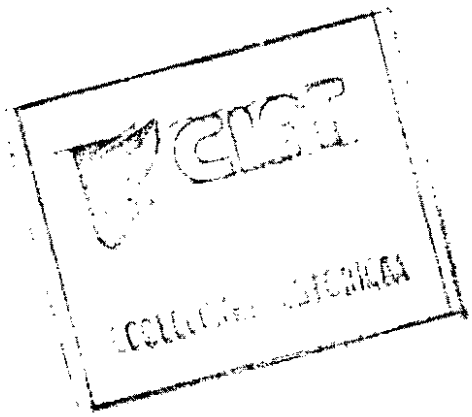
Working Document No. 81

Pasture Research in Southeast Asia:
Current Status, Problems, and Resources Available

CIAT Centro Internacional de Agricultura Tropical



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PREFACE

Per capita income in southeast Asia is increasing at an annual rate of 1.5%-2.5%-2.5%, and this growth in income has stimulated demand for milk and beef. However, the animal population in much of the region is relatively low, with the ratio of cattle to humans being about one-fourth that of tropical America, and large deficits already exist. Therefore, to satisfy growing demands for milk and beef, production will have to be intensified.

In addition, large areas of tropical forest with low-fertility acid soils in the Philippines, Thailand, southern China, Sri Lanka, and Malaysia have been disturbed by migratory crops, and this has favored the presence of *Imperata cylindrica*, a highly invading grass with low forage value. In order to improve these areas, grasses and both herbaceous and tree legumes adapted to the biophysical constraints of the region will have to be quickly identified and evaluated, and management practices relevant to extant and new farming systems should be developed.

In May 1989, national institutions of Southeast Asia, in association with the Centro Internacional de Agricultura Tropical (CIAT) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO), created the Southeast Asian Forages Research and Development Network (SEAFRAD) (see Appendix) to undertake a large cooperative research effort in the region.

The Network's principal objectives are: (1) to introduce and evaluate tropical forage germplasm; (2) to develop and implement relevant research methodologies and common protocols for pasture evaluation; and (3) to promote the training of pasture researchers in these techniques as well as foster the interchange of technical information.

This document is the product of a working consultation meeting sponsored by CIAT and the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD) and held 11-12 May 1989 at Los Baños, Laguna, Philippines, at the time of the first SEAFRAD meeting. It summarizes the status of research, problems, and resources available for pasture research in Malaysia, Thailand, the Philippines, China, and Sri Lanka.

SITUATION AND OUTLOOK OF FORAGE RESEARCH AND PRODUCTION IN PENINSULAR MALAYSIA

C. P. Chen and Z. Ahmad Tajuddin*

Introduction

Forage is still featured as the most prominent ruminant feed in Malaysia, despite the existence of more than five million metric tons of agro-byproducts. Sizable quantities of these byproducts are utilized as nonruminant feed while the remainder, which comprise mainly fibrous byproducts, are not fully exploited commercially. Palm kernel cake (PKC) is the only fibrous agro-byproduct that has been commercially exploited. In fact, 95% of the PKC is being exported to EEC countries. Except for PKC, the utilization of agro-byproducts is confined only to production areas, which are highly localized. The byproducts are normally used as supplements or combined as rations for a particular growing phase of animals, particularly fattening.

The Malaysian government is committed to livestock production in the country through many forms of assistance such as the Pawah Beef Cattle Project, the Milk Collection Centre (MCC) Scheme, the National Lamb Plan, the Grazing Reserves Forage Development Programme, among others, other than the technical research, education, and development program. Yet, the ruminant industry is still lagging and the self-sufficiency level in both beef and mutton is experiencing a downward trend except milk production, where production is still negligible (Table 1). In view of the future market demand (Table 2) for ruminant products, it is certainly a big and urgent task for the people to reckon with.

Forage Research and Development

Stages of development

Forage research and development in Malaysia can be categorized into three phases:

1. Exploratory forage research was conducted between 1920 and 1960. The emphasis then was on the introduction and evaluation of tropical grasses and

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Table 1. Estimated local production and consumption of beef, mutton, and milk in Malaysia.

Year	Beef (metric tons)		Mutton		Milk	
	Total consumption	(%) Self-sufficiency	Total consumption	(%) Self-sufficiency	Total consumption ($\times 10^3$ liters)	(%) Self-sufficiency as LME*
1970	14,935	86.91	4147	24.84	--	--
1971	16,034	91.18	4230	28.37	--	--
1972	17,751	92.56	4453	31.66	--	--
1973	13,208	91.76	2802	35.33	--	--
1974	16,674	89.42	2931	31.05	249,663	0.12
1975	16,396	77.60	3629	22.98	300,660	0.47
1976	18,202	72.90	4558	18.12	308,003	0.80
1977	19,749	63.01	5034	15.97	328,331	1.25
1978	24,960	51.90	3300	24.94	426,561	1.44
1979	21,667	51.84	3476	20.02	478,020	1.56
1980	20,479	63.54	6607	11.53	223,750	3.66
1981	20,533	59.16	3893	16.47	468,729	3.18
1982	24,477	55.80	4101	14.09	357,664	4.68
1983	24,160	54.95	5383	10.89	518,207	3.65
1984	29,728	44.15	5149	12.00	560,840	3.60
1985	32,973	37.67	6302	9.20	489,055	4.46
1986	31,239	39.40	5698	9.24	538,015	4.46

* LME = Liquid milk equivalent.

SOURCE: DVS, 1987.

Table 2. Projected demand for livestock products.

Product	Unit	Year		
		1990	1995	2000
Beef	$\times 10^3$ tons	34	41	50
Mutton	$\times 10^3$ tons	8	9.5	11.5
Milk	$\times 10^6$ liters	830	1120	1500

SOURCE: DVS, 1987.

legumes. Improved grasses were intended for use as animal feed while legumes were utilized as cover crops for plantations.

2. In the 1970s, large-scale ranching development was established. Two commercial and eight corporatized government cattle farms under the management of MAJUTERNAK (National Livestock Development Authority) were established. To serve these developments, MARDI intensified its research on pasture introduction and evaluation.

3. In the 1980s, there was a general shift toward the utilization of forage under plantation crops for the production of ruminants. This development could be attributed to the conversion of granary (paddy) areas into dual-cropping schemes and the subsequent reduction in area for animal production; and also the economic downturn (in the mid-1980s) for major agricultural commodities such as rubber, palm oil, coconut, and even cocoa. Land development agencies and private plantations stepped up their involvement in livestock production in order to buffer the impact of the recession.

There was also a concurrent shift in research priorities in which the integration of forage-livestock-tree crops was emphasized.

Research results

During the exploratory phase between 1920 and 1960, the introduction, performance, and adaptation of tropical grasses and legumes were documented (Hamilton and Pillay, 1941; Keeping, 1951; Henderson, 1955; Ure and Jamil, 1957; Watson, 1957; Lim, 1968; Balachandran, 1969).

