green leaf in dry season[3] | Pests /diseases[4] |
|---|---|---|---|---|---|---|
| *Aeschynomene americana* cv. Glenn | 3 | 3 | 1 | 3 | 0 | 0 |
| *Aeschynomene americana* cv. Lee | 4 | 3 | 1 | 3 | 1 | 0 |
| *Aeschynomene americana* CPI 93667 | 3 | 2 | 1 | 1 | 0 | 0 |
| *Aeschynomene brasilianum* CIAT 8628 | 3 | 2 | 1 | 2 | 1 | 0 |
| *Aeschynomene histrix* CIAT 9690 | 2 | 2 | 2 | 1 | 0 | 0 |
| *Aeschynomene histrix* CIAT 93595 | 3 | 3 | 1 | 3 | 2 | 0 |
| *Aeschynomene villosa* CPI 93621 | 3 | 2 | 1 | 2 | 0 | 0 |
| *Aeschynomene villosa* CPI 91209 | 2 | 1 | 1 | 2 | 0 | 0 |
| *Alysicarpus monilifer* CPI 52343 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Alysicarpus rugosus* CPI 30034 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Alysicarpus rugosus* CPI 52348 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Alysicarpus vaginalis* CPI 100856 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Arachis pintoi* CIAT 18748 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Arachis pintoi* CIAT 17434 (Amarillo) | 2 | 1 | 3 | 1 | 2 | 0 |

**(continued next page)**

**Table 3 (cont.). Performance of forage species at Namsuang.**

| Species | Establishment success [1] | Yield potential [2] | Persistence [2] | Seed production [2] | Maintains green leaf in dry season [3] | Pests /diseases [4] |
|---|---|---|---|---|---|---|
| *Arachis pintoi* CIAT 18744 | 1 | 1 | 1 | 1 | 3 | 0 |
| *Arachis pintoi* CIAT 18750 | 2 | 1 | 3 | 1 | 3 | 0 |
| *Centrosema acutifolium* CIAT 5277 | 3 | 3 | 3 | 3 | 3 | 0 |
| *Centrosema brasilianum* CPI55698 | 2 | 2 | 2 | 1 | 2 | 0 |
| Centrosema macrocarpum *CIAT 15014* | 2 | 2 | 3 | 1 | 2 | 0 |
| *Centrosema pascuorum* cv. Cavalcade | 3 | 1 | 1 | 1 | 1 | 0 |
| Centrosema plumieri *CPI 58567* | 2 | 2 | 1 | 1 | 2 | 0 |
| *Centrosema pubescens* CIAT 438 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Centrosema pubescens* CIAT 15160 | 2 | 2 | 3 | 1 | 3 | 0 |
| *Chamaecrista rotundifolia* Q 10057 | 2 | 2 | 2 | 2 | 2 | 0 |
| *Chamaecrista rotundifolia* CPI 86127 | 3 | 3 | 2 | 4 | 2 | 0 |
| *Chamaecrista rotundifolia* cv. Wynn | 4 | 3 | 3 | 4 | 2 | 0 |
| *Clitoria ternatea* cv. Milgarra | 0 | 0 | 0 | 0 | 0 | 0 |
| *Clitoria ternatea* CIAT 772 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Calopogonium mucunoides* CIAT 7722 | 2 | 2 | 1 | 3 | 0 | 0 |
| *Desmodium distortum* CPI 38568 | 1 | 1 | 1 | 2 | 1 | 0 |
| *Desmodium heterocarpon* CPI 86227 | 2 | 1 | 1 | 1 | 1 | 0 |
| *Desmodium heterophyllum* CIAT349 | 2 | 2 | 1 | 2 | 1 | 0 |
| *Desmodium ovalifolium* CIAT 3666 | 2 | 2 | 1 | 1 | 1 | 0 |
| *Desmodium ovalifolium* CIAT 13098 | 2 | 2 | 2 | 2 | 1 | 0 |
| *Desmodium cinerea* CPI 46562 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Desmodium subsericeum* CPI 78402 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Desmodium sericophilum* CPI 91147 | 2 | 1 | 1 | 1 | 1 | 0 |
| *Desmanthus virgatus* ex. IRRI | 0 | 0 | 0 | 0 | 0 | 0 |
| *Desmanthus virgatus* cv. Bayamo | 0 | 0 | 0 | 0 | 0 | 0 |
| *Desmanthus virgatus* cv. Mark | 0 | 0 | 0 | 0 | 0 | 0 |
| *Macroptilium atropurpureum* cv. Aztec | 3 | 1 | 1 | 1 | 1 | 0 |
| *Macroptilium atropurpureum* CPI 90844 | 2 | 1 | 1 | 1 | 1 | 0 |
| *Macroptilium bracteatum* CPI 27404 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Macrotyloma daltonii* CPI 60303 | 1 | 1 | 0 | 1 | 0 | 0 |
| *Macroptilium gracile* cv. Maldonado | 2 | 1 | 1 | 1 | 1 | 0 |
| *Macroptilium gracile* CPI 91340 | 2 | 1 | 1 | 1 | 1 | 0 |
| *Macroptilium gracile* CPI 91049 | 2 | 1 | 1 | 2 | 0 | 0 |
| *Macroptilium gracile* CPI 33498 | 2 | 1 | 1 | 2 | 1 | 0 |
| *Stylosanthes capitata* CIAT 11280 | 2 | 2 | 3 | 2 | 3 | 0 |
| *Stylosanthes hamata* cv. Amiga | 2 | 2 | 1 | 3 | 1 | 0 |
| *Stylosanthes hamata* cv. Verano | 3 | 2 | 3 | 2 | 3 | 3 |
| *Stylosanthes mexicana* CPI 87487 | 4 | 2 | 1 | 2 | 1 | 0 |
| *Stylosanthes guianensis* SSD-12 | 4 | 3 | 4 | 3 | 4 | 0 |
| *Stylosanthes guianensis* FM07-1 | 4 | 3 | 4 | 2 | 3 | 0 |
| *Stylosanthes guianensis* FM05-3 | 3 | 3 | 4 | 2 | 3 | 0 |
| *Stylosanthes guianensis* FM05-2 | 4 | 3 | 4 | 3 | 3 | 0 |
| *Stylosanthes guianensis* FM05-1 | 4 | 2 | 4 | 2 | 3 | 0 |
| *Stylosanthes guianensis* CIAT 184 | 4 | 4 | 4 | 2 | 4 | 0 |
| *Teramnus uncinatum* CIAT 7315 | 1 | 1 | 1 | 1 | 1 | 0 |
| *Vigna decipiens* CPI 73602 | 2 | 1 | 1 | 1 | 0 | 0 |
| *Vigna oblongifolia* CPI 121699 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Vigna trilobota* CPI 13671 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Vigna vexillata* CPI 65484 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Zornia latifolia* CIAT 728 | 2 | 2 | 1 | 3 | 0 | 0 |

**(continued next page)**

**Table 3 (cont.). Performance of forage species at Namsuang.**

| Species | Establishment success [1] | Yield potential [2] | Persistence [2] | Seed production [2] | Maintains green leaf in dry season [3] | Pests /diseases [4] |
|---|---|---|---|---|---|---|
| *Andropogon gayanus* cv. Kent | 3 | 3 | 3 | 3 | 2 | 0 |
| *Bothriochloa inseupta* cv. Bisset | 0 | 0 | 0 | 0 | 0 | 0 |
| *Brachiaria brizantha* CIAT 6780 | 2 | 4 | 4 | 1 | 4 | 0 |
| *Brachiaria brizantha* CIAT 16318 | 3 | 3 | 4 | 1 | 4 | 0 |
| *Brachiaria decumbens* cv. Basilisk | 3 | 3 | 4 | 1 | 4 | 0 |
| *Brachiaria humidicola* cv. Tully | 3 | 3 | 4 | 1 | 3 | 0 |
| *Brachiaria humidicola* CIAT 6133 | 3 | 2 | 4 | 1 | 3 | 0 |
| *Brachiaria humidicola* CIAT 16886 | 3 | 2 | 4 | 1 | 3 | 0 |
| *Cenchrus ciliaris* cv. Biloela | 1 | 1 | 1 | 1 | 1 | 0 |
| *Dichanthium aristatum* cv. Floren | 1 | 1 | 1 | 1 | 0 | 0 |
| *Digitaria milanjiana* cv. Jarra | 2 | 2 | 3 | 1 | 2 | 0 |
| *Digitaria milanjiana* CPI 41192 | 2 | 1 | 3 | 1 | 2 | 0 |
| *Digitaria milanjiana* CPI 40700 | 3 | 2 | 2 | 1 | 2 | 0 |
| *Panicum coloratum* CPI 16796 | 2 | 1 | 1 | 1 | 1 | 0 |
| *Panicum maximum* cv. Petrie | 1 | 1 | 2 | 1 | 2 | 0 |
| *Panicum maximum* CIAT 6299 | 3 | 3 | 2 | 2 | 3 | 0 |
| *Paspalum notatum* cv. Competidor | 2 | 2 | 2 | 1 | 1 | 0 |
| *Paspalum nicorae* CPI 37526 | 2 | 1 | 2 | 1 | 1 | 0 |
| *Urochloa mosambicensis* cv. Nixon | 2 | 2 | 2 | 2 | 2 | 0 |
| *Urochloa stolonifera* CPI 60128 | 0 | 0 | 0 | 0 | 0 | 0 |

[1] Establishment success: 0=did not emerge, 1=poor, 2=moderate, 3=good, 4=excellent.
[2] Yield potential, persistence, and seed production: 1=poor, 2=moderate, 3=good, 4=excellent.
[3] Maintains green leaf in dry season: 0=very poor, 1=poor, 2=average, 3=good, 4=excellent
[4] Pests/diseases: 0= no pests/diseases, 1=little impact, 2=moderate impact, 3=severe impact, 4=plants killed.

### Houakhoth

Sixty-one forage species (48 legumes and 13 grasses) were planted at the end of June 1995. The grass species adapted to this site were *Brachiaria brizantha* (CIAT 6780 and CIAT 16318), *Brachiaria decumbens* cv. Basilisk, *Brachiaria humidicola* CIAT 16886, and *Panicum maximum* CIAT 6299. Of the legumes, only *Stylosanthes guianensis* (various accessions) showed good adaptation and performance. The performance of each species at the Houakhoth site is presented in Table 4.

**Table 4. Performance of forage species at Houakhoth.**

| Species | Establishment success [1] | Yield potential [2] | Persistence [2] | Seed production [2] | Maintains green leaf in dry season [3] | Pests /diseases [4] |
|---|---|---|---|---|---|---|
| *Aeschynomene americana* cv. Glenn | 4 | 2 | 1 | 4 | 0 | 0 |
| *Aeschynomene americana* cv. Lee | 4 | 2 | 1 | 4 | 0 | 0 |
| *Aeschynomene americana* CPI 93667 | 3 | 2 | 1 | 4 | 0 | 0 |
| *Aeschynomene brasilianum* CIAT 8628 | 2 | 2 | 1 | 4 | 1 | 0 |
| *Aeschynomene histrix* CIAT 9690 | 4 | 2 | 1 | 3 | 1 | 0 |
| *Aeschynomene histrix* CIAT 93595 | 1 | 1 | 1 | 4 | 1 | 0 |
| *Aeschynomene villosa* CPI 93621 | 1 | 1 | 1 | 3 | 0 | 0 |
| *Aeschynomene villosa* CPI 91209 | 1 | 1 | 1 | 3 | 0 | 0 |
| *Alysicarpus monilifer CPI 52343* | 1 | 1 | 1 | 1 | 1 | 0 |
| *Alysicarpus rugosus CPI 30034* | 1 | 2 | 1 | 2 | 0 | 0 |
| *Alysicarpus rugosus CPI 52348* | 1 | 1 | 1 | 1 | 1 | 0 |

**(continued next page)**

**Table 4 (cont.). Performance of forage species at Houakhoth.**

| Species | Establishment success [1] | Yield potential [2] | Persistence [2] | Seed production [2] | Maintains green leaf in dry season [3] | Pests /diseases [4] |
|---|---|---|---|---|---|---|
| *Alysicarpus vaginalis* CPI 100856 | 2 | 1 | 1 | 2 | 1 | 0 |
| *Arachis pintoi* CIAT 18744 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Arachis pintoi* CIAT 18750 | 1 | 2 | 2 | 1 | 2 | 0 |
| *Centrosema acutifolium* CIAT 5277 | 1 | 3 | 2 | 2 | 3 | 0 |
| *Centrosema brasilianum* CPI 55698 | 1 | 2 | 1 | 1 | 1 | 0 |
| Centrosema macrocarpum *CIAT15014* | 1 | 2 | 1 | 1 | 2 | 0 |
| *Centrosema pascuorum* cv. Calvacade | 2 | 1 | 1 | 1 | 0 | 0 |
| *Centrosema plumieri* CPI 58567 | 2 | 2 | 2 | 1 | 2 | 0 |
| *Centrosema pubescens* CIAT 438 | 1 | 1 | 2 | 1 | 2 | 0 |
| *Centrosema pubescens* CIAT 15160 | 2 | 2 | 2 | 2 | 3 | 0 |
| *Chamaecrista rotundifolia* Q 10057 | 1 | 1 | 1 | 3 | 1 | 0 |
| *Chamaecrista rotundifolia* 86127 | 2 | 3 | 2 | 4 | 2 | 0 |
| *Chamaecrista rotundifolia* cv. Wynn | 2 | 3 | 2 | 4 | 2 | 0 |
| *Clitoria ternatea* cv. Milgarra | 2 | 2 | 2 | 2 | 2 | 0 |
| *Clitoria ternatea* CIAT 772 | 2 | 2 | 2 | 3 | 1 | 0 |
| *Calopogonium mucunoides* CIAT 7722 | 2 | 2 | 1 | 3 | 1 | 0 |
| *Desmodium heterophyllum* CIAT349 | 2 | 1 | 1 | 1 | 1 | 0 |
| *Desmodium ovalifolium* CIAT 13098 | 2 | 2 | 2 | 2 | 2 | 0 |
| *Desmodium cinerea* ex. Davao | 3 | 2 | 2 | 2 | 2 | 0 |
| *Macroptilium atropurpureum* cv. Aztec | 1 | 2 | 1 | 2 | 2 | 0 |
| *Macroptilium atropurpureum* CPI 90844 | 1 | 1 | 1 | 1 | 1 | 0 |
| *Macroptilium bracteatum* CPI 27404 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Macrotyloma daltonii* CPI 60303 | 1 | 1 | 1 | 1 | 0 | 1 |
| *Macroptilium gracile* cv. Maldonado | 1 | 2 | 1 | 2 | 1 | 0 |
| *Macroptilium gracile* CPI 91340 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Macroptilium gracile* CPI 91049 | 2 | 1 | 1 | 1 | 0 | 0 |
| *Macroptilium gracile* CPI 33498 | 1 | 1 | 1 | 1 | 1 | 0 |
| *Stylosanthes capitata* CIAT 11280 | 1 | 2 | 2 | 1 | 4 | 0 |
| *Stylosanthes guianensis* FM05-3 | 3 | 3 | 3 | 3 | 4 | 0 |
| *Stylosanthes guianensis* FM05-2 | 4 | 3 | 4 | 3 | 4 | 0 |
| *Stylosanthes guianensis* FM05-1 | 3 | 3 | 3 | 3 | 4 | 0 |
| *Stylosanthes guianensis* CIAT 184 | 4 | 4 | 4 | 3 | 4 | 0 |
| *Vigna decipiens* CPI 73602 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Vigna oblongifolia* 121699 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Vigna trilobota* CPI13671 | 1 | 1 | 1 | 1 | 1 | 0 |
| *Vigna vexillata* CPI 65484 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Zornia latifolia* CIAT 728 | 1 | 1 | 1 | 1 | 1 | 0 |
| *Brachiaria brizantha* CIAT 6780 | 3 | 4 | 4 | 1 | 4 | 0 |
| *Brachiaria brizantha* CIAT 16318 | 2 | 3 | 3 | 1 | 4 | 0 |
| *Brachiaria decumbens* cv. Basilisk | 3 | 4 | 4 | 1 | 4 | 0 |
| *Brachiaria humidicola* cv. Tully | 2 | 2 | 4 | 1 | 3 | 0 |
| *Brachiaria humidicola* CIAT 6133 | 2 | 2 | 4 | 1 | 3 | 0 |
| *Brachiaria humidicola* CIAT 16886 | 3 | 3 | 4 | 1 | 3 | 0 |
| *Cenchrus ciliaris* cv. Biloela | 1 | 2 | 2 | 1 | 1 | 0 |
| *Digitaria milanjiana* cv. Jarra | 2 | 2 | 2 | 1 | 2 | 0 |
| *Digitaria milanjiana* CPI 41192 | 1 | 2 | 2 | 1 | 1 | 0 |
| *Panicum coloratum* CPI 16796 | 1 | 2 | 2 | 1 | 2 | 0 |
| *Panicum maximum* CIAT 6299 | 2 | 3 | 3 | 4 | 3 | 0 |
| *Urochloa mosambicensis* cv. Nixon | 2 | 3 | 2 | 3 | 3 | 0 |
| *Urochloa stolonifera* CPI 60128 | 2 | 1 | 2 | 1 | 1 | 0 |

[1] Establishment success: 0=did not emerge, 1=poor, 2=moderate, 3=good, 4=excellent.
[2] Yield potential, persistence, and seed production: 1=poor, 2=moderate, 3=good, 4=excellent.
[3] Maintains green leaf in dry season: 0=very poor, 1=poor, 2=average, 3=good, 4=excellent
[4] Pests/diseases: 0= no pests/diseases, 1=little impact, 2=moderate impact, 3=severe impact, 4=plants killed.

### Houaphai

Fifty-six forage species (42 legumes and 14 grasses) were planted at the end of June 1995. Grass species, which were well adapted to this site were *Brachiaria brizantha* CIAT 6780 and CIAT 16318, *Brachiaria decumbens* cv. Basilisk, *Brachiaria humidicola* CIAT 16886 and Tully, and *Panicum maximum* CIAT 6299. Of the legumes, only *Chamaecrista rotundifolia* cv. Wynn and *Stylosanthes guianensis* (especially CIAT 184), were well adapted. The details of performance of each species at the Houaphai site are presented in Table 5.

**Table 5. Performance of forage species at Houaphai**

| Species | Establishment success [1] | Yield potential [2] | Persistence [2] | Seed production [2] | Maintains green leaf in dry season [3] | Pests /diseases [4] |
|---|---|---|---|---|---|---|
| *Aeschynomene americana* cv. Glenn | 2 | 2 | 1 | 4 | 0 | 0 |
| *Aeschynomene americana* cv. Lee | 2 | 2 | 1 | 4 | 1 | 0 |
| *Aeschynomene americana* CPI93667 | 2 | 2 | 1 | 3 | 0 | 0 |
| *Aeschynomene brasilianum* CIAT 8628 | 2 | 2 | 1 | 2 | 1 | 0 |
| *Aeschynomene histrix* CIAT 9690 | 3 | 2 | 2 | 1 | 1 | 0 |
| *Aeschynomene histrix* CIAT 93595 | 2 | 1 | 1 | 3 | 1 | 1 |
| *Aeschynomene villosa* CPI 93621 | 3 | 1 | 1 | 3 | 0 | 0 |
| *Aeschynomene villosa* CPI 91209 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Alysicarpus monilifer* CPI 52343 | 1 | 1 | 1 | 2 | 0 | 0 |
| *Alysicarpus rugosus* CPI 30034 | 3 | 3 | 1 | 2 | 0 | 1 |
| *Alysicarpus rugosus* CPI 52348 | 2 | 2 | 1 | 2 | 1 | 0 |
| *Alysicarpus vaginalis* CPI 100856 | 4 | 2 | 1 | 2 | 1 | 1 |
| *Centrosema acutifolium* CIAT 5277 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Centrosema brasilianum* CPI 55698 | 1 | 1 | 1 | 1 | 1 | 0 |
| Centrosema macrocarpum *CIAT 15014* | 1 | 2 | 1 | 1 | 2 | 1 |
| *Centrosema pascuorum* cv. Calvacade | 2 | 2 | 1 | 1 | 0 | 0 |
| *Centrosema plumieri* CPI 58567 | 2 | 1 | 3 | 1 | 1 | 1 |
| *Centrosema pubescens* CIAT 438 | 2 | 2 | 2 | 1 | 2 | 0 |
| *Centrosema pubescens* CIAT 15160 | 1 | 1 | 3 | 1 | 2 | 0 |
| *Chamaecrista rotundifolia* Q 10057 | 3 | 2 | 2 | 4 | 1 | 0 |
| *Chamaecrista rotundifolia* cv. Wynn | 4 | 3 | 3 | 2 | 2 | 0 |
| *Clitoria ternatea* CIAT 772 | 3 | 3 | 1 | 2 | 1 | 0 |
| *Calopogonium mucunoides* CIAT 7722 | 3 | 3 | 1 | 1 | 0 | 0 |
| *Desmodium ovalifolium* CIAT 3666 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Desmodium ovalifolium* CIAT 13098 | 1 | 1 | 1 | 1 | 1 | 0 |
| *Macroptilium atropurpureum* cv. Aztec | 1 | 1 | 2 | 1 | 1 | 0 |
| *Macroptilium atropurpureum* CPI 90844 | 1 | 1 | 1 | 1 | 1 | 0 |
| *Macroptilium bracteatum* CPI 27404 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Macrotyloma daltonii* CPI 60303 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Macroptilium gracile* cv. Maldonado | 1 | 1 | 1 | 1 | 1 | 0 |
| *Macroptilium gracile* CPI 91049 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Macroptilium gracile* CPI 33498 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Stylosanthes capitata* CIAT 11280 | 1 | 1 | 1 | 1 | 1 | 0 |
| *Stylosanthes guianensis* FM05-3 | 4 | 3 | 4 | 2 | 4 | 0 |
| *Stylosanthes guianensis* FM05-2 | 4 | 4 | 4 | 2 | 4 | 0 |
| *Stylosanthes guianensis* CIAT 184 | 4 | 4 | 4 | 3 | 4 | 0 |
| *Teramnus uncinatum* CIAT 7315 | 2 | 2 | 1 | 1 | 1 | 0 |
| *Vigna decipiens* CPI 73602 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Vigna oblongifolia* CPI 121699 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Vigna trilobota* CPI 13671 | 2 | 1 | 1 | 1 | 0 | 0 |
| *Vigna vexillata* CPI 65484 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Zornia latifolia* CIAT 728 | 3 | 2 | 1 | 3 | 0 | 0 |

**(continued next page)**

**Table 5 (cont.). Performance of forage species at Houaphai.**

| Species | Establishment success [1] | Yield potential [2] | Persistence [2] | Seed production [2] | Maintains green leaf in dry season [3] | Pests /diseases [4] |
|---|---|---|---|---|---|---|
| *Brachiaria brizantha* CIAT 6780 | 4 | 4 | 4 | 1 | 4 | 0 |
| *Brachiaria brizantha* CIAT 16318 | 3 | 3 | 4 | 1 | 4 | 0 |
| *Brachiaria decumbens* cv. Basilisk | 3 | 3 | 4 | 1 | 4 | 0 |
| *Brachiaria humidicola* cv. Tully | 3 | 2 | 4 | 1 | 3 | 0 |
| *Brachiaria humidicola* CIAT 6133 | 3 | 2 | 4 | 1 | 3 | 0 |
| *Brachiaria humidicola* CIAT 16886 | 3 | 2 | 4 | 1 | 4 | 0 |
| *Cenchrus ciliaris* cv. Biloela | 3 | 2 | 3 | 1 | 1 | 0 |
| *Dichanthium aristatum* cv. Floren | 3 | 2 | 3 | 1 | 1 | 0 |
| *Digitaria milanjiana* cv. Jarra | 3 | 2 | 3 | 1 | 2 | 0 |
| *Digitaria milanjiana* CPI 41192 | 2 | 1 | 2 | 1 | 1 | 0 |
| *Panicum coloratum* CPI 16796 | 1 | 2 | 1 | 2 | 1 | 0 |
| *Panicum maximum* CIAT 6299 | 3 | 3 | 3 | 2 | 3 | 0 |
| *Urochloa mosambicensis* cv. Nixon | 3 | 2 | 3 | 2 | 2 | 0 |
| *Urochloa stolonifera* CPI 60128 | 1 | 2 | 1 | 1 | 1 | 0 |

[1] Establishment success: 0=did not emerge, 1=poor, 2=moderate, 3=good, 4=excellent.
[2] Yield potential, persistence, and seed production: 1=poor, 2=moderate, 3=good, 4=excellent.
[3] Maintains green leaf in dry season: 0=very poor, 1=poor, 2=average, 3=good, 4=excellent
[4] Pests/diseases: 0= no pests/diseases, 1=little impact, 2=moderate impact, 3=severe impact, 4=plants killed.

### Khinak

Fifty-two forage species (25 legumes and 27 grasses) were planted at the end of June 1996. Of the grass species, *Brachiaria brizantha* (including CIAT 6387, CIAT 6780, CIAT 16318, CIAT 16827, CIAT 16835, CIAT 26110), *Brachiaria decumbens* cv. Basilisk, and *Panicum maximum* CIAT 6299 were well adapted and productive. Only a few legumes showed good adaptation and performance: *Centrosema pubescens* CIAT 15160, *Chamaecrista rotundifolia* cv. Wynn, *Stylosanthes guianensis* CIAT 184, and *Stylosanthes hamata* cv. Verano. The details of performance of each species at the Khinak site are presented in Table 6.

**Table 6. Performance of forage species at Khinak.**

| Species | Establishment success [1] | Yield potential [2] | Persistence [2] | Seed production [2] | Pests /diseases [3] |
|---|---|---|---|---|---|
| *Aeschynomene histrix* CIAT 9690 | 2 | 2 | 2 | 2 | 1 |
| *Arachis pintoi* CIAT 17434 (Amarillo) | 0 | 0 | 0 | 0 | 0 |
| *Arachis pintoi* CIAT 22160 | 1 | 2 | 3 | 1 | 0 |
| *Centrosema acutifolium* CIAT 5277 | 1 | 1 | 1 | 1 | 0 |
| *Centrosema macrocarpum* CIAT 25522 | 1 | 1 | 3 | 1 | 1 |
| *Centrosema pubescens* CIAT 15160 | 2 | 3 | 3 | 1 | 0 |
| *Chamaecrista rotundifolia* Q 10057 | 1 | 2 | 2 | 3 | 0 |
| *Chamaecrista rotundifolia* CPI 86127 | 2 | 3 | 2 | 2 | 0 |
| *Chamaecrista rotundifolia* cv. Wynn | 3 | 2 | 2 | 3 | 0 |
| *Desmodium heterophyllum* CIAT 349 | 2 | 2 | 1 | 1 | 0 |
| *Desmodium ovalifolium* CIAT 13305 | 2 | 2 | 3 | 1 | 0 |
| *Desmodium cinerea* CPI 46562 | 1 | 1 | 2 | 1 | 0 |
| *Flemingia macrophylla* CIAT 17403 | 3 | 3 | 3 | 1 | 0 |

**(continued next page)**

**Table 6 (cont.). Performance of forage species at Khinak.**

| Species | Establishment success [1] | Yield potential [2] | Persistence [2] | Seed production [2] | Pests /diseases [3] |
|---|---|---|---|---|---|
| *Macroptilium atropurpureum* cv. Aztec | 1 | 1 | 1 | 1 | 0 |
| *Macroptilium atropurpureum* CPI 90844 | 1 | 1 | 1 | 1 | 0 |
| *Macroptilium gracile* cv. Maldonado | 2 | 1 | 1 | 1 | 0 |
| *Macroptilium gracile* CPI 33498 | 2 | 1 | 1 | 1 | 0 |
| *Stylosanthes capitata* Multiline 5 | 2 | 1 | 2 | 1 | 0 |
| *Stylosanthes hamata* cv. Verano | 3 | 3 | 3 | 3 | 0 |
| *Stylosanthes guianensis* FM05-1 | 2 | 3 | 4 | 2 | 0 |
| *Stylosanthes guianensis* CIAT 184 | 3 | 4 | 4 | 2 | 0 |
| *Stylosanthes scabra* cv. Siran | 1 | 3 | 4 | 2 | 0 |
| *Stylosanthes scabra* cv. Seca | 2 | 3 | 4 | 2 | 0 |
| *Vigna parkeri* cv. Shaw | 1 | 1 | 1 | 1 | 2 |
| *Zornia latifolia* CIAT 728 | 0 | 0 | 0 | 0 | 0 |
| *Andropogon gayanus* cv. Kent | 0 | 0 | 0 | 0 | 0 |
| *Bothriochloa inseupta* cv. Bisset | 1 | 1 | 3 | 1 | 0 |
| *Bothriochloa bladhii* cv. Swann | 1 | 2 | 2 | 3 | 0 |
| *Bothriochloa pertusa* cv. Medway | 1 | 2 | 3 | 2 | 0 |
| *Brachiaria brizantha* CIAT 6387 | 1 | 4 | 4 | 2 | 0 |
| *Brachiaria brizantha* CIAT 6780 | 2 | 4 | 4 | 1 | 0 |
| *Brachiaria brizantha* CIAT 16318 | 1 | 3 | 4 | 1 | 0 |
| *Brachiaria brizantha* CIAT 16827 | 1 | 3 | 4 | 1 | 0 |
| *Brachiaria brizantha* CIAT 16835 | 1 | 4 | 4 | 2 | 0 |
| *Brachiaria brizantha* CIAT 26110 | 2 | 4 | 4 | 1 | 0 |
| *Brachiaria decumbens* cv. Basilisk | 1 | 4 | 4 | 1 | 0 |
| *Brachiaria humidicola* cv. Tully | 1 | 2 | 4 | 1 | 0 |
| *Brachiaria humidicola* CIAT 6133 | 0 | 0 | 0 | 0 | 0 |
| *Brachiaria humidicola* CIAT 26149 | 1 | 2 | 4 | 1 | 0 |
| *Brachiaria ruziziensis* ex. Thailand | 2 | 2 | 3 | 3 | 0 |
| *Cenchrus ciliaris* cv. Biloela | 2 | 2 | 3 | 1 | 0 |
| *Dichanthium aristatum* cv. Floren | 1 | 2 | 2 | 1 | 0 |
| *Digitaria milanjiana* cv. Jarra | 3 | 2 | 3 | 2 | 0 |
| *Digitaria milanjiana* cv. Strickland | 2 | 2 | 3 | 1 | 0 |
| *Panicum maximum* TD 58 | 2 | 2 | 3 | 1 | 0 |
| *Panicum maximum* CIAT 6299 | 2 | 4 | 3 | 1 | 0 |
| *Paspalum atratum* BRA 9610 | 2 | 3 | 3 | 1 | 0 |
| *Paspalum guenoarum* BRA 3824 | 1 | 2 | 3 | 1 | 0 |
| *Urochloa mosambicensis* CPI 46876 | 3 | 2 | 3 | 1 | 0 |
| *Urochloa mosambicensis* CPI 60128 | 1 | 1 | 3 | 1 | 0 |
| Urochloa mosambicensis *CPI 60147* | 2 | 2 | 3 | 1 | 0 |
| *Urochloa mosambicensis* cv. Nixon | 1 | 3 | 3 | 2 | 0 |

[1] Establishment success: 0=did not emerge, 1=poor, 2=moderate, 3=good, 4=excellent.
[2] Yield potential, persistence, and seed production: 1=poor, 2=moderate, 3=good, 4=excellent.
[3] Pests/diseases: 0= no pests/diseases, 1=little impact, 2=moderate impact, 3=severe impact, 4=plants killed.

### Ban Km 32

Forty-five forage species (25 legumes and 20 grasses) were planted in the middle of July 1996. *Brachiaria brizantha* (CIAT 6780, CIAT 6387, CIAT 16827, CIAT 16835 and CIAT 26110), *Brachiaria decumbens* cv. Basilisk, *Brachiaria ruziziensis* ex. Thailand, and *Panicum maximum* CIAT 6299 all performed well. Only a few legumes showed good adaptation to the local conditions: *Stylosanthes hamata* cv. Verano and *Stylosanthes guianensis* CIAT 184. The details of performance of each species at Ban Km 32 site are presented in Table 7.

**Table 7. The performance of forage species at Ban Km 32.**

| Species | Establishment success [1] | Yield potential [2] | Persistence [2] | Seed production [2] | Maintains green leaf in dry season [3] | Pests /diseases [4] |
|---|---|---|---|---|---|---|
| *Aeschynomene histrix* CIAT 9690 | 3 | 2 | 2 | 1 | 1 | 0 |
| *Aeschynomene histrix* CIAT 93595 | 3 | 2 | 2 | 2 | 1 | 1 |
| *Arachis pintoi* CIAT 17434 (Amarillo) | 0 | 0 | 0 | 0 | 0 | 0 |
| *Arachis pintoi* CIAT 22160 | 1 | 1 | 3 | 1 | 3 | 1 |
| *Centrosema acutifolium* CIAT 5277 | 2 | 2 | 2 | 1 | 2 | 0 |
| *Centrosema brasilianum* 55698 | 3 | 2 | 3 | 1 | 2 | 0 |
| *Centrosema macrocarpum* CIAT 25522 | 2 | 1 | 3 | 1 | 3 | 0 |
| *Centrosema pascuorum* cv. Calvacade | 3 | 2 | 2 | 2 | 2 | 0 |
| *Centrosema pubescens* cv. Cardillo | 3 | 1 | 3 | 1 | 2 | 0 |
| *Centrosema pubescens* CIAT 15160 | 2 | 2 | 2 | 1 | 2 | 0 |
| *Desmodium heterophyllum* CIAT 349 | 4 | 2 | 4 | 2 | 2 | 0 |
| *Desmodium ovalifolium* CIAT 13305 | 4 | 1 | 4 | 1 | 1 | 0 |
| *Desmodium cinerea* CPI 46562 | 4 | 2 | 4 | 2 | 3 | 0 |
| *Flemingia macrophylla* CIAT 17403 | 2 | 2 | 3 | 1 | 3 | 0 |
| *Macroptilium atropurpureum* cv. Aztec | 3 | 1 | 2 | 2 | 2 | 0 |
| *Macroptilium atropurpureum* CPI 90844 | 2 | 1 | 2 | 1 | 2 | 0 |
| *Macroptilium gracile* cv. Maldonado | 3 | 2 | 3 | 2 | 2 | 0 |
| *Macroptilium gracile* CPI 33498 | 3 | 1 | 2 | 1 | 2 | 0 |
| *Stylosanthes hamata* cv. Verano | 4 | 3 | 3 | 2 | 3 | 0 |
| *Stylosanthes guianensis* FM05-1 | 2 | 3 | 4 | 2 | 4 | 0 |
| *Stylosanthes guianensis* CIAT 184 | 4 | 4 | 4 | 3 | 4 | 0 |
| *Stylosanthes scabra* cv. Siran | 2 | 2 | 4 | 2 | 3 | 0 |
| *Stylosanthes scabra* cv. Seca | 3 | 2 | 4 | 1 | 3 | 0 |
| *Vigna parkeri* cv. Shaw | 3 | 1 | 2 | 1 | 1 | 0 |
| *Zornia latifolia* CIAT 728 | 1 | 1 | 1 | 2 | 1 | 0 |
| *Andropogon gayanus* cv. Kent | 0 | 0 | 0 | 0 | 0 | 0 |
| *Brachiaria brizantha* CIAT 6387 | 1 | 4 | 4 | 2 | 4 | 0 |
| *Brachiaria brizantha* CIAT 6780 | 1 | 3 | 4 | 1 | 4 | 0 |
| *Brachiaria brizantha* CIAT 16318 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Brachiaria brizantha* CIAT 16827 | 1 | 3 | 4 | 2 | 4 | 0 |
| *Brachiaria brizantha* CIAT 16835 | 1 | 3 | 4 | 3 | 4 | 0 |
| *Brachiaria brizantha* CIAT 26110 | 1 | 3 | 4 | 1 | 4 | 0 |
| *Brachiaria decumbens* cv. Basilisk | 1 | 3 | 4 | 1 | 4 | 0 |
| *Brachiaria humidicola* cv. Tully | 1 | 2 | 4 | 1 | 4 | 0 |
| *Brachiaria humidicola* CIAT 6133 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Brachiaria humidicola* CIAT 26149 | 1 | 1 | 3 | 1 | 4 | 0 |
| *Brachiaria ruziziensis* ex. Thailand | 3 | 3 | 3 | 4 | 3 | 0 |
| *Panicum maximum* TD 58 | 2 | 3 | 3 | 3 | 3 | 0 |
| *Panicum maximum* CIAT 6299 | 2 | 4 | 3 | 3 | 3 | 0 |
| *Paspalum atratum* BRA 9610 | 1 | 2 | 3 | 1 | 2 | 0 |
| *Paspalum guenoarum* BRA 3824 | 3 | 2 | 2 | 1 | 2 | 0 |
| *Urochloa mosambicensis* CPI 46876 | 2 | 3 | 2 | 2 | 3 | 0 |
| *Urochloa mosambicensis* CPI 60128 | 1 | 1 | 3 | 1 | 3 | 0 |
| *Urochloa mosambicensis* CPI 60147 | 3 | 2 | 3 | 2 | 3 | 0 |
| *Urochloa mosambicensis* cv. Nixon | 1 | 1 | 3 | 2 | 3 | 0 |

[1] Establishment success: 0=did not emerge, 1=poor, 2=moderate, 3=good, 4=excellent.
[2] Yield potential, persistence, and seed production: 1=poor, 2=moderate, 3=good, 4=excellent.
[3] Maintains green leaf in dry season: 0=very poor, 1=poor, 2=average, 3=good, 4=excellent
[4] Pests/diseases: 0= no pests/diseases, 1=little impact, 2=moderate impact, 3=severe impact, 4=plants killed.

## Discussion

Across all sites, some grass species proved to be persistent, productive, and broadly adapted. These included *Brachiaria brizantha* CIAT 6780*, Brachiaria brizantha* CIAT 16318, *Brachiaria decumbens* cv. Basilisk, and *Panicum maximum* CIAT 6299. They grew well in a wide range of soils – from very acid (at Namsuang) to more fertile (at Ban km 35). They were tolerant of drought and showed high yield potential in the wet season. However, these species had only poor to moderate establishment at some sites. This may have been due to ant theft of seed, as reported by some technicians, or poor seed quality. *Andropogon gayanus* appears to have potential but it was not planted at all sites because of lack of seed.

The main limitation for many of the legumes was surviving the long and severe dry season. Growth of the legumes was generally vigorous in the first wet season, but many did not survive the dry season. Only *Stylosanthes guianensis* CIAT184 persisted and grew vigorously at all sites. *Chamaecrista rotundifolia* cv. Wynn was reasonably successful, but is largely annual.

Some species performed well and persisted in some locations but not in others. These were *Brachiaria humidicola* (cv. Tully, CIAT 16886 and CIAT 6133*), Urochloa mosambicensis* cv. Nixon, *Zornia latifolia* CIAT 728, and *Centrosema acutifolium* CIAT 5277.

## Conclusions

The nurseries have identified a small range of broadly adapted forage species for Lao PDR (especially *Brachiaria brizantha* CIAT 6780, CIAT 16318, *Brachiaria decumbens* cv. Basilisk, *Panicum maximum* CIAT 6299 and TD58, and *Stylosanthes guianensis* CIAT 184). There is no shortage of grass species for farmers to evaluate, but there are few legumes adapted to the poor soils and long dry season typical of much of Lao PDR.

Some species need further evaluation for various reasons: either because they have not been tried, were only tried at some sites, did not establish well (because of poor seed/ant predation), or may have specific adaptation to particular conditions (for example, higher altitude areas of the northern provinces). These include *Andropogon gayanus* (which is well adapted to the acid and poorly drained soil of the Namsuang site), *Brachiaria humidicola* (which established poorly from seed at most sites but is easily propagated vegetatively), *Setaria sphacelata* cv. Solander and cv. Kazungula (which have performed well in the cooler areas of Xieng Khouang), *Chamaecrista rotundifolia* cv. Wynn and other leafier accessions, *Zornia latifolia* CIAT 728 and *Centrosema acutifolium* CIAT 5277.

The lack of adapted legumes points to the need for more work on tree legumes. At Ban km 32, for example, *Calliandra calothyrsus* has performed extremely well. *Leucaena* is generally not well adapted to most of Lao PDR because of the acid soils. However, some of the cold-tolerant *Leucaena* varieties should be tried in the more fertile soils of the northern provinces. *Gliricidia sepium* appears to have potential in the moderately fertile soils of Luang Phabang but has not performed well on either the poorer soils or in areas with low winter temperatures.

## Acknowledgements

The authors thank the provincial and district officers (Mr. Bounthong, Mr. Daosadet, Miss Thongbay, Mr. Sengpasith, Mr. Simuang, Mr. Sisomvang) and Mrs. Kaysone for their assistance in the management of the nursery and in data collection. We also thank Miss

Soukanhya for her assistance in data management. The assistance and financial support of the Forages for Smallholders Project and the Division of Livestock Development, Department of Livestock and Fisheries, MAF are much appreciated.

# Regional evaluation of forages in Indonesia: Aceh, Kalimantan, North Sulawesi and North Sumatra

**Ibrahim[1] and Maimunah Tuhulele[2]**

## Introduction

The Forages for Smallholders Project (FSP) was able to make use of the results of species evaluations of the Forage Seeds Project (1992 – 1994). Several species were identified which had shown broad adaptation to environmental conditions in Kalimantan. These species were offered to farmers for evaluation on-farm in the Forages for Smallholders Project. Regional evaluation was continued at some sites of the Forage Seeds Project in Kalimantan, adding new species which had shown promise in other countries. New regional evaluation sites were established in areas where the FSP intended to work with farmers. These were tailored to the needs expressed by farmers and therefore did not include all species at every site. New regional evaluation sites were established in Aceh, North Sumatra, North Sulawesi and East Kalimantan. We would like to thank all of our local collaborators who provided data for this paper.

## Site description

**Table 1. Physical characteristics of sites for regional evaluations.**

| Site | Alt. (m) | Annual rainfall (mm) | Wet season | No. of wet months (>100mm) | Soil characteristics | | | Dominant farming system |
|---|---|---|---|---|---|---|---|---|
| | | | | | pH[1] (% Al sat) | Texture (drainage)[2] | Fertility[3] | |
| Gorontalo, North Sulawesi | 18 | 1290 | Nov-Jun | 5 – 7 | 6.8 | grey-brown fine sandy loam (seasonally flooded) | moderate (low S) | moderately intensive upland agriculture, mostly under coconuts |
| Loa Janan, East Kalimantan | <100 | 2020 | Nov-Jun | 7 – 11 | 4.8 (35% Al) | red loam (well drained) | moderate | degraded *Imperata cylindrica* grassland, extensive upland agriculture |
| Makroman, East Kalimantan | <100 | 2040 | Nov-Jun | 7 – 11 | 4.6 (65% Al) | yellow-brown silty loam (well drained) | moderate (low P) | mixture (50:50) of extensive upland (*Imperata* grassland) and rainfed lowland rice |
| Sepaku, East Kalimantan | <100 | 2400 | Nov-Jun | 7 – 11 | 4.8 (64% Al) | yellow-brown silty loam (well drained) | infertile (low P) | extensive upland agriculture (*Imperata* grassland), livestock production and home gardens around houses |
| Kanamit, Central Kalimantan | <20 | 2750 | Nov-Jun | 8 – 11 | 4.3 (82% Al) | organic black loam (poorly drained, seasonally flooded) | infertile (low P, S, Mn) | low-lying, seasonally flooded acid sulphate peat areas, lowland rice |
| Marenu, North Sumatra | 300 | 2330 | Oct-Apr | 7 – 10 | 4.7 (82% Al) | brown, fine sandy loam (well drained) | infertile (low P, Mg) | natural grasslands, sheep production transmigration area in otherwise extensive uplands |
| Saree, Aceh | 500 | 1580 | Oct- Apr | 4 – 8 | 5.1 (5% Al) | brown, silty loam (moderate drainage) | fertile | intensive upland, vegetable production and home gardens |
| Blang Ubo-ubo, Aceh | 700 | >1550 | Oct- Apr | 4 – 8 | 5.6 | brown loam (well drained) | moderate | natural grassland, managed communal grazing in mountainous upland |

[1] soil pH measured in 1:5 $H_2O$ (% Al saturation in brackets).
[2] drainage (poorly drained, moderate drainage, well drained, seasonally flooded).
[3] major soil fertility deficiencies or problems (eg. low P).

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The selected sites represent a range of upland agro-ecosystems (Table 1). These range from relatively fertile soils in Saree, Aceh to extremely infertile soils in Marenu, North Sumatra (Table 2). All sites apart from Gorontalo are relatively humid with average annual rainfall ranging from 1290 to 2750 mm (Fig 1). 1997 was an unusually dry year which tested the ability of species to withstand dry conditions.

Aceh has vast areas of degraded natural grasslands in mountainous areas which traditionally have been used for communal grazing. Two evaluation sites were established; one in an area of intensive upland cropping (Saree) where farmers fatten cattle bred on the communal grazing areas and the second site (Blang Ubo-ubo) in a communal grazing area in the mountains. The latter is managed by a group of farmers. In Saree, forages are intended mainly for cut & carry. Those in Blang Ubo-ubo are for both cut & carry (supplementary feeding) near the cattle shed and for improvement of communally managed grazing areas.

South Tapanuli in North Sumatra is an area of extensive upland agriculture which has traditionally been used for grazing of cattle and buffaloes. The evaluation site is located in a transmigration area which has only recently been established. The transmigration area is based on sheep production. Farmers were given 20 sheep and 2 rams to start breeding sheep. Forages are needed mainly for cut and carry but there may also be some potential for improvement of grazing areas.

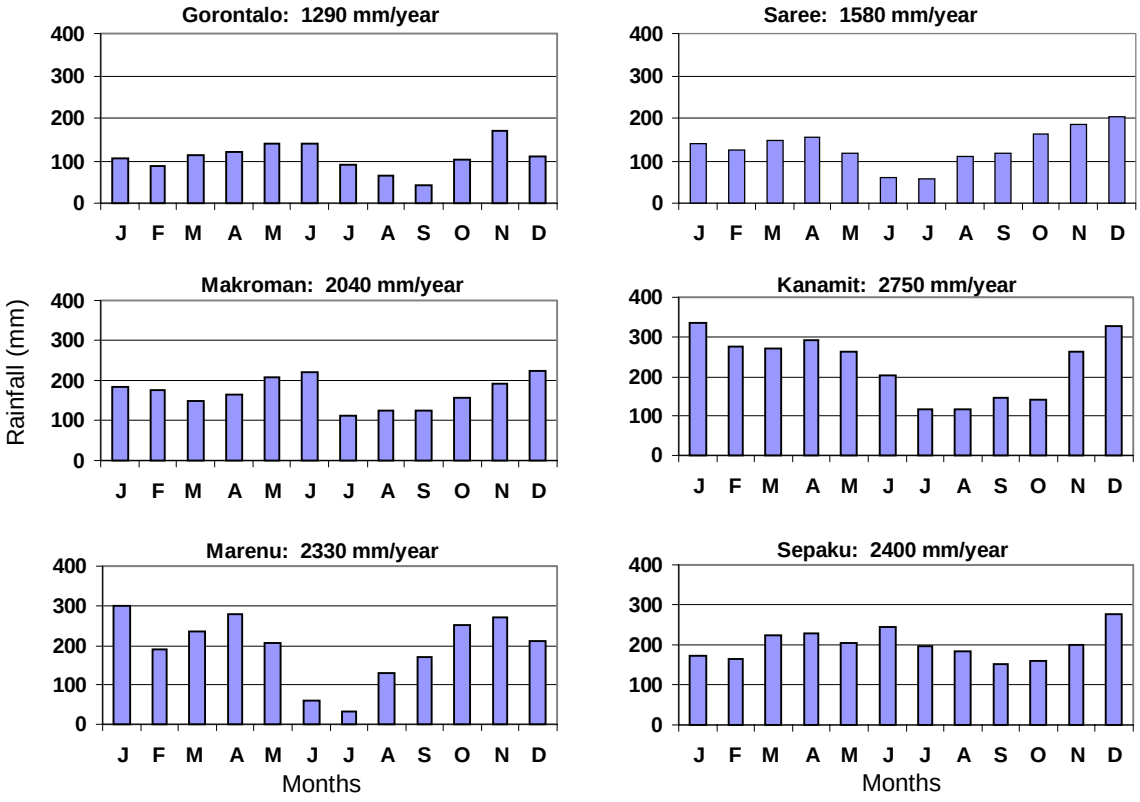


**Fig. 1. Mean monthly rainfall (mm) at forage evaluation sites (10-year data).**

Sepaku, Makroman and Loa Janan in East Kalimantan are located in *Imperata*-dominated upland areas, but represent a range of soil fertility and farming systems and thus the need for different types of forages. Farmers in Sepaku graze cattle on the poor-quality *Imperata* grasslands. Makroman has a mix of lowland and upland areas and farmers keep both cattle and goats. Farmers at Makroman are particularly interested in the use of legumes for weed control and soil fertility improvement in their upland cropping areas. Loa Janan was carried on from the Forage Seeds Project to complete a comprehensive evaluation.

Kanamit, Kuala Kapuas in Central Kalimantan is located in seasonally flooded lowland area of acid-sulphate peat soils This site was carried over from the Forage Seeds Project but new species were added which had shown potential in other countries.

Gorontalo in North Sulawesi is an area of moderately intensive upland agriculture, mainly under coconut plantations. Soils are moderately fertile but it is the site with the lowest rainfall and longest dry season. Farmers are interested in both grazing and cut & carry species.

**Table 2. Soil analysis results at regional evaluation sites.**

| Site | pH | Organic carbon | N | P[1] | S | K | Ca | Mg | Al | Na | CEC | Cu | Zn | Mn | Fe | B | Al sat. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1:5 $H_2O$) | (%) | $NO_3$ | ppm | | meq/100g | | | | | | | | | % | | |
| Gorontalo, North Sulawesi | 6.8 | 1.0 | 0.4 | 26 | 4 | 0.29 | 7.4 | 3.5 | 0 | 0.1 | 11.3 | 1.8 | 0.5 | 15 | 19 | 0.5 | 0 |
| Loa Janan, East Kalimantan | 4.8 | 2.4 | 7.0 | 58 | 32 | 0.51 | 2.7 | 1.6 | 2.6 | - | 7.4 | 0.8 | 0.7 | 9 | - | 0.7 | 35 |
| Makroman, East Kalimantan | 4.6 | 1.7 | 6.7 | 5 | 9 | 0.15 | 0.8 | 0.7 | 3.2 | 0.02 | 4.9 | 0.4 | 0.8 | 5 | 276 | 0.5 | 65 |
| Sepaku II, East Kalimantan | 4.8 | 1.2 | 0.5 | 5 | 6 | 0.14 | 0.8 | 0.4 | 2.4 | 0.02 | 3.8 | 0.3 | 0.2 | 3 | 113 | 0.3 | 64 |
| Kanamit, Central Kalimantan | 4.3 | 12.6 | 14 | - | - | 0.17 | 1.1 | 0.6 | 8.3 | - | 10.2 | 0.4 | 0.2 | - | - | 0.3 | 82 |
| Marenu, North Sumatra | 4.7 | 3.0 | 0.3 | 5 | 10 | 0.13 | 0.4 | 0.1 | 3.1 | 0.07 | 3.8 | 0.3 | 0.3 | 2 | 168 | 0.6 | 82 |
| Saree, Aceh | 5.1 | 2.2 | 19.8 | 40 | 8 | 0.38 | 6.5 | 1.8 | 0.4 | 0.07 | 9.1 | 2.0 | 2.5 | 14 | 169 | 0.7 | 5 |
| Blang Ubo-ubo, Aceh | 5.6 | 3.2 | 4.4 | 21 | 18 | 0.82 | 6.7 | 3.1 | 0 | 0.03 | 10.6 | 2.1 | 3.8 | 229 | 120 | 1.3 | 0 |
| Concentration low, if | <5 | <1.0 | - | <5 | <5 | <0.1 | <0.1 | <0.2 | - | - | - | <0.2 | <0.2 | <1 | <1 | <0.2 | - |

1 = P (BSES)

## Methods

Forage varieties included in regional evaluations are shown in Table 3.

Small plots were established from either seed or vegetative planting material. Plot size ranged from 4 x 4 m plots to 10 x 10 m plots, depending on availability of land and resources. Plots were not fertilised. Weeding was restricted to the establishment period and occasional slashing or grazing. Performance of species, including yield, seed production, incidence of pests and diseases, was recorded periodically. Most sites were also used as demonstration sites for farmers and as a source of planting material for farmer evaluations.

**Table 3. List of forages evaluated at regional sites in Indonesia.**

| Species | Sites | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Gorontalo | Loa Janan | Makroman | Sepaku II | Kanamit | Marenu | Saree | Blang Ubo-ubo |
| **Grasses** | | | | | | | | |
| *Andropogon gayanus* CIAT 621 | ✔ | ✔ | - | - | ✔ | - | ✔ | ✔ |
| *A. gayanus* cv. Kent | ✔ | - | ✔ | ✔ | - | ✔ | - | - |
| *Brachiaria brizantha* CIAT 6387 | - | - | - | ✔ | - | - | - | - |
| *B. brizantha* CIAT 6780 | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| *B. brizantha* CIAT 16835 | - | - | - | ✔ | - | ✔ | - | - |
| *B. brizantha* CIAT 26110 | ✔ | - | ✔ | ✔ | - | - | ✔ | ✔ |
| *B. brizantha* ex. Sungai Putih | - | - | - | - | - | ✔ | - | - |
| *B. decumbens* cv. Basilisk | ✔ | ✔ | ✔ | ✔ | ✔ | - | ✔ | ✔ |
| *B. humidicola* CIAT 6133 | ✔ | ✔ | ✔ | ✔ | ✔ | - | ✔ | ✔ |
| *B. humidicola* CIAT 6369 | - | ✔ | ✔ | ✔ | ✔ | - | - | - |
| *B. humidicola* cv. Tully | ✔ | - | ✔ | ✔ | - | ✔ | ✔ | ✔ |
| *Chloris gayana* cv. Callide | - | ✔ | - | - | ✔ | - | - | - |
| *Digitaria milanjiana* cv. Jarra | - | ✔ | - | - | ✔ | ✔ | ✔ | - |
| *D. swynnertonii* CPI 59749 | - | ✔ | - | - | ✔ | - | - | - |
| *Panicum maximum* T-58 | - | - | - | - | - | ✔ | - | - |
| *P. maximum* CIAT 6299 | - | - | ✔ | - | - | - | ✔ | ✔ |
| *P. maximum* cv. Makueni | - | ✔ | - | - | ✔ | - | - | - |
| *P. maximum* cv. Riversdale | - | ✔ | - | - | ✔ | - | - | - |
| *Paspalum atratum* BRA 9610 | ✔ | ✔ | ✔ | ✔ | - | ✔ | ✔ | ✔ |
| *P. atratum* 'Pantaneira' | - | - | - | - | - | ✔ | - | - |
| *P. conjugatum* 'local' | - | - | - | - | ✔ | - | - | - |
| *P. guenoarum* BRA 3824 | - | ✔ | - | ✔ | - | ✔ | - | - |
| *P. malacophyllum* CPI 27690 | - | ✔ | - | - | ✔ | - | - | - |
| *P. notatum* cv. Competidor | ✔ | - | - | - | - | - | - | - |
| *Pennisetum* hybrid ('King' grass) | ✔ | - | ✔ | ✔ | ✔ | ✔ | - | - |
| *Pennisetum* hybrid cv. Mott (dwarf napier) | ✔ | - | ✔ | - | - | ✔ | - | - |
| *P. purpureum* 'local' | ✔ | - | - | - | ✔ | - | - | - |
| *Setaria sphacelata* var. *splendida* | ✔ | - | ✔ | ✔ | ✔ | ✔ | - | - |
| *Stenotaphrum secundatum* cv. Floratam | ✔ | - | - | - | - | - | - | - |
| **Herbaceous legumes** | | | | | | | | |
| *Aeschynomene americana* cv. Glenn | - | ✔ | - | - | ✔ | - | - | - |
| *A. americana* cv. Lee | - | ✔ | - | - | ✔ | - | - | - |
| *Arachis glabrata* | ✔ | - | - | - | - | - | - | - |
| *A. pintoi* cv. Amarillo (CIAT17434) | ✔ | ✔ | - | - | ✔ | - | - | - |
| *A. pintoi* CIAT 18744 | ✔ | - | - | - | - | - | - | - |
| *A. pintoi* CIAT 22160 | ✔ | - | - | ✔ | - | - | ✔ | - |
| *Cajanus cajan* CIAT 18700 | - | ✔ | - | - | ✔ | - | - | - |
| *Calopogonium mucunoides* 'local' | - | - | - | - | - | - | - | - |
| *Centrosema acutifolium* CIAT 5277 | ✔ | ✔ | - | ✔ | ✔ | - | - | - |
| *C. macrocarpum* CIAT 25522 | ✔ | - | - | ✔ | - | ✔ | - | - |
| *C. macrocarpum* CIAT 5452 | - | ✔ | - | - | ✔ | - | - | - |
| *C. macrocarpum* CIAT 15014 | - | ✔ | - | - | ✔ | - | - | - |
| *C. macrocarpum* CIAT 15047 | - | ✔ | - | - | ✔ | - | - | - |
| *C. pascuorum* cv. Cavalcade | - | ✔ | - | - | ✔ | - | - | - |
| *C. pubescens* CIAT 15160 | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| *C. pubescens* CIAT 438 | - | ✔ | - | - | ✔ | - | - | - |
| *C. schiedeanum* cv. Belalto | - | ✔ | - | - | ✔ | - | - | - |
| *Chamaecrista rotundifolia* cv. Wynn | - | - | - | - | ✔ | - | - | - |
| *D. heterophyllum* CIAT 349 | ✔ | ✔ | - | ✔ | - | ✔ | ✔ | - |
| *D. ovalifolium* CIAT 13089 | - | ✔ | - | - | - | - | - | - |
| *D. ovalifolium* CIAT 13305 | - | - | - | ✔ | - | - | - | - |
| *D. velutinum* CIAT 13220 | - | ✔ | - | - | ✔ | - | - | - |
| *Macroptilium gracile* cv. Maldonado | - | ✔ | - | - | ✔ | - | - | - |
| *Stylosanthes capitata* CIAT 10280 | - | ✔ | - | - | - | - | - | - |
| *S. guianensis* cv. Cook | - | ✔ | - | - | ✔ | - | - | - |
| *S. guianensis* cv. Graham | - | ✔ | - | - | ✔ | - | - | - |
| *S. guianensis* CIAT 184 | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |

**(continued next page)**

**Table 3 (cont.) List of forages evaluated at regional sites in Indonesia.**

| Species | Sites | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Gorontalo | Loa Janan | Makroman | Sepaku II | Kanamit | Marenu | Saree | Blang Ubo-ubo |
| *S. hamata* cv. Verano | - | ✔ | - | - | ✔ | - | ✔ | ✔ |
| *S. scabra* cv. Seca | - | - | - | - | - | - | - | - |
| *S. scabra* cv. Siran | - | - | - | - | - | ✔ | ✔ | ✔ |
| **Tree legumes** | | | | | | | | |
| *Calliandra calothyrsus* ex. Indonesia (CPI 115690) | ✔ | ✔ | ✔ | - | - | ✔ | - | ✔ |
| *Codariocalyx gyroides* CIAT 3001 | - | ✔ | - | - | ✔ | - | - | - |
| *Cratylia argentea* CIAT 18516 | - | ✔ | - | - | ✔ | ✔ | - | - |
| *Desmodium cinerea* ex. MBRLC (CPI 46562) | ✔ | - | ✔ | - | - | ✔ | ✔ | ✔ |
| *Flemingia macrophylla* CIAT 17403 | ✔ | ✔ | ✔ | - | ✔ | ✔ | - | - |
| *Gliricidia sepium* 'Retalhuleu' | ✔ | - | ✔ | ✔ | - | ✔ | ✔ | ✔ |
| *G. sepium* 'Monterrico' | ✔ | - | ✔ | ✔ | - | ✔ | ✔ | ✔ |
| *G. sepium* 'Belen Rivas' | ✔ | - | ✔ | ✔ | - | ✔ | ✔ | ✔ |
| *G. sepium* 'local' | ✔ | - | - | - | - | - | ✔ | ✔ |
| *Leucaena collinsii* QF 152/88 | - | - | - | - | - | ✔ | - | - |
| *L. leucocephala* K636 | ✔ | - | ✔ | ✔ | - | ✔ | ✔ | ✔ |
| *L. leucocephala* 'local' | ✔ | - | - | - | - | - | ✔ | - |
| *Sesbania grandiflora* 'local' | - | - | ✔ | - | - | - | - | - |

## Results

Several forage are broadly adapted across the wide range of soil fertility and rainfall conditions (Table 4).

The most broadly adapted forages were *Andropogon gayanus*, *Brachiaria brizantha*, *Brachiaria humidicola*, *Stylosanthes guianensis* CIAT 184, *Centrosema pubescens* CIAT 15160 and the tree legume *Gliricidia sepium*. Particular accessions have been identified within these species which are vigorous, persistent and produce seed at all locations.

There were also some other species which were adapted to particular environments (Table 4).

Detailed data on performance of species included in regional evaluations are presented in the Appendix.

## Conclusions

Environmental adaptation is only one part of successful forage technology. The next step is to find out how these forages fit into farming systems, and how they can be utilized to provide maximum benefits to smallholder farmers and the environment. This can best be achieved through farmer evaluation of forages. The broadly adapted forage species identified through regional evaluation form the basis for farmer testing. To make these forages widely available to farmers outside FSP sites, large-scale seed multiplication is needed.

**Table 4. Broadly adapted forages in Indonesia.**

| | Site | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Saree | Ubo-ubo | Gorontalo | L. Janan | Makroman | Sepaku | Marenu | Kanamit |
| Soil fertility[1] | H | M | M | M | M | L | L | L |
| **Grasses** | | | | | | | | |
| *Andropogon gayanus* | 4 | - | - | 3 | 3 | 4 | 3 | 4 |
| *Brachiaria brizantha* CIAT 6780 | 4 | - | 4 | 4 | 4 | 4 | 3 | 4 |
| *Brachiaria brizantha* CIAT 26110 | 4 | 3 | 4 | - | 3 | 4 | - | - |
| *Brachiaria decumbens* | 4 | 4 | 3 | 3 | 3 | 3 | - | 3 |
| *Brachiaria humidicola* | 4 | 4 | 3 | 4 | 3 | 4 | - | 3 |
| *Panicum maximum* | 4 | 4 | 2 | 4 | 2 | - | 1 | 2 |
| *Paspalum atratum* | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| *Pennisetum* spp. | 4 | 3 | 3 | 2 | 3 | 2 | 1 | 2 |
| **Legumes** | | | | | | | | |
| *Arachis pintoi* | 3 | - | 4 | 1 | - | 1 | - | 1 |
| *Centrosema macrocarpum* | - | - | 1 | 4 | - | 2 | 4 | 3 |
| *Centrosema pubescens* CIAT 15160 | 3 | 3 | 4 | 4 | 4 | 3 | 3 | 3 |
| *Desmodium heterophyllum* | 3 | - | 4 | 2 | - | 3 | - | - |
| *Stylosanthes guianensis* CIAT 184 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 4 |
| **Tree legumes** | | | | | | | | |
| *Calliandra calothyrsus* | - | 3 | 2 | 1 | 1 | - | 1 | - |
| *Flemingia macrophylla* | - | - | 4 | 4 | - | - | 4 | 4 |
| *Desmodium cinerea* (prev. *D. rensonii)* | 4 | 4 | 2 | 1 | - | - | 1 | - |
| *Gliricidia sepium* | 4 | 4 | 4 | 4 | - | 2 | 4 | - |
| *Leucaena leucocephala* | 4 | 4 | 1 | - | - | 1 | 1 | - |

[1] Soil fertility: H = high, M = moderate, L = low.
[2] Overall performance: 4 = excellent, 3 = good, 2 = moderate, 1 = poor, - == not evaluated at this site.

# Appendices

**Appendix 1. Performance of forage species at Gorontalo, North Sulawesi.**

| | Establishment success[1] | Yield Potential[2] | Persistence[2] | Seed Production[2] | Pests/ Diseases[3] |
|---|---|---|---|---|---|
| **Grasses** | | | | | |
| *Andropogon gayanus* cv. Kent | 0 | - | - | - | - |
| *Brachiaria brizantha* CIAT 6780 | 3 | 2 | 2 | 1 | 0 |
| *B. brizantha CIAT 26110* | 3 | 3 | 3 | 1 | 0 |
| *B. decumbens* cv. Basilisk | 2 | 2 | 3 | 1 | 0 |
| *B. humidicola* CIAT 6133 | 0 | - | - | - | - |
| *B. humidicola* cv. Tully | 3 | 3 | 3 | 1 | 0 |
| *Panicum maximum* CIAT 6299 | 2 | 2 | 2 | 1 | 0 |
| *Paspalum atratum* CIAT 9160 | 4 | 4 | 4 | 1 | 0 |
| *P. notatum* cv. Competidor | 3 | 2 | 3 | 1 | 0 |
| *Pennisetum* hybrid 'King' grass | 4 | 3 | 3 | 1 | 0 |
| *Pennisetum purpureum* cv. Mott | 3 | 2 | 3 | 1 | 0 |
| *P. purpureum* 'local' | 3 | 3 | 3 | 1 | 0 |
| *Setaria sphacelata* var. s*plendida* | 0 | - | - | - | - |
| *Stenotaphrum secundatum* cv. Floratam | 2 | 2 | 4 | 1 | 0 |
| **Legumes** | | | | | |
| *Arachis glabrata* | 1 | 1 | 2 | 1 | 1 |
| *A, pintoi* cv. Amarillo | 1 | 1 | 2 | 1 | 1 |
| *A. pintoi* CIAT 18744 | 0 | - | - | - | - |
| *A. pintoi* CIAT 22160 | 4 | 3 | 4 | 1 | 0 |
| *Centrosema acutifolium* | 1 | 1 | 2 | 1 | 1 |
| *C. macrocarpum* CIAT 25522 | 1 | 1 | 2 | 1 | 1 |
| *C. pubescens* CIAT 15160 | 4 | 3 | 3 | 2 | 1 |
| *Desmodium heterophyllum* CIAT 349 | 3 | 1 | 3 | 1 | 1 |
| *Macroptilium gracile* cv. Maldonado | 0 | - | - | - | - |
| *Stylosanthes guianensis* CIAT 184 | 4 | 4 | 4 | 3 | 1 |
| **Trees and shrubs** | | | | | |
| *Calliandra calothyrsus* | 1 | 2 | 2 | 1 | 1 |
| *Desmodium cinerea* CIAT 46562 (*D. rensonii)* | 2 | 1 | 2 | 2 | 1 |
| *Flemingia macrophylla* CIAT 17403 | 4 | 3 | 2 | 3 | 1 |
| *Gliricidia sepium* 'Belen Rivas' | 3 | 3 | 2 | 1 | 1 |
| *G. sepium* 'Monterrico' | 3 | 3 | 2 | 1 | 1 |
| *G. sepium* 'Retalhuleu' | 3 | 3 | 2 | 1 | 1 |
| *Leucaena leucocephala* K636 | 3 | 2 | 3 | 3 | 2 |

[1] Establishment success: 0=did not emerge, 1=poor, 2= moderate, 3=good, 4=excellent.
[2] Yield potential, persistence and seed production: 1=poor, 2=moderate, 3=good, 4=excellent.
[3] Pests/Diseases: 0=none, 1=little impact, 2=moderate impact, 3=severe impact, 4=plants killed.

**Appendix 2. Performance of forage species at Loa Janan, East Kalimantan.**

| | Establishment success[1] | Yield Potential[2] | Persistence[2] | Seed Production[2] | Pests/ Diseases[3] |
|---|---|---|---|---|---|
| **Grasses** | | | | | |
| *Andropogon gayanus* CIAT 621 | 4 | 3 | 3 | 1 | 0 |
| *Brachiaria brizantha* CIAT 6780 | 4 | 4 | 4 | 1 | 0 |
| *B. decumbens* cv. Basilisk | 4 | 3 | 4 | 1 | 0 |
| *B. humidicola* CIAT 6369 | 4 | 4 | 4 | 1 | 0 |
| *Digitaria milanjiana* cv. Jarra | 2 | 1 | 1 | 1 | 0 |
| *Panicum maximum* cv. Makueni | 1 | 1 | 1 | - | - |
| *P. maximum* cv. Riversdale | 3 | 4 | 2 | 1 | 0 |
| *Paspalum atratum* BRA 9610 | 3 | 4 | 3 | 1 | 0 |
| **Legumes** | | | | | |
| Aeschynomene americana cv. Glenn | 3 | 1 | 1 | 1 | 0 |
| *A. americana* cv. Lee | 3 | 1 | 1 | 1 | 0 |
| *Arachis pintoi* cv. Amarillo | 3 | - | - | - | - |
| *Cajanus cajan* CIAT 18700 | 1 | - | - | - | - |
| *Centrosema acutifolium* CIAT 5277 | 2 | 2 | 2 | 1 | 0 |
| *C. macrocarpum* CIAT 15047&15014&5452 | 2 | 3 | 3 | 1 | 1 |
| *C. pascuorum* cv. Cavalcade | 3 | ? | ? | ? | ? |
| *C. pubescens* CIAT 15160/438? | 4 | 4 | 4 | 3 | 0 |
| *C. schiedeanum* cv. Belalto | 3 | 2 | 2 | 1 | 0 |
| *Desmodium heterophyllum* CIAT 349 | 3 | ? | | | |
| *D. ovalifolium* CIAT 13089 | 2 | ? | | | |
| *Macroptilium gracile* cv. Maldonado | 3 | ? | | | |
| *Stylosanthes capitata* CIAT 10280 | 1 | - | - | - | - |
| *S. guianensis* cv. Cook | 3 | 2 | 2 | 1 | 1 |
| *S. guianensis* cv. Graham | 3 | ? | | | |
| *S. guianensis* CIAT 184 | 4 | 4 | 3 | 2 | 0 |
| *S. guianensis* SSD-12 | 2 | ? | | | |
| *S. hamata* cv. Verano | 2 | - | - | - | - |
| **Trees and shrubs** | | | | | |
| *Calliandra calothyrsus* | 2 | ? | | | |
| *Codariocalyx gyroides* CIAT 3001 | 3 | ? | | | |
| *Flemingia macrophylla* CIAT 17403 | 4 | 4 | 3 | 2 | 0 |

[1] Establishment success: 0=did not emerge, 1=poor, 2= moderate, 3=good, 4=excellent.
[2] Yield potential, persistence and seed production: 1=poor, 2=moderate, 3=good, 4=excellent.
[3] Pests/Diseases: 0=none, 1=little impact, 2=moderate impact, 3=severe impact, 4=plants killed.

**Appendix 3. Performance of forage species at Makroman, East Kalimantan.**

| | Establishment success [1] | Yield Potential [2] | Persistence [2] | Seed Production [2] | Pests/ Diseases [3] |
|---|---|---|---|---|---|
| **Grasses** | | | | | |
| *Andropogon gayanus* cv. Kent | 3 | 3 | 2 | 1 | 0 |
| *Brachiaria brizantha* CIAT 6780 | 4 | 4 | 3 | 1 | 0 |
| *B. decumbens* cv. Basilisk | 3 | 3 | 3 | 1 | 0 |
| *B. humidicola* CIAT 6369 | 4 | 3 | 3 | 1 | 0 |
| *B. humidicola* cv. Tully | 4 | 3 | 4 | 1 | 0 |
| *B. humidicola* CIAT 6133 | 3 | 3 | 4 | 1 | 0 |
| *Paspalum atratum* BRA 9610 | 4 | 4 | 3 | 1 | 0 |
| *P. guenoarum* | ? | | | 1 | 0 |
| *Pennisetum* hybrid 'King' grass | 2 | 3 | 2 | 1 | 0 |
| *Setaria sphacelata* cv. Splendida | 3 | 3 | 2 | 1 | 0 |
| *Panicum maximum* CIAT 629 | 2 | 2 | 3 | 1 | 0 |
| *Pennisetum purpureum* cv. Mott | 2 | 2 | 3 | 1 | 0 |
| **Legumes** | | | | | |
| *Arachis pintoi* CIAT 22160 | - | - | - | - | - |
| *Centrosema pubescens* CIAT 15160 | 4 | 2 | 3 | 1 | 0 |
| *C. acutifolium* CIAT 5277 | 3 | 1 | 3 | 1 | 0 |
| *C. macrocarpum* CIAT 25522 | 2 | 1 | 3 | 1 | 0 |
| *Stylosanthes guianensis* CIAT 184 | 3 | 2 | 3 | 1 | 0 |
| **Trees and shrubs** | | | | | |
| *Calliandra calothyrsus* | 1 | - | - | - | 0 |
| *Desmodium cinerea CIAT 46562* | 3 | - | - | - | 0 |
| *Gliricidia sepium* 'Belen Rivas' | 3 | - | - | - | 1 |
| *G. sepium* 'Monterrico' | 3 | - | - | - | 1 |
| *G. sepium* 'Retalhuleu' | 4 | - | - | - | 1 |
| *Leucaena leucocephala* K636 | 3 | - | - | - | 1 |
| *Sesbania grandiflora 'local'* | 2 | - | - | - | 1 |

[1] Establishment success: 0=did not emerge, 1=poor, 2= moderate, 3=good, 4=excellent.
[2] Yield potential, persistence and seed production: 1=poor, 2=moderate, 3=good, 4=excellent.
[3] Pests/Diseases: 0=none, 1=little impact, 2=moderate impact, 3=severe impact, 4=plants killed.