In the 1970s, the major aims of forage research were to serve commercial ranching in ruminant production (Tan et al., 1973; Chin et al., 1974; Wan Mohamad and Kamaruddin, 1977; Wong, 1980; Tham and Kerridge, 1982; Wong et al., 1982a and 1982b). However, based on earlier work by Walker (1940), exploratory work on the integration of sheep under rubber was initiated (Lowe, 1968; Verseema, 1968). In 1972, a comprehensive pasture research program based on the open ranching system was initiated by MARDI. Some of the major findings follow.

Pasture introduction, evaluation, and production. Over 700 types of grasses and legumes were introduced. The grass introductions are mainly of the following genera: *Brachiaria, Cynodon, Digitaria, Panicum, Paspalum, Pennisetum,* and *Setaria;* while the legumes are *Cajanus, Calopogonium, Cassia,*

Centrosema, Desmanthus, Desmodium, Leucaena, Pueraria, Stylosanthes, Vigna, and *Zornia.*

This first phase of forage evaluation and selection has been compiled (Wong and Mannetje, 1981; Wong, 1982; Wong et al., 1982a and 1982b). The intensive selection for potential production of *Leucaena leucocephala* in an acid-soil environment has led to the release of two varieties, ML1 and ML2, capable of producing 18.8-21.9 t/ha/yr dry matter yield (Wong et al., 1983). The above species are the major pastures supporting current ruminant production in Malaysia.

The second phase of the introduction and evaluation program began in 1979. The following are brief reports of work mentioned by Wong (1989). From ICRISAT, six accessions of *Cajanus cajan* were introduced in July 1979. From Beltsville, Md., USA, a total of 90 miscellaneous tropical legumes from the genera *Aeschynomene, Centrosema, Clitoria, Desmanthus, Desmodium,* and *Leucaena* were introduced. Of these, only 63 introductions survived in the first year. In 1981, 76 miscellaneous legume accessions from CIAT, Palmira, Colombia, mainly *Aeschynomene, Centrosema, Stylosanthes, Zornia, Galactia,* and *Andropogon gayanus* were evaluated. In 1982, a local collection of *Desmodium* and *Pueraria* was made, with the help of two scientists from CIAT and Thailand. In 1982, another 54 new introductions comprising mainly *Digitaria* and *Pennisetum* hybrids were brought from the University of Florida, Gainesville, Fla., USA. In that year, a total of 172 accessions of indigenous legumes belonging to the genera *Desmodium* and *Pueraria* were collected.

In 1983, six *Leucaena* species were introduced at MARDI station, Serdang. Later, 72 *Centrosema macrocarpum* accessions from CIAT were added to the germplasm collection for assessment. In 1986, *Arachis pintoi* CIAT 17434, *Setaria* (synthetic) cv. Splenda, *Arachis pintoi* CSIRO 58113, *Setaria* hybrid cv. Splendida, *Coradiocalyx gyroides, Cassia pilosa, Cassia rotundifolia* CPI 49713, and *Cassia rotundifolia* cv. Wynn were introduced. Again, in 1986, 19 new introductions were added to the present collection. In 1987, a collection of recommended fodder shrubs was assessed.

Some of the promising introductions from above were *Aeschynomene histrix* CIAT 9690 (6228 kg DM/ha/yr), *Centrosema macrocarpum* CIAT 5065 (4377 kg DM/ha/yr), *Stylosanthes capitata* CIAT 1693 (4679 kg DM/ha/yr), *S. guianensis* CIAT 136 (6597 kg DM/ha/yr), and CIAT 148. *Zornia latifolia* from CIAT is good, with profuse seed setting and good forage yields. In the further assessment of *Cajanus cajan,* the accession ICRISAT 1641 (15,368 kg DM/ha/yr) outyielded the other six accessions

(7421-14,727 kg DM/ha/yr) when cut at a 90-cm height and a 16-week interval. Promising *Stylosanthes* accessions were also evaluated in a small sward trial giving mean DM production of 9856-14,479 kg DM/ha/yr (Wong, 1989).

Potential fodder shrubs, namely, *Gliricidia sepium, Leucaena leucocephala,* and *Manihot esculenta,* were evaluated with cutting intervals at 4, 8, and 12 weeks (Wong and Mohd. Sharudin, 1986). Noxious weed, *Asystasia intrusa,* with high crude protein (25.4%) and IVDMD (56%), was included in the cutting trial, producing 3494-7833 kg DM/ha/yr (Wong et al., 1989). *A. intrusa*, very palatable to grazing animals, is a shade-loving species under plantation canopy.

Pasture management and utilization. A) Pasture in the open ranch. In line with the setting up of a commercial ranching operation, the first grazing management study was established by MARDI in 1974, at both Kluang and Serdang stations. The results of some of the grazing experiments reported by various workers are summarized in a review by Chen (1985). The overall grazing pressure that the legume-based tropical pastures can sustain is around 850-1000 kg/ha of animal biomass or 4-4.5 head/ha of local Kedah-Kelantan cattle (KK), grazed continuously (Table 3). The N-based pastures can support about 1200-1800 kg/ha total liveweight or 5.3-8.0 KK/ha, depending upon the forage species and the amount of fertilizer (Table 4). Under rotational grazing systems, higher carrying capacities of 1-1.5 head/ha of KK cattle above the carrying capacity of N-fertilized pasture could be achieved. For native *Imperata cylindrica* pasture, where various combinations of species such as signal grass and *Centrosema pubescens* are planted, the stocking rate is 3 KK/ha (Eng and Mohd. Zin, 1985). The results from a buffalo stocking rate study on signal grass with 300 kg N/ha/yr, grazed continuously, are 2 head/ha (P. K. Eng, personal communication, 1988).

The potential animal production of the above well-managed forages ranges from about 350-850 kg/ha/yr liveweight gain (legume-based pasture) to 480-900 kg/ha/yr liveweight gain (N-based pasture).

The optimum carrying capacity of *Digitaria setivalva* Stent fertilized with 150 kg N/ha/yr grazed continuously by goats is between 20 and 40 goats/ha. Animal production is about 450 kg/ha/yr liveweight (Chen and Devendra, 1989).

B) Forage under tree crops. In view of the high maintenance cost in controlling weeds, animals are brought into the plantation to reduce the

Table 3. Summary of animal production in relation to stocking rate and grazing management from legume-based pastures in Peninsular Malaysia.

Type of pasture	Type of animal and stocking rate (head/ha)	Year and grazing system	Mean liveweight gain g/head/day	Mean liveweight gain kg/ha/yr	References
Guinea + centro + puero + stylo	4 K.K.*	3 years continuous	281	410	Eng et al., 1978
Guinea + centro + stylo	4 K.K.	5 years continuous	257	374	Eng, 1983
Guinea + centro + stylo + D. ovalifolium	2.6 D.M.	1 year continuous	448	433	
Transvala + digit + centro + stylo + D. ovalifolium	2.6 D.M.	1 year continuous	366	353	Eng, 1981
Native grasses + centro + stylo + D. ovalifolium	2-2.6 D.M.	1 year continuous	324	311	
Native grasses + Leucaena	5 K.K. and Brahman x K.K.	40 weeks rotational (4 weeks on, 4 weeks off)	305	557	Izham et al., 1982
Signal grass + Leucaena	5 K.K. and Brahman x K.K.	Rotational (same)	353	644	
Signal grass + Leucaena	5 S x F	1 year rotational (2 weeks on, 6 weeks off)	433 (Grazing) 368 (Cutting)	788 669	Wong and Devendra, 1982
Kazungula setaria + centro + stylo + puero	Biomass 1064 kg/ha of K.K.	Continuous	360	--	Clayton, 1983
Legume-based guinea/setaria pasture	850-1000 kg/ha	5 years continuous	360	--	Bauer, 1985
Signal grass + Leucaena	7.3 K.K.	19 months rotational monthly	325	855	Izham and Hassan, 1984

* K.K. = Kedah-Kelantan cattle = 200 kg; D.M. = Droughtmaster = 380 kg; B x K.K. = Brahman x Kedah-Kelantan cattle = 330 kg; S x F = Sahiwal x

Table 4. Summary of animal production in relation to stocking rate and grazing management from N-based pastures in Peninsular Malaysia.

Type of pastures	Type of animal and stocking rate (head/ha)	Year and grazing system	Fertilizer (kg N/ha/yr)	Mean liveweight gain		References
				g/head/day	kg/ha/yr	
Digitaria setivalva	6 K.K.*	2 years continuous	150	276	570	Chen et al., 1981
			300	341	698	
Panicum maximum	6 K.K.	3 years continuous	150	335	665	
			300	403	789	
Brachiaria decumbens	8 K.K.	3 years continuous	150	286	752	
			300	353	902	
Digitaria setivalva	5.3 K.K.	2 years continuous	300	272	485	Chen and Othman, 1986
	6.7 K.K.	4 years rotational	300	304	703	
Digitaria setivalva	20 goats	1.5 years continuous	110	35	257	Chen and Devendra, 1989
	40 goats	1.5 years continious	150	31	445	
Brachiaria decumbens	2 buffalo	2 years continuous	300	--	--	Eng, 1988
Imperata cylindrica/B. decumbens/ Centrosema sp.	3 K.K.	20 months	100	200-250	605	Eng and Mohd. Zin, 1985

* K.K. = Kedah-Kelantan cattle.

burden, and subsequently some animals are produced (Walker, 1940; Lowe, 1968; Verseema, 1968). In the mid-1980s, there was a keen interest in livestock projects with plantation crops. The interest in undertaking the integration of livestock under tree crops arises partly because of low commodity prices and partly because of sufficient accumulation of research information for the establishment of such a production system. More critically, there were attempts to show that a livestock-tree integrated cropping system was not only economically feasible but also beneficial to overall plantation-based production systems, resulting in savings in weeding cost, recycling of nutrients, and a more balanced ecology (Ahmad Tajuddin et al., 1984; Ani et al., 1985). Livestock-tree cropping research and development in Malaysia has been reviewed by Chen et al. (1988).

The plantation forms a good ecological niche for animal production not only because of the shady and cooler environment but also because of the good composition of forage feed resources underneath for grazing animals. There are more than 60 forage species ranging from mono- to dicotyledons of varying nutrient levels (Chen et al., 1978; Wong et al., 1988). Hence, nutritionally, the forage on offer to animals, if not superior, is at least equivalent to the improved pasture in the open. The performance of Dorset Horn crossbred sheep was reported to achieve a 145% lambing rate, 3.5 kg birth weight, 15 kg weaning weight, and, thereafter, 100-120 g/head/day liveweight gain (Wan Mohamed et al., 1988).

Various stocking rates in relation to different stages of tree growth and forage on offer have already been worked out (Chen et al., 1978; Chen and Othman, 1983; Othman et al., 1985; Dahlan, 1989). When the natural vegetation together with the leguminous cover crops are allowed to grow without any form of disturbance except for circle weeding, the potential stocking rate under oil palm will be 3 KK/ha at the third to fourth year, 2 KK/ha at the fourth to fifth year, and 1 KK/ha at the fifth to sixth year. For 7-year-old oil palm and older, the stocking rate should be adjusted to between 0.5 and 0.3 KK/ha if continuous set stocking is to be implemented (Table 5).

As discussed earlier, the carrying capacity of forage can be increased slightly when rotational grazing is adopted for the livestock-tree cropping system. The declining stocking capacity of forage under canopy may lead directly to the deterioration of animal performance. Mohamad et al. (1987) reported that the anestrus of KK cattle increased from 12% to 41% under 18-20-year-old oil palm when grazing pressure increased from 3.5 to 2.5 kg DM/kg liveweight.

Table 5. A summary of some of the published data on animal grazing under plantation crops in Peninsular Malaysia.

Type of pasture	Type of animal and stocking rate (head/ha)	Grazing system and duration	Age of tree crop (years)	Mean liveweight gain		References
				g/head/day	kg/ha/yr	
Guinea + stylo + native grass under oil palm	1 K.K.[a]	23 months, continuous	5-7	321	117	Chen et al., 1978
				123-303	100	
Native grasses + stylo + centro + puero + D. ovalifolium + calopo under young oil palm	1 K.K.	24 months, continuous	1-3	379	138	Chen and Othman, 1983
	2 K.K.			321	234	
	3 K.K.			260	284	
Native grasses under rubber						
Copra cake (1% body wt)	2 goats	26 weeks, continuous	6	75	55[b]	Mohd. Jaafar and Mohd. Khusahry, 1983
Cattle pellet (1% body wt)	2 goats	26 weeks, continuous	6	63	45[b]	
Native pasture under rubber supplemented with improved pasture	10 sheep	3-6 months, continuous	3-5	70	255[b]	Lee et al., 1978
	8 goats			60	175[b]	
	10 sheep			95	346[b]	
Native pasture under rubber	21-118 sheep on 120 ha	25 months, continuous	--	65 (4 months record)	--	Wan Mansor and Tan, 1982
Native pasture under coconut	LID x AMZ cattle	368 days grazing and stall feeding	--			Abdullah Sani and Basery, 1982
Grazing + copra				900	331	
Stallfed + copra				835	307	
Grazing				769	283	
Stall feeding				725	267	

(Continued)

Table 5. Continued.

Type of pasture	Type of animal and stocking rate (head/ha)	Grazing system and duration	Age of tree crop (years)	Mean liveweight gain		References
				g/head/day	kg/ha/yr	
Guinea + centro + D. hererophyllum + puero under young oil palm	Biomass 720-960 kg liveweight of K.K. cattle	30-month grazing/ cutting 12-month stall feeding 18-month stall feeding	1-2.5	 804[b] 789[b]	 735[c] 718[c]	Mohd. Sukri et al., 1982
Native forage under oil palm	300 K.K. cattle on 400 ha oil palm	Free grazing for 2 years	15-18	Anestrus increased from 12% to 41% due to shortage of feed		Mohamad et al., 1987
Native forage under oil palm	24 swamp buffalo for drought	Free grazing	10	300-400		Liang and Rahman, 1985
Guinea, signal, slenderstem digit, pangola star grass under coconut	6 local goats	Monthly rotational grazing for 1.5 years	18	46	100	Wong et al., 1988
Native forage under rubber and oil palm	Local Malin sheep, Dorset Horn, Wiltshire Horn crosses (total 7000 head)	Production farm	Young and mature	49	--	Wan Mohamed and Aminuddin, 1986
Native forage under rubber	Malin sheep, Dorset Horn crosses	Production farm	Young and mature	--	--	Tan and Goh, 1988

a. K.K. = Kedah-Kelantan cattle.
b. Estimated figure.
c. At 30 months.