**Appendix 4. Performance of forage species at Sepaku II, East Kalimantan.**

| | Establishment success[1] | Yield Potential[2] | Persistence[2] | Seed Production[2] | Pests/ Diseases[3] |
|---|---|---|---|---|---|
| **Grasses** | | | | | |
| *Andropogon gayanus* cv. Kent | 4 | 4 | 4 | 1 | 0 |
| *Brachiaria brizantha* CIAT 6780 | 4 | 4 | 4 | 1 | 0 |
| *B. decumbens* cv. Basilisk | 4 | 3 | 4 | 1 | 0 |
| *B. brizantha* CIAT 2610 | 3 | 3 | 4 | 1 | 0 |
| *B. brizantha* CIAT 6387 | 3 | 3 | 3 | 1 | 0 |
| *B. humidicola* CIAT 6369 | 4 | 3 | 4 | 1 | 0 |
| *B. humidicola* cv. Tully | 3 | 3 | 4 | 1 | 0 |
| *B. humidicola* CIAT 6133 | 4 | 3 | 4 | 1 | 0 |
| *Paspalum atratum* BRA 9610 | 3 | 3 | 4 | 1 | 0 |
| *P. guenoarum* BRA 3824 | 3 | 3 | 3 | 1 | 0 |
| *Pennisetum* hybrid 'King' grass | 3 | 2 | 3 | 1 | 0 |
| *Setaria sphacelata* cv. Splendida | 3 | 2 | 4 | 1 | 0 |
| *Panicum maximum* CIAT 629 | ? | - | 3 | 1 | 0 |
| *Pennisetum purpureum* cv. Mott | -? | - | 3 | 1 | 0 |
| **Legumes** | | | | | |
| *Arachis pintoi* CIAT 22160 | 1 | 1 | - | - | - |
| *Centrosema pubescens* CIAT 15160 | 3 | 2 | 3 | 2 | 0 |
| *C. acutifolium* CIAT 5277 | 2 | 1 | 3 | 1 | 0 |
| *C. macrocarpum* CIAT 25522 | 2 | 1 | 3 | 1 | 0 |
| *Desmodium heterophyllum* CIAT 349 | 3 | 1 | 3 | 1 | 0 |
| *D. ovalifolium* CIAT 13305 | 4 | 1 | 3 | 1 | 0 |
| *Stylosanthes guianensis* CIAT 184 | 4 | 2 | 4 | 2 | 0 |
| **Trees and shrubs** | | | | | |
| *Desmodium cinerea* CIAT 46562 | -? | - | 1 | - | - |
| *Flemingia macrophylla* CIAT 7403 | -? | - | 1 | - | - |
| *Gliricidia sepium* 'Belen Rivas' | 3 | - | - | - | 0 |
| *G. sepium* 'Monterrico' | 3 | - | - | - | 0 |
| *G. sepium* 'Retalhuleu' | 3 | - | - | - | 0 |
| *Leucaena leucocephala* K636 | 3 | - | - | - | 0 |

[1] Establishment success: 0=did not emerge, 1=poor, 2= moderate, 3=good, 4=excellent.
[2] Yield potential, persistence and seed production: 1=poor, 2=moderate, 3=good, 4=excellent.
[3] Pests/Diseases: 0=none, 1=little impact, 2=moderate impact, 3=severe impact, 4=plants killed.

**Appendix 5. Performance of forage species at Kanamit, Central Kalimantan.**

| | Establishment success[1] | Yield Potential[2] | Persistence[2] | Seed Production[2] | Pests/ Diseases[3] |
|---|---|---|---|---|---|
| **Grasses** | | | | | |
| *Andropogon gayanus* CIAT 639 | 3 | 3 | 4 | 2 | 0 |
| *Brachiaria brizantha* CIAT 6780 | 3 | 4 | 4 | 1 | 0 |
| *B. decumbens* cv. Basilisk | 3 | 3 | 4 | 1 | 0 |
| *B. humidicola* CIAT 6133 | 3 | 3 | 3 | 1 | 0 |
| *B. humidicola* CIAT 6369 | 3 | 3 | 4 | 1 | 0 |
| *Chloris gayana* cv. Callide | 2 | 2 | 1 | - | - |
| *Digitaria milanjiana* CPI 41192 | 2 | 2 | 2 | 1 | 0 |
| *D. swynnertonii* CPI 59749 | 4 | 3 | 4 | 2 | 0 |
| *Panicum maximum* cv. Makueni | 2 | 2 | 2 | 1 | 0 |
| *P. maximum* cv. Riversdale | 2 | 3 | 3 | 1 | 0 |
| *Paspalum conjugatum* 'local' | 3 | 2 | 3 | 1 | 0 |
| *P. malacophyllum* CPI 27690 | 2 | 1 | 1 | 1 | 0 |
| *Pennisetum* hybrid ('King' grass) | 3 | 2 | 2 | 1 | 0 |
| *P. purpureum* 'local' | 3 | 3 | 3 | 1 | 0 |
| *Setaria sphacelata* cv. Splendida | 3 | 3 | 2 | 1 | 0 |
| **Legumes** | | | | | |
| *Aeschynomene americana* cv. Glenn | 4 | 1 | 1 | 1 | 0 |
| *A. americana* cv. Lee | 2 | 1 | 1 | 1 | 0 |
| *Arachis pintoi* cv. Amarillo | 2 | 1 | 1 | 1 | 0 |
| *Cajanus cajan* CIAT 18700 | 1 | - | - | - | - |
| *Calopogonium mucunoides* 'local' | 2 | 2 | 3 | 1 | 0 |
| *Centrosema acutifolium* CIAT 5277 | 3 | 3 | 3 | 1 | 0 |
| *C. macrocarpum* CIAT 5452 | 3 | 3 | 3 | 1 | 0 |
| *C. macrocarpum* CIAT 15014 | 3 | 3 | 3 | 1 | 0 |
| *C. macrocarpum* CIAT 15047 | 3 | 3 | 3 | 1 | 0 |
| *C. pascuorum* cv. Cavalcade | 2 | 3 | - | - | - |
| *C. pubescens* CIAT 438 | 3 | 3 | 3 | 1 | 0 |
| *C. pubescens* CIAT 15160 | 3 | 3 | 4 | 1 | 0 |
| *C. schiedeanum* cv. Belalto | 2 | 2 | 2 | 1 | 0 |
| *Chamaecrista rotundifolia* cv. Wynn | 2 | 2 | 2 | 1 | 0 |
| *Desmodium velutinum* CIAT 13220 | 1 | - | - | - | - |
| *Macroptilium gracile* cv. Maldonado | 2 | 3 | 2 | - | - |
| *Stylosanthes guianensis* cv. Cook | 2 | 1 | 1 | 1 | 0 |
| *S. guianensis* cv. Graham | 2 | 1 | 1 | 1 | 0 |
| *S. guianensis* CIAT 184 | 4 | 3 | 4 | 2 | 0 |
| *S. hamata* cv. Verano | 2 | 1 | 2 | 1 | 0 |
| **Trees and shrubs** | | | | | |
| *Codariocalyx gyroides* CIAT 3001 | 0 | - | - | - | - |
| *Cratylia argentea* CIAT 18516 | 0 | - | - | - | - |
| *Flemingia macrophylla* CIAT 17403 | 4 | 3 | 4 | 3 | - |

[1] Establishment success: 0=did not emerge, 1=poor, 2= moderate, 3=good, 4=excellent.
[2] Yield potential, persistence and seed production: 1=poor, 2=moderate, 3=good, 4=excellent.
[3] Pests/Diseases: 0=none, 1=little impact, 2=moderate impact, 3=severe impact, 4=plants killed.

**Appendix 5. Performance of forage species at Marenu, North Sumatra.**

| | Establishment success[1] | Yield Potential[2] | Persistence[2] | Seed Production[2] | Pests/ Diseases[3] |
|---|---|---|---|---|---|
| **Grasses** | | | | | |
| *Andropogon gayanus* cv. Kent | 4 | 3 | 4 | 1 | 0 |
| *Brachiaria brizantha* CIAT 6780 | 4 | 3 | 4 | 1 | 0 |
| *B. brizantha* CIAT 16835 | 4 | 1 | 4 | 1 | 0 |
| *B. brizantha* ex. Sungai Putih | 4 | 2 | 4 | 1 | 0 |
| *B. humidicola* cv. Tully | 4 | 2 | 4 | 1 | 0 |
| *Digitaria milanjiana* cv. Jarra | 4 | - | 4 | - | 0 |
| *Panicum maximum* T-58 | 4 | 1 | 2 | 3 | 0 |
| *Paspalum atratum* BRA 9610 | 4 | 4 | 4 | 1 | 0 |
| *P. atratum* cv. Pantaneira | 4 | 4 | 4 | 1 | 0 |
| *P. guenoarum* BRA 3824 | 4 | 4 | 4 | 1 | 1 |
| *Pennisetum* hybrid ('King' grass) | 4 | 1 | 2 | 1 | 2 |
| *P. purpureum* cv. Mott | 4 | 1 | 2 | 1 | 0 |
| *Setaria sphacelata* var. *splendida* | 4 | 1 | 3 | 2 | 0 |
| **Legumes** | | | | | |
| *Centrosema macrocarpum* 25522 | 4 | 4 | 4 | 1 | 0 |
| *C. pubescens* CIAT 15160 | 4 | 3 | 3 | 1 | 1 |
| *Desmodium heterophyllum* CIAT 349 | 2 | 1 | 2 | 1 | 4 |
| *Stylosanthes guianensis* CIAT 184 | 4 | 2 | 4 | 3 | 1 |
| *S. scabra* cv. Siran | 2 | 1 | 2 | 2 | 1 |
| **Trees and shrubs** | | | | | |
| *Calliandra calothyrsus* CPI 115690 | 2 | 1 | 2 | 1 | 0 |
| *Cratylia argentea* CIAT 18516 | 0 | - | - | - | - |
| *Desmodium cinerea* CPI 46562 | 2 | 1 | 2 | 1 | 4 |
| *Flemingia macrophylla* CIAT 17403 | 4 | 4 | 4 | 2 | 1 |
| *Gliricidia sepium* 'Belen Rivas' | 4 | 4 | 4 | 1 | 0 |
| *G. sepium* 'Monterrico' | 4 | 1 | 3 | 1 | 0 |
| *G. sepium* 'Retalhuleu' | 4 | 1 | 3 | 1 | 0 |
| *Leucaena collinsii* QFI 152/88 | 4 | 1 | 3 | 1 | 0 |
| *L. leucocephala* K636 | 4 | 3 | 4 | 1 | 0 |

[1] Establishment success: 0=did not emerge, 1=poor, 2= moderate, 3=good, 4=excellent.
[2] Yield potential, persistence and seed production: 1=poor, 2=moderate, 3=good, 4=excellent.
[3] Pests/Diseases: 0=none, 1=little impact, 2=moderate impact, 3=severe impact, 4=plants killed.

**Appendix 6. Performance of forage species at SPK Saree, Aceh.**

| | Establishment success[1] | Yield Potential[2] | Persistence[2] | Seed Production[2] | Pests/ Diseases[3] |
|---|---|---|---|---|---|
| **Grasses** | | | | | |
| *Andropogon gayanus* CIAT 621 | 0 | - | - | - | - |
| *Brachiaria brizantha* CIAT 26110 | 3 | 3 | 4 | 1 | 0 |
| *B. decumbens* cv. Basilisk | 3 | 4 | 4 | 1 | 0 |
| *B. humidicola* CIAT 6133 | 3 | 3 | 4 | 1 | 0 |
| *B. humidicola* cv. Tully | 3 | 3 | 4 | 1 | 0 |
| *Panicum maximum* CIAT 6299 | 4 | 4 | 4 | 2 | 0 |
| *Paspalum atratum* BRA 9610 | 3 | 4 | 3 | 1 | 0 |
| **Legumes** | | | | | |
| *Arachis pintoi* CIAT 22160 | 3 | 3 | 3 | 1 | 0 |
| *Centrosema pubescens* CIAT 15160 | 3 | 3 | 3 | 2 | 0 |
| *Desmodium heterophyllum* CIAT 349 | 3 | 3 | 3 | 1 | 0 |
| *Stylosanthes guianensis* CIAT 184 | 3 | 3 | 3 | 3 | 0 |
| *S. hamata* cv. Verano | 3 | 3 | 3 | 3 | 0 |
| *S. scabra* cv. Siran | 2 | 3 | 3 | 2 | 0 |
| **Trees and shrubs** | | | | | |
| *Desmodium cinerea* CPI 46562 | 4 | 4 | 4 | 3 | 0 |
| *Gliricidia sepium* 'Belen Rivas' | 4 | 4 | 4 | - | 0 |
| *G. sepium* 'local' | 2 | 2 | 3 | - | 0 |
| *G. sepium* Monterrico' | 4 | 4 | 4 | - | 0 |
| *G. sepium* ,Retalhuleu' | 4 | 4 | 4 | - | 0 |
| *Leucaena leucocephala* K636 | 2 | 4 | 4 | 2 | 1 |
| *L. leucocephala* 'local' | 2 | 2 | 2 | 2 | 1 |

[1] Establishment success: 0=did not emerge, 1=poor, 2= moderate, 3=good, 4=excellent.
[2] Yield potential, persistence and seed production: 1=poor, 2=moderate, 3=good, 4=excellent.
[3] Pests/Diseases: 0=none, 1=little impact, 2=moderate impact, 3=severe impact, 4=plants killed.

**Appendix 7. Performance of forage species at Blang Ubo-ubo, Saree, Aceh.**

| | Establishment success[1] | Yield Potential[2] | Persistence[2] | Seed Production[2] | Pests/ Diseases[3] |
|---|---|---|---|---|---|
| **Grasses** | | | | | |
| *Andropogon gayanus* CIAT 621 | 0 | - | - | - | - |
| *Brachiaria brizantha* CIAT 26110 | 3 | 3 | 4 | 1 | 0 |
| *B. decumbens* cv. Basilisk | 3 | 4 | 4 | 1 | 0 |
| *B. humidicola* CIAT 6133 | 1 | 3 | 4 | 1 | 0 |
| *B. humidicola* cv. Tully | 3 | 4 | 4 | 1 | 0 |
| *Panicum maximum* CIAT 6299 | 4 | 4 | 4 | 2 | 0 |
| *Paspalum atratum* BRA 9610 | 3 | 4 | 3 | 1 | 0 |
| **Legumes** | | | | | |
| *Centrosema* 'mixture' | 3 | 3 | 3 | 2 | 0 |
| *Stylosanthes guianensis* CIAT 184 | 3 | 3 | 3 | 3 | 0 |
| *S. hamata* cv. Verano | 3 | 3 | 3 | 3 | 0 |
| *S. scabra* cv. Siran | 2 | 3 | 3 | 2 | 0 |
| **Trees and shrubs** | | | | | |
| *Calliandra calothyrsus* | 3 | 3 | 3 | 2 | 0 |
| *Desmodium cinerea* CPI 46562 | 4 | 4 | 4 | 3 | 0 |
| *Gliricidia sepium* 'Belen Rivas' | 4 | 4 | 4 | - | 0 |
| *G. sepium* 'local' | 2 | 2 | 3 | - | 0 |
| *G. sepium* 'Monterrico' | 4 | 4 | 4 | - | 0 |
| *G. sepium* 'Retalhuleu' | 4 | 4 | 4 | - | 0 |
| *Leucaena leucocephala* K636 | 2 | 4 | 4 | 2 | 0 |
| *L. leucocephala* 'local' | 2 | 2 | 2 | 2 | 1 |

[1] Establishment success: 0=did not emerge, 1=poor, 2= moderate, 3=good, 4=excellent.
[2] Yield potential, persistence and seed production: 1=poor, 2=moderate, 3=good, 4=excellent.
[3] Pests/Diseases: 0=none, 1=little impact, 2=moderate impact, 3=severe impact, 4=plants killed.

# Environmental adaptation of forages in Vietnam

Le Hoa Binh[1], Truong Tan Khanh[2] and Le Van An[3]

The land area of Vietnam is relatively small (33.6 million ha) with a large population (75 million people). Steep hills and mountains cover two-thirds of the country. The average agricultural landholding per capita is only 0.1 ha. Population growth rate is more than 2% per year. As a result, land under cultivation for food and industrial crops is expanding at a fast rate while grassland and forests, which are the traditional resources for grazing, are shrinking.

The Vietnamese Government aims to change the structure of agricultural production and actively promote livestock production. To address the problem of diminishing feed resources for livestock, studies to identify new, adapted forage species are being conducted in collaboration with the Forages for Smallholders Project (FSP). Farmers normally prefer forage species which are productive, are easy to propagate, and are adapted to a wide range of environments and farming systems. This paper presents the results of forage evaluations conducted at three sites in Vietnam.

## Site descriptions

Forages were evaluated at Ba Vi (Ha Tay province), FRC (Phu To), Xuan Loc (Hue) and M'Drak, (Daklak). A brief site description is provided in Table 1. Actual rainfall and air temperature data are attached in the Appendix 1.

## Results

A total of 101 forage species were included in the nursery evaluations. This consisted of 63 legumes, 31 grasses and 7 tree legumes. The number of species evaluated at each site is presented in Table 2. The complete list of species tested at each site is attached in the Appendix 2.

**Table 1. Physical characteristics of sites for nursery evaluation.**

| Site | Latitude | Altitude (m) | Annual rainfall (mm) | Wet season | Number of wet months (>50mm) | Soil characteristics | Farming systems |
|---|---|---|---|---|---|---|---|
| Ba Vi (Ha Tay) | 21°N | 50 | 1840 | Apr – Nov | 8 | pH (KCl) 5.5-5.7, light loam, moderately fertile, well drained | Forestry in highland, industrial and other crops, home gardens, irrigated rice and livestock. |
| FRC (Phu Tho) | 21° N | 40 | 1850 | Apr – Nov | 8 | pH (KC): 3.8-4.0, light loam, moderate drainage, poor soil | Forestry and upland crops, lowland rice and livestock. |
| Xuan Loc (Hue) | 16°N | 150 | 2300 | Jul - Feb | 8 | pH (1:5 water) 5.0-5.5, Sandy loam soil, light to medium texture and well drained | Slash-and-burn cultivation on steep hills, irrigated rice, home gardens, livestock. |
| M'Drak (Daklak) | 12°N | 550 | 1895 | Apr - Nov | 8 | pH(1:5 water):5, sandy loam, well drained, moderately fertile but P deficient | Shifting cultivation on steep hills, home gardens and lowland rice in the valleys. |

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**Table 2. Number of forage varieties evaluated at each site.**

| | Ba Vi | M'Drak | Xuan Loc | FRC |
|---|---|---|---|---|
| Grasses | 20 | 22 | 21 | 24 |
| Herbaceous legumes | 49 | 49 | 28 | 18 |
| Tree legumes | 0 | 4 | 4 | 0 |
| Total | 69 | 75 | 53 | 42 |

A list of the best-adapted species at each site is presented in Table 3. Of the species evaluated in the study, some proved to be broadly adapted. These were *Brachiaria brizantha*, *Panicum maximum*, *Stylosanthes guianensis* CIAT 184, and *Flemingia macrophylla*. These species produced not only a lot of green leaf but also had good seed production potential.

Some species performed well only at some sites – *Paspalum atratum* at Hue, *Brachiaria ruziziensis* at Hue and Phu Tho, *Brachiaria humidicola* at M'Drak, and *Andropogon gayanus* at M'Drak and Ba Vi.

The performance of all forage accessions evaluated at Ba Vi, Hue and Xuan Loc is detailed in Appendices 4 to 6.

**Table 3. List of best species at the four nursery sites.**

| Species | Ba Vi (Hatay) | M'Drak (Dak Lak) | Xuan Loc (Hue) | FRC (Phu Tho) |
|---|---|---|---|---|
| **Grasses** | | | | |
| *Brachiaria decumbens* cv. Basilisk | ✔ | ✔ | - | - |
| *B. brizantha* CIAT 6780 | ✔ | ✔ | ✔ | ✔ |
| *Andropogon gayanus* cv. Kent | ✔ | ✔ | - | - |
| *Panicum maximum* TD58 | ✔ | ✔ | ✔ | ✔ |
| *Brachiaria humidicola* (several varieties) | - | ✔ | - | - |
| *Brachiaria ruziziensis* ex. Thailand | - | - | ✔ | ✔ |
| *Paspalum atratum* BRA 9610 | - | - | ✔ | - |
| **Legumes** | | | | |
| *Stylosanthes guianensis* CIAT 184 | ✔ | ✔ | ✔ | ✔ |
| *Stylosanthes guianensis* FM 05-2 | - | ✔ | - | ✔ |
| *Stylosanthes hamata* cv. Verano | - | - | ✔ | ✔ |
| *Aeschynomene histrix* CIAT 9690 | ✔ | - | - | ✔ |
| *Centrosema pubescens* CIAT 15160 | - | - | - | ✔ |
| **Tree legumes** | | | | |
| *Gliricidia sepium* | - | ✔ | ✔ | - |
| *Flemingia macrophylla* | - | ✔ | ✔ | ✔ |

## Conclusions and recommendations

There is a range broadly adapted species which can be used for on-farm evaluations. These include Brachiaria species, Panicum maximum, and Stylosanthes guianensis. The lack of broadly adapted legumes suggests that we need to do more work on tree legumes for living fences, erosion control, soil improvement, and weed suppression.

We need to continue to evaluate new species for particular niches (such as Setaria sphacelata cv. Solander for the cooler northern regions). We need to organize training courses on forage agronomy and management for farmers.

## Acknowledgements

The authors thank CIAT and CSIRO for supporting this work through the FSP. We also acknowledge the strong contribution and cooperation of the different institutions and agencies in Vietnam, including the National Institute of Animal Husbandry, the Tay Nguyen University, the Hue University of Agriculture and Forestry, the College of Agriculture and Forestry Ho Chi Minh City, and the Vietnam-Sweden Mountain Region Development Program.

# Appendices

**Appendix 1. Climatic data for the period of nursery evaluation at each site.**

| | | | Month | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Year | J | F | M | A | M | J | J | A | S | O | N | D | Total |
| Ba Vi (Ha Tay) | Rainfall (mm) | 1996 | 10 | 14 | 130 | 49 | 169 | 309 | 620 | 451 | 133 | 157 | 287 | 5 | 2332 |
| | | 1997 | 30 | 15 | 157 | 188 | 89 | 258 | 602 | 438 | 99 | 256 | 10 | 17 | 2156 |
| | Number of rain days | 1996 | 14 | 5 | 20 | 22 | 16 | 22 | 19 | 16 | 13 | 6 | 13 | 3 | 169 |
| | | 1997 | 08 | 13 | 19 | 14 | 11 | 12 | 21 | 17 | 15 | 12 | 03 | 08 | 153 |
| | Mean max. temp ($^{o}$C) | 1996 | 26 | 29 | 39 | 32 | 40 | 37 | 38 | 36 | 34 | 34 | 30 | 27 | |
| | | 1997 | 28 | 26 | 28 | 31 | 37 | 40 | 36 | 38 | 35 | 33 | 35 | 29 | |
| | Mean min. temp ($^{o}$C) | 1996 | 5 | 6 | 12 | 13 | 20 | 23 | 23 | 22 | 21 | 16 | 14 | 10 | |
| | | 1997 | 10 | 11 | 16 | 17 | 22 | 24 | 24 | 22 | 18 | 17 | 14 | 11 | |
| FRC (Phu Tho) | Rainfall (mm) | 1996 | 27 | 13 | 126 | 89 | 280 | 389 | 335 | 474 | 79 | 98 | 161 | 13 | 1781 |
| | | 1997 | 24 | 34 | 167 | 170 | 104 | 142 | 380 | 289 | 121 | 178 | 61 | -[1] | 1670[2] |
| | Number of rain days | 1996 | 12 | 10 | 17 | 22 | 17 | 18 | 20 | 16 | 13 | 7 | 11 | 8 | 171 |
| | | 1997 | 12 | 16 | 21 | 16 | 8 | 15 | 24 | 14 | 14 | 13 | 3 | - | 156[2] |
| | Mean max. temp ($^{o}$C) | 1996 | 26 | 29 | 32 | 32 | 38 | 36 | 37 | 36 | 34 | 33 | 29 | 27 | |
| | | 1997 | 27 | 26 | 28 | 32 | 36 | 40 | 34 | 37 | 34 | 33 | 33 | - | |
| | Mean min. temp ($^{o}$C) | 1996 | 7 | 6 | 12 | 13 | 20 | 22 | 24 | 23 | 22 | 18 | 16 | 11 | |
| | | 1997 | 10 | 12 | 16 | 18 | 22 | 23 | 24 | 23 | 17 | 18 | 15 | - | |
| Xuan Loc (Hue) | Rainfall (mm) | 1996 | 29 | 137 | 9 | 73 | 120 | 9 | 51 | 66 | 66 | 760 | 824 | 363 | 2507 |
| | | 1997 | 51 | 80 | 38 | 90 | 118 | 17.1 | 63 | 151 | 559 | 726 | - | - | 1892[2] |
| | Number of rain days | 1996 | 11 | 20 | 6 | 8 | 12 | 17 | 8 | 10 | 23 | 24 | 25 | 23 | 177 |
| | | 1997 | 11 | 18 | 7 | 18 | 13 | 4 | 11 | 8 | 18 | 16 | - | - | 124[2] |
| | Mean max. temp ($^{o}$C) | 1996 | 29 | 33 | 37 | 39 | 36 | 38 | 38 | 38 | 34 | 34 | 31 | 28 | |
| | | 1997 | 30 | 28 | 35 | 36 | 38 | 38 | 39 | 38 | 37 | 34 | - | - | |
| | Mean min. temp ($^{o}$C) | 1996 | 11 | 12 | 15 | 17 | 23 | 23 | 23 | 23 | 22 | 21 | 18 | 14 | |
| | | 1997 | 12 | 15 | 15 | 20 | 22 | 23 | 24 | 24 | 20 | 21 | - | - | |
| M'Drak (Daklak) | Rainfall (mm) | 1996 | 24 | 53 | 4 | 93 | 160 | 122 | 95 | 109 | 357 | 605 | 1057 | 656 | 3334 |
| | | 1997 | 56 | 6 | 10 | 14 | 235 | 28 | 150 | 102 | 87 | 350 | 201 | 150 | 1389 |
| | Number of rain days | 1996 | 12 | 12 | 3 | 9 | 18 | 15 | 20 | 16 | 26 | 25 | 25 | 24 | 205 |
| | | 1997 | 7 | 7 | 3 | 9 | 15 | 9 | 15 | 16 | 19 | 19 | 15 | 13 | 147 |
| | Mean max. temp ($^{o}$C) | 1996 | 27 | 35 | 36 | 36 | 35 | 34 | 33 | 34 | 31 | 32 | 30 | 25 | |
| | | 1997 | 29 | 34 | 35 | 36 | 36 | 35 | 32 | 32 | 32 | 30 | 28 | 28 | |
| | Mean min. temp ($^{o}$C) | 1996 | 14 | 16 | 15 | 19 | 21 | 20 | 21 | 21 | 20 | 19 | 18 | 15 | |
| | | 1997 | 11 | 14 | 15 | 21 | 22 | 20 | 21 | 22 | 20 | 20 | 16 | 15 | |

[1] Data not yet available.
[2] Most recent data not yet included.

## Appendix 2. Forage varieties evaluated at each site.

| Species | M'Drak (Daklak) | Xuan Loc (Hue) | FRC (Phu Tho) | Ba Vi (Ha Tay) |
|---|---|---|---|---|
| **Legumes** | | | | |
| *Aeschynomene americana* CPI 93667 | ✔ | - | - | ✔ |
| *Aeschynomene americana* cv. Glenn | ✔ | ✔ | - | ✔ |
| *Aeschynomene americana* cv. Lee | ✔ | ✔ | - | ✔ |
| *Aeschynomene brasiliana* CIAT 8628 | ✔ | - | - | ✔ |
| *Aeschynomene histrix* CIAT 9690 | ✔ | ✔ | ✔ | ✔ |
| *Aeschynomene histrix* CPI 93595 | ✔ | ✔ | ✔ | ✔ |
| *Aeschynomene villosa* CPI 91209 | ✔ | - | - | ✔ |
| *Aeschynomene villosa* CPI 93621 | ✔ | - | - | ✔ |
| *Alysicarpus rugosus* CPI 30034 | ✔ | - | - | ✔ |
| *Alysicarpus rugosus* CPI 52348 | ✔ | - | - | ✔ |
| *Alysicarpus vaginalis* CPI 100856 | ✔ | - | - | ✔ |
| *Arachis pintoi* CIAT 17434 | ✔ | ✔ | ✔ | ✔ |
| *Arachis pintoi* CIAT 18744 | ✔ | - | - | ✔ |
| *Arachis pintoi* CIAT 18748 | ✔ | - | - | ✔ |
| *Arachis pintoi* CIAT 18750 | ✔ | - | - | ✔ |
| *Arachis pintoi* CIAT 22160 | - | ✔ | ✔ | - |
| *Calopogonium mucunoides* CIAT 7722 | ✔ | - | - | - |
| *Centrosema acutifolium* CIAT 5277 | ✔ | ✔ | ✔ | ✔ |
| *Centrosema brasilianum* CPI 55698 | ✔ | ✔ | ✔ | ✔ |
| *Centrosema macrocarpum* CIAT 15014 | ✔ | - | - | ✔ |
| *Centrosema macrocarpum* CIAT 25522 | - | ✔ | ✔ | - |
| *Centrosema pascuorum* cv. Cavalcade | - | ✔ | ✔ | ✔ |
| *Centrosema plumieri* CPI 58657 | ✔ | - | - | ✔ |
| *Centrosema pubescens* CIAT 15160 | ✔ | ✔ | ✔ | ✔ |
| *Centrosema pubescens* CIAT 438 | ✔ | - | - | ✔ |
| *Centrosema pubescens* cv. Cardillo | - | ✔ | ✔ | - |
| *Chamaecrista rotundifolia* CPI 86172 | ✔ | - | - | ✔ |
| *Chamaecrista rotundifolia* cv. Wynn | ✔ | - | - | ✔ |
| *Chamaecrista rotundifolia* Q 10067 | ✔ | - | - | ✔ |
| *Clitoria ternatea* CIAT 772 | ✔ | - | - | ✔ |
| *Clitoria ternatea* cv. Milgarra | ✔ | ✔ | - | ✔ |
| *Desmanthus virgatus* cv. Bayamo | ✔ | ✔ | - | ✔ |
| *Desmanthus virgatus* cv. Marc | ✔ | ✔ | - | ✔ |
| *Desmanthus virgatus* ex. Thailand (CPI 52401) | - | ✔ | - | - |
| *Desmodium distortum* CPI 38568 | ✔ | - | - | - |
| *Desmodium heterocarpon* CPI 86277 | ✔ | - | - | ✔ |
| *Desmodium heterophyllum* CIAT 394 | ✔ | - | ✔ | ✔ |
| *Desmodium ovalifolium* CIAT 13089 | ✔ | - | - | ✔ |
| *Desmodium ovalifolium* CIAT 3666 | ✔ | - | - | ✔ |
| *Desmodium sericophyllum* CPI 91147 | ✔ | | | |
| *Desmodium subsericeum* CPI 78402 | ✔ | - | - | ✔ |
| *Macroptilium atropurpureum* CPI 90844 | ✔ | ✔ | ✔ | ✔ |
| *Macroptilium atropurpureum* cv. Aztec | ✔ | ✔ | ✔ | ✔ |
| *Macroptilium bracteatum* CPI 27404 | - | ✔ | ✔ | ✔ |
| *Macroptilium gracile* cv. Maldonado | - | ✔ | - | ✔ |
| *Macrotyloma daltonii* CPI 6030 | - | - | - | ✔ |
| *Stylosanthes scabra* cv. Seca | - | ✔ | ✔ | - |
| *Stylosanthes scabra* cv. Siran | - | ✔ | ✔ | - |
| *Vigna oblongifolia* CPI 121699 | - | - | - | ✔ |
| *Vigna parkeri* cv. Shaw | - | ✔ | ✔ | - |
| *Vigna trilobata* CPI 13671 | - | - | - | ✔ |

**(continued next page)**

**Appendix 2 (cont.). Forage varieties evaluated at each site.**

| Species | M'Drak (Daklak) | Xuan Loc (Hue) | FRC (Phu Tho) | Ba Vi (Ha Tay) |
|---|---|---|---|---|
| *Macroptilium gracile* CPI 33498 | ✔ | ✔ | - | ✔ |
| *Macroptilium gracile* CPI 91094 | ✔ | - | - | ✔ |
| *Macroptilium gracile* CPI 91340 | ✔ | - | - | ✔ |
| *Stylosanthes guianensis* CIAT 184 | ✔ | ✔ | ✔ | ✔ |
| *Stylosanthes guianensis* FM05-2 | ✔ | ✔ | ✔ | ✔ |
| *Stylosanthes hamata* cv. Amiga | ✔ | - | - | ✔ |
| *Stylosanthes hamata* cv. Verano | ✔ | ✔ | ✔ | ✔ |
| *Stylosanthes mexicana* CPI 87484 | ✔ | - | - | - |
| *Teramnus uncinatum* CIAT 7315 | ✔ | - | - | ✔ |
| *Vigna decipiens* CPI 73602 | ✔ | - | - | ✔ |
| *Zornia latifolia* CIAT 728 | ✔ | ✔ | ✔ | ✔ |
| **Grasses** | | | | |
| *Andropogon gayanus* cv. Kent | ✔ | ✔ | ✔ | ✔ |
| *Bothriochloa insculpta* cv. Bisset | ✔ | - | - | ✔ |
| *Bothriochloa pertusa* cv. Dawson | ✔ | - | - | ✔ |
| *Brachiaria brizantha* CIAT 16318 | ✔ | ✔ | ✔ | ✔ |
| *Brachiaria brizantha* CIAT 16827 | - | ✔ | ✔ | - |
| *Brachiaria brizantha* CIAT 16835 | - | ✔ | ✔ | - |
| *Brachiaria brizantha* CIAT 26110 | - | ✔ | ✔ | - |
| *Brachiaria brizantha* CIAT 6387 | - | ✔ | ✔ | - |
| *Brachiaria brizantha* CIAT 6780 | ✔ | ✔ | ✔ | ✔ |
| *Brachiaria decumbens* cv. Basilisk | ✔ | ✔ | ✔ | ✔ |
| *Brachiaria humidicola* CIAT 16886 | ✔ | - | - | ✔ |
| *Brachiaria humidicola* CIAT 26144 | - | ✔ | ✔ | - |
| *Brachiaria humidicola* CIAT 6133 | ✔ | ✔ | - | ✔ |
| *Brachiaria humidicola* cv. Tully | ✔ | ✔ | ✔ | ✔ |
| *Brachiaria ruziziensis* ex. Thailand | ✔ | ✔ | ✔ | ✔ |
| *Cenchrus ciliaris* cv. Biloela | ✔ | - | - | ✔ |
| *Dichanthium aristatum* cv. Floren | ✔ | - | - | ✔ |
| *Digitaria milanjiana* CPI 40700 | ✔ | - | - | ✔ |
| *Digitaria milanjiana* CPI 41192 | ✔ | - | - | ✔ |
| *Digitaria milanjiana* cv. Jarra | ✔ | - | - | ✔ |
| *Panicum maximum* CIAT 6299 | ✔ | ✔ | ✔ | ✔ |
| *Panicum maximum* TD 58 | - | ✔ | ✔ | - |
| *Paspalum atratum* BRA 9610 | ✔ | ✔ | ✔ | ✔ |
| *Paspalum guenoarum* BRA 3824 | ✔ | ✔ | ✔ | ✔ |
| *Paspalum nicorea* CPI 37526 | ✔ | - | - | - |
| *Paspalum notatum* cv. Competidor | ✔ | - | - | ✔ |
| *Urochloa mosambicensis* CP 46876 | - | ✔ | - | - |
| *Urochloa mosambicensis* CPI 60128 | - | ✔ | ✔ | - |
| *Urochloa mosambicensis* CPI 60147 | - | ✔ | - | - |
| *Urochloa mosambicensis* Nixon | ✔ | ✔ | ✔ | ✔ |
| *Urochloa stolonifera* CPI 60128 | ✔ | - | - | ✔ |
| **Tree and shrub legumes** | | | | |
| *Calliandra calothyrsus* CPI 115690 | - | ✔ | - | - |
| *Flemingia macrophylla* CIAT 17403 | ✔ | ✔ | ✔ | ✔ |
| *Gliricidia sepium* ex. Costa Rica | ✔ | - | - | - |
| *Gliricidia sepium* OFI 124/91 | - | ✔ | - | - |
| *Gliricidia sepium* OFI 82/94 | - | ✔ | - | - |
| *Leucaena leucocephala* K636 | ✔ | ✔ | - | - |
| *Zapoteca tetragona* ex. Indonesia | ✔ | - | - | - |

## Appendix 3. Results of nursery evaluation at Ba Vi, Ha Tay Province.

| Species | Establish-ment | Yield | Persist-ence | Seed production | Pest/ disease damage |
|---|---|---|---|---|---|
| **Grasses** | | | | | |
| *Andropogon gayanus* cv. Kent | 1 | 4 | 4 | 2 | 0 |
| *Bothriochloa insculpta* Bisset | 1 | 1 | 2 | 1 | 0 |
| *Bothriochloa pertusa* cv. Dawson | 1 | 1 | - | 2 | 0 |
| *Brachiaria brizantha* CIAT 16318 | 1 | 3 | 4 | 3 | 0 |
| *Brachiaria brizantha* CIAT 6780 | 2 | 4 | 4 | 3 | 0 |
| *Brachiaria decumbens* CIAT 606 | 1 | 3 | 3 | 3 | 0 |
| *Brachiaria humidicola* CIAT 16886 | 1 | 2 | 3 | 3 | 0 |
| *Brachiaria humidicola* CIAT 6133 | 1 | 2 | 4 | 3 | 0 |
| *Brachiaria humidicola* CIAT 679 (Tully) | 1 | 2 | 4 | 3 | 0 |
| *Cenchrus ciliaris* cv. Biloela | 1 | 1 | - | 3 | 0 |
| *Dichanthium aristatum* cv. Floren | 1 | 1 | - | 1 | 0 |
| *Digitaria milanjiana* CPI 40700 | 1 | 2 | - | 3 | 0 |
| *Digitaria milanjiana* CPI 41192 | 1 | 2 | 1 | 2 | 0 |
| *Digitaria milanjiana* cv. Jarra | 2 | 2 | 1 | 3 | 0 |
| *Panicum maximum* CIAT 6299 | 1 | 4 | 4 | 3 | 0 |
| *Paspalum atratum* BRA 9610 | 4 | 4 | 1 | 2 | 0 |
| *Paspalum guenoarum* BRA 3824 | 2 | 3 | 1 | 3 | 0 |
| *Paspalum notatum* cv. Competidor | 2 | 1 | 1 | - | 0 |
| *Urochloa mosambicensis* cv. Nixon | 1 | 1 | 2 | 3 | 0 |
| *Urochloa stolonifera* CPI 60128 | - | - | - | - | - |
| **Legumes** | | | | | |
| *Aeschynomene americana* cv. Glenn | 1 | 2 | 1 | 3 | 1 |
| *Aeschynomene americana* cv. Lee | 2 | 2 | 1 | 3 | 1 |
| *Aeschynomene americana* 93667 | 2 | 2 | 1 | 3 | 1 |
| *Aeschynomene brasiliana* CIAT 8628 | 3 | 3 | 2 | 3 | 0 |
| *Aeschynomene histrix* CIAT 9690 | 2 | 4 | 3 | 3 | 0 |
| *Aeschynomene histrix* CPI 93595 | 1 | 2 | 2 | 3 | 0 |
| *Aeschynomene villosa* CPI 91209 | 1 | 1 | - | 3 | 0 |
| *Aeschynomene Villosa* CPI 93621 | 2 | 1 | - | 2 | 0 |
| *Alysicarpus rugosus* CPI 52348 | 1 | 1 | - | 2 | 2 |
| *Alysicarpus monilepher* CPI 52343 | 1 | 1 | - | 2 | 2 |
| *Alysicarpus vaginalis* CPI 100856 | 2 | 1 | - | 1 | 0 |
| *Arachis pintoi* CIAT 17434 | 1 | 1 | 4 | 1 | 0 |
| *Arachis pintoi* CIAT 18744 | 1 | 1 | 1 | 2 | 0 |
| *Arachis pintoi* CIAT 18748 | - | - | - | - | - |
| *Arachis pintoi* CIAT 18750 | 1 | 1 | 1 | 1 | 0 |
| *Centrosema acutifolium* CIAT 5277 | 1 | 1 | - | 2 | 1 |
| *Centrosema brasilianum* CPI 55698 | 2 | 2 | 1 | 3 | 0 |
| *Centrosema macrocarpum* CIAT 15014 | 1 | 1 | 2 | 1 | 0 |
| *Centrosema pascuorum* cv. Cavalcade | 2 | 2 | - | 3 | 1 |
| *Centrosema plumieri* CPI 58567 | 1 | 1 | - | 2 | 1 |
| *Centrosema pubescens* CIAT 438 | 3 | 1 | 3 | 2 | 1 |
| *Centrosema pubescens* CIAT 15160 | 1 | 1 | 4 | 3 | 1 |
| *Chamaecrista rotundifolia* CPI 86172 | 1 | 2 | 4 | 3 | 0 |
| *Chamaecrista rotundifolia* cv. Wynn | 1 | 2 | 4 | 3 | 0 |
| *Chamaecrista rotundifolia* Q10057 | 1 | 1 | - | - | 0 |
| *Clitoria ternatea* CIAT 772 | 1 | 1 | - | 3 | 1 |
| *Clitoria ternatea* cv. Milgarra | 1 | 1 | - | 2 | 1 |
| *Desmodium heterocarpon* CPI 86277 | 2 | 1 | - | 2 | 1 |
| *Desmodium heterophyllum* CIAT 349 | 2 | 1 | - | - | 1 |

**(continued next page)**

**Appendix 3 (cont.). Results of nursery evaluation at Ba Vi, Ha Tay Province.**

| Species | Establish-ment | Yield | Persist-ence | Seed production | Pest/ disease damage |
|---|---|---|---|---|---|
| *Desmodium ovalifolium* CIAT 13089 | 3 | 1 | 2 | 1 | 1 |
| *Desmodium ovalifolium* CIAT 3666 | 3 | 1 | - | 1 | 1 |
| *Desmodium subsericeum* CPI 78402 | - | - | - | - | - |
| *Macroptilium atropurpureum* cv. Aztec | 2 | 2 | 1 | 3 | 1 |
| *Macroptilium atropurpureum* CPI 90844 | 1 | 1 | 1 | 1 | 2 |
| *Macroptilium bracteatum* CPI 27404 | - | - | - | - | - |
| *Macroptilium gracile* CPI 33498 | 1 | 2 | - | 2 | 1 |
| *Macroptilium gracile* CPI 91094 | 1 | 1 | - | - | 2 |
| *Macroptilium gracile* CPI 91340 | 2 | 1 | - | - | 2 |
| *Macroptilium gracile* cv. Maldonado | 2 | 2 | - | 2 | 1 |
| *Macrotyloma daltonii* CPI 60303 | 1 | 1 | - | - | 2 |
| *Stylosanthes guianensis* CIAT 184 | 4 | 4 | 2 | 2 | 0 |
| *Stylosanthes guianensis* FM 05-2 | 4 | 3 | 2 | 2 | 1 |
| *Stylosanthes hamata* cv. Amiga | 2 | 3 | - | 3 | 0 |
| *Stylosanthes hamata* cv. Verano | 1 | 2 | - | 3 | 0 |
| *Teramnus uncinatum* CIAT 7315 | 1 | 1 | - | - | 1 |
| *Vigna decipiens* CPI 73602 | 2 | 1 | - | 3 | 0 |
| *Vigna oblongifolia* CPI 121699 | 1 | 1 | - | - | 2 |
| *Vigna trilobata* CPI 13671 | - | - | - | - | - |
| *Zornia latifolia* CIAT 728 | 1 | 1 | 3 | 2 | 0 |

Establishment success: 0=did not emerge, 1=poor, 2=moderate, 3=good, 4=excellent.
Yield potential, persistence, and seed production: 1=poor, 2=moderate, 3=good, 4=excellent.
Pests/diseases: 0= none, 1=little impact, 2=moderate impact, 3=severe impact, 4=plants killed.

## Appendix 4. Results of nursery evaluation at Xuan Loc, Hue Province.

| Species | Establish-ment | Yield | Persist-ence | Pest / disease damage |
|---|---|---|---|---|
| **Grasses** | | | | |
| *Andropogon gayanus* CIAT 621 | 0 | - | - | - |
| *Brachiaria brizantha* CIAT 16318 | 0 | - | - | - |
| *Brachiaria brizantha* CIAT 6387 | 3 | 3 | 3 | 4 |
| *Brachiaria brizantha* CIAT 678044 | 4 | 4 | 4 | 4 |
| *Brachiaria brizantha* CIAT 26110 | 4 | 4 | 4 | 4 |
| *Brachiaria brizantha* CIAT 16835 | 3 | 3 | 3 | 4 |
| *Brachiaria brizantha* CIAT 16827 | 4 | 4 | 4 | 4 |
| *Brachiaria decumbens* cv. Basilisk | 4 | 3 | 3 | 4 |
| *Brachiaria humidicola* cv. Tully | 0 | - | - | - |
| *Brachiaria humidicola* CIAT 6133 | 0 | - | - | - |
| *Brachiaria humidicola* CIAT 26149 | 0 | - | - | - |
| *Brachiaria ruziziensis* ex. Thailand | 4 | 4 | 3 | 4 |
| *Desmanthus virgatus* ex. Thailand (CPI 52401) | 0 | - | - | - |
| *Panicum maximum* TD58 | 4 | 4 | 4 | 4 |
| *Panicum maximum* CIAT 6299 | 4 | 4 | 4 | 4 |
| *Paspalum atratum* BRA 9610 | 4 | 4 | 4 | 4 |
| *Paspalum guenoarum* BRA 3824 | 3 | 1 | 2 | 4 |
| *Urochloa mosambicensis* CPI 46876 | 2 | 1 | 2 | 4 |
| *Urochloa mosambicensis* CPI 60128 | 0 | - | - | - |
| *Urochloa mosambicensis* CPI 60147 | 1 | 1 | 1 | 4 |
| *Urochloa mosambicensis* cv. Nixon | 1 | 1 | 1 | 4 |
| **Legumes** | | | | |
| *Aeschynomene histrix* CIAT 9690 | 2 | 2 | 4 | 4 |
| *Aeschynomene americana* cv. Lee | 1 | 1 | 3 | 4 |
| *Aeschynomene americana* cv. Glenn | 0 | - | - | - |
| *Aeschynomene histrix* CPI 93595 | 3 | 3 | 3 | 4 |
| *Arachis pintoi* CIAT 22160 | 3 | 2 | 4 | 4 |
| *Arachis pintoi* cv. Amarillo | 0 | - | - | - |
| *Centrosema acutifolium* CIAT 5277 | 1 | 1 | 3 | 2 |
| *Centrosema brasilianum* CPI 55698 | 2 | 2 | 3 | 2 |
| *Centrosema macrocarpum* CIAT 25522 | 1 | 1 | 2 | 2 |
| *Centrosema pubescens* CIAT 15160 | 2 | 2 | 3 | 2 |
| *Centrosema pascuorum* cv. Cavalcade | 1 | 1 | 2 | 2 |
| *Centrosema pubescens* cv. Cardillo | 1 | 2 | 2 | 2 |
| *Clitoria ternatea* cv. Milgarra | 1 | 1 | 2 | 4 |
| *Desmanthus virgatus* cv. Marc | 0 | - | - | - |
| *Desmanthus virgatus* cv. Bayamo | 0 | - | - | 4 |
| *Macroptilium atropurpureum* CPI 90844 | 3 | 2 | 2 | 4 |
| *Macroptilium atropurpureum* cv. Aztec | 1 | 3 | 2 | 3 |
| *Macroptilium bracteatum* CPI 27404 | 3 | 3 | 2 | 3 |
| *Macroptilium gracile* CPI 33498 | 1 | 2 | 2 | 3 |
| *Macroptilium gracile* cv. Maldonado | 2 | 3 | 3 | 3 |
| *Stylosanthes guianensis* CIAT 184 | 4 | 4 | 4 | 4 |
| *Stylosanthes guianensis* FM05-1 | 3 | 3 | 4 | 4 |
| *Stylosanthes hamata* cv. Verano | 3 | 3 | 3 | 4 |
| *Stylosanthes scabra* cv. Siran | 3 | 2 | 3 | 4 |
| *Stylosanthes scabra* cv. Seca | 4 | 4 | 4 | 4 |
| *Vigna parkeri* cv. Shaw | 0 | - | - | - |
| *Zornia latifolia* CIAT 728 | 0 | - | - | - |
| **Tree legumes** | | | | |
| *Calliandra calothyrsus* CPI 115690 | 3 | 2 | 3 | 4 |
| *Gliricidia sepium* OFI 124/91 | 2 | 1 | 3 | 4 |
| *Gliricidia sepium* OFI 82/94 | 3 | 4 | 4 | 4 |
| *Flemingia macrophylla* CIAT 17403 | 4 | 4 | 4 | 4 |
| *Leucaena leucocephala* K636 | 1 | 1 | 2 | 2 |

Establishment success: 0=did not emerge, 1=poor, 2=moderate, 3=good, 4=excellent.
Yield potential, and persistence: 1=poor, 2=moderate, 3=good, 4=excellent.
Pests/diseases: 0= none, 1=little impact, 2=moderate impact, 3=severe impact, 4=plants killed.

**Appendix 5. Results of nursery evaluation at M'Drak, Daklak Province.**

| Species | Establish-ment | Yield potential | ersist-ence | Seed production | Pest-/-disease damage |
|---|---|---|---|---|---|
| **Legume species** | | | | | |
| *Aeschynomene americana* cv. Gienm | 1 | 1 | 1 | 2 | 2 |
| *Aeschynomene histrix* CIAT 9690 | 1 | 1 | 1 | 2 | 2 |
| *Aeschynomene histrix* CPI 93696 | 2 | 1 | 1 | 2 | 2 |
| *Arachis pintoi* CIAT 17434 | 3 | 2 | 3 | 2 | 0 |
| *Arachis pintoi* CIAT 18744 | 3 | 2 | 3 | 2 | 0 |
| *Arachis pintoi* CIAT 18748 | 3 | 2 | 3 | 2 | 0 |
| *Arachis pintoi* CIAT 18750 | 3 | 2 | 3 | 2 | 0 |
| *Centrosema plumieri* CPI 58567 | 3 | 2 | 1 | 2 | 2 |
| *Centrosema acutifolium* CIAT 2577 | 3 | 1 | 1 | 2 | 2 |
| *Centrosema macrocarpum* CIAT 15014 | 3 | 1 | 1 | 2 | 2 |
| *Centrosema pubescens* CIAT 438 | 3 | 1 | 1 | 1 | 2 |
| *Centrosema pubescens* CIAT 15160 | 3 | 1 | 1 | 1 | 2 |
| *Chamaecrista rotundifolia* cv. Wynn | 3 | 3 | 3 | 1 | 1 |
| *Chamaecrista rotundifolia* CPI 86172 | 2 | 2 | 2 | 3 | 1 |
| *Chamaecrista rotundifolia* Q10067 | 3 | 2 | 2 | 3 | 1 |
| *Desmanthus virgatus* cv. Marc | 3 | 2 | 2 | 2 | 2 |
| *Desmanthus virgatus* cv. Bayamo | 3 | 2 | 3 | 2 | 2 |
| *Desmodium distortum* CPI 38568 | 3 | 2 | 3 | 3 | 1 |
| *Desmodium heterocarpon* CPI 86277 | 3 | 2 | 3 | 3 | 1 |
| *Desmodium heterophyllum* CIAT 349 | 3 | 2 | 3 | 3 | 1 |
| *Desmodium ovalifolium* CIAT 3666 | 3 | 2 | 3 | 2 | 1 |
| *Desmodium ovalifolium* CIAT 13089 | 3 | 2 | 3 | 2 | 1 |
| *Desmodium sericophyllum* CPI 91147 | 3 | 2 | 3 | 2 | 2 |
| *Desmodium subsericeum* CPI 78402 | 3 | 2 | 2 | 2 | 2 |
| *Macroptilium atropurpureum* cv. Aztec | 4 | 2 | 1 | 3 | 2 |
| *Macroptilium atropurpureum* CPI 90844 | 4 | 2 | 1 | 3 | 2 |
| *Macroptilium gracile* cv. Maldonado | 2 | 1 | 1 | 2 | 3 |
| *Macroptilium gracile* CPI 33498 | 3 | 1 | 1 | 2 | 3 |
| *Macroptilium gracile* CPI 91094 | 3 | 1 | 1 | 2 | 3 |
| *Macroptilium gracile* CPI 91340 | 3 | 1 | 1 | 2 | 3 |
| *Stylosanthes guianensis* CIAT 184 | 4 | 4 | 4 | 4 | 1 |
| *Stylosanthes guianensis* FM05-2 | 4 | 4 | 4 | 3 | 1 |
| *Stylosanthes hamata* cv. Amiga | 2 | 2 | 2 | 3 | 2 |
| *Stylosanthes hamata* cv. Verano | 2 | 2 | 2 | 3 | 2 |
| *Stylosanthes mexicana* CPI 87484 | 1 | 1 | 1 | 1 | 3 |
| **Grasses** | | | | | |
| *Andropogon gayanus* CIAT 621 | 4 | 3 | 4 | 4 | 0 |
| *Brachiaria brizantha* CIAT 16318 | 3 | 4 | 4 | 3 | 0 |
| *Brachiaria brizantha* CIAT 6780 | 3 | 4 | 4 | 3 | 0 |
| *Brachiaria decumbens* CIAT 606 | 3 | 3 | 4 | 2 | 0 |
| *Brachiaria humidicola* CIAT 16886 | 2 | 2 | 4 | 1 | 0 |
| *Brachiaria humidicola* CIAT 679 | 2 | 3 | 4 | 1 | 0 |
| *Brachiaria humidicola* CIAT 6133 | 2 | 2 | 4 | 1 | 0 |
| *Brachiaria ruziziensis* ex. Thailand | 3 | 2 | 2 | 4 | 1 |
| *Panicum maximum* CIAT 6299 | 4 | 3 | 3 | 4 | 0 |
| *Paspalum atratum* BRA 9610 | 3 | 2 | 3 | 1 | 1 |
| *Paspalum guenoarum* BRA 3824 | 3 | 2 | 3 | 1 | 1 |
| *Paspalum nicorea* CPI 37526 | 2 | 2 | 1 | 1 | 1 |
| **Tree legumes** | | | | | |
| *Flemingia macrophylla* CIAT 17403 | 3 | 4 | 4 | 3 | 1 |
| *Gliricidia sepium* ex. Costa Rica | 4 | 3 | 4 | 2 | 1 |
| *Leucaena diversifolia* ex. Davao | 3 | 1 | 1 | 0 | 3 |
| *Leucaena leucocephala* CIAT 17263 | 3 | 1 | 1 | 0 | 3 |
| *Zapoteca tetragona* ex. Indonesia | 3 | 1 | 2 | 2 | 0 |

**(continued next page)**

**Appendix 5 (cont.). Results of nursery evaluation at M'Drak, Daklak Province.**

| Species | Establish-ment | Yield potential | ersist-ence | Seed production | Pest-/-disease damage |
|---|---|---|---|---|---|
| *Leucaena diversifolia* CPI 33820 | 2 | 1 | 1 | 0 | 3 |
| *Leucaena diversifolia* CPI 35134 | 3 | 1 | 1 | 0 | 3 |
| *Leucaena* hybrid ex. tropical America | 2 | 1 | 1 | 0 | 3 |
| *Leucaena leucocephala* CPI 61227 | 3 | 1 | 1 | 0 | 3 |
| *Leucaena leucocephala* CPI 64189 | 3 | 1 | 1 | 0 | 3 |
| *Leucaena leucocephala* cv. Cunningham | 3 | 1 | 1 | 0 | 3 |
| *Leucaena leucocephala* cv. Peru | 3 | 1 | 1 | 0 | 3 |
| *Leucaena leucocephala* K636 | 3 | 1 | 1 | 0 | 3 |
| *Leucaena pallida* CQ 3439 | 3 | 1 | 1 | 0 | 3 |

Establishment success: 0=did not emerge, 1=poor, 2=moderate, 3=good, 4=excellent.
Yield potential, persistence, and seed production: 1=poor, 2=moderate, 3=good, 4=excellent.
Pests/diseases: 0= none, 1=little impact, 2=moderate impact, 3=severe impact, 4=plants killed.

# Regional evaluation of forages in the Philippines

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In the Philippines, about 90% of the ruminant population belong to the backyard or smallholder sector (Lanting et al. 1995). In this sector, livestock production is a component of an intensive, mixed farming system (Horne, et al. 1997). Most of the smallholders are basically crop farmers; few are specialised livestock producers. Livestock are kept for draft and, at the same time, as source of cash income. Under this system, livestock accounts for more than half of the household income, representing a component that is maintained with minimal inputs and readily converted to cash in times of need.

Ruminants raised in smallholder systems are fed native vegetation and crop residues with minimal or no supplementation. Fattening is not commonly practiced. The major objective is reproduction, as more offspring means more sources of income and less risk. Animals are usually sold on a per head basis, with little incentive for well-fattened stock.

Most of the smallholder farmers in the Philippines have observed poor performance of their animals, which they attribute to insufficient quality and quantity of feed. This is associated with little feed in the dry season and limited area for grazing and has lead to overgrazing. In sloping areas, crop production has declined primarily due to soil erosion.

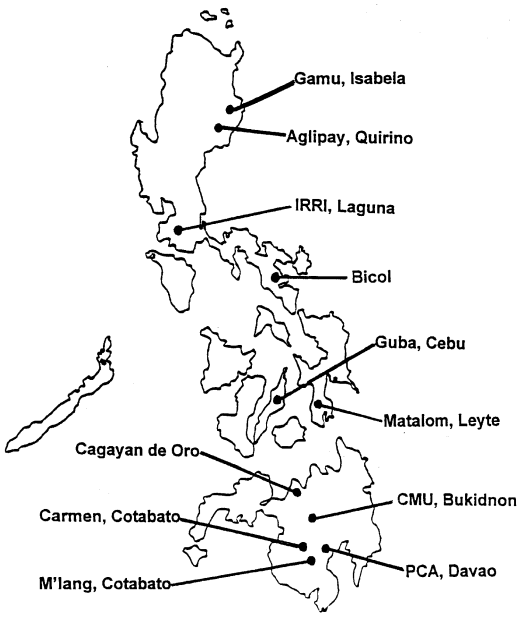


**Fig. 1. FSP regional evaluation sites in the Philippines.**

The Forages for Smallholders Project (FSP), in collaboration with local agencies, has conducted regional evaluation of forages at different sites in the Philippines. Farmers at these sites have experienced, in varying degrees, the previously mentioned problems. Regional evaluation was done as a first step towards on-farm evaluation of forages by farmers.

## Site description

Regional evaluation was carried out at 13 sites in the Philippines (Fig. 1) – four sites in Luzon, three in the Visayas and six in Mindanao. Seven of the sites were located on experiment stations and were managed by local agency collaborators. The rest were located in communal areas volunteered by farmer-groups (Bicol, Guba, Montealegre, Pagalungan, Carmen, and M'lang) and were managed by farmers in consultation with local agency collaborators. These sites doubled as multiplication areas

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of planting materials for later testing by farmers. Some localities have two evaluation sites.

The physical characteristics of the sites are shown in Table 1. Detailed soil analysis results are shown in Appendix 1. Climate information is shown in Appendix 2 (long-term) and Appendix 3 (actual during the evaluation period).

**Table 1. Physical characteristics of sites for regional evaluation.**

| Site | Lat. | Alt. (m) | Annual rainfall (mm) | Wet season | No. wet months (>50mm) | Soil characteristics | | | Dominant farming system |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | pH[a] (% Al sat) | Texture (drainage)[b] | Fertility[c] | |
| Gamu | 17° N | 60 | 1890 | May-Dec | 10 | 5.6 | Brown, gritty clay-loam, well drained | Moderate low P, S | Moderately extensive upland cropping, *Imperata*-dominated native vegetation |
| Aglipay | 16° N | | 2530 | May-Jan | 11 | 5.1 (3) | Yellow-brown, silty clay-loam, well drained | Moderate low P | Moderately extensive upland cropping, *Imperata*-dominated native vegetation |
| IRRI | 14° N | 20 | 1500 | May-Dec | 9 | 6.5 (1) | Brown, clay-loam, well drained | Fertile, low S | Intensive, irrigated lowland rice |
| Bicol | 13° N | 20 | 3900 | All year | 12 | 5.6 | Brown, clay-loam, well drained | Moderate | Extensive upland agriculture under coconut |
| Guba | 10° N | 550 | 1680 | May-Jan | 12 | 4.9 (31) | Yellow brown, clay-loam, well-drained | Fertile, low pH | Intensive upland agriculture (maize, vegetables, fruit trees); cut-and-carry feeding |
| Matalom: San Salvador | 10° N | 30 | 1970 | June-Apr | 12 | 4.9 (13) | Brown, clay-loam, well-drained | Moderate low P, K | Moderately intensive upland agriculture; overgrazed and dominated by *Chrysopogon* |
| Matalom: Montealegre | 10° N | 300 | 1970 | June-Apr | 12 | 6.0 | Brown, clay-loam, well drained | Fertile | Extensive upland agriculture, grazing areas dominated by *Imperata* |
| Cagayan de Oro: CCC | 8° N | 150 | 1500 | June-Nov | 10 | 6.5 | Brown, clay-loam, well drained | Moderate | Moderately extensive upland cropping, grazing areas invaded by *Chromolaena* |
| Cag. de Oro: Pagalungan | 8° N | 180 | 1500 | June-Nov | 10 | 5.8 | Brown, clay-loam, well drained | Moderate low S | Moderately extensive upland cropping; grazing areas invaded by *Chromolaena* |
| CMU | 7° N | | 2200 | May-Dec | 12 | 5.5 | Brown, clay-loam, well drained | Fertile | Intensive upland agriculture (corn, sugarcane), native vegetation grazed |
| Carmen | 7° N | | 1590 | April-Nov | 12 | 6.5 | Brown, clay-loam, well drained | Fertile | Moderately intensive upland agriculture; native vegetation grazed |
| M'lang | 7° N | | 1590 | April-Nov | 12 | 6.5 | Brown, clay-loam, area is subsoil-recently scraped off | Infertile | Moderately intensive rainfed lowland rice and maize, native vegetation used for grazing |
| Davao: PCA ) | 7° N | 120 | 2210 | April-Jan | 12 | 5.1-6.1 | Black, clay-loam, well drained | Fertile | Moderately intensive upland agriculture under coconuts |

[a] soil pH measured in 1:5 $H_2O$ (% Al saturation in brackets).
[b] drainage (poorly drained, moderate drainage, well drained, seasonally flooded).
[c] major soil fertility deficiencies or problems (eg. low P).

Most of the sites (except IRRI and M'lang) are upland areas with soil fertility varying from moderate to good. The evaluation at M'lang was done in a recently scraped area, thus only the subsoil was left. All sites have clay soils with pH (1:5 $H_2O$) lower than 7. Annual rainfall varied from 1500 to 3900 mm with most sites having an average of around 2000 mm.

The evaluation did not start at the same time. As such, in some sites, the first year was wetter than normal while in others, it was drier. However, the deviation was not

significant. Rainfall was generally slightly higher than normal in 1995 at all sites except Aglipay, CMU, Carmen, and M'lang. In 1996, rainfall was slightly higher at all sites except Aglipay, IRRI, Cagayan de Oro, Carmen, and M'lang. In 1997, rainfall was lower at all sites due to the *El Niño* phenomenon.

## Methodology

Establishment procedures were similar at all sites. Grasses were planted vegetatively, as was the legumes *Arachis pintoi*. The rest of the species were sown by seed, either directly in the plots (herbaceous and shrub legumes) or transplanted as seedlings from a seedbed (tree legumes).

Plot size and planting distance varied between sites and ranged from 1000 $m^2$ plots with a planting distance of 0.5 x 0.5 m at Gamu and Aglipay to single rows with a planting distance of 0.5 – 1.0 m at other sites. Legume trees and shrubs were usually planted in single rows at a distance of 0.5 m between hills. Some species were established as mixtures (usually grasses for grazing mixed with *Arachis* spp., *Centrosema* spp., *Desmodium heterophyllum,* and Stylo 184). In this case, each species was planted in alternate rows at a closer planting distance (about 25 cm between hills).

During the establishment period missing hills were replanted as necessary. Plots were weeded regularly, except for plots planted with cover crop species (twining legumes) and those for grazing (mixtures of stoloniferous grasses and creeping legumes). The latter were weeded only once or twice during establishment. No fertiliser was applied except to species planted for seed production. Cutting frequency varied from regular harvests at CMU, Bicol and Davao to irregular harvests at Gamu, Aglipay and IRRI.

The forage varieties tested at each site are shown in Table 2. Species performance was visually assessed for a period of at least two years after establishment. The major factors considered in these ratings were establishment success, yield, persistence, seed production, and presence of pests and diseases.