Because of grazing and shading effects, the ecology of forage species may favor certain dominant species that could later upset the nutritional balance of grazing animals, particularly those nursing, pregnant, and newly born animals. It was reported that when *Asystasia intrusa*, a shade-tolerant species, dominated 60% of the total undergrowth vegetation, the production of grazing sheep was disturbed, with a high accumulation of Cu (1015 ppm) in the liver (Wong et al., 1988 and 1989). *A. intrusa* contains 12 ppm of copper.

Development Constraints for Forage Production

Four constraints limit the development of forage production.

An acute shortage of trained personnel for development and extension of improved forage results in inefficient management, and poor forage production and persistence under cutting and grazing in smallholdings, ranching, and integrated livestock-tree cropping production systems.

The low and slow returns of pasture production systems signify an uncompetitive and unattractive undertaking in forage and animal production for entrepreneurs when compared to other economic crops such as rubber, oil palm, and cocoa. Moreover, the existing small farm size has also rendered pasture development unattractive.

Highly leached and weathered soils have led to a deficiency of macro- and microelements, poor soil structure, and acidic conditions, making soil amelioration difficult and expensive. Hence, reports on diminishing yield of tropical pastures under cutting were documented (Bauer, 1984; Chen and Abdullah Hashim, 1984).

Unfavorable climatic conditions for forage flowering and seed setting subsequently incur a high cost in forage development and production.

Research Priorities

Based on the strategic systems planning analysis (Appendixes 1 and 2), the information gap, and resources available in the country, the following areas are considered as priorities in forage research and development.

1. The integration of forage and animals with tree crops.
2. Species introduction and evaluation with emphasis on leguminous shrubs and indigenous tree species.
3. Selection of acid-tolerant and psyllip-resistant *Leucaena.*

4. Development of feeding systems through the rational exploitation of food and industrial crops and forages as feed resources for animal production.
5. Minor-scale seed production of adapted/selected forage species for local requirements.

Resources and Prospects

Climatic and environmental conditions

The equatorial climate with a mean temperature of 21-32 °C, rainfall between 1779 and 3444 mm, and 12 hours constant daylight favors vegetative growth of all species. There is no distinct seasonal moisture deficiency and growing period except in the north (Nieuwolt, 1982). In such an environment, the foliage is evergreen throughout the year. However, there are negative factors such as highly leached soil, low pH, high aluminum saturation, and poor soil structure. High humidity and even rainfall encourage the multiplication of pests and diseases, and that discourages seed setting of forages.

Although there is a need for a breeding program to upgrade the desirable characteristics of selected species, present circumstances do not warrant such an undertaking. Hence, a program for the introduction and evaluation of forage germplasm remains the primary means of obtaining upgraded genetic resources.

Potential of a forage-tree cropping system

Currently, there are more than four million hectares of rubber, oil palm, and coconut plantation land in the country. The potential production of livestock on ground vegetation under plantation canopies has been reported (Ani et al., 1985; Wan Mohamed et al., 1987; Shelton et al., 1987). The holistic research approach toward production systems management related to forage-livestock-tree cropping will help to relieve the problems of estate managers. Recycling and competitiveness of soil nutrients in association with forage and tree crops may be of great economic interest to plantation management also.

Idle paddy land and grazing reserves

There are about 400,000 ha of paddy land in Malaysia. Out of that, 170,000 ha are rainfed single cropping areas where traditionally large numbers

of animals are found. Because of poor forage quality and low availability, these animals generally suffered from malnutrition (Wan Zahari and Devendra, 1984). Through the introduction of fast-growing, high-quality forages, together with suitable feed and an industrial crop production program, these "idled" lands had great potential to further upgrade their animal production.

Lately, a few of the scattered 38,267 ha of government livestock grazing reserve land have been developed into mini-livestock farms (Chin, 1989) where proper management regulations on stocks and forages are strictly observed. These mini-livestock farms are variable in size, and probably range from 50 to 200-300 head of cattle. Such medium-sized farms could probably revive the open ranching system in animal farming. Management for medium-sized farms is appropriate for a family-run business in a commercialized operation. It may eventually encourage the farmers to turn to commercial livestock farming rather than remain as small, traditional animal owners as suggested by Ahmad Mustaffa (1988). Due to the shortage of managerial personnel, extra-large commercial ranching may face great difficulty in efficient farming operations. Currently, there are about 25,000 ha of improved pastures under ranch management for ruminant production in Malaysia.

Summary

Since 1972, over 700 accessions of tropical grasses and legumes have been introduced for evaluation and selection in Malaysia. A wide range of grasses, but few legumes, are selected for cultivation. Hot, humid climate favors vegetative growth of all species but not reproductive growth in seed setting of selected forage plants. Present circumstances do not warrant a breeding program to upgrade the desirable characteristics of selected species. Hence, a program for the introduction and evaluation of forage germplasm remains the primary means of obtaining upgraded genetic resources.

A tremendous amount of research information is available on forage evaluation, establishment, production, plant nutrition, legume-grass combining ability, and grassland ecology in relation to soil fertility and animal production under different systems of cutting, grazing, and integration of forage-livestock-tree cropping. However, overall constraints in forage development and extension have limited forage cultivation for animal production. Nevertheless, the pasture research program has been fulfilling the changing needs of forage development for ruminant production in the country. Suggestions on forage research priorities, strategy, and formation of research programs based on available natural resources are also made.

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Appendix 1. A strategic systems planning analysis for forage utilization under plantation.

Mission: To generate technology on the rational utilization of forage under plantation for ruminant production.

Objective: To determine the technical feasibility and economic viability integration of forage and ruminants under plantation.

Strategies:

1. Understand the interrelationship of crop and forage availability.

2. Understand forage ecology in association with animal production (for multiplication, fattening, and draft).

3. Generate technical and economic models for a Decision Support System (DSS) for technology transfer on the integration of livestock with plantation crops.

Programs:

1. Relationship between canopy (light penetration, forage production) and species succession; alteration of spatial arrangement of tree crops; screening for shade tolerance of forage species.

2. Relationship between energy availability in forages and different physiological stages of livestock production.

3. Study interrelationship between forage and livestock on the production of tree crops (nutrient recycling, physical damage to tree crops and soils) with the presence of animals.

4. Study other factors (terrains, water availability, soil type, etc.) which affect forage production.

5. Development of mathematical and economic models for integration of different ruminants under plantation crops.

6. Transfer of technology on integration of livestock.

Appendix 2. A strategic systems planning analysis of forage evaluation.

Mission: Screening, evaluation, and utilization of forage species.

Objective: To obtain species with desirable characteristics (yield, pest and disease tolerance, shade tolerance, seed set) for different agroecological zones of Malaysia.

Strategies:

1. Continue introduction and screening of forage (exotic and native species) under different ecological zones.

2. Screen for nutrient requirements in relation to soil fertility.

3. Large-scale production assessment for potential species under cutting and grazing system.

4. Development of a local verification trial and pilot projects for potential species.

Programs:

1. Germplasm collection and evaluation of exotic and native forages under four ecological zones.

2. Development of fertilizer regimes for different species in different soil types.

3. Rhizobium specificity study for legumes in different soils and ecological zones.

4. Compatibility study on legume-grass mixtures.

5. Screening for shade, acid soil, pest and disease tolerance, and seed set.

6. Productivity study under grazing and cutting for promising species, including development of production models.

7. Demonstration and establishment of home-plot forage and feeding system.

PASTURE AND FODDER PRODUCTION IN SRI LANKA: PRESENT STATUS AND FUTURE TRENDS

L. V. K. Liyanage*

Introduction

The republic of Sri Lanka is a tropical island located between 5° 55' and 9° 51' N and 79° 42' and 81° 53' E. The total land area is 6.56 million hectares, extending to a maximum of 410 km in a north-south direction and 225 km in an east-west direction. Topographically, the island has a crown of mountains rising to 2000-2400 m in the southcentral region surrounded on all sides by fairly flat lowlands. Rivers radiate out from the highlands following geological faultlines.

Its climate is characterized by small fluctuations in temperature and heavy rainfall intensity. There is a considerable variation in the amount and reliability of monthly rainfall between agroecological zones and between locations within a zone. Rainfall mostly occurs as high-intensity precipitation, leading to excessive runoff and erosion. Only 50%-60% of rainfall is effective.

Three major agroecological zones, that is, the wet zone, dry zone, and intermediate zone, have been defined on the basis of rainfall pattern, soil, terrain, and natural vegetation (Figure 1). The wet zone receives an annual rainfall ranging from 1875 to 5000 mm, the intermediate zone between 1500 and 2250 mm, and the dry zone from 875 to 1500 mm. These three zones have been further subdivided into seven agroecological zones: wet zone (low country, mid country, and up country); intermediate zone (low country, mid country, and up country); and dry zone (low country). The terms "up country," "mid country," and "low country" are empirically used to denote altitude: hill country (> 900 m.a.s.l.); mid country (333-900 m.a.s.l.); and low country (< 333 m.a.s.l.). The most widespread soils are the Alfisols, Ultisols, Oxisols, Histosols, Vertisols, and various Entisols. High soil acidity is predominant in many parts of the country.

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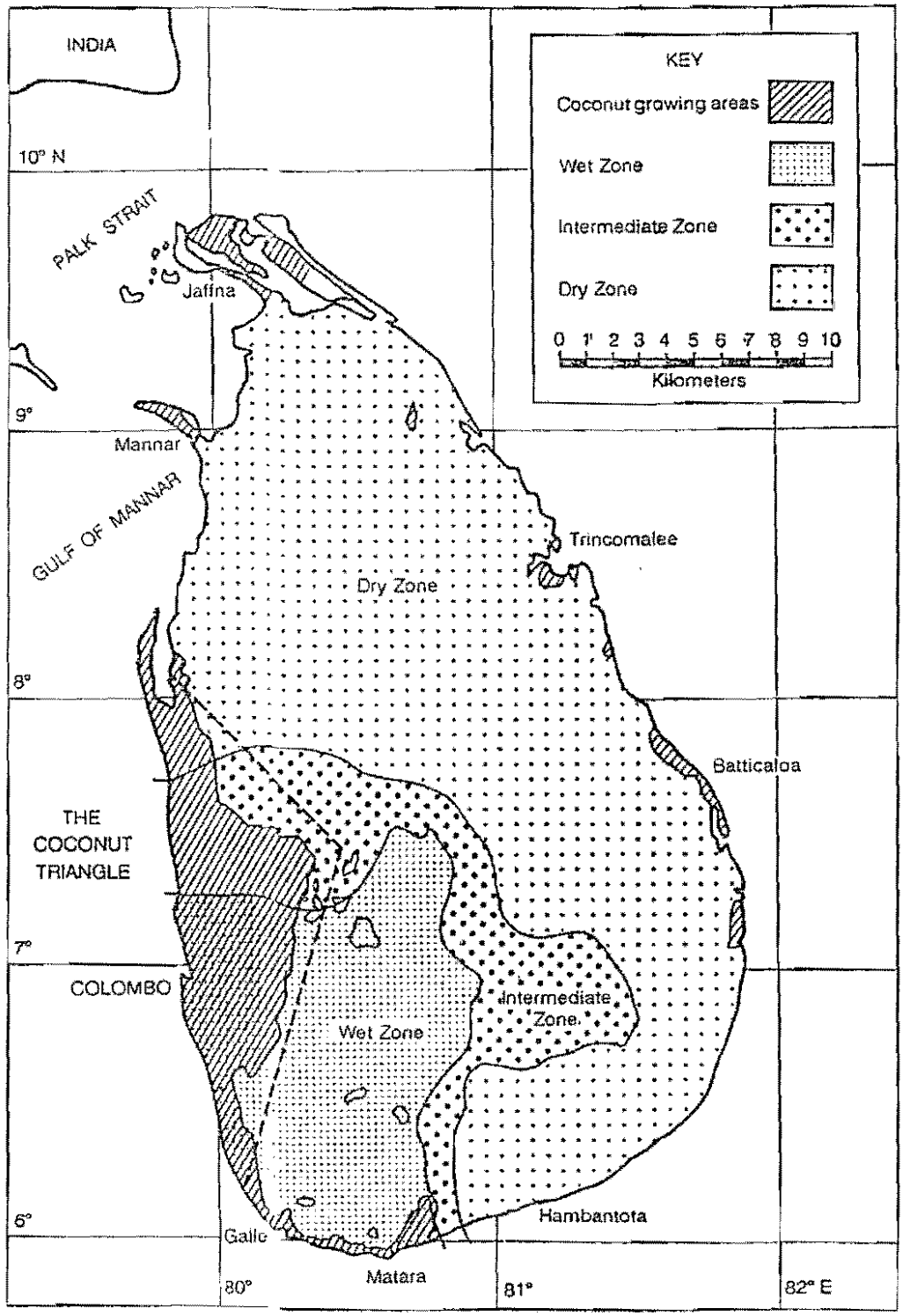

Figure 1. Map of Sri Lanka showing the three major rainfall zones.

Present Status of Ruminant Livestock in the Country

Like many other developing countries, Sri Lanka is not self-sufficient in livestock production. The contribution of the dairy industry has stagnated at around 2% of gross domestic production. Daily consumption of milk is around 840,000 liters, while national milk production is estimated at around 450,000 liters per day. Imports of dairy products amount to nearly 50% of the country's requirement, based on the present consumption level of about 1.2 ounces per day (Rajaguru, 1986). With regard to other ruminant livestock species, goat and sheep production has remained rather static since 1953.