**Table 2. Forage varieties tested at regional evaluation sites in the Philippines.**

| Species | Davao-PCA | IRRI | Montealegre | Guba | Carmen | CMU | Gamu | Aglipay | Bicol | San Salvador | CCC | Pagalungan | M'lang |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Erect Grasses** | | | | | | | | | | | | | |
| *Andropogon gayanus* CIAT 621 | - | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | - | ✔ | ✔ | - | ✔ |
| *Brachiaria brizantha* CIAT 16318 | - | ✔ | - | - | - | - | - | - | - | ✔ | - | - | - |
| *Brachiaria brizantha* CIAT 16827 | ✔ | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Brachiaria brizantha* CIAT 16835 | - | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Brachiaria brizantha* CIAT 26110 | ✔ | ✔ | - | ✔ | ✔ | - | - | - | - | ✔ | ✔ | ✔ | ✔ |
| *Brachiaria brizantha* CIAT 6387 | - | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Brachiaria brizantha* CIAT 6780 | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | - | ✔ | ✔ | - | ✔ |
| *Pennisetum purpureum* cv. Capricorn | ✔ | ✔ | ✔ | - | - | ✔ | - | - | - | ✔ | ✔ | - | |
| *Pennisetum purpureum* cv. Mott | ✔ | ✔ | - | ✔ | ✔ | - | - | - | - | ✔ | ✔ | - | ✔ |
| *Pennisetum hybrid* 'Florida' | ✔ | ✔ | - | - | ✔ | - | ✔ | - | - | ✔ | ✔ | ✔ | ✔ |
| *Pennisetum purpureum* 'Local' | ✔ | ✔ | - | - | ✔ | - | - | - | - | ✔ | ✔ | ✔ | ✔ |
| *Pennisetum* hybrid 'King' grass | ✔ | ✔ | - | ✔ | ✔ | - | - | - | - | ✔ | ✔ | - | |
| *Panicum maximum* CIAT 6299 | ✔ | ✔ | ✔ | ✔ | ✔ | - | - | - | - | ✔ | ✔ | - | ✔ |
| *Panicum maximum* T58 | ✔ | ✔ | - | - | - | - | - | - | - | - | - | - | - |

**(continued next page)**

**Table 2 (cont.). Forage varieties tested at regional evaluation sites in the Philippines.**

| Species | Davao-PCA | IRRI | Montealegre | Guba | Carmen | CMU | Gamu | Aglipay | Bicol | San Salvador | CCC | Pagalungan | M'lang |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Panicum maximum* cv. Tanzania | - | - | - | - | - | ✔ | - | - | - | - | ✔ | - | - |
| *Paspalum atratum* BRA 9610 | ✔ | ✔ | - | ✔ | ✔ | - | - | - | - | ✔ | ✔ | ✔ | ✔ |
| *Paspalum guenoarum* BRA 3824 | - | ✔ | - | - | - | - | - | - | - | - | ✔ | - | - |
| *Setaria sphacelata* cv. Golden Timothy | ✔ | ✔ | - | ✔ | ✔ | - | - | - | - | - | - | - | ✔ |
| *Setaria sphacelata* cv. Splenda | - | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Setaria sphacelata* var. *splendida* ex. Indonesia | ✔ | ✔ | ✔ | ✔ | ✔ | - | - | - | - | ✔ | ✔ | - | ✔ |
| **Decumbent and Stoloniferous Grasses** | | | | | | | | | | | | | |
| *Brachiaria decumbens* cv. Basilisk | ✔ | ✔ | ✔ | - | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| *Brachiaria humidicola* CIAT 6133 | ✔ | ✔ | - | - | ✔ | ✔ | - | - | ✔ | ✔ | ✔ | ✔ | ✔ |
| *Brachiaria humidicola* CIAT16886 | - | ✔ | ✔ | - | - | ✔ | - | - | ✔ | ✔ | - | - | - |
| *Brachiaria humidicola* CIAT 26149 | - | ✔ | - | - | - | ✔ | - | - | - | - | - | - | - |
| *Brachiaria humidicola* cv. Tully | ✔ | ✔ | - | - | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | - | ✔ |
| *Brachiaria ruziziensis* | - | ✔ | - | - | - | ✔ | - | - | - | - | - | - | - |
| *Cynodon plectostachyus* | - | - | - | - | - | ✔ | - | - | - | - | - | - | - |
| *Stenotaphrum secundatum* cv. Floratam | ✔ | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| **Shrub/tree Legumes** | | | | | | | | | | | | | |
| *Calliandra calothyrsus* ex. Indonesia | ✔ | ✔ | - | ✔ | - | - | - | - | - | - | ✔ | - | - |
| *Calliandra calothyrsus* ATF 2014 | - | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Cratylia argentea* CIAT 18516 | - | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* ex. IRRI | - | ✔ | ✔ | - | ✔ | - | - | - | - | ✔ | ✔ | - | ✔ |
| *Desmanthus virgatus* CPI 40071 | ✔ | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* CPI 52401 | - | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* CPI 82285 (cv. Bayamo) | - | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* CPI 91146 | - | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* CPI 92803 (=cv. Uman) | - | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Desmodium cinerea* ex. MBRLC | ✔ | ✔ | ✔ | ✔ | ✔ | - | ✔ | - | - | ✔ | ✔ | ✔ | ✔ |
| *Desmodium cinerea* CPI 46561 | - | ✔ | - | - | - | ✔ | - | - | - | - | - | - | - |
| *Desmodium cinerea* CPI 76099 | - | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Flemingia macrophylla* CIAT 17403 | - | ✔ | - | - | - | ✔ | - | - | - | ✔ | - | - | - |
| *Gliricidia sepium* 'Monterrico' | ✔ | ✔ | - | ✔ | ✔ | - | ✔ | - | - | ✔ | - | - | ✔ |
| *Gliricidia sepium* 'Retalhuleu' | ✔ | ✔ | - | ✔ | ✔ | - | ✔ | - | - | ✔ | - | - | ✔ |
| *Gliricidia sepium* 'Belen Rivas' | ✔ | ✔ | - | ✔ | ✔ | - | ✔ | - | - | ✔ | - | - | ✔ |
| *Gliricidia sepium* 'Local' | ✔ | - | ✔ | - | ✔ | ✔ | - | - | - | ✔ | ✔ | ✔ | ✔ |
| *Leucaena diversifolia* ex. MBRLC | ✔ | - | - | ✔ | ✔ | - | - | - | - | ✔ | - | - | ✔ |
| *Leucaena leucocephala* 'Local' | ✔ | - | ✔ | - | ✔ | - | - | - | - | - | ✔ | - | ✔ |
| *Leucaena leucocephala* K584 | - | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Leucaena leucocephala* K636 | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | - | - | | ✔ | ✔ | ✔ | ✔ |
| *Leucaena pallida* CQ3439 | ✔ | ✔ | - | - | ✔ | - | - | - | - | - | - | - | |
| *Sesbania rostrata* ex. IRRI | - | - | - | - | - | - | - | - | - | - | - | - | ✔ |
| *Sesbania grandiflora* | - | - | - | - | - | - | - | - | - | - | ✔ | - | - |
| **Herbaceous Legumes** | | | | | | | | | | | | | |
| *Aeschynomene histrix* CIAT 9690 | - | ✔ | - | - | - | - | - | - | - | ✔ | - | - | - |
| *Arachis glabrata* cv. Florigraze | - | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Arachis glabrata* IRFL 3112 | ✔ | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Arachis glabrata* CPI 12121 | - | ✔ | - | ✔ | - | - | - | - | - | - | - | - | - |
| *Arachis glabrata* CPI 93483 | - | ✔ | - | ✔ | - | - | - | - | - | - | - | - | - |
| *Arachis* hybrid IRFL 3014 | - | ✔ | - | - | - | - | ✔ | - | - | - | - | - | - |
| *Arachis pintoi* CIAT 17434 | - | ✔ | - | ✔ | - | ✔ | - | ✔ | ✔ | - | - | - | - |
| *Arachis pintoi* CIAT 18744 | - | ✔ | - | - | - | ✔ | - | ✔ | - | - | ✔ | ✔ | - |

**(continued next page)**

**Table 2 (cont.). Forage varieties tested at regional evaluation sites in the Philippines.**

| Species | Davao-PCA | IRRI | Montealegre | Guba | Carmen | CMU | Gamu | Aglipay | Bicol | San Salvador | CCC | Pagalungan | M'lang |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Arachis pintoi* CIAT 18747 | - | ✔ | - | - | - | ✔ | - | - | - | - | - | - | - |
| *Arachis pintoi* CIAT 18748 | - | ✔ | - | - | - | ✔ | - | ✔ | - | - | - | - | - |
| *Arachis pintoi* CIAT 18750 | - | ✔ | - | ✔ | - | ✔ | - | ✔ | ✔ | - | - | - | - |
| *Arachis pintoi* CIAT 22160 | ✔ | ✔ | ✔ | ✔ | ✔ | - | ✔ | ✔ | - | ✔ | ✔ | ✔ | ✔ |
| *Calopogonium caeruleum* CIAT 7304 | ✔ | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Calopogonium mucunoides* CIAT 772 | - | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Calopogonium mucunoides* CIAT 822 | - | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Calopogonium mucunoides* CIAT 17856 | ✔ | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Calopogonium mucunoides* CIAT 20709 | - | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Centrosema acutifolium* CIAT 5277 | ✔ | ✔ | ✔ | - | - | ✔ | - | - | - | ✔ | ✔ | ✔ | - |
| *Centrosema acutifolium* CIAT 5568 | - | - | - | - | - | ✔ | - | - | - | - | - | - | - |
| *Centrosema macrocarpum* CIAT 25522 | ✔ | ✔ | - | ✔ | - | - | - | - | - | - | ✔ | - | - |
| *Centrosema macrocarpum* CIAT 5713 | - | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Centrosema pascuorum* cv. Cavalcade | ✔ | - | - | - | - | - | - | - | - | - | - | - | - |
| *Centrosema pubescens* ex. Davao | ✔ | - | - | - | - | - | - | - | - | - | - | - | - |
| *Centrosema* mix (CIAT 5277, 15160, 15470, 438, 442) | - | - | - | - | - | ✔ | - | - | ✔ | - | - | - | - |
| *Centrosema pubescens* CIAT 15160 | ✔ | ✔ | - | - | ✔ | - | ✔ | ✔ | - | ✔ | ✔ | ✔ | ✔ |
| *Centrosema pubescens* cv. Cardillo | - | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Clitoria ternatea* | - | - | - | - | - | - | - | - | - | - | - | - | ✔ |
| *Desmodium heterophyllum* CIAT 349 | ✔ | ✔ | - | - | - | - | - | - | ✔ | - | ✔ | - | - |
| *Desmodium intortum* | ✔ | - | - | - | - | - | - | - | - | - | - | - | - |
| *Desmodium ovalifolium* CIAT 130329 | - | - | - | - | - | ✔ | - | - | - | - | - | - | - |
| *Desmodium ovalifolium* CIAT 13305 | ✔ | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Desmodium ovalifolium* CIAT 350 | - | ✔ | - | - | - | ✔ | - | - | - | - | - | - | - |
| *Desmodium ovalifolium* CIAT 3666 | - | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Lablab purpureus* cv. Highworth | - | - | - | - | - | - | - | - | - | - | - | - | ✔ |
| *Lablab purpureus* cv. Rongai | - | - | - | - | - | - | - | - | - | - | - | - | ✔ |
| *Macroptilium atropurpureum* cv. Aztec | - | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Macroptilium atropurpureum* cv. Siratro | - | ✔ | - | - | - | - | - | - | - | - | - | - | ✔ |
| *Macroptilium gracile* cv. Maldonado | ✔ | ✔ | - | - | - | - | - | - | - | - | - | - | ✔ |
| *Mimosa invisa* ex. MBRLC (spineless) | - | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Mucuna pruriens* CIAT 9349 | ✔ | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Pueraria phaseoloides* ex. Davao | ✔ | - | - | - | - | - | - | - | - | - | - | - | - |
| *Pueraria phaseoloides* CIAT 7182 | ✔ | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Pueraria phaseoloides* CIAT 8042 | ✔ | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Pueraria phaseoloides* CIAT 9900 | - | - | - | - | - | - | - | - | - | - | ✔ | - | - |
| *Pueraria phaseoloides* CIAT 32118 | - | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT 184 | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | - | ✔ | ✔ | ✔ | ✔ |
| *Stylosanthes guianensis* cv. Cook | - | ✔ | - | - | - | - | ✔ | ✔ | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM05-1 | - | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM05-2 | - | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM05-3 | - | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM07-1 | - | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM07-2 | - | ✔ | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM07-3 | - | ✔ | - | - | - | - | - | - | - | - | - | - | - |

## Results

The performance of forage varieties will be summarised in the following pages (and Tables). More details are provided in Appendices 4 – 8.

### Grasses

Among the erect growing grass species (Table 3), *Pennisetum purpureum* and its hybrids as well as *Panicum maximum* CIAT 6299 had the highest yield potentials. However, these species had slow regrowth when subjected to regular cutting under shade at the PCA-Davao site. Fertilisation improved regrowth, implying that these species require considerable fertilisation to improve herbage production. Moreover, there were difficulties in vegetative establishment of *P. maximum*.

*Paspalum atratum* BRA 9610 and *Setaria sphacelata var. splendida* ex. Indonesia also had very high yields. These species had more leaves and succulent stems than the *Pennisetum* or *Panicum* varieties. Moreover, seed production of *P. atratum* was good. However, *P. atratum* and *S. sphacelata* easily dried up and did not grow well in the dry season and in less fertile sites.

*Brachiaria brizantha* (CIAT 6780 and CIAT 26110) also had good herbage yield, especially in the wet season. *Brachiaria brizantha* CIAT 26110 produced high seed yields towards the end of the wet season and remained green up to the middle of the dry season. *Brachiaria brizantha* CIAT 6780 was affected by leaf fungal diseases (*Rhizoctonia* or *Cercospera*) and had only moderate seed yields.

**Table 3. Performance of erect grasses with broad adaptation at sites in the Philippines.**

| Species | Strengths | Weaknesses | Potential uses |
|---|---|---|---|
| *Pennisetum purpureum* and hybrids | • Easy vegetative establishment<br>• Very good yield potential | • Moderate persistence under frequent cutting and under shade<br>• Needs fertilisation for good regrowth when cut frequently | • Cut-and-carry either as blocks or hedgerows |
| *Panicum maximum* CIAT 6299 | • Very good yield potential<br>• Good seed yield | • Difficult to establish vegetatively<br>• Moderate persistence under frequent cutting and under shade<br>• Needs fertilisation for good regrowth when cut frequently | • Cut-and-carry either as blocks or hedgerows |
| *Paspalum atratum* BRA 9610 | • Very good yield potential<br>• High leaf yield<br>• Good seed yield | • Highly susceptible to dry periods<br>• Moderate persistence under frequent cutting and under shade | • Cut-and-carry either as blocks or hedgerows |
| *Brachiaria brizantha* CIAT 6780, and ' 26110 | • Good yield potential<br>• CIAT 26110 has considerable tolerance to dry condition and produces good seed | • Moderate persistence under frequent cutting and under shade<br>• CIAT 6780 affected by fungal diseases during wet periods | • Cut-and-carry either as blocks or hedgerows |
| *Andropogon gayanus* CIAT 621 | • Good yield potential<br>• Good performance in low pH soils<br>• Excellent dry season tolerance | • Poor seed germination<br>• Difficult to establish vegetatively<br>• Seeds difficult to clean | • Cut-and-carry either as blocks or hedgerows |
| *Setaria sphacelata var. splendida* ex. Indonesia | • Very good yield potential<br>• Succulent leaf and stem<br>• Easy establishment (vegetative) | • Highly susceptible to dry periods<br>• Moderate persistence with frequent cutting and under shade<br>• Low performance in poor soil | • Cut-and-carry either as blocks or hedgerows |

*Andropogon gayanus* CIAT 621 grew well at most sites. This was particularly noticeable at sites where pH was so low that performance of other species was severely

affected. It also remained green long into the dry season. Unfortunately, this species had establishment problems both from the seed and vegetative material – because of the seed's fluffiness, seed is difficult to clean and so overall germination tended to be poor. It was also difficult to get good rootstock planting material from mature plants because of their very strong root system.

The evaluation results also showed that, generally, erect growing grasses had only moderate performance under shade in spite of good soil fertility. This was observed at the PCA-Davao site.

Among decumbent and stoloniferous grasses (Table 4), *Brachiaria decumbens* and *B. humidicola*. (CIAT 6133, cv. Tully, CIAT 16886) had good performance, both in the open and under shade. These species also had good regrowth when cut or grazed frequently and when established in mixture with legumes. Among these species, only *B. decumbens* showed some yellowing in soils with poor fertility and during the dry season. These species had low growth habits and were often affected by companion legumes or weeds when grazed only lightly or cut infrequently. Seed production from these species was generally low. *Brachiaria* decumbens and *B. humidicola* cv. Tully had problems with establishment, both from the seed and vegetative material. The seed had low germination while vegetative materials had slow growth and often died. *B. humidicola* CIAT 6133 and CIAT 16886 established much better, especially from stolons since the nodes of these species produced roots and leaves much faster.

Generally for grasses, establishment from vegetative material was a problem with species established from rootstock, especially if the tillers used were not young. This was not a problem for species propagated from cuttings and stolons that already had good roots and young leaves.

All the broadly adapted erect species have good potential for cut-and-carry systems. They can be integrated in the farm as hedgerow or in blocks. On the other hand, decumbent and stoloniferous grasses had good potential as grazing species especially when mixed with legumes. *Brachiaria humidicola* produced very good regrowth even under frequent defoliation.

**Table 4. Performance of decumbent and stoloniferous grasses with broad adaptability at sites in the Philippines.**

| Species | Strengths | Weaknesses | Potential uses |
|---|---|---|---|
| *Brachiaria decumbens* cv. Basilisk | • Good yield potential | • Turns yellow with frequent defoliation and in dry periods | • Grazing in monoculture or mixtures |
| *Brachiaria humidicola* CIAT 6133 cv. Tully CIAT 16886 | • CIAT 6133 has good yield potential and is leafy<br>• cv. Tully and CIAT 16886 had moderate yield potential<br>• Good tolerance to frequent defoliation<br>• Moderate seed production only<br>• CIAT 16886 was very easy to establish vegetatively | • Dominated by weeds or companion creeping legumes if not cut/grazed frequently<br>• cv. Tully difficult to establish vegetatively<br>• Low seed production | • Grazing in monoculture or mixtures |

### Legumes

Only seven of the herbaceous legumes were tested in most sites. Among those tested (Table 5), *Arachis pintoi* (CIAT 18744 and CIAT 22160) and *Stylosanthes guianensis* CIAT 184 consistently performed well. The latter established well, had good yields even

in the dry season, and produced seeds but was found not to persist under grazing pressure and lasted only for 2-3 yr. On the other hand, *A. pintoi* did not tolerate dry periods and was growing better under partial shade compared with open field. This species was also easily dominated by companion grasses or weeds. Among the *A. pintoi* accessions, CIAT 22160 established most easily from cuttings while another accession, CIAT 18748 stayed greener a little longer into the dry season.

Another legume tested in most sites was *Centrosema pubescens* CIAT 15160. This legume had good establishment, persistence and seed production. It did well at moderate and high-fertility sites but not at the low-fertility site at M'lang. This species performed well in the wet season but not during the dry season.

**Table 5. Performance of herbaceous legumes with good potential in Philippine sites.**

| Species | Strengths | Weaknesses | Potential Uses |
|---|---|---|---|
| *Stylosanthes guianensis* CIAT 184 | • Good establishment and yield<br>• Tolerates low-fertility soil<br>• Considerable dry-season tolerance | • Not long-lived<br>• Cannot tolerate heavy grazing | • Weed control<br>• Fallow improvement<br>• Cut-and-carry feed |
| *Arachis pintoi* CIAT 18744 CIAT 18748 CIAT 22160 | • Tolerates heavy grazing<br>• CIAT 22160 easy to establish vegetatively<br>• CIAT 18748 has some tolerance for dry periods | • Dominated by weeds or companion species in mixtures<br>• Only CIAT 22160 is easy to establish | • Grazing, especially under trees<br>• Mixtures with low-growing grasses |
| *Centrosema pubescens* CIAT 15160 | • Good establishment and persistence<br>• Good yield in wet season<br>• Good seed yield and easy to harvest | • Low performance in dry season<br>• Low performance in poor soils | • Grazing in mixtures with grasses |
| *Centrosema pubescens* cv. Cardillo[a] | • Good establishment and persistence<br>• Good seed yield and easy to harvest<br>• Excellent dry-season performance | • Moderate performance in wet season | • Grazing in mixtures with grasses |
| *Centrosema macrocarpum* CIAT 5713 CIAT 25522[b] | • Excellent performance in dry season and under shade<br>• Good herbage yield | • Low seed yield | • Cover crop<br>• Fallow improvement |
| *Calopogonium caeruleum* CIAT 7304[b] | • Excellent performance in dry season and under shade<br>• Good herbage and seed yield | | • Cover crop<br>• Fallow improvement |
| *Pueraria phaseoloides* CIAT 7182[b] | • Good herbage and seed yield<br>• Good performance under shade | • Low performance in dry season | • Cover crop |

[a] Evaluation done only at IRRI.
[b] Evaluation done only at PCA-Davao (under coconut) and IRRI (open); both areas have fertile soils.

Among the other herbaceous legumes tested in only a few sites, there were species that did very well in the dry season (much better than the aforementioned species) – *Calopogonium caeruleum* CIAT 7304, *Centrosema macrocarpum* (CIAT 25522 and CIAT

5713), and *C. pubescens* cv. Cardillo. Other species also yielded well in the wet season – *Mucuna pruriens* CIAT 9349 and *Pueraria phaseoloides* CIAT 7182.

Of the herbaceous legumes, only *Arachis pintoi* had establishment problems, basically because they were established vegetatively. *Centrosema macrocarpum* had low seed yields. *Mucuna pruriens* had problems with leaf-cutting insects while *P. phaseoloides* had poor dry season performance.

Herbaceous legumes have good potential as cover crops and as a soil fertility improvement tool aside from being a good source of feed. Most can be used as companions to grasses for grazing while *S. guianensis* CIAT 184 can also be used for cut-and-carry systems.

To date, most of the shrub and tree legumes in the site are still in the establishment stage. As such, the observations obtained were more on establishment and yield at the early stage (Table 6). All the shrub legumes tested (*Desmanthus, Flemingia,* and *Desmodium cinerea – previously called D. rensonii*) had variable performance. *Desmanthus virgatus* generally did not do well in acid soil sites and were also infested to some degree by psyllids (*Heteropsylla cubana*) especially in the dry season. *Desmodium cinerea* had good yields but did not perform well in the dry season.

Among the tree legumes, Gliricidia *sepium* (cv. Retalhuleu, cv. Monterrico and cv. Belen Rivas) consistently had good yields despite slow initial growth. *Calliandra calothyrsus* did very well at high-altitude sites. *Leucaena leucocephala* K636 had good establishment in slightly acidic soil conditions (pH>6.0). In moderately acidic soils, it established only when the soil was very fertile (e.g. at the Guba site). In this case, *L. leucocephala* has shown signs of poor persistence with plants dying in the first dry season. Moreover, it did not do very well under shade and was infested with psyllids.

**Table 6. Performance of shrub and tree legumes with good potential at sites in the Philippines.**

| Species | Strengths | Weaknesses | Potential uses |
|---|---|---|---|
| *Desmanthus virgatus*<br>ex. IRRI<br>CPI 40071<br>CPI 52401 | • Good herbage and seed yield | • Affected by psyllids (*H. cubana)*<br>• Moderate in dry season<br>• Low performance in poor and acid soil | • Cut-and-carry either as blocks or hedgerows |
| *Desmodium cinerea (prev. D. rensonii)*<br>ex. MBRLC = *CPI 46562* | • Good herbage and seed yield | • Moderate in dry season and acid soil | • Cut-and-carry either as blocks or hedgerows |
| *Flemingia macrophylla*<br>CIAT 17403 | • Good herbage and seed yield | • Coarse and hard herbage | • Cut-and-carry either as blocks or hedgerows |
| *Calliandra calothyrsus* | • Good performance in high -altitude sites | • Moderate establishment<br>• Poor regrowth in low -altitude sites | • Cut-and-carry as hedgerows, fence lines or blocks |
| *Gliricidia sepium*<br>cv. Retalhuleu<br>cv. Monterrico<br>cv. Belen Rivas | • Good herbage yield<br>• Good performance in acid soil | • Moderate establishment<br>• Low seed production<br>• Sheds leaves in dry season | • Cut-and-carry as hedgerows, fence lines or blocks |
| *Leucaena leucocephala*<br>K636 | • Good herbage yield | • Low persistence in acid soil<br>• Affected by psyllids (*H. cubana*) | • Cut-and-carry as hedgerows, fence lines or blocks |

A major observation with shrub and tree legumes was their relatively slow establishment. This was aggravated by dry spells during the establishment period. Once established, shrub and tree legumes find good potential as cut-and-carry feed especially in the dry season when grasses and shallow-rooted herbaceous legumes dry up. They have potential for integration in smallholder farms as hedgerows or fences. Experience in the Philippines has shown that uncontrolled grazing is a common problem, thus using tree legumes as fences warrants considerable attention.

## Conclusions and recommendations

The results of the evaluation yielded considerable information on what species have good chances of performing well in farmers' fields. It also gave insights on the attributes and weaknesses of potential species. This has led to identification of areas and issues for further development.

The evaluation activity was able to point out the need of high yielding grass species (e.g. *Pennisetum* and *Panicum*) for nutrients to sustain production. It has also highlighted the sustained production of stoloniferous *Brachiaria* species despite low nutrient availability. *Stylosanthes guianensis* CIAT 184 was also notable in terms of performance in poor soils while *A. gayanus* performed relatively better than did other erect species in very acid soils.

Another interesting finding was the potential of *Paspalum atratum* BRA 9610 and *Setaria sphacelata var. splendida* ex. Indonesia. These species are very leafy and have succulent stems as well as high yields. Farmers commented that these species were not itchy and were more convenient to cut, providing a good amount of feed from a small area.

Another attribute shown by some species is good performance during dry periods. This is very important since feed availability in the dry season is a major problem of smallholder farmers. Varieties with good dry season performance were *Andropogon gayanus* CIAT 621, *Brachiaria brizantha* CIAT 26110, *Calopogonium caeruleum* and *C. macrocarpum* (CIAT 25522 and CIAT 5713). Finding a way to integrate these species in farmers' fields to provide feed during the dry season will be the next challenge. For example, establishing these species in mixtures with other species that do well in the wet season may be a good option.

Another issue related to forage delivery system is the production of seed and planting material. Some grass species were difficult to establish from seed and vegetative material. An example is *A. gayanus*, which had low seed germination (primarily because the seeds are difficult to clean) and, at the same time had poor vegetative establishment. The species has a very strong root system and preparing rootstocks for planting was rather difficult. In other grasses propagated by rootstock, it was observed that those taken from old tillers had low survival. This therefore warrants development of simple and practical techniques of vegetative propagation.

Seed production and seed collection were difficult especially for grasses. Lack of uniformity in seed ripening was a major constraint and, some species just did not produce enough good seed. This problem has to be addressed to enhance adoption and use of forages by a larger number of farmers.

Some species tested mainly at IRRI showed good potential for seed production. These include *Brachiaria ruziziensis* and *B. brizantha* CIAT 6387. The former have been proven elsewhere to be a good seed producer, with uniform seed ripening and little shedding of ripe seeds. *Brachiaria brizantha* CIAT 6387 was observed to produce seed more than once a year. This is a considerable trait especially with *Brachiaria* species because they produce seed in the Philippines early in the wet season. With *B. brizantha*

CIAT 6387, it is possible to harvest seed in the later part of the wet season, when rainfall is lower making harvesting easier. Another *Brachiaria brizantha* accession that was observed to produce seed late in the dry season was CIAT 26110.

The issue of seed production can also be tackled by improving the methods of seed collection. This is important because aside from seed shedding, there are problems with birds and rats that feed on the seeds even before they are harvestable.

## Acknowledgements

We thank our research partners who are based at different sites for carrying out the fieldwork and data collection. The collaborating agencies are the Cagayan Valley Integrated Agricultural Research Centre (UPROS and LES), the Bureau of Animal Industry, FARMI at the Visayas State College of Agriculture, Mag-uugmad Foundation Incorporated, Cagayan de Oro City Veterinary Office, Philippine Coconut Authority-Davao Research Centre, and Philippine Carabao Centre at University of Southern Mindanao. We also thank the farmers in Guba, Matalom, Cagayan de Oro, Carmen, and M'lang for their interest and effort in maintaining their forage plots.

## References

Lanting, E.F., Gabunada, F., Ocfemia, G., Salamat, S., Bugayong, A., Marasigan, C. and Garcia, N. 1995. Forage seeds project in the Philippines : activities, results and conclusions. In: Stür, W.W., Cameron, A.G. and Hacker, J.B. (eds) . 1995. Forages for smallholders. Proceedings of the Third Meeting of the Southeast Asian Regional Forage Seeds Project. Samarinda, Indonesia, 23-28 Oct 1994. CIAT Working Document No. 143.

Horne, P.M., Stür, W.W., Gabunada, F. Jr., Phengsavanh, P. 1997. Prospects for introducing forages in smallholder farming systems in Southeast Asia. In: W.W. Stür (ed). Feed resources for Smallholder Livestock Farmers in Southeast Asia. Proceedings of the First Regional Meeting of the Forages for Smallholders Project, FAO Regional Working Group on Feed and Grazing Resources in Southeast Asia, and FAO Regional Working Network on Better Use of Locally Available Feed Resources for Sustainable Livestock Production in Southeast Asia. CIAT Working Document No. 156. Vientiane, Lao PDR. p 11-20.

# Appendices

**Appendix 1. Results of soil analysis results at regional evaluation sites.**

| ite | pH (1:5 $H_2O$) | Organic carbon (%) | N $NO_3$ | P[a] | S | K | Ca | Mg | Al | Na | CEC | Cu | Zn | Mn | Fe | Bo | Al sat. (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ––– (ppm) ––– | | | ––––––––– (meq/100g) ––––––––– | | | | | | ––––––––– (mg/kg) ––––––––– | | | | | |
| amu | 5.6 | 1.4 | 1.3 | 10 | 9 | 0.4 | 9 | 5 | - | 0.09 | 13.7 | 2 | 1 | 54 | 38 | 0.5 | - |
| glipay | 5.1 | 1.2 | 6.0 | 7 | 14 | 0.2 | 12 | 6 | 0.5 | 0.19 | 18.5 | 3 | 11 | 102 | 38 | 0.4 | 3 |
| RRI | 6.5 | 1.4 | 0.7 | 105 | 9 | 1.1 | 14 | 6 | - | 0.21 | 21.2 | 8 | 3 | 20 | 69 | 0.7 | 1 |
| icol | 5.6 | 1.7 | 1.3 | 18 | 16 | 0.2 | 4 | 2 | - | 0.39 | 6.0 | 4 | 3 | 84 | 37 | 0.5 | - |
| uba | 4.9 | 1.2 | 14.0 | 23 | 35 | 0.8 | 9 | 3 | 6.2 | 0.38 | 20.0 | 17 | 4 | 42 | 109 | 0.8 | 31 |
| atalom: San alvador | 4.9 | 1.4 | 3.1 | 10 | 20 | 0.1 | 2 | 1 | 0.5 | 0.07 | 4.0 | 2 | 2 | 97 | 43 | 0.4 | 13 |
| atalom: ontealegre | 6.0 | 1.4 | >60.0 | 42 | 13 | 0.9 | 19 | 4 | - | 0.05 | 23.6 | 2 | 2 | 19 | 44 | 0.3 | - |
| agayan de ro: CCC | 6.5 | 1.7 | 4.7 | 20 | 11 | 0.3 | 15 | 9 | - | 0.12 | 25.8 | 5 | 2 | 20 | 27 | 0.6 | - |
| ag. de Oro: agalungan | 5.8 | 1.5 | 20.7 | 24 | 7 | 0.6 | 15 | 10 | - | 0.16 | 25.4 | 3 | 1 | 28 | 45 | 0.5 | - |
| MU | 5.4 | 2.4 | 4.0 | 17 | 15 | 0.2 | 3 | 3 | 0.3 | 0.06 | 6.1 | 6 | 1 | 73 | 54 | 0.5 | 4 |
| armen | 6.5 | 1.2 | 18.2 | 35 | 12 | 1.3 | 10 | 4 | - | 0.08 | 15.7 | 6 | 4 | 42 | 23 | 0.5 | - |
| avao: PCA[a] | 5.1-6.1 | 0.9 | | 13 | | 1.2 | 10 | 3 | - | 0.07 | 25.0 | - | - | - | - | - | - |

[a] BSES

[b] Analysis taken from a local laboratory; methods differ from analysis in other sites.

## Appendix 2. Long-term climatic data at regional evaluation sites in the Philippines.

| Site | Climatic Data | J | F | M | A | M | J | J | A | S | O | N | D | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gamu, | Mean rainfall (mm) | 64 | 47 | 43 | 87 | 140 | 167 | 207 | 246 | 211 | 317 | 218 | 150 | 1898 |
| Isabela | No. of rain days | 9 | 7 | 6 | 7 | 9 | 9 | 12 | 11 | 12 | 15 | 15 | 12 | 122 |
| | Mean max. temp. (°C) | 27 | 29 | 32 | 34 | 35 | 35 | 33 | 33 | 32 | 31 | 29 | 27 | |
| | Mean min. temp. (°C) | 20 | 20 | 22 | 24 | 25 | 25 | 25 | 25 | 24 | 23 | 22 | 21 | |
| Aglipay, | Mean rainfall (mm) | 120 | 38 | 73 | 80 | 430 | 285 | 472 | 140 | 270 | 242 | 214 | 163 | 2527 |
| Quirino | No. of rain days | 15 | 8 | 6 | 4 | 13 | 8 | 16 | 13 | 17 | 18 | 16 | 14 | 146 |
| | Mean max. temp. (°C) | 26 | 28 | 30 | 33 | 34 | 34 | 32 | 32 | 31 | 29 | 28 | 25 | |
| | Mean min. temp. (°C) | 18 | 19 | 20 | - | - | - | - | - | 22 | 21 | 21 | 18 | |
| Bicol | Mean rainfall (mm) | 439 | 224 | 244 | 155 | 141 | 243 | 263 | 217 | 234 | 307 | 581 | 854 | 3902 |
| | No. of rain days | 22 | 15 | 16 | 14 | 15 | 14 | 17 | 17 | 16 | 18 | 22 | 26 | 212 |
| | Mean max. temp. (°C) | 29 | 29 | 30 | 32 | 32 | 32 | 31 | 29 | 31 | 31 | 30 | 29 | |
| | Mean min. temp. (°C) | 23 | 23 | 23 | 24 | 25 | 25 | 27 | 25 | 24 | 24 | 24 | 23 | |
| IRRI, | Mean rainfall (mm) | 41 | 20 | 31 | 52 | 135 | 265 | 320 | 257 | 246 | 320 | 252 | 143 | 2082 |
| Laguna | No. of rain days | 6 | 4 | 4 | 6 | 11 | 17 | 18 | 17 | 17 | 17 | 15 | 13 | 145 |
| | Mean max. temp. (°C) | 29 | 31 | 32 | 34 | 34 | 33 | 32 | 32 | 32 | 31 | 30 | 29 | |
| | Mean min. temp. (°C) | 22 | 22 | 22 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 23 | 22 | |
| Guba, Cebu | Mean rainfall (mm) | 107 | 79 | 72 | 90 | 104 | 191 | 190 | 121 | 182 | 232 | 202 | 111 | 1680 |
| | No. of rain days | 10 | 7 | 6 | 4 | 7 | 12 | 11 | 8 | 10 | 12 | 11 | 9 | 101 |
| | Mean max. temp. (°C) | 30 | 30 | 31 | 32 | 32 | 32 | 32 | 32 | 32 | 31 | 31 | 30 | |
| | Mean min. temp. (°C) | 24 | 24 | 24 | 25 | 26 | 25 | 25 | 25 | 25 | 25 | 25 | 24 | |
| Matalom, Leyte | Mean rainfall (mm) | 144 | 214 | 139 | 104 | 58 | 218 | 181 | 197 | 265 | 195 | 198 | 236 | 1972 |
| (San Salvador, | No. of rain days | 11 | 13 | 12 | 8 | 7 | 16 | 16 | 13 | 16 | 17 | 16 | 15 | 163 |
| Montealegre) | Mean max. temp. (°C) | 31 | 32 | 32 | 33 | 34 | 33 | 33 | 33 | 32 | 32 | 33 | 32 | |
| | Mean min. temp. (°C) | 24 | 24 | 23 | 24 | 26 | 26 | 26 | 25 | 25 | 25 | 25 | 24 | |
| Cagayan de Oro | Mean rainfall (mm) | 72 | 46 | 38 | 56 | 77 | 222 | 213 | 171 | 199 | 190 | 126 | 89 | 1501 |
| Pagalungan | No. of rain days | 10 | 6 | 6 | 6 | 9 | 16 | 18 | 14 | 17 | 14 | 11 | 8 | 135 |
| and CCC | Mean max. temp. (°C) | 31 | 32 | 32 | 33 | 34 | 34 | 33 | 34 | 33 | 33 | 33 | 32 | |
| | Mean min. temp. (°C) | 22 | 22 | 23 | 23 | 24 | 24 | 23 | 24 | 23 | 23 | 23 | 23 | |
| CMU, Bukidnon | Mean rainfall (mm) | 73 | 65 | 64 | 82 | 240 | 327 | 320 | 253 | 278 | 252 | 130 | 117 | 2201 |
| | No. of rain days | 8 | 3 | 5 | 7 | 13 | 18 | 18 | 14 | 17 | 17 | 10 | 9 | 137 |
| | Mean max. temp. (°C) | 33 | 32 | 33 | 34 | 34 | 33 | 32 | 32 | 32 | 33 | 33 | 33 | |
| | Mean min. temp. (°C) | 20 | 19 | 20 | 21 | 22 | 21 | 21 | 20 | 20 | 20 | 21 | 21 | |
| PCA, Davao | Mean rainfall (mm) | 139 | 63 | 96 | 165 | 277 | 247 | 215 | 247 | 243 | 254 | 158 | 110 | 2215 |
| | No. of rain days | 10 | 7 | 8 | 10 | 15 | 16 | 12 | 15 | 15 | 13 | 12 | 10 | 142 |
| | Mean max. temp. (°C) | 31 | 31 | 32 | 32 | 31 | 31 | 30 | 31 | 31 | 30 | 31 | 31 | |
| | Mean min. temp. (°C) | 21 | 22 | 21 | 21 | 22 | 20 | 21 | 20 | 20 | 21 | 20 | 20 | |
| Cotabato | Mean rainfall (mm) | 68 | 65 | 87 | 101 | 232 | 238 | 173 | 116 | 165 | 126 | 134 | 85 | 1593 |
| (Carmen, | No. of rain days | not available | | | | | | | | | | | | |
| M'lang) | Mean max. temp. (°C) | not available | | | | | | | | | | | | |
| | Mean min. temp. (°C) | not available | | | | | | | | | | | | |

## Appendix 3. Actual climatic data at regional evaluation sites in the Philippines.

| Site | Climatic Data | J | F | M | A | M | J | J | A | S | O | N | D | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gamu, | Rainfall (mm)-1995 | - | - | - | - | - | 92 | 313 | 121 | 304 | 425 | 280 | 545 | 2078 |
| Isabela | Rainfall (mm)-1996 | 54 | 24 | 7 | 54 | 145 | 47 | 241 | 223 | 209 | 484 | 439 | 57 | 1984 |
| | Rainfall (mm)-1997 | 31 | 71 | 118 | 61 | 102 | 293 | 157 | 133 | 147 | 238 | 196 | 70 | 1616 |
| | No. of rain days - 1995 | - | - | - | - | - | 7 | 17 | 14 | 21 | 20 | 17 | 20 | 116 |
| | No. of rain days - 1996 | 5 | 6 | 2 | 6 | 14 | 7 | 13 | 10 | 8 | 19 | 20 | 11 | 121 |
| | No. of rain days - 1997 | 8 | 13 | 6 | 7 | 10 | 10 | 10 | 9 | 10 | 9 | 9 | 13 | 114 |
| | Mean max. temp. ($^{o}$C)-1995 | - | - | - | - | - | 36 | 33 | 33 | 32 | 29 | 29 | 25 | |
| | Mean max. temp. ($^{o}$C)-1996 | 28 | 28 | 32 | 33 | 35 | 36 | 30 | 34 | 34 | 32 | 29 | 26 | |
| | Mean max. temp. ($^{o}$C)-1997 | 27 | 28 | 30 | 32 | 34 | 34 | 33 | 34 | 32 | 32 | 29 | 27 | |
| | Mean min. temp. ($^{o}$C)-1995 | - | - | - | - | - | 25 | 25 | 25 | 24 | 25 | 23 | 20 | |
| | Mean min. temp. ($^{o}$C)-1996 | 20 | 20 | 22 | 23 | 24 | 26 | 26 | 26 | 25 | 25 | 23 | 20 | |
| | Mean min. temp. ($^{o}$C)-1997 | 20 | 21 | 22 | 24 | 26 | 26 | 25 | 26 | 24 | 24 | 23 | 22 | |
| Aglipay, | Rainfall (mm)-1995 | 84 | 23 | 3 | 2 | 227 | 77 | 264 | 206 | 267 | 351 | 161 | 249 | 1914 |
| Quirino | Rainfall (mm)-1996 | 68 | 17 | 5 | 102 | 373 | 58 | 238 | 150 | 155 | 151 | 389 | 34 | 1741 |
| | Rainfall (mm)-1997 | 18 | 68 | 54 | - | - | - | - | - | - | - | - | - | 139 |
| | No. of rain days - 1995 | 17 | 8 | 1 | 1 | 14 | 6 | 16 | 17 | 17 | 19 | 17 | 20 | 153 |
| | No. of rain days - 1996 | 14 | 9 | 10 | 2 | 16 | 8 | 22 | 12 | 21 | 13 | 14 | 9 | 150 |
| | No. of rain days - 1997 | 11 | 15 | 12 | - | - | - | - | - | - | - | - | - | 38 |
| | Mean max. temp. ($^{o}$C)-1995 | 27 | 28 | 32 | 35 | 34 | 34 | 31 | 31 | 31 | 29 | 28 | 24 | |
| | Mean max. temp. ($^{o}$C)-1996 | 27 | 27 | 31 | 32 | 33 | 34 | 32 | 32 | 32 | 31 | 28 | 26 | |
| | Mean max. temp. ($^{o}$C)-1997 | 27 | 27 | 30 | - | - | - | - | - | - | - | - | - | |
| | Mean min. temp. ($^{o}$C)-1995 | 18 | 18 | 19 | 21 | 22 | 23 | 22 | 22 | 22 | 21 | 21 | 18 | |
| | Mean min. temp. ($^{o}$C)-1996 | 17 | 17 | 19 | 21 | 22 | 22 | 21 | 22 | 22 | 21 | 20 | 17 | |
| | Mean min. temp. ($^{o}$C)-1997 | 25 | 18 | 18 | - | - | - | - | - | - | - | - | - | |
| Bicol | Mean max. temp. ($^{o}$C)-1995 | 28 | 29 | 29 | 31 | 32 | 33 | 31 | 31 | 31 | 31 | - | 28 | |
| | Mean max. temp. ($^{o}$C)-1996 | 28 | 28 | 29 | 30 | 32 | 31 | 31 | 32 | 32 | 32 | 30 | 28 | |
| | Mean max. temp. ($^{o}$C)-1997 | 28 | 29 | 29 | 32 | 32 | 33 | 31 | 32 | 31 | 32 | 30 | 30 | |
| | Mean min. temp. ($^{o}$C)-1995 | 23 | 23 | 23 | 25 | 25 | 25 | 25 | 24 | 25 | 24 | - | 23 | |
| | Mean min. temp. ($^{o}$C)-1996 | 24 | 24 | 25 | 25 | 26 | 26 | 25 | 25 | 25 | 25 | 25 | 24 | |
| | Mean min. temp. ($^{o}$C)-1997 | 24 | 23 | 23 | 25 | 26 | 25 | 25 | 26 | 24 | 25 | 24 | 24 | |
| IRRI, | Rainfall (mm)-1995 | 11 | 83 | 0 | 5 | 136 | 58 | 262 | 234 | 521 | 274 | 446 | 382 | 2412 |
| Laguna | Rainfall (mm)-1996 | 46 | 10 | 31 | 68 | 95 | 176 | 461 | 161 | 207 | 196 | 393 | 62 | 1905 |
| | Rainfall (mm)-1997 | 17 | 29 | 5 | 5 | 195 | 225 | 373 | 252 | 252 | 34 | 41 | 31 | 1459 |
| | No. of rain days - 1995 | 4 | 3 | 0 | 2 | 8 | 14 | 14 | 18 | 21 | 13 | 16 | 20 | 133 |
| | No. of rain days - 1996 | 7 | 4 | 3 | 11 | 12 | 16 | 15 | 10 | 15 | 13 | 18 | 9 | 133 |
| | No. of rain days - 1997 | 2 | 7 | 1 | 2 | 9 | 13 | 22 | 12 | 18 | 10 | 5 | 4 | 105 |
| | Mean max. temp. (oC)-1995 | 29 | 30 | 32 | 35 | 34 | 34 | 33 | 32 | 31 | 31 | 31 | 28 | |
| | Mean max. temp. ($^{o}$C)-1996 | 29 | 29 | 32 | 32 | 34 | 33 | 32 | 33 | 32 | 33 | 30 | 29 | |
| | Mean min. temp. ($^{o}$C)-1996 | 22 | 22 | 23 | 24 | 25 | 25 | 24 | 24 | 24 | 24 | 24 | 22 | |
| | Mean min. temp. ($^{o}$C)-1997 | 21 | 22 | 22 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 23 | |
| Guba, Cebu | Rainfall (mm)-1996 | - | - | - | - | - | 426 | 41 | 68 | 51 | 372 | 247 | 49 | 1693 |
| | Rainfall (mm)-1997 | 140 | 113 | 34 | 0 | 17 | 40 | 381 | 26 | 333 | 136 | 22 | 37 | 1278 |
| | No. of rain days - 1996 | - | - | - | - | - | 21 | 7 | 6 | 10 | 17 | 12 | 10 | 128 |
| | No. of rain days - 1997 | 10 | 10 | 4 | 0 | 3 | 3 | 13 | 2 | 17 | 6 | 4 | 5 | 77 |
| | Mean max. temp. ($^{o}$C)-1996 | - | - | - | - | - | 32 | 32 | 32 | 33 | 32 | 30 | 29 | |
| | Mean max. temp. ($^{o}$C)-1997 | 30 | 30 | 30 | 32 | 33 | 32 | 33 | 33 | 33 | 31 | 31 | 30 | |
| | Mean min. temp. ($^{o}$C)-1996 | - | - | - | - | - | 25 | 26 | 25 | 25 | 25 | 25 | 24 | |
| | Mean min. temp. ($^{o}$C)-1997 | 23 | 24 | 24 | 25 | 26 | 25 | 25 | 25 | 25 | 25 | 25 | 24 | |

**(continued next page)**

**Appendix 3 (cont.). Actual climatic data at regional evaluation sites in the Philippines.**

| Site | Climatic Data | J | F | M | A | M | J | J | A | S | O | N | D | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Matalom, Leyte | Rainfall (mm)-1995 | 107 | 32 | 151 | 38 | 62 | 216 | 253 | 257 | 325 | 264 | 167 | 286 | 2159 |
| (San Salvador, | Rainfall (mm)-1996 | 214 | 355 | 38 | 114 | 33 | 162 | 113 | 157 | 91 | 161 | 389 | 182 | 2010 |
| Montealegre) | Rainfall (mm)-1997 | 85 | 220 | 137 | 7 | 60 | 165 | 141 | 42 | 258 | 116 | 73 | 81 | 1385 |
| | No. of rain days - 1995 | 14 | 6 | 11 | 6 | 6 | 12 | 20 | 15 | 11 | 17 | 15 | 18 | 151 |
| | No. of rain days - 1996 | 14 | 21 | 12 | 15 | 8 | 16 | 10 | 18 | 14 | 18 | 18 | 15 | 179 |
| | No. of rain days - 1997 | 10 | 13 | 13 | 3 | 8 | 20 | 21 | 5 | 17 | 18 | 15 | 14 | 157 |
| | Mean max. temp. ($^{o}$C)-1995 | 30 | 32 | 32 | 34 | 35 | 34 | 34 | 33 | 33 | 32 | 33 | 32 | |
| | Mean max. temp. ($^{o}$C)-1996 | 31 | 32 | 32 | 33 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | |
| | Mean max. temp. ($^{o}$C)-1997 | 33 | 33 | 33 | 32 | 35 | 35 | 35 | 34 | 32 | 31 | 33 | 32 | |
| | Mean min. temp. ($^{o}$C)-1995 | 25 | 24 | 24 | 26 | 27 | 27 | 26 | 26 | 26 | 26 | 26 | 25 | |
| | Mean min. temp. ($^{o}$C)-1996 | 24 | 24 | 24 | 22 | 24 | 23 | 23 | 23 | 23 | 23 | 23 | 22 | |
| | Mean min. temp. ($^{o}$C)-1997 | 20 | 20 | 19 | 19 | 22 | 23 | 24 | 24 | 24 | 21 | 22 | 22 | |
| Cagayan de Oro | Rainfall (mm)-1995 | 87 | 35 | 48 | 15 | 82 | 258 | 253 | 167 | 273 | 168 | 55 | 288 | 1727 |
| (Pagalungan | Rainfall (mm)-1996 | 72 | 137 | 20 | 189 | 103 | 126 | 146 | 122 | 163 | 144 | 187 | 21 | 1429 |
| and CCC) | Rainfall (mm)-1997 | 100 | 47 | 93 | 25 | 34 | 192 | 208 | 89 | 263 | 163 | 40 | 27 | 1280 |
| | No. of rain days - 1995 | 10 | 6 | 4 | 4 | 10 | 12 | 27 | 18 | 20 | 13 | 7 | 11 | 142 |
| | No. of rain days - 1996 | 12 | 14 | 2 | 9 | 7 | 11 | 13 | 12 | 13 | 9 | 17 | 5 | 124 |
| | No. of rain days - 1997 | 9 | 8 | 5 | 1 | 5 | 12 | 16 | 5 | 12 | 11 | 5 | 4 | 93 |
| | Mean max. temp. ($^{o}$C)-1995 | 32 | 32 | 33 | 34 | 35 | 34 | 33 | 33 | 32 | 33 | 33 | 32 | |
| | Mean max. temp. ($^{o}$C)-1996 | 30 | 30 | 33 | 33 | 34 | 34 | 33 | 34 | 34 | 33 | 32 | 32 | |
| | Mean max. temp. ($^{o}$C)-1997 | 31 | 31 | 32 | 34 | 35 | 34 | 33 | 34 | 34 | 34 | 34 | 33 | |
| | Mean min. temp. ($^{o}$C)-1995 | 22 | 23 | 23 | 23 | 25 | 24 | 24 | 24 | 24 | 25 | 24 | 23 | |
| | Mean min. temp. ($^{o}$C)-1996 | 23 | 22 | 23 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 23 | 23 | |
| | Mean min. temp. ($^{o}$C)-1997 | 22 | 23 | 23 | 23 | 24 | 24 | 23 | 24 | 24 | 23 | 23 | 22 | |
| CMU, Bukidnon | Rainfall (mm)-1992 | 6 | 6 | 3 | 31 | 139 | 219 | 372 | 235 | 100 | 257 | 152 | 120 | 1641 |
| | Rainfall (mm)-1993 | 69 | 78 | 152 | 32 | 141 | 350 | 493 | 322 | 388 | 274 | 195 | 197 | 2691 |
| | Rainfall (mm)-1994 | 43 | 80 | 139 | 84 | 452 | 322 | 199 | 301 | 284 | 156 | 10 | 90 | 2160 |
| | No. of rain days - 1992 | 2 | 2 | 2 | 3 | 11 | 13 | 20 | 13 | 10 | 18 | 8 | 9 | 111 |
| | No. of rain days - 1993 | 5 | 6 | 6 | 6 | 9 | 19 | 19 | 18 | 20 | 15 | 16 | 14 | 153 |
| | No. of rain days - 1994 | 8 | 6 | 10 | 6 | 21 | 27 | 12 | 16 | 21 | 13 | 4 | 9 | 153 |
| | Mean max. temp. ($^{o}$C)-1992 | 33 | 33 | 34 | 36 | 36 | 33 | 33 | 32 | 34 | 32 | 33 | 32 | |
| | Mean max. temp. ($^{o}$C)-1993 | 33 | 33 | 34 | 33 | 35 | 34 | 33 | 32 | 33 | 33 | 33 | 33 | |
| | Mean max. temp. ($^{o}$C)-1994 | 33 | 33 | 33 | 35 | 34 | 33 | 32 | 32 | 30 | 33 | 33 | 32 | |
| | Mean min. temp. ($^{o}$C)-1992 | 19 | 19 | 20 | 21 | 21 | 20 | 20 | 20 | 19 | 19 | 19 | 19 | |
| | Mean min. temp. ($^{o}$C)-1993 | 21 | 20 | 20 | 20 | 21 | 21 | 21 | 20 | 20 | 20 | 20 | 21 | |
| | Mean min. temp. ($^{o}$C)-1994 | 20 | 20 | 21 | 21 | 21 | 21 | 20 | 20 | 20 | 20 | 20 | 20 | |
| PCA, Davao | Rainfall (mm)-1996 | 214 | 92 | 130 | 324 | 289 | 197 | 418 | 318 | 284 | 312 | 201 | 86 | 2865 |
| | Rainfall (mm)-1997 | 557 | 97 | 116 | 302 | 348 | 245 | 229 | 162 | 340 | 331 | 153 | 65 | 2945 |
| | No. of rain days - 1996 | 19 | 15 | 15 | 18 | 16 | 23 | 17 | 24 | 17 | 19 | 17 | 11 | 211 |
| | No. of rain days - 1997 | 17 | 14 | 9 | 13 | 24 | 15 | 16 | 18 | 15 | 25 | 14 | 12 | 192 |
| | Mean max. temp. ($^{o}$C)-1996 | 30 | 30 | 32 | 31 | 30 | 31 | 31 | 31 | 31 | 31 | 31 | 31 | |
| | Mean max. temp. ($^{o}$C)-1997 | 30 | 31 | 31 | 32 | 31 | 31 | 28 | 31 | 30 | 30 | 30 | 30 | |
| | Mean min. temp. ($^{o}$C)-1996 | 20 | 22 | 22 | 21 | 21 | 20 | 20 | 21 | 22 | 21 | 20 | 21 | |
| | Mean min. temp. ($^{o}$C)-1997 | 21 | 22 | 21 | 21 | 22 | 22 | 24 | 21 | 21 | 20 | 21 | 21 | |
| Cotabato | Rainfall (mm)-1996 | 161 | 120 | 107 | 70 | 71 | 79 | 56 | 85 | 137 | 33 | 43 | 61 | 1024 |
| Carmen, M'lang | Rainfall (mm)-1997 | 56 | 35 | 34 | 17 | 48 | 92 | 287 | 15 | 58 | 72 | 46 | 40 | 799 |

## Appendix 4. Establishment success of forages at regional evaluation sites in the Philippines.

| Species | Davao-PCA | IRRI | Montealegre | Guba | Carmen | CMU | Gamu | Aglipay | Bicol | San Salvador | CCC | Pagalungan | M'lang |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A. Grasses for Cut-and-Carry** | | | | | | | | | | | | | |
| *Andropogon gayanus* CIAT 621 | -[a] | 2[a] | 1 | 0 | 0 | 4 | 3 | 4 | - | 2 | 3 | - | 0 |
| *Brachiaria brizantha* CIAT 16318 | - | 4 | - | - | - | - | - | - | - | 3 | - | - | - |
| *Brachiaria brizantha* CIAT 16827 | 2 | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Brachiaria brizantha* CIAT 16835 | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Brachiaria brizantha* CIAT 26110 | 1 | 4 | - | 2 | 2 | - | - | - | - | 4 | 4 | 4 | 2 |
| *Brachiaria brizantha* CIAT 6387 | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Brachiaria brizantha* CIAT 6780 | 2 | 2 | 4 | 0 | 2 | 4 | 4 | 4 | - | 4 | 4 | - | 2 |
| *Pennisetum purpureum* cv. Capricorn | 4 | 4 | 4 | - | - | 4 | - | - | - | 4 | 4 | - | - |
| *Pennisetum purpureum* cv. Mott | 4 | 4 | - | 4 | 4 | - | - | - | - | 4 | 4 | - | 2 |
| *Pennisetum* hybrid 'Florida' | 4 | 4 | - | - | 4 | - | 4 | - | - | 4 | 4 | 4 | 2 |
| *Pennisetum purpureum* 'Local' | 4 | 4 | - | - | 4 | - | - | - | - | 4 | 4 | 4 | 2 |
| *Pennisetum* hybrid 'King' grass | 4 | 4 | - | 4 | - | - | - | - | - | 4 | 4 | - | - |
| *Panicum maximum* CIAT 6299 | 2 | 4 | 4 | 4 | 3 | - | - | - | - | 3 | 4 | - | 1 |
| *Panicum maximum* T58 | 3 | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Panicum maximum* cv. Tanzania | - | - | - | - | - | 4 | - | - | - | - | 4 | - | - |
| *Paspalum atratum* BRA 9610 | 4 | 4 | - | 4 | 4 | - | - | - | - | 4 | 4 | 4 | 4 |
| *Paspalum guenoarum* BRA 3824 | - | 2 | - | - | - | - | - | - | - | - | 0 | - | - |
| *Setaria sphacelata* cv. Golden Timothy | 4 | 4 | - | 4 | 4 | - | - | - | - | - | - | - | 1 |
| *Setaria sphacelata* cv. Splenda | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Setaria sphacelata var. splendida* ex. Indonesia | 4 | 4 | 3 | 4 | 3 | - | - | - | - | 4 | 4 | - | 2 |
| **B. Grasses for Grazing** | | | | | | | | | | | | | |
| *Brachiaria decumbens* cv. Basilisk | 2 | 4 | 3 | - | 2 | 4 | 3 | 3 | 4 | 3 | 4 | 4 | 2 |
| *Brachiaria humidicola* CIAT 6133 | 3 | 4 | - | - | 2 | 4 | - | - | 4 | 3 | 4 | 4 | 2 |
| *Brachiaria humidicola* CIAT16886 | - | 4 | 4 | - | - | 4 | - | - | 4 | 4 | - | - | - |
| *Brachiaria humidicola* CIAT 26149 | - | 2 | - | - | - | 4 | - | - | - | - | - | - | - |
| *Brachiaria humidicola* cv. Tully | 0 | 3 | - | - | 2 | 4 | 4 | 4 | 4 | 2 | 4 | - | 2 |
| *Brachiaria ruziziensis* | - | 4 | - | - | - | 4 | - | - | - | - | - | - | - |
| *Cynodon plectostachyus* | - | - | - | - | - | 4 | - | - | - | - | - | - | - |
| *Stenotaphrum secundatum* cv. Floratam | 3 | 3 | - | - | - | - | - | - | - | - | - | - | - |
| **C. Shrub/tree Legumes** | | | | | | | | | | | | | |
| *Calliandra calothyrsus* ex. Indonesia | 4 | 1 | - | 4 | - | - | - | - | - | - | 3 | - | - |
| *Calliandra calothyrsus* ATF 2014 | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Cratylia argentea* CIAT 18516 | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* ex. IRRI | - | 2 | 4 | - | 4 | - | - | - | - | 2 | 3 | - | 1 |
| *Desmanthus virgatus* CPI 40071 | 3 | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* CPI 52401 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* CPI 82285 (=cv. Bayamo) | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* CPI 91146 | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* CPI 92803 (=cv. Uman) | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmodium cinerea* ex. MBRLC | 4 | 4 | 4 | 4 | 4 | - | 2 | - | - | 4 | 3 | 3 | 1 |
| *Desmodium cinerea* CPI 46561 | - | 4 | - | - | - | 4 | - | - | - | - | - | - | - |
| *Desmodium cinerea* CPI 76099 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Flemingia macrophylla* CIAT 17403 | - | 4 | - | - | - | 4 | - | - | - | 4 | - | - | - |
| *Gliricidia sepium* 'Monterrico' | 4 | 2 | - | 4 | 4 | - | 3 | - | - | 3 | - | - | 1 |
| *Gliricidia sepium* 'Retalhuleu' | 4 | 2 | - | 4 | 4 | - | 3 | - | - | 3 | - | - | 1 |
| *Gliricidia sepium* 'Belen Rivas' | 4 | 2 | - | 4 | 4 | - | 3 | - | - | 3 | - | - | 1 |
| *Gliricidia sepium* 'Local' | 3 | - | 3 | - | 4 | 3 | - | - | - | 3 | 2 | 2 | 1 |
| *Leucaena diversifolia* ex. MBRLC | 1 | - | - | 4 | 3 | - | - | - | - | 1 | - | - | 1 |
| *Leucaena leucocephala* ' Local' | 1 | - | 4 | - | 3 | - | - | - | - | - | 3 | - | 1 |
| *Leucaena leucocephala* K584 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Leucaena leucocephala* K636 | 2 | 4 | 2 | 4 | 3 | 4 | - | - | - | 1 | 2 | 2 | 1 |
| *Leucaena pallida* CQ3439 | 0 | 4 | - | - | 3 | - | - | - | - | - | - | - | - |
| *Sesbania rostrata* ex. IRRI | - | - | - | - | - | - | - | - | - | - | - | - | 2 |
| *Sesbania grandiflora* | - | - | - | - | - | - | - | - | - | - | 3 | - | - |

[a] Rating scale: 0=did not emerge, 1=poor, 2=moderate, 3=good, 4=excellent.

**(continued next page)**

**Appendix 4 (cont.). Establishment success of forages at regional evaluation sites in the Philippines.**

| Species | Davao-PCA | IRRI | Montealegre | Guba | Carmen | CMU | Gamu | Aglipay | Bicol | San Salvador | CCC | Pagalungan | M'lang |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **D. Herbaceous Legumes** | | | | | | | | | | | | | |
| *Aeschynomene histrix* CIAT 9690 | -[a] | 4[a] | - | - | - | - | - | - | - | 4 | - | - | - |
| *Arachis glabrata* cv. Florigraze | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Arachis glabrata* IRFL 3112 | 2 | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Arachis glabrata* CPI 12121 | - | 2 | - | 1 | - | - | - | - | - | - | - | - | - |
| *Arachis glabrata* CPI 93483 | - | 2 | - | 1 | - | - | - | - | - | - | - | - | - |
| *Arachis* hybrid IRFL 3014 | - | 3 | - | - | - | - | 2 | - | - | - | - | - | - |
| *Arachis pintoi* CIAT 17434 | - | 2 | - | 3 | - | 4 | - | 3 | 1 | - | - | - | - |
| *Arachis pintoi* CIAT 18744 | - | 3 | - | - | - | 4 | - | 3 | - | - | 4 | 3 | - |
| *Arachis pintoi* CIAT 18747 | - | 3 | - | - | - | 4 | - | - | - | - | - | - | - |
| *Arachis pintoi* CIAT 18748 | - | 3 | - | - | - | 4 | - | 3 | - | - | - | - | - |
| *Arachis pintoi* CIAT 18750 | - | 3 | - | 3 | - | 4 | - | 3 | 1 | - | - | - | - |
| *Arachis pintoi* CIAT 22160 | 4 | 4 | 3 | 4 | 1 | - | 3 | 4 | - | 3 | 4 | 4 | 1 |
| *Calopogonium caeruleum* CIAT 7304 | 4 | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Calopogonium mucunoides* CIAT 772 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Calopogonium mucunoides* CIAT 822 | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Calopogonium mucunoides* CIAT 17856 | 4 | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Calopogonium mucunoides* CIAT 20709 | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Centrosema acutifolium* CIAT 5277 | 4 | 4 | 3 | - | - | 4 | - | - | - | 4 | 4 | 3 | - |
| *Centrosema acutifolium* CIAT 5568 | - | - | - | - | - | 4 | - | - | - | - | - | - | - |
| *Centrosema macrocarpum* CIAT 25522 | 4 | 4 | - | 0 | - | - | - | - | - | - | 2 | - | - |
| *Centrosema macrocarpum* CIAT 5713 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Centrosema pascuorum* cv. Cavalcade | 2 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Centrosema pubescens* ex. Davao | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Centrosema* mix (CIAT5277, 15160, 15470, 438, 442) | - | - | - | - | - | 4 | - | - | 4 | - | - | - | - |
| *Centrosema pubescens* CIAT 15160 | 4 | 4 | - | - | 3 | - | 3 | 4 | - | 4 | 4 | 4 | 2 |
| *Centrosema pubescens* cv. Cardillo | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Clitoria ternatea* | - | - | - | - | - | - | - | - | - | - | - | - | 2 |
| *Desmodium heterophyllum* CIAT 349 | 3 | 2 | - | - | - | - | - | - | 3 | - | 1 | - | - |
| *Desmodium intortum* | 2 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Desmodium ovalifolium* CIAT 130329 | - | - | - | - | - | 4 | - | - | - | - | - | - | - |
| *Desmodium ovalifolium* CIAT 13305 | 3 | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmodium ovalifolium* CIAT 350 | - | 2 | - | - | - | 4 | - | - | - | - | - | - | - |
| *Desmodium ovalifolium* CIAT 3666 | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Lablab purpureus* cv. Highworth | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| *Lablab purpureus* cv. Rongai | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| *Macroptilium atropurpureum* cv. Aztec | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Macroptilium atropurpureum* cv. Siratro | - | 4 | - | - | - | - | - | - | - | - | - | - | 3 |
| *Macroptilium gracile* cv. Maldonado | 2 | 3 | - | - | - | - | - | - | - | - | - | - | 2 |
| *Mimosa invisa* ex. MBRLC (spineless) | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Mucuna pruriens* CIAT 9349 | 4 | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Pueraria phaseoloides* ex. Davao | 3 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Pueraria phaseoloides* CIAT 7182 | 4 | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Pueraria phaseoloides* CIAT 8042 | 4 | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Pueraria phaseoloides* CIAT 9900 | - | - | - | - | - | - | - | - | - | - | 2 | - | - |
| *Pueraria phaseoloides* CIAT 32118 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT 184 | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | - | 4 | 4 | 4 | 4 |
| *Stylosanthes guianensis* cv. Cook | - | 4 | - | - | - | - | 4 | 4 | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM05-1 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM05-2 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM05-3 | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM07-1 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM07-2 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM07-3 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |

[a] Rating scale: 0=did not emerge, 1=poor, 2=moderate, 3=good, 4=excellent.

## Appendix 5. Yield of forages at regional evaluation sites in the Philippines.

| Species | Davao-PCA | IRRI | Montealegre | Guba | Carmen | CMU | Gamu | Aglipay | Bicol | San Salvador | CCC | Pagalungan | M'lang |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A. Grasses for Cut-and-Carry** | | | | | | | | | | | | | |
| *Andropogon gayanus* CIAT 621 | -[a] | 4[a] | 2 | - | - | 4 | 3 | 4 | - | 3 | 2 | - | - |
| *Brachiaria brizantha* CIAT 16318 | - | 4 | - | - | - | - | - | - | - | 3 | - | - | - |
| *Brachiaria brizantha* CIAT 16827 | 2 | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Brachiaria brizantha* CIAT 16835 | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Brachiaria brizantha* CIAT 26110 | 2 | 4 | - | 4 | 3 | - | - | - | - | 3 | 4 | 4 | 2 |
| *Brachiaria brizantha* CIAT 6387 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Brachiaria brizantha* CIAT 6780 | 2 | 4 | 4 | - | 3 | 3 | 4 | 4 | - | 3 | 4 | - | 2 |
| *Pennisetum purpureum* cv. Capricorn | 4 | 4 | 4 | - | - | 4 | - | - | - | 3 | 4 | - | - |
| *Pennisetum purpureum* cv. Mott | 4 | 3 | - | 4 | 4 | - | - | - | - | 3 | 4 | - | 4 |
| *Pennisetum* hybrid 'Florida' | 4 | 4 | - | - | 4 | - | 4 | - | - | 4 | 4 | 3 | 4 |
| *Pennisetum purpureum* 'Local' | 4 | 4 | - | - | 4 | - | - | - | - | 4 | 4 | 3 | 3 |
| *Pennisetum* hybrid 'King' grass | 4 | 4 | - | 4 | - | - | - | - | - | 3 | 4 | - | - |
| *Panicum maximum* CIAT 6299 | 3 | 4 | 4 | 4 | 3 | - | - | - | - | 3 | 4 | - | 3 |
| *Panicum maximum* T58 | 3 | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Panicum maximum* cv. Tanzania | - | - | - | - | - | 4 | - | - | - | - | 3 | - | - |
| *Paspalum atratum* BRA 9610 | 4 | 4 | - | 4 | 3 | - | - | - | - | 4 | 3 | 4 | 4 |
| *Paspalum guenoarum* BRA 3824 | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Setaria sphacelata* cv. Golden Timothy | 4 | 2 | - | 3 | 3 | - | - | - | - | - | - | - | 2 |
| *Setaria sphacelata* cv. Splenda | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Setaria sphacelata var. splendida* ex. Indonesia | 4 | 4 | 4 | 4 | 3 | - | - | - | - | 4 | 3 | - | 2 |
| **B. Grasses for Grazing** | | | | | | | | | | | | | |
| *Brachiaria decumbens* cv. Basilisk | 4 | 4 | 4 | - | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 4 |
| *Brachiaria humidicola* CIAT 6133 | 3 | 4 | - | - | 3 | 4 | - | - | 3 | 4 | 4 | 4 | 3 |
| *Brachiaria humidicola* CIAT16886 | - | 4 | 4 | - | - | 3 | - | - | 3 | 3 | - | - | - |
| *Brachiaria humidicola* CIAT 26149 | - | 1 | - | - | - | 2 | - | - | - | - | - | - | - |
| *Brachiaria humidicola* cv. Tully | - | 3 | - | - | 3 | 3 | 4 | 4 | 3 | 3 | 4 | - | 3 |
| *Brachiaria ruziziensis* | - | 4 | - | - | - | 3 | - | - | - | - | - | - | - |
| *Cynodon plectostachyus* | - | - | - | - | - | 3 | - | - | - | - | - | - | - |
| *Stenotaphrum secundatum* cv. Floratam | 2 | 2 | - | - | - | - | - | - | - | - | - | - | - |
| **C. Shrub/tree Legumes** | | | | | | | | | | | | | |
| *Calliandra calothyrsus ex.* Indonesia | 4 | 1 | - | 4 | - | - | - | - | - | - | 4 | - | - |
| *Calliandra calothyrsus* ATF 2014 | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Cratylia argentea* CIAT 18516 | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* ex. IRRI | - | 4 | 3 | - | 3 | - | - | - | - | 3 | 2 | - | |
| *Desmanthus virgatus* CPI 40071 | 3 | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* CPI 52401 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* CPI 82285 (=cv. Bayamo) | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* CPI 91146 | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* CPI 92803 (=cv. Uman) | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmodium cinerea* ex. MBRLC | 4 | 3 | 4 | 4 | 3 | - | 2 | - | - | 3 | 4 | 3 | - |
| *Desmodium cinerea* CPI 46561 | - | 4 | - | - | - | 2 | - | - | - | - | - | - | - |
| *Desmodium cinerea* CPI 76099 | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Flemingia macrophylla* CIAT 17403 | - | 4 | - | - | - | 2 | - | - | - | 3 | - | - | - |
| *Gliricidia sepium* 'Monterrico' | 4 | 4 | - | - | 4 | - | 3 | - | - | - | - | - | - |
| *Gliricidia sepium* 'Retalhuleu' | 4 | 4 | - | - | 4 | - | 3 | - | - | - | - | - | - |
| *Gliricidia sepium* 'Belen Rivas' | 4 | 3 | - | - | 4 | - | 3 | - | - | - | - | - | - |
| *Gliricidia sepium* 'Local' | 3 | - | 4 | - | 4 | 4 | - | - | - | 3 | 3 | 4 | - |
| *Leucaena diversifolia* ex. MBRLC | 2 | - | - | 4 | 4 | - | - | - | - | - | - | - | - |
| *Leucaena leucocephala* 'Local' | 1 | - | 4 | - | 3 | - | - | - | - | - | 3 | - | - |
| *Leucaena leucocephala* K584 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Leucaena leucocephala* K636 | 2 | 4 | 3 | 4 | 4 | 4 | - | - | - | - | 3 | 2 | - |
| *Leucaena pallida* CQ3439 | - | 4 | - | - | 4 | - | - | - | - | - | - | - | - |
| *Sesbania rostrata* ex. IRRI | - | - | - | - | - | - | - | - | - | - | - | - | 2 |
| *Sesbania grandiflora* | - | - | - | - | - | - | - | - | - | - | 4 | - | - |

[a] Rating scale: 1=poor, 2=moderate, 3=good, 4=excellent.

**(continued next page**

## Appendix 5 (cont.). Yield of forages at regional evaluation sites in the Philippines.

| Species | Davao-PCA | IRRI | Montealegre | Guba | Carmen | CMU | Gamu | Aglipay | Bicol | San Salvador | CCC | Pagalungan | M'lang |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **D. Herbaceous Legumes** | | | | | | | | | | | | | |
| *Aeschynomene histrix* CIAT 9690 | -[a] | 4[a] | - | - | - | - | - | - | - | 2 | - | - | - |
| *Arachis glabrata* cv. Florigraze | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Arachis glabrata* IRFL 3112 | 2 | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Arachis glabrata* CPI 12121 | - | 3 | - | 2 | - | - | - | - | - | - | - | - | - |
| *Arachis glabrata* CPI 93483 | - | 3 | - | 2 | - | - | - | - | - | - | - | - | - |
| *Arachis* hybrid IRFL 3014 | - | 3 | - | - | - | - | 2 | - | - | - | - | - | - |
| *Arachis pintoi* CIAT 17434 | - | 4 | - | 3 | - | 3 | - | 4 | 2 | - | - | - | - |
| *Arachis pintoi* CIAT 18744 | - | 4 | - | - | - | 3 | - | 4 | - | - | 4 | 3 | - |
| *Arachis pintoi* CIAT 18747 | - | 3 | - | - | - | 3 | - | - | - | - | - | - | - |
| *Arachis pintoi* CIAT 18748 | - | 3 | - | - | - | 3 | - | 3 | - | - | - | - | - |
| *Arachis pintoi* CIAT 18750 | - | 4 | - | 3 | - | 4 | - | 4 | 2 | - | - | - | - |
| *Arachis pintoi* CIAT 22160 | 4 | 4 | 4 | 3 | 3 | - | 3 | 3 | - | 3 | 4 | 3 | 2 |
| *Calopogonium caeruleum* CIAT 7304 | 4 | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Calopogonium mucunoides* CIAT 772 | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Calopogonium mucunoides* CIAT 822 | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Calopogonium mucunoides* CIAT 17856 | 3 | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Calopogonium mucunoides* CIAT 20709 | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Centrosema acutifolium* CIAT 5277 | 3 | 3 | 2 | - | - | 2 | - | - | - | 2 | 3 | 2 | - |
| *Centrosema acutifolium* CIAT 5568 | - | - | - | - | - | 2 | - | - | - | - | - | - | - |
| *Centrosema macrocarpum* CIAT 25522 | 4 | 4 | - | - | - | - | - | - | - | - | 4 | - | - |
| *Centrosema macrocarpum* CIAT 5713 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Centrosema pascuorum* cv. Cavalcade | 2 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Centrosema pubescens* ex. Davao | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Centrosema* mix (CIAT5277, 15160, 15470, 438, 442) | - | - | - | - | - | 3 | - | - | 3 | - | - | - | - |
| *Centrosema pubescens* CIAT 15160 | 4 | 4 | - | - | 4 | - | 3 | 4 | - | 3 | 4 | 3 | 2 |
| *Centrosema pubescens* cv. Cardillo | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Clitoria ternatea* | - | - | - | - | - | - | - | - | - | - | - | - | 4 |
| *Desmodium heterophyllum* CIAT 349 | 3 | 2 | - | - | - | - | - | - | 2 | - | 1 | - | - |
| *Desmodium intortum* | 2 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Desmodium ovalifolium* CIAT 130329 | - | - | - | - | - | 3 | - | - | - | - | - | - | - |
| *Desmodium ovalifolium* CIAT 13305 | 3 | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmodium ovalifolium* CIAT 350 | - | 2 | - | - | - | 3 | - | - | - | - | - | - | - |
| *Desmodium ovalifolium* CIAT 3666 | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Lablab purpureus* cv. Highworth | - | - | - | - | - | - | - | - | - | - | - | - | 3 |
| *Lablab purpureus* cv. Rongai | - | - | - | - | - | - | - | - | - | - | - | - | 3 |
| *Macroptilium atropurpureum* cv. Aztec | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Macroptilium atropurpureum* cv. Siratro | - | 4 | - | - | - | - | - | - | - | - | - | - | 4 |
| *Macroptilium gracile* cv. Maldonado | 2 | 3 | - | - | - | - | - | - | - | - | - | - | 4 |
| *Mimosa invisa* ex. MBRLC (spineless) | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Mucuna pruriens* CIAT 9349 | 4 | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Pueraria phaseoloides* ex. Davao | 3 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Pueraria phaseoloides* CIAT 7182 | 4 | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Pueraria phaseoloides* CIAT 8042 | 2 | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Pueraria phaseoloides* CIAT 9900 | - | - | - | - | - | - | - | - | - | - | 2 | - | - |
| *Pueraria phaseoloides* CIAT 32118 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT 184 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | - | 4 | 4 | 4 | 4 |
| *Stylosanthes guianensis* cv. Cook | - | 4 | - | - | - | - | 3 | 3 | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM05-1 | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM05-2 | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM05-3 | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM07-1 | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM07-2 | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM07-3 | - | 3 | - | - | - | - | - | - | - | - | - | - | - |

[a] Rating scale: 1=poor, 2=moderate, 3=good, 4=excellent.