The livestock statistics for 1982 indicate that cattle and buffalo populations in Sri Lanka are estimated at 1.698 million and 0.879 million, respectively (Table 1). Of these, 0.888 million and 0.403 million comprise female cattle and buffalo. More than 60% of the total cow herd is considered unproductive.

As in most parts of Asia, most Sri Lanka farmers involved in dairy farming belong to the category of small subsistence farmers. They normally keep 1-2 milking animals as a subsidiary occupation to supplement their income. Milk production in small holdings is relatively low as a result of poor management. However, it has been estimated that a larger percentage of present milk production is contributed by small dairy farms, practicing a "cut-and-carry" system of forage production, while a smaller percentage is produced by specialist dairy farmers and government farms.

Pasture and Fodder Production

According to distribution of land use, natural grasslands occupy 4% of the total cultivable land (6.56 million hectares) of the island. The total area available for herbage production in Sri Lanka as estimated by a team from the Tropical Products Institute in 1979 is 700,000 hectares (Table 2).

This information gives a general picture of the present situation, but land development projects (e.g., the Mahaweli Diversion Scheme) have resulted in some of the fertile land becoming unavailable for pasture and fodder production. In other instances, high-value crops with export potential have emerged, and this has changed the entire agricultural land-use pattern.

The present national milk production average per day for beef and buffalo cows taken together is 0.81 liters per day. One of the main causes for low cow production of a local livestock herd is poor nutrition due to acute

Table 1. Ruminant livestock population in Sri Lanka by agroclimatic zones, 1982.

Agroclimatic zone	Kind of livestock							
	Cattle	% by area	Buffalo	% by area	Goats	% by area	Sheep	% by area
Hill and mid country	223,200	13.14	108,000	12.28	69,900	13.47	4,500	14.38
Low country wet zone	235,300	13.85	132,000	15.02	61,600	12.04	700	2.29
Low country dry zone	1,240,100	73.00	639,200	72.71	374,800	73.20	25,400	83.01
Total	1,698,600		879,200		506,300		30,600	

SOURCE: Department of Census and Statistics, 1982.

Table 2. Total area available for herbage production in Sri Lanka.

Land area	No. of hectares
Unirrigated highlands in the dry zone	325,000
"Villu"* and similar lands in the dry zone	80,000
30% of area under coconut	140,000
Marginal tea land in the mid country	40,000
5% of hill country tea estates	4,500
"Patna"* lands in the hill country	55,000
Herbage from paddy fields	30,000
Roadsides, etc.	5,500
Other areas forming part of mixed-farming homestead systems in the wet zone	20,000
Total	700,000

* "Villu" = natural grasslands in submerged lands in the dry zone;
"Patna" = natural grasslands in the hill country above 900 m.a.s.l.

SOURCE: Siriwardana and Clarke, 1986.

shortage of forage. There is a seasonal shortage of herbage because of periodic droughts in all agroclimatic zones except the low country wet zone. The 17,000 ha of improved herbage area and the poorly organized forage conservation program in the country are insufficient to overcome the herbage shortage of about 6 million tons and to satisfy the herbage requirement in lean periods. If 200,000 ha out of 700,000 ha could be brought under improved pastures, it would be possible to produce 16 more liters of milk per hectare and increase milk consumption per capita per day by over 2 ounces.

In assessing current utilization of available pasture and fodder resources, it is necessary to take up each ecological zone separately and assess its potential. Even in the same ecological zone, method of utilization differs according to size of holding, factors governing farmers' sources of income and means of livelihood, and also the main agricultural systems of the area.

Hill and mid country

Kandy, Nuwara Eliya, part of Badulla, and Matale districts come under this zone. Elevation ranges from 333 to 900 m.a.s.l. for the mid country and from 900 m.a.s.l. to the highest altitudes on the island for the hill country.

Mid country

Annual rainfall is around 2000 mm and is well distributed, resulting in even growth of grass throughout the year. Thus, feed conservation is not needed except during short spells of feed scarcities. The area is characterized by the presence of a large number of small holdings, 0.5-2.0 ha each. Around 40% of smallholders keep cattle of exotic and crossbred types. They plant plots of improved pastures and adopt systems of integrated farming with tea, coconut, and paddy among the crops. Straw is utilized for feeding cattle. They also cut grass from roadsides and paddy fields to supplement their limited supplies.

Hill country

Hill country is the main tea-producing area, having over 90% of land under tea. Most of this belongs to state plantations and a little to private estates. Smallholder dairy farmers are estate laborers who do not own any pasture lands. Apart from these, some estates provide a limited extent of land close to their homesteads for fodder cultivation. Their herbage yields are generally better compared to those of the dry zone. The majority of cattle owners have exotic breeds such as Friesian, Ayrshire, and Jersey, along with

other crosses. As high feed demand of these cattle cannot be met by grass alone, farmers resort to high levels of concentrate feeding, which is about one ton per year.

Apart from these small holdings, this area also has large estate farms established in the "wet Patna" land (i.e., land in high-rainfall areas at an elevation of above 1500 m). Average rainfall is about 2000 mm and is well distributed. Pastures are planted with *Pennisetum clandestinum* and *Paspalum* varieties. Cattle reared are Freisian, Ayrshire, and Jersey breeds. Supplementary feeding of concentrates is carried out at the rate of 1-1.5 tons per cow per year.

Adjacent to the "wet Patnas" are the "dry Patnas" (i.e., lands in low-rainfall areas at an elevation of 900-1500 m) in the Badulla district. They receive a lesser rainfall of 1960 mm per year. Natural pastures are composed of low-yielding, coarse-type grasses, which provide poor grazing.

Coconut Triangle

The districts of Colombo, Kurunegala, and Kegalle comprise the Coconut Triangle, and, ecologically, the low country intermediate and wet zones fall under this area. Around 141,000 ha of coconut lands lie within the zone. Extensions of 2-3 ha and 0.5 ha of natural pastures and improved pastures, respectively, under coconut would be sufficient for an animal. Satisfactory pasture growth could be obtained in new plantings up to the fifth year of coconuts, and again from about 30 years onward in adult plantations. The smallholders who comprise about 80% of the total holdings each own 1-2 head of cattle normally tethered to trees for grazing. The availability of high-value alternate crops and poor yields from animals have retarded the progress of pasture development.

Dry zone

Over 60% of the total cattle population is accommodated in this zone. Mostly, animals thrive on natural grasslands, which include about 80,000 ha of "Villu" land, around 300,000 ha of highlands, and 200,000 ha of paddy fields under stubble grazing. The "Villus" on the banks of the Mahaweli River represent some of the most intensively grazed areas in the dry zone. These lands are subjected to regular flooding during northeast monsoons (October to December) and become unavailable for grazing. Cattle are removed from the "Villus" to highland areas during this rainy season. In addition, about 200,000 ha of fallow paddy fields that are cultivated only during the northeast monsoon

become available to cattle for a period of about 5-6 months of the year. State farms in the dry zone represent an area of about 14,000 ha.