## Appendix 6. Persistence of forages at regional evaluation sites in the Philippines.

| Species | Davao-PCA | IRRI | Montealegre | Guba | Carmen | CMU | Gamu | Aglipay | Bicol | San Salvador | CCC | Pagalungan | M'lang |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A. Grasses for Cut-and-Carry** | | | | | | | | | | | | | |
| *Andropogon gayanus* CIAT 621 | -[a] | 4[a] | 3 | - | - | 4 | 3 | 4 | - | 4 | 2 | - | - |
| *Brachiaria brizantha* CIAT 16318 | - | 3 | - | - | - | - | - | - | - | 3 | - | - | - |
| *Brachiaria brizantha* CIAT 16827 | 1 | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Brachiaria brizantha* CIAT 16835 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Brachiaria brizantha* CIAT 26110 | 1 | 4 | - | - | 3 | - | - | - | - | 3 | 4 | 4 | 3 |
| *Brachiaria brizantha* CIAT 6387 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Brachiaria brizantha* CIAT 6780 | 1 | 4 | 4 | - | 3 | 4 | 4 | 4 | - | 3 | 4 | - | 3 |
| *Pennisetum purpureum* cv. Capricorn | 1 | 4 | 4 | - | - | 4 | - | - | - | 2 | 4 | - | - |
| *Pennisetum purpureum* cv. Mott | 1 | 4 | - | 4 | 3 | - | - | - | - | 3 | 3 | - | 3 |
| *Pennisetum hybrid* 'Florida' | 1 | 4 | - | - | 3 | - | 4 | - | - | 3 | 3 | 3 | 3 |
| *Pennisetum purpureum* 'Local' | 1 | 4 | - | - | 3 | - | - | - | - | 3 | 3 | 3 | 3 |
| *Pennisetum hybrid* 'King' grass | 1 | 4 | - | 3 | - | - | - | - | - | 3 | 3 | - | - |
| *Panicum maximum* CIAT 6299 | 1 | 4 | 4 | 4 | 3 | - | - | - | - | 3 | 3 | - | 3 |
| *Panicum maximum* T58 | 1 | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Panicum maximum* cv. Tanzania | - | - | - | - | - | 3 | - | - | - | - | 3 | - | - |
| *Paspalum atratum* BRA 9610 | 1 | 4 | - | 4 | 3 | - | - | - | - | 3 | 4 | 4 | 3 |
| *Paspalum guenoarum* BRA 3824 | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Setaria sphacelata* cv. Golden Timothy | 1 | 3 | - | 4 | 3 | - | - | - | - | - | - | - | 3 |
| *Setaria sphacelata* cv. Splenda | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Setaria sphacelata var. splendida* ex. Indonesia | 1 | 4 | 3 | 4 | 3 | - | - | - | - | 4 | 3 | - | 3 |
| **B. Grasses for Grazing** | | | | | | | | | | | | | |
| *Brachiaria decumbens* cv. Basilisk | 1 | 4 | 3 | - | 3 | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 3 |
| *Brachiaria humidicola* CIAT 6133 | 1 | 4 | - | - | 3 | 4 | - | - | 4 | 3 | 4 | 4 | 3 |
| *Brachiaria humidicola* CIAT16886 | - | 4 | 4 | - | - | 4 | - | - | 4 | 4 | - | - | - |
| *Brachiaria humidicola* CIAT 26149 | - | 2 | - | - | - | 3 | - | - | - | - | - | - | - |
| *Brachiaria humidicola* cv. Tully | - | 4 | - | - | 3 | 3 | 4 | 4 | 4 | 3 | 4 | - | 3 |
| *Brachiaria ruziziensis* | - | 4 | - | - | - | 2 | - | - | - | - | - | - | - |
| *Cynodon plectostachyus* | - | - | - | - | - | 4 | - | - | - | - | - | - | - |
| *Stenotaphrum secundatum* cv. Floratam | 1 | 2 | - | - | - | - | - | - | - | - | - | - | - |
| **C. Shrub/tree Legumes** | | | | | | | | | | | | | |
| *Calliandra calothyrsus* ex. Indonesia | 3 | 1 | - | 4 | - | - | - | - | - | - | 4 | - | - |
| *Calliandra calothyrsus* ATF 2014 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Cratylia argentea* CIAT 18516 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* ex. IRRI | - | 4 | 4 | - | 3 | - | - | - | - | 2 | 1 | - | - |
| *Desmanthus virgatus* CPI 40071 | 3 | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* CPI 52401 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* CPI 82285 (=cv. Bayamo) | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* CPI 91146 | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* CPI 92803 (=cv. Uman) | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmodium cinerea* ex. MBRLC | 4 | 4 | 4 | 2 | 3 | - | 2 | - | - | 3 | 4 | 3 | - |
| *Desmodium cinerea* CPI 46561 | - | 4 | - | - | - | 3 | - | - | - | - | - | - | - |
| *Desmodium cinerea* CPI 76099 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Flemingia macrophylla* CIAT 17403 | - | 4 | - | - | - | 3 | - | - | - | 3 | - | - | - |
| *Gliricidia sepium* 'Monterrico' | 3 | 4 | - | - | 3 | - | 3 | - | - | 3 | - | - | - |
| *Gliricidia sepium* 'Retalhuleu' | 3 | 4 | - | - | 3 | - | 3 | - | - | 3 | - | - | - |
| *Gliricidia sepium* 'Belen Rivas' | 3 | 4 | - | - | 3 | - | 3 | - | - | 3 | - | - | - |
| *Gliricidia sepium* 'Local' | 2 | - | 4 | - | 3 | 3 | - | - | - | 4 | 4 | 3 | - |
| *Leucaena diversifolia* ex. MBRLC | 2 | - | - | 4 | 3 | - | - | - | - | - | - | - | - |
| *Leucaena leucocephala* 'Local' | 2 | - | 4 | - | 3 | - | - | - | - | - | 4 | - | - |
| *Leucaena leucocephala* K584 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Leucaena leucocephala* K636 | 2 | 4 | 3 | 3 | 3 | 4 | - | - | - | 1 | 4 | 3 | - |
| *Leucaena pallida* CQ3439 | - | 1 | - | - | 3 | - | - | - | - | - | - | - | - |
| *Sesbania rostrata* ex. IRRI | - | - | - | - | - | - | - | - | - | - | - | - | 2 |
| *Sesbania grandiflora* | - | - | - | - | - | - | - | - | - | - | 4 | - | - |

[a] Rating scale: 1=poor, 2=moderate, 3=good, 4=excellent.

**(continued next page)**

## Appendix 6 (cont.). Persistence of forages at regional evaluation sites in the Philippines.

| Species | Davao-PCA | IRRI | Montealegre | Guba | Carmen | CMU | Gamu | Aglipay | Bicol | San Salvador | CCC | Pagalungan | M'lang |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **D. Herbaceous Legumes** | | | | | | | | | | | | | |
| *Aeschynomene histrix* CIAT 9690 | -[a] | 1[a] | - | - | - | - | - | - | - | 1 | - | - | - |
| *Arachis glabrata* cv. Florigraze | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Arachis glabrata* IRFL 3112 | 3 | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Arachis glabrata* CPI 12121 | - | 4 | - | 2 | - | - | - | - | - | - | - | - | - |
| *Arachis glabrata* CPI 93483 | - | 4 | - | 2 | - | - | - | - | - | - | - | - | - |
| *Arachis* hybrid IRFL 3014 | - | 4 | - | - | - | - | 2 | - | - | - | - | - | - |
| *Arachis pintoi* CIAT 17434 | - | 4 | - | 4 | - | 2 | - | 3 | 1 | - | - | - | - |
| *Arachis pintoi* CIAT 18744 | - | 4 | - | - | - | 3 | - | 3 | - | - | 4 | 4 | - |
| *Arachis pintoi* CIAT 18747 | - | 4 | - | - | - | 2 | - | - | - | - | - | - | - |
| *Arachis pintoi* CIAT 18748 | - | 4 | - | - | - | 2 | - | 3 | - | - | - | - | - |
| *Arachis pintoi* CIAT 18750 | - | 4 | - | 4 | - | 2 | - | 4 | 1 | - | - | - | - |
| *Arachis pintoi* CIAT 22160 | 3 | 4 | 4 | 4 | 3 | - | 3 | 3 | - | 3 | 4 | 4 | 3 |
| *Calopogonium caeruleum* CIAT 7304 | 4 | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Calopogonium mucunoides* CIAT 772 | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Calopogonium mucunoides* CIAT 822 | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Calopogonium mucunoides* CIAT 17856 | 2 | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Calopogonium mucunoides* CIAT 20709 | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Centrosema acutifolium* CIAT 5277 | 4 | 2 | 2 | - | - | 2 | - | - | - | 2 | 3 | 2 | - |
| *Centrosema acutifolium* CIAT 5568 | - | - | - | - | - | 2 | - | - | - | - | - | - | - |
| *Centrosema macrocarpum* CIAT 25522 | 4 | 4 | - | - | - | - | - | - | - | - | 4 | - | - |
| *Centrosema macrocarpum* CIAT 5713 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Centrosema pascuorum* cv. Cavalcade | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Centrosema pubescens* ex. Davao | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Centrosema* mix (CIAT 5277, 15160, 15470, 438, 442) | - | - | - | - | - | 2 | - | - | 4 | - | - | - | - |
| *Centrosema pubescens* CIAT 15160 | 3 | 4 | - | - | 3 | - | 3 | 4 | - | 3 | 4 | 2 | 3 |
| *Centrosema pubescens* cv. Cardillo | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Clitoria ternatea* | - | - | - | - | - | - | - | - | - | - | - | - | 3 |
| *Desmodium heterophyllum* CIAT 349 | 1 | 2 | - | - | - | - | - | - | 4 | - | 1 | - | - |
| *Desmodium intortum* | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Desmodium ovalifolium* CIAT 130329 | - | - | - | - | - | 2 | - | - | - | - | - | - | - |
| *Desmodium ovalifolium* CIAT 13305 | 2 | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmodium ovalifolium* CIAT 350 | - | 2 | - | - | - | 2 | - | - | - | - | - | - | - |
| *Desmodium ovalifolium* CIAT 3666 | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Lablab purpureus* cv. Highworth | - | - | - | - | - | - | - | - | - | - | - | - | 3 |
| *Lablab purpureus* cv. Rongai | - | - | - | - | - | - | - | - | - | - | - | - | 3 |
| *Macroptilium atropurpureum* cv. Aztec | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Macroptilium atropurpureum* cv. Siratro | - | 4 | - | - | - | - | - | - | - | - | - | - | 3 |
| *Macroptilium gracile* cv. Maldonado | 2 | 3 | - | - | - | - | - | - | - | - | - | - | 3 |
| *Mimosa invisa* ex. MBRLC (spineless) | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Mucuna pruriens* CIAT 9349 | 1 | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Pueraria phaseoloides* ex. Davao | 3 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Pueraria phaseoloides* CIAT 7182 | 2 | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Pueraria phaseoloides* CIAT 8042 | 2 | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Pueraria phaseoloides* CIAT 9900 | - | - | - | - | - | - | - | - | - | - | 2 | - | - |
| *Pueraria phaseoloides* CIAT 32118 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT 184 | 2 | 4 | 3 | 3 | 3 | 3 | 4 | 4 | - | 3 | 3 | 3 | 3 |
| *Stylosanthes guianensis* cv. Cook | - | 2 | - | - | - | - | 1 | 2 | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM05-1 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM05-2 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM05-3 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM07-1 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM07-2 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM07-3 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |

[a] Rating scale: 1=poor, 2=moderate, 3=good, 4=excellent.

## Appendix 7. Seed yield potential of forages at regional evaluation sites in the Philippines.

| Species | Davao-PCA | IRRI | Montealegre | Guba | Carmen | CMU | Gamu | Aglipay | Bicol | San Salvador | CCC | Pagalungan | M'lang |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A. Grasses for Cut-and-Carry** | | | | | | | | | | | | | |
| *Andropogon gayanus* CIAT 621 | -[a] | 4[a] | 2 | -2 | - | 2 | 2 | 3 | - | 3 | 2 | - | - |
| *Brachiaria brizantha* CIAT 16318 | - | 3 | - | - | - | - | - | - | - | 3 | - | - | - |
| *Brachiaria brizantha* CIAT 16827 | 0 | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Brachiaria brizantha* CIAT 16835 | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Brachiaria brizantha* CIAT 26110 | 0 | 4 | - | - | - | - | - | - | - | 3 | 4 | 3 | - |
| *Brachiaria brizantha* CIAT 6387 | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Brachiaria brizantha* CIAT 6780 | 0 | 2 | 2 | - | - | 2 | 1 | 2 | - | 3 | 4 | - | - |
| *Pennisetum purpureum* cv. Capricorn | 0 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Pennisetum purpureum* cv. Mott | 0 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Pennisetum hybrid* 'Florida' | 0 | - | - | - | - | - | 0 | - | - | - | - | - | - |
| *Pennisetum purpureum* 'Local' | 0 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Pennisetum hybrid* 'King' grass | 0 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Panicum maximum* CIAT 6299 | 3 | 4 | 2 | - | - | - | - | - | - | 3 | 2 | - | - |
| *Panicum maximum* T58 | 3 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Panicum maximum* cv. Tanzania | - | - | - | - | - | 3 | - | - | - | - | 2 | - | - |
| *Paspalum atratum* BRA 9610 | 0 | 4 | - | - | - | - | - | - | - | 2 | - | - | - |
| *Paspalum guenoarum* BRA 3824 | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Setaria sphacelata* cv. Golden Timothy | 0 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Setaria sphacelata* cv. Splenda | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Setaria sphacelata var. splendida* ex. Indonesia | 0 | - | - | - | - | - | - | - | - | - | - | - | - |
| **B. Grasses for Grazing** | | | | | | | | | | | | | |
| *Brachiaria decumbens* cv. Basilisk | 1 | 2 | 2 | - | - | - | 1 | 2 | - | 2 | 3 | 3 | - |
| *Brachiaria humidicola* CIAT 6133 | 1 | 3 | - | - | - | - | - | - | - | 2 | 2 | 2 | - |
| *Brachiaria humidicola* CIAT16886 | - | 2 | 2 | - | - | - | - | - | - | 2 | - | - | - |
| *Brachiaria humidicola* CIAT 26149 | - | 1 | - | - | - | - | - | - | - | - | - | - | - |
| *Brachiaria humidicola* cv. Tully | - | 2 | - | - | - | - | 1 | 2 | - | 2 | 1 | - | - |
| *Brachiaria ruziziensis* | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Cynodon plectostachyus* | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Stenotaphrum secundatum* cv. Floratam | 0 | - | - | - | - | - | - | - | - | - | - | - | - |
| **C. Shrub/tree Legumes** | | | | | | | | | | | | | |
| *Calliandra calothyrsus* ex. Indonesia | 1 | 1 | - | 4 | - | - | - | - | - | - | 1 | - | - |
| *Calliandra calothyrsus* ATF 2014 | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Cratylia argentea* CIAT 18516 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* ex. IRRI | - | 4 | 3 | - | 4 | - | - | - | - | 3 | 2 | - | - |
| *Desmanthus virgatus* CPI 40071 | 4 | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* CPI 52401 | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* CPI 82285 (=cv. Bayamo) | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* CPI 91146 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* CPI 92803 (=cv. Uman) | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmodium cinerea* ex. MBRLC | 3 | 4 | 4 | 4 | 4 | - | - | - | - | 3 | 3 | 3 | - |
| *Desmodium cinerea* CPI 46561 | - | 3 | - | - | - | 1 | - | - | - | - | - | - | - |
| *Desmodium cinerea* CPI 76099 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Flemingia macrophylla* CIAT 17403 | - | 4 | - | - | - | - | - | - | - | 3 | - | - | - |
| *Gliricidia sepium* 'Monterrico' | 0 | 1 | - | - | - | - | - | - | - | - | - | - | - |
| *Gliricidia sepium* 'Retalhuleu' | 0 | 1 | - | - | - | - | - | - | - | - | - | - | - |
| *Gliricidia sepium* 'Belen Rivas' | 0 | 1 | - | - | - | - | - | - | - | - | - | - | - |
| *Gliricidia sepium* 'Local' | 0 | - | - | - | - | - | - | - | - | 2 | - | - | - |
| *Leucaena diversifolia* ex. MBRLC | 0 | - | - | 4 | 2 | - | - | - | - | - | - | - | - |
| *Leucaena leucocephala* 'Local' | 0 | - | 4 | - | 3 | - | - | - | - | - | - | - | - |
| *Leucaena leucocephala* K584 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Leucaena leucocephala* K636 | 0 | 4 | 3 | 4 | 2 | 2 | - | - | - | - | 2 | - | - |
| *Leucaena pallida* CQ3439 | - | 4 | - | - | 1 | - | - | - | - | - | - | - | - |
| *Sesbania rostrata* ex. IRRI | - | - | - | - | - | - | - | - | - | - | - | - | 3 |
| *Sesbania grandiflora* | - | - | - | - | - | - | - | - | - | - | 2 | - | - |

[a] Rating scale: 1=poor, 2=moderate, 3=good, 4=excellent.

**(continued next page)**

**Appendix 7 (cont.). Seed yield potential of forages at regional evaluation sites in the Philippines.**

| Species | Davao-PCA | IRRI | Montealegre | Guba | Carmen | CMU | Gamu | Aglipay | Bicol | San Salvador | CCC | Pagalungan | M'lang |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **D. Herbaceous Legumes** | | | | | | | | | | | | | |
| *Aeschynomene histrix* CIAT 9690 | -[a] | 4[a] | - | - | - | - | - | - | - | 4 | - | - | - |
| *Arachis glabrata* cv. Florigraze | - | 1 | - | - | - | - | - | - | - | - | - | - | - |
| *Arachis glabrata* IRFL 3112 | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - |
| *Arachis glabrata* CPI 12121 | - | 1 | - | - | - | - | - | - | - | - | - | - | - |
| *Arachis glabrata* CPI 93483 | - | 1 | - | - | - | - | - | - | - | - | - | - | - |
| *Arachis* hybrid IRFL 3014 | - | 1 | - | - | - | - | 0 | - | - | - | - | - | - |
| *Arachis pintoi* CIAT 17434 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Arachis pintoi* CIAT 18744 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Arachis pintoi* CIAT 18747 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Arachis pintoi* CIAT 18748 | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Arachis pintoi* CIAT 18750 | - | 1 | - | - | - | - | - | - | - | - | - | - | - |
| *Arachis pintoi* CIAT 22160 | 3 | 3 | 3 | - | 1 | - | 0 | - | - | 3 | - | - | 1 |
| *Calopogonium caeruleum* CIAT 7304 | 2 | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Calopogonium mucunoides* CIAT 772 | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Calopogonium mucunoides* CIAT 822 | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Calopogonium mucunoides* CIAT 17856 | 1 | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Calopogonium mucunoides* CIAT 20709 | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Centrosema acutifolium* CIAT 5277 | 1 | 3 | 2 | - | - | 2 | - | - | - | 2 | 2 | 1 | - |
| *Centrosema acutifolium* CIAT 5568 | - | - | - | - | - | 2 | - | - | - | - | - | - | - |
| *Centrosema macrocarpum* CIAT 25522 | 1 | 2 | - | - | - | - | - | - | - | - | 2 | - | - |
| *Centrosema macrocarpum* CIAT 5713 | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Centrosema pascuorum* cv. Cavalcade | 2 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Centrosema pubescens* ex. Davao | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Centrosema* mix (CIAT 5277, 15160, 15470, 438, 442) | - | - | - | - | - | 2 | - | - | - | - | - | - | - |
| *Centrosema pubescens* CIAT 15160 | 1 | 4 | - | - | 2 | - | 3 | 4 | - | 3 | 2 | - | 3 |
| *Centrosema pubescens* cv. Cardillo | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Clitoria ternatea* | - | - | - | - | - | - | - | - | - | - | - | - | 2 |
| *Desmodium heterophyllum* CIAT 349 | 1 | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmodium intortum* | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Desmodium ovalifolium* CIAT 130329 | - | - | - | - | - | 3 | - | - | - | - | - | - | - |
| *Desmodium ovalifolium* CIAT 13305 | 2 | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmodium ovalifolium* CIAT 350 | - | 2 | - | - | - | 3 | - | - | - | - | - | - | - |
| *Desmodium ovalifolium* CIAT 3666 | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Lablab purpureus* cv. Highworth | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| *Lablab purpureus* cv. Rongai | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| *Macroptilium atropurpureum* cv. Aztec | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Macroptilium atropurpureum* cv. Siratro | - | 4 | - | - | - | - | - | - | - | - | - | - | 2 |
| *Macroptilium gracile* cv. Maldonado | 2 | 4 | - | - | - | - | - | - | - | - | - | - | 1 |
| *Mimosa invisa* ex. MBRLC (spineless) | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Mucuna pruriens* CIAT 9349 | 2 | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Pueraria phaseoloides* ex. Davao | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Pueraria phaseoloides* CIAT 7182 | 1 | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Pueraria phaseoloides* CIAT 8042 | 2 | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Pueraria phaseoloides* CIAT 9900 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Pueraria phaseoloides* CIAT 32118 | - | 4 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT 184 | 3 | 4 | 3 | 4 | 3 | 3 | 3 | 4 | - | 3 | 3 | 3 | 3 |
| *Stylosanthes guianensis* cv. Cook | - | 4 | - | - | - | - | - | 4 | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM05-1 | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM05-2 | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM05-3 | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM07-1 | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM07-2 | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM07-3 | - | 3 | - | - | - | - | - | - | - | - | - | - | - |

[a] Rating scale: 1=poor, 2=moderate, 3=good, 4=excellent.

## Appendix 8. Pest and disease damage of forages at regional evaluation sites in the Philippines.

| Species | Davao-PCA | IRRI | Montealegre | Guba | Carmen | CMU | Gamu | Aglipay | Bicol | San Salvador | CCC | Pagalungan | M'lang |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A. Grasses for Cut-and-Carry** | | | | | | | | | | | | | |
| *Andropogon gayanus* CIAT 621 | -[a] | 0[a] | 0 | - | - | 0 | 0 | 0 | - | 0 | 0 | - | - |
| *Brachiaria brizantha* CIAT 16318 | - | 0 | - | - | - | - | - | - | - | 0 | - | - | - |
| *Brachiaria brizantha* CIAT 16827 | 1 | 0 | - | - | - | - | - | - | - | - | - | - | - |
| *Brachiaria brizantha* CIAT 16835 | - | 0 | - | - | - | - | - | - | - | - | - | - | - |
| *Brachiaria brizantha* CIAT 26110 | 1 | 0 | - | 0 | 0 | - | - | - | - | 2 | 0 | 0 | 0 |
| *Brachiaria brizantha* CIAT 6387 | - | 0 | - | - | - | - | - | - | - | - | - | - | - |
| *Brachiaria brizantha* CIAT 6780 | 1 | 0 | 2 | - | 0 | 0 | 0 | 0 | - | 1 | 0 | - | 0 |
| *Pennisetum purpureum* cv. Capricorn | 1 | 0 | 0 | - | - | 0 | - | - | - | 1 | 0 | - | - |
| *Pennisetum purpureum* cv. Mott | 1 | 0 | - | 0 | 0 | - | - | - | - | 2 | 0 | - | 0 |
| *Pennisetum hybrid* 'Florida' | 1 | 0 | - | - | 0 | - | 0 | - | - | 1 | 0 | 0 | 0 |
| *Pennisetum purpureum* 'Local' | 1 | 0 | - | - | 0 | - | - | - | - | 0 | 0 | 0 | 0 |
| *Pennisetum hybrid* 'King' grass | 1 | 0 | - | 0 | - | - | - | - | - | 1 | 0 | - | - |
| *Panicum maximum* CIAT 6299 | 1 | 0 | 0 | 0 | 0 | - | - | - | - | 1 | 1 | - | 0 |
| *Panicum maximum* T58 | 1 | 0 | - | - | - | - | - | - | - | - | - | - | - |
| *Panicum maximum* cv. Tanzania | - | - | - | - | - | 0 | - | - | - | - | 1 | - | - |
| *Paspalum atratum* BRA 9610 | 1 | 0 | - | 0 | 0 | - | - | - | - | 0 | 0 | 0 | 0 |
| *Paspalum guenoarum* BRA 3824 | - | 0 | - | - | - | - | - | - | - | - | - | - | - |
| *Setaria sphacelata* cv. Golden Timothy | 1 | 0 | - | 0 | 0 | - | - | - | - | - | - | - | 0 |
| *Setaria sphacelata* cv. Splenda | - | 0 | - | - | - | - | - | - | - | - | - | - | - |
| *Setaria sphacelata var. splendida* ex. Indonesia | 1 | 0 | 0 | 0 | 0 | - | - | - | - | 0 | 0 | - | 0 |
| **B. Grasses for Grazing** | | | | | | | | | | | | | |
| *Brachiaria decumbens* cv. Basilisk | 1 | 0 | 1 | - | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| *Brachiaria humidicola* CIAT 6133 | 1 | 0 | - | - | 0 | 0 | - | - | 1 | 0 | 0 | 0 | 0 |
| *Brachiaria humidicola* CIAT16886 | - | 0 | 0 | - | - | 0 | - | - | 1 | 0 | - | - | - |
| *Brachiaria humidicola* CIAT 26149 | - | 0 | - | - | - | 0 | - | - | - | - | - | - | - |
| *Brachiaria humidicola* cv. Tully | - | 0 | - | - | 0 | 0 | 0 | 0 | 1 | 0 | 0 | - | 0 |
| *Brachiaria ruziziensis* | - | 0 | - | - | - | 0 | - | - | - | - | - | - | - |
| *Cynodon plectostachyus* | - | - | - | - | - | 0 | - | - | - | - | - | - | - |
| *Stenotaphrum secundatum* cv. Floratam | 1 | 0 | - | - | - | - | - | - | - | - | - | - | - |
| **C. Shrub/tree Legumes** | | | | | | | | | | | | | |
| *Calliandra calothyrsus* ex. Indonesia | 0 | 0 | - | 0 | - | - | - | - | - | - | 0 | - | - |
| *Calliandra calothyrsus* ATF 2014 | - | 0 | - | - | - | - | - | - | - | - | - | - | - |
| *Cratylia argentea* CIAT 18516 | - | 0 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* ex. IRRI | - | 0 | 0 | - | 0 | - | - | - | - | 0 | 1 | - | 0 |
| *Desmanthus virgatus* CPI 40071 | 1 | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* CPI 52401 | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* CPI 82285 (=cv. Bayamo) | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* CPI 91146 | - | 0 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmanthus virgatus* CPI 92803 (=cv. Uman) | - | 0 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmodium cinerea* ex. MBRLC | 0 | 0 | 1 | 0 | 1 | - | 0 | - | - | 0 | 4 | 0 | 0 |
| *Desmodium cinerea* CPI 46561 | - | 0 | - | - | - | 0 | - | - | - | - | - | - | - |
| *Desmodium cinerea* CPI 76099 | - | 0 | - | - | - | - | - | - | - | - | - | - | - |
| *Flemingia macrophylla* CIAT 17403 | - | 0 | - | - | - | 0 | - | - | - | 0 | - | - | - |
| *Gliricidia sepium* 'Monterrico' | 0 | 0 | - | 0 | 0 | - | 0 | - | - | 0 | - | - | 0 |
| *Gliricidia sepium* 'Retalhuleu' | 0 | 0 | - | 0 | 0 | - | 0 | - | - | 0 | - | - | 0 |
| *Gliricidia sepium* 'Belen Rivas' | 0 | 0 | - | 0 | 0 | - | 0 | - | - | 0 | - | - | 0 |
| *Gliricidia sepium* 'Local' | 0 | - | 0 | - | 0 | 0 | - | - | - | 1 | 0 | 0 | 0 |
| *Leucaena diversifolia* ex. MBRLC | 1 | - | - | 0 | 2 | - | - | - | - | 0 | - | - | 0 |
| *Leucaena leucocephala* 'Local' | 2 | - | 0 | - | 2 | - | - | - | - | - | 2 | - | 0 |
| *Leucaena leucocephala* K584 | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Leucaena leucocephala* K636 | 2 | 2 | 0 | 0 | 2 | 2 | - | - | - | 0 | 1 | 0 | 0 |
| *Leucaena pallida* CQ3439 | - | 0 | - | - | 0 | - | - | - | - | - | - | - | - |
| *Sesbania rostrata* ex. IRRI | - | - | - | - | - | - | - | - | - | - | - | - | 0 |
| *Sesbania grandiflora* | - | - | - | - | - | - | - | - | - | - | 1 | - | - |

[a] Rating scale: 0=no pest/diseases, 1=little damage, 2=moderate damage, 3=severe damage, 4=plants killed.

**(continued next page)**

**Appendix 8 (cont.). Pest and disease damage of forages at regional evaluation sites in the Philippines.**

| Species | Davao-PCA | IRRI | Montealegre | Guba | Carmen | CMU | Gamu | Aglipay | Bicol | San Salvador | CCC | Pagalungan | M'lang |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **D. Herbaceous Legumes** | | | | | | | | | | | | | |
| *Aeschynomene histrix* CIAT 9690 | -[a] | 0[a] | - | - | - | - | - | - | - | 1 | - | - | - |
| *Arachis glabrata* cv. Florigraze | - | 0 | - | - | - | - | - | - | - | - | - | - | - |
| *Arachis glabrata* IRFL 3112 | 1 | 0 | - | - | - | - | - | - | - | - | - | - | - |
| *Arachis glabrata* CPI 12121 | - | 0 | - | 0 | - | - | - | - | - | - | - | - | - |
| *Arachis glabrata* CPI 93483 | - | 0 | - | 0 | - | - | - | - | - | - | - | - | - |
| *Arachis* hybrid IRFL 3014 | - | 0 | - | - | - | - | 0 | - | - | - | - | - | - |
| *Arachis pintoi* CIAT 17434 | - | 0 | - | 0 | - | 0 | - | 0 | 0 | - | - | - | - |
| *Arachis pintoi* CIAT 18744 | - | 0 | - | - | - | 0 | - | 0 | - | - | 0 | 1 | - |
| *Arachis pintoi* CIAT 18747 | - | 0 | - | - | - | 0 | - | - | - | - | - | - | - |
| *Arachis pintoi* CIAT 18748 | - | 0 | - | - | - | 0 | - | 0 | - | - | - | - | - |
| *Arachis pintoi* CIAT 18750 | - | 0 | - | 0 | - | 0 | - | 0 | 0 | - | - | - | - |
| *Arachis pintoi* CIAT 22160 | 2 | 0 | 1 | 0 | 0 | - | 0 | 0 | - | 0 | 0 | 1 | 1 |
| *Calopogonium caeruleum* CIAT 7304 | 2 | 0 | - | - | - | - | - | - | - | - | - | - | - |
| *Calopogonium mucunoides* CIAT 772 | - | 0 | - | - | - | - | - | - | - | - | - | - | - |
| *Calopogonium mucunoides* CIAT 822 | - | 0 | - | - | - | - | - | - | - | - | - | - | - |
| *Calopogonium mucunoides* CIAT 17856 | 2 | 0 | - | - | - | - | - | - | - | - | - | - | - |
| *Calopogonium mucunoides* CIAT 20709 | - | 0 | - | - | - | - | - | - | - | - | - | - | - |
| *Centrosema acutifolium* CIAT 5277 | 2 | 0 | 1 | - | - | 3 | - | - | - | 0 | 1 | 3 | - |
| *Centrosema acutifolium* CIAT 5568 | - | - | - | - | - | 3 | - | - | - | - | - | - | - |
| *Centrosema macrocarpum* CIAT 25522 | 2 | 0 | - | - | - | - | - | - | - | - | 1 | - | - |
| *Centrosema macrocarpum* CIAT 5713 | - | 0 | - | - | - | - | - | - | - | - | - | - | - |
| *Centrosema pascuorum* cv. Cavalcade | 4 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Centrosema pubescens* ex. Davao | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Centrosema* mix (CIAT5277, 15160, 15470, 438, 442) | - | - | - | - | - | 2 | - | - | 1 | - | - | - | - |
| *Centrosema pubescens* CIAT 15160 | 2 | 1 | - | - | 1 | - | 0 | 0 | - | 0 | 1 | 0 | 1 |
| *Centrosema pubescens* cv. Cardillo | - | 0 | - | - | - | - | - | - | - | - | - | - | - |
| *Clitoria ternatea* | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| *Desmodium heterophyllum* CIAT 349 | 1 | 0 | - | - | - | - | - | - | 1 | - | 3 | - | - |
| *Desmodium intortum* | 3 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Desmodium ovalifolium* CIAT 130329 | - | - | - | - | - | 1 | - | - | - | - | - | - | - |
| *Desmodium ovalifolium* CIAT 13305 | 2 | 0 | - | - | - | - | - | - | - | - | - | - | - |
| *Desmodium ovalifolium* CIAT 350 | - | 0 | - | - | - | 1 | - | - | - | - | - | - | - |
| *Desmodium ovalifolium* CIAT 3666 | - | 0 | - | - | - | - | - | - | - | - | - | - | - |
| *Lablab purpureus* cv. Highworth | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| *Lablab purpureus* cv. Rongai | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| *Macroptilium atropurpureum* cv. Aztec | - | 1 | - | - | - | - | - | - | - | - | - | - | - |
| *Macroptilium atropurpureum* cv. Siratro | - | 1 | - | - | - | - | - | - | - | - | - | - | 1 |
| *Macroptilium gracile* cv. Maldonado | 3 | 1 | - | - | - | - | - | - | - | - | - | - | 1 |
| *Mimosa invisa* ex. MBRLC (spineless) | - | 0 | - | - | - | - | - | - | - | - | - | - | - |
| *Mucuna pruriens* CIAT 9349 | 1 | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Pueraria phaseoloides* ex. Davao | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Pueraria phaseoloides* CIAT 7182 | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - |
| *Pueraria phaseoloides* CIAT 8042 | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - |
| *Pueraria phaseoloides* CIAT 9900 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Pueraria phaseoloides* CIAT 32118 | - | 1 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT 184 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | - | 0 | 0 | 0 | 1 |
| *Stylosanthes guianensis* cv. Cook | - | 3 | - | - | - | - | 4 | 4 | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM05-1 | - | 0 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM05-2 | - | 0 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM05-3 | - | 0 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM07-1 | - | 0 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM07-2 | - | 0 | - | - | - | - | - | - | - | - | - | - | - |
| *Stylosanthes guianensis* CIAT FM07-3 | - | 0 | - | - | - | - | - | - | - | - | - | - | - |

[a] Rating scale: 0=no pest/diseases, 1=little damage, 2=moderate damage, 3=severe damage, 4=plants killed.

# Developing and evaluating forage technologies with farmers

# Farmer evaluation of forages in the Philippines: Progress, experiences, and future plans

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On-farm evaluation of forages in cooperation with the Forages for Smallholders Project (FSP) in the Philippines began in 1995. From then on, the work expanded to include seven sites located in the Visayas and Mindanao regions (Table 1).

Collaborators based at the sites include non-government organizations, state colleges/universities, local government units, and the Philippine Coconut Authority (PCA). These institutions have personnel based in the communities. These collaborators had previous working relationships with either the Southeast Asian Forage Seeds Project or the Philippine Council for Agriculture, Forestry, and Natural Resources Research and Development (PCARRD) through its Regional Forage Performance Trials (RPT) Network and Pilot Provincial Agricultural Extension Project (PPAEP). All had previous experience in research and development work either with forages or with farmers.

**Table 1. Collaborators and location of FSP sites in the Philippines.**

| Site (start of work) | Collaborator | Forage-related activities |
|---|---|---|
| Guba, Cebu (June1996) | Mag-uugmad Foundation Incorporated (MFI) | Promotion of agroforestry technologies; facilitation of livestock dispersal |
| Matalom, Leyte (June 1995) | Farm and Resource Management Institute (FARMI), Visayas State College of Agriculture (ViSCA) | Development and promotion of upland agricultural technologies |
| Cagayan de Oro (Oct 1995) | City Veterinary Office | Livestock improvement and dispersal; livestock extension |
| Malitbog, Bukidnon (Oct 1996) | Office of the Municipal Agriculturist | Agricultural extension including livestock dispersal |
| Davao (Jul 1997) | Philippine Coconut Authority | Small coconut farmer development |
| Cotabato – 2 sites (Aug 1996) | Philippine Carabao Centre at University of Southern Mindanao;<br>Gagmayang Kristohanong Katilingban – Kidapawan Diocesan Federation of Cooperatives | Forage research (USM);<br>Cooperative development (GKK-KDFC) |

## Description of sites

Tables 2 and 3 provide brief descriptions of FSP sites in the Philippines. A more detailed description of these sites is shown in Appendix 1.

[1] Forages for Smallholders Project, CIAT, c/o IRRI, College, Los Baños, Laguna, Philippines.
[2] Livestock Research Division, PCARRD, Los Baños, Laguna, Philippines.
[3] Mag-uugmad Foundation Inc., Manreza Building Inc., F. Ramos St., Cebu City, Philippines.
[4] FARMI, Visayas State College of Agriculture, Baybay, Leyte, Philippines.
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[8] Philippine Carabao Center, University of Southern Mindanao, Kabacan, Cotabato, Philippines.

**Table 2. Physical characteristics of FSP sites in the Philippines.**

| Site | Latitude | Altitude (m) | Annual rainfall (mm) | Wet season (start-end) | Wet months (>50 mm) |
|---|---|---|---|---|---|
| Cebu | 10° N | 550 | 1500 | Jun – Dec | 12 |
| Matalom | 10° N | 0 - 300 | 1970 | Jun – Dec | 12 |
| Cagayan de Oro | 8° N | 185 | 1500 | Jun – Nov | 12 |
| Malitbog | 8° N | 700 | 1830 | Jun – Oct | 12 |
| Davao | 7° N | 175 - 360 | 2210 | May – Oct | 12 |
| Carmen, M'lang | 7° N | <200 m | 1600 | May – Nov | 8 |

Most of the sites are upland, except for M'lang, Cotabato, which is rainfed lowland. The site in Davao is mainly under coconuts, while the others are planted mainly to annual crops. Soils are generally of the clay loam type, with pH varying from acidic to slightly acidic, and moderate to good fertility. Cagayan de Oro and Matalom have soils with pH higher than 7. All the upland sites vary in topography, from slightly undulating to steep. Altitude varies from less than 100 m to more than 500 m above sea level. Erosion is a problem at all upland sites. Matalom and, to a lesser extent, Cebu are prone to typhoons during the rainy season.

All sites have farms that are crop-based, but livestock play a vital role as source of draft power and cash income. Often, maize is the major food and rice is cultivated in valleys or flat areas. Farmers in M'lang and Carmen plant fruit tree, crops, rubber and sugarcane. Fruit crops, vegetables, and ornamentals are cultivated in Cebu and Davao. Farmers in Cagayan de Oro and Malitbog plant banana as a cash crop. Farmers in all sites (except those in Matalom) use fertiliser.

The sale of crops and livestock is a major source of cash income in most sites, except in Matalom where food crops are mostly for subsistence and farmers gain income from sale of other products like toddy, bamboo, etc., as well as remittances received from household members working off-farm. All the sites experience an increase in area devoted to crop production, thereby reducing the grazing areas available for ruminants.

All farmers raise carabao, cattle, and goats. Carabao and cattle (only in Cagayan de Oro and Malitbog) are used as draft animals except in Davao where farmers rely more on tractors. Goats are popularly raised for cash only in M'lang. In all sites, except Cebu and Davao (dairy animals), ruminants are tethered in vacant areas to graze on native vegetation with basically minimal or no supplementation.

Farmers in Davao raise dairy cattle. These animals are stall-fed and are provided with commercial feeds and cut herbage. Some farmers in Davao also practice semi-commercial poultry production. Farmers in Cebu also practice stall-feeding with forage but not commercial concentrates.

**Table 3. Description of soils and farming systems at FSP sites in the Philippines.**

| Site | Soil Characteristics | Farming system |
|---|---|---|
| Cebu, Visayas | • Sandy clay<br>• PH 4.8-6.5<br>• Moderate fertility<br>• Well-drained<br>• Eroded; rolling to steep topography | • Both upland cropping and agroforestry (tree farms, hedgerow) system<br>• Small area and intensive<br>• Crops: maize, vegetable, fruit trees, flowers<br>• Crops are fertilised and sold for cash<br>• Animals include carabao (draft), cattle and goats<br>• Ruminants are stall-fed with herbage from hedgerows; little grazing |
| Matalom, Leyte, Visayas | • Clay loam<br>• Two soil types:<br>• Acid (pH4.8-<7)<br>• Low P and high Al saturation,<br>• Calcareous (pH>7)<br>• Well-drained<br>• Eroded; rolling to steep | • Upland cropping (crop-fallow rotation)<br>• Crops: maize (calcareous), rainfed rice (valleys and flat areas), upland rice (acid), root crops and coconut<br>• Crops not fertilised; mainly for consumption<br>• Animals include carabao (draft), cattle, goats<br>• Ruminants tethered to graze on native vegetation with no or minimal supplementation |
| Cagayan de Oro, northern Mindanao | • Clay loam<br>• pH 5.8-8.8<br>• Good fertility<br>• Well-drained<br>• Eroded<br>• Rolling to steep | • Upland cropping<br>• Crops: maize, banana, coconut, root crops<br>• Crops fertilised and for cash<br>• Animals include carabao (draft), cattle (draft), horses, goats<br>• Ruminants tethered to graze on native vegetation with no or minimal supplementation |
| Malitbog, Bukidnon, MIndanao | • Clay-loam<br>• pH 5.6<br>• Low N and P<br>• Well-drained<br>• Eroded<br>• Rolling to steep | • Upland cropping<br>• Crops: maize, banana, coffee, coconut, vegetables, root crops<br>• Crops fertilised and for cash<br>• Animals include carabao (draft), cattle (draft), goats<br>• Ruminants tethered to graze on native vegetation with no or minimal supplementation |
| Davao, Mindanao | • Clay-loam<br>• pH 5.1-5.6<br>• Fertile<br>• Well-drained<br>• Eroded<br>• Rolling to steep | • Under coconut<br>• Crops: coconut, maize, banana, fruit trees, vegetables, flowers<br>• Crops fertilised and for cash<br>• Animals include carabao (less use for draft), cattle (beef and dairy), goats<br>• Ruminants (except dairy cattle) tethered to graze on native vegetation with no or minimal supplementation<br>• Dairy cattle stall fed with forages with concentrate supplementation |
| Carmen, North Cotabatu, Mindanao | • Clay-loam<br>• pH 6.5<br>• Fertile<br>• Well-drained<br>• Eroded<br>• Rolling to steep | • Upland cropping<br>• Crops : corn, upland rice, coffee, coconut, vegetables, fruit trees<br>• Crops fertilised and for cash<br>• Animals include carabao (draft), cattle, goats<br>• Ruminants tethered to graze on native vegetation with no or minimal supplementation |
| M'lang, North Cotabatu, Mindanao | • Clay-loam<br>• pH 6.5-7<br>• Fertile<br>• Well-drained<br>• Flat | • Rainfed lowland<br>• Crops: maize, rice, rubber, sugarcane, fruit trees<br>• Crops fertilised and for cash<br>• Animals include carabao (draft), cattle, goats<br>• Ruminants tethered to graze on native vegetation with no or minimal supplementation |

Table 4 shows a summary of the problems identified by farmers and those addressed by on-farm activities in the respective sites. Insufficiency of feed was a problem cited in all sites. This was the result of increased animal population and more area being devoted to crops. Unavailability of feed was a problem especially in the dry season in most sites. In M'lang, lack of feed persists during the cropping season, when most areas are planted to crops. Soil erosion, despite being evident in all upland sites, was recognized as a problem only in Malitbog and Davao.

**Table 4. Summary of problems identified[1] by farmers during participatory diagnosis and addressed[2] by the FSP.**

| Problem | Cebu | Matalom | Cagayan de Oro | Malitbog | Davao | Carmen | M'lang |
|---|---|---|---|---|---|---|---|
| Lack of feed due to limited grazing area | ✗ ✔ | ✗ ✔ | ✗ ✔ | ✗ ✔ | ✗ ✔ | ✗ ✔ | ✗ ✔ |
| Lack of feed in dry season | ✗ ✔ | ✗ ✔ | ✗ ✔ | - | - | ✗ ✔ | ✗ ✔ |
| Uncontrolled grazing | - | ✗ ✔ | ✗ ✔ | ✗ ✔ | ✗ ✔ | ✗ ✔ | ✗ ✔ |
| Increase in unpalatable weeds | - | - | ✗ ✔ | ✗ ✔ | - | ✗ ✔ | - |
| Diseases in animals | - | | - | - | - | - | ✗ |
| Poor animal performance | - | ✗ | - | - | - | ✗ | - |
| Unavailability of adapted forages | - | - | - | - | ✗ ✔ | - | - |
| High cost of concentrates | - | - | - | - | ✗ ✔ | - | - |
| Lack of food | - | - | - | ✗ | - | - | - |
| Low crop production | - | - | - | ✗ | - | - | - |
| Increasing need for fertiliser | - | - | - | - | ✗ | - | - |
| Disease in crops | - | - | - | - | ✗ | - | - |
| Soil erosion | - | - | - | ✗ ✔ | - | - | - |
| Flooding in cropped areas | - | - | - | - | ✗ | - | - |
| Low market price | - | - | - | - | ✗ | - | - |
| Lack of capital | - | - | - | - | ✗ | - | - |

[1] ✗ = Problem identified by farmers.
[2] ✔ = Problem addressed by on-farm activities.

In most sites, farmers considered the feed unavailability problem to have just started. Consequently, most farmers (except in Cebu) still have access to other farmers' grazing area and restrictions have not been implemented. Thus, in most sites, uncontrolled grazing becomes a big problem for farmers who have tried to establish forages. In addition, farmers in Cagayan de Oro, Malitbog, Davao, and Carmen reported an increase in unpalatable weeds in the grazing areas, pointing out that some degree of overgrazing has occurred.

Farmers in Davao expressed a need for adapted forages. These farmers have tried establishing plots of Napier grass for their dairy cattle. They observed that this species was not able to persist under their management system (cut-and-carry with some degree of uncontrolled grazing).

Farmers in the sites have evolved some coping mechanisms in times of feed unavailability. These include taking the animals to far-away areas to graze and gathering tree leaves, banana trunks, and green forage as feed for animals.

More details on the results of the PDs are included in Appendix 2.

## Activities conducted in the sites

Activities vary in terms of nature and time (Table 5). The basic procedure involves consulting the farmers (PD and planning), followed by the establishment of initial testing and multiplication area, and then individual testing by farmers. In between these stages, field days, trainings, and cross-visits are done. Regular meetings with farmers provide a venue for sharing experiences (participatory evaluation) and are a means for maintaining the initial testing area. Likewise, visits to farmers were done to gather feedback.

**Table 5. Summary of activities at FSP sites in the Philippines.**

| | Cebu | Matalom | Cagayan de Oro | Malitbog | Davao | Carmen | M'lang |
|---|---|---|---|---|---|---|---|
| **Type of Activity (no. of farmers)** | | | | | | | |
| Communal – formal[1] | - | ✔ (3) | ✔ (6) | ✔ (4) | - | ✔ (1) | ✔ (1) |
| Individual – formal[1] | ✔ (4) | ✔ (10) | ✔ (12) | - | ✔ (1) | - | - |
| Individual – informal[2] | ✔ (30) | ✔ (21) | ✔ (300) | ✔ (15) | -[3] | ✔ (2) | -[3] |
| **Method of planting material distribution** | | | | | | | |
| Field days | ✔ | ✔ | ✔ | ✔ | - | - | - |
| Individual contact | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| **Possible forage types/options** | | | | | | | |
| Grasses for cut-and-carry | | | | | | | |
| - in hedgerows | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| - in blocks | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| Grasses for grazing | - | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| Herbaceous legumes | | | | | | | |
| - for grazing | - | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| - as cover crops | ✔ | ✔ | ✔ | ✔ | ✔ | - | - |
| - for soil improvement | ✔ | ✔ | ✔ | ✔ | - | - | - |
| - as relay to main crop | - | - | - | - | - | - | - |
| Tree/shrub legumes | | | | | | | |
| - in hedgerows | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | - |
| - in fence lines | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| - in blocks | - | ✔ | ✔ | - | - | - | - |

[1] Technicians and farmers together decide on what species and what option to test.
[2] Farmers chose the species and option by themselves.
[3] To be started.

The initial testing and multiplication areas were established and managed by farmer groups. The decision on which species to try is made after consultation between collaborators and farmers. These areas were very useful for conducting field days and trainings. Farmers look at the species and decide for themselves which ones they would like to try individually.

There were some cases when farmers and collaborators agreed to collaboratively set up more formal forage experiments, testing them for a certain option. This usually involves key farmers who test a range of species for a specific purpose. These experiments are used not only for the purpose of demonstration but also as basis of comparison among species. These farmers live far from the initial testing area and are requested to join when farmers in nearby areas choose only a limited range of species. The major criteria for selecting farmer-cooperators were their interest and the availability of their areas to try out the forages. Whenever possible, innovative farmers who possess leadership skills and good communication abilities were chosen.

Planting materials were distributed either during field days or upon individual requests. The latter seems to lead to better establishment, since the farmer is usually ready at the time he makes the request for planting materials. This was done in cases when farmers wanted a large amount of planting materials.

On the other hand, farmers always ask for planting materials during field days. In such cases farmers are advised to prepare an area before the field day. Otherwise, they request the farmers to plant a few hills near their house, later to serve as source of planting materials if farmers want to expand forages on their farm.

More details on the activities at each site are shown in Appendix 3.

# Progress of forage technology development, evaluation, and adoption

### General observations

The pace and progress of on-farm work varied between sites because of the different starting times of the activities. Sites that started early are already into individual farmer testing and into trainings and field days as well as participatory evaluation of most forages except legume trees (still in nursery). On the other hand, sites that commenced on-farm work more recently are still in the initial testing and multiplication stage. Sites that began work between these two periods are in the process of maintaining their initial testing areas as well as finding more farmers to test the forages.

In sites that started early, a major proportion of the work consists of informal testing with individual farmers since the more formal initial testing and multiplication areas (Matalom, Cagayan de Oro and Malitbog) have already been established. The other sites are still in the more formal stage of initial evaluation and multiplication.

Collaborators observed that it takes time for establishing forages with farmers. Factors like farmer availability and occurrence of dry periods often slow down the process despite frequent visits and careful scheduling.

Farmers, who have a strong need for forages, are the ones who establish forages , first; they even approach the technicians and get their planting materials ahead of their scheduled date. On the other hand, there are farmers who get planting materials only because of peer pressure. And then there are also the 'wait-and-see' types of farmers. Farmer visits, field days, trainings, and cross-visits were very useful in sustaining the interest of farmers. During these activities, farmers and technicians share ideas, learn from each other, and plan activities.

It was also observed that more farmers who obtained planting materials come from places where livestock dispersal programs exist. This implies that forage technology development would be facilitated if implemented with a livestock improvement program. Moreover, successful forage establishment was facilitated in cases where strong farmer organizations exist. The existence of *alayon* (mutual help groups) was a big factor in the rapid establishment of forages in individual farmers' fields. The same factor was instrumental in the establishment and maintenance of the initial testing and multiplication plots.

### Farmers' feedback

Farmers reacted well to the participatory approach. They felt involved and free to choose whatever species, options, and establishment method they wanted. Involving these farmers in field days and in training other farmers has been beneficial for both trainees and trainers as well.

In establishing a structured forage set-up farmers thought that establishment of forage mixtures as designed by technicians was complicated. This aspect has to be considered when establishing species mixtures on-farm.

In terms of individual forage species, farmer preferences varied with sites. At the early stages (initial testing and multiplication), farmers tended to prefer species which grew well and showed good yield potential. Their major criteria were adaptability to local conditions and ability to provide an adequate amount of herbage.

When farmers tested forages on their own farms and started to feed them to their animals, new criteria surfaced. For grazing species, farmers realized the value of grazing tolerance, ability to spread and produce ground cover, and palatability to

animals. For instance, Matalom farmers found *B. humidicola* to spread fast, to tolerate close grazing, and to be palatable.

*Arachis pintoi* was found to thrive well under shade, making it useful as a cover crop (in Cagayan de Oro and Cebu) and was palatable to rabbits (in Davao). A farmer in Malitbog observed improved egg production when his ducks started feeding on *A. pintoi*.

Farmers favoured tall and upright grasses like Napier (King, cv. Mott and Florida), *P. maximum*, *Setaria sphacelata* var*. splendida*, *Brachiaria brizantha* and *B. decumbens* as cut-and-carry species because of their good yield and palatability. In addition *S. sphacelata* var. *splendida* was found to have good regrowth/tillering ability and good tolerance for occasional flooding and did not cause itchiness when cut.

Two farmers in Malitbog (*P. maximum* CIAT 6299) and the farmer group in Cagayan de Oro (Napier grass) evaluated the effect of fertilisation on the cut-and-carry species. They observed that yield was increased and they were able to take cuttings as frequently as every 2 weeks.

*Brachiaria brizantha* CIAT 6780 was observed to be affected by *Rhizoctonia* (or *Cercospera*?) in some sites. A rare case of bacterial and fungal infection occurred in upright grasses like Napier, *B. brizantha* and *P. maximum* CIAT 6299 at the initial testing and multiplication area of Matalom. The case occurred in the dry season with the species left uncut for a long time. The symptoms were alleviated and did not recur at the start of the wet season and thereafter.

Farmers have also observed that legumes like *Centrosema pubescens* and S*tylosanthes guianensis* 184 were not as palatable to animals as grasses. These cases were noted when these species were planted side by side with grasses. Moreover, these legumes were found to have low persistence under heavy grazing. In addition, farmers observed that *Desmodium heterophyllum* CIAT 349 and *Arachis pintoi* did not persist when weeds dominated them.

Farmers favoured legumes like Stylo 184, Desmanthus *virgatus,* and *Desmodium cinerea* because of their good growth, palatability, and yield. These species have been tried and found suitable as hedgerows in some sites.

**Farmer management of different species**

As of this stage, most individual farmers are still planting the species in small plots (either in blocks or short hedgerow lines) either near their houses or in portions of their farms. The species are either grazed or cut and fed to animals from time to time.

A farmer in Carmen planted Napier near a spring that supports the community's water needs. He observed that since the forages were planted, the well did not dry up as quickly during dry season and it did not become flooded with muddy water in the wet season.

Other upright grasses (Napier grass) and shrub legumes (*D. virgatus*) were also planted as live fence. *Arachis pintoi* was established by a farmer in Cagayan de Oro in her yard and became a good lawn material. A farmer in Cebu also planted this species as a cover crop for his grapes. Both are now expanding their planted area.

Many farmers have started expanding the areas planted to forages. These are mostly cut-and-carry species.

**Learning from participatory evaluation**

Participatory evaluation (PE) has been done in most sites especially in the initial testing and multiplication area. Farmers observed the species and commented on their performance. In some sites where individual testing has been done, farmers'

observations of the forages that they established were also taken. An open-ended evaluation method was used.

Farmers' comments varied, depending on whether they have planted and used the species in their own farms. Most comments of farmers who have not used the species were just perceptions on how good and useful the species are. The perceptions are usually related to their previous experiences with native species and what they have heard during training. For instance, it is not unusual to hear comments about the usefulness of a species (*Leucaena diversifolia*) in providing firewood and improving soil fertility even at the seedling stage.

In evaluations at this stage, the most useful information is the farmers' criteria for choosing the species that they want to adopt. These are '*high herbage yield that gives plenty of feed even from a small area'* or '*the good adaptation of the species because of its good growth*'. Similarly, insights on how farmers could integrate forages in their farms are also obtained. Comments like '*this species can be used for hedgerow/fence*' provide ideas on how farmers may utilise different species.

On the other hand, evaluation of farmers who have established the species themselves can give information on the characteristics related to the utilization of a particular species. This includes information on regrowth ability, itchiness when cutting, persistence, reaction to utilization, as well as palatability and effect of forages when fed to animals.

There is still a need to gain more experience and skills in evaluation techniques such as probing and asking questions as well as getting farmers' criteria in selecting a certain species. In the process of evaluation, many things can happen and the person handling the evaluation must know how to deal with the situation. These skills can only be obtained by practice, reflection, and training. Every evaluation session is different from another.

## Technical issues

In working with forages on-farm, a major issue is the production and handling of seeds. At this stage, most forage establishment is done using vegetative planting materials. The problem is exacerbated by the fact that there is no existing commercial market for forage seeds in the Philippines. Moreover, seed production attempts at the farmers' level have not been successful. Greater attention must be given to seed production research to induce rapid adoption of forages.

# Appendices

## Appendix 1. Detailed Description of FSP Sites in the Philippines.

### Guba, Cebu:

*General description of the area*

- Guba is located in the uplands of Cebu, central Philippines (10°25' N).
- Average annual rainfall is about 1495 mm, with peak rainfall from June to December. Considerable rains (>50 mm) are experienced throughout the year.
- Soils are sandy clay and moderately fertile with pH varying from 4.8 to 6.5.
- It is an upland area consisting of slightly rolling to steep hills.
- About 50% of the area (slightly rolling to moderately steep) is used for cropping (maize, vegetables, and flowers) and agroforestry while steeper areas are either used as tree farms (mangoes, fruit trees, and forest species). There are few areas with native vegetation which are used as pasture land.

*Description of the community*

- Farmers in Guba have been cultivating their areas since 1945 when the area was forested. These farmers were traditional suppliers of vegetables and flowers for Cebu City.
- There are two dominant upland farming systems: purely cropping and agroforestry (contour hedgerows and trees inter-planted with crops). Livestock are also kept to support cropping as well as a source of income and food.
- They grow maize (basically for home consumption) as well as cash crops like flowers, vegetables, and fruits like mangoes. Forest tree species like Gmelina are likewise grown in small tree farms. Commercial and organic fertiliser application is a common practice.
- Almost all of the farmers (90%) keep livestock for draft (carabao), cash income, and food for special occasions. These animals are either owned or availed of from dispersal programs. The predominant production system is breeding or reproduction. Few farmers attempt to fatten cattle for slaughter. These animals are marketed through middlemen who purchase them on a per head basis.
- Ruminants are mainly stall-fed with cut-and-carry herbage from hedgerows and vegetation around the farm with some grazing within the farm area. Due to limitations in area, farmers do not allow other animals to graze in their own farm. Inputs like de-wormers and veterinary medicine are used. Commercial feed supplements are not used.
- Farmers in the area are either owners or tenants in the farms.
- Cropping system shifts from monocropping to intensive farming (agroforestry integrating livestock). Livestock management is gradually changing from purely grazing/tethering to stall-feeding.

### Matalom, Leyte

*General description of the area*

- Matalom is located on the southwest coast of Leyte island, Central Philippines (10o17' N).
- Average annual rainfall is about 1972 mm, with peak rainfall from June to December. Considerable rains (>50 mm) are experienced throughout the year. The area is prone to typhoons that occur between June and December.
- Soils are clay loam and moderately fertile. Two types of soil exist in the area: a) acid soils (pH 4.5-5.5, low P, and high Al saturation) and b) calcareous soils (pH >7).
- It is an upland area consisting of rolling to steep hills. Slightly rolling areas have acid soils and form the dominant landscape (47% of total area), covering the coastal portion and lower elevations (up to around 100 m asl) while calcareous soils are in the steeper and higher altitude areas (up to 300 m asl) inland.
- The flat areas near the coast are used mainly for rice production. Most of the sloping areas are used for upland cropping under a crop-fallow rotation system. The system involves cropping for a few seasons before the area is left fallow to regenerate soil fertility. During the fallow period, these areas become dominated by native vegetation and are used as common grazing areas for livestock. In the steeper slopes which are not suitable to grazing, fallow areas are often dominated by trees (predominantly *Leucaena leucocephala*) which are used for firewood. Sloping areas are planted to upland crops during the cropping period while valleys, where water catchment is possible, are planted to rainfed lowland rice. There is a recent increase in irrigated areas in the slightly sloping portions where irrigation is possible.

*Description of the community*

- Farmers in Matalom have been cultivating their areas since 1910 when the area was forested. Upland crops are planted.
- The dominant farming system in the sloping areas is upland cropping with livestock being kept to support cropping as well as a source of income and food. Valleys and water catchment areas are used for rainfed lowland rice.
- The slightly sloping and undulating acid soil areas are planted to upland rice, sweet potato and peanut. The higher calcareous areas are planted to maize and root crops such as sweet potato, yam, and gabi. Rainfed rice is planted in valleys both in the acid soil and calcareous areas. Most of the produce is used for home consumption with little surplus sold.
- Almost all farmers keep livestock for draft (carabao), cash income and food for special occasions. These animals are either owned or availed of under local sharing arrangement (alima). The predominant production system is breeding or reproduction; fattening for slaughter is not practiced except for swine. These animals are marketed through middlemen who purchase them on a per head basis. A farm household usually raises 1-2 heads of carabao or cattle. Commercial de-wormers and veterinary drugs are sometimes used.
- Ruminants are mainly tethered in vacant areas to graze on native vegetation. Supplementation is minimal (usually only done for draft animals during periods of peak use). No commercial feed supplements are used; only cut forage, corn stover and other available crop residues. During long dry periods when native vegetation for grazing becomes scarce, farmers use tree leaves and banana trunk as feed.
- Farmers in the area are either owners or tenants in the farms. Tenure arrangements are unclear.
- There is a recent move toward agroforestry in the upland areas. The area being irrigated is also increased with the initiative of the local government.
- Sale of products from bamboo, coconut toddy, small stores, abaca and remittances from household members working in Manila or abroad are primary sources of income. Sale of livestock, especially cattle, is the secondary source of income.

**Pagalungan, Cagayan de Oro**

*General description of the area*

- Pagalungan is located in Misamis Oriental Province in the Mindanao Region. Farms are generally hilly (up to 50% slope) with reasonable soil fertility. Upland management includes cultivation of coconut, abaca, and upland rice. The plain valley, on the other hand, is cultivated for coconut, rice, and banana.
- Soil pH ranges from 5.1 to 8.8; the lower limit of the range is more common while the upper limit occurs in eroded areas. Soil type is clay loam. Altitude is 185 m asl.
- The area has two types of climate: type 2 = no dry season with a pronounced maximum rainfall from Nov to Jan and type 3 = relatively dry from Nov to Apr and wet for the rest of the year. Average annual rainfall is 1500.87 mm.

*Description of the community*

- Pagalungan is 19 km from the capital of Misamis Oriental which is Cagayan de Oro. The area is hilly with vast expanses of uncultivated bushlands and grasslands (cogon). About 80% of the people belong to the Higaonon tribe, native to the place but assimilated to lowland culture.
- There are more than 850 ha of public timber and only 192 ha of alienable and disposable land.
- Maize constitutes the main product of 90% of the farm families. Only 7% rely on coconut as a major source of income. Root crops and bananas are regular crops. Patches of flat and lightly rolling country are suitable for a variety of crops such as pineapple with pasture intercropped. There are only a few work animals.
- Livestock ownership varies among species: carabao and horse are 100% owned; cattle is 75% owned, 15% on loan coming from the Cattle Breeding Program funded by PPAEP, and 10% from the Cattle Dispersal Program funded by the City Vet; and pigs and goats are 90% owned.
- Animals are tethered among native vegetation in vacant areas; some are left to graze along the road, river, or under coconut trees with minimal or no supplements at all (farmers use corn bran). Only a few farmers practice cut-and-carry.
- Farmers are now integrating forage into their farming system. Others increased the number of their livestock due to the good performance of their animals.

**Malitbog, Bukidnon**

*General description of the area*

- Malitbog is located in Bukidnon which is a landlocked province in the central part of northern Mindanao.
- It is predominantly an agricultural province with about 38% of the total land area devoted to agricultural crops, livestock/poultry, and vegetables. With rich fertile soil, big processing/manufacturing firms put up large-scale plantation-type farms in the area.
- Wet season occurs from June to October with an average annual rainfall of 1826.15 mm.
- Soil has a pH range of 5.6 – 6.5 and has three major soil types: clay loam, sandy loam, and loam.

*Description of the community*

- Brgy. San Luis ,Malitbog, Bukidnon, located at 700 m asl, was formerly inhabited by natives (Bukidnons). With an estimated land area of 38,867.75 ha., farming (90.2%) is the major source of income. This is followed by employment in government (2.5%), private firms, (2.2%), and self-employed (1.9%).
- Maize, rice, banana, coffee, coconut, a variety of root crops, and vegetables are the major crops planted by farmers while cows, carabao, chickens, pigs, horse, ducks, and goats are being raised in the municipality as draft animals (carabao), for market (cattle, chicken) and for home consumption (chicken).
- 95% of the farmers are keeping livestock. Ruminants are usually tethered. But now, it can be observed that cut-and-carry is being done specially in pilot areas. There are still farmers though with large areas who are still not concerned with forage cropping. Corn bran feeding is done during the bumper harvest of corn in the months of August-September and November-December.

**Riverside, Davao**

*General description of the area*

- Riverside is located in Calinan District (7o05' N), Davao City in the island of Mindanao.
- Average annual rainfall is 2215 mm with peak rainfall from May to October. Considerable rains (>50 mm) are experienced throughout the year.
- Soils vary from silty loam in the flat areas to clay loam in the higher areas. In the upland areas, soil pH is around 5.1-5.6. Drainage and fertility are good.
- The barangay is located at an elevation around 175 m asl. Topography is generally rolling in the upper portions and flat in the valleys and lower portions.
- Most of the area is used for agricultural purposes (97%). Only a small portion (3%) is used for residential and other purposes.

*Description of the community*

- Farmers in Riverside settled in the area from as early as 1965. Majority were settlers from the Visayas while the rest were from Luzon. The area was originally forested. As early as 1940s, the natives and the Japanese were already practicing agriculture in the area. The Japanese introduced abaca cultivation while the natives were cultivating food crops. The abaca was later wiped out with a disease. This paved the way for cultivation of other crops. In 1965, the area was offered to settlers who then settled and cultivated the land.
- Upland farming with high-value cash crops is the dominant system. Small flat areas have irrigation and are planted to lowland rice. Vacant lands are used as common grazing areas.
- Most of the flat portions in the area are planted to rice or vegetables. Areas near the house are used for flower production. The sloping areas are often planted to coconut and other fruit trees. Maize is planted either as intercrop to coconut or in the open. Fertilisation and use of chemical inputs are widely practiced.
- Livestock raised include carabao, cattle (both beef and dairy), goats, swine, chickens and ducks. Almost all farmers keep livestock for draft (carabao to a little extent due to presence of tractors), cash income, and food for special occasions and domestic consumption. These animals are mostly owned except for dairy and Brahman beef cattle, which are obtained as loan from a government program. The predominant production system is breeding or reproduction fattening for slaughter is not practiced except for swine and broiler poultry. These animals are marketed through middlemen who purchase them on a per head basis. There are fewer carabao than cattle in the area because of availability of tractors for ploughing. Dairy cattle are intensively managed for milk production (complete with commercial and home-mixed concentrates, supplements, and biologics). Beef cattle and carabao are managed to a lesser extent, with minimal supplementation; however, veterinary medicines and de-wormers are also used.

- Ruminants except dairy cattle are mainly tethered in vacant areas to graze on native vegetation. Supplementation is seldom practiced. No commercial feed supplements are used; only cut forage and other available crop residues. On the other hand, dairy cattle are stall-fed with cut forages and provided with commercial supplements and concentrate (either home-mixed or purchased as premix).
- Almost all of the farms are owned by the farmers themselves.
- Tractors replaced carabao for draft. With the expansion of dairy production and the use of vacant areas for high-value crops, availability of grazing space has decreased. Commercial poultry and swine operations as well as conversion of some areas for commercial or industrial purposes are also evident.
- Sale of agricultural products (coconut, milk, and other farm products) is the primary source of income. Working in the city as well as in other farms is the next major source of income.

**Malagos, Davao**

*General description of area*

- Malagos is located in Bagio District (7o05' N), Davao City in the island of Mindanao.
- Average annual rainfall is 2215 mm with peak rainfall from May to October. Considerable rains (>50 mm) are experienced throughout the year.
- The soil is clay loam, generally fertile, and well drained with good texture. Soil pH is around 5.2-5.6.
- The barangay is located at an elevation around 354 m asl. Topography is generally rolling to steep in the upper portions and flat in the valleys and lower portions.
- Most of the area is used for agricultural purposes (82%). Only a small portion (18%) is used for residential, resort, and government reserve purposes (basically the highest part which is a forest and watershed of Davao City).

*Description of the community*

- The present farmers in Riverside settled in the area as early as 1970. Majority came from Visayas while the rest were from Luzon. The area was originally forested. Since the early 1940s, the natives and Japanese were already practicing agriculture in the area. The Japanese introduced abaca cultivation while the natives were cultivating food crops. Abaca was later wiped out with a disease (1950s). This paved the way for cultivation of other crops. In 1970, the area was offered to settlers who then settled and cultivated the land. From the late 1970s to the 1980s, most of the area was abandoned due to unstable peace and order situation. However, when the situation stabilized, a greater number of farmers came and settled in the area.
- Upland farming with high-value cash crops is the dominant system. Commercial poultry and swine production is likewise practiced. Small flat areas have irrigation and are planted to lowland rice. Vacant lands are used as common grazing areas.
- Most of the flat portions in the area are planted to rice or vegetables. Areas near residences are used for flower production. The sloping areas are often planted to coconut and other fruit trees. Maize is planted either as intercrop to coconut or in the open. Fertilisation and use of chemical inputs are widely practiced.
- Almost all of the farmers (96%) raise livestock -- these include carabao, cattle (both beef and dairy), goats, swine, chickens, and ducks. Almost all of the farmers keep livestock for draft (carabao to a little extent due to presence of tractors), cash income, and food for special occasions and domestic consumption. These animals are mostly owned except for dairy and Brahman beef cattle, which were loaned from a government program. The predominant production system is breeding or reproduction fattening for slaughter is not practiced except for swine and broiler poultry. These animals are marketed through middlemen who make purchases on a per head basis. There are fewer carabao than cattle in the area because availability of tractors for ploughing. Dairy cattle are intensively managed for milk production (complete with commercial and home-mixed concentrates, supplements, and biologics). Beef cattle and carabao are managed to a lesser extent, with minimal supplementation; however, veterinary medicines and de-wormers are also used.
- Ruminants except dairy cattle are mainly tethered in vacant areas to graze on native vegetation. Supplementation is seldom practiced. No commercial feed supplements are used; only cut forage and other available crop residues. On the other hand, dairy cattle are stall-fed with cut forages and provided with commercial supplements and concentrate (either home-mixed or purchased as premix).
- Majority of the farms (70%) are owned by the farmers. The rest are either tenanted or under lease.
- There is a recent change from carabao to tractors as source of draft power. With expansion of dairy production and use of vacant areas for high-value crops, grazing space availability has

decreased. Commercial poultry and swine operations as well as conversion of some areas for commercial or industrial purposes also occur.
- Sale of agricultural products (coconut, milk, and other farm products) is the primary source of income.

**Carmen, Cotabato**

*General description of area*

- Carmen is located in the north-western part of Cotabato province (7o17' N) in the island of Mindanao.
- Average annual rainfall is 1593 mm with peak rainfall from May to November. Considerable rains (>50 mm) are experienced throughout the year.
- Soils are clay loam with pH around 6.5 and of good fertility.
- The southern portion is somewhat flat, and gradually becomes rolling, then steep, as one goes to the north.
- Most of the area is used for agriculture. There is still a small forest in the municipality. Only a small portion is used for residential and commercial purposes. The flat areas are planted to rice (especially irrigated) and maize. Rolling areas are planted to maize and upland rice. Steeper areas are used for rubber and other plantation crops.

*Description of the community*

- Farmers in Carmen settled in the area as early as 1940. Majority were settlers from Visayas while the rest were from Luzon. There are also some natives in the area. The area was originally forested. The settlers and loggers started clearing the area and paved the way for settled cultivation.
- Upland farming is the dominant system. Small flat areas have irrigation and are planted to lowland rice. Vacant lands are used as common grazing areas.
- Maize and upland rice are the dominant food crops in the upland area. Rubber, cotton, mungbean, peanut, coffee, banana, coconut, and mangoes are also cultivated. Rice is the sole crop in irrigated areas. Fertiliser and chemicals are applied to all these crops.
- Majority of the farmers (75%) raise livestock. These include carabao, cattle, goats, swine, chickens, and ducks. Almost all farmers keep livestock for draft (carabao), cash income, and food for special occasions and domestic consumption. These animals are either owned or availed of under a local sharing arrangement. The predominant production system is breeding or reproduction. Fattening for slaughter is not practiced except for swine. These animals are marketed through middlemen who purchase them on a per head basis. A farm household usually raises 1-2 heads of carabao or cattle and a few heads of goat. Commercial de-wormers and veterinary drugs are sometimes used.
- Ruminants are mainly tethered in vacant areas to graze on native vegetation during the day and then they are kept near the house at night. Supplementation is seldom practiced (usually only done for draft animals during periods of peak utilization). No commercial feed supplements are used, only cut forage and other available crop residues.
- Presently, some areas which were once vacant or planted to maize have been converted for planting of sugarcane and other high-valued crops (e.g. durian, mangoes, rambutan, and others). This change has also caused a decrease in grazing/tethering area for livestock.
- Sale of agricultural products (both crops and livestock) is the main source of income. Running small businesses like stores and acting as middlemen in the sale of agricultural products are secondary sources of income (15 % of households).