Infrastructure for Forage Research and Development

All pasture research and development programs before 1977 were handled by the Division of Animal Production and Health of the Department of Agriculture, under the Ministry of Agriculture. From 1977 to early 1989, the Ministry of Rural Industrial Development was responsible for pasture work. At present, these programs are handled by the Ministry of Agriculture, Food, and Cooperatives, under the Ministry of State for Livestock and Dairy Development. Certain aspects of pasture work related to coconut, tea, and rubber are handled by the Ministry of Plantation Industries.

Research on pasture and fodder is being conducted by the Veterinary Research Institute; Departments of Animal Science of the University of Peradeniya, University of Ruhuna, and Eastern University of Sri Lanka; Department of Veterinary Medicine of the University of Peradeniya; and the Department of Animal Science of Agriculture Faculties of the University of Matara and Batticaloa. Investigations by the Cropping Systems Project of the Department of Agriculture, the Asian Development Bank-sponsored Livestock Development Project, and the Sri Lanka-Swiss Dairy Development Project in the Eastern Province are also under way. The Coconut Research Institute of Sri Lanka, which has pioneered pasture research work in the Coconut Triangle for over 30 years, has now diverted its resources toward crop-livestock integration, mostly in the intermediate and dry agroecological zones.

Cultivation of improved pasture and fodder on state farms has been undertaken since mid-1940. These farms were managed either by the Department of Animal Production and Health (DAPH) or by the National Livestock Development Board (NLDB).

Various support plans have been introduced from time to time to encourage pasture cultivation among livestock farms. They include the following:

1. IDA/Dairy Development Project Loan Scheme for private farms in the mid country and Coconut Triangle.
2. IDA Hill and Mid Country Estate Pasture Development Subsidy Scheme for planting pastures in state-owned plantations managed by government organizations, namely, the Janatha Estates Development Board (JEDB) and State Plantation Corporation (SPC).

3. Pasture establishment in the Coconut Triangle by the Coconut Cultivation Board.
4. All-Island Pasture Assistance Scheme for paying subsidies on planting pastures in all parts of the country, through the DAPH.

The Ministry of Rural Industrial Development, which was earlier responsible for pasture/livestock development programs, envisaged in 1986 a dairy development program through the Dairy Development Foundation (DDF), which generates funds from donated dairy commodities and from a World Bank loan. The Milk Industries of Lanka Company (MILCO), owned 49% by rural milk producers and 51% by public investors, was also established in 1986, replacing the National Milk Board.

Other organizations that are involved in pasture and dairy development programs in the country are the Mahaweli Authority of Sri Lanka, Nestles Lanka Limited, the Sri Lanka-ADB Livestock Development Project, the Integrated Rural Development Project, the Sri Lanka-Netherlands Livestock Development Project, the Sri Lanka-Finland Technical Corporation, the Sri Lanka-Swiss Livestock Development Project, and Sri Lanka Milk Foods Limited.

Achievements in Pasture and Fodder Research

The achievements and accepted recommendations for pasture and fodder are given below under four agroclimatic zones (i.e., hill country, mid country, dry zone, and Coconut Triangle). Information on pasture species, yield, fertilizer recommendations, and management practices relevant to each region are included.

Recommendations for the hill country

Pastures. Recommendations of pasture species for the well-drained soils in the wet zone below the 1500 m contour follow.

Grasses: *Panicum maximum* (Guinea A and Guinea B); *Pennisetum purpureum* (Napier); *Paspalum dilatatum; Paspalum plicatulum; Setaria anceps;* and hybrid Napier.

Legumes: *Desmodium intortum; Stylosanthes;* Velvet bean; and *Desmodium uncinatum.*

Fodder trees: *Erythrina, Albizia,* and *Gliricidia.*

Recommendations for water-logged soils in the wet zone include: for grasses, *Paspalum plicatulum, Paspalum urvellei,* and *Brachiaria mutica*; and for legumes, *Desmodium* species.

Recommendations for regions above 1500 m include: for grasses, *Pennisetum clandestinum* (Kikuyu); *Setaria anceps; Paspalum urvellei;* Tall Fescue; *Dactylis glomerata* (cocksfoot); and for legumes, *Desmodium uncinatum* (Silverleaf Desmodium).

Recommendations for the "dry Patna" area include: for grasses, *Brachiaria brizantha* and *Setaria anceps*; for fodder, hybrid napier, sorghum (annuals), and *Panicum maximum* (Guinea B); for legumes, *Desmodium intortum* (Greenleaf Desmodium), *Stylosanthes* species, and Velvet bean; and for fodder trees, *Erythrina, Sesbania,* and *Gliricidia.*

The "dry Patna" lands are dominated by natural grass of the coarse tussocky type that is very low in fodder value. Three main categories are recognized: *Cymbopogon confertiflorus* (Mana), *Chrysopogon zeylanica* (Gavara), and *Themeda tremula* (Pini baru tana).

Sithamparanatham (1966), working with temperate grasses in the wet zone, has shown that some temperate grass-legume combinations showed promise. These are *Dactylis glomerata* (cocksfoot) and *Lolium* species (rye grass) in combination with *Trifolium pratense* (red clover) and *Trifolium repens* (white clover). One limitation was that these grasses have to be reestablished over 2-3 years and seeds have to be imported. These combinations also tended to be smothered by kikuyu grass if this grass existed in the vicinity or existed on the land prior to cultivation of the temperate grasses.

Research has been carried out at the Tea Research Institute on the use of grasses in the rehabilitation of tea land in order to eliminate root disease-producing organisms and parasitic nematodes and also to improve the soil structure and organic matter content. The choice of grasses was made on the basis of their ability to produce extensive root systems. Guatemala grass (*Tripsacum laxum*) and Mana (*Cymbopogon confertiflorus*) have been extensively used on tea plantations, but these are of very poor quality as fodder grasses. Kikuyu grass, which is predominant in the hill country wet zone, gave yields around 9000 kg/ha without any application of fertilizer. When fertilized with 200 kg/ha of nitrogen, yield increases to nearly 15,000 kg/ha.

Fertilizer. For pasture establishment, a basal dressing of 1000 kg/ha of dolomite, 150 kg/ha of triple superphosphate, 200 kg/ha of muriate of potash, 10 kg/ha of sulfur, and 5-6 kg/ha of minor elements is recommended. A positive response was obtained when Ca, N, S, and K were applied.

For maintenance, the following quantities in kg/ha/year are recommended for grass pastures: triple superphosphate, 100-150; muriate of potash, 100-150; sulfur, 5-7; and dolomite, 500-1000. In addition, for pure grass stands, 300-500 kg of urea are recommended for application in 4 split doses.

It is recommended that cows on good kikuyu grass be fed on an individual production basis at the rate of a pound of concentrate per 2 pints of milk produced in excess of 8 pints. Investigations showed that *Panicum maximum* and *Brachiaria*, when well fertilized, can yield up to 17,000 kg/ha/year when grown under young rubber trees. Under zero grazing, the carrying capacity is estimated to be 7 cows/ha.