**M'lang, Cotabato**

*General description of area*

- M'lang is located in the south-eastern part of Cotabato province (7o10' N) in the island of Mindanao.
- Average annual rainfall is 1593 mm with peak rainfall from May to November. Considerable rains (>50 mm) are experienced throughout the year.
- Soils are clay loam pH ranging from 6.5 to 7.0 and of good fertility.
- The town has the widest flatlands in the Philippines (38,900 ha).
- Most of the area is used for agricultural purposes (77%). The rest are either used as fishponds (15.57%), institutional areas, residential, commercial, and road areas.

*Description of the community*

- Farmers in M'lang settled in the area in the early 1930s. Majority came from the Visayas (Panay Island) while the rest came from Northern and Central Luzon (Ilocos, Pampanga).

There are also some ethnic groups/natives in the area. The area was originally forested. The settlers themselves started clearing the area and paved the way for settled cultivation.

- Rainfed farming is the dominant system, representing two-thirds of the total agricultural area. The rest is irrigated rice area which is located near two major rivers. Freshwater fishponds are also common.
- Rice is the dominant crop in both irrigated and rainfed ecosystems. In the rainfed area, the other crops planted include rubber, sugarcane, coconut, banana, fruit trees, and coffee. All crops are fertilised and food crops are raised both for commercial and household consumption.
- Livestock raised include carabao, cattle, goats, swine, chickens, ducks and turkeys. Almost all farmers keep livestock for draft (carabao), cash income, and food for special occasions and domestic consumption. These animals are either owned or availed of under a local sharing arrangement. The predominant production system is breeding or reproduction fattening for slaughter is not practiced except for swine. These animals are marketed through middlemen who purchase them on a per head basis. A farm household usually raises 1-2 heads of carabao or cattle and a few heads of goat. Commercial de-wormers and veterinary drugs are sometimes used.
- Ruminants are mainly tethered in vacant areas to graze on native vegetation. Supplementation is minimal (usually only done for draft animals during periods of peak utilization). No commercial feed supplements are used; only cut forage and other available crop residues. During the dry season, when native vegetation for grazing becomes scarce, farmers cut and carry native grasses and tree leaves for feeding. A similar practice is done while the rice crop is growing due to limitations in grazing area.
- Sale of agricultural products (both crops and livestock, especially goats), working as hired labourers (both agricultural and non-agricultural) and remittances from household members working in Manila or abroad are primary sources of income.

## Appendix 2. Results of Participatory Diagnoses at FSP sites in the Philippines.

### Matalom, Leyte

- Attendance : The 24 farmers participating in the PD were members of alayon groups coming from Barangay San Salvador, Matalom, Leyte.
- Problems identified by farmers :
  1) Lack of feed during dry season caused by the limited grazing area and insufficient knowledge of new technologies;
  2) poor animal nutrition and performance leading to low productivity (parasite/disease susceptibility especially in carabao; underweight and overworked animals)
  3) uncontrolled grazing.
- Coping mechanisms:
  1) Bringing animals to faraway places for grazing
  2) Using tree leaves and banana trunks for feed when all the native vegetation dries out
  3) Consulting livestock experts regarding animal diseases and giving supplementary inputs to animals;
  4) Getting exchange/hired labour to help in land preparation
- Decision: The farmer group agreed to work with FSP to evaluate forages for cut-and-carry and for grazing on their own land. First, they will try the species as a group. The results of the group activity will be used to decide which species the farmers will try individually. The species they plan to test will include those that can be used as hedgerows and fence lines.

### Pagalungan, Cagayan de Oro

- Attendance: The 26 farmers participating in the PD were members of existing farmer associations (Tribal and Settlers Association, Women's Association) in the barangay. Some barangay officials likewise attended the meeting.
- Problems identified by farmers :
  1) Lack of feed especially during the dry season
  2) Increase in unpalatable weeds (especially Chromolaena odorata) in existing grazing areas
  3) Insufficient feed due to increase in number of animals and areas devoted to cropping
  4) Uncontrolled grazing
- Coping mechanisms:
  1) Use of cut-and-carry native forages existing near rivers and waterways as well as using banana trunks and rice bran for feeding during the dry season
  2) Grazing in vacant areas owned by other farmers

3) Establishing their own forage areas – only a few; problem of illegal grazing and decline of forage productivity

- Decision: The farmer groups agreed to test the species for cut-and-carry and for grazing. The plan was to try out as a group first. The results of the initial trial will be the basis for selecting species for individual farmer testing. The species for testing also include those which could be used as fence lines, cover crops/weed control, and contour hedgerows.

**Malitbog, Bukidnon**

- Attendance: Three participatory diagnoses were done involving members of farmer associations (rural improvement clubs [women's groups] and cooperatives) in sitios within Barangay San Luis, Malitbog, Bukidnon. These farmers were beneficiaries of the animal dispersal programs of the Department of Agriculture (either goat or cattle).
- Problems identified by farmers:
  1) Lack of food for the household due to low production and income
  2) Low crop production due to surface runoff
  3) Soil erosion
  4) Insufficient quality and quantity of feed due to limited area for grazing brought about by an increase in cropping area
  5) Increase in unpalatable weeds (especially Imperata cylindrica) in existing grazing areas
  6) Uncontrolled grazing
- Coping mechanisms:
  1) Establishment of contour hedgerows using forages and stones
  2) Adopting multi-cropping technology (banana-maize-vegetable)
  3) Planting of other food crops like banana, ubi, gabi, and sweet potato
  4) Tethering animals in faraway areas
  5) Establishing forages in marginal areas and small plots near houses
  6) Cut-and-carry system for native forages and trees existing near rivers and waterways as well as using banana trunk and rice bran as feed during the dry season
  7) Grazing in vacant areas owned by other farmers
- Decisions: The farmer groups agreed to test the species for cut-and-carry and for grazing. The plan was to establish forages both in individual and common farms with the help of the whole group (*alayon*).

**Aroman, Carmen**

- Attendance: The 26 farmers who participated in the PD were members of a cooperative coordinated by a non-government organization (Gagmayng Kristohanong Katilingban-Kidapawan Diocesan Federation of Cooperatives).
- Problems identified by farmers:
  1) Lack of feed due to increase in cropped area, number of animals, and number of unpalatable weeds
  2) Poor animal performance due to feed scarcity
  3) Lack of feed specially during the dry season
- Coping mechanisms:
  1) Planting of forages such as Napier grass, *Desmodium cinerea*, and *Flemingia macrophylla*;
  2) Using stunted maize plants to feed the animals.
- Decisions of the farmers will test different forage species for grazing and cut-and carry. They will at first establish and manage the evaluation in a common farm as a group. The results of the initial evaluation will be the basis for selecting the species that will be tested individually. The area shall therefore serve as initial multiplication and testing site. The species that they plan to test will include those which can be used as hedgerows and fence lines.

**M'lang, Cotabato**

- Attendance: The 24 farmers who participated in the PD came from different barangays around Pag-asa, M'lang, Cotabato. All were members of cooperatives coordinated by a non-government organization (Gagmayng Kristohanong Katilingban-Kidapawan Diocesan Federation of Cooperatives).
- Problems identified by farmers:
  1) Lack of feed due to increase in cropped area and in numbers of animals
  2) Lack of feed in the dry season and during the rice cropping period
  3) Occurrence of diseases in animals (diarrhoea, respiratory symptoms, liver fluke)
- Coping mechanisms:
  1) Cut-and-carry native forages whenever feed is scarce (especially during rice cropping season)

2) Grazing in vacant areas owned by other farmers
3) Uncontrolled grazing

- Decision: The farmer groups agreed to test species for cut-and-carry, grazing, as well as those that can be used as relay crops for rice (during dry season). Some of these species were useful as fence lines. The plan was to try out as a group first. The results of the initial trial will be the basis for selecting species for individual farmer testing. One of the cooperatives located in the common testing area was assigned to maintain the plots but all the other cooperatives were to help in the planting and in the evaluation. The initial evaluation area was also intended to serve as source of planting materials for individual testing.

**Malagos, Davao City**

- Attendance: The 16 farmers participating in the PD were members of either small coconut farmers' organization (SCFO) or a dairy cooperative or both. Barangay officials likewise attended the meeting.
- Problems identified by farmers:
  1) Diseases and low market price of crops and livestock
  2) Decreasing feed supply due to increase in cattle population and cropped areas
  3) Increase in cost of concentrate feeds for dairy animals
  4) Unavailability of adapted and productive forages
  5) Lack of capital for proper establishment of forages
  6) Increasing need of fertiliser for crops
  7) Uncontrolled grazing
- Coping mechanisms:
  1) Grazing in vacant areas owned by other farmers
  2) Maintaining a manageable number of animals by selling and sharing excess animals
  3) Establishing their own forage areas – only a few; problem of illegal grazing and decline of forage productivity
- Decision: A field day was conducted after the PD. The farmers made a list of species they would try in their area. The plan is to try out as a group first. The results of the initial trial will be the basis for selecting species for individual farmer testing. The species farmers wanted to test include those that were useful for grazing, cut-and-carry, and as cover crops under coconut. The initial testing area shall serve as source of planting materials for individual farmer testing.

**Riverside, Davao City**

- Attendance: The 10 farmers who participated in the PD were members of either a small coconut farmer organization (SCFO) or a dairy cooperative or both. Some barangay officials likewise attended the meeting.
- Problems identified by farmers:
  1) Lack of capital for farm inputs (e.g. fertiliser, fencing of forage area, feed supplements)
  2) Crops need more fertilisers and time to produce well
  3) Increasing cost of commercial supplements for dairy cattle
  4) Lack of feed due to increase in cropped areas and in animal number
  5) Diseases in crops
  6) Lack of adapted forages
  7) Uncontrolled grazing
  8) Occasional flooding in flat areas
  9) Increase in unpalatable weeds in grazing areas
  10) Erosion in sloping farms
- Coping mechanisms:
  1) Grazing in vacant areas owned by other farmers
  2) Establishing their own forage areas – only a few; problem of illegal grazing and decline of forage productivity
- Decision: A field day was conducted after the PD. The farmers made a list of species they would try in their area. The plan is to try out as a group first. The results of the initial trial will be the basis for selecting species for individual farmer testing. The species farmers wanted to test include those that were useful for grazing, cut-and-carry, and as cover crops under coconut. The initial testing area was to serve as source if planting materials for individual farmer testing.

## Appendix 3. Description of activities conducted at each site in the Philippines

### Matalom, Leyte

**1995**

- Participatory diagnosis and planning of activities conducted with alayons from San Salvador and Montealegre.
- Establishment of initial testing and multiplication areas in San Salvador and Montealegre. Alayon leaders from the barangay provided the areas. The plots were established and managed by the alayon members. In addition, FARMI established a backup area for multiplication of the same species.
- The species tested in San Salvador (acid soil) and Montealegre were as follows :

| Species | San Salvador | Montealegre |
|---|---|---|
| *Aeschynomene histrix* CIAT 9690 | ✓ | - |
| *Arachis pintoi* CIAT 22160 | ✓ | ✓ |
| *Centrosema acutifolium* CIAT 5277 | ✓ | ✓ |
| *Centrosema pubescens* CIAT 15160 | ✓ | - |
| *Desmanthus virgatus* CPI 40071 | ✓ | ✓ |
| *Desmodium cinerea* (ex) MBRLC | ✓ | ✓ |
| *Flemingia macrophylla* CIAT 17403 | ✓ | - |
| *Gliricidia sepium* (Local) | ✓ | ✓ |
| *Leucaena leucocephala* K636 | ✓ | - |
| *Stylosanthes guianensis* CIAT 184 | ✓ | ✓ |
| *Andropogon gayanus* CIAT 621 | ✓ | ✓ |
| *Brachiaria brizantha* CIAT 6780 | ✓ | ✓ |
| *Brachiaria decumbens* CIAT 606 (cv. Basilisk) | ✓ | ✓ |
| *Brachiaria humidicola* CIAT 16886 | ✓ | ✓ |
| *Panicum maximum* CIAT 6299 | ✓ | ✓ |
| *Paspalum atratum* CIAT 9610 | ✓ | - |
| *Pennisetum purpureum* cv. Capricorn | ✓ | ✓ |
| Florida Napier | ✓ | - |
| *Setaria sphacelata* var. *splendida* (ex) Indonesia | ✓ | ✓ |

- Distribution of small amount of planting materials/seeds to interested alayon leaders. A total of 26 farmers were able to receive planting materials in small amounts (10 g of seeds or 10-20 pieces of vegetative planting materials).
- Open-ended evaluation of forages planted by *alayon* leaders. Only 16 *alayon* leaders were successful in establishing the forages. The species evaluated and their comments were as follows:

  Grasses

  *A. gayanus* CIAT 621 (vegetative) – moderate establishment; good vigour and palatability
  *B. brizantha* CIAT 6780 (vegetative) – moderate establishment; good vigour and palatability
  *B. humidicola* CIAT 6133 (vegetative) – poor establishment
  Florida Napier (vegetative) – good establishment, growth, and palatability
  *P. purpureum* cv. Capricorn (vegetative) – good establishment; palatable to carabao only
  *S. splendida* (vegetative)– good growth and palatability (3 farmers)

  Legumes

  *A. pintoi* (vegetative) – moderate establishment; slow growth
  *C. acutifolium* CIAT 5277 (seeds) – good germination poor vigour (yellow)
  *C. pubescens* CIAT 15160 – moderate germination; poor vigour (yellow)
  *D. cinerea* (seeds) – moderate establishment; poor vigour (yellow)
  *D. virgatus* CIAT 40071 (seeds) – moderate germination; good vigour
  *P. maximum* CIAT 6299 (vegetative) – poor establishment
  *S. guianensis* CIAT 184 – good germination; poor vigour in calcareous soil; good palatability

**1996**

- Group evaluation of forages in the initial testing and multiplication areas. Among the legumes tested, all farmers in San Salvador (acid soil area) favoured *Stylo* 184, and *C. pubescens* CIAT 15160. In Montealegre, all farmers favoured *D. cinerea* and *Stylo* 184. Their major criteria were vigour and herbage yield. Among the grasses tested, all farmers in San Salvador favoured *B. humidicola* CIAT 16886, *P. purpureum* cv. Capricorn, Florida Napier, and *S. sphacelata var. splendida*. In Montealegre (with less acidic and relatively fertile soil), all farmers favoured *B. brizantha* CIAT 6780 and *P. maximum* CIAT 6299. The farmers expressed the same criteria in selecting these grasses. The other species were favoured by some farmers but not by others.
- Conduct of quarterly *alayon* leaders' meeting. At the end of the year, an annual *alayon* leaders' meeting was done to report what has been accomplished by the groups and plan out their activities for the next year.
- Farmer-training in forage and livestock management. Three trainings were conducted: (a) San Salvador alayon, attended by 8 farmers, (b) Montealegre alayon, attended by 12 farmers, and (c) general training for alayon leaders, attended by 20 farmers. The topics covered were on the importance of good feeding to ruminants, the different types of forages and where forages can be integrated into their farms. The trainings were conducted, with farmers taken to existing forage plots and asking them to choose what species they were interested to plant. Arrangements were then made as to when those interested would establish the forages.
- Establishment of more or less structured experiments in their farmers' fields. These experiments involved comparison of forage species as used for different purposes: (a) cut-and-carry, (b) hedgerows, (c) grazing, and (d) fence lines. Two farmers were able to establish the experiments late in the year.
- Establishment of a larger range of forage species in a nursery in Matalom (managed by FARMI). This nursery aimed to produce planting materials for distribution to farmers. The species planted were as follows :

  Grasses
  - *Andropogon gayanus* CIAT 621
  - *Brachiaria brizantha* CIAT 6780
  - *Brachiaria brizantha* CIAT 16318
  - *Brachiaria brizantha* CIAT 26110
  - *Brachiaria decumbens* CIAT 606 (=cv. Basilisk)
  - *Brachiaria humidicola* CIAT 6133
  - *Brachiaria humidicola* CIAT 16886
  - *Brachiaria humidicola* cv. Tully
  - *Panicum maximum* CIAT 6299
  - *Paspalum atratum* BRA 9610
  - *Pennisetum purpureum* cv. Mott
  - *Pennisetum* hybrid (Florida grass)
  - *Pennisetum* hybrid (King grass)
  - *Setaria sphacelata* var. *splendida* (ex) Indonesia

  Legumes:
  - *Arachis pintoi* CIAT 22160
  - *Centrosema pubescens* CIAT 15160
  - *Desmodium cinerea* (ex) MBRLC
  - *Flemingia macrophylla* CIAT 17403
  - *Gliricidia sepium* cv. Monterrico
  - *Gliricidia sepium* cv. Retalhuleu
  - *Gliricidia sepium* (ex) Belen Rivas

**1997**

- Assisted farmers in establishing structured experiments. Eight more on-farm experiments were established. Details of the experiments were as follows:

| Option | Calcareous Soil | Acid Soil | Total number of farmers |
|---|---|---|---|
| Hedgerows | 1 | 1 | 2 |
| Block | 2 | 2 | 4 |
| Grazing: | | | |
| Under shade | - | 1 | 1 |
| Open area | 1 | 2 | 3 |
| Fence line | Seedlings still in nursery | | |

- Conducted two field days for 18 farmers in Inopacan, Leyte (a nearby municipality)
- Conducted a field day for 20 farmers in Barangay Sta. Paz, Matalom. Farmers from San Salvador and Elevado who have planted the forages served as resource persons in the field day. A planning session was done as part of the field day.
- Establishment of initial multiplication and demonstration area at Sta. Paz, Matalom, Leyte.
- Conduct of quarterly alayon leaders' meeting. At the end of the year, an annual alayon leaders' meeting was done to report what has been accomplished by the groups and plan out their activities for the next year.

**Guba, Cebu**

**1996**

- Visit of four farmer-instructors to the FSP nursery and distribution of planting materials.
- Establishment of forages by farmer-instructors. The species established by the farmer instructors were as follows :

Grasses

A. *gayanus*
*B. brizantha* CIAT 26110
*P. maximum* CIAT 6299
*P. atratum* BRA 9610
*S. sphacelata var. splendida* (ex) Indonesia
*P. purpureum* cv. Mott

Legumes

*A. pintoi* CPI 12121
*A. pintoi* CIAT 17850
*A. pintoi* CIAT 26110
*A. glabrata* CPI 93483
*C. macrocarpum* CIAT 25522
*D. cinerea* (ex) MBRLC
*F. macrophylla* CIAT 17403
*L. leucocephala* K636
*S. guianensis* CIAT 184

**1997**

- Distribution of planting materials to other farmers trained by farmer-instructors (32 farmers).
- Meeting with farmers in Cambinocot and Tag-ubi on extension of forage trials.
- Seminar on forage production and management in Cambinocot and Tag-ubi.
- Distribution of planting materials to 30 farmers in Guba and Cambinocot.
- Cross-visit of farmers in Cambinocot and Tag-ubi to farm of Teo Llena in Balisong, Guba.

**Cagayan de Oro**

**1995**

- Participatory diagnosis and planning of activities with farmers in Pagalungan.
- Establishment of initial multiplication area at Cagayan Capitol College (CCC) and Pagalungan. The area for establishment of the different forages was provided by CCC and a farmer-leader in Pagalungan, respectively. Establishment and management were done by CCC students and farmer association members in Pagalungan, respectively. The different forages established were as follows:

| Species | CCC | Pagalungan |
|---|---|---|
| *Arachis pintoi* CIAT 18744 | ✓ | - |
| *Arachis pintoi* CIAT 22160 | ✓ | ✓ |
| *Calliandra calothyrsus* (ex) Indonesia | ✓ | - |
| *Centrosema acutifolium* CIAT 5277 | ✓ | ✓ |
| *Centrosema macrocarpum* CIAT 25522 | ✓ | - |
| *Centrosema pubescens* CIAT 15160 | ✓ | - |
| *Desmanthus virgatus* (ex) IRRI | ✓ | - |
| *Desmodium heterophyllum* CIAT 349 | ✓ | - |
| *Desmodium cinerea* (ex) MBRLC | ✓ | ✓ |
| *Gliricidia sepium* (Local) | - | ✓ |
| *Leucaena leucocephala* K636 | ✓ | ✓ |
| *Leucaena leucocephala* (Local) | ✓ | - |
| *Pueraria phaseoloides* CIAT 9900 | ✓ | - |

**(continued next page)**

**Table (cont.)**

| Species | CCC | Pagalungan |
|---|---|---|
| *Sesbania sesban* | ✓ | - |
| *Stylosanthes guianensis* CIAT 184 | ✓ | ✓ |
| *Andropogon gayanus* CIAT 621 | ✓ | - |
| *Brachiaria brizantha* CIAT 6780 | ✓ | - |
| *Brachiaria brizantha* CIAT 26110 | ✓ | ✓ |
| *Brachiaria decumbens* CIAT 606 (cv. Basilisk) | ✓ | ✓ |
| *Brachiaria humidicola* CIAT 6133 | ✓ | ✓ |
| *Brachiaria humidicola* CIAT cv. Tully | ✓ | - |
| *Panicum maximum* CIAT 6299 | ✓ | - |
| *Panicum maximum* cv. Tanzania | ✓ | - |
| *Paspalum atratum* BRA 9610 | ✓ | ✓ |
| *Paspalum guenoarum* BRA 3824 | ✓ | - |
| *Pennisetum purpureum* cv. Mott | ✓ | - |
| *Pennisetum purpureum* cv. Capricorn | ✓ | - |
| *Pennisetum purpureum* (Local) | ✓ | ✓ |
| Florida Napier | ✓ | ✓ |
| *Pennisetum* hybrid (King grass) | ✓ | - |
| *Setaria sphacelata var. splendida* (ex) Indonesia | ✓ | ✓ |

**1996**

- Conduct of farmer training on livestock and forage management at CCC to interested farmer groups. A field day was always a part of the training. It consists of bringing the farmers to forage plots and discussing the forage trials. Four training courses involving 135 farmers from six barangays were conducted.
- Distribution of forage planting materials to members of farmer groups attending the farmer trainings. Farmers who received planting materials from CCC plots came from Pagalungan (33), Bayanga (39), Canituan (14), San Simon (16), Indahag (19), and Mambuaya (14).
- Conduct of field days/cross-visits to farms/areas where forages are established and used. This was done with 24 farmers from Pagalungan.
- Monthly regular meeting and cooperative work (pahina) to maintain the initial multiplication area with farmers in Pagalungan.
- Open-ended evaluation of forages in the demonstration area done with Pagalungan farmers.

**1997**

- Establishment of initial multiplication areas at Bayanga, Indahag, and San Simon.
- Monthly regular meeting and cooperative work (pahina) to maintain the initial multiplication area with farmers in Pagalungan, Bayanga, Indahag, and San Simon.
- Monitoring and feedback from farmers on their experiences with forages.
- Conduct of two field days attended by 20 farmers in Pagalungan. The topics discussed were feed requirement of animals and importance of fertilisation in fast-growing cut-and-carry forages.
- Distribution of planting materials to interested farmers. A total of 215 farmers coming from 10 upland barangays in Cagayan de Oro received forage planting materials for the year.
- Conduct of farmer training courses for 16 farmers from Lumbia. The training covered topics on forage and pasture.
- Conduct of cross-visits to successful agroforestry farmers in Cebu. A total of 9 farmers and 3 technicians from Cagayan de Oro were involved.

**Malitbog, Bukidnon**

**1996**

- Conduct of participatory diagnosis and planning at Kaluluwayan, San Luis. The activity was attended by 16 farmers.
- Cross-visits to Cagayan de Oro and Bukidnon. Thirty farmers participated in the activity as part of the visit, the farmers were shown the forages and were able to get planting materials for their communal initial establishment area.
- Establishment of forages in a common area and in individual farmers' fields. Farmers organized themselves into *alayons* (cooperative groups) to facilitate establishment. Three individual farmers were able to plant.

**1997**

- Conduct of participatory diagnosis and planning in two more barangays at Malitbog. The farmers involved also decided to test forages in their farms, starting with common area and using the alayon method in establishing the forages.

- Establishment of forages in common areas and individual farmers' fields. Fourteen farms were able to establish forages. The alayon method was adopted to facilitate the work. Aside from forage establishment, the farmers were also able to establish contour hedgerows.
- Distribution of legume tree seeds to seven farmers. The agreement was that farmers will establish the seeds in plastic bags for later transplanting of seedlings.
- Cross-visits to other areas and farms in Bukidnon where forages were planted and used. Twenty farmers participated in the activity.
- Conduct of farmer training on developing forage technologies with 21 farmers attending.
- Regular meetings and visits to exchange experiences and feedback on forage performance.

**Carmen, Cotabato**

**1996**

- Participatory diagnosis at Aroman. The activity was attended by 26 farmers coming from barangays around Aroman. The farmers decided that they would test forages, first in a common area and later to individual farms.
- Establishment of forages managed by farmer groups. The farmers provided the area and labour for establishment and management.
- Regular meetings and visits to share experiences and get feedback on forages trials.

**1997**

- Farmer training and field day on forages. The topics included use and integration of forages on-farm. An evaluation and planning session was done as part of the training.
- Distribution of planting materials to interested farmers. Two farmers were able to receive planting materials and establish forages in their farms.
- Regular meetings and visits to exchange experiences and feedback on forages.

**M'lang, Cotabato**

**1996**

- Participatory diagnosis at Aroman. The activity was attended by 26 farmers coming from barangays around Aroman. The farmers decided that they would test forages, first in a common area and later to individual farms.
- Establishment of forages managed by farmer groups. The farmers provided the area and labour for establishment and management.
- Regular meetings and visits to compare experiences with forages.

**1997**

- Farmer training and field day on forages. The topics included use and integration of forages on-farm. An evaluation and planning session was done as part of the training.
- Regular meetings and visits to get feedback on forages performance.

**Riverside, Davao**

**1997**

- Participatory diagnosis with farmers. Ten farmers participated in the activity. The farmers decided to evaluate forages, first in a common area, then to individual farms.
- Conduct of a field day at the PCA research centre. The farmers were shown different forages and options for integration of forages. From these, the farmers planned and decided what species they would try.
- Distribution of planting materials and establishment of initial evaluation and multiplication area. The area was provided by one farmer who established and managed the area himself. He plans to expand his area and to distribute planting materials to other interested farmers.

**Malagos, Davao**

**1997**

- Participatory diagnosis with farmers. The activity was participated in by 10 farmers. The farmers decided to evaluate forages, first in a common area, then to individual farms.
- Conduct of a field day at the PCA research centre. The farmers were shown different forages and options for integration of forages. From these, the farmers planned and decided what species they would try.
- Distribution of planting materials for establishment of initial testing and multiplication area.

# Impact of participatory approaches on sheep production in North Sumatra, Indonesia

Tatang Ibrahim[1]

## Introduction

The low annual per capita meat consumption in North Sumatra (Disnak Sumut 1994) is mainly due to the limited supply of meat. Only 45% of North Sumatra's demand for small ruminants is met by local suppliers (Karokaro et al. 1993). This short supply is a reflection of the low animal population and the low productivity in the region where most of the ruminants are raised by smallholders. There is a need to increase both the population and productivity of ruminants within this region.

A new settlement at Marenu, South Tapanuli in North Sumatra Province aimed to organise smallholders whose main source of income is sheep production. A flock of 25 ewes and 2 rams were given to each transmigrant by the government in 1996. In addition, a simple woody house, a barn, and 1 ha of upland area were also made available to them. Approximately 0.5 ha of this land was planted to King grass (*Pennisetum hybrid*), while another 0.5 ha was used to grow cash crops to augment the still meagre income from sheep production. A cost of living allowance and feed supplements were also provided by the government for the first year. Income projections show that each transmigrant family with 40 ewes would earn a monthly income of 350,000 rupiah by selling 6 young rams per month.

Field visits in 1996 observed the poor condition of both sheep and forages, resulting in poor sheep production at Marenu. Therefore, this site was selected by the Forages for Smallholders Project as a pilot area for developing forage technology to improve sheep production. The participatory research (PR) method was used with farmers to ensure active and equal participation. Through this approach, their needs and their perceptions of the new technologies would be clear from the beginning (Horne 1996).

This paper discusses the impact of the PR approach on the performance of sheep production at Marenu.

## Material and methods

### Site description

The site is located at Marenu village, in sub-district Barumun Tengah, Tapanuli Selatan district, North Sumatra Province. This is a new settlement which has been occupied by some 100 families of transmigrants since 1996. These families depend on sheep production for livelihood. The Government provided some facilities to assist them. Soil is classified as a Tropudult; it has low fertility and low organic matter, nitrogen, and phosphorous content. Annual rainfall ranges from 2,500 to 3,000 mm and there are distinct dry and wet seasons. The rainy season can be expected from December to March. The driest months are July to October.

Marenu is contrasted with a lowland site, Pulau Gambar, near Medan where a women's group raises goats in pens. Feed is available from rice fields and nearby oil palm and rubber plantations.

[1] Balai Pengkajian Teknologi Pertanian, BPTP Gedong Johor, Medan, North Sumatra, Indonesia.

### Stratification of farmers and sheep husbandry

The farmers were classified into the PR group and the non-PR group. Farmers in the first group were introduced to forage technologies through the PR approach. The non-PR group were farmers who only availed of the facilities offered by the government and whose main source of forages is King grass. A semi-intensive system was used by both groups, including both grazing and cutting forages, to feed their animals.

Farmers in the PR group were involved in all stages of the PR approach including participatory diagnosis, planning, experimentation and evaluation. Ibrahim (1997) reported that farmers agreed to try forage species with drought tolerance to improve sheep production. Using their own criteria, the farmers ranked *Paspalum atratum* BRA 9610 as the best accession among the grasses tested. This was followed by *Paspalum guenoarum*, *Brachiaria humidicola*, *Brachiaria brizantha*, *Paspalum atratum* cv. Pantaneira, and *Brachiaria humidicola* CIAT6133. These species were valued higher than King grass and are still being developed and used. Among the legumes, farmers ranked *Gliricidia sepium* as the most preferred species followed by *Leucaena leucocephala*, *Stylosanthes guianensis*, *Centrosema pubescens,* and *Calliandra calothyrsus*. However, due to its limited number, these introduced legumes did not develop at the expected pace and were not used as fast as the grasses.

### Measurements of impact of the PR approach

The parameters used to evaluate sheep production – present population, time allocated for collecting cutting material and grazing, body weight of sheep and income – were measured in both PR and non-PR groups.

The data were obtained from a survey using five farmers per group as respondents. The body weights of sheep were measured monthly but comparison was made only between the two groups at the same age. The present population of sheep owned by a farmer, the time consumed for feeding, and the income generated by the PR and non-PR groups were also obtained.

## Results and discussion

Starting with the same number of animals (2 rams and 25 ewes in 1996), it was shown that the total number of sheep owned by an individual farmer belonging to the PR group was considerably higher than those of the non-PR group after two years (Table 1).

**Table 1. Average numbers of sheep own by farmers in January 1998, stratified by age (months).**

| Farmer group | Marenu, Tapsel | | | | Pulau Gambar | | | |
|---|---|---|---|---|---|---|---|---|
| | <3 months | 3-<12 months | >12 months | Total | <3 months | 3-<12 months | >12 months | Total |
| PR group | | | | | | | | |
| - rams | 2 | 6 | 2 | | 2 | 3 | 1 | |
| - ewes | 2 | 7 | 26 | | 1 | 4 | 11 | |
| Total | 4 | 13 | 28 | 46 | 3 | 7 | 12 | 22 |
| Non-PR group | | | | | | | | |
| - rams | 2 | 2 | 1 | | 1 | 2 | 2 | |
| - ewes | 2 | 2 | 18 | | 3 | 3 | 10 | |
| Total | 4 | 4 | 19 | 27 | 4 | 5 | 12 | 21 |

The number of sheep owned by farmers increased by 74% in the PR group; it remained the same in the non-PR group. The difference between the two groups may be due to the higher mortality observed in sheep owned by the non-PR group. Farmers

claimed that diarrhoea was the most common cause of death of sheep. However, the real reason for the high mortality must be further investigated, although irregular timing of drenching and lack of feed were thought to be responsible.

In general, the PR group used less time for cutting forages and grazing activities than did the non-PR group at Marenu, Tapsel (Table 2). This time reduction was attributed to the shorter distance travelled to get forage. The larger amount and easier to cut forages available in their backyard also reduced the time allocated for grazing.

**Table 2. Time needed for obtaining feed for animals.**

| Group | Cutting forages | | Grazing | |
|---|---|---|---|---|
| | Time (hours/day) | Location | Time (hours/day) | Location |
| Marenu | | | | |
| – PR group | 1 | Backyards | 4 | Backyards |
| – Non-PR group | 2 | Swamps | 6 | Forests |
| Pulau Gambar | | | | |
| – PR group | 2 | Backyards | 3 | Rice fields |
| – Non-PR group | 3 | Plantations | 5 | Rice fields |

At the Marenu site, the sources of cut forages of the non-PR group farmers where the swampy areas almost 2 km away from their barns. Grazing was done on open native grassland available around the forest. The average body weight of sheep reared at Marenu was observed to be higher in the PR group than in the non-PR group (Table 3).

**Table 3. Average body weight (kg) of sheep.**

| | Ages (month) | | | | | |
|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 |
| **Marenu** | | | | | | |
| Rams | | | | | | |
| - PR group | 10.8 | 11.1 | 11.7 | 12.5 | 13.2 | 12.5 |
| - Non-PR group | 5.8 | 7.0 | 7.0 | 8.1 | 8.9 | 8.5 |
| Ewes | | | | | | |
| - PR group | 9.4 | 10.2 | 11.1 | 11.3 | 11.5 | 12.2 |
| - Non-PR group | 7.2 | 7.7 | 8.0 | 8.6 | 9.3 | 9.9 |
| **Pulau Gambar** | | | | | | |
| Rams | | | | | | |
| - PR group | 8.8 | 9.1 | 11.9 | - | - | - |
| - Non-PR group | 7.1 | 11.0 | 12.2 | - | - | - |
| Ewes | | | | | | |
| - PR group | 8.8 | 9.1 | 12.0 | - | - | - |
| - Non-PR group | 7.5 | 9.7 | 12.0 | - | - | - |

Table 3 shows that differences in body weight between the two groups remained similar (about 4 kg) at any given age. This would indicate that the difference started from birth; the weight might have been related to both quantity and quality of feed given to the pregnant ewes.

Since concentrates are expensive, the need for protein may be met by legumes. Therefore, the practice of planting and using legumes (herbaceous, shrubs, trees) is an important component of sheep husbandry of smallholders. Farmers in the PR group had already planted some legumes, using them as animal feed.

At Marenu, because of the greater body weight and better physical condition, the sheep owned by the PR group commanded better prices (Table 4). Manure production was also higher in the PR group because of the larger population. Therefore, farmers in

the PR group obtained an income which was 31% higher than that earned by the non-PR group.

**Table 4. Income per month per farmer from sheep sales.**

| | Sheep (head/Rp) | Manure (bags/Rp) | Total (Rp) |
|---|---|---|---|
| **Marenu** | | | |
| - PR group | 2 / 105,000 | 8 / 12,000 | 117,000 |
| - Non PR group | 2 / 80,000 | 6 / 9,000 | 89,000 |
| **Pulau Gambar** | | | |
| - PR group | -[1] | - | - |
| - Non-PR group | - | - | - |

[1] No regular sales

However, the present monthly income of Rp 117,000 at Marenu is only 33% of the target of Rp 350,000. Each farmer has to sell around 6 young rams per month to achieve this target. This number may be produced from a flock of 40 ewes. Each farmer currently owns only 26 ewes on average and they are able to sell only 2 rams per month. Further subsidies from government are needed to achieve the ideal flock size of 40 ewes. A larger flock needs more feed. Because forages (grasses and legumes) are relatively cheap sources of feed further development on this aspect is important.

## Conclusions

The application of forage technology through the PR approach improved sheep production of smallholders at Marenu. This was closely related to problems faced by farmers. The opinions and criteria used by farmers in selecting the technology were the factors that mattered most in the development and adoption process of the said technology.

## Acknowledgements

The authors acknowledge the financial assistance of the Australian Agency for International Development (AusAID) through CIAT and FSP. They also thank the Regional Office of Transmigration of North Sumatra for their hospitality during the field visits.

## References

Disnak Sumut 1994. Peternakan dalam angka di Sumatera Utara Tahun 1993. Pemerintah Propinsi Daerah Tingkat I Sumatera Utara, Dinas Peternakan Tkt I Sumatera Utara, Medan.

Horne, P.M. 1996. Partnership in research and technology transfer for livestock production through farmers' involvement. Paper presented at the 18th Annual Conference of the Malaysian Society of Animal Production 'New Perspectives in Animal Production', 28-31 May 1996, Kuching.

Ibrahim, T.M. 1997. Participatory research in North Sumatra. Paper presented at the 2nd Annual Meeting of Forages for Smallholders Project at Hainan, China.

Karo-karo, S., Juniar, S. and Knipscheer, H.C. 1993. Farmers, shares, marketing, margin and demand for small ruminants in North Sumatra. SR-CRSP Working Paper No. 150.

# Developing and evaluating forage technologies with farmers in Lao PDR

**Viengsavanh Phimphachanhvongsod[1] and Phonepaseuth Phengsavanh[2]**

The livestock sector in Lao PDR is almost exclusively smallholder-based. The livestock practices of smallholders are very traditional, with minimal or no inputs used. Animals are generally left to graze, either on native grass that is available in forests and grassland or on crop residues in harvested fields.

Although the livestock production systems of Lao PDR are highly diverse, four broad categories exist:

**1. Livestock in association with lowland agriculture**

These systems are dominated by intensive rice cultivation and livestock play a vital role in providing draft power and manure and in stubble recycling. The opportunities for forage development in these systems are often limited by lack of land for planting forages.

**2. Livestock associated with long-rotation shifting cultivation systems.**

In these areas (predominantly in the northern part of the country), livestock producers often have very low-input systems of livestock management. Frequently, buffalo and cattle are allowed to graze in the mountains and forests year-round. They are only brought back for work or for sale. The opportunities for forage development in these systems appear limited, as farmers perceive few problems with the existing feed resource. However, in some areas, there is growing activity at the farm level and animal raisers plan to sell livestock to neighbouring countries, especially to Thailand, Vietnam, and China. Under these situations, livestock management systems are likely to change rapidly and a demand for forages may emerge.

**3. Livestock in association with short-rotation shifting cultivation systems**

In these areas (principally in the central north area such as Luang Phabang, Xieng Khouang), few forests remain. Agricultural systems are under increasing pressure from shorter fallow cycles and increasing populations. Livestock, especially in the more remote areas, is a major buffer against calamity in the household or community. Only a few other commodities exist that can be produced with little labour and resources, that can be sold at any time, and that are relatively easy to bring to market regardless of distance.

In these systems, the opportunities for forage development appear to be very high. Many farm communities are recognising both the value of livestock in maintaining their livelihoods and the need for better livestock management. Interest in managed forages is already high, with farmers in some areas already attempting to manage their feed resources by cultivating grasses.

[1] Livestock Development Division, Department of Livestock and Fisheries, Vientiane, Lao PDR.
[2] Forages for Smallholders Project, Vientiane, Lao PDR.

**4. Livestock in the southern sandstone regions and Pek savannas**

These areas in the southern provinces have very poor soils, long dry seasons, and low population densities. The livestock management systems are based on extensive grazing. The opportunities for improvement with forages appear limited, partly because the existing feed resource (though poor) is extensive and partly because farmers are heavily occupied with trying to support their fragile agricultural livelihood. However, the government is trying to promote livestock production for smallholders in these areas.

The Forages for Smallholders Project (FSP) has been working in Lao PDR to develop forage technologies with farmers in these regions. Some common problems are experienced by farmers in raising livestock across these regions:

- Disease.
- Lack of feed throughout the dry season.
- Lack of feed at critical times during the wet season (such as planting and harvesting), when animals must be kept penned to prevent damage to crops but there is not enough labour to care for animals.
- Loss of animals (that graze in far villages) to thieves and predators.
- Damage to other farmers' fields, causing conflicts in villages.

Many of these problems can be addressed by planting forages. Therefore, the FSP began on-farm development of forage technologies in 1997. The sites initially selected were those identified by local agriculture officers or rural development workers as having potential for forage development. These are found in two provinces: Xieng Khouang and Luang Phabang. The characteristics of these two areas are listed in Table 1.

**Table 1. Physical characteristics of locations for on-farm forage evaluations.**

| Site | Latitude | Altitude (m) | Annual rainfall (mm) | Wet season | No. of wet months (>50 mm) | Soil characteristics | Farming system |
|---|---|---|---|---|---|---|---|
| Xieng Khouang | 18.5-20° | 1100 to >2000 | 1300 to 1700 | April to September | 8 | – pH (1:5 $H_2O$): 5.4 (4.7-7.7) upland; 4.8-5.0 on the plain.<br>– Loam – clay loam (upland).<br>– Alluvium (plain).<br>– Moderately fertile upland.<br>– Very infertile (plain).<br>– Well drained.<br>– P deficient to extremely deficient. | – Wetland rice in valleys and shifting cultivation on the slopes.<br>– Some shifting cultivation on ploughed savanna grassland.<br>– Upland crops in pine tree zone (rice, maize, and other crops) with integration of livestock production. |
| Luang Phabang | 19-21° | 300 to 1900 | 1300 to 1700 | May to October | 7 | – pH (1:5 H2O): 5-7.<br>– Loams, sandy loam.<br>– Well drained.<br>– Infertile to moderately fertile.<br>– Low organic matter content and low base saturation. | – Shifting cultivation and upland cropping on slopes.<br>– Rainfed rice in lowland with livestock production integrated. |

## Description of sites

### Chomphet, Luang Phabang

*General description*

Chomphet is located opposite of Luang Phabang township on the other side of the Mekong River. About 80% of the area is mountainous or hilly. Altitude varies from 300 to 1900 m. The upland area has mostly been cleared for shifting cultivation. Rice

production is practiced in the lowlands. Annual rainfall ranges from 1100 to 1800 mm. The dry season lasts from November to March, with December to February being particularly dry (about 1-3% of total rainfall). Soil is mostly infertile and moderately acidic (pH 5-6).

*Description of community*

There are three main ethnic groups in Chomphet: the Lao Lum, Lao Theung and Lao Soung. The latter groups normally live in upland areas. The farming systems common in Chomphet District are subsistence cultivation of rainfed paddy and upland rice integrated with livestock raising. In upland and mountainous areas, farmers cultivate upland rice in swidden fields as the primary crop and staple food. The crops are sometimes inter-planted with additional food and cash crops such as maize, cassava, taro, eggplant, and cucumber. Rice is mostly planted in narrow valleys. Most of the fields in the district are rainfed; only a very small portion is set aside for irrigated dry season rice. In addition to rice, farmers also plant maize, soybean, garlic, spring onion, and other vegetables. The livestock raising system in Chomphet varies from village to village. In the lowland areas where rice is grown, farmers keep buffalo. In some villages, there are no cattle at all. In these areas, villagers do not like to eat cattle meat. Cattle are mostly kept in the upland areas. Animals provide food, income, savings, draft power, transport, and manure. Ruminants in the upland areas can freely graze on native grasslands and forests year-round. They are brought back to the village only when they are sick or if they will be sold. In lowland areas, livestock are released into the forest during the dry season, after which they are taken back to the village to be used for land preparation. The agricultural land for each household ranges from 0.5 to 2 ha, depending on the availability of labour in each household. Family cash income is mostly derived from the sale of animals and occasional crop surpluses (including maize, vegetables, cotton, and rice). Other off-farm activities (such as handicraft, off-farm work) can also be an important source of income for villages that are not too remote.

*Participatory diagnosis*

Participatory diagnosis was conducted at Ban Thapho. The problems identified by farmers (in order of priority) were

- Animal diseases, especially in pigs and poultry.
- Shortage of feed for working animals during the planting season.
- Poor-quality forage during the dry season.
- Long calving interval (24-30 months).

Farmers tried to solve these problems by

- Using vaccination (but only against haemorrhagic septicaemia in buffalo).
- Storing rice straw to feed their working animals during the planting season.

*On-farm activity*

1996

- Establishment of regional evaluation of forages managed by farmers.
- Organising field trips to forage evaluation nursery.
- Training of farmers on basic forage agronomy.

1997

- On-farm work started this year with individual farmers and groups of farmers in five surrounding villages. The forages selected by the farmers from the regional nursery were *B. brizantha* CIAT 6780*, B decumbens* cv. Basilisk, *B. ruziziensis*, *Panicum maximum* TD58, *Stylosanthes guianensis* CIAT 184, and *Centrosema pubescens* cv. Cardillo.

**Xieng Ngeun, Luang Phabang**

*General description*

Xieng Ngeun is one of 11 districts within Luang Phabang Province. It is located about 30 km to the south of Luang Phabang City. Mountains and hills dominate the area, with elevation varying from 300 to 1900 m. The area has mostly been cleared for shifting cultivation. Annual rainfall ranges from 1100 to 1800 mm. The dry season lasts from November to March, with December to February being particularly dry (about 1-3% of total rainfall). Soil is mostly infertile and moderately acidic (with soils on the limestone bluffs being more fertile).

*Description of community*

The farming systems in Xieng Ngeun District are based on various practices of rice production: (1) subsistence swidden farming system, (2) subsistence paddy rice, and (3) mixed swidden and paddy farming systems. Many similarities exist between the farming systems of Xieng Ngeun and Chomphet districts. In the upland and mountainous areas, farmers cultivate upland rice in swidden fields as the primary crop and staple food and often interplant with additional food and cash crops such as maize, cassava, taro, eggplant, cucumber, squash, kale, etc. Separate upland fields may be also used for maize, ginger, and soybean. Paddy rice is mostly practiced in narrow valley bottoms by the Lao Loum ethnic group. Most of the agriculture in the district is rainfed and only a small portion is reserved for irrigated dry-season paddy rice. Livestock is an integral part of all farming systems. They provide food, income, saving, draft power, means of transport, and manure. The dominant livestock are cattle, buffalo, goat, pigs, and chickens. The cattle usually graze freely on native pastures in high mountain areas or in swidden areas for the whole year and are brought back to the village only for sale. Family cash income is derived from various sources but the main source is livestock (especially cattle). Occasional crop surpluses (including maize, ginger, vegetable, cotton, rice) are sold locally. Off-farm activities include making handicrafts and providing labour (but many villages are too remote for this).

*Participatory diagnosis*

Participatory diagnosis was conducted once in this district at Ban Kieuw Taloun Yai (a Hmong village). The problems identified by farmers, in order of priority, were:

- Livestock disease.
- Feed shortages in both dry and rainy seasons due to competition for land from cropping and shortening fallow periods.
- High mortality among young animals (falling from high mountains, starvation during dry season, cold weather).
- Animals wandering off and becoming lost or causing damage to other farmers' fields.

The interventions the farmers have been able to make to minimise these constraints include:

- Vaccination.
- Regularly visiting and caring for their animals in the grazing area.
- Growing elephant grass be used as feed in the dry season.
- Establishing village rules allocating specific areas for grazing and cropping.

*On-farm activity*

1995

- A forage evaluation nursery (60 species) was established at Houakhoth. It was managed by provincial and district livestock officers.

1996

- Establishment of regional nurseries throughout the province; best species planted and managed by farmers.

- Farmers were brought to the forage evaluation nursery to see what forage species were available and to get feedback on which species looked promising and why.
- Farmer training on basic forage agronomy was provided.

1997

- On-farm evaluation of the best forage species started in May 1997 at six villages in the area with both individual farmers and farmer groups. The species included in the evaluation are *Brachiaria brizantha* CIAT 6780, *B. decumbens* cv. Basilisk, *B. ruziziensis*, *Panicum maximum* TD58, *Stylosanthes guianensis* CIAT 184, and *Centrosema pubescens* cv. Cardillo. Some farmers have already started to expand the area of their preferred *species (Brachiaria brizantha* CIAT 6780, *B. ruziziensis,* and *Panicum maximum* TD58). They are beginning to change their opinions on which species they like after seeing the dry season performance. There is substantial interest from other farmers to join the evaluations this year and some farmers already started to expand their areas.

**Luang Phabang district, Luang Phabang**

*General description*

Luang Phabang District is located between Chomphet and Xieng Ngeun districts and has similar climate, soils, topography, and land use systems. Mountains and hills dominate the area, but not as much as in the other two districts. The sloping areas have mostly been cleared for shifting cultivation. Annual rainfall ranges from 1100 to 1800 mm. The dry season lasts from November to March, with December to February being particularly dry (about 1-3% of total rainfall). Soil is mostly infertile and moderately acidic (with soils on the limestone bluffs being more fertile).

*Description of community*

The farming systems in Luang Phabang are similar to those in Chomphet and Xieng Ngeun. In the upland and mountainous areas, farmers cultivate upland rice in swidden fields as the primary crop and staple food and often use additional food and cash crops such as maize, cassava, taro, eggplant, cucumber, squash, kale, etc as interplant. Separate upland fields may be also set aside for maize, ginger, and soybean cultivation. Paddy rice is grown in the valleys of the Mekong and Khan rivers. Livestock is an integral part of all farming systems, especially in the upland areas. As in the other districts, the animals provide food, income, saving, draft power, means of transport, and manure. The dominant livestock are cattle, buffalo, goat, pigs, and chickens. The cattle and buffalo usually graze freely in the cropland (dry season only) and among the swidden fields. They are generally kept closer to the villages. Family cash income is derived from various sources. Being close to Luang Phabang, markets for many products exist and livestock plays a less dominant role in augmenting family cash income.

*Participatory diagnosis*

- Participatory diagnosis has not yet been conducted.

*On-farm activity*

1995

- A forage evaluation nursery (57 species) managed by provincial and district livestock officers, was established at Houakhoth.

1996

- A regional nursery of the best species (planted and managed by farmers) was established in the district. Farmers were brought to the forage evaluation nursery to see what forage species were available and to obtain feedback on what species are promising and why.
- Farmers were given training on basic forage agronomy.

1997

- On-farm evaluation started without having conducted a PD, as the district livestock officer had already identified farmers who appeared keen on planting forages and wanted to begin immediately. Seeds of the most promising species were given to five individual farmers. The species distributed were *Brachiaria brizantha* CIAT 6780, *B. decumbens* cv. Basilisk, *B. ruziziensis*, *Panicum maximum* TD58, *Stylosanthes guianensis* CIAT 184, and *Centrosema pubescens* cv. Cardillo. All these farmers have not been successful. This maybe attributed to the lack of diagnostic work at the beginning – they were not able to identify problems and farmers who are most motivated to solve these problems.

**Nonghet, Xieng Khouang**

*General description*

Nong Het is located in the western part of Xieng Khouang Province (about 150 km from the provincial capital Phonsavanh). The area is mountainous with altitudes up to 2000 m. Rainfall data are not available for this district, but it is likely to be in 1800-2000 mm range. The dry season lasts from November to March. Soils are moderately fertile and moderately acidic (soil pH varies from 5.0 to 5.5). For many years, the land has been cleared for shifting cultivation and growing upland rice and other cash crops.

*Description of community*

The communities in Nong Het District are dominated by the Hmong people who cultivate valley areas for wetland rice and practise shifting cultivation on slopes, growing upland rice and maize. There are also separate upland fields used for maize and soybean production. These crops are normally used to feed pigs but are also reserved for human consumption in case of rice shortages. The district is well known for its pig production. Most communities keep small to moderate-size herd of cattle and buffalo, which graze on abandoned upland rice fields, roadsides, and native pasture. The cleared areas utilised for grazing on the upper hill slopes are dominated by *Imperata cylindrica*. Livestock provide food, income, slaughter for traditional ceremony, draft power, transport, and manure. Goats, pigs, and chickens are also common. Cattle and buffalo are normally left in the forest, being brought back only when needed. The main source of family cash income is cattle and cash crops. Handicrafts and non-timber forest products are also occasional sources of farmer income.

*Participatory diagnosis*

- Participatory diagnosis has not yet been conducted.

*On-farm activity*

1997

- On-farm work commenced here without conducting a PD. The provincial livestock officers reported farmers who planted elephant grass to feed their animals at critical times of the year, but who were not satisfied with its performance. The provincial officers decided to begin work as soon as possible with the species they had seen growing in the regional nursery in Lat Sen. On-farm evaluations started with individual farmers from two villages participating. The species evaluated were: *Brachiaria brizantha* CIAT 6780, *B. decumbens* cv. Basilisk, *B. ruziziensis*, *Panicum maximum* TD58, *Stylosanthes guianensis* CIAT 184, and *Centrosema pubescens* cv. Cardillo.

**Pek, Xieng Khouang**

*General description*

Pek District is near the capital of Xieng Khouang Province. The area consists of rolling hills interspersed with lowland paddies, savannah, and large areas of grassland. The upland areas are cleared for planting upland rice and other crops. The lowland areas are

used for paddy rice. Average rainfall varies from 1000 to 1500 mm. The rainy season lasts from April to October. Altitude varies from 800 to 1200 mm. Soil in the grasslands is extremely infertile and very acidic (pH 4.0-5.0) but soil in the hills can be neutral and relatively fertile (as a result of the underlying limestone).

*Description of community*

Members of the communities in Pek District are often of mixed ethnic origin, mostly Lao Loum and Lao Soung with some Lao Theung. Farmers in upland areas cultivate rice through shifting cultivation on slopes. Only very small areas of rice are found in narrow valleys. In addition to rice, many crops, including maize, soybean, cucumber, taro, cassava and peanut are either planted with rice or in separate fields. These crops are mostly for home consumption; occasional surpluses are sold in local markets. Most villagers keep cattle, buffalo, pigs, and chickens. The cattle and buffalo graze on vacant upland rice fields, roadsides, and in large native grassland on mountain tops. The cleared area used for grazing on the upper hill slopes are often dominated by *Imperata cylindrica*. In some places, livestock is an essential source of manure for maintaining fertility in crop fields. Livestock also provides income, and draft power and is slaughtered for traditional ceremonies. In some places, animals are left in the forest year-round and brought back to the village only when needed (for land preparation or for sale). In other villages, animals are allowed to graze in the high grasslands during the wet season but they return to the village to graze on fallow cropland in the dry season. Family cash income is derived mainly from livestock and crop surpluses (if there are any). Non-timber forest products and hunting are also occasional sources of farmer income.

*Participatory diagnosis*

The on-farm work in Pek District is a collaboration between the FSP, the GTZ NAWACOP project (a broad-based rural development project), and the Provincial Agriculture and Forestry Office. In 1995 and 1996, detailed PRAs were conducted by the GTZ project in eight villages. In all the villages, farmers identified livestock feeding as a major concern (after diseases), because of their dependence on livestock for livelihood security and manure. In two villages, farmers had already started to plant forages on their own initiative. The collaboration with FSP was a result of the outcome of these PRAs.

*On-farm activity*

1997

- On-farm evaluation of forages began this year with individual farmers in three villages ( Ban Sang, Ban Phousy, and Ban Ta). In all locations, *Brachiaria brizantha* CIAT6780, *Brachiaria decumbens* cv. Basilisk, *Panicum maximum* TD58, and *Stylosanthes guianensis* CIAT184 have performed well. These trials have generated substantial interest from other farmers (within the same villages and from surrounding villages). The number of farmers evaluating forage technologies will be greatly expanded in 1998.

## Results and lessons learned after one year of on-farm activities

The on-farm work described above involves 71 individual farmers and 7 groups of farmers in 23 villages. In some locations (especially Xieng Ngeun and Pek districts), there is significant and spontaneous demand from farmers for expansion of the evaluations in 1998. In most of the on-farm evaluations, *Brachiaria brizantha* CIAT6780, *B. decumbens* cv. Basilisk, *Panicum maximum* TD58, and *Stylosanthes guianensis* have performed very well and have been selected as promising by farmers. Before the end of the first wet season five farmers and three farmers groups had already expanded the forage area.

We have learned some useful lessons from the first year that should help us make plans for expansion of activities in 1998.

**1. Careful selection of sites and farmer participants is essential**

We learned that choosing locations and farmer participants very carefully is critical to the success of the program. The FSP is working with district development workers, most of whom have not had any experience with participatory methods. Often, their role is to promote livestock raising rather than try to solve existing problems. For this reason, we find that they are sometimes too keen to nominate some farmers who do not even own livestock yet but who are just trying to get credit to start a livestock business. These are not the farmers who will innovate and expand forage technologies to solve the widespread local problems. More participatory diagnosis activities will help us understand farmers' needs and enable us to select innovative farmers for on-farm evaluation.

**2. Working with informal farmer groups was not very successful**

In some cases, farmers were keen on planting forages in a single village plot controlled by an informal group of farmers. This has not worked well as enthusiasm for maintaining and evaluating the forages disappears when farmers have no feeling of 'ownership'.

**3. Evaluations must be done over several seasons**

It is critical that we continue evaluating forages with farmers over several seasons rather than for one season. Their preferences will change as they see how species perform over seasons. For example, in some of our sites, farmers liked the performance of *Brachiaria ruziziensis* and expanded it to other areas. However, in the current dry season it has not performed well. Most farmers now prefer *Brachiaria brizantha* CIAT6780 because of its better dry season growth.

**4. More training and planning activities for farmers are needed**

We have not provided farmers with enough basic information about forages from the beginning of the evaluations. For example, sowing rates have frequently been too high. We need to put more efforts into familiarising farmers with the basic features of forages and answering any of their questions before planning what evaluations they would like to do.

**5. Opportunities exist for bargaining with farmers**

A possible trap with the participatory approach is that, early in the process, farmers may reject technologies with broader, long-term benefits. In these cases, we could bargain with farmers to try some technologies that they may not prefer initially but which we think have long-term promise. For example, at initial stages, farmers almost always select species for intensively managed plots. However, we may also see opportunities for forages for gully stabilisation. We should provide the species that the farmers want for cut feed, but we should also encourage them to establish an area for planting forages to be used for gully stabilisation.

**6. Seed must be made available early**

Last year, at some sites, farmers obtained seed rather late. The start of the wet season varies, depending on the area. Farmers use local indicators to decide when to plant. We need to supply them with seed early enough so they can decide to plant whenever they see fit.

**7. On-going, informal training is needed**

Under the project, we have so far focused on formal training (FPR and forage agronomy). However, district officers must be provided informal training opportunities. Participatory evaluation, for example, is an activity that needs to be learned, practiced, and refined. Bringing groups of district officers together to practice and revise these skills on-site is both helpful for the evaluations and also for building their enthusiasm. These are the people who hold the key to the successful development of forage technologies in villages.

**8. The evaluation methodology may have to be improved**

Simply ranking the species does not tell us how much farmers like one species over the other. We are trying a modified preference-ranking methodology to include 'rating' of species. The change involves asking farmers to rate how much they like each species on a scale of 0-10 (where 0=extremely poor species and 10=excellent species). A rating evaluation might look like the example in Table 2.

**Table 2. Example of preference rating.**

| Species | Farmers A | Farmers B | Farmers C | Average Rating | Rank | Number of farmers |
|---|---|---|---|---|---|---|
| P | 8 | 9 | 6 | 7.6 | 1 | 3 |
| Q | 7 | 9 | 7 | 7.6 | 1 | 3 |
| R | 4 | 4 | 4 | 4.0 | 3 | 3 |
| S | 0 | - | 3 | 1.5 | 5 | 2 |
| T | - | - | 3 | 3 | 4 | 1 |

This will give an indication of the relative performance of the species. It also allows for evaluation of different numbers of species by farmers (which is going to be common at our sites).

## Future activities

The farmer participatory research approach requires a substantial commitment of time from researchers and development workers. In Lao PDR, the major activities are being planned for the next year:

- Conduct at least one training course on 'Developing forage technologies with farmers' to increase the skills of district officers.
- Conduct regular on-site farmer training in forage management .
- Continue to work with farmers who are currently testing and developing forage technologies.
- Expand the on-farm evaluations in Luang Phabang and Xieng Khouang and begin work in Oudomxay, Luang Namtha and Savannaket provinces.

## Acknowledgements

We are grateful to Mr. Thongvanh, Soukanh, Soulivanh, Situk, Hongthong and Ms. Tongbay who worked directly with farmers in Xieng Khouang and Luang Phabang provinces. We also acknowledge the collaboration with GTZ in Xieng Khouang and the assistance of Peter Horne.

# Farmer evaluation of forages in Vietnam: Progress and plans

**Bui Xuan An[1], Le Van An[2], Truong Tan Khanh[3], Le Hoa Binh[4] and Bui The Hung[5]**

Farmer participatory research with forages began at four locations in Vietnam in 1997. A brief description of the four sites is presented in Table 1. The aim of this work was to identify which broadly adapted forage species are preferred by farmers and why.

## Site descriptions

The descriptions of each of the locations where the project has commenced on-farm evaluations are as follows:

### M'Drak, Daklak Province

*General description*

M'Drak District is located in the central highlands of Vietnam. Of 196,600 ha, more than 65,000 ha are *Imperata* grasslands and 'bare hills.' Rolling hills dominate the landscape with a high degree of sloping land (>70% of land has a slope >10%). Soil is moderately infertile and acidic (pH: 5.0-5.5). The altitude varies from 500 to 900m. Average annual rainfall is 2000 mm, with 8 wet months.

**Table 1. Physical characteristics of sites for on-farm forage evaluations.**

| Site | Latitude | Altitude (m) | Annual rainfall (mm) | Wet season | No. of wet months (>50 mm) | Soil characteristics | Farming system |
|---|---|---|---|---|---|---|---|
| M'Drak | 12 °N | 500 | 1890 | May-Dec | 8 | – PH ($H_2O$): 5.0-5.5<br>– Sandy loam<br>– Well drained<br>– Moderately fertile<br>– P deficient | – Shifting cultivation on steep hills<br>– Extensive grasslands<br>– Home-gardens<br>– Small areas of paddy rice in the valleys |
| Xuan Loc, Hue | 16° N | 150 | 2300 | Jul-Feb | 8 | – PH ($H_2O$): 5.0-5.5<br>– Sandy loams<br>– Light to medium-textured<br>– Well drained | – Slash-and-burn cultivation on steep hills<br>– Irrigated rice<br>– Home gardens<br>– Livestock |
| Ha Giang | 22 °N | 70 | 1800 | Apr-Nov | 8 | – PH ($H_2O$): 5-6<br>– Fertility medium<br>– Well drained<br>– P deficient | – Wetland rice in the lowlands<br>– Forestry<br>– Home-gardens of fruit trees<br>– Intensive upland cropping |
| Tuyen Quang | 21 °N | 40 | 1640 | Apr-Oct | 7 | – PH ($H_2O$): 5-6<br>– Fertility medium<br>– Well drained<br>– P deficient | – Wetland rice in the lowlands<br>– Forestry<br>– Home gardens of fruit trees<br>– Intensive upland cropping |

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*Description of the community*

There are two main ethnic groups in M'Drak: the *Ede* and *Kinh.* The Ede, a local minority group, has been living in the M'Drak area for a long time. Their main farming system is shifting cultivation. Maize and upland rice are grown. After 3-4 crops, when soil fertility is exhausted, they move to another place. Since 1975, there have been attempts by the government to settle the Ede people and discourage shifting cultivation. Consequently, the main farming system consisted of replanting forests, keeping livestock (mainly cattle), and cultivating intensive annual crops (mainly wetland rice, upland rice, maize, and beans). The Kinh people migrated from different areas to M'Drak 10 years ago. This group has experience in agricultural production. Their intensive farming includes industrial crops (coffee, pepper, rubber), intensive upland cropping, lowland rice, and livestock (raising cattle). Most families in the area raise cattle and goats, with income from livestock contributing about 30-40% to total household income. The main feed resource for cattle is *Imperata* grassland. Agricultural and forest land was allocated to farmers, according to the capability of each family to work that land. Few farmers have private land for grazing. Some are now trying to improve *Imperata* grassland and to plant forages to maintain a regular feed for their animals.

**Xuan loc, Thua Thien Hue Province**

*General description*

Xuan loc commune is located in Phuloc District, Thua Thien Hue Province at 16$^{o}$15'N. It is an upland area with an altitude ranging from100 to 300 m and a high proportion of sloping land. The original forest vegetation was destroyed by herbicides during the war, slash-and-burn cultivation and timber harvesting. *Imperata* grassland has rapidly replaced all areas where forests were destroyed. The total land area of the commune is 42,000 ha. Of this, cultivated agricultural land occupies only 120 ha, with 30 ha for wetland rice and 90 ha for cassava and other upland crops. The climate is monsoonal with a short dry season from March to July. Annual rainfall is about 2,600 mm, with 80% falling in September-November. Soils are mainly infertile, well-drained sandy loam, with pH - ($H_2O$) ranging from 5.0 to 5.5.

*Description of the community*

There are two ethnic groups in the commune – the dominant lowlanders (Kinh) and the Vankieu. The population of the commune is more than 2,000 people who belong to 450 households. Lowlanders migrated to this district from the coast in 1976. Many were poor fishermen seeking a better future. The Vankieu people migrated from another province in the north in the 1980s. The main agricultural activity of the Kinhs is cultivating irrigated rice and food crops such as cassava, sweet potato, and beans. The Vankieus practice slash-and-burn farming with cassava and upland rice as main crops. With the clearing of the forest in the early 1980s, 4,000 ha of communal grazing land (mainly *Imperata*) became available. Cattle number increased rapidly, providing a new and reliable source of income, requiring little investment or labour. About 60% of farmers in the commune depended on cattle raising for their livelihood. However, deforestation also created problems. The intensive rainfall in September-November and the steepness of the slopes resulted in erosion problems. In 1993, a reafforestation program was implemented. This included a ban on cattle grazing in the reafforested areas. Suddenly the increased cattle number and reafforestation efforts left farmers with insufficient feed for their animals. Cattle and buffalo are a major source of income for most households. There are more than 1600 cattle and 200 buffaloes. Some families have 10–30 head of cattle. A few farmers have started to raise goats. Most animals graze freely on the *Imperata* grasslands, with cut native forages provided as additional feed. Some locally available by products (rice straw, sweet potato leaf and root, rice bran) are also used.

### Ha Giang and Tuyen Quang provinces

*General description*

Ha giang and Tuyen Quang are located in the northern mountain region of Vietnam. Winters are cold with strong winds. Rainfall ranges from 1600-1800 mm (with some mountain areas receive as much as 4800 mm). The wet season begins in April and last 7-8 months. The soils of the mountainous and hilly regions are medium-textured, moderately fertile, and well drained. The land use systems are mainly wetland rice in lowlands, home gardens with fruit trees, forest plots, and shifting cultivation and natural grassland (in a few areas). Cattle and buffalo are kept for sale, meat, and draft power. The demand for meat increases at about 6% per year in this northern region, while the number of animal is increases only 2-3% per year. Animals graze freely on natural grasslands, forest, and fallow cropland during the day and are brought back to the houses at night. Some farmers supply extra feed at night, especially during cold weather or during ploughing. Feed shortages are becoming severe in these communities.

## Procedures and outcomes of participatory diagnoses

### Xuanloc Commune, Hue

*Participatory diagnosis*

A PRA conducted at Xuanloc in 1995 showed that livestock provides a vital source of income for most villagers. But their major problem is year-round feed shortage because of reduced land areas for grazing. In 1996, the College of Agriculture and Forestry in Hue conducted a PD of 50 households within the commune.

Problems identified by farmers, in order of priority, were:

- Lack of feed for their cattle. Farmers said that their cattle have very low weight gain and are thin. Some die during the cold, wet weather.
- Less land available for grazing. Most land was used for replanting forest trees. Animals were forbidden to graze in the new forests.
- Poor quality of animal breed. The farmers wanted to try crossbred cattle which have become common in other districts.
- Children spend a lot of time taking care of the animals. They do not have enough time for their studies.
- Wandering animals destroy crops.
- Soil erosion as a result of heavy rain.

Current coping mechanisms:

- Feeding animals with agricultural by products.
- Planting elephant grass for use as cattle feed.
- Obtaining credit to acquire crossbred cattle.
- Make plans for forest land use.

A nursery of forage species established in the commune in 1996 became a useful demonstration area. Farmers were able to see what the forage species look like.

*On-farm activities*

1996

- Established a forage nursery of 53 species. The nursery was set up on 2,000 m2 of a farmer's field.
- Farmer's meetings convened to discuss potential use of forages according to their farming system.
- Data collected on growth and development of forage in the nursery every month.

1997

- Farmer participation in the nursery evaluation was encouraged to gain initial feedback on what species are liked and why.
- Data collection from the nursery continued.

- 5000 seedlings of Leucaena leucocephala; Calliandra calothyrsus and Gliricidia sepium were produced and distributed to eight farmers for evaluation.
- It was initially planned to begin on-farm evaluation in 1998, but some farmers were so keen in getting started that seeds of *Stylosanthes guianensis* CIAT184; *Brachiaria brizantha*, *B. decumbens*, *B. ruziziensis,* and *Panicum maximum* were distributed to eight farmers ahead of schedule.

1998

- The number of farmers evaluating the forages will be expanded.
- A training course on developing forage technologies with farmers was conducted in February 1998.

**M'Drak, Daklak**

*Participatory diagnosis*

Participatory diagnosis has not yet been conducted in M'Drak but is planned for April 1998. However, on-farm work began in 1997 because the FSP local partners have considerable experience in the area. Moreover, farmers at the Chu' kroa commune had substantial livestock feeding problems which they were anxious to solve. Chu' kroa commune was established in 1987 by the Kinh migrants from the over-populated areas of north Vietnam. The commune consists of 320 families in six villages situated on 20,000 ha of land. However, the commune has very little rice land (65 ha) and *Imperata* dominates large areas of the hills. After the commune was established, land was allocated to farmers according to their capacity to use the land. In this way, families with excess labour received more land than families with none. As a result, large differences in land area exist: some households have more than 90 ha and others have less than 1 ha. The primary agricultural activities are upland cropping (cassava, beans, sweet potato), forest plots (government pays farmers for maintaining small plots of *Eucalyptus* and *Acacia*), and livestock (cattle, pigs, chickens and fish). Approximately 1500 head of cattle are kept by 90% of the households, with number per household ranging from 1-2 up to 90 animals. Cattle raising is an essential source of livelihood for these farmers, providing income and using land that cannot be used for any other activity (the *Imperata* grasslands). Usually, the cattle graze during the day and are put in pens at night. The most common problem mentioned by farmers is the very poor quality of grassland. As a result, they have to take the animals over long distances to find green feed each day. During the wettest time of the year (November and December), animals are frightened by the thunderstorms and become lost. They, therefore, need to keep their animals closer to home during this time.

*On-farm activities*

1995/1996

- A nursery evaluation (comprising 70 grasses and legumes) was established on a farmer's field in M'Drak District. After two years of evaluation, 20 promising (adapted) species emerged. The best species were *Andropogon gayanus* CIAT 621*, Brachiaria brizantha* (several accessions), *Brachiaria decumbens* cv. Basilisk, *Panicum maximum* CIAT6299, *Brachiaria humidicola* (various accessions*), Stylosanthes guianensis* CIAT 184, *Chamaecrista rotundifolia* cv. Wynn and *Arachis pintoi* CIAT 17434.
- These species were planted in three other regional sites to confirm their broad adaptation (one in an area near M'Drak, one at Buon Don, and one at Kontum). The broad adaptation of these species was confirmed. The regional evaluations generated interest among the local farmer groups who visited the nurseries and brought home some planting materials.

1997

- Farmers from Chu' kroa commune visited the forage nursery and identified forage species that they want to test. 15 farmers in the commune and 5 farmers who have

been allocated land by the Daklak Livestock Production Company planted these forages.
- The species planted were *Andropogon gayanus* cv. Kent, *Brachiaria brizantha* CIAT6780, *Brachiaria decumbens* cv. Basilisk, *Panicum maximum* TD58, *Brachiaria ruziziensis*, and *Stylosanthes guianensis* CIAT 184.
- Regular meetings with farmers were held. Some farmers have already begun to expand the area that they are cultivating. A significant demand exists from other farmers in the commune who have seen these forages growing and who want to become involved in the project.

**Ha Giang and Tuyen Quang Provinces**

*Participatory diagnosis*

The work in Ha Giang and Tuyen Quang is conducted in collaboration with the Vietnam Sweden Mountain Rural Development Program (MRDP). This program has been going on for 7 years. Detailed PRAs were conducted in the target villages over the first 5 years. A consistent finding was the identification of livestock feed shortage as a major problem. As a result, the MRDP invited FSP to participate in forage technology development in their target areas.

The main problems identified by the farmers in raising livestock were:
- Lack of good animal breeds.
- Disease.
- General feed shortages (particularly in the dry season).
- Lack of cheap feeds for fish and pigs.

To overcome feeding problems, farmers use many agricultural residues and by-products as substitute feed.

*On-farm activities*

1997
- Innovative farmers were identified in each location to take part in the evaluation of forages for intensive backyard systems. The species originally offered were those that performed well in a regional nursery established at the Forestry Research Centre in Vinh Phu. These were legumes: *Stylosanthes guianensis* CIAT 184, *Stylosanthes hamata*, *Centrosema pubescens* cv. Cardillo, *Centrosema brasilianum*; and grasses: *Brachiaria brizantha* CIAT6780, *Brachiaria decumbens* cv. Basilisk, *Brachiaria ruziziensis*, and *Panicum maximum* TD58.
- In Ha Giang, 11 farmers planted forages. However, within the same wet season, 10 other farmers multiplied the species they liked (vegetatively) and planted these on their own land.
- In Tuyen Quang, a similar situation occurred. Seven households initially planted forages and 3 others joined spontaneously using vegetative planting material.
- Most forages were planted in small backyard plots. Participatory evaluation showed that the most preferred species are *Brachiaria, Panicum maximum* TD58, and *Stylosanthes guianensis* CIAT184. The main reason is that these species can also be fed to fish and pigs.

## Conclusions and future activities

Farmer evaluation of forages began in 1997. At four locations, we have started working with a small number of farmers. In the process we have gained a lot of experience in using participatory methodologies. These methodologies, though time-consuming, are an effective way of working with poor farmers. If we really want to help these poor farmers solve their livestock feeding problems, we need to commit ourselves to working closely with them over a number of years, not months.

We have learned that, at all sites, there is considerable demand and potential for expanding on-farm work in 1998. The species that proved to be broadly adapted include *Brachiaria brizantha* CIAT 6780, *Brachiaria decumbens* cv. Basilisk, *Panicum maximum* TD58, and *Stylosanthes guianensis* CIAT 184.

The activities planned for 1998 include:

1) Getting more farmers involved in each site.
2) Expanding to other villages in the target areas. In Ha Giang, we will collaborate with World Neighbours in an area where Hmong farmers have started to manage grasses and *Leucaena* to feed their livestock. In Daklak, we will begin collaborative work with a GTZ rural development project that has found many farmers who want to eradicate *Imperata* (a problem similar to that in Chu' Kroa) Also, in Daklak, we will start evaluating cover crop species for erosion control in smallholder coffee plantations with DANIDA.
3) Commencing on-farm evaluations in Binh Thuan Province under the supervision of the College of Agriculture and Forestry in Ho Chi Minh City.
4) Conducting regular participatory evaluations of forages at existing sites and new sites.
5) Introducing some potentially promising species for evaluation, including *Setaria sphacelata* cv. Solander (for the north), *Chamaecrista rotundifolia* for ground cover in fruit orchards, earlier flowering lines of *Stylosanthes guianensis* for the north, and *Flemingia macrophylla* for fish feed.
6) Conducting a training course on 'Developing forage technologies with farmers' (in February 1998) and provide follow up field experience and informal training for participating farmers.
7) Training farmers on forage production, management, and utilisation.
8) Continuing other activities which support our on-farm work, including forage tree legume evaluations and seed production in Daklak (OFI), *Gliricidia* evaluations on farm in Quang Ninh province (FAO), and *Brachiaria* seed production trials in Daklak.
9) Translating and publishing the manual *'Field experiments with forages and crops. Practical tips for getting it right the first time'.*

## Acknowledgements

The authors thank the following for supporting the program with funds, facilities, and staff: the FSP regional program, local villages and districts authorities at all sites, Hue University of Agriculture and Forestry, Tay Nguyen University, College of Agriculture, (Ho Chi Minh City), National Institute of Animal Husbandry, and all the farmers in the various sites.

# Developing forage systems with smallholder farmers in Malitbog, Bukidnon, Philippines

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The development of viable forage systems is needed to sustain ruminant production in Malitbog. This can only be achieved by making improved forage species available to smallholder farmers and working with them to integrate these forages into the existing farming system. From the farmers' perspective, their limited landholdings have to be intensively developed for crop production while animal production is usually regarded as a by-product which is less important. In the past little effort was made to integrate improved forage species because of lack of access to planting materials and the perception that livestock has less commercial value than crops. This situation is likely to change as policymakers realise the negative influence of increased beef imports on the domestic economy.

As land becomes more and more limiting, the potential for integrating ruminants with cash crops will have to be explored. Successful exploitation of these resources requires that suitable forage species and management strategies are developed. This case study describes how farmers established and evaluated different forage options to select a range of forages suited to their situations in Malitbog.

## Forage establishment options

### Rows of forages in crops

Where time, labour, and capital are substantially limited, smallholders were able to integrate forage species with a standing corn crop. After the hilling-up operations, species, which were erect and perceived as shade-tolerant, were planted in between the corn furrows. Farmers who grew forages this way said that it is practical and economical. The system, they added, can provide them with food and their animals with feed in just one cycle of land preparation. In some sites, a number of farmers were able to establish five or more different grass and legume varieties.

To ensure food availability, vegetables such as okra and eggplant, were incorporated in between rows of cut-and-carry forages. Farmers expected competition between lines of Napier, *Panicum maximum*, *Setaria sphacelata* and *Andropogon gayanus* and the food crops. Thus, they applied manure to fertilise food and forage crops to minimize this competition.

Almost all farmers involved in the project have expanded their forage area with cut-and-carry species grown in rows. Forage grasses and tree legumes were planted separately in rows adjoining each other or alternately in 10 m rows. One farmer said that due to area limitation and personal preferences, cut-and-carry species were wanted more than grazing species. Between the cut-and-carry rows farmers can still grow crops such as vegetables.

### Plots

Several farmers involved in the FSP planted cut-and-carry species in separate plots. Each farmer has 4 - 5 plots. These forage species were planted along or under banana and coconut trees and also in open areas. The farmers grew the various species to

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establish their yield performance and ability to survive. *Arachis pintoi, Stylosanthes guianensis* and *Centrosema pubescens* may also be noticed as intercrops in some cases.

*Arachis pintoi* was also planted in blocks, usually in front of the farmer s' house as an ornamental and soil cover. Growing forages in this way not only makes the surroundings clean but also provides a feeding ground for ducks which relish on the protein-rich flowers and leaves. As a result of this better nutrition, egg production doubled.

**Hedgerows**

To arrest soil erosion, which is a major agricultural problem in the community, farmers planted Napier as hedgerows. To get more yield, better quality feeds, and reduce surface runoff, *Calliandra calothyrsus, Gliricidia sepium* and *Leucaena leucocephala* (K636) were grown as newly established hedgerows.

Participatory diagnosis identified problems of soil erosion, low income, and inadequate livestock feed. Instituting an option such as planting forages in hedgerows has positive consequences in terms of reduced water run off. Though the aim of farmers in the earlier stage of FSP is to assure a plentiful supply of livestock feed (almost all have established forages in blocks or home gardens for feed availability) efforts to establish hedgerows still continue after farmers realize its importance in the long run.

## Conclusions

The participatory process proved to be crucial in finding solutions to major problems in the farming systems. One farmer commented that although the participatory process itself is new to them, the whole system itself is understandable. The information given helps them to make decisions on forage development objectively. The farmers added that the farmer participatory approach faces problems and needs squarely. It also encourages positive outlook and advocacy toward a self-reliant farming community.

# Farmer evaluation of forages in Indonesia: Progress, experiences and future plans

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## Introduction

On-farm evaluation of forages with the Forages for Smallholders Project commenced in East Kalimantan in 1995. Since then farmer evaluation of forages expanded to seven sites in East and Central Kalimantan, Aceh, North Sumatra and North Sulawesi. Collaborators based at these sites are from Provincial and District Livestock Services, and the Agency for Agriculture Technology Assessment, all under the Ministry of Agriculture. These institutions have personnel based in the communities where the FSP is working (Table 1).

**Table 1. Sites and collaborating institutions of the FSP in Indonesia.**

| Site | Collaborators |
|---|---|
| Saree, Aceh | Provincial Livestock Services |
| Pulau Gambar, North Sumatra | Assessment Institute for Agriculture Technology |
| Marenu, North Sumatra | Assessment Institute for Agriculture Technology and the Transmigration Office of North Sumatra |
| Sepaku, East Kalimantan | Provincial Livestock Services |
| Makroman, East Kalimantan | Provincial Livestock Services |
| Kanamit, Central Kalimantan | Provincial Livestock Services |
| Gorontalo, North Sulawesi | Provincial Livestock Services |

Collaborators from East and Central Kalimantan worked already with the Southeast Asian Forage Seeds Project from 1992 to 1994. All collaborators had experience in research and / or development work either with forages or with farmers.

## Description of sites

Table 2 shows the location and brief climatic summary of FSP sites in Indonesia. A brief description of soils and the farming system is presented in Table 3.

Most of the sites are upland areas, except for Pulau Gambar and Kanamit which are flat. Kanamit is in an areas which is seasonally flooded and recent efforts to drain the area have resulted in large areas of acid sulphate peat soils with extremely low pH. The site in Gorontalo is dominated by smallholder coconut plantations with farmers growing annual food crops under the plantations. Sepaku is located in *Imperata* grasslands which have partially been allocated to farmers (1-2 ha per farmer). Wild pigs make upland

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cropping difficult at this site and farmers rely more on cattle and pepper for cash income. Generally, soils are of clay type, with pH varying from very acidic to slightly acidic and low to moderate fertility. Topography varies from flat to steep. Altitude ranges from sea level to more than 500 m above sea level in Saree, Aceh and Marenu, North Sumatra.

All sites have farms that are crop-based but livestock play an important role as a source of draft, cash income and manure. Often, corn and cassava are the major food and crops; rice is cultivated in valleys or flat areas. Farmers in North Sumatra plant fruit crops, vegetables and oil palm. Fruit crops, vegetables and peppers are cultivated in East Kalimantan. Farmers in Central Kalimantan plant banana, coconut and coffee as cash crop. Most farmers in all sites use fertiliser and manure for their crops, and some also sell manure.

Sale of crops is a major source of cash income in all sites. Chicken and goats are used for religious ceremonies, festivals, or provide cash for immediate needs, while cattle or buffalo is sold when the family needs a large amount of cash; like for schooling, weddings, or building a house. In some cases, during dry season, male members of the families, go to adjacent towns, working off-farm. All the sites experience an increase in area devoted to crop production, thereby reducing the grazing areas available for ruminants.

In most areas, except in Aceh and Central Kalimantan, cattle and buffalo are tethered or graze freely on native vegetation in vacant areas during the day with basically no or minimal supplementation of salt. Only animals kept in pens or tethered near the house for fattening are supplemented with rice bran and extra cut feed. Farmers cut native grasses from roadsides, rice fields, forest areas, or near plantation crops, for night feeding. In Aceh, large areas of natural grassland are still available, but these are in poor condition. Farmers graze their animals on these grasslands, relying solely on the vegetation available there. Since forages became available through the FSP, farmers grow forage banks near their communal sheds and use this feed for night feeding. In Central Kalimantan most of the cattle are kept near the houses and are supplemented with grasses cut by the farmers.

**Table 2. General description of FSP sites in Indonesia: Physical characteristics.**

| Site | Latitude | Altitude (m) | Annual rainfall (mm) | Wet season | Wet months (>50mm) |
|---|---|---|---|---|---|
| Saree, Aceh | $5^0$ N | 500 | 1580 | Oct - Apr | 4-8 |
| Marenu, North Sumatra | $4^0$ N | 300 | 2330 | Oct - Apr | 7-10 |
| Pulau Gambar, North Sumatra | $3^0$ N | <100 | >2000 | Oct. - Apr | 7-10 |
| Sepaku, East Kalimantan | $1^0$ S | <100 | 2400 | Nov - Jun | 7-11 |
| Makroman, East Kalimantan | $1^0$ S | <100 | 2040 | Nov - Jun | 7-11 |
| Kanamit, Central Kalimantan | $3^0$ S | <20 | 2750 | Nov - Jun | 8-11 |
| Gorontalo, North Sulawesi | $0^0$N | 18 | 1290 | Nov - Jun | 5-7 |

**Table 3. General description of FSP sites in Indonesia: Soils and farming system.**

| Site | Soil Characteristics | Description of farming system |
|---|---|---|
| Saree, Aceh | • Clay-loam<br>• Slightly acidic<br>• Moderately fertile<br>• Well-drained<br>• Flat to steep | • Intensive upland farming and grassland<br>• Crops: corn, sweet potato, peanuts, vegetables, for consumption and cash<br>• Crops fertilised with manure and inorganic fertiliser<br>• Animals: locally-breed beef cattle<br>• Grazed native vegetation with salt supplementation |
| Pulau Gambar, North Sumatra | • Clay<br>• Slightly acidic - neutral<br>• Moderately fertile<br>• Poorly drained<br>• Flat | • Intensive rainfed rice and access to oil palm and rubber plantations<br>• Crops: lowland rice, vegetables for consumption and cash<br>• Crops fertilised with manure and inorganic fertiliser<br>• Animals: sheep<br>• Pen-feeding |
| Marenu, North Sumatra | • Clay-loam<br>• Extremely acidic<br>• Very low fertility<br>• Well-drained<br>• Rolling | • Intensive upland farming<br>• Crops: corn, upland rice, vegetables, and oil palm for consumption and cash<br>• Crops fertilised with manure<br>• Animals: sheep<br>• Pen-feeding |
| Sepaku, East Kalimantan | • Red-yellow podsolic<br>• Very acidic<br>• Low fertility<br>• Well-drained<br>• Rolling to steep | • Large areas of *Imperata* grasslands<br>• Crops: small areas of lowland rainfed rice and small areas of upland vegetables (home garden), and upland pepper for consumption and cash<br>• Crops are fertilised with manure<br>• Animals: beef cattle (Brahman crossbred)<br>• Tethered to graze native vegetation during the day, and cut and carry for night feeding |
| Makroman, East Kalimantan | • Podsolic<br>• Very acid<br>• Well-drained<br>• Low to moderate fertility<br>• Rolling to steep | • Mixed lowland rainfed rice and upland crops<br>• Crops: corn, rainfed rice (valleys and flat areas), cassava, sweet potato, vegetables for consumption and cash<br>• Crops are fertilised with manure and inorganic fertiliser<br>• Animals: beef cattle and goats<br>• Mostly pen-feeding |
| Kanamit, Central Kalimantan | • Acid sulphate peat<br>• Clay soils in higher areas<br>• Extremely acidic soils<br>• Seasonally flooded<br>• Low fertility<br>• Flat | • Under lowland rain-fed rice and upland crops<br>• Crops: coconut, corn, banana, fruit trees, coffee, vegetables; for consumption and cash<br>• Crops fertilised with manure and inorganic fertiliser<br>• Animals: beef cattle<br>• Animals tethered near the house, and fed cut and carry forages during the day and for night feeding. |
| Gorontalo, North Sulawesi | • Clay-loam<br>• Seasonally flooded<br>• Moderately fertile<br>• Flat | • Large areas are under coconuts; upland crops are grown under coconuts<br>• Crops: coconut, corn, banana, fruit trees, vegetables; for consumption and cash<br>• Crops fertilised with manure<br>• Animals: beef cattle<br>• Animals tethered to graze native vegetation, and cut and carry for night feeding. During dry season feeds are bought. Some farmers grow a third corn (leave only, no cobs) for feeding animals during the dry season. |

## Procedure and results of participatory diagnosis

Participatory diagnosis (PD) has been done at all sites. The basis for selecting farmers in the activity were their membership in farmer groups that already had a good working relationship with the collaborators and their perceived need for forages. Table 4 shows a summary of the problems expressed by farmers and those that are being addressed by on-farm activities.

Lack of feed during dry season, poor animal performance and unavailability of adapted forage species were problems expressed at most sites. This problem was mostly due to increases in animal population and a declining area available for grazing. At some sites, a lack of feed during cropping season, when most areas are planted to crops, was also a problem. Farmers did not see soil erosion as a major problem, despite it being clearly evident at some sites (eg. Saree). Uncontrolled grazing is a problem for farmers in Saree and Pulau Gambar where farmers have tried to establish forages which were then damaged by animals of other farmers.

Farmers in East Kalimantan and Marenu expressed a need for new forage varieties. These farmers had previously grown giant Napier grass (King grass) or *Setaria sphacelata* var. *splendida* for their animals. They observed that these species were not able to persist under their conditions.

**Table 4. Major problems identified by farmers in Participatory Diagnoses in Indonesia.**

| Problem | Saree | Pulau Gambar | Marenu | Sepaku | Makroman | Kanamit | Gorontalo | Kanamit | Gorontalo |
|---|---|---|---|---|---|---|---|---|---|
| Lack of feed in dry season | + ✔ | + ✔ | ++ ✔ | ++ ✔ | + ✔ | + ✔ | ++ ✔ | - | ++ ✔ |
| Uncontrolled grazing | + | + | - | - | - | - | - | - | + |
| Increase in unpalatable weeds | + | - | - | - | - | - | - | - | - |
| Diseases in animals | - | + | + | + | - | - | - | + | - |
| Poor animal performance | + | + | + | + | + | - | - | + | + |
| Unavailability of adapted forages | + ✔ | + ✔ | +++ ✔ | + ✔ | + ✔ | + ✔ | + ✔ | - | - |

[1] + = moderate priority; ++ = high priority; +++ = very high priority.
[2] ✔ = Problem is being addressed by on-farm activities.

Farmers are coping with the lack of feed by using rice straw and other agricultural by-products, taking their animals to far away areas to graze, gathering tree leaves and banana trunks, gathering native forages from areas along roadsides, rice fields, or near plantation and forest areas, and carrying these to their animals. Some farmers also provide salt supplementation.

## Activities conducted at the sites

Activities vary between sites (Table 5). The basic procedure, however, involves consulting with farmers (PD and planning), followed by establishment of initial testing and multiplication areas, followed by individual testing by farmers on their own land. In between these stages, field days, trainings and cross-visits are arranged. Regular meetings with farmers were done to exchange experiences (eg. participatory evaluation) and maintain the initial testing area. Likewise, farmers were visited to gather feedback.

The initial testing and multiplication areas were established and managed by farmer groups. The decision on which species to try was made in consultation between site collaborators and farmers. These multiplication areas were very useful for conducting field days and trainings. Farmers could see the species and decide for themselves which ones they would like to try on their farms.

The major basis for selecting farmer-co-operators was their interest and availability of land to plant forages. Whenever possible, innovative farmers with leadership and communication skills were chosen.

Distribution of planting materials was done either during field days or by individual request. The latter seemed to result in better establishment since the farmers are keen and ready to plant before they gets the planting materials. This was done in cases when farmers wanted large amount of planting materials.

On the other hand, farmers always ask and get planting materials during field days. In this case, collaborators ask the farmers to plant just a few plants near their houses to later serve as source of planting materials if farmers want to expand.

**Table 5. Summary of FSP site activities in Indonesia.**

| | Saree | Pulau Gambar | Marenu | Sepaku | Makroman | Kanamit | Gorontalo |
|---|---|---|---|---|---|---|---|
| **Type of activity** | | | | | | | |
| Communal – formal[1] | ✔ | ✔ | ✔ | ✔ | ✔ | - | ✔ |
| Individual – formal[1] | | ✔ | ✔ | ✔ | ✔ | - | ✔ |
| Individual – informal[2] | ✔ | - | ✔ | ✔ | ✔ | ✔ | ✔ |
| **Method of planting material distribution** | | | | | | | |
| Field days | - | - | - | ✔ | ✔ | ✔ | ✔ |
| From FSP | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| Individual contact | - | - | - | ✔ | ✔ | ✔ | ✔ |
| **Possible forage types/options** | | | | | | | |
| Grasses for cut-and-carry | | | | | | | |
| - in hedgerows | - | - | - | ✔ | ✔ | ✔ | ✔ |
| - in blocks | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| Grasses for grazing | ✔ | - | - | - | ✔ | ✔ | ✔ |
| Herbaceous legumes | | | | | | | |
| - for grazing | ✔ | - | - | - | ✔ | ✔ | ✔ |
| - as cover crops | - | - | - | - | ✔ | - | ✔ |
| - for soil improvement | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| - as relay to main crop | - | - | ✔ | ✔ | ✔ | ✔ | ✔ |
| Tree/shrub legumes | | | | | | | |
| - in hedgerows | - | - | ✔ | ✔ | ✔ | ✔ | ✔ |
| - in fence lines | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |

[1] Technicians and farmers together decide on what species and what option to test.
[2] Farmers chose the species and option by themselves.

## Progress of forage technology development, evaluation and adoption

Validation of the result of PD was conducted two to three months after the PD. If the farmers still expressed their needs for forages, the meeting continued to participatory planning. During participatory planing, farmers proposed what they need individually and as a group. Later on, the technicians and the field extension workers, assisted by the chairman of the group, helped the farmers in setting up their forage plots.

The pace and progress of on-farm work varied between sites, but most sites are now into individual farmer testing (except Aceh), trainings and farmer field days as well as participatory evaluation, except legume trees in East Kalimantan and Gorontalo (still in early stages of growth) and Central Kalimantan (have not started individual planting).

Collaborators at all sites report that it takes time for establishing forages on-farm with the farmers. Factors like farmers' access to other cash crops, income sources other than livestock, the availability of native species often slow down the process despite frequent visits and discussions.

It is the farmers with a strong need who are the ones establishing forages, even to a point where they approach the technicians or pay some money to get planting materials.. On the other hand, there are farmers who succumb to peer pressure or to an impulsive, but temporary instinct, to get planting materials. Moreover, there are also 'wait-and-see' types of farmers.

Farmer visits, field days, trainings and cross-visits were very useful in sustaining interest of farmers. It is during these activities that farmers and technicians share ideas, learn from each other and plan activities for the next few weeks.

It was also observed that there were more farmers who obtained planting materials in sites where livestock dispersal programs exist. This implies that forage technology development would be facilitated if implemented with livestock improvement program.

Moreover, successful forage establishment was facilitated in cases where strong farmer organisations existed. The existence of 'kelompok tani ternak' (farmer groups) also was a big factor in rapid establishment of forages in individual farmers' fields.

## Farmers' feedback

Farmers reacted well to the participatory approach. They felt involved and free to choose whatever species, options and way of establishment they wanted. Involving these farmers in field days and in training other farmers has been beneficial for the trainees and the farmer trainers as well.

In terms of individual forage species, farmer preferences varied with sites. At early stages (initial testing and multiplication), farmers tended to prefer species which grew well and showed good yield potential. Later, other major criteria were palatability, easy establishment and management, and persistence during dry season.

For grazing species, farmers started to realise the value of grazing tolerance (for grazing species), ability to spread and produce ground cover and palatability. For instance, farmers in East Kalimantan found that *Brachiaria humidicola* spread fast, tolerate close grazing and possess good palatability. Even for cut and carry species, farmers in Central Kalimantan found it very useful.

A farmer in East Kalimantan observed that the meat quality of his cattle improved when his cattle grazing this grass.

*Centrosema pubescens* CIAT 15160 was found to suppress *Imperata* in Makroman, making it a useful cover crop and was palatable to goats and cattle. They also observed

that when they intercropped it with corn and cassava, the taste of the crop did not change while the need for fertiliser and weeding decreased, the yield of corn increased and the yield of cassava was reduced only slightly.

Farmers favoured tall and upright grasses like Napier (King and elephant grass), *P. maximum*, *Setaria sphacelata var. splendida*, *Paspalum atratum, Paspalum guenoarum* and *Andropogon gayanus* for cut-and-carry, especially because of their good yield and palatability. In addition, *P. atratum* and *P. guenoarum* were found tolerant to occasional flooding and was not itchy when cut, but *P. atratum* has sharp leaves which may reduce its spread.

Farmers have also observed that legumes like S*tylosanthes guianensis* 184 were not as palatable as grasses for cattle. These cases occurred when these species were fed with grasses during wet season.

*Desmodium cinerea* (previously called *D. rensonii)* was found to posses de-worming effects in Saree, while *Desmodium heterophyllum* CIAT 349 died during dry season, even though it formed a dense ground cover during wet season.

## Farmers' management of forages

As of this stage, many individual farmers in East and Central Kalimantan, and Marenu are planting larger areas, while farmers in Pulau Gambar and Gorontalo are still planting the species in small plots (either in blocks or short hedgerow lines), either near their houses or in portions of their farms. The farmers' group in Aceh has not yet expanded the initial area of the pasture; the species are either grazed or cut and fed to animals from time to time.

The farmers' group in Saree also planted *Panicum maximum, Paspalum atratum, and Brachiaria brizantha* near the communal shed, and they cut them every 2 – 3 weeks, even during dry season. They said that if they let them grow more than 3 weeks, leaves are too coarse for the animals. This is also the case with *Brachiaria humidicola* in Central Kalimantan.

Grasses and shrub/tree legumes were also planted in fence lines. A farmer in Makroman started planting *Centrosema pubescens* CIAT 15160 and *Stylosanthes guianensis* CIAT 184 between the rows of corn and cassava. He then observed that *C. pubescens* preserved the moisture of the soil, suppressed the weed, kept the soil friable, reduced the need for fertiliser, as well as providing good feed for his goat. Learning these results, his neighbours were excited to try this 'new technology' to the point that they planted *Paspalum atratum* between the rows of corn. When they were told that the grass may reduce the yield of the corn, they said it did not matter, since they also needed the forages for their animals.

## Experiences with participatory evaluation

Participatory evaluation (PE) has been carried out at most sites. This was done mostly in the initial testing and multiplication area. Farmers observed the species and gave their comments. In some sites where farmers have planted forages on their own farms, farmers' observations on the forages that they established were also taken. Open-ended evaluation and preference ranking were used for PE.

Farmers answered on characteristics related to the utilisation of a particular species. This includes information on yield, palatability, regrowth ability, itchiness, persistence, as well as easy management and time saving effect of forages when planted near the house.

There is still a need to gain more experience and skills in evaluation techniques like probing and asking questions as well as obtaining farmers' criteria in selection of a certain species. In the process of evaluation, a lot of things can happen and the person handling the evaluation has to learn how to deal with the situation. These skills only be obtained by practice, reflection and training. Every evaluation session is different from another.

## Technical issues

A major issue for expanding on-farm evaluation is the production and handling of seeds. At this stage, most of the grasses are established using vegetative planting material. Legume species are usually established from seed. The problem is there is no commercial production of forage seeds in Indonesia. Government stations only produce a small amount of legume seed, due to their location and climatic factors. Moreover, there has been no successful seed production attempt at the farmers' level. With the hot, humid climatic conditions in most of Indonesia, it is difficult to store seeds for any length of time. This problem needs close attention if rapid expansion of forages is to be attained.

# Forage research papers

# Seed production potential of *Brachiaria s*pecies in northeast Thailand

**Ganda Nakamanee[1] and Chaisang Phaikaew[2]**

## Introduction

The northeast region of Thailand, which accounts for approximately one-third of the national land area, has a tropical climate with pronounced dry and rainy seasons. The mean annual rainfall is 1300 mm with 85% falling from mid-April to mid-October (Shelton 1982). The majority of cattle and buffalo in Thailand are concentrated in this region. Feed shortages are a major concern, especially during the 6-months long dry season when livestock are mainly fed rice straw. To ease this problem, Thai research organisations have been developing improved forages and appropriate management guidelines for their use. As a result, Ruzi grass (*Brachiaria ruziziensis*) has become widespread, primarily because of its high seed yields and ease of establishment. However, although seed production is relatively easy, Ruzi is poorly adapted to areas with long dry seasons.

Within the same genus, one species (*B. decumbens*) has been identified in several agronomic trials as having better dry season growth (Thinnakorn and Kreethapon 1993, Phaikaew et al. 1996). However, its use in Thailand is constrained by low seed yield and poor seed quality (Boonpukdee et al. 1996, Gobius et al. 1996).

The approach taken in the present study was to screen a larger range of *Brachiaria* accessions for their seed production potential. Accessions with promising seed yields will be further tested for their environmental adaptation, with particular emphasis on dry season performance.

## Materials and methods

The experiment was conducted at Pakchong Animal Nutrition Research Centre, Nakornratchasima, northeast Thailand (latitude 14°42'N, longitude 101°25'E, altitude 330 m, mean annual rainfall 1100 mm – see Fig. 1). The soil is a red clay with a pH 5.8.

Thirty two accessions of *Brachiaria* spp., comprising five species (*B. brizantha, B. decumbens, B. humidicola, B. jubata* and *B. ruziziensis,)* introduced from CIAT Colombia, were established along with a control (*B. ruziziensis*). As the quantity of seed available was very limited, seed was pre-germinated in polyethylene bags in May 1996 and transplanted to the field in August 1996. Plots were arranged in a randomised complete block design with three replications. Each plot consisted of nine plants arranged in a 0.4x-0.4m grid pattern. 300 kg/ha compound fertiliser (15-15-15) and 60 kg/ha urea were applied at transplanting. Plants were cut back after seed


**Fig. 1. Experimental site.**

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harvest in the first year (Jan 1997) and were sampled for dry matter yield during the dry season (May 1997).

### Data collection and seed harvesting

Dry matter yields during the dry season and at initial flowering were recorded for each plot. Regrowth after cutting and drought tolerance were visually estimated. To measure seed yield, seed heads were tied together into manageable bunches. When seed was almost ripe, the bunches were covered by nylon net bags which remained there for the duration of the harvest. Inflorescence density and number of tillers per plant were recorded in December 1997. Tiller fertility was expressed as the number of inflorescences divided by the total number of tillers.

Random samples of 15g seed were used to measure seed purity (in accordance with ISTA rules for seed testing) and one-thousand seed weight. The pure seed component was estimated as the number of caryopses in a sample of 100 spikelets. A germination test will be conducted in March/April 1998, and a tetrazolium test will determine the viability of seed that fails to germinate. Data on dry matter yield and seed yield were recorded only in the second year because of late transplanting in the first year.

## Results and discussion

The experiment was conducted in a year of adverse rainfall conditions. The 1997 total rainfall was 663 mm, which was only 60% of the long-term mean annual rainfall for Pakchong (Fig. 2). This makes the drought tolerance measurements particularly relevant. However, seed production is likely to have been adversely affected by moisture stress.

All the accessions established well, but *B. humidicola* CIAT 16886 and 26149 died during the first year. In 1996, only 20 accessions flowered due to late planting (Table 1). It is likely that some accessions need a long juvenile phase before they reach their critical daylength for flowering.

In 1997, all accessions flowered except *B. brizantha* CIAT 16306 (Table1). Flower initiation varied from June to October (31-161 after closing cut on 22 May 1997). Ten accessions initiated flowers by June, three accessions by July, four by August, five by September and seven by October.

There was a large variation in inflorescence density, noted on 12 December 1997 (Table 2). Flowering in most species was adequate, except in *B. brizantha* CIAT 16288, CIAT 26566, and *B. decumbens* CIAT 26297.

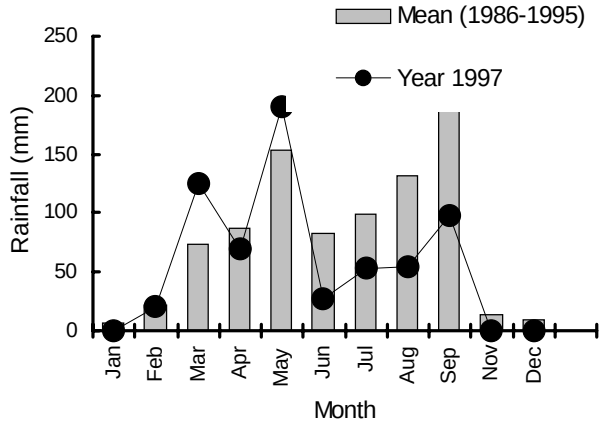


**Fig. 2. Mean monthly rainfall (1986-95) and monthly rainfall in 1997 at Pakchong.**

**Table 1. Survival and flowering of 33 *Brachiaria* accessions.**

| Species | CIAT Accession Number | Survival | Flowering | |
|---|---|---|---|---|
| | | | 1996 | 1997 |
| *Brachiaria brizantha* | 667 | ✔ | ✔ | ✔ |
| " | 6387 | ✔ | ✔ | ✔ |
| " | 6780 | ✔ | ✘ | ✔ |
| " | 16288 | ✔ | ✔ | ✔ |
| " | 16306 | ✔ | ✘ | ✘ |
| " | 16307 | ✔ | ✘ | ✔ |
| " | 16309 | ✔ | ✘ | ✔ |
| " | 16311 | ✔ | ✔ | ✔ |
| " | 16319 | ✔ | ✘ | ✔ |
| " | 16444 | ✔ | ✔ | ✔ |
| " | 16463 | ✔ | ✔ | ✔ |
| " | 16464 | ✔ | ✔ | ✔ |
| " | 16472 | ✔ | ✔ | ✔ |
| " | 16488 | ✔ | ✘ | ✔ |
| " | 16549 | ✔ | ✔ | ✔ |
| " | 16779 | ✔ | ✔ | ✔ |
| " | 16827 | ✔ | ✔ | ✔ |
| " | 16829 | ✔ | ✔ | ✔ |
| " | 16830 | ✔ | ✘ | ✔ |
| " | 16835 | ✔ | ✔ | ✔ |
| " | 26110 | ✔ | ✘ | ✔ |
| " | 26566 | ✔ | ✘ | ✔ |
| *Brachiaria decumbens* | cv. Basilisk | ✔ | ✔ | ✔ |
| " | 16497 | ✔ | ✘ | ✔ |
| " | 26112 | ✔ | ✘ | ✔ |
| " | 26297 | ✔ | ✔ | ✔ |
| " | Brazil | ✔ | ✔ | ✔ |
| *Brachiaria humidicola* | cv. Tully | ✔ | ✔ | ✔ |
| " | 6133 | ✔ | ✔ | ✔ |
| " | 16886 | ✘ | – | – |
| " | 26149 | ✘ | – | – |
| *Brachiaria jubata* | 26188 | ✔ | ✔ | ✔ |
| *Brachiaria ruziziensis* | 'Ruzi' | ✔ | ✔ | ✔ |

The seed yield components are presented in Table 2. There was wide variation in tiller fertility, from 9% in *B. brizantha* CIAT 16488 to 68% in *B. ruziziensis.* The highest inflorescence density occurred in *B. decumbens* CIAT 16497. Inflorescence density was not always associated with high seed yield because soil moisture was limiting during the flowering period. The number of racemes per inflorescence varied: 2.2 - 9.8 in *B. brizantha*, 2.4 – 7.0 in *B. decumbens,* 2.6 - 3.7 in *B. humidicola*, 3.9 for *B. jubata,* and 4.9 for *B. ruziziensis.*

**Table 2. The components of seed yield in *Brachiaria* species.**

| Accessions | Onset of flowering | Tiller fertility (%) | Inflorescence density (no./plant) | Racemes/ inflorescence (no.) | Raceme length (cm) | Spikelet density (no./cm) |
|---|---|---|---|---|---|---|
| *Brachiaria brizantha* | | | | | | |
| CIAT 667 | 5 Aug | 34 | 50 | 4.0 | 4.0 | 7.2 |
| CIAT 6387 | 20 Jun | 60 | 75 | 7.3 | 2.2 | 5.5 |
| CIAT 6780 | 1 Oct | -[1] | - | 3.4 | 7 | 5.3 |
| CIAT 16288 | 5 Jun | 27 | 11 | 3.0 | 11.6 | 4.3 |
| CIAT 16306 | x[2] | x | x | x | x | x |
| CIAT 16307 | 1 Oct | - | - | - | - | - |
| CIAT 16309 | 20 Sep | - | - | - | - | - |
| CIAT 16311 | 25 Jun | 32 | 41 | 5.0 | 7.0 | 5.1 |
| CIAT 16319 | 25 Oct | - | - | - | - | - |
| CIAT 16444 | 20 Jun | 17 | 33 | 3.1 | 7.6 | 5.2 |
| CIAT 16463 | 20 Jun | 29 | 55 | 2.6 | 7.7 | 5.1 |
| CIAT 16464 | 20 Jun | 23 | 54 | 3.4 | 7.7 | 6.1 |
| CIAT 16472 | 25 Jun | 38 | 93 | 2.7 | 5.2 | 6.0 |
| CIAT 16488 | 14 Jul | 9 | 19 | 5.4 | 6.4 | 6.0 |
| CIAT 16549 | 20 Jun | 45 | 100 | 4.1 | 5.5 | 5.6 |
| CIAT 16779 | 23 Sep | - | - | 3.2 | 7.2 | 3.8 |
| CIAT 16827 | 14 Oct | 22 | 22 | 3.9 | 9.4 | 4.7 |
| CIAT 16829 | 23 Sep | - | - | 4.0 | 7.2 | 4.8 |
| CIAT 16830 | 23 Sep | 40 | 39 | 2.9 | 7.0 | 5.6 |
| CIAT 16835 | 30 Aug | 55 | 80 | 3.0 | 9.8 | 4.5 |
| CIAT 26110 | 28 Oct | 13 | 19 | 4.5 | 6.8 | 4.6 |
| CIAT 26566 | 14 Oct | 28 | 14 | 4.6 | 9.6 | 4.8 |
| *Brachiaria decumbens* | | | | | | |
| cv. Basilisk | 23 Sep | - | - | 4.0 | 3.3 | 8.3 |
| CIAT 16497 | 27 Jun | 57 | 141 | 2.4 | 5.0 | 7.3 |
| CIAT 26112 | 16 Jul | - | - | 3.0 | 5.8 | 6.7 |
| CIAT 26297 | 14 Oct | - | - | 3.5 | 6.2 | 4.8 |
| BRAZIL | 23 Sep | - | - | 4.6 | 7.0 | 5.2 |
| *Brachiaria humidicola* | | | | | | |
| cv. Tully | 18 Jul | 26 | 61 | 2.6 | 4.8 | 4.0 |
| CIAT 6133 | 23 Jun | 40 | 35 | 3.7 | 4.2 | 4.5 |
| *Brachiaria jubata* | | | | | | |
| CIAT 26188 | 22 Aug | 56 | 35 | 2.8 | 3.9 | 7.5 |
| *Brachiaria ruziziensis* | 5 Aug | 68 | 75 | 2.6 | 4.9 | 9.3 |

[1] - = data unavailable

[2] x = did not flower

Seed yields are presented in Table 3. Significant differences were observed among the 31 accessions. Pure seed yield ranged between 0 and 601 kg/ha. *Brachiaria ruziziensis* and *B. brizantha* CIAT 16835 were the most productive accessions, yielding 601 kg/ha. All other accessions produced significantly lower yields, mostly less than half of these two accessions. The very high seed production potential of *B. ruziziensis* has been reported earlier (Phaikaew and Pholsen 1993). However, the result for *Brachiaria brizantha* CIAT 16835 was new.

**Table 3. Pure seed yield (kg/ha), 1000-seed weight (g), and caryopsis content (%) of 31 *Brachiaria* accessions.**

| Accession | Pure seed yield | | | 1000 seed weight (g) | Caryopsis content (%) |
|---|---|---|---|---|---|
| | (kg/ha) | Relative yield[1] | Rank | | |
| *Brachiaria brizantha* | | | | | |
| CIAT 667 | 43 | 7 | 20 | 5.6 | 14 |
| CIAT 6780 | 249 | 41 | 7 | 7.7 | 30 |
| CIAT 16288 | 75 | 12 | 18 | 7.9 | 35 |
| CIAT 16306 | 0 | 0 | 27 | 0 | 0 |
| CIAT 16307 | 0 | 0 | 27 | 0 | 0 |
| CIAT 16309 | 0 | 0 | 27 | 0 | 0 |
| CIAT 16311 | 150 | 30 | 12 | 7.4 | 16 |
| CIAT 16319 | 9 | 2 | 26 | 7.5 | 8 |
| CIAT 16444 | 0 | 0 | 27 | 0 | 0 |
| CIAT 16463 | 158 | 26 | 11 | 6.9 | 28 |
| CIAT 16464 | 98 | 16 | 15 | 6 | 12 |
| CIAT 16472 | 128 | 21 | 13 | 6.8 | 14 |
| CIAT 16488 | 18 | 3 | 23 | 5.8 | 7 |
| CIAT 16549 | 64 | 11 | 19 | 5.8 | 12 |
| CIAT 16779 | 281 | 47 | 6 | 7 | 38 |
| CIAT 16829 | 286 | 48 | 5 | 7.2 | 30 |
| CIAT 16830 | 220 | 37 | 8 | 7.3 | 14 |
| CIAT 26110 | 15 | 2 | 24 | 8.4 | 6 |
| CIAT 26566 | 28 | 5 | 21 | 7.8 | 15 |
| CIAT 6387 | 333 | 55 | 3 | 7.2 | 30 |
| CIAT 16835 | 601 | 100 | 1 | 7.1 | 43 |
| CIAT 16827 | 311 | 52 | 4 | 7.5 | 43 |
| *Brachiaria decumbens* | | | | | |
| cv. Basilisk | 19 | 3 | 22 | 43 | 93 |
| CIAT 16497 | 168 | 28 | 10 | 6.4 | 23 |
| CIAT 26112 | 178 | 30 | 9 | 5.6 | 25 |
| CIAT 26297 | 86 | 14 | 16 | 9.8 | 18 |
| Brazil | 11 | 2 | 25 | 5.6 | 2 |
| *Brachiaria humidicola* | | | | | |
| cv. Tully | 0 | 0 | 27 | - | 0 |
| CIAT 6133 | 84 | 14 | 17 | 4.9 | 34 |
| *Brachiaria jubata* | | | | | |
| CIAT 26188 | 102 | 17 | 14 | 5.6 | 36 |
| *Brachiaria ruziziensis* | *601* | *100* | *1* | *6.2* | *41* |
| LSD ($p < 0.05$) | 171 | | | | |

[1] Pure seed yield (%) relative to the *B. ruziziensis* control.

Seven accessions produced little or no seed (*B. brizantha* CIAT 16306, CIAT 16307, CIAT 16309, CIAT 16319, CIAT 16444, *B. humidicola* cv. Tully and *B. decumbens* Brazil). Of these, *B. brizantha* CIAT 16307, CIAT 16309, CIAT 16444, and *B. humidicola* cv. Tully showed good flowering but failed to set seed.

From these results, it appears that seed yield was related to flowering time. Accessions that flowered during severe moisture stress (June and July) produced low seed yields. The exception was *B. brizantha* CIAT 6387, which had a series of flowerings throughout the year. The highest seed yields were obtained from accessions which flowered in August, probably because of the better soil moisture conditions. Continuous soil moisture availability is one of the factors needed for high seed production in grasses (Loch, 1980).

Dry matter yields over a period of 114 days (27 Jan-22 May) were measured to assess forage production potential in the dry period. *B. decumbens* Brazil was the most productive accession, yielding 22.5 t dry matter/ha or 215% of the yield of the control (*B. ruziziensis*). *Brachiaria decumbens* CIAT 16497, CIAT 26112, and *B. brizantha* CIAT 16472 produced yields of about 20 t/ha, or about 200% of the yield of the control. The lowest yield was obtained from *B. brizantha* CIAT 26566 (3.2 t/ha).

Visual scoring for drought tolerance, conducted during the dry period, revealed that *B. decumbens* cv. Basilisk, CIAT 26112, and CIAT 26297 were the most tolerant, remaining green throughout much of the dry season (Table 4). Visual scoring for regrowth potential was conducted 7 days after cutting in January 1997 (Table 4). *B. decumbens* CIAT26297, CIAT 26112 and Brazil and *B. brizantha* CIAT16472 had the highest regrowth scores, with fast, dense regrowth after cutting. The regrowth scores of 22 accessions were superior to that of the control.

## Conclusions

Based on seed production potential, seven *B. brizantha* (CIAT 16835, CIAT 6387, CIAT 16827, CIAT 16829, CIAT 16779, CIAT 6780 and CIAT 16830) and two *B. decumbens* accessions (CIAT 26112 and CIAT 16497) appear promising for northeast Thailand. In particular, *B. brizantha* CIAT 16835 equalled the seed yield of *B. ruziziensis*. The other accessions produced half or less of the pure seed yield of these two high-yielding accessions. However, not all of these accessions performed well in the dry season.

The highest yielding accession in the dry season was *B. decumbens* Brazil, but this accession produced almost no seed. The most promising accessions on the basis of both seed yields and dry season performance were:

*B. brizantha* CIAT 6387 (which produced 64% of dry matter of the highest yielding accession and 55% of the pure seed yield of *B. brizantha* CIAT 16835)
*B. decumbens* CIAT 26112 and CIAT 16497 (which both produced 88% of the dry matter yield of the highest yielding accession but produced only about 30% of the pure seed yield of *B. brizantha* CIAT 16835).

Further monitoring is needed on both seed production and forage production potential in the dry season. This trial will be continued in the 1998 season, with the addition of 19 more accessions. On-farm trials will start in 1998 using promising accessions from this trial, to gain early feedback from farmers about their potential.

**Table 4. Drought tolerance, regrowth score, and dry matter yield over 114 days in the dry season of *Brachiaria* species.**

| Accession | Regrowth score[1] | Drought tolerance[1] | DM Yield t/ha | DM Yield Relative yield[2] | DM Yield Rank |
|---|---|---|---|---|---|
| *Brachiaria brizantha* | | | | | |
| CIAT 667 | 2 | 4 | 11.4 | 51 | 11 |
| CIAT 6780 | 2 | 4 | 10.3 | 46 | 14 |
| CIAT 16288 | 4 | 4 | 9.1 | 40 | 18 |
| CIAT 16306 | 4 | 2 | 14.0 | 62 | 9 |
| CIAT 16307 | 1 | 2 | 8.6 | 38 | 19 |
| CIAT 16309 | 2 | 1 | 8.4 | 37 | 20 |
| CIAT 16311 | 3 | 3 | 8.3 | 37 | 21 |
| CIAT 16319 | 2 | 1 | 7.4 | 33 | 22 |
| CIAT 16444 | 1 | 3 | 3.4 | 15 | 26 |
| CIAT 16463 | 2 | 3 | 12.1 | 54 | 10 |
| CIAT 16464 | 1 | 4 | 14.8 | 66 | 6 |
| CIAT 16472 | 5 | 4 | 20.5 | 91 | 2 |
| CIAT 16488 | 3 | 3 | 11.5 | 51 | 13 |
| CIAT 16549 | 1 | 3 | 6.7 | 30 | 23 |
| CIAT 16779 | 1 | 2 | 9.4 | 42 | 16 |
| CIAT 16829 | 3 | 4 | 9.2 | 41 | 17 |
| CIAT 16830 | 1 | 4 | 5.8 | 26 | 24 |
| CIAT 26110 | 2 | 2 | 11.1 | 49 | 12 |
| CIAT 26566 | 1 | 4 | 3.2 | 14 | 27 |
| CIAT 6387 | 3 | 4 | 14.5 | 64 | 7 |
| CIAT 16835 | 3 | 3 | 9.2 | 41 | 17 |
| CIAT 16827 | 4 | 3 | 4.7 | 21 | 25 |
| *Brachiaria decumbens* | | | | | |
| cv. Basilisk | 3 | 5 | 17.1 | 76 | 5 |
| CIAT 16497 | 4 | 4 | 19.8 | 88 | 4 |
| CIAT 26112 | 5 | 5 | 19.8 | 88 | 3 |
| CIAT 26297 | 5 | 5 | 13.1 | 58 | 9 |
| 'Brazil' | 5 | 4 | 22.5 | 100 | 1 |
| *Brachiaria humidicola* | | | | | |
| cv. Tully | 1 | 3 | 10.2 | 45 | 14 |
| CIAT 6133 | 2 | 3 | 8.8 | 39 | 19 |
| *Brachiaria jubata* | | | | | |
| CIAT 26188 | 2 | 4 | 14.2 | 63 | 8 |
| *Brachiaria ruziziensis* | 1 | 3 | 10.5 | 47 | 15 |
| LSD (5%) | | | 9.1 | | |

[1] Visual scores: 1 = very poor, 2 = poor, 3 = fair, 4 = good, 5 = excellent.
[2] DM yield (%) relative to the highest yielding accession (*B. decumbens* Brazil).

## Acknowledgements

The authors thank Dr. Werner Stür and Dr. Peter Horne for their advice and support. Thanks are also due the Director of the Division of Animal Nutrition, and the Director and staff of the Pakchong Animal Nutrition Research Centre who through their support, contributed greatly to the success of the study.

## References

Boonpukdee, W., Udchachon, S., Phoophasoock, T. 1996. Effect of some plant hormones and boron on seed production of Signal grass *(Brachiaria decumbens*). Annual Report, Division of Animal Nutrition, Department of Livestock Development, Ministry of Agriculture and Cooperatives. p173 - 181.

Gobius, N.R., Phaikaew, C., Pholsen, P., Rodchompoo, O., Susena, W. 1996. Effect of varying rates of nitrogen on seed production components of *Brachiaria decumbens* cv. Basilisk, *Andropogon gayanus* cv. Kent, and *Digitaria milanjiana* cv. Jarra. Final Report, Pasture Research Chiang Yuen Animal Nutrition Station, Mahasarakarm, Thailand.

Loch, D.S. 1980. Selection of environment and cropping system for tropical grass seed production. Tropical Grasslands 14:159 - 168.

Phaikaew, C. and Pholsen, P. 1993. Ruzi grass (*Brachiaria ruziziensis)* seed production and research in Thailand. In: Chen C P, Satjipanon C (eds.). Strategies for suitable forage-based livestock production in Southeast Asia. Proceedings of the Third Meeting, FAO Regional Working Group on Grazing and Feed Resources of Southeast Asia, Khon Kaen, Thailand, 31 Jan-6 Feb 1993, FAO, Rome, Italy. p 148 - 173.

Phaikaew, C., Udchachon, S., Pholsen P. and Chompoosor B. 1996. Annual forage yield from mixed and pure pasture of Ruzi and Signal grasses. Annual Report, Division of Animal Nutrition, Department of Livestock Development, Ministry of Agriculture and Cooperatives. p 148 - 159.

Shelton, H.M. 1982. The physical and socio economic environment for pasture and beef production in northeast Thailand. 1981-82 Annual Report, Khon Kaen University Pasture Improvement Project, Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand. p 4 - 7

Thinnakorn, S. and Kreethapon, I. 1993. Demonstration trial on suitable backyard pasture utilization for small dairy farms in Pakchong. In: Chen C P and Satjipanon C (eds.). Strategies for suitable forage - based livestock production in Southeast Asia . Proceedings of the Third Meeting, FAO Regional Working Group on Grazing and Feed Resources of Southeast Asia, Khon Kaen , Thailand, 31 Jan- 6 Feb 1993, FAO, Rome, Italy. p 59 - 62.

# Evaluation of *Stylosanthes* species for resistance to *anthracnose* and suitability for leaf meal production

**Liu Guodao, Zhuo Jiasuo, Bai Changjun and Hong Caixiang**[1]

*Stylosanthes* species very important legumes in South China which are used for green cover, leaf meal production, and pasture improvement. New accessions of the *Stylosanthes* species have been introduced from the Centro Internacional de Agricultura Tropical (CIAT, Colombia), Commonwealth Scientific and Industrial Research Organization of Australia (CSIRO, Australia) and CIAT/IRRI (Philippines). Together with four Chinese Academy of Tropical Agriculture Sciences (CATAS) released varieties as controls, these accessions were evaluated in an experiment to determine their resistance to anthracnose and their suitability for leaf meal production.

## Materials and methods

The accessions included in the experiment are listed in Table 1.

**Table 1. *Stylosanthes* spp. used for leaf meal production.**

| Accession | Source of seed |
|---|---|
| *S. capitata* multiline 5 | B. Grof |
| *S. capitata/S. macrocephala* GC 1580 | CIAT |
| *S. guianensis* CIAT 10417 | CIAT (Philippines) |
| *S. guianensis* CIAT 11833 | CIAT |
| *S. guianensis* CIAT 11844 | CIAT |
| *S. guianensis* CIAT 136 | China (from CIAT in 1982) |
| *S. guianensis* CIAT 184 | CIAT |
| *S. guianensis* CIAT 2312 | CIAT |
| *S. guianensis* CPI 55848 | CSIRO |
| *S. guianensis* CPI 58719 | CSIRO |
| *S. guianensis* CPI 67652 | CSIRO |
| *S. guianensis* CPI 87830 | CISRO |
| *S. guianensis* cv. Cook | China (from Australia in the early 1980s) |
| *S. guianensis* cv. Cook (L1-82) | CSIRO |
| *S. guianensis* cv. Graham | China (from Australia in the early 1980s |
| *S. guianensis* cv. Graham (L7-84) | CSIRO |
| *S. guianensis* cv. Mineirao | CIAT |
| *S. guianensis* cv. Semilla negra | China, selected from CIAT 184 |
| *S. guianensis* FM05-1 | CIAT (Philippines) |
| *S. guianensis* FM05-2 | CIAT (Philippines) |
| *S. guianensis* FM05-3 | CIAT (Philippines) |
| *S. guianensis* FM07-2 | CIAT (Philippines) |
| *S. guianensis* FM9405 Parcela 3 | CIAT |
| *S. guianensis* FM9405 Parcela 5 | CIAT |
| *S. guianensis* FM9405 Parcela 6 | CIAT |

**(continued next page)**

**Table 1 (cont.). *Stylosanthes* spp. used for leaf meal production.**

| Accession | Source of seed |
|---|---|
| *S. guianensis* GC 1578 | CIAT |
| *S. guianensis* GC 1579 | CIAT |
| *S. guianensis* GC 1581 | CIAT |
| *S. scabra* cv. Siran (L3-93) | CSIRO |
| *S. scabra* cv. Seca | China (from Australia in the early 1980s |
| *S. guianensis* CIAT 184 | China (from CIAT in 1982) |
| *S. hamata* cv. Verano | China (from Australia in the early 1980s) |
| *S. guianensis* L8 | China, selected from CIAT 184 |
| *S. guianensis* E3 | China, selected from CIAT 184 |

The experiment was designed as a randomised complete block with three replications. The experimental units were 5-m-long, single-row plots, 1.5 m apart. *Anthracnose* damage was visually estimated every month (Table 2).

All plots were cut three times a year to measure dry matter yield. Seed was harvested at the end of each season to measure seed yield.

**Table 2. Anthracnose damage ratings.**

| Rating | Symptoms |
|---|---|
| 0 | no visible disease symptom |
| 1 | 1-3% of tissue is necrotic |
| 2 | 4-6% of tissue is necrotic |
| 3 | 7-12% of tissue is necrotic |
| 4 | 13-25% of tissue is necrotic |
| 5 | 26-50% of tissue is necrotic |
| 6 | 51-75% of tissue is necrotic |
| 7 | 76-87% of tissue is necrotic |
| 8 | 88-94% of tissue is necrotic |
| 9 | 95-100% of tissue is necrotic |

## Results and discussion

Most of the accessions have no visible disease symptom or have very low anthracnose severity visual scale (Table 3). *Stylosanthes guianensis* cv. Cook (CATAS) and *S. guianensis* cv. Cook L1-82 were nearly destroyed by the disease at the seedling stage.

Stylosanthes *scabra* cv. Seca, *S. guianensis* cv. Mineiro, *S. guianensis* CIAT 11844, *S. guianensis* FM07-2, *S. guianensis* L3 98, *S. guianensis*, 58719, *S. guianensis* L8, *S. guianensis* E3, *S. guianensis* CIAT 184, *S. guianensis* cv. Semilla negra, *S. hamata* cv. Verano, *S. guianensis* CIAT 184 (CATAS), *S. guianensis* FM03-2, *S. guianensis* CIAT 10417, *S. guianensis* FM05 3, and *S. guianensis* GC1578 Parcela 3, showed very strong resistance to anthracnose, while *S. guianensis* cv. Graham L7 84 was destroyed by the disease in the second year. *S. guianensis* cv. Graham (CATAS), *S. guianensis* 87830 scored very high in the *anthracnose* severity visual scale.

[1] Tropical Pasture Research Centre, Chinese Academy of Tropical Agriculture Sciences, Hainan, P.R. China.

**Table 3. Mean *anthracnose* damage rating, biomass yield and seed yield.**

| Accession | Mean *Anthracnose* Damage | | | Dry matter yield (kg/plot) | Seed yield (g/plot) |
|---|---|---|---|---|---|
| | Seedlings | Year 1 | Year 2 | | |
| *S. capitata* / *S. macrocephala* GC 1580 | 0 | 1 | 0.4 | 0 | 3 |
| *S. guianensis* CIAT 10417 | 1 | 1 | 1 | 0.2 | 0.1 |
| *S. guianensis* CIAT 11833 | 1 | 1.3 | 1.2 | 4.0 | 0 |
| *S. guianensis* CIAT 11844 | 0 | 1.2 | 0.3 | 6.4 | 0 |
| *S. guianensis* CIAT 136 | 2 | 2 | 2 | 10.5 | 43 |
| *S. guianensis* CIAT 184 | 1 | 1 | 1 | 5.6 | 113 |
| *S. guianensis* CIAT 2312 | 0 | 3.9 | 1.8 | 1.6 | 4 |
| *S. guianensis* CPI 55848 | 2 | 1.2 | 2.2 | 1.4 | 7 |
| *S. guianensis* CPI 58719 | 0 | 0.9 | 0.3 | 1.0 | 0.1 |
| *S. guianensis* CPI 67652 | 1 | 2.4 | 1.6 | 4.4 | 81 |
| *S. guianensis* CPI 87830 | 3 | 4.5 | 3.8 | 3.0 | 0 |
| *S. guianensis* cv. Cook | 9 | 4.7 | 6.1 | 1.0 | 12 |
| *S. guianensis* cv. Cook (L1-82) | 6 | 7.8 | 6.9 | 1.4 | 3 |
| *S. guianensis* cv. Graham | 1 | 1.5 | 5.5 | 6.0 | 226 |
| *S. guianensis* cv. Graham (L7-84) | 1 | 1.2 | 6.8 | 2.3 | 18 |
| *S. guianensis* cv. Mineirao | 0 | 0.8 | 0.3 | 10.6 | 0 |
| *S. guianensis* cv. Semilla negra | 2 | 1.9 | 1 | 18.2 | 25 |
| *S. guianensis* FM05-1 | 0 | 1.3 | 0.6 | 1.1 | 172 |
| *S. guianensis* FM05-2 | 0 | 1.3 | 0.3 | 0.1 | 96 |
| *S. guianensis* FM05-3 | 1 | 1.3 | 1 | 3.4 | 104 |
| *S. guianensis* FM07-2 | 1 | 1.3 | 1 | 3.4 | 240 |
| *S. guianensis* FM9405 Parcela 3 | 2 | 1.4 | 1.3 | 5.0 | 187 |
| *S. guianensis* FM9405 Parcela 5 | 1 | 1.3 | 1.6 | 1.0 | 0 |
| *S. guianensis* FM9405 Parcela 6 | 2 | 1.4 | 1.3 | 2.9 | 0 |
| *S. guianensis* GC 1578 | 1 | 1.1 | 1 | 1.8 | 162 |
| *S. guianensis* GC 1579 | 3 | 4.2 | 2.9 | 7.2 | 152 |
| *S. guianensis* GC 1581 | 2 | 2.1 | 2.2 | 17.3 | 0.1 |
| *S. scabra* cv. Siran (L3-93) | 0 | 1.2 | 0.3 | 3.21 | 6 |
| *S. scabra* cv. Seca | 0 | 1 | 0 | 6.3 | 11 |
| *S. guianensis* CIAT 184 | 1 | 1 | 1 | 5.6 | 113 |
| *S. hamata* cv. Verano | 1 | 1 | 1 | 1.4 | 104 |
| *S. guianensis* L8 | 0 | 1.2 | 0.6 | 9.0 | 21 |
| *S. guianensis* E3 | 1 | 1 | 1 | 5 | 315 |

In the early part and toward the end of the year, the plants showed very low disease severity visual scores (Table 4). In June, July, August, and September very high disease severity scores were noted.

*Stylosanthes guianensis* cv. Semilla negra, *S. guianensis* CG1581, *S. guianensis* CIAT 184 (CATAS), *S. guianensis* cv. Mineirao, *S. guianensis* CIAT 136, and *S. guianensis* L8 had very high dry matter yield. Those of *S. capitata*/*S. macrocephala* GC 1580, *S. guianensis* FM05-3, *S. guianensis* CIAT 10417 and *S. capitata* Multiline-6 had a very low yield.

*Stylosanthes* guianensis E3, *S. guianensis* FM03-2, *S. guianensis* cv. Semilla negra, *S. guianensis* FM9405 Parcela 3, and *S. guianensis* FM05-1 showed very high potential for seed production, while *S. guianensis* FM9405 Parcela-6, *S. guianensis* cv.

Mineirao, *S. guianensis* CIAT 11844, and *S. guianensis* 87830 cannot get seed in the second year.

Eighty percent of *S. guianensis* CIAT 11833, 50% of *S. guianensis* FM05-3 and *S. guianensis* FM9405 Parcela-6, and 40% of *S. guianensis* CIAT 11844 and *S. guianensis* FM9405 Parcela-5 died in low temperatures (<10$^{o}$C) in the winter.

These results point to some promising accessions (in terms of seed yield and cold resistance) that should be further evaluated in a regional evaluation.

**Table 4. Monthly *anthracnose* damage rating in 1997.**

| Accessions | Month | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| *S. capitata / S. macrocephala* GC 1580 | 0 | 0 | 0 | 0 | 0 | 0.6 | 1 | 1.3 | 1.3 | 0.3 | 0 | 0 |
| *S. guianensis* CIAT 10417 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *S. guianensis* CIAT 11833 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1.3 | 1 | 1 |
| *S. guianensis* CIAT 11844 | 0 | 0 | 0 | 0 | 0 | 0.3 | 1 | 1 | 0.6 | 0.3 | 0 | 0 |
| *S. guianensis* CIAT 136 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| *S. guianensis* CIAT 184 (CIAT) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *S. guianensis* CIAT 2312 | 0 | 0.3 | 0.3 | 1.3 | 2 | 2.3 | 3.7 | 4 | 3.7 | 2 | 1.3 | 1 |
| *S. guianensis* CPI 55848 | 2 | 2 | 2 | 2 | 2 | 2 | 2.3 | 3 | 3 | 2 | 2 | 2 |
| *S. guianensis* CPI 58719 | 0 | 0 | 0 | 0 | 0 | 0 | 0.3 | 0.3 | 1 | 1 | 1 | 0 |
| *S. guianensis* CPI 67652 | 1 | 1 | 1 | 1 | 1.3 | 2 | 2 | 2 | 3 | 3 | 2 | 1 |
| *S. guianensis* CPI 87830 | 3 | 3 | 3 | 3.3 | 3.7 | 4 | 4.7 | 5 | 5 | 4.3 | 3.3 | 3.3 |
| *S. guianensis* cv. Cook | 4 | 4 | 4.3 | 5 | 5.3 | 7 | 7.7 | 8 | 8 | 7 | 5.3 | 5 |
| *S. guianensis* cv. Cook (L1-82) | 6 | 6 | 6 | 7 | 7 | 7 | 7.3 | 8 | 8 | 8 | 6 | 5.3 |
| *S. guianensis* cv. Graham | 2.3 | 3 | 3.7 | 4 | 5 | 6.3 | 6.7 | 7 | 7.7 | 7.7 | 7 | 6.3 |
| *S. guianensis* cv. Graham (L7-84) | 3 | 3.3 | 4 | 5.3 | 6.7 | 7.3 | 8.3 | 9 | 9 | 9 | 9 | 9 |
| *S. guianensis* cv. Mineirao | 0 | 0 | 0 | 0 | 0 | 0 | 0.3 | 1 | 1 | 0.7 | 0 | 0 |
| *S. guianensis* cv. Semilla negra | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *S. guianensis* FM05-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.3 | 1 | 1 | 2 | 1.7 | 1 |
| *S. guianensis* FM05-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0.6 | 1 | 1 | 1 | 0.3 | 0 |
| *S. guianensis* FM05-3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *S. guianensis* FM07-2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *S. guianensis* FM9405 Parcela 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *S. guianensis* FM9405 Parcela 5 | 1 | 1 | 1 | 1 | 1.7 | 1.7 | 2.7 | 2.7 | 2.3 | 1.3 | 1 | 1 |
| *S. guianensis* FM9405 Parcela 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1.7 | 2 | 2 | 2 | 1 | 1 |
| *S. guianensis* GC 1578 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *S. guianensis* GC 1579 | 3 | 2.3 | 2.3 | 3.7 | 3 | 3.7 | 3.7 | 4 | 4 | 3.3 | 3.7 | 2 |
| *S. guianensis* GC 1581 | 2 | 2 | 2 | 2 | 2 | 2.3 | 2.7 | 3 | 3 | 2.7 | 1.7 | 1.7 |
| *S. scabra* cv. Siran (L3-93) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.3 | 1 | 1 | 0.6 | 0 |
| *S. scabra* cv. Seca | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *S. guianensis* CIAT 184 (CATAS) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *S. hamata* cv. Verano | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *S. guianensis* L8 | 0 | 0 | 0 | 0 | 0.3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *S. guianensis* E3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *S. capitata* Multiline-6 | 1 | 1 | 1 | 1 | 1 | 1 | 1.7 | 2 | 2 | 2 | 1 | 1 |

# Some natural and induced grasslands of the Lao PDR

**JB Hacker[1], Soulivanh Novaha[2] and Vanthong Phengvichith[3]**

The raising of livestock is a major industry in the Lao PDR. Livestock is not only a major source of livelihood security for rural families but also livestock exports contribute approximately 15% to gross domestic product. The Lao Department of Livestock and Fisheries is therefore interested in supporting and promoting this industry, particularly ruminants (Sihanath 1995). Currently, all of the ruminant livestock (cattle, buffalo, and goats) of Laos are raised by farmers in rural communities. The AusAID-funded Forages for Smallholders Project (FSP) is contributing to the improvement of ruminant production through the introduction, development, and distribution of high-yielding, adapted forage species and promoting their adoption by smallholders through participatory techniques (Stür et al. 1995, Hacker and Kerridge 1997).

Although the adoption of high yielding, adapted forages should make a substantial impact on livestock productivity, most production will continue to be dependent on traditional feed sources, including natural and induced grasslands and savannas. There is therefore an interest in the production potential of these grasslands and savannas, the extent to which they have been degraded, and the relative abundance of the more productive and palatable species. This led to a request to the FSP to assemble botanical information on the grasses of Lao PDR, with particular emphasis on pek savannas (dominated by the dwarf bamboo known as 'pek') and the grasslands of Xieng Khouang Province. The results of surveys covering these two regions have been published (Hacker et al. 1997, 1998), and the present paper provides an overview of findings.

## Why are there grasslands in tropical Lao PDR?

Southeast Asia is more typically a region of forests than of grasslands and savannas. The presence of these vegetation types is likely to be due to environmental constraints, or previous management, that has prevented a forest cover from developing. In Lao PDR, environmental constraints include a long dry season and low soil fertility. Management effects include burning, cultivation, and fire. The presence of natural grasslands does not necessarily indicate a rich grazing resource, but may indicate that the soils are too poor to support a forest cover. This is apparently the case on the Plain of Jars, Xieng Khouang, where poor calving percentages and extremely low animal production are attributable to low soil fertility, with very low phosphorus (P) percentages (Gibson 1997), rather a grass flora comprising species which are intrinsically low in quality.

### Pek savannas

Pek savannas occur in Lao PDR south of about latitude 17$^{o}$ N, and at altitudes up to about 500 m. They have an understorey which is dominated by two species of dwarf bamboo, previously known as *Arundinaria ciliata* and *A. pusilla* and since 1990 known as *Vietnamosasa ciliata* and *V. pusilla*. This new genus includes a third species, *V. darlacensis*, restricted to southern Vietnam (Nguyen To Quyen 1990). *Vietnamosasa pusilla* is known as pek in Thailand and Lao and grows in dry dipterocarp forest from the

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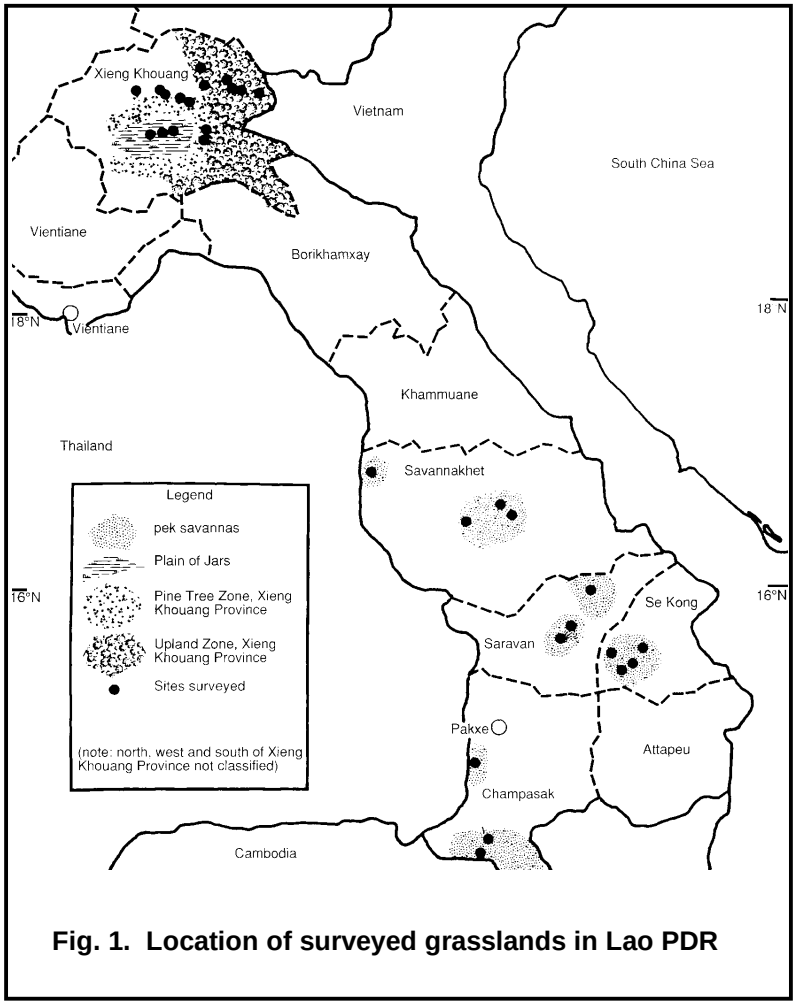


**Fig. 1. Location of surveyed grasslands in Lao PDR**

Korat Plateau in Thailand to Vietnam. *Vietnamosasa ciliata*, known as 'chote' in Thailand, 'chawd' in Lao, is larger than 'pek', and grows wild in any open place in dipterocarp forest throughout the same range (Sujatmi Dransfield, pers. comm. to J. Veldkamp).

Twenty sites where pek was a significant component of the herbaceous vegetation were examined during the survey (November 1995). These ranged from relatively small areas of several hectares to extensive areas of many square kilometres. In general, areas which were more remote from habitation, and hence from grazing, had an understorey which was close to 100% dominated by *Vietnamosasa pusilla*, growing to heights of 1.6 m tall. Few other species of grass could tolerate this level of competition, together with the shade from the trees. These species were all growing to heights of 2 m or more. In areas which had evidently been subjected to heavier grazing, low shrubs tended to dominate the understorey, together with a few lower growing grasses (Table 1). In tracks and pathways, grasses were annuals or weakly perennials (checks), producing large numbers of seed, thus ensuring success at reestablishment.

**Table 1. Some grasses characteristic of pek savannas (Species tabulated are those considered to be of more value to livestock – after Phengvichith and Hacker 1997).**

| Competition from pek | | Tracks and bare areas | Glades |
|---|---|---|---|
| **Strong** | **Moderate** | | |
| *Heteropogon triticeus*[a] | *Andropogon chinensis*[a] | *Aristida cumingiana* | *Chrysopogon aciculatus*[b] |
| *Schizachyrium sanguineum*[a] | *Heteropogon contortus*[a] | *Gymnopogon delicatulus* | *Germainia capitata* |
| *Themeda arundinacea*[a] | *Isachne globosa* [a] | *Eragrostis brownii* | *Germainia ?khasyana* |
| *Sorghum nitidum*[a] | *Diectomis fastigiata*[a] | *Eragrostis tremula* | *Paspalum scrobiculatum* |
| *Chionachne ?koenigii* | *Eulalia trispicata* [a] | *Schizachyrium brevifolium* | |

[a] Generally considered a useful species for livestock.
[b] In areas subjected to heavy grazing.

## Xieng Khouang

A very diverse province, much of Xieng Khouang is not readily accessible. Hacker et al. (1998) recognised four agro-ecological zones: the Plain of Jars, the Pine Tree Zone, the Upland Zone, and the Valley Zone. The latter zone, being of more significance to cropping than to livestock, was not surveyed.

### The Plain of Jars

As defined by Hacker et al. (1998), the Plain of Jars is a plain 1,100 m above sea level and is probably an old lakebed. It is a natural grassland, devoid of trees. Soils are acidic, with a high aluminium saturation, and are low in nitrogen and phosphorus (Table 2). Areas close to the provincial capital of Phonsavanh were too heavily grazed for botanical analysis. In other areas, the flora was dominated by *Themeda triandra*, which comprised 70-90% of the vegetation, with other grasses as minor components of the vegetation (Table 2). Small valleys and other areas protected from grazing commonly include tall-growing species such as *Themeda intermedia* and *Sorghum nitidum*.

### The Pine Tree Zone

The Pine Tree Zone is a hilly area to the west, south and east of the Plain of Jars. It includes forested areas dominated by conifers *Pinus merkusii* and *P. kesiya* and areas where trees are occasional or absent, which are presumed to have been cleared of forest. Soils are similar to those of the Plain of Jars (Table 2) and, where cleared, support a generally similar grass flora, dominated by *Themeda triandra* (Table 3). In the one forested area surveyed, *Eulalia phaeothrix* was the dominant grass, with a range of herbaceous legumes which were absent in nearby cleared areas.

**Table 2. Soils (0-10 cm) of the Plain of Jars, Pine Tree Zone, and Upland Zone of Xieng Khouang (Hacker et al. 1998).**

| | Plain of Jars | Pine Tree Zone | Upland Zone |
|---|---|---|---|
| pH (1:5 water) | 4.9 (4.8-5.0) | 4.9 (4.7-5.2) | 5.4 (4.7-7.7) |
| $NO_3$ (mg/kg) | 0.6 (0.2-1.3) | 3.0 (0.4-10.8) | 14.9 (0.4-58.5) |
| P (Colwell) (mg/kg) | 2 (2-3) | 2 (1-2) | 7 (3-15) |
| Al saturation (%) | 77 (74-79) | 62 (43-81) | 34 (0-79) |

**Table 3. Some grasses characteristic of the Plain of Jars and open grasslands in the Pine Tree Zone.**

| Dominant species | Minor species | | |
|---|---|---|---|
| | Palatable | Palatable when young | Unpalatable |
| *Themeda triandra* | *Eulalia spp.* | *Hyparrhenia diplandra* | *Arundinella nepalensis* |
| | | *Hyparrhenia newtonii* | *Arundinella setosa* |
| | | *Sorghum nitidum* | *Cymbopogon nardus* |

### The Upland Zone

The Upland Zone is extremely variable in topography, geology, and soils (Table 2), with some soils as infertile as those on the Plain of Jars and others alkaline and fertile. Altitude is up to 2,450 m; the sites surveyed were restricted to 1,000-1,450 m, owing to difficulty of access to higher altitudes.

The only true grasslands seen in the Upland Zone apparently resulted from previous management. These were either grasslands comprising almost pure stands of *Imperata cylindrica* or small areas of heavily grazed grass in the vicinity of villages. A high proportion of the Upland Zone is subject to slash-and-burn farming for the production of upland rice, maize and other crops.

**Table 4. Some grasses characteristic of the Upland Zone.**

| Often growing in full sun | | | Shaded (palatable) |
|---|---|---|---|
| **Palatable** | **Palatable when young** | **Unpalatable** | |
| *Leersia hexandra*[a] | *Imperata cylindrica* | *Miscanthus floridulus*[b] | *Centotheca latifolia* |
| *Thysanolaena latifolia* | *Neyraudia arundinacea* | | *Cyrtococcum accrescens* |
| | *Saccharum spontaneum* | | *Microstegium spp.* |
| | *Themeda arundinacea* | | *Panicum spp.* |

[a] swamps
[b] in Xieng Khouang, considered to be palatable when young.

While not being actively farmed, this land has varying proportions of native grasses, shrubs, and trees, with shrubby weeds *Chromolaena odorata*, *Tithonia diversifolia*, and *Artemisia* sp. frequently being dominant components of the vegetation. In these situations (and also in *Imperata grasslands*), large tussocks of the robust grasses *Neyraudia arundinacea*, *Thysanolaena latifolia*, *Miscanthus floridulus*, and *Saccharum spontaneum* are significant features of the vegetation. Other frequently encountered grasses are listed in Table 4. Some Upland Zone grasses only occur in moderately shaded conditions; these include palatable grasses such as *Panicum* and *Isachne* spp., and grasses of forest margins which scramble over vegetation in order to access better lit situations, such as *Microstegium* spp. and *Panicum sarmentosum*. Most grasses under shaded conditions are reputedly palatable to livestock, although most do not yield a high biomass.

Heavily grazed areas in the Upland Zone tend to be dominated by stoloniferous grasses or low-growing tussock grasses (Table 5). A high proportion of the unpalatable *Sporobolus indicus* is indicative of serious overgrazing and reduced productivity. Similar grasslands almost certainly occur at lower altitudes, as all the species listed in Table 5 are widespread.

**Table 5. Some grasses of heavily grazed areas in the Upland Zone.**

| Dominant/subdominant | | Occasional |
|---|---|---|
| **Palatable species** | **Unpalatable species** | |
| *Axonopus compressus* | *Sporobolus indicus* | *Cynodon dactylon* |
| *Chrysopogon aciculatus* | | |
| *Paspalum conjugatum* | | |

## A comparison between the grass floras of pek savannas and Xieng Khouang

Although not geographically widely separated, the grass floras of the Plain of Jars (together with the Pine Tree Zone), the Upland Zone, and the pek savannas were radically different. As the surveys were of short duration, some species present in the three regions would not have been collected. However, although 66 grass species were collected in Xieng Khouang and 41 species (excluding bamboos) in the pek savannas, only 14 species were common to the two regions. The most notable variations were the complete absence of *Heteropogon* spp. from Xieng Khouang and of *Miscanthus*, *Neyraudia* and *Saccharum* spp. from the pek savannas. These differences reflect variation in climatic and edaphic adaptation of the species, differences which are also likely to occur with introduced forage species.

## Some general principles

It is frequently possible to obtain information about the environmental conditions of a site and its management history from the species present, and their abundance. Several examples come from the present studies:

- Some grass species are indicative of degraded, infertile soils and overgrazing. These include *Schizachyrium brevifolium* and *Aristida cumingiana*.
- A high proportion of unpalatable grasses, such as *Sporobolus indicus*, in a pasture is likely to be associated with overgrazing.
- A high proportion of low shrubs in pek savannas is likely to be indicative of long periods of heavy grazing. However, *Vietnamosasa ciliata* appears not to be susceptible to heavy grazing pressure over periods of up to 4 years (Gutteridge 1985).
- In Xieng Khouang, dominance of *Themeda triandra* in grasslands is indicative of extreme infertility (this is not necessarily the case in other regions).

## Opportunities for improving production from Lao grasslands

Opportunities for improving pek savannas without total replacement of the native vegetation appear to be limited. In northern Thailand, *Vietnamosasa ciliata* provides reasonable forage in the early wet season and after fire, but quality rapidly declines. Attempts to introduce exotic legumes into pek savannas (following tree removal and slashing) were unsuccessful, the legumes failing to persist for more than 2-4 years (Gutteridge 1985). The slashing treatment also failed to result in a long-term increase in the proportion of native grasses other than bamboos. The best opportunity for improving production from pek savannas in Lao PDR is probably to maintain undisturbed areas of pek savanna as a sustainable resource, while fully improving smaller areas around villages with introduced grasses and legumes such as *Brachiaria decumbens* and *Stylosanthes* spp. In northern Thailand, liveweight gain per hectare was four times higher from improved pasture than from pek grasslands, whether or not any attempt had been made to improve the pek grasslands (Gutteridge et al. 1983). Also in Thailand, supplementation of cattle grazing pek grasslands with salt doubled liveweight gain, this being an inexpensive treatment which could be recommended in Lao PDR.

On the Plain of Jars and in the Pine Tree Zone, the dominant grass is *Themeda triandra*, a species which is widely accepted as being a high-quality and productive grass for grazing (Bogdan 1977), although not always persistent in grazed pastures (Mannetje and Jones 1992). As the soils are so P-deficient, any improvement will necessitate P input into the system. Improvement in ruminant production will be limited by the low P status of the soils, rather than the intrinsic quality of the grass. Management will need to avoid fertility transfer (through corralling cattle and using manure for cropping), and hence further reduction in soil fertility. However, the tendency in some countries for *T. triandra* not to persist with moderate to heavy grazing is a matter of concern.

In the Upland Zone, many native grasses are used by smallholders as cut-and-carry feeds. Many are locally and widely known to be palatable species. However, these are growing naturally, often at some distance from smallholder farmsteads. For cut-and-carry systems, adequate areas of planted forage close to homesteads would reduce the time and effort required for a smallholder to feed his stock. One farmer was already doing this, of his own initiative, with the annual *Coix lacrima-jobi*. Productive and leafy exotic forages could be used, but there could also be opportunities for planting local species of grass. The species selected for this purpose should be those which are high-yielding and retain a high percentage of leaf throughout growth. The late-flowering *Thysanolaena latifolia* is a species which could be considered for this purpose.

## Acknowledgement

We are grateful to AusAID for the provision of funding through the Forages for Smallholders Project.

## References

Bogdan, A.V. 1977. Tropical Pasture and Fodder Plants. Longman, London.

Gibson, T. 1997. The plain of jars: an example of phosphorus deficiency for forages and livestock. SEAFRAD News 4: 2.

Gutteridge, R.C. 1985. The productivity of native grasslands oversown with legumes and grazed at five stocking rates in northeast Thailand. J. of Agric. Sci., 104: 191-198.

Gutteridge, R.C, Shelton, H.M., Wilaipon, B. and Humphreys, L.R. 1983. Productivity of pastures and response to salt supplements by beef cattle on native pasture in northeast Thailand. Trop. Grassl. 17: 105-114.

Hacker, J.B. and Kerridge, P.C. 1997. The Forages for Smallholders Project – aims, activities and achievements. In: Stür, W.W., Ed. Feed resources for smallholder livestock production in Southeast Asia. CIAT Working Document No. 156. Centro Internacional Agricultura Tropical, Colombia.

Hacker, J.B., Simon, B.K. and Phenvichith, V. 1997. The pek savannas of the Lao People's Democratic Republic. Genetic Resources Communication No. 23. CSIRO Division of Tropical Crops and Pastures, St. Lucia, Queensland, Australia.

Hacker, J.B, Phimphachanhvongsod, V., Novaha, S., Kordnavong, P., Veldkamp, J. and Simon B K 1998. A guide to the grasses of Xieng Khouang Province, Lao PDR, and some notes on the ecology of grazing lands in the province. Genetic Resources Communication No. 28. CSIRO Tropical Agriculture, St. Lucia, Queensland, Australia.

Mannetje, L. 't and Jones, R.M. (eds.) 1992. Plant Resources of Southeast Asia. 4. Forages. Pudoc: Wageningen, The Netherlands.

Nguyen To Quyen. 1990. New taxa of bamboo (Poaceae, Bambusoideae) from Vietnam. Bot. Zhurn. 75: 221-225.

Sihanath, G., 1995. Forage development in Lao PDR. In: Wong, C.C. and Le Viet Ly (eds.). Enhancing sustainable livestock-crop production in smallholder farming systems. Proceedings of the Fourth Regional Working Group on Grazing and Feed Resources in Southeast Asia, Nha Trang, Vietnam, 20-24 Mar 1995. p 17-23. FAO, Rome.

Stür, W.W., Horne, P.C., Hacker, J.B. and Kerridge, P.C. 1995. The Forages for Smallholders Project. In: Wong, C.C. and Le Viet Ly (eds.) Enhancing Sustainable Livestock-Crop Production in Smallholder Farming Systems. Proceedings of the Fourth Regional Working Group on Grazing and Feed Resources in Southeast Asia, Nha Trang, Vietnam, 20-24 Mar1995. FAO, Rome. p. 63-66.

# New forage developments in Bali, Indonesia: *Arachis pintoi* as a cover crop and *Calliandra calothyrsus* for cattle fattening

**I Ketut Rika1**

*Calliandra Calothyrsus* (Calliandra) provides fuel, shade, soil stabilisation, and feed for ruminants in several villages in Bali (Kintamani, Besakih, Petang, Pempatan, Rendang and others). These villages are located in upland areas above 500 m altitude with good rainfall. *Calliandra* was introduced to Bali some time between 1970 and 1975, after the eruption of Mount Agung in 1963. At the beginning, it was introduced for reforestation in areas in the south and west of Mount Agung. *Calliandra* grew very well and spread on sloping lands on the foothills of Mount Agung. At present, *Calliandra* has spread out from the forestry area into the farmers' fields and is planted by farmers, mostly as living fences, for feed for cattle and for firewood.

Calliandra can grow on low-fertility soil, grows throughout the year in high rainfall areas and is not attacked by psyllids. For feeding of ruminants, *Calliandra* is used in the cut-and-carry system. It has now spread from the Besakih area (region of Karangasem) to other areas bordering the Besakih village.

Recent research in Australia showed that the digestibility and voluntary feed intake of *Calliandra* was higher for fresh than for dried or wilted material (Palmer et al. 1994). In Bali, the farmers feed *Calliandra* fresh to cattle as soon as it is cut. The taxonomy, botanical description, phenology, and breeding system of *Calliandra* are well covered in the literature (Wiersum and Rika 1992).

*Arachis pintoi* cv. Amarillo, known as Kacang Pinto in Bali, was first evaluated in 1988-89 in small plots (2-m x 2-m) at Pulukan village in Bali, as one of the species from 37 legumes and 35 grasses (Rika et al. 1990). Kacang Pinto was one of the species selected from the evaluation, and this was based on its good growth and ability to grow well in shade (about 50-60 % shading). All selected species were evaluated in a larger area at the same site (Pulukan village) under a coconut plantation. Kacang Pinto was found suitable under shade in plantations (50% light) as well as a cover crop (Rika et al. 1994).

Kacang Pinto has also shown high potential as a cover crop in coffee, banana, oil palm, macadamia and hearts of palm (Cruz et al. 1994). It was found capable of controlling weeds and fixing large amounts of nitrogen. In Bali, Kacang Pinto has been used as cover crops under orange plantations at Bangli (about 700 m above sea level). It is presently evaluated in Petang (30 km north of Denpasar, about 600 m above sea level with average rainfall of 3000 mm/year) as forage (in cut-and-carry system with dual purpose as forage and cover crop under cassava). The evaluation aims to observe effect on cattle weight, as well as on cassava growth and tuber production. Smallholder farmers are interested to adopt Kacang Pinto both as a cover crop and as a forage. Kacang Pinto is not only eaten by ruminants but also by pigs and kampong chickens. This adds to its potential for adoption by small farmers.

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## Spread and use of *Calliandra* as forage in Bali

After Mount Agung erupted in 1963, most of the villages around it were swept by lava or covered by sandy material. Since 1970, the forest and the farm land bordering the forest area were replanted by trees and forage. For food purposes, smallholder farmers tried to plant cassava. To plant cassava, they had to dig out the sand first (30-40 cm depth) to find the top soil.

In the forestry area, the government planted *Calliandra* in 1980. The Forestry Department contracted smallholders farmers to look after the plantation trees (mainly *Pinus* trees) which had been planted by government at the border area (just beyond the land belonging to farmers), at the southern and western parts of Mount Agung (mainly around Besakih village). As compensation, the farmers were allowed to plant *Calliandra* and *Pennisetum* grass under *Pinus* trees and to harvest the branches of *Calliandra* and *Pennisetum* grass regularly for forage (seeds of *Calliandra* and planting materials of *Pennisetum* were provided by the government). This system has been successful up to now and has spread to other villages bordering the forest in the other areas in Bali (Bangli, Gianyar, Badung, and Tabanan at 700 – 1,100 m above sea level).

Farmers currently plant *Calliandra* in their land as live fence together with *Pennisetum* grass planted at about 2 m width from the fence. As a live fence *Calliandra* produces about 1.8 - 3 t dry matter per km of fence in 10 months (Wiersum and Rika 1992). The spread of *Calliandra* was through the efforts of farmers themselves, upon learning that *Calliandra* was good forage for cattle.

**Table 1. Production of major tree/shrub legumes used in five areas of Bali.**

| Tree/shrub legume | Badung | Tabanan | Gianyar | Bangli | Karangasem |
|---|---|---|---|---|---|
| | | (Dry Matter yield in tonnes/year) | | | |
| *Gliricidia* | 16.3 | 12.0 | 1.9 | 8.5 | 6.3 |
| *Leucaena* | 1.0 | 8.3 | 0.4 | 2.1 | 0.4 |
| *Calliandra* | 0.2 | 7.1 | 13.9 | 17.8 | 1.3 |
| *Erythrina* | 2.3 | 14.1 | 2.2 | 7.8 | 1.0 |

Source: Forage Survey in Bali, 1992

Table 1 shows the amount of tree/shrub legumes produced in five areas of Bali. Bangli has the highest production of *Calliandra,* followed by Gianyar and Tabanan. *Calliandra* is the second most popularly used tree forage after *Gliricidia* despite the fact that it was the most recently introduced species.

## Utilisation and benefits of *Calliandra*

Calliandra is used both as forage and firewood by farmers. Trees of *Calliandra* planted in 1985 at Besakih were sampled and measured for wood production (Table 2).

**Table 2. Wood production of *Calliandra* at Besakih.**

| Yield component | When cut 4 times a year | When cut at the onset of flowering |
|---|---|---|
| Tree diameter (cm) | 20.5 | 23.5 |
| Tree height up to branches (m) | 2.0 | 2.5 |
| Fresh weight of young branches and leaves (kg) | 5.1 | 5.9 |
| Fresh weight of branches for fire wood (kg) | 0.8 | 5.5 |

Farmers cut *Calliandra* 3 – 4 times a year. If more branches are needed for fuel, they wait until *Calliandra* produces flowers. Because of lack of knowledge and extension efforts from the government, legumes are not always used as a source of high-protein feed for cattle. *Calliandra* and *Pennisetum* grasses are only given in the dry season. During the rainy season, when *Pennisetum* and other pioneer grasses grow very well, some farmers use these for feed and *Calliandra* is cut for fuel.

*Calliandra* is eaten by cattle when fed fresh. If wilted, it is not eaten, and the leaflets drop to the ground. In addition to *Calliandra, Erythrina* leaves are also fed to cattle and farmers around Besakih boil 2 – 3 kg sweet potato, mix it with water, and give this mixture to cattle every 2 days. In most cases, feed for fattening cattle in Besakih consists of 70-80% *Calliandra* and *Pennisetum;* the remainder being pioneer grass, broadleaf weeds, and sweet potato pulp in drinking water. Farmers who fatten two head of cattle can earn Rp 2,000,000 – 2,500,000 per year from cattle sales. In addition, they can earn about Rp 75,000 per year from manure sales.

Cattle in the Besakih area command a higher price per kg than cattle from other areas in Bali and often win national competitions for best animals (Table 3).

**Table 3. Winners in the 1991 National Cattle Contest (Balinese cattle) at Magelang.**

| Rank | Growing Bull | Growing Female | Bull | Male |
|---|---|---|---|---|
| First prize | Besakih[a]<br>696 kg | Rendang[a]<br>260 kg | Pempatan[a]<br>800 kg | Panasan[a]<br>410 kg |
| Second prize | other area from outside Bali | other area from outside Bali | Bangli[a]<br>647 kg | Blega<br>449 kg |
| Third prize | Pempatan[a]<br>(700 m)<br>650 kg | other area from outside Bali | other area from outside Bali | other area from outside Bali |

[a] Villages at foothills of Mount Agung near Besakih.
Source: The Livestock Services in Bali, 1996.

## *Arachis pintoi* a cover crop

After 6 years of research in Bali, Kacang Pintoi was identified as having good potential as forage and ground cover. As a result, Kacang Pinto has spread to 15-20 villages in northern Denpasar. These villages are located in a relatively dry upland areas, about 600 – 800 m above sea level with annual rainfall about 2,500 – 3,000 mm.

Kacang Pinto has a high degree of shade tolerance (up to 50 % light), and has shown high potential as a cover crop (Rika et al. 1994). It has shown good capacity to control weeds and can fix large amounts of nitrogen. Kacang Pinto has been used as cover crop in orange plantations in demo plot area in Bangli (700 m above sea level). Because of its high degree of shade tolerance, Kacang Pinto finds application not only as a pasture legume in tree plantations but also as a ground cover (cover crop) in plantation (Cook 1992). Release of nutrients (N,P,K and Ca) from the litter of Kacang Pinto is extremely rapid (Thomas, 1994).

As a cover crop Kacang Pinto has been used in coffee, banana, and oil palm. Preliminary research on the crop has indicated its general capacity for weed control, as

well as nematode control in tomato and coffee. Other uses include soil protection, soil improvement and as ornaments in urban areas, (Cruz et al. 1994).

Kacang Pinto therefore has potential to contribute to physical and chemical improvement (as well as protection) of the soil to supply nutrient, and to increase feed availability and organic matter production. Research in Bali, using Kacang Pinto, *Stenotaphrum* grass (cv. Floratam and ex. Vanuatu) as cover crop in cassava, showed that Kacang Pinto on its own did not reduce cassava tuber yield significantly (Table 4). If grown with grasses, cassava tuber yields were affected. On the other hand, forage production was increased.

**Table 4. Production of cassava (tuber and leaves + young stem) and composition and production of cover crop (1st and 2nd harvest)[1].**

| Treatment | Cassava leaves and young stem yield (DM g/plant) | | Tuber yield (DM g/plant) | | Botanical composition (%) | | Forage Yield (DM t/ha) |
|---|---|---|---|---|---|---|---|
| | H-1 | H-2 | H-1 | H-2 | H-1 | H-2 | H-2 |
| Control (cassava only) | 114 | 143 | 505 | 745 | 0 | 0 | 1.6 |
| Cassava with | 108 | 152 | 559 | 681 | - | - | 4.4 |
| - K. Pinto | | | | | 93 | 88 | |
| - Weeds | | | | | 7 | 12 | |
| Cassava with | 145 | 89 | 617 | 461 | - | - | 3.9 |
| - K. Pinto | | | | | 78 | 94 | |
| - Floratam | | | | | 12 | 6 | |
| - Weeds | | | | | 10 | 0 | |
| Cassava with | 132 | 73 | 515 | 407 | - | - | 4.2 |
| - K. Pinto | | | | | 72 | 71 | |
| - Vanuatu | | | | | 22 | 26 | |
| - Weeds | | | | | 6 | 3 | |
| Cassava with | 162 | 63 | 482 | 377 | - | - | 4.0 |
| - K. Pinto | | | | | 47 | 60 | |
| - Vanuatu | | | | | 32 | 32 | |
| - Floratam | | | | | 21 | 8 | |
| - Weeds | | | | | | | |

[1] 1st harvest in 9-months-old cassava (after 1st harvest, cassava is replanted in the same hole). Cover crop was 4 month old. 2nd harvest in 10-months-old cassava. Cover crop was 14 month old. Plot size: 5 m x 5 m. Cassava planted at 1 m x 1 m. Forage harvest 3 times in 10 months.

As a cover crop, Kacang Pinto forms very good stolons and also produces a lot of seed in the soil. At Manado and Bali (Surabrata), Kacang Pinto plots were burned in the dry season without any stolons left behind. At the beginning of the rainy season many young seedlings grew from seeds in the soil.

## *Arachis pintoi* as forage

In Bali (Pulukan area), Kacang Pintoi established in mixtures under coconut plantations, were found to be very resistant to heavy grazing (Rika et al. 1994). In vitro digestibility varied from 60 to 76%, N content ranged from 2.5 to 3 %, and P was in the 0.18 – 0.37% range (Cook 1992). Kacang Pinto (*Arachis pintoi*) pasture has resulted in increased live weight gains 20 - 200% and milk yields (17 - 20%) compared with pasture consisting of

grass alone. Highest gains occurred when there was 30% legume in the pasture. Even in heavily grazed pasture and in the dry season, live weight gains are higher in pasture with *A. pintoi* than in pasture with grass alone (Cruz et al. 1994).

Annual liveweight gains in pasture with *A. pintoi* have ranged from 160 to 200kg/head/year and from 250 to 600 kg/ha depending on the species of the companion grass and the dry season stress existing in the location (Lascano 1994).

## References

Cruz, R. de la, Suares, S. and Ferguson, J.E. (1994). The contribution of *Arachis pintoi* as a ground cover in some farming systems of tropical America. In: Biology and agronomy of forage *Arachis*, CIAT.

Cook, B.G. 1992. *Arachis pintoi* Krap and Greg., nom. pud., PROCEA, 4, Forages. Pudoc Science Publishing Wageningen. P 48-50.

Lascano, C.E. 1994. Nutritive value and animal production of forage *Arachis*. In: Biology and agronomy of forage *Arachis*, CIAT.

Mendra, I.K., Rika, I.K., Suarna, I.M., Kaca, I.W., Mullen, B.F. and Stür, W.W. 1994. Grass – legume mixture for coconut plantation in Bali. Integration of ruminants into plantation systems in Southeast Asia. (ACIAR Proceedings. No. 64).

Rika, I.K., Mendra, I.K., Nurjaya, M.G., Oka and Oka Mgusti. 1990. New forage species for coconut plantations in Bali. Forages for plantation crops, ACIAR Proceedings No.32.

Rika, I.K., Kaca, I.N., Stür, W.W. and Mullen, B.F. 1994. Pasture establishment and grazing management in Bali. Observations from the Pulukan grazing trial (Integration of ruminants into plantation systems in Southeast Asia. (ACIAR Proceedings No. 64.

Palmer, B., Macqueen, D.J. and Bray, R.A. 1994. Opportunities and limitations in *Calliandra*, ACIAR Proceedings No. 57.

Thomas, R.J. 1994. *Rhizobium* requirements, Nitrogen fixation and nutrient cycling in forage *Arachis* (Biology and agronomy of forage *Arachis* CIAT.

Wiersum, K.F. and Rika, I.K. 1992. *Calliandra calothyrsus* Meissn. PROSEA 4, Forages. Pudoc. Science Publishing, Wageningen. p. 68-70.

# The use of *Leucaena leucocephala* in farming systems in Nusa Tenggara, eastern Indonesia

**Jacob Nulik**[1]

Nusa Tenggara consists of three provinces -- East Timor, East Nusa Tenggara, and West Nusa Tenggara which are a group of islands in eastern Indonesia known as Kawasan Timur Indonesia (KTI).

The province of East Timor lies in the western part of Timor island, stretching between 125$^{o}$ and 127$^{o}$ 19' S. The northern part is bordered by the Wetar Strait, the eastern part by the Maluku Sea, the southern part by the Timor Sea, and the western part by East Nusa Tenggara. It has a total area of 14,609 km$^2$ and is administratively divided into 13 *Kabupaten* (districts), 62 *Kecamatan* (subdistricts), and 442 villages. East Timor is in the tropics. The southern part is influenced by climate conditions in Australia, where the lowest temperature can reach 18$^{o}$C in June-August, the maximum temperatures 32-34 $^{o}$C, and annual rainfall is 800 to 1500 mm. In the southern coastal areas, average annual rainfall is in the 1500-2000 mm range, while it could reach 2500 to 3000 mm in the mountain region. Potential areas for animal grazing can be found in Kabupaten Kovalima, Manufahi, Viqueque, Lautem, and Baucau dan Bobonaro (IPPTP Comoro, 1997).

The East Nusa Tenggara Province lies between 12-18 $^{o}$S and 118-125 $^{o}$E. It is an archipelago with 156 islands; 4 are large islands (Timor, Flores, Sumba, and Alor) and the remainder are small islands which may or may not have inhabitants.

Administratively, this province consists of 12 Kabupaten and 1 Kotamadya, with a total area of 47,350 km$^2$ and a population of about 3.3 million people in 1993. The climate is influenced by its geographic position, which is between the Flores Sea and the Indian Ocean. The southern parts are drier than the northern parts. The dry condition is significantly influenced by the dry wind blowing from the Australia continent. The island of Flores, which lies quite far from Australia, generally, has better rainfall than Timor and Sumba islands. Based on the analysis of Pramudia et. al. (1997) East Nusa Tenggara in general has single rainfall pattern (91%). This indicates a clear difference between total rainfall in the rainy season and that in the dry season. Double rainfall patterns were only found in some places (6%) such as at Bajawa and Weluli (Kabupaten Belu), Lewa (Kabupaten Sumba Timur) and at Palla and Medakalada (Kabupaten Sumba Barat) (Basuki et al. 1997). The double pattern indicates no clear differences between rainy and dry season, although rainfall is not evenly distributed in all years.

The province of West Nusa Tenggara consists of two large islands, Lombok and Sumbawa. Total area is around 20,153 km$^2$, with Lombok having around 4,738 km$^2$ (23% of province size) and Sumbawa, 15,414 km$^2$ (77%). The province has a tropical climate. Maximum temperature is 33.2 $^{o}$C and minimum temperature is 19.0 $^{o}$C, with maximum relative humidity of 93-98% and a minimum of 48-65%. The average rainfall ranges from 1000 to 2000 mm/yr with 36-86 rainy days/year; 4-5 months are wet months and 7-8 are dry months. The dominant soil types are Complex Regosol, Lithosol, Mediterranean, and Rendzina which cover 67% of West Nusa Tenggara. The rest (23%) of the soils consists of complex brown forest and nonalcic brown; the remaining 10% consist of alluvial, Grumosol, and Andosol types. The soils are grouped into Alfisols, Entisols, Inceptisols, and Vertisols. The agroecology characterized is by dry land with

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dry climate, especially in Sumbawa Island and in the north and south parts of Lombok (IPPTP Mataram, 1997).

The development and use of *Leucaena leucocephala* in the farming system are much more pronounced in East Nusa Tenggara, especially in Amarasi on Timor island and Sikka on Flores Island. There are some small areas in West Nusa Tenggara and East Timor through where *L. leucocephala* can be seen. This paper focuses on the two locations mentioned.

## Farming systems in Nusa Tenggara

Except for those in Lombok island in West Nusa Tenggara and Flores Island in East Nusa Timor, which have better rainfall and where the agricultural sector has been intensively managed, Nusa Tenggara farmers are subsistence farmers. They work to obtain enough food to support their family and only a small amount of production is sold to earn extra income for their daily needs.

### Livestock industry

Nusa Tenggara plays an important role in the supply of beef as well as breeding animals to other areas of Indonesia. Bali cattle are one of the leading ruminant livestock exported from Nusa Tenggara. In Lombok Island, West Nusa Tenggara, the cattle industry is currently engaged in cross breeding with larger size cattle such as Aberdeen Angus and Simmenthal Sumbawa, on the other hand, is the source of pure Bali cattle.

East Nusa Tenggara is concentrating on Bali cattle in Timor and Flores islands, while Ongole cattle are produced on Sumba island. In Timor, extensive cattle raising is mainly practiced in the eastern part where more land is available for grazing and only 1 or 2 animals are tethered per farm household for fattening. Animals are sold whenever the farmer needs cash. This region provides breeding cattle for other parts of the island. Meanwhile, at Amarasi, cattle are mainly tethered for fattening. In Sumba Island, cattle are extensively raised and allowed to graze in native grasslands.

East Nusa Tenggara exported up to 50,000-70,000 cattle per year for beef and breeding animal. These cattle come mainly from Timor. However, with the increasing occurrence of *Brucellosis,* fewer breeding cattle are exported now from Timor. East Timor's Bali cattle industry is just developing. It has good potential for raising the breed.

## The use of *Leucaena leucocephala* in farming systems

### Development of *Leucaena leucocephala*

*Leucaena leucocephala* is well known by farmers in Timor, East Nusa Tenggara. This legume/tree shrub was introduced in the 1930s. At that time, under the strong rule of the Amarasi King (Raja Koroh), farmers in Amarasi were obligated to plant *L. leucocephala* in rows in an effort to get rid of *Lantana camara* weeds in the region. Farmers practicing shifting cultivation were not allowed to move to another land until they establish *Leucaena* in the former land. The short variety of common *Leucaena* (also called shrubby Leucaena) used in this activity had been widely distributed in the west part of Timor by the 1960s, especially around Kupang (the provincial city of East Nusa Tenggara) and was an important source of firewood. Planting was still encouraged through primary school students in Kupang who facilitated seed collection.

This practice of *Leucaena* planting was well undertaken and became a specific system of farming in the Amarasi region. It became known as the Amarasi model. By the 1970s, large areas in Amarasi were covered by *L. leucocephala* and the Dinas Peternakan (Government Livestock Services) started promoting cattle fattening through

the introduction of the PUTP system Panca Usaha Ternak Potong or Five Efforts in Beef Cattle Fattening). By this time, the 'K-number' varieties of *L. leucocephala* from the University of Hawaii, were starting to be widely used. Planting of the K varieties started in early of 1960s at Flores Island. The district of Sikka used the local variety, while the K varieties were grown at about the same time in Amarasi, Timor. The system of planting is currently known as the Sikka model.

A detailed history of *Leucaena* development in East Nusa Tenggara was described by Piggin and Parera (1984). Planting of *Leucaena* in West Nusa Tenggara was done mainly through seed production programs started by IFAD at the sub-district of Sekotong in Lombok where *L. leucocephala* cv. Cunningham from Australia was used. However, in as much as many areas in Lombok, especially the rice fields are intensively cultivated, farmers are more interested in planting *Sesbania grandiflora* along the rice bunds. This legume provides less shade so beans such as *Dolichos lablab* may be planted under the trees. On the other hand, a *Leucaena* stand makes heavy shade, thus preventing any other plant to grown under it.

With the arrival of *Heteropsylla cubana* (psyllid insect) in 1986-87 many *L. leucocephala* areas have been greatly reduced and alternative legume trees have been planted to support animal production in the region. Recently, however, *Leucaena* in Nusa Tenggara seems to have made a good recovery and is again being considered an important fodder plant in the region besides *Sesbania grandiflora, G. sepium*, and *Acacia angustissima* and lesser species in use such as *Calliandra calothyrsus*, *C. tetragona* as well as other fodder sources from non-legume trees such as *Macaranga tanarius, Hibiscus tileaceus*, and *Ficus* spp.

**Practical use of *Leucaena* in farming systems**

Initially, planting of *L. leucocephala* was done by establishing thick rows of *Leucaena* 2-3 m apart in poor degraded lands (mainly hilly) with contour arrangement. After 3-4 yeas of planting of *L. leucocephala,* a good cover is achieved, and the land was then used for planting food crops such as maize, peas, and other preferred crops. In the model, the rows of *L. leucocephala* were cut to the ground level. The materials cut (leaves and wood) were used as animal fodder and firewood or left in the field and burned when dry. *Leucaena* transformed this degraded land into fields suitable for food crop cultivation. When the soil condition improved, farmers started to grow banana, coconut, and other useful food crops. This turned degraded *Lantana camara* land to arable land for the Amarasi farmers.

As years went by, the area became thick with *L. leucocephala* but farmers continued to cultivate the land using row plantings of *Leucaena* or land that was already covered by a thicket of *Leucaena* where rows could no longer be identified. Such slash-and-burn systems are still practiced in many areas in Amarasi today.

In the 1970s, as the 'K varieties' of *Leucaena* were being introduced, farmers in Amarasi began to use these taller varieties. In the Sikka model*, Leucaena* was planted in wider rows (5-6 m apart) and the land in the alley was used for planting food crops. No slash-and-burn cultivation was introduced. Livestock was thus of secondary importance to farmers in Sikka, where only a few owned cattle. By the 1980s intensive cattle raising become popular in Sikka, before the arrival of psyllids. The Psyllid forced farmers to use alternative trees such as *G. sepium* and *C. calothyrsus*. In some places of Flores (Manggarai), Timor (TTS), and East Sumba (Lewa), farmers are used *Leucaena* as a shade tree for coffee plantations (Momuat et al. 1990).

With the close distance between rows in the Amarasi system, better control of soil erosion was observed. Also, farmers spent less time in weeding their crops because weeds were effectively controlled.

**Animal fodder**

In the past, Amarasi farmers used *L. leucocephala* leaves alone. In some places where water was scarce, banana stems were fed to the animals. This practice is still being followed today.

Farmers in Amarasi still practice fallow systems using land grown with local *Leucaena*. A family with 5-7 members can manage to fallow 2-4 ha of *Leucaena* land to grow corn and peas and to establish 1.5-3 ha of forage garden grown 2-3 m apart in rows of mixed legumes such as *L. leucocephala* (K varieties), *G. sepium* (local) and *Sesbania grandiflora*. This forage garden is usually established 2-3 km from the farmers' house and is used as source of fodder from the middle to the peak of the dry season when it is difficult to get enough forage for the tethered animals. During the rainy season, many diverse varieties of fodder can be obtained – native grasses (*Sorghum timorensis* and an annual *Pennisetum* spp.) or introduced grasses (*P. purpureum)* or *Pennisetum* hybrids mixed with *Leucaena* leaves (local or K varieties). The current practice of forage cultivation may still be improved through the introduction of other grasses into the rows of the legume trees which grow better in shade such as *Panicum maximum* and *Andropogon gayanus* (Nulik 1996). At present, only native grasses such as the annual *Pennisetum* spp. and *S. timorensis* occupy the rows; they can only produce fodder during the rainy season.

The daily weight gain of Bali cattle under the fattening system in Amarasi can reach up to 0.4-0.5 kg/day (Field 1988; Ataupah 1983) which compares with 0.1-0.2 kg/day under natural range conditions in Timor (Field 1988).

## Future use of *Leucaena*

Although *Leucaena* in Nusa Tenggara has made a good recovery, farmers, have learned that there is a need to plant a larger variety of species of tree legumes. Varieties of psyllid-resistant *Leucaena* also have been tried and evaluated in Timor Island (in Besipae) and some promising species/varieties have already been identified for further development (Piggin et al. 1982). However, because of lack of seeds and the scant information given to farmers, these species/varieties are still not adopted by farmers in the region.

Research on *Leucaena* establishment in various types of soils in Timor and possible forage production has been conducted by Field (1988). Thus, a technology exists for growing the legume under Nusa Tenggara conditions.

*Leucaena* planting in other areas of Nusa Tenggara is promising – the legume may be grown in the eastern part of Sumba and eastern part of West Timor in East Nusa Tenggara, in East Timor, and in the eastern part of Lombok and Sumbawa in West Nusa Tenggara.

## Conclusions

The use of *Leucaena* in the farming system in Nusa Tenggara has long been practiced for a variety of reasons: to prevent invasion of *Lantana camara* weeds, to improve the quality of degraded lands, and to prevent erosion. The arrival of *H. cubana* in 1986-87 has set back *Leucaena* development, but its recent recovery promises a brighter future in areas of Nusa Tenggara where it fits well into the farming practices. Inadequate technology transfer and unavailability of seed are slowing the adoption of the psyllid-resistant *Leucaena* species/varieties. Farmers are interested to grow other *Leucaena* varieties and other tree legume species as well as grasses as sources of fodder. There

thus is an immediate need to provide seed/seedlings to the farmers and to let them select the type of fodder suited to their system of farming.

## References

Basuki, T., daSilva, H., Wirdahayati, R.B., Subandi, Bamualim, A. 1997. Karakterisasi zona agroekosistem (AEZs) di Nusa Tenggara Timur. Hasil-hasil Penelitian NTAADP, BPTP, Naibonat, p.1-38.

Burke, T., Rachmawati, I., Agung, K. and Pa, S.M. 1995. Investigation on traditional and introduced agroforestry systems in Timor, Rote, and East Suma. Balai Penelitian Kehutanan Kupang.

IPPTP Comoro. 1997. Rencana strategis instalasi penelitian and pengkajian teknologi pertanian mataram 1997-2007. IPPTP Mataram.

Jones, P.H. 1983. Leucaena and the Amarasi model from Timor. Indonesia-Australia Eastern Universities Project, LPIU Nusa Cendana University (unpubl).

Momuat, E.O., Field, S.P., Mamualim, A. 1990. Forage production systems in Nusa Tenggara. Paper presented at the seminar on Production and Utilization of Shrub Legumes in the Tropics, 31 Jul – 1 Aug 1990, Denpasar.

Nulik, J. 1996. Pengembangan tanaman hijauan makanan ternak di Nusa Tenggara dan Timor. Laporan konsultan pada Eastern Islands Veterinary Services Project, Phase II, Kupang.

Piggin, C.M., Parera, V. 1984. The use of Leucaena in Nusa Tenggara Timor. In: Proceedings of the Shrub Legume Research Meeting in Indonesia and Australia, 2 February 1984, Balai Penelitian Ternak Ciawi-Bogor. ACIAR.

# Forage research and development in the Kingdom of Bhutan

**Walter Roder**[1]

The Himalayan Kingdom of Bhutan has an area of about 46,500 km$^2$ and a population of 0.6 million. Its mountainous topography was aptly described by an early visitor (Marakham 1876) as 'a succession of lofty and rugged mountains, separated by gorges and a few valleys somewhat wider than the generality of ravines.' The elevation ranges from about 200 m in the south to almost 8000 m in the north.

The climate is dominated by the monsoon with a dry winter season and high precipitation during June-September. Influenced by topography, elevation, and rainfall pattern, Bhutan has a wide variety of climatic conditions and, consequently, a wide diversity in vegetation and farming systems.

Agriculture is the main economy of the country. About 85% of the population live in rural areas and depend on agriculture. Due to the mountainous topography, only a very small percentage of the land is suitable for agriculture. Crops cultivated (in order of importance) are maize, rice, millet, wheat, buckwheat, potato, mustard, and barley (Table 1). Rice is cultivated on small terraces made on slopes with gradients up to 80%. Topography and market accessibility favour livestock production, especially in regions with elevations above 2000 m. Livestock production is traditionally an integrated part of the Bhutanese farming system.

**Table 1. Land use and livestock statistics.**

| Land use[1] | Area ('000 ha) |
|---|---|
| Forest (x1000ha) | 2904 |
| Lowland rice (x1000ha) | 39 |
| Upland agriculture (maize, wheat, barley, buckwheat) (x1000ha) | 182 |
| Shifting cultivation (Tsheri and Pangshing) (x1000ha) | 88 |
| Horticulture plantations (apple, orange, cardamom) (x1000ha) | 6 |
| Natural pasture (x1000ha) | 155 |
| Improved pasture (x1000ha) | 1 |
| Livestock (1995 data)[b] (x1000 head) | 1000 |
| Cattle (x1000 head) | 305 |
| Buffalo (x1000 head) | 1 |
| Yak (x1000 head) | 30 |
| Equine (horse, mules, donkeys) (x1000 head) | 26 |
| Goat (x1000 head) | 16 |
| Sheep (x1000 head) | 31 |

[1] Source: MOA, 1997; [b] Source: MOA 1995.

## Research institutions

The Ministry of Agriculture was reorganized during the period 1993-95. Separate divisions were formed: 1) Research, Extension and Irrigation; 2) Crop and Livestock Service Division (mostly input supply); and 3) Forest Service Division (territorial forest

[1] Renewable Natural Resources Research Centre, Jakar, Bhutan.

management). Under the Research, Extension and Irrigation Division, four national renewable natural resources research centres (RNR-RCs) were established and given specific regional and national mandates (Table 2). Each research centre was assigned to lead one of the national programs that deal with field crops, horticulture, livestock and forestry. Additionally, the farming systems program under each centre also includes socio-economic, cross-sectoral, and other activities not directly associated with a single program.

**Table 2. Existing research centres, mandates, and regions.**

| Research centre | National mandate | Region |
|---|---|---|
| Yusipang | Forest | Western Region |
| Bajo | Field crops | West Central Region |
| Jakar | Livestock | East Central Region |
| Kangma | Horticulture | Eastern Region |

In its respective region, each centre is responsible for the implementation of all research activities. Besides the main task of importing, adapting, or generating technologies to be used in the extension programs, the centres are responsible for building up a pool of expertise and information and for supporting the extension and development programs by way of technical assistance, training, and general backstopping.

The National Livestock Research Program, coordinated by the Research Centre in Jakar, has been divided into 3 subprograms: breeding and management, feed and fodder, and health.

With the assumption that technologies under the subprograms breeding and management and health can, to a certain extent, be imported from other countries with little or no further adaptation, major emphasis is given to the subprogram feed and fodder with an allocation of 70-80% of the available resources (RNR-RC 1997).

## Research needs, priorities, and constraints

Matching the limited resources available with the needs of the tremendously variable production systems and climates has and will always be a challenge. Rigorous priority setting and judicious planning are given due importance. In a recent attempt to prioritise research needs and opportunities, the identification of main nutritional limitations was given the highest priority (Table 3), followed by fodder produced from intensively managed permanent grasslands.

The same areas received top ranking when research priorities were set in the late 1980s. Compared with earlier rankings there was a shift toward fodder resources in integrated systems. Similarly, crop residues were given more importance. This is largely attributed to the change in the research system. Through the integration of crop, horticulture, livestock, and forestry research, more emphasis is given to fodder production in crop or horticulture systems.

Regional priorities deviate from national priorities. At higher elevations, extensively managed permanent grasslands will have priority, whereas at lower elevations, arable fodders, tree fodders, and crop residues become important. Regional research priorities, needs, and opportunities are currently reviewed by the newly formed research centres.

**Table 3. Ranking of research priorities at the national level[1].**

| Rank | Area of research |
|---|---|
| 1 | Identification of main nutritional limitations to animal production (seasonal fodder production, deficiencies in energy/protein/minerals, etc.). |
| 2 | Intensively managed permanent grassland (small plots in the vicinity of settlements, also includes orchards). |
| 3 | Arable fodder (in rotation or in combination with annual crops, winter fodder) for fodder, soil improvement, and/or soil conservation. |
| 4 | Extensively managed permanent grassland (range land). |
| 4 | Tree fodders, agroforestry and silvopastoral systems. |
| 4 | Use of crop residues and by-products (rice straw, maize stems, buckwheat stems, home brewing). |
| 5 | Technology development to support various programs (seed production, fodder conservation, etc.). |
| 5 | Grazing effects on forest systems. |
| 6 | Social and cultural aspects (migration, culling of unproductive animals, land ownership, communal agreements on protection of crops, etc.). |

[1] Source: RNR-RC 1996.

A review of earlier research activities showed that the main constraint was the lack of rigorous priority setting (Table 4). Insufficient interaction with farmers and herders and poor representation of target environments as well as insufficient academic background of research personnel were considered the second most important constraints.

**Table 4. Constraints to successful research in feed and fodder[1].**

| Rank | Constraint/limitation |
|---|---|
| 1 | Lack of focus or realistic identification of research needs |
| 2 | Insufficient interaction with farmers and herders and poor representation of target environments |
| 2 | Insufficient academic background of research personnel |
| 3 | Insufficient access to information |
| 3 | Insufficient research personnel |
| 4 | Wrong priorities |
| 5 | Most experimental activities limited to on-station work |
| 6 | Lack of coordination with extension activities |
| 7 | Lack of motivation of Bhutanese research personnel |
| 7 | Lack of fund |
| 8 | Lack of equipment |
| 9 | Too much dependence on expatriate advice |
| 10 | Insufficient support by the Ministry |
| 11 | Too much time absorbed in administrative work |

[1] Source: RNR-RC, 1996.

## Current research activities

All four research centres are strongly committed to regional research activities under the feed and fodder subprogram. Activities largely focus on:

- Description of resources and their management.
- Monitoring trends in the resource base and production.
- Identification and import of pertinent available information and technologies.
- Adaptation of technologies.

These activities are carried out in three sub-projects (Table 5). In addition, various activities are conducted in collaboration with other programs (forestry, field crops and horticulture).

Field work is done on-station and on-farm, with various levels of farmers' participation. Depending on the objectives of the individual activity, attempts are made to include extensionists and farmers or herders at all stages of the technology development and adaptation process.

**Table 5. Sub-projects under the feed and fodder subprogram[1].**

| Subproject | Purpose/objective |
|---|---|
| Description of past and present management, monitoring trends | • Document past research and development activities<br>• Describe existing fodder resource in terms of their management and potential<br>• Monitor trends in resource quality and production |
| Genetic evaluation and improvement | • Characterize native grassland and fodder species<br>• Import and evaluate exotic species |
| Production management | • Verify/adapt/develop technologies to optimise production and improve production efficiency and/or optimise synergistic effects between fodder production and other components |

[1] Source: RNR-RC (1997).

### Past and present management systems and monitoring trends

The extreme variations in climate, soils, and topography and the resulting adaptations by farmers and herders result in a huge range in vegetation, fodder sources, and production systems. Documenting fodder resources and existing management practices is thus a tremendous challenge for the small research team. Taking on the challenge, a process was initiated in 1996 to:

- Review past fodder research and development efforts.
- Document existing and potential fodder resources, farmers' practices, nutritional constraints to livestock production and quality of existing fodder.
- Generate information on farmers' practices, effect of management interventions, and productivity of natural grasslands.

The information collected and synthesized will provide inputs for planning and policy decisions and will also serve as basis for planning future research activities.

With increasing confidence in the accumulated base line information, monitoring trends in the resource base is gradually becoming more important. Considering the fragility of the grassland resources and the potentially harmful effects any management interactions may have on biodiversity, as well as on forest, water, and agricultural resources, it is important to build up mechanisms and develop key indicators which can quantify trends and changes over time.

### Genetic evaluation and improvement

The species selected in the early phase of the fodder development program have many positive properties and have shown good potential over a wide range of prevailing conditions. There is, however, an urgent need to select additional species for

- All environments in the subtropical regions (woody and herbaceous).
- Temperate legumes with better adaptation to P and moisture stress.
- Fodder species providing winter feed for temperate and subtropical regions (woody and herbaceous).
- Species, especially legumes, for fodder production in cropping systems with field crops.

- Species for soil and moisture conservation (woody and herbaceous), soil cover, green manure, and/or weed suppression.

Native and exotic materials are included in the program. Emphasis is laid on the acquisition and testing of plant materials to be used in integrated field crop, horticulture, or forestry systems and for soil conservation.

### Production management

The subproject on production management includes a wide range of activities with emphasis on establishment, soil fertility management, seed production, and winter feed (Table 6).

### Cross-sectoral activities

Various silvopastoral studies focusing on fodder and timber production and the interaction of the two are carried out in collaboration with the forestry program.

Similarly several studies focus on systems which integrate fodder production in apple or citrus production systems.

**Table 6. Ongoing activities in sub-project 3: Production Management.**

| Subproject 3 | Activity |
|---|---|
| Establishment | • Studies of temperate herbaceous species in bamboo-dominated grassland focusing on species, establishment methods, and P effects.<br>• Studies of subtropical species in maize and rice systems with main focus on species, effect of planting date relative to crop maturity, and planting method.<br>• Nursery methods for *Ficus roxburghii.* |
| Management | • Effects of fertiliser (N and P) and cutting interval effects on yield and species composition of temperate grassland systems.<br>• Willow in combination with herbaceous fodder: studies evaluating the effect of plant density and plant height on dry matter production of both components of the system. |
| Seed production | • Various studies evaluating the effect of location, plant density and irrigation.<br>• Effects of other management interventions on *Lotus pedunculatus* and Greenleaf *Desmodium* and *Lucerne* seed production (aim is to develop technologies that will result in economically viable seed production of these species). |
| Fodder preservation – winter fodder | • Testing of selected winter fodder species in potato, maize and rice systems.<br>• Development of systems to optimise use of existing fodder resources with studies focusing on deferred grazing, use of willow leaves, and the preservation of arable fodder biomass in the field. |

## Selected research findings

Past research activities have identified or generated a wide range of information and technologies:

- Description of major fodder resources and farmers' management practices.
- Characterisation of selected native grassland and fodder species.
- Selection of suitable herbaceous and woody fodder species for major environments and farming systems.
- Establishment methods (including inoculation) for temperate and subtropical species.
- Quantification of the effects of fertilisers (mainly P and N) on selected species and mixture of species and development of recommendations for fertiliser use.
- Evaluations of effects of micronutrients on establishment and dry matter production
- Development of appropriate seed production technologies for selected grass and legume species.

In this section, selected results from these activities are described in detail.

### Introduction and initial screening of exotic species

Planned germplasm introduction and evaluation started in the early seventies. Over the past two decades, more than 150 legume species and 70 grass species have been introduced and evaluated for their fodder production potential across a wide range of environments. Substantial information was generated on the performance of temperate species over several locations and years (Table 7). With a few exceptions, white clover and cocksfoot produced the highest yields. Good yields were also observed in lotus, red clover, Lucerne, tall fescue, and Italian rye grass.

**Table 7. Yield of selected temperate perennial fodder species[1].**

| Location | Batbalathang, Bumthang | Karsumphe, Bumthang |
|---|---|---|
| Elevation | 2,650 m | 2,700 m |
| Period/duration | 1980-82 (3 yr) | 1983-85 (3 yr) |
| | ***(legume yield relative to white clover)*** | |
| White clover | 100 | 100 |
| *Lathyrus silvestris* | - | 43 |
| *Lotus corniculatus* | 92 | 24 |
| *Lotus pedunculatus* | 111 | 17 |
| *Medicago glutinosa* | 94 | - |
| *Medicago media* | - | 66 |
| *Medicago sativa* | 72 | 87 |
| *Trifolium hybridum* | 76 | - |
| *Trifolium pretense* | 103 | 84 |
| *Trifolium semipilosum* | 89 | - |
| *Vicia tenuifolia* | - | 53 |
| | ***(grass yield relative to cocksfoot)*** | |
| *Cocksfoot* | 100 | 100 |
| *Arrhenatherum elatior* | 79 | - |
| *Festuca arundinacea* | 105 | 96 |
| *Festuca pratensis* | 93 | - |
| *Festuca rubra* | 87 | 99 |
| *Lolium multiflorum* | 112 | 93 |
| *Lolium perenne* | 78 | - |
| *Paspalum notatum* | - | 76 |
| *Poa pratensis* | 73 | 98 |
| *Phleum pratense* | 86 | - |

[1] Source: RNR-RC (1998).

**Species recommended for dissemination**

A considerable number of annual and perennial species and varieties have been recommended for fodder production in specific environments (Table 8). Some of them have been included in extension programs, while others are still under investigation or have been discarded because of seed production problems, limited potential for Bhutan, or other reasons.

**Table 8. Species recommended for use in Bhutan[1].**

| Species | Year[2] | Area (ha) | Present status |
|---|---|---|---|
| **Annual species** | | | |
| Oat | <1975 | <100 | Recommended for winter feed |
| Fodder beet | 1982 | <10 | On-farm evaluation |
| Winter vetch | 1978 | <5 | |
| Swede | 1982 | - | On-farm evaluation |
| Kale | 1982 | - | |
| Field pea | 1978 | - | |
| **Herbaceous perennials** | | | |
| White clover | 1978 | 100,000 | Extension program since 1978 |
| Cocksfoot | 1978 | 20,000 | |
| Italian ryegrass | 1978 | 15,000 | |
| Tall fescue | 1982 | 15,000 | |
| Kikuyu grass | 1982 | 2000 | Not multiplied, weed problems |
| Napier grass | 1982 | 500 | Extension program since 1980? |
| Greenleaf desmodium | | <500 | Provisionally in extension |
| Lotus | 1979 | <50 | program for limited periods |
| Lucerne | 1978 | <5 | Problems in seed production |
| Red clover | 1978 | - | Seed production studies |
| Stylo (*S. guianensis*) | 1982 | <50 | On-farm evaluation |
| Red fescue | 1982 | <10 | |
| Silverleaf desmodium | 1982 | - | |
| Kentucky blue grass | | - | |
| Guinea grass | 1982 | - | |
| Setaria (*S. sphacelata*) | 1982 | - | |
| Crown vetch | 1982 | - | Under observation |
| Glenn joint vetch | 1988 | | |
| *T. ruepellianum* | 1988 | | |
| **Woody perennials[3]** | | | |
| Willow | 1981 | 100 | Extension program since 1982 |
| *Leucaena leucocephala* | | <5 | |
| *Ficus roxburghii* | 1982 | 5000 | |
| *Ficus nemoralis* | 1982 | <100 | |
| *Bauhinia purpurea* | 1982 | <100 | |
| *Bauhinia variegata* | 1982 | <100 | |
| *Artocarpus lakoocha* | 1982 | <100 | |
| *Brassaiopsis hainla* | 1982 | <100 | |
| *Lytsea polyantha,* | 1982 | <100 | |
| *Saurauia nepaulensis* | 1982 | <100 | |
| *Prunus cerasoides* | 1982 | | |

[1] Source: RNR-RC Jakar (1998).
[2] Year when species was first recommended for extension.
[3] Area for woody perennials based on 200 tree/ha.

### Experiences with white clover

White clover is the most widely used exotic fodder species in Bhutan. The first recorded introductions were made in 1970 (RNR-RC 1998). Within a relatively short time, white clover has proven to be the most suitable legume for grassland improvement over a wide range of conditions within the altitude belt of 2000-4000 m (Gyamtshso 1996). Its introduction was, however, only successful with inoculation and P application. White clover not only increased dry matter yield but also substantially increased fodder quality and potential milk production (Tables 9 and 10).

The exceptionally successful introduction of white clover has alarmed among various parties. While some are mainly concerned by its bloat-inducing property, others have called for caution in future extension programs because they see it as a serious weed, even considering it as a threat to the existing biodiversity (Roder 1997). Although this may be largely an overreaction, there clearly is a need to reassess the status of white clover in future fodder development activities and to identify techniques and species that

- have lower P requirements and/or are more efficient in P uptake,
- can accumulate good-quality fodder over the entire growing season which will be available for winter feed, and
- are less susceptible to water stress.

**Table 9. Fodder quality of white clover compared with local species.**

| | Crude protein (%) | Crude fibre (%) | P (%) |
|---|---|---|---|
| *Schizachyrium delavayi* (before flowering) | 5.4 | 42 | 0.11 |
| *Lespedeza* sp. (before flowering) | 14 | 35 | 0.16 |
| White clover (at flowering) | 18 | 22 | 0.29 |
| Local hay | 5.0 | 40 | 0.17 |
| Hay from grass/clover mixture | 11.0 | 30 | 0.21 |

Source: RNR-RC (1998).

**Table 10. Milk production potential of selected fodder sources.**

| Fodder type | Milk potential (kg/animal) |
|---|---|
| Local pasture winter | <0.5 |
| Local pasture summer | 8 |
| Local pasture with white clover | 15 |
| Hay from local pasture | 2 |
| Hay from white clover/grass mixture | 14 |

Source: RNR-RC (1998).

## Extension

Modest extension activities aimed at increasing fodder production or quality started in the late sixties or early seventies. Early activities were sporadic and generally dependent on projects which are limited in time and space. Most of the development centres initiated in the late 1960s such as the Samchi farm, Lingmethang farm, Gogona farm, and Bondey farm had, at some stage, promoted fodder species (RNR-RC 1998). Although these activities had little impact, the lessons learned from these experiences provided valuable inputs for the later programs.

## Extension network

The Animal Husbandry Department begun to build up a network of extension centres in the seventies. These centres located at the Gewog level (subunit of a district comprising 150-800 households) were generally staffed with veterinary compounders. The main objectives are to provide health care and to supervise crossbreeding activities. Extension workers (pasture assistants) for fodder development were trained from 1978 onwards. While some of these fodder specialists were placed at Gewog levels, others were attached to the district headquarters.

## Extension programmes

**Promotion of perennial herbaceous fodder species in temperate regions**

The earliest documented and sustained extension activities focusing on fodder development started in Bumthang. District in 1978 (RNR-RC 1998). The package of practices recommended in 1978, included:

- Species and seed rate (kg/ha): white clover, 4 kg; Italian rye grass, 8 kg; cocksfoot, 4 kg or tall fescue, 4 kg.
- Inoculation: clover seed were inoculated and coated with gum arabic and rock phosphate.
- Subsidies: seed were charged a nominal rate of Nu 2.0 kg-1 (approximately 10% of the production cost). Phosphate fertiliser was provided free of cost.
- Establishment: undersowing into sweet buckwheat was recommended as the preferred method. Other establishment methods recommended were seeding after cultivation or transplanting white clover without cultivation.
- Management: grazing and cut-and-carry were recommended. Scythes were introduced and distributed at subsidized rates.
- Preservation: winter feed preservation through hay or silo making was recommended. Simple pit silo systems were introduced.

This package of practices became the model for nationwide extension programs promoted by the Department of Animal Husbandry, with the first countrywide activities initiated in 1978. Minor changes introduced over the years included the following:

- With more cocksfoot and tall fescue seed available, it became possible to replace some of the Italian rye grass seed by these species.
- Seed costs were fully subsidized from 1983 onward.
- Fertiliser subsidies were discontinued in 1996.

An early assessment after 3 years of field activities mentioned the following problems (Roder 1981):

- Extreme variations in climate exist.
- Some ambiguity in the rules and regulations regarding grazing land are not resolved.
- Farmers are not motivated enough as the idea of cultivating fodder is new to them and no examples are available.
- High phosphate inputs are required.
- Very expensive inputs in the form of seeds are given to farmers free or at nominal cost, resulting in farmers' complacency not motivated to optimise coverage and establishment success).
- Inoculation failures are common due to poor inoculum quality.

### Promotion of herbaceous fodder species in subtropical regions

Because seed and suitable methodologies are lacking the extension activities in subtropical regions were less successful. The species recommended changed with every plan period. The species recommended were (RNR-RC, 1998):

- Fifth plan: Kikuyu grass, Guinea grass, *Setaria sphacelata*, Rhodes grass, and Napier, Silverleaf desmodium, Glycine, and *Stylosanthes guianensis*.
- Sixth and seventh plan: Signal grass, Molasses grass, Guinea grass, *Setaria sphacelata*, Greenleaf desmodium, Silverleaf desmodium, Glycine, centro (*Centrosema pubescens*), siratro (*Macroptilium atropurpureum*), and *Stylosanthes guianensis*.

A review carried out in 1992 (Wangdi 1992) concluded that the main achievement made in subtropical areas was the creation an awareness for fodder development. It was observed that many sites had reverted back to weeds or shrubs. The main constraints listed were wild boar damage, overgrazing by wild animals, fencing problems, weed dominance and failure of establishment.

### Promotion of tree fodder or woody species

Fodder tree extension activities were launched in 1982, with local fodder tree species (RNR-RC 1998). Farmers were advised to plant the following species: *Artocarpus lakoocha, Bauhinia variegata, Bauhinia purpurea, Lytsea polyantha, Ficus roxburghii, Ficus nemoralis, Brassaiopsis hainla, Saurauia napaulensis, Prunus creasoides* and willow. During the fifth plan, the farmers were paid US$ 0.012 as subsidy for each tree planted.

The only exotic fodder tree species recommended and distributed to farmers were Leucaena (*Leucaena leucocephala*) and *Robina pseudoacaicia* (RNR-RC 1998). The acceptance of these exotic species with farmers was, however, marginal at best. Psyllid infestation on Leucaena was observed at various locations.

The number of species recommended was reduced for the sixth plan to *Artocarpus lakoocha, B. variegata, B. purpurea, F. roxburghii, F. cunia, F. lakoor* and *Celtis australis.* Where suitable, farmers show a strong preference for *F. roxburghii.* This species is preferred for its wide adaptation, good biomass yield, availability during the dry season, and relatively good fodder quality (Tshering et al. 1997).

### Paddy straw treatment, urea molasses block

Urea treatment of paddy straw was an important component of the extension program during the sixth and part of the seventh plan. Farmers were given free urea and training on treatment methods. An extension booklet was issued in 1987 (RNR-RC 1998). The advantages of urea treatment were supposed to include higher palatability and intake, better digestibility, higher N intake (from the urea) and reduction of liver fluke infestations.

Following a survey carried out in 1996, the technology was, however, not adapted. This in spite of the fact that almost all rice growers feed paddy straw to their cattle and consider liver fluke as a serious problem. The reasons cited for non-adoption include reduced intake, additional labour required and urea cost.

### Impact of extension activities

Based on the progress reports the following were achieved through the extension activities during the fifth, sixth and seventh plan period (1982-1997):

- Pasture development: 34,000 acres.
- Fodder trees planted: 735,819 trees.

- Large coverage for paddy straw treatment (>50% of rice-growing households in selected districts.

The impact of these activities can be quantified at different levels: dry matter production, fodder quality, livestock production, socio-economic issues, and environment (Table 11).

**Table 11. Impact of fodder development activities[1].**

| Component of the system | At national level | Selected pockets in temperate regions |
|---|---|---|
| Dry matter production increase | <1 % | 10% |
| Fodder quality increase during summer | 5% | 50% |
| Fodder quality increase during winter | 20% | 200% |
| Milk production increase | 100% | 500% |
| Migration (reduced) | 15% | 60% |

[1] Estimates by the author.

### Impact on dry matter production

On a national level, the impact of fodder development activities on total dry matter production may be negligible. A recent estimate (RNR-RC 1998) puts additional dry matter production at would be about 15,000 t annually, sufficient to feed 1800 animals or about 0.5% of the total population of large ruminants.

### Impact on nutritional quality

The impact of subtropical herbaceous fodder species and tree fodder in general on the nutritional quality of the diet is negligible. In temperate regions, the introduction of white clover, however, has resulted in a substantial increase in fodder quality in the wet and dry season. White clover has spread through the grazing animals over large areas of permanent grazing land. Because of its excellent nutritional qualities (high palatability, high protein content and low crude fibre), small additions of white clover to the native grassland vegetation will substantially increase the quality of the fodder. It is largely through this increased fodder quality that the milk potential of crossbreed animals can be realized (Tables 9 and 10).

### Impact on winter fodder

Tree fodder species are almost exclusively used for winter fodder. Herbaceous fodder species contribute substantially towards improved winter fodder quality and quantity. The traditional winter fodder such as paddy straw, buckwheat straw, native pasture and tree fodder leaves are all of very poor quality. Most of them are insufficient to even maintain the body weight of large ruminants. Small improvements in the quality of winter fodder will have substantial impact on infertility problems, mortality and production over the entire season.

### Impact on animal production

The number of animals (yak and cattle) increased from 165,000 in 1976 (review undated) to 335,000 in 1995 (MOA 1995). We can assume that a 100% increase in livestock number resulted in a 100% increase in feed requirement. The increased requirement was largely covered by traditional fodder resources. Improved feed availability and quality in the dry season has, however, contributed substantially to make this tremendous increase in livestock number possible. The impact of fodder development on animal production is mainly realized in terms of change in seasonal draft availability and increased milk production.

**Impact on migration**

The traditional system of cattle migration to lower elevations during the dry/cold winter period has many disadvantages including spread of livestock diseases, limited production potential of livestock, and limited options for field crop and horticulture production in the lower areas.

Changes in migration are, however, only possible if alternative feed sources for the critical periods can be found. Fodder development activities in the temperate regions have had substantial impact on cattle migration. For Bumthang District, a 19% reduction in migration was already reported for 1983 (RNR-RC 1998).

## References

AHD. 1987. Proceedings of the departmental conference. Thimphu, Bhutan.

AHD. 1987. Urea treatment of straw. AHD Extension Division Leaflet No. 1. Thimphu, Bhutan.

Gyamthso, P. 1996 Assessment of the condition and potential for improvement of high altitude rangeland of Bhutan. Diss. ETH No. 11726, Zurich.

Marakham, C.R. 1876. Narratives of the mission of George Bogle to Tibet and of the journey of Thomas Manning to Lhasa. Reprinted 1971. Manjusri Publishing House, New Delhi.

Ministry of Agriculture. 1995. LUPP Dzongkhag data sheets for Bhutan Land Use Planning Project, Thimphu, Bhutan.

Ministry of Agriculture. 1997. Atlas of Bhutan. Land Use Planning Project, Thimphu, Bhutan.

RNR-RC Jakar. 1996. Annual report, Bhumtang, Bhutan.

RNR-RC Jakar. 1996. RNR-RC Jakar, 1997. Proceedings of the 1st Annual National Feed and Fodder Research Workshop, Bathplathang, Bumthang, Bhutan.

RNR-RC Jakar. 1997. Proceedings of the 2nd Annual National Livestock Research Workshop, Bathplathang, Bumthang, Bhutan.

RNR-RC Jakar. 1997. 8th Five-year plan document (draft). Bumthang, Bhutan.

RNR-RC Jakar. 1998. Feed and fodder resources - Review of research and development activities. Bhumtang, Bhutan.

Roder, W. 1981. Fodder development. Annexure IX. p 26-33 In: Proceedings of the departmental conference. AHD, Thimphu, Bhutan.

Roder, W. 1982. Fodder trees. Report form a study tour to Nepal. RDP, Bhumthang, Bhutan.

Roder, W. 1982. Pasture/fodder development. In: Seminar on pasture/fodder development. AHD/RGOB, Thimphu, Bhutan. p 1-42.

Roder, W. 1983. Fodder growing -- experimental activities under RDP project and Animal Husbandry Department Bumdmg, 1974-1982. Helvetas, Thimphu, Bhutan.

Roder, W. 1984. Controversial tree -- *Robinia pseudoacacia.* Bhutan J. Husb. 7:93-97.

Roder, W. 1989. Master plan for fodder research activities. AHD, Thimphu, Bhutan.

Roder, W. 1996. Experiences in feed and fodder research in Bumthang. In: Proceedings of the 1st Annual National Feed and Fodder Research Workshop Bathplathang, Bumthang. RNR-RC Jakar. p. 17-20.

Roder, W. 1996. White clover a dangerous weed? In: Proceedings of the 1st Annual National Feed and Fodder Research Workshop, RNR-RC Jakar. Bathplathang, Bumthan, Bhutan. p. 53-56.

Roder, W., Thinley, P., Wangdi, K. 1997. Experiences with temperate mixtures – a review. In: Proceedings of the 2nd Annual National Livestock Research Workshop, RNR-RC Jakar, Bathplathang, Bumthang.. p 69-78.

Roder, W., Wangdi, K., Gyamtsho, P. 1997. Introduction of white clover in native grasslands of Bhutan - impact, potential, and problems. In: Proceedings of the 8th International Grassland Congress, Winnipeg and Manitoba, Canada.

Tshering, G., Gyeltshen, T., Penjor, T., Wangdi, R., Roder, W. 1997. Tree fodder in subtropical regions of Bhutan. In Proceedings of the 2nd Annual National Livestock Research Workshop, RNR-RC Jakar, Bathplathang, Bumthang, Bhutan.

Wangdi, K. 1992. Those five years - review of pasture development in eastern Dzongkhags. HLDP/AHD Thimphu, Bhutan.

Wangdi, K. 1996. Experiences of the Highland livestock development project in feed and fodder research. In: Proceedings of the 1st Annual National Feed and Fodder Research Workshop, RNR-RC Jakar. Bathplathang, Bumthang, Bhutan. p. 13-16.

# The use of forages for soil fertility maintenance and erosion control in cassava in Asia

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## Introduction

Cassava (*Manihot esculenta* Crantz) has the reputation to extracts large amounts of nutrients from the soil. However, Howeler (1991) and Putthacharoen et al. (1998) have shown that on an area basis, less nitrogen (N) and phosphorus (P) are removed in the harvested cassava roots than in the harvested products of most other crops, while the amount of potassium (K) removed in the harvested roots is similar to that removed by many other crops. Thus, continuous cassava production on the same land without nutrient inputs is likely to result in depletion of soil K, followed by that of N, and finally P. To maintain soil productivity, nutrients lost from the system should be compensated by application of chemical fertilisers and animal manures, by fallowing of natural vegetation, or by 'improved' fallows using mainly forage legumes as green manures and cover crops, or as hedgerows in alley cropping. In the latter case, the legumes add N to the system through biological N-fixation, and recycle P and K by absorbing these nutrients from the lower soil strata and returning them to the soil surface in leaf litter, in leaf pruning, or plant residues. After cutting, burning, mulching or incorporation of the vegetation, the surface soil tends to be enriched with these nutrients, which enhances the production of crops.

When crops are grown on slopes, heavy rains may cause dislodging and movement down-slope of soil particles resulting in soil erosion. Over time, this will reduce soil depth and a loss of soil productivity due to the loss of organic matter (OM), nutrients and beneficial soil microorganisms, such as *mycorrhiza*. Putthacharoen et al. (1998), Wargiono et al. (1998) and Howeler (1995) have shown that production of cassava tends to result in more erosion than that of other crops, mainly because cassava is planted at a wide spacing and has a slow initial growth, resulting in poor protection of the soil from direct rainfall impact during the first three months of the crop cycle. However, it was found (Howeler 1987 and 1994; Ruppenthal et al. 1997) that erosion can be markedly reduced by soil/crop management practices, such as minimal tillage, mulching, contour ridging, fertilisation, intercropping, closer plant spacing, or the planting of cover crops or contour hedgerows of grasses or leguminous species.

The objective of this paper is to review research conducted in Asia on the use of forage species for improving soil fertility through green manuring, alley cropping and cover cropping, or for reducing erosion by the planting of contour hedgerows in cassava fields. The research summarized in this paper spans a 11-year period, from 1987 to 1998, and was conducted in three locations in Thailand and one location in Indonesia.

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## Materials and methods

The principal climatic and soil conditions at the experimental sites are summarized in Table 1. Most experiments were conducted in Thailand, at Rayong Field Crops Research Centre in Huay Pong, Rayong; at the King's Project site, in Pluak Daeng, Rayong; and at Kasetsart University Research Station in Khaw Hin Sorn, Chasoengsao. These sites have similar climatic and soil conditions, characterized by a year-round hot climate, a 6-month dry season, and sandy clay or sandy clay loam soils with low levels of OM, and intermediate levels of soil nutrients. In Indonesia, the experiment was conducted at Jatikerto Experiment Station in Malang district of East Java. The soil is derived from volcanic ash, has a clay texture, a slightly acid pH, and is low in OM and P, but high in Ca, Mg and K.

The experimental methods used in each experiment are summarized in Table 2, and will be discussed in more detail below together with the results obtained.

**Table 1a. Principal climatic of the experimental sites in Thailand and Indonesia.**

| Experimental sites | Elevation (masl) | Annual rainfall (mm) | Rainy season | Mean air temp. ($^0$C) |
|---|---|---|---|---|
| 1. Rayong Field Crops Research Centre, Rayong Thailand | 20 | 1350 | May-Oct | 28 |
| 2. Pluak Daeng, Rayong, Thailand | | 1200 | May-Oct | 28 |
| 3. Khaw Hin Sorn, KU Exp. Station., Chachoengsao, Thailand | 50 | 1200 | May-Oct | 28 |
| 4. Jatikerto, Brawijaya Univ. Exp. Station, Malang, Indonesia | 400 | 2000 | Oct-May | 27 |

**Table 1b. Principal soil characteristics of the experimental sites in Thailand and Indonesia.**

| | pH | OM % | P ppm | Al | Ca | Mg | K | Al-sat. % | Texture | sand % | silt % | clay % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | ——— | me/100g | | ——— | | | | | |
| 1. Rayong | 5.0 | 1.3 | 8.8 | 0.20 | 1.10 | 0.15 | 0.11 | 13 | sandy clay loam | 63 | 8 | 29 |
| 2. Pluak Daeng | 6.4 | 0.8 | 8.0 | 0 | 1.12 | 0.17 | 0.22 | 0 | sandy clay | 67 | 15 | 18 |
| 3. Khaw Hin Sorn | 6.2 | 1.6 | 7.4 | 0 | 2.13 | 0.34 | 0.22 | 0 | sandy clay | 69 | 14 | 17 |
| 4. Jatikerto | 5.9 | 1.0 | 1.6 | 0.20 | 7.52 | 2.90 | 1.16 | 0 | clay | 25 | 25 | 50 |

**Table 2. Experimental methods used in the experiments.**

| Location | Years | Cassava variety | Planting method | Forage species and methods used |
|---|---|---|---|---|
| Rayong | 1987-1988 | - | evaluation | 32 accessions of leguminous species |
| Pluak Daeng | 1988-1991 | Rayong 1 | green manuring | 10 green manure species |
| Pluak Daeng | 1991-1994 | Rayong 1 | green manuring | 6 green manure species x 2 management practices |
| Rayong | 1994-1998 | Rayong 90 | green manuring | 4 green manure species x 3 management practices |
| Pluak Daeng | 1988-1990 | Rayong 1 | cover cropping | 9 forage legumes |
| Pluak Daeng | 1991-1993 | Rayong 1 | cover cropping | 7 forage legumes x 2 cassava spacings |
| Rayong | 1990-1991 | - | evaluation | 12 accessions of leguminous shrubs |
| Malang | 1991-1995 | Faroka | alley cropping | 2 tree legumes as hedgerows, 1 cover crop, intercrop, grass hedgerows |
| Khaw Hin Sorn | 1996-1998 | KU-50 | hedgerows | 15 grass species |

## Results and discussion

### The use of forages as green manures for soil fertility improvement

*Adaptation of grain and forage legumes to conditions in Rayong, Thailand*

Green manures can be effective only if they are productive and well adapted to the local soil and climatic conditions. To determine their productivity under the conditions in which cassava is grown in Thailand, 32 accessions of grain and forage legumes, including some leguminous tree species, were planted at the Rayong Field Crops Research Centre in Huay Pong, Rayong, Thailand in 1987/88.

Table 3 shows some growth parameters as well as the nutrient uptake of the species.

**Table 3. Growth and nutrient uptake of leguminous species grown at Rayong Field Crops Research Centre, Rayong, Thailand in 1987.**

| | Days to 50% flowering | Seed yield (t/ha) | Stem + leaf weight[1] (t/ha) | | Nutrient content (kg/ha) | | |
|---|---|---|---|---|---|---|---|
| | | | fresh | dry | N | P | K |
| **Grain legumes** | | | | | | | |
| Peanut (Tainan 9) | 32 | 0.48 | 12.8 | 3.50 | 42 | 6 | 73 |
| Mungbean (U-Thong 1) | 32 | 0.24 | 3.5 | 1.00 | 10 | 1 | 13 |
| Cowpea (local variety) | 33 | 1.55 | 8.6 | 1.69 | 47 | 5 | 39 |
| Cowpea (TVX 1193-059) | 36 | 3.78 | 15.7 | 3.09 | 83 | 9 | 69 |
| Soybean (SJ 5) | 32 | 0.44 | 2.6 | 0.94 | 15 | 3 | 14 |
| **Green manures** | | | | | | | |
| *Sesbania aculiata* from IRRI | 60 | 0.60 | 19.3 | 7.09 | 80 | 13 | 71 |
| *Sesbania aculiata* | 67 | 0.85 | 27.5 | 12.31 | 170 | 17 | 113 |
| *Sesbania speciosa* | 127 | 0.52 | 55.6 | 19.37 | 281 | 27 | 213 |
| *Sesbania rostrata* from IRRI | 67 | 0.78 | 16.0 | 6.65 | 89 | 18 | 66 |
| *Sesbania rostrata* | 71 | 1.89 | 19.1 | 7.69 | 81 | 8 | 78 |
| *Indigofera sp.* | 106 | 1.59 | 42.6 | 17.69 | 457 | 32 | 195 |
| *Canavalia ensiformis* | 50 | 1.30 | 22.4 | 3.91 | 113 | 9 | 59 |
| *Mucuna* sp. from CIAT | 131 | 0.30 | 38.4 | 8.16 | 224 | 16 | 135 |
| *Mucuna fospeada* | 122 | 1.82 | 42.2 | 11.31 | 244 | 20 | 119 |
| *Crotalaria juncea* | 67 | 0.00 | 21.1 | 9.50 | 130 | 11 | 86 |
| *Crotalaria spectabilis* (Brazil) | 60 | 0.15 | 28.0 | 8.00 | 134 | 14 | 112 |
| *Crotalaria spectabilis* (Colombia) | 54 | 0.06 | 20.3 | 5.56 | 95 | 13 | 31 |
| *Crotalaria mucronata* 7790 | 60 | 0.38 | 38.6 | 10.84 | 295 | 17 | 157 |
| *Crotalaria mucronata* 9293 | 54 | 0.02 | 21.6 | 6.06 | 120 | 13 | 100 |
| *Lablab purpureus* | 173 | 0.94 | 29.2 | 7.44 | 171 | 19 | 119 |
| Pigeon pea from ICRISAT | 54 | 0.35 | 25.5 | 10.16 | 240 | 23 | 112 |
| Pigeon pea from USA | 184 | 0.25 | 105.9 | 40.34 | 980 | 77 | 867 |
| **Cover crops** | | | | | | | |
| *Macroptilium atropurpureum* | 50 | 0.22 | 43.8 | 11.28 | 235 | 20 | 214 |
| *Mimosa* sp.[2] | 147 | 0.87 | 50.9 | 18.34 | 262 | 29 | 248 |
| *Calopogonium mucunoides* | 149 | 0.06 | 22.1 | 7.37 | 159 | 20 | 103 |
| *Pueraria phaseoloides* | 146 | -[3] | 33.4 | 8.75 | 209 | 21 | 148 |
| *Stylosanthes hamata* | 50 | 1.22 | 29.5 | 10.94 | 237 | 14 | 113 |
| *Centrosema pubescens* | 153 | 0.09 | 13.4 | 3.97 | 101 | 11 | 66 |
| **Alley crop hedgerow species** | | | | | | | |
| *Sesbania javanica* | 114 | 0.14 | 21.0 | 7.91 | 137 | 12 | 85 |

[1] At cutting (5 months); soybean, peanut and mungbean at harvest of each species.
[2] Mimosa sp. (a thornless variant of *M. invisa*).
[3] Drought at flowering caused no pod set.

From the results obtained the most promising species were separated into four groups according to their specific potential usage:

- For green manures: *Sesbania speciosa*, *S. aculeata*, *S. rostrata*, *Crotalaria juncea*, *C. mucronata*, *C. spectabilis*, *Indigofera* sp., *Canavalia ensiformis* (sword bean), *Mucuna fospeada* (velvet bean) and *Cajanas cajan* (pigeon pea).
- For cover crops: *Centrosema pubescens*, *Macroptilium atropurpureum* (siratro), *Mimosa* sp. (a spineless variant of *M. invisa*), *Stylosanthes hamata* and *Indigofera* sp.
- For intercropping: peanut, mungbean, cowpea and soybean.
- For alley cropping: *Sesbania aculeata*, *S. javanica* and perennial pigeon pea.

*Green manuring of cassava with forage legumes in Pluak Daeng, Thailand*

The use of forage legumes as green manures to maintain soil fertility in sandy clay soils was studied by planting 10 green manure species at the beginning of the wet season in Pluak Daeng of Rayong province. After 3-4 months the above-ground parts were cut and incorporated into the soil before planting cassava in the mid to late wet season. Cassava did not receive any fertilisers, except in one of the two treatments without green manure which received 100 kg N and 50 $K_2O$/ha. The crop was harvested after about 8 months at the start of the next wet season. The trial was repeated in a similar fashion in 1989/90 and 1990/91, except that green manures were mulched on the soil surface and cassava was planted without land preparation.

Table 4 shows the productivity of the green manures and their effect on cassava yield during the three years of testing. There was a significant effect of green manure application on cassava yields in the first two years, but the effect was not significant in the last year. *Crotalaria juncea* and *Canavalia ensiformis* were the most productive species, and the most effective in recycling nutrients (Tongglum et al. 1992), while incorporation or mulching of *Crotalaria juncea* usually resulted in the highest cassava yields; these yields were similar to those obtained with chemical fertilisers. Other promising species were *Mucuna fospeada* and *Canavalia ensiformis*. Nevertheless, in the first two years, cassava yields were extremely low because cassava could only be planted late in the rainy season after the green manures had been incorporated or mulched; as such, cassava suffered from drought stress during much of the growth cycle. In the third year, cassava was not harvested until Aug 1991 (11 months), resulting in much higher yields, but no significant response to green manure application.

**Table 4. The effect of green manures on cassava yield in three trials in Pluak Daeng, Thailand.**

| Green manure treatments[1)] | DM green manures (t/ha) | | | Cassava fresh root yield (t/ha) | | |
|---|---|---|---|---|---|---|
| | 1988/89 | 1989/90 | 1990/91 | 1988/89 | 1989/90 | 1990/91 |
| No green manure, no fertiliser | - | - | - | 3.21 cd | 5.75 bcd | 16.36 |
| *Sesbania rostrata*, no fertiliser | 9.71 b | 3.46 b | 9.91 b | 9.29 a | 5.37 bcd | 15.04 |
| *Sesbania speciosa*, no fertiliser | 2.58 ef | 2.15 b | 9.73 b | 5.61 abcd | 4.46 cd | 17.52 |
| *Sesbania aculeata*, no fertiliser | 4.20 de | 2.54 b | 7.58 b | 5.19 bcd | 4.42 cd | 13.23 |
| *Crotalaria juncea*, no fertiliser | 13.46 a | 6.88 a | 24.79 a | 9.04 ab | 8.83 a | 17.29 |
| *Crotalaria mucronata* CIAT 7790, no fertiliser | 6.77 c | 2.86 b | 10.36 b | 6.71 abc | 5.17 bcd | 11.77 |
| *Crotalaria spectabilis*, no fertiliser | 5.49 cd | 2.98 b | 12.75 ab | 5.81 abcd | 3.96 d | 17.64 |
| *Canavalia ensiformis*, no fertiliser | 6.63 c | 6.96 a | 24.79 a | 5.37 bcd | 7.00 abc | 14.67 |
| *Indigo*, no fertiliser | 6.36 c | 3.21 b | 10.94 b | 5.37 bcd | 5.08 bcd | 16.61 |
| *Mucuna fospeada*, no fertiliser | 5.66 cd | 2.70 b | 10.74 b | 5.21 bcd | 6.08 abcd | 16.45 |
| Pigeon pea (ICRISAT), no fertiliser | 2.11 f | 3.46 b | 2.29 b | 2.06 d | 4.50 cd | 14.79 |
| No green manure, with fertilisers[2)] | - | - | - | 8.75 ab | 7.71 ab | 17.04 |
| F-test | ** | ** | ** | ** | * | NS |

[1)] Green manures were planted in May/June, cut in Aug/Sept and cassava planted in Oct, harvested after 8-9 months in the first two years and after 11 months in the third year.

[2)] 100 N, 0 P, 50 kg/ha $K_2O$.

Analyses of soil samples taken before planting and after harvest of cassava indicate that green manures had no significant effect on pH, OM and available P or exchangeable K (CIAT, 1992). In all treatments, soil pH gradually decreased from 6.6 to 5.5, OM decreased slightly from 1.0 to 0.8 %, P was quite variable, while available K decreased from 95 to about 30 ppm during three years of consecutive cropping.

A similar experiment was conducted for three years (1991 to 1994) in an adjacent field in Pluak Daeng using six species of green manures. These were again planted in the early wet season (May/June), cut after about 3 months, and (in subplots) either mulched on the soil surface or incorporated into the soil with a hand tractor. In the mulched subplots cassava was planted without further land preparation. Cassava was planted in the mid to late rainy season (Aug/Sept) and harvested after 9-10 months. For comparison, two additional plots without green manures were planted at the more traditional planting time at the start of the rainy season (May/June); these were also harvested after 9-10 months. At both planting times one of the two check plots without green manures received 100 kg N and 50 $K_2O$ per hectare as fertilisers.

Table 5 shows that planting in the early rainy season resulted in much higher cassava yields than planting towards the end of the rainy season. Application of NK fertilisers increased yields but not significantly. Among the six green manures, *Crotalaria juncea* was consistently the most productive species, while *Sesbania rostrata* was the least productive. *Crotalaria juncea,* either when mulched or incorporated, also produced the highest cassava yields. While these yields were higher than those planted in September with fertilisers, they were not significantly different from yields obtained without fertiliser when cassava was planted in the early wet season, and they were considerably lower than those obtained with fertilisers and planted in May/June. Soil analyses again indicate that incorporation or mulching of green manures had no significant effect on soil fertility parameters. This indicates that nutrients leached from the decomposing green manures were directly absorbed by cassava roots without having a long-term effect on soil fertility.

**Table 5. Effect of cassava planting time, fertilisation and green manuring on green manure production and cassava yields in Pluak Daeng, Thailand (dates are mean values for three cropping cycles, 1991/92, 1992/93 and 1993/94).**

| | Green manure yield – DM (t/ha) | | Cassava fresh root yield (t/ha) | | |
|---|---|---|---|---|---|
| **Green manure treatments** | **incorporated** | **mulched** | **incorporated** | **mulched[1]** | **Mean** |
| No green manure, June planting, no fertiliser | - | - | 11.06 | 9.13 | 10.09 ab |
| No green manure, June planting, with fertiliser[2)] | - | - | 13.69 | 13.17 | 13.43 a |
| No green manure, Sept. planting, no fertiliser | - | - | 5.76 | 4.45 | 5.11 cd |
| No green manure, Sept. planting, with fertiliser[2)] | - | - | 6.49 | 5.57 | 6.03 cd |
| *Sesbania rostrata*, Sept. planting, no fertiliser | 0.84 | 1.11 | 5.25 | 3.63 | 4.44 d |
| *Mucuna fospeada*, Sept. planting, no fertiliser | 3.08 | 3.78 | 7.44 | 9.41 | 8.42 bc |
| *Crotalaria juncea*, Sept. planting, no fertiliser | 6.22 | 6.92 | 9.92 | 10.47 | 10.20 ab |
| *Canavalia ensiformis*, Sept. planting, no fertiliser | 3.27 | 3.64 | 6.83 | 6.94 | 6.88 bcd |
| Cowpea, Sept. planting, no fertiliser | 2.10 | 2.97 | 7.40 | 4.61 | 6.00 cd |
| Pigeon pea, Sept. planting, no fertiliser | 3.10 | 3.57 | 9.31 | 6.17 | 7.74 bcd |
| Mean | 3.10 | 3.66 | 8.32A | 7.36A | |
| F-test for cassava yield: main plots (A) NS; green manure treatments (B) **; AxB NS | | | | | |

[1] cassava planted without land preparation.
[2] 94 N, 0 P, 50 kg/ha $K_2O$.

From these two experiments conducted in Pluak Daeng it was concluded that among the green manures tested, *Crotalaria juncea* was the most productive and the most effective in increasing cassava yields; that incorporation resulted in slightly higher yields than mulching (not statistically significant); and that some green manures were as effective or even more effective than chemical fertilisers in increasing yield. However, under the climatic conditions of Thailand, which has a 6-month dry season, the traditional use of green manures is impractical, since the better part of the rainy season is used for production of green manures, while the following cassava crop produces low yields due to drought stress in the dry season.

*Alternative management of green manure species in Rayong, Thailand*

To overcome some of the above-mentioned constraints alternative management practices were tested in a green manure trial conducted at Rayong Research Centre from 1994 to 1998, using *Crotalaria juncea, Canavalia ensiformis,* pigeon pea and cowpea as the green manures. Three methods of green manure management were tested: a) green manures were intercropped with cassava, pulled out at two months after planting (MAP) and mulched between cassava rows; b) green manures were interplanted into a mature cassava stand at 7 MAP; they were pulled up and mulched at the time of next cassava planting; or 3) green manures were grown as a conventional green manure crop before being pulled up at 3-4 MAP and mulched, after which cassava was planted without further land preparation and left to grow for 18 months. The last method resulted in a two-year crop cycle, while in methods 1 and 2 cassava was harvested at 11 months for a normal one-year crop cycle.

The results, shown in Table 6, indicate that *Crotalaria juncea* usually had the highest dry matter (DM) production, followed by pigeon pea or cowpea. Pigeon pea was particularly productive as a green manure crop when interplanted at 7 MAP, in which case the green manure remained in the field during the dry season. Because of their high DM production, *Crotalaria* and pigeon pea were the most effective in recycling nutrients.

In the first cycle almost all green manure treatments increased cassava yields compared with the check without green manure ($T_1$); however, these yields were still below those obtained with a higher fertilisation rate ($T_2$). In the second cycle, intercropping or interplanting of the green manures had no significant effect on cassava yields, which were again considerably below that obtained with a higher rate of fertilisation ($T_2$). Leaving cassava grow for 18 months after a conventional green manure crop ($T_{11}$-$T_{14}$) resulted in very high yields while having little effect on root starch content. This may be an effective way for farmers to reduce production costs, since land preparation, weeding and harvesting is done only once in two years, while total production from one 2-year cycle was only slightly lower than that of two 1-year cycles.

Again, there were no consistent effects of any of the green manure treatments on soil pH, organic matter (OM), available P or exchangeable K. Thus, while green manuring may have some short-term benefits in terms of crop productivity, the long-term effects on soil fertility are not very clear. Whenever labour is scarce or expensive, such as in Thailand, farmers will probably prefer to maximize their yields through the use of chemical fertilisers instead of green manures.

Nevertheless, Paisarncharoen *et al*. (1990) reported that incorporation of vegetative cowpea (Tita-3) increased significantly the yield of the following cassava crop during five consecutive years in Khon Kaen in Northeast Thailand. Incorporation of *Crotalaria juncea* also increased yields, but not significantly, while pigeon pea had little beneficial effect (Sittibusaya et al. 1995).

**Table 6. Effect of fertiliser application, three alternative green manure practices and four different species on green manure production and nutrient uptake, as well as on the yield of cassava (cv. Rayong 90) grown for two consecutive cropping cycles at Rayong Research Centre in Thailand from 1994 to1998.**

| Treatments[1] | | DM yield green manures (t/ha) | | Nutrient content of green manures (kg/ha) | | | | | | Cassava fresh root yield (t/ha) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | N | | P | | K | | | |
| | | 1st[2)] | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd |
| 1. | Cassava without green manure, with 156 kg/ha 13-13-21 fertiliser | - | - | - | - | - | - | - | - | 17.6 | 30.1 |
| 2. | Cassava without green manure, with 468 kg/ha 13-13-21 fertiliser | - | - | - | - | - | - | - | - | 29.8 | 40.4 |
| 3. | Cassava intercropped with *Crotalaria juncea*, mulched at 2 MAP | 1.9 | 4.7 | 44.7 | 94.9 | 3.0 | 12.7 | 27.6 | 31.1 | 23.8 | 29.2 |
| 4. | Cassava intercropped with *Canavalia ensiformis*, mulched at 2 MAP | 0.9 | 1.8 | 20.1 | 51.7 | 2.4 | 6.6 | 14.6 | 25.9 | 26.9 | 27.8 |
| 5. | Cassava intercropped with pigeon pea, mulched at 2 MAP | 1.1 | 2.1 | 27.0 | 48.7 | 2.2 | 6.7 | 12.5 | 19.0 | 21.4 | 27.0 |
| 6. | Cassava intercropped with cowpea, mulched at 2 MAP | - | 2.8 | - | 53.7 | - | 7.2 | - | 27.1 | 20.3 | 18.8 |
| 7. | Cassava interplanted with *Crotalia juncea* at 7 MAP and mulched | 9.9 | 1.2 | 262.1 | 21.7 | 23.7 | 4.6 | 102.9 | 7.4 | 8.8 | 31.4 |
| 8. | Cassava interplanted with *Canavalia ensiformis* at 7MAP and mulched | 1.5 | 0.7 | 36.6 | 16.0 | 4.1 | 3.1 | 28.0 | 8.2 | 22.8 | 24.2 |
| 9. | Cassava interplanted with pigeon pea at 7 MAP and mulched | 8.9 | 2.3 | 221.7 | 45.5 | 20.0 | 7.3 | 108.8 | 15.9 | 15.9 | 28.8 |
| 10. | Cassava interplanted with cowpea at 7 MAP and mulched | - | 0.7 | - | 14.2 | - | 2.9 | - | 7.6 | 17.3 | 27.0 |
| 11. | *Crotalaria juncea* green manure, mulched, cassava for 18months | 1.4 | 4.4 | 39.9 | 79.9 | 3.6 | 17.7 | 14.7 | 31.6 | 46.2[3)] | 49.0[3)] |
| 12. | *Canavalia ensiformis* green manure, mulched, cassava for 18months | 0.9 | 1.4 | 18.4 | 45.7 | 2.3 | 7.2 | 15.8 | 17.2 | 42.9 | 43.8 |
| 13. | Pigeon pea green manure, mulched, cassava for 18months | 1.1 | 2.7 | 25.6 | 68.7 | 2.3 | 13.2 | 12.8 | 21.7 | 38.8 | 46.0 |
| 14. | Cowpea green manure, mulched, cassava for 18months | - | 2.9 | - | 68.2 | - | 12.6 | - | 31.0 | 38.9 | 46.3 |

1) Fertiliser applied 13-13-21 fertiliser kg/ha. In T3-T14 cassava received 156 kg/ha 13-13-21 fertiliser (like T1). In T3-T6 cassava was intercropped with 1 row of green manure, which was pulled out and mulched at 2 MAP; cassava was harvested at 11 months for a total crop cycle of 12 months. In T7-T10 the green manures were inter-planted in the cassava stand at 7 MAP; they remain after the cassava harvest and were pulled up and mulched at time of next cassava planting; cassava was harvested at 11 months for a total crop cycle of 12 months. In T11-14 the green manures were planted, pulled out and mulched at 3-4 months, after which cassava was planted and remains in the field for 18 months for a total crop cycle of 24 months. In the first cycle, T6, T10 and T14 had *Mucuna pruriens* as the green manure, but this species did not germinate well and was replaced by cowpea in the 2nd cycle.

2) 1st and 2nd refer to the two cropping cycles.

3) High yields in T11-14 is mainly due to a longer (18 months) cropping cycle compared with a normal 1-year (11 months) cropping cycle for the other treatments.

### The use of forages as cover crops to improve fertility and reduce erosion

Erosion losses in cassava fields were found to be high (Puttacharoen et al. 1998) mainly because much of the soil surface remains exposed to the direct impact of raindrops during the first 3-4 months after planting. This problem can be reduced by minimum tillage (Reining, 1992), application of mulch (Evangelio et al. 1995), intercropping (Reining, 1992), or by the use of forage legumes as a cover crop for cassava (Ruppenthal, 1995). These practices can be very effective in controlling erosion (Howeler, 1995) and may also improve soil fertility, but they have negative aspects such as weeding problems, high labour requirements, or competition effects from the cover crops. To determine the potential of several forage legumes for their use as cover crops in cassava, various experiments were conducted in Thailand.

*Cover cropping of cassava with forage legumes in Pluak Daeng, Thailand*

After evaluating a large number of forage species for adaptation to soil and climatic conditions in Rayong, Thailand, some species were identified as potential cover crops for use with cassava (Table 3). Nine leguminous forage species were planted in double rows in between rows of cassava, cv. Rayong 1, spaced at 1.80 x 0.55 m. Cassava received 156 kg/ha of 15-15-15 fertiliser.

All forage species established well, resulting in complete soil cover in 3-4 months after planting, except for *Arachis pintoi* and *Stylosanthes hamata,* which established more slowly. In the first year, cover crops were not cut back, resulting in competition with cassava, both for light and for soil moisture during the dry season. After the first cassava harvest, all cover crops were slashed back and mulched. Plots were subdivided and cassava was replanted at a spacing of 1.10 x 0.90 m in 60-cm wide strips prepared either with hand tractor or by spraying the cover crops with Paraquat. The same methodology was used in the third year. In the second and third year cover crops were regularly slashed back at 20 cm above ground level to reduce competition with cassava.

Nevertheless, Table 7 shows that cassava yields were low and severely affected by competition from the cover crops. Most competitive was *Stylosanthes guianensis,* followed by *Centrosema pubescens. Stylosanthes hamata and Arachis pintoi* were not very competitive during the first year of establishment, but became very competitive in subsequent years. Least competitive was *Centrosema acutifolium*, but this was partly due to less vigorous growth resulting in only partial soil cover.

**Table 7. Effect of intercropping cassava with leguminous cover crops on the yield of cassava, cv. Rayong 1, in three trials in Pluak Daeng, Thailand.**

| | DM cover crops (t/ha) | | Cassava fresh root yield (t/ha)[1)] | | |
|---|---|---|---|---|---|
| **Cover crop treatments** | **1988/89[2)]** | **1990/91[3)]** | **1988/89** | **1989/90** | **1990/91** |
| No cover crop | - | - | 11.68 a | 7.79 a | 19.62 a |
| *Stylosanthes hamata* | 1.74 d | 1.68 ab | 10.27 ab | 3.91 c | 4.45 de |
| *Stylosanthes guianensis* | 9.22 a | 2.19 a | 3.21 d | 6.56 ab | 0.83 e |
| *Arachis pintoi* | 0.87 d | - | 8.46 bc | 6.56 ab | 9.71 cd |
| *Centrosema acutifolium* | 2.17 bcd | 0.93 bc | 7.66 bc | 6.69 ab | 15.33 ab |
| *Centrosema pubescens* | 1.04 d | 1.34 bc | 7.51 bc | 5.60 bc | 6.17 d |
| *Mimosa invisa* | 1.97 cd | 1.36 bc | 7.49 bc | 6.48 ab | 13.33 bc |
| *Desmodium ovalifolium* | 3.81 b | 0.68 c | 7.26 bc | 6.78 ab | 13.46 bc |
| *Macroptilium atropurpureum* | 2.19 bcd | 0.78 c | 6.61 c | 7.70 a | 8.96 cd |
| *Indigofera* sp. | 3.25 bc | 1.27 bc | 3.05 d | 6.36 ab | 8.50 c |
| F-test | ** | ** | ** | * | ** |

1 Cassava received 25 kg N, 25 $P_2O_5$ and 25 $K_2O$/ha; data for 1989 and 1990 refer to those plots with tractor preparation of cassava planting strips.
2 at 10 months after planting.
3 at 3 months; average of mechanical and chemical land preparation treatments.

A similar experiment was conducted in an adjacent field. In main plots two cassava plant spacings were used, i.e. 1.0 x 1.0 m and 1.50 x 0.67 m, both giving a plant population of 10,000 plants/ha. In subplots various forage species were planted in between cassava rows. Cassava received 156 kg/ha of 15-15-15 fertiliser. After the first cassava harvest, the cover crops were slashed back and cassava was replanted in 60-cm wide strips prepared with a hand tractor. In the second year all cover crops were well established and competed strongly with cassava, mainly for soil moisture during cassava establishment. Table 8 shows that there were no significant differences in cassava

yields due to plant spacing, but that nearly all cover crops reduced cassava yields, some more than 50%. Most competitive were *Indigofera* and *Mimosa* sp. which were also among the most productive forage species tested. Less productive and thus less competitive were *Zornia glabra*, *Alysicarpus vaginales* and *Arachis pintoi,* although the latter still caused a marked yield reduction in the second year.

From these two cover crop experiments it can be concluded that cassava is a weak competitor and yields are reduced markedly if the plants have to compete with deep rooted and well established forage legumes used as a cover crop. This competition is particularly strong during cassava plant establishment, especially when this coincides with a period of drought. Thus, cover cropping with most forage legumes would not be practical since it tends to reduce cassava yields and requires considerable additional labour. Ruppenthal (1995) and Ruppenthal et al. (1997) showed that cover crops, once well established, were effective in reducing soil erosion in cassava fields in two locations in Colombia, but that erosion can be controlled more effectively and with less reduction of cassava yield with the use of contour hedgerows of vetiver grass (*Vetiveria zizanioides*).

**Table 8. Dry matter production of various cover crops and their effect on the yield of cassava, cv. Rayong 1, planted at either 1.0x1.0m or at 1.5x0.67m at Pluak Daeng, Thailand. Data are average values for the two plant spacings.**

| | DM cover crops (t/ha) | | Fresh cassava root yield (t/ha) | |
|---|---|---|---|---|
| **Cover crop treatments** | **1991/92** | **1992/93** | **1991/92** | **1992/93** |
| No cover crop | - | - | 18.61 a | 7.14 a |
| *Indigofera* sp. | 6.55 | 3.15 | 8.33 c | 4.19 abc |
| *Zornia latifolia* 9199 | 1.08 | 1.14 | 16.34 ab | 3.94 bc |
| *Zornia glabra* 8283 | 0.47 | 1.68 | 22.23 a | 5.44 ab |
| *Alysicarpus vaginales* | 1.37 | 0.27 | 17.19 ab | 6.70 ab |
| *Mimosa invisa* | 4.61 | 2.96 | 12.71 bc | 2.15 c |
| *Stylosanthes hamata* | 3.21 | 5.23 | 13.61 bc | 2.12 c |
| *Arachis pintoi* | 0.26 | 0.42 | 15.97 b | 2.30 c |
| F-test for cassava spacing (S) | | | NS | NS |
| Cover crops (C) | | | ** | ** |
| S x C | | | NS | * |

### The use of leguminous tree species in alley cropping to improve soil fertility

Growing crops between contour hedgerows of leguminous trees is called alley cropping, and is another alternative to improve soil fertility and reduce erosion. The space between hedgerows can be varied, but is usually around 4-5 meters, so that less than 20% of total land area is occupied by the hedgerows. The hedgerows are pruned before and at regular intervals after planting the crop and the pruning are distributed among crop plants to serve as a mulch, to supply nutrients (especially N), and to control weeds and erosion.

*Adaptation of leguminous shrubs and tree species to conditions in Rayong, Thailand*

Various leguminous shrubs were tested in Rayong, Thailand, to determine their general adaptation, ease of establishment, productivity of leaf/stem biomass, resistance to regular pruning and drought tolerance.

Table 9 shows that several species of *Sesbania* were highly productive in the first year, but did not resist regular pruning. Perennial pigeon pea varieties were easy to establish, were highly productive and drought tolerant, but they will last only a few years. *Leucaena leucocephala, Gliricidia sepium* and *Cassia siamea* were more difficult and slow to establish, but once established they were highly productive, resistant to pruning and very persistent. *Cassia siamea* is a non-N-fixing legume tree and serves mainly to produce biomass as mulch, to recycle nutrients and protect the soil from erosion. This species was also found to be particularly tolerant of acid soils (Howeler et al. 1999). Other species like *Flemingia macrophylla* and *Tephrosia candida* have been used successfully in other countries.

Some farmers in northern Thailand adopt hedgerows consisting of a mixture of fast-growing pigeon pea with a slower growing but more persistent tree species like *Leucaena leucocephala* (Boonchee et al. 1997).

**Table 9. Total dry weight of pruning at three harvests as well as total nutrient content of the pruning of alley crop hedgerow species grown at Rayong Field Crops Research Centre, Rayong, Thailand in 1990/91.**

| Alley crop hedgerow species | Total dry matter (t/ha) Months after planting | | | Total nutrient content[1)] (kg/ha) | | |
|---|---|---|---|---|---|---|
| | 3 | 6 | 13.5 | N | P | K |
| *Leucaena leucocephala* | 0 | 0.6 | 12.0 | - | - | - |
| *Gliricidia sepium* | 0.1 | 0.02 | 0.7 | 20 | 2 | 28 |
| *Cassia siamea* | 0.2 | 1.2 | 25.4 | 526 | 37 | 668 |
| *Sesbania grandiflora* | 1.1 | 0.4 | 0.3 | 49 | 3 | 51 |
| *Sesbania sesban* | 3.0 | 2.5 | 0 | 79 | 8 | 116 |
| *Sesbania aculeata* | 4.8 | 1.3 | 0.4 | 130 | 12 | 126 |
| *Sesbania javanica* | 1.6 | 0.7 | 0.4 | 53 | 4 | 52 |
| *Sesbania rostrata* | 3.7 | 1.2 | 0 | 77 | 5 | 73 |
| Pigeon pea from USA | 2.3 | 3.7 | 15.0 | 388 | 26 | 480 |
| Pigeon pea ICP 8094 | 3.7 | 2.7 | 12.4 | 345 | 23 | 403 |
| Pigeon pea ICP 8860 | 3.6 | 4.6 | 14.6 | 384 | 28 | 527 |
| Pigeon pea ICP 11890 | 4.0 | 3.2 | 21.0 | 517 | 33 | 565 |

[1] Sum of nutrients in leaves and stems from 3 harvests.

*Alley cropping of cassava with leguminous shrubs in Malang, Indonesia*

The use of hedgerows of *Flemingia macrophylla* and *Gliricidia sepium* in cassava fields were investigated for four years in Malang, Indonesia. The experiment had eight treatments without replication. Eroded soil was collected in concrete channels below each plot.

The two hedgerow species were initially difficult to establish and during the first three years they had no beneficial effect on cassava yield or erosion (Wargiono et al. 1998). However, in the fourth year, when cassava in other plots suffered from severe N-deficiency after intercropping with maize, the cassava plants in the alley-cropped treatments were tall and had dark green leaves, indicating that the pruning of the hedgerows had supplied considerable amounts of N. Table 10 indicates that during the fourth year the two alley-cropped treatments produced high cassava yields and had the lowest levels of erosion (by enhancing early canopy cover).

In a previous experiment in the same site, hedgerows of *Leucaena leucocephala* and *Gliricidia sepium* also produced the highest cassava yields and lowest levels of erosion during the fourth year of consecutive planting; these two treatments also resulted in the highest levels of soil organic matter , the lowest bulk density and the highest infiltration rates and soil aggregate stability (Wargiono et al. 1995). Table 10 also shows that cover cropping with *Mimosa* sp. reduced cassava yields only slightly in the first two years, but markedly in the subsequent two years.

**Table 10. Effect of various crop/soil management practices on soil loss due to erosion and on cassava and maize yields during four consecutive cropping cycles on 5% slope in Jatikerto Experiment Station, Malang, Indonesia.**

| Crop/soil management treatments | Dry soil loss (t/ha) | | | | Cassava yield (t/ha) | | | | Maize yield (t/ha) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 91/92 | 92/93 | 93/94 | 94/95 | 91/92 | 92/93 | 93/94 | 94/95 | 91/92 | 92/93 | 93/94 |
| 1. C+M[1)], no fertilisers, no ridges | 58.3 | 49.3 | 55.7 | 8.5 | 16.3 | 15.8 | 5.1 | 6.6 | - | - | 0 |
| 2. C+M, no fertilisers, contour ridges | 43.0 | 36.9 | 36.7 | 2.8 | 25.4 | 23.2 | 5.1 | 13.3 | - | - | 0 |
| 3. C+M, with fertilisers, contour ridges | 39.2 | 24.8 | 28.1 | 3.8 | 20.4 | 20.5 | 17.8 | 16.7 | 1.98 | 2.27 | 2.88 |
| 4. C+M, with fertilisers, contour ridges, elephant grass hedgerows | 36.9 | 19.8 | 20.8 | 2.4 | 18.4 | 17.4 | 11.8 | 19.3 | 1.36 | 1.42 | 1.96 |
| 5. C+M, with fertilisers, contour ridges, *Gliricidia* hedgerows | 43.2 | 22.3 | 20.9 | 2.2 | 16.3 | 18.0 | 16.1 | 20.7 | 1.16 | 1.28 | 2.80 |
| 6. C+M, with fertilisers, contour ridges, *Flemingia* hedgerows | 41.3 | 17.7 | 17.3 | 1.9 | 17.2 | 18.1 | 14.2 | 21.6 | 1.26 | 1.46 | 3.20 |
| 7. C+M, with fertilisers, contour ridges, *Mimosa* cover crop | 38.4 | 18.3 | 24.7 | 2.4 | 17.1 | 18.2 | 12.2 | 9.9 | 1.44 | 1.63 | 3.36 |
| 8. C+M[1)], with fertilisers, contour ridges, peanut intercrop | 36.4 | 21.7 | 26.3 | 4.5 | 23.7 | 23.7 | 19.9 | 25.3 | - | - | 2.10 |

[1] During the first two years there was no intercropped maize in treatments 1, 2 and 8 ; C+M= cassava intercropped with maize.

Thus, once well established, hedgerows of leguminous shrubs used for mulch significantly enhanced soil fertility and improved the soil's physical characteristics. However, in less fertile soils or in areas with a long dry season, hedgerows can severely compete with neighbouring cassava for water and nutrients (Jantawat et al. 1994); they also require additional labour to keep properly pruned to prevent light competition.

### The use of grasses as contour hedgerows to reduce erosion on hillsides

Many researchers (Ruppenthal 1995; Ruppenthal et al. 1997; Vongkasem et al. 1998; Nguyen The Dang et al. 1998; Zhang et al. 1998) have shown that planting contour hedgerows of vetiver grass is a very effective way to reduce erosion when cassava is grown on hillsides. In farmer participatory research (FPR) trials in Vietnam and Thailand, farmers have consistently identified this as the most effective way of controlling erosion (Howeler et al. 1998). Nevertheless, few farmers have actually adopted the technology because vetiver grass can only be propagated vegetatively, planting material is often difficult to obtain, and transport and planting costs are high. Moreover, vetiver grass is not a good animal feed, the stems do not provide fuel wood, and the leaves do not add nitrogen to the soil. To overcome some of these problems, other grasses were evaluated for their ability to form a dense hedgerow that is effective in reducing erosion, without competing excessively with neighbouring cassava or spreading by seed or stolons into adjacent cropland.

*Contour hedgerows of grass species for erosion control in Khaw Hin Sorn, Thailand*

In 1996, cassava cv. Kasetsart 50, was planted along contour lines at a spacing of 1.0 x 1.0 m in plots of 7 x 10 m on a gentle slope (5-6%) in Khaw Hin Sorn. Fifteen grass species were tested as contour hedgerows by planting them between every third cassava row to give three hedgerows per plot. Treatments were not replicated. Eroded soil was trapped in a plastic-covered ditches along the bottom end of each plot. These eroded sediments were collected and weighed to determine soil loss due to erosion. Most grasses were planted vegetatively, but *Brachiaria ruziziensis, B. brizantha, Setaria sphacelata, Paspalum atratum* and *Panicum maximum* were planted from seed. Three

accessions of vetiver grass were also included. Cassava was fertilised with 312 kg/ha of 15-15-15. All grasses established well in the first year. Hedgerows were cut back at a height of 30 cm 2-3 times a year, and the cut leaves were mulched between cassava plants. After 11 months, cassava plants were harvested row by row. The same plots were replanted with cassava in 1997 and 1998, while hedgerows were maintained by regular pruning.

Table 11 shows that in the first and second year cassava in check plots without hedgerows produced 19.6 and 21.5 t/ha of fresh roots, respectively. During the first year of establishment, some plots with grass hedgerows, i.e. *Paspalum atratum* and *Setaria sphacelata,* produced higher cassava yields than the check plot, but most other grasses, notably Napier (*Pennisetum purpureum*), *Brachiaria ruziziensis* and *Panicum maximum CIAT* 6299, competed strongly with neighbouring cassava plants, resulting in a marked reduction in yield.

**Table 11. Effect of contour hedgerows of various grass species planted between every third cassava row on cassava root yield and soil erosion when grown on 5% slope in Khaw Hin Sorn, Thailand in 1996/97 and 1997/98.**

| Hedgerow treatments | Cassava fresh root yield (t/ha) | | Dry soil loss (t/ha) | |
|---|---|---|---|---|
| | 1996/97 | 1997/98 | 1996/97 | 1997/98 |
| Control without hedgerows | 19.6 | 21.5 | 3.6 | 3.7 |
| Vetiver grass 'Nakorn Sawan' | 15.7 | 6.8 | 3.3 | 2.9 |
| Vetiver grass 'Sri Lanka' | 16.9 | 8.2 | 4.3 | 1.6 |
| Vetiver grass 'Songkhla 3' | 19.6 | 6.5 | 4.0 | 3.4 |
| Lemon grass | 12.9 | 12.1 | 4.2 | 2.1 |
| Citronella grass | 13.7 | 8.8 | 2.7 | 2.0 |
| *Panicum maximum* TD 58 | 13.3 | 7.1 | 9.0 | 14.8 |
| *Panicum maximum* CIAT 6299 | 9.6 | 5.5 | 3.4 | 2.2 |
| *Paspalum atratum* BRA 9610 | 33.0 | 14.8 | 3.1 | 2.1 |
| *Setaria sphacelata* | 22.1 | 7.8 | 3.4 | 3.1 |
| *Brachiaria brizantha* | 16.4 | 7.5 | 2.0 | 1.7 |
| *Brachiaria ruziziensis* | 9.0 | 5.9 | 2.0 | 2.1 |
| Dwarf napier grass | 5.1 | 4.6 | 2.9 | 1.7 |
| Normal napier grass | 2.4 | 0.2 | 5.2 | 1.8 |
| King grass | 10.7 | 1.4 | 7.7 | 3.8 |
| Sugarcane (for chewing) | 12.5 | 5.8 | 2.5 | 1.5 |

In the second year, cassava encountered drought during the establishment phase and suffered from strong competition for water from the neighbouring grass hedgerows of all species. Figure 1 shows that napier grass and King grass *Pennisetum* were particularly competitive, reducing cassava yields dramatically, not only in the neighbouring rows but also in the centre row, 1.5 meter away from the grass. Most other grasses affected the yield of cassava mainly in the neighbouring rows but not in the centre row. *Paspalum atratum* was again least competitive, followed by lemon grass (*Cymbopogon citratus*) and citronella grass (*Cymbopogon nardus* Rendle); the vetiver grasses were intermediately competitive. Soil erosion losses were relatively low and differences among the plots are probably not related to treatments.

During the third year, 1998/99, it was observed that all grasses seriously competed with cassava in neighbouring rows except for lemon and citronella grass and the vetiver grasses; the latter have a vertical root system that does not overlap with the rooting zone of cassava (Tscherning et al. 1995). *Paspalum atratum*, which did not compete much in

the first two years, tended to expand somewhat laterally, causing more competition for light in the neighbouring cassava rows. Thus, while *Paspalum atratum* seems like an attractive option, as the grass makes an excellent animal feed and can be grown from seed as well as from vegetative planting material, in those areas where animal feed is not important to farmers, the best alternatives probably remain vetiver grass and lemon grass. The latter is an important ingredient in Thai cooking and thus has market value for the farmer.

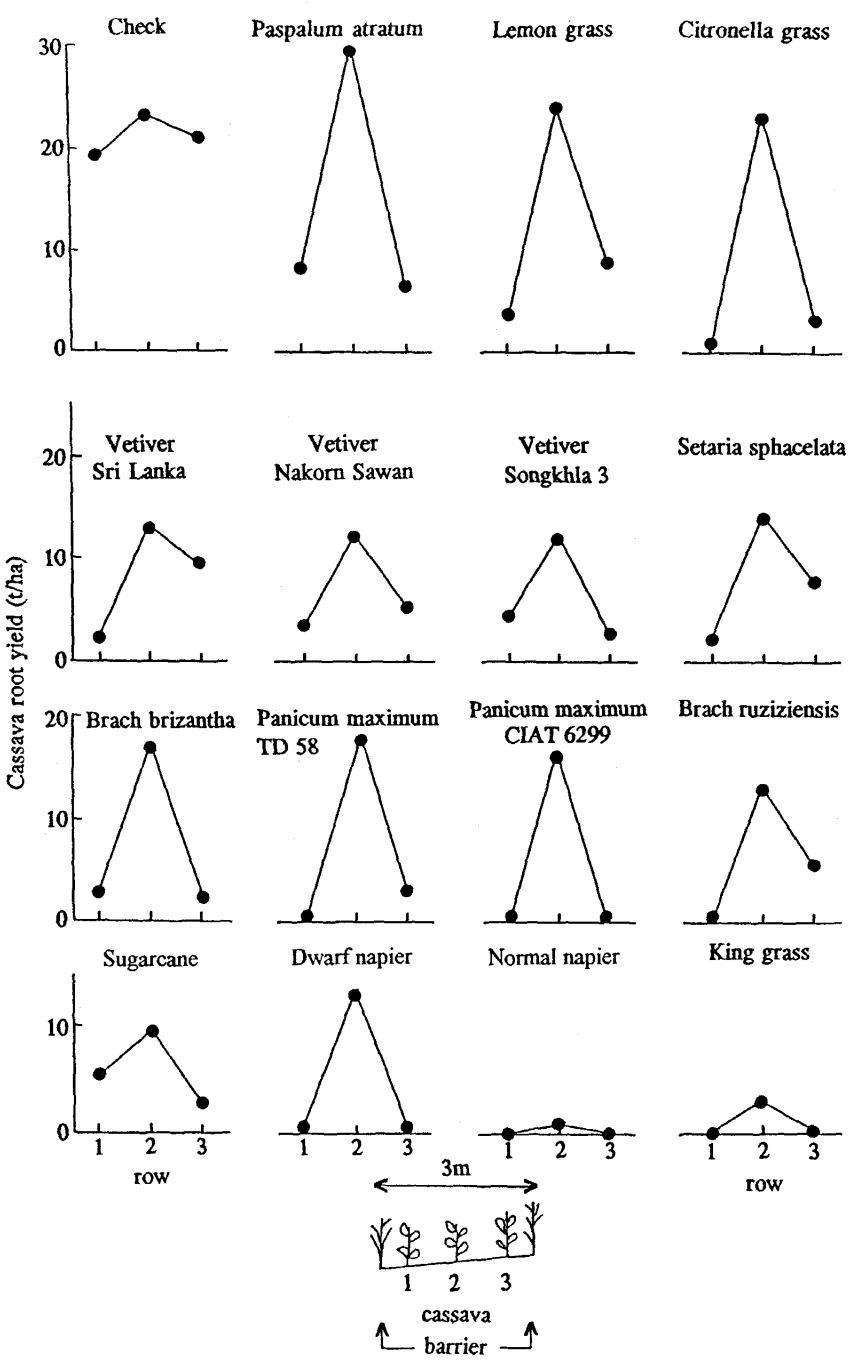


**Fig. 1. The effect of different grass species used as contour barriers on the fresh root yield of cassava, cv. KU 50, grown in three rows between barriers in Khaw Hin Sorn, Chachoengsao, Thailand in 1997/98.**

## Summary and conclusions

Results from the experiments described above can be summarized as follows:

Intercropping and cover cropping – Cassava is a weak competitor and yields were seriously reduced when the crop had to compete with intercropped species, especially vigorously growing perennial species, like *Stylosanthes guianensis, S. hamata, Centrosema pubescens, Indigofera hursita, Mimosa* sp. and *Pueraria phaseoloides* or long-duration annuals like *Mucuna* sp. (velvet bean) pigeon pea or cowpea. However, intercropping with short-duration grain legumes, such as peanut, mungbean, soybean and erect types of cowpea, usually has little effect on cassava yield and provide farmers with additional income (Nguyen Huu Hy et al. 1995), protect the soil from erosion (Tongglum et al. 1992) and may improve fertility if crop residues are incorporated. Intercropping with peanut is commonly practiced in Vietnam, China and Indonesia, while intercropping with soybean or peanut is common on the calcareous soils of southern Java of Indonesia.

Green manuring – Growing a green manure crop before cassava and either incorporating or mulching of the crop residues before planting cassava generally improved soil fertility and increased cassava yields, especially in sandy and low fertility soils. In areas with intermediate soil pH, the most productive species were pigeon pea, *Indigofera hirsuta* and *Sesbania speciosa.* In soils of higher pH in Pluak Daeng, *Crotalaria juncea* was consistently the most productive and most effective specie in increasing cassava yields, followed by velvet bean and *Canavalia ensiformis.* However, in areas with only one relatively short wet season, green manuring may not be practical since the green manure is grown during much of the wet season, resulting in low cassava yields due to drought stress in the following dry season.

Alley cropping – Cassava is grown in strips (alleys) between single or double rows of perennial tree legumes; the legumes are cut back regularly and the leaves are mulched between cassava plants. *Cassia siamea* was found to be very productive, but there is little experience with the use of this species in alley cropping. In high pH soil in Indonesia alley cropping with *Leucaena leucocephala, Gliricidia sepium* and *Flemingia macrophylla* was found to be effective in increasing cassava yields and reducing erosion.

Grass hedgerows – These are planted along the contour in hilly areas, usually at 1-2 m vertical distance to reduce runoff and trap eroded sediments. The most effective species so far identified are vetiver grass, lemon grass, citronella and *Paspalum atratum.* The latter has the advantage of being a useful animal feed, while it can be propagated either from seed or from vegetative material, thus reducing the cost of establishment. Napier grass is commonly used as a hedgerow along contours or plot borders in Indonesia (Wargiono et al. 1995; 1998), where it does not seem nearly as vigorous and competitive as in Thailand (Jantawat et al. 1994), either due to more frequent cutting or because of a different ecotype used.

It may be concluded that forage legumes can play a role in improving soil fertility in cassava, mainly when used as a green manure before planting cassava or as a hedgerow (alley crop) between cassava, but whether or not it is practical depends on the rainfall distribution, availability of land and labour, as well as the cost and availability of alternative nutrient sources, like animal manures and chemical fertilisers.

Cover cropping with perennial forage legumes in cassava does not seem practical, as the legumes compete too strongly with cassava, especially for soil moisture during the early cassava establishment phase.

Alley cropping with hedgerows of leguminous tree species seem to increase cassava yields once the hedges are well established, but may decrease yields in the short-term by occupying a considerable portion of the land.

Contour hedgerows of grasses, such as vetiver and lemon grass, or *Paspalum atratum*, have been shown to be very effective in controlling erosion while not competing too strongly with neighbouring cassava plants. If the grass has some additional value, either through direct sale (lemon grass) or as animal feed, this will be an attractive option for farmers.

Thus, while forage species can play an important role in maintaining soil fertility and reducing erosion, the use of all these species has both advantages and disadvantages. Ultimately, farmers themselves have to decide whether any of these are useful under their particular conditions.

## References

Boonchee, S., Inthaphan, P. and Ut Pong, N. 1997. Management of sloping lands for sustainable agriculture in Thailand (the Chiang Mai site). In: A. Sajjapongse (Ed.). The Management of Sloping Lands in Asia (IBSRAM/ASIALAND). Network Doc. 22, IBSRAM, Bangkok, Thailand. pp. 195-210.

Centro Internacional de Agricultura Tropical (CIAT). 1992. Cassava Program. 1987-1991. Working Document No. 116. CIAT, Cali, Colombia.

Evangelio, F.A., Villamayor Jr., F.G., Dingal, A.G., Ladera, J.C., Medellin, A.C., Miranda, J. and Sajise Jr., G.E. 1995. Recent progress in cassava agronomy research in the Philippines. In: R.H. Howeler (Ed.). Cassava Breeding, Agronomy Research and Technology Transfer in Asia. Proc. 4th Regional Workshop, held in Trivandrum, Kerala, India. Nov 2-6, 1993. pp. 290-305.

Howeler, R.H. 1987. Soil conservation practices in cassava-based cropping systems. *In*: T.H. Thay, A.M. Mokhtaruddin and A.B. Zahari (Eds.). Proc. Intern. Conf. Steepland Agric. in Humid Tropics, held in Kuala Lumpur, Malaysia. Aug 16-21, 1987. pp. 490-517.

Howeler, R.H. 1991. Long-term effect of cassava cultivation on soil productivity. Field Crops Research 26: 1-18.

Howeler, R.H. 1994. Integrated soil and crop management to prevent environmental degradation in cassava-based cropping systems in Asia. *In*: J.W.T. Bottema and D. R. Stoltz (Eds.). Upland Agriculture in Asia. Proc. Workshop held in Bogor, Indonesia. April 6-8, 1993. pp.195-224.

Howeler, R.H. 1995. Agronomy research in the Asian Cassava Network-Towards better production without soil degradation. *In*: R.H. Howeler (Ed.). Cassava Breeding, Agronomy Research and Technology Transfer in Asia. Proc. 4th Regional Workshop, held in Trivandrum, Kerala, India. Nov 2-6, 1993. pp.368-409.

Howeler, R.H, Nguyen The Dang and Vongkasem, W. 1998. Farmer participatory selection of vetiver grass as the most effective way to control erosion in cassava-based cropping systems in Vietnam and Thailand. *In*: Proc. International Conference on Vetiver, held in Chiang Rai, Thailand. Feb 4-8, 1996. pp. 259-272.

Howeler, R.H., El-Sharkawy, M.A. and Cadavid, L.F. 1999. The potential use of grain and forage legumes for soil fertility maintenance and erosion control in cassava in Colombia. (in preparation)

Jantawat, S., Tongglum, A., Puthacharoen, S., Poolsanguan, P. and Howeler, R.H. 1994. Conservation practices for sustainable production of cassava on sloping land. *In:* Sustaining environmental Quality: The Erosion Control Challenge. Proc. 25th Conference, held Feb 15-18, 1994, Reno, Nevada, USA. pp. 521-526.

Nguyen Huu Hy, Tran Dai Nghia and Pham Van Bien. 1995. Recent progress in cassava agronomy research in Vietnam. *In:* R.H. Howeler (Ed.). Cassava Breeding,

Agronomy Research and Technology Transfer in Asia. Proc. 4th Regional Workshop, held in Trivandrum, Kerala, India. Nov 2-6, 1993. pp. 237-252.

Nguyen The Dang, Tran Ngoc Ngoan, Le Sy Loi, Dinh Ngoc Lan and Thai Phien. 1998. Farmer participatory research in cassava soil management and varietal dissemination in Vietnam. *In*: R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Farmer Participatory Research in Asia. Proc. 5th Regional Workshop, held in Danzhou, Hainan, China. Nov 3-8, 1996. pp. 454-470.

Paisarncharoen, K., Wibunsuk, N., Bunyong, B., Wongwiwathanachay, C., Naakwirot, C., Suwan, S., Sittibusaya, C., Kesawatphitak P. and Soomnat, P. 1990. Influence of green manures and chemical fertilisers on yield of Rayong 3 cassava cultivar. *In:* Annual Report 1990. Field Crops Soil and Fertiliser Group, Soil Science Division, Dept. of Agric., Bangkok, Thailand. pp. 296-312. (in Thai)

Putthacharoen, S., Howeler, R.H., Jantawat, S. and Vichukit, V. 1998. Nutrient uptake and soil erosion losses in cassava and six other crops in a Psamment in eastern Thailand. Field Crops Research 57:113-126.

Reining, L. 1992. Erosion in Andean Hillside Farming. Hohenheim Tropical Agric. Series #1. Hohenheim Univ., Germany. 219 p.

Ruppenthal, M. 1995. Soil Conservation in Andean Cropping Systems. Hohenheim Tropical Agric. Series #3. Hohenheim Univ., Germany. 110 p.

Ruppenthal, M., Leihner, D.E., Steinmuller, N. and EL-Sharkawy, M.A. 1997. Losses of organic matter and nutrients by water erosion in cassava-based cropping systems. Experimental Agriculture. 33:487-498

Sittibusaya, C., Thiraporn, C., Tongglum, A., Cenpukdee, U., Vichukit, V., Jantawat, S. and Howeler, R.H.. 1995. Recent progress in cassava agronomy research in Thailand. *In*: R.H. Howeler (Ed.). Cassava Breeding, Agronomy Research and Technology Transfer in Asia. Proc. 4th Regional Workshop, held in Trivandrum, Kerala, India. Nov 2-6, 1993. pp. 110-123.

Tongglum, A., Vichukit, N., Jantawat, S., Sittibusaya, C., Tiraporn, C., Sinthuprama, S. and Howeler, R.H.. 1992. *In*: R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Utilization Research in Asia. Proc. 3rd Regional Workshop, held in Malang, Indonesia. Oct 22-27, 1990. pp. 199-223.

Tscherning, T., Leihner, D.E., Hilger, T.H., Mueller-Saemann K.M., and El-Sharkawy M.A. 1995. Grass barriers in cassava hillside cultivation: rooting patterns and growth dynamics. Field Crops Research 43: 131-140.

Vongkasem, V., Klakhaeng, K., Hemvijit, S., Tongglum, A., Katong, S. and Suparhan, D. 1998. Farmer participatory research in soil management and varietal selection in Thailand. *In*: R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Farmer Participatory Research in Asia. Proc. 5th Regional Workshop, held in Danzhou, Hainan, China. Nov 3-8, 1996. pp. 412-437.

Wargiono, J., Guritno, B., Sugito Y. and Widodo, Y. 1995. Recent progress in cassava agronomy research in Indonesia. *In*: R.H. Howeler (Ed.). Cassava Breeding, Agronomy Research and Technology Transfer in Asia. Proc. 4th Regional Workshop, held in Trivandrum, Kerala, India. Nov 2-6, 1993. pp. 147-174.

Wargiono, J., Kushartoyo, Suyamto H. and Guritno, B.. 1998. Recent progress in cassava agronomy research in Indonesia. *In*: R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Farmer Participatory Research in Asia. Proc. 5th Regional Workshop, held in Danzhou, Hainan, China. Nov 3-8, 1996. pp. 307-330.

Zhang Weite, Lin Xiong, Li Kaimian and Hung Jie. 1998. Farmer participatory research in cassava soil management and varietal dissemination in China. *In*: R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Farmer Participatory Research in Asia. Proc. 5th Regional Workshop, held in Danzhou, Hainan, China. Nov 3-8, 1996. pp. 389-411.

# Discussion papers on networking and impact assessment

# Sustaining a research and development network: Experiences with SEAFRAD

**Wong Choi Chee[1] and Peter Horne[2]**

The South East Asia Forage and Feed Resources Research and Development Network (SEAFRAD) is an informal network of scientists, researchers, extensionists, and producers who share a common interest in improving the productivity and utility of tropical forages. The general objective of SEAFRAD is to provide a structure to enhance collaboration and communication between scientific and extension groups working on research, development, and promotion of tropical forages for the benefit of the rural communities around this region. With this set-up, it is hoped that SEAFRAD will be able to stimulate research programs and facilitate cooperation among groups and individuals.

The SEAFRAD Network was established with the following specific objective to:

- Facilitate communication and networking within and between countries.
- Make new forage germplasm and forage component technology available.
- Develop collaborative research and development activities with national scientists in the tropics.
- Produce and distribute a regional newsletter with assistance from national coordinators.
- Hold annual regional meetings.
- Conduct training in forage technology and technology transfer.

SEAFRAD activities began in 1995, are carried out jointly with Commonwealth Scientific and Industrial Research Organization (CSIRO) Division of Tropical Crops and Pastures. Funding was provided by the Australian Government under a special project – the Forages for Smallholders Project (FSP) which commenced in January 1995. SEAFRAD collaborates with the FAO Regional Working Group on Grazing and Feed Resources. Linkages established with many government and non-government organizations in the region (e.g. the LAO-IRRI Project, Lao-Swedish Forestry Project, ACIAR Leucaena Project, FAO Regional Working Group on Feed Resources, FAO Locally Available Feed Resources Project) have been continued or expanded.

## Achievements

In the context of the abovementioned objectives, tremendous achievements have been attained by SEAFRAD under the umbrella of FSP. Many of the activities were carried out with the help of core CIAT representatives assigned in the region and who spent considerable amount of time on network activities. What will happen if FSP no longer exists? Can SEAFRAD sustain itself without financial backing and leadership? In this scenario, SEAFRAD should take on a more responsible international image, with wider membership covering all regions of the humid tropics. External funding is needed to enable member countries to participate. Member countries should look into the future and assist each other on such matters. CIAT's involvement in the network is crucial in providing financial assistance, genetic material, and tropical forage technologies.

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## SEAFRAD newsletter

The SEAFRAD Newsletter was put up to serve as a medium for exchanging results. Production is done on a rotation basis. Each member country takes charge of producing and distributing the newsletter. There are two issues per year. The Philippines produced the first issue and the succeeding issues were published by Lao PDR, then Malaysia, and Indonesia.

The main problem encountered in the production and distribution of the newsletter is not so much the technical difficulties or workload. The responses of member countries reflected some degree of indifference to the newsletter. For coordinators it is an extra task which adds to their already high workload. The responsibility of reporting their R & D activities is relegated to the background. In spite of e-mail facilities provided to ensure greater participation, results have been disappointing. To sustain the SEAFRAD newsletter, some remedial measures need to be taken.

Making national coordinators in charge of the newsletter is not a good idea. Many of them hold important positions and are already busy with official matters. They have very little time for the newsletter. To solve this problem, coordinators must be carefully selected. Each member country should nominate its own representative who is dynamic and proactive. Besides, consideration should be given to language proficiency of the staff. In this way, we can ensure more active participation from members within each country.

This brings to the fore the question about the purpose of the newsletter. Has the newsletter served its objective? Judging from the renewal forms received, it appears that there is a lot of interest even among people outside the FSP project. There is a demand for it, but on a limited scale. Because it is in English, distribution in Asian countries is not as wide as when it would be in the local languages. The newsletter may have outlived its usefulness. Each country should now develop its own mode of information dissemination. Meanwhile the network should aim to have annual meetings where member countries can share and exchange knowledge and experiences.

# Assessing the impact of forages at the farm level

**Peter Kerridge[1] and Sam Fujisaka[2]**

Farmer participatory evaluation of forages in the FSP is usually taking place where farmers have expressed a need for improving feed supply for livestock and expressed an interest in evaluating new forage technologies. At some sites, other farmers have joined in the evaluation. There is now a need to move beyond evaluation and determine the impact of new forage technologies on various aspects of farmers' livelihoods.

The FSP on-farm sites represent different farming systems ranging from agroforestry, upland, plantation, and grasslands to lowland. Different forage varieties and uses for grasses and legumes are being tested at each site. There is considerable diversity in systems, in the particular, the needs of individual farmers and the potential uses for improved forages. Can we take this into account and still assess impact at the farm level?

We are currently using a three-step framework in evaluating forages in the FSP:

*Step 1. Identification of potential sites using PRA*

Method: We use secondary information such as data on livestock numbers and livestock production, look at maps, and make own observations. This includes discussions with our collaborators, the provincial and district officers as to how they perceive a need. Potential sites are visited and we may interview some farmers or groups of farmers.

Output: The output of this PRA is a brief description of climate, soils, landscape and land use, a description of the farming system and an assessment as to whether the site has a need and is suitable as an FPR site for evaluation of forages. That is, there needs to be a clear indication that there is a real problem that can be solved with new forage technologies, there are farmers trying to solve the problems and local partners able to support work in the area.

*Step 2. Diagnosis of problems and possible solutions using PD*

Method: Participatory diagnosis.

Outputs: The outputs are:

1. Detailed description of the farming system.
2. Problem diagnosis with farmers individually and as a group.
3. Understanding of the causes of problems.
4. Suggestions of possible solutions.
5. Decision to work together (or not).
6. Commitment by farmers and the project.

*Step 3. Planning and working with farmers*

Method: Participatory planning with farmers.

Output: Agreement on activities and commencement of work.

We are suggesting that there should be another step in which there would be an assessment of the impact of forage technologies. This might be done by some form of participatory evaluation, surveys, interviews with individual farmers and some data collection. The outputs would be knowledge of the impact of forage technologies on livelihoods (such increased income, less drudgery in looking after animals and more

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efficient use of labour. We would also hope that there might be some positive impact of benefits on maintaining natural resources.

## How can we measure impact?

Preferably we would interview individuals or groups of farmers and make our assessment against baseline information using a common set of indicators chosen with farmers and district officers.

Which group of farmers do we choose for studying impact? We have four groups of farmers in the communities in which we work:

1. Participating farmers who adopt new forages.
2. Participating farmers who do not adopt forages
3. Non-participating farmers who adopt forages.
4. Non-participating farmers who do not adopt forages.

Let us take a theoretical example: There are 300 families in the village, 40 families have participated in evaluating forages with us and 30 of them are still enthusiastic and are our friends. Surely we can get the story of impact of new forages from them. However, the real impact of the new technology needs to be assessed against the situation that existed before the technology was introduced. Also, it is important for us to know why some farmers adopted and why others did not and what attracted non-participating farmers to adopt and why others outside the participating group chose not to do so. A survey for impact needs to include both adopters and non-adopters and those who spontaneously chose to adopt or to reject the technology.

How are we going to objectively assess the impact, including the rate of adoption and the magnitude of the impact? It is 1998, and the project has been running 3 years; there have been changes in staff and memories are short. It is obvious that it would help to know what was the situation when the project commenced. Hence we need to have baseline data or a baseline characterisation. And as we need to interview or assess the four groups of farmers we need baseline information of all four groups. When we started we did not know who would participate and who would adopt. Thus the baseline data needs to be collected once a suitable site has been selected and we are conducting the first participatory diagnosis.

## Suggested new procedure

Step 1. Identification of potential sites using PRA.
Step 2. Diagnosis of problems and possible solutions using PD.
Step 3. Collect baseline data at villages or sites where we are conducting PD.
Step 4. Evaluation of possible solutions and monitoring.
Step 5. Follow-up assessment on impact of new forage technologies.

What data do we collect for baseline characterisation? This sets us a problem. It takes time to collect data. Is it all going to be useful? Also, why wait until the end of the project to make an assessment of impact.

It would help us and the farmers to identify indicators of impact which can be used to monitor the development of new technologies. Farmers innately know or can sense if something is likely to be successful or not. It is more difficult for us to do so. Hence, we need specific data or indicators that will provide us information on the direction of impact; and we need to be selective. When we conduct the initial PRA and then the PD we obtain a good idea of problems facing the farmers.

For example, lack of forage to feed animals, the time it takes to collect feed for their animals, money available for purchasing household essentials, equity of income sharing

between family members, low yields low due to declining soil fertility. This gives us some idea of choosing a restricted set of data that can be used as indicators in monitoring progress and assessing impact. Table 1 shows indicators which Tatang Ibrahim suggested for the FSP site Pulau Gambar where the project is working with women to improve feed supply for sheep.

**Table 1. Suggested indicators for Pulau Gambar.**

| Criteria | Indicators |
|---|---|
| Less time for feeding sheep | Hours of labour required |
| More rapid weight gain | kg of liveweight gain over time |
| Lower lamb mortality | Lambing percentage |
| Larger herd size | Number of sheep |
| Higher income | Monthly cash income |

What are other examples of useful indicators to verify the output of an activity?

- Number of cuttings distributed ⩾ ha of sown grass.
- Number of vials of semen distributed ⩾ number of calves produced.
- Number of cows distributed ⩾ litres of milk produced.
- Number of packets of seed distributed ⩾ did these grow?

It is obvious that the second set of indicators is more meaningful than the first.

## Some indicators that might be appropriate for the FSP

Forage adoption:

- Area of new forage grown.
- Productivity of forages.
- Contribution of forage towards total feed requirements.

Animal productivity:

- Live weight gain of small ruminants sheep and goats (girth of cattle).
- Indirect measurements of productivity of large ruminants, e.g. sale price, body condition, hours can work as a draft animal.
- Reproductive performance (calving interval, litter size).
- Off-spring (mortality and growth).
- Animal health (evidence of internal parasites).

Labour productivity:

- Time spent cutting naturally occurring forages along roads vs. cutting improved forages.
- Time spent herding cattle for grazing vs. time spent in tethering.
- Time spent in land preparation following legume fallow vs. natural fallow.
- Time spent weeding crops following legume fallow vs. natural fallow.

For impacts additional to those directly associated with livestock production:

- Amount and quality of manure used for crop production.
- Crop yield following forage or legume phase.
- Earthworm activity (due to changes in soil structure and soil fertility).
- Weediness.
- Change in land use, e.g. area of land terraced with erosion barriers or proportion of farm using some form of forage integration.

Livelihood changes:

- Changes in assets.
- Income through sale of animals, forage, planting materials.
- Value of manure through sales or used for crop/forage production.

- More leisure time or less hours spent in unpleasant tasks.

It is likely that only a restricted set of the above would be used for each locality.

## In summary

1. Conduct PRA, site selection, initial participatory diagnosis and the initial selection of possible problem-solving alternatives. Target communities or sites and problems should be tentatively identified at this stage.
2. Conduct Participatory Diagnosis to define problems and potential technology solutions.
3. Conduct a baseline survey of individual families / groups which focuses on current land use, labour allocation, assets, a measure of productivity output plus disposable income. Remember, the baseline survey is to provide a basis for comparison before and after adoption of forages technologies. Hence, it will be useful to develop specific sets of measurable indicators for each site which relate to the outputs we are trying to achieve. Choose indicators that can be monitored periodically throughout the project. Where there is expertise available, the baseline data can contribute to a reasonable ex-ante analysis of potential problem-solving alternatives.
4. Participatory Technology Development, accompanied by monitoring of impact using indicators selected.
5. Ex-post impact study at the project level. Benefits can be calculated; and characteristics of adopters vs. non-adopters identified.
6. Recommendations that can be used for policy decisions.

At this stage projects will usually not have influenced change over large areas. However, analysis of benefits and costs, farmers' assessments, and knowledge about who does and does not adopt can lead to recommendations and actions to facilitate adoption over the larger target area. In a sense, sound ex-post impact analysis at the project level will serve as an ex-ante impact analysis for national or regional efforts to facilitate widespread change.

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