Recommendations for the mid country

Pastures. A number of species have been tested from time to time both in varietal trials in small plot experiments as well as in field demonstrations. The results of those activities, together with the experiences of pasture specialists, have been put together in making these recommendations.

Guinea A and B, which are local ecotypes of *Panicum maximum*, have been traditionally utilized by farmers for feeding dairy cattle. Those grasses grow and persist on poor eroded soils and are abundantly available on waste lands. Guinea A is a stemmy, coarse, and early flowering fodder grass producing large quantities of viable seed. Thus, multiplication is easy. Guinea B, on the other hand, is not coarse and is preferred because of its leafiness and late-flowering habit. However, it does not produce enough viable seed and, therefore, its multiplication ability is limited.

Those two grasses are easy to establish and manage under low soil fertility conditions and are therefore recommended for cultivation in situations where farmers are reluctant to make capital investment on establishment of improved pasture.

In order to find more promising grasses and legumes, intensive research was initiated in the late 1960s. Work done during this period and the early 1970s was mostly limited to grasses grown with the use of nitrogen fertilizer on fertile soils in proximity to the banks of the Mahaweli River.

Recommendations for fodder grasses include: *Panicum maximum* (cv. Guinea), *Panicum maximum* (cv. Hamil), and hybrid Napier; for pasture grasses, *B. decumbens, B. ruziziensis*, and *B. brizantha*; for legumes, *Stylosanthes guianensis, Macrotyloma axillare,* and *Desmodium* spp.; for tree fodder crops, *Gliricidia, Leucaena,* and *Erythrina.*

Recommendations for the mid country dry zone include: for fodder grasses, *Panicum maximum* (cv. Guinea) and *Panicum maximum* (cv. Hamil); for pasture grasses, *B. decumbens* and *B. brizantha*; for legumes, *Stylosanthes* **axillare**, Siratro, *Desmodium* spp.; and for tree fodder crops, *Gliricidia, Leucaena,* and *Erythrina.*

Recommendations for the dry zone

Pastures. Recommendations for this area include: for fodder grasses, *Panicum maximum* (Guinea A), *Panicum maximum* (Guinea B), and *Panicum maximum* cv. Hamil; for pasture grasses, *Brachiaria brizantha, B. mutica, B. ruziziensis, Cenchrus ciliaris,* and *Setaria anceps*; for legumes, Siratro, *Stylosanthes guianensis, Stylosanthes hamata,* and *Centrosema pubescens*; for tree fodder, *Gliricidia, Leucaena,* and *Erythrina.*

Fertilizer. For pasture establishment, 50 kg of triple superphosphate, 75 kg of muriate of potash, 10 kg of sulfur, and 75 kg of urea are recommended. For maintenance, 100-200 kg of urea per hectare per year or 12 tons of organic manure per hectare per year are recommended.

Pasture yields. Study results showed relatively consistent yields from grasses. *B. mutica* produced 12,445 kg/ha while the highest was 16,875 kg/ha for *Setaria sphacelata.*

Recommendations for the Coconut Triangle

Recommendations for this area include: for pasture grasses, *B. milliformis, B. brizantha, B. ruziziensis, B. decumbens* (Pangola), and *B. dictyoneura;* for fodder, Panicum maximum, hybrid Napier, and *Setaria anceps*; for legumes, *Centrosema pubescens, P. phaseoloides, Macroptilium atropurpureum* (Siratro), *S. guianensis*, and *S. hamata*; for legume fodder trees, *L. leucocephala* and *Gliricidia maculata.*

Fertilizer. Recommendations for application per 0.4 ha after each harvesting include: on pasture grasses, 50 kg of ammonium sulfate or 25 kg of urea, 25 kg of saphos phosphate, and 25 kg of muriate of potash; on fodder

grasses, 25 kg of ammonium sulfate, 25 kg of saphos phosphate, and 25 kg of muriate of potash. In addition, coconuts should be fertilized with a coconut fertilizer mixture at the rate of 3 kg/palm. It was reported that dry matter yield of grasses increased with increases in the height of cutting, nitrogen application, and harvesting interval. Results also indicate that *B. milliformis* cannot any longer be regarded as the pasture grass most suited to growing under coconut.

Dry Season Feeding

Straw

It is estimated that 3.5 million tons of crop residues are available annually (Siriwardena and Clarke, 1986). Of this, 2.7 million tons are rice straw. A considerable amount of research has been done in Sri Lanka on the use of rice straw as ruminant feed, both as treated straw and supplemented straw during the dry season. Animals yielding 4 liters of milk could be fed economically with straw supplemented either with urea or legume leaves and a little low-cost concentrate. For purposes of urea supplementation of straw, sprinkling with a 2% solution of urea prior to feeding is recommended. For treatment, a minimum level of 4% urea in straw as a solution in a 1:1 ratio of water to straw is recommended. This straw is ensiled for 7-10 days under airtight conditions before use.

Leguminous fodder trees

Three legume fodder trees (i.e., *Gliricidia sepium, Leucaena leucocephala,* and *Erythrina*) are recommended for cultivation. Considerable research information is available on the cultivation and utilization of *Gliricidia* and *Leucaena* (Chadhokar and Lacamwasam, 1982; Liyanage and Wijeratne, 1987; Liyanage et al., 1989).

Gliricidia. This tree grows well up to an elevation of about 1000 m.a.s.l. Establishment is generally by vegetative means. For large-scale planting, seeds are preferred. The leaf contains high protein levels between 23% and 27%. Generally, harvesting should be carried out every 3 months after a continuous growth of about 9 months after planting. Yield is 1 meter of fresh leaf material from trees along boundary fences in 1.0 ha of land. Continuous feeding of *Gliricidia* leaves has no adverse effects on the breeding of heifers, contrary to the belief among some dairy farmers.

Leucaena. This tree thrives on land where the pH is between 5.2 and 8.5. It is more productive on land below 750 m.a.s.l. Propagation is by seed, at the rate of 5-8 kg/ha. First harvesting after planting is recommended at 8-12 months. Yields of up to 20 tons of edible dry matter per hectare per year have been obtained. The leaves have about 25% crude protein. No adverse effects from feeding cattle on higher percentages of *Leucaena* were observed in trials on growing heifers.

Erythrina. This is a quick-growing tree which grows well in most regions. Propagation is both by seeds and cuttings. The trees can be lopped every 2-3 months and yields between 25 and 30 kg of fresh leaves per harvest per tree can be obtained. It has been demonstrated that a 450-kg cow fed a daily ration of 25 kg of fresh *Erythrina* and 6 kg of rice straw could produce 8-10 liters of milk per day without supplementary concentrate feeding.

Constraints for Forage Research and Research Priorities

It has been estimated that about 90% of current milk production is contributed by small dairymen while the remaining 10% is produced by specialists, dairy farmers, and government farms. Present total milk production is estimated to be about 25% of the estimated total daily requirement of milk for the country (Rajaguru, 1979).

Constraints

Small farmers have been heavily dependent on concentrate feeding in the past. But, with the escalation in the price of feed, it became an uneconomic proposition. These farmers produced very little of their own forage. They are reluctant to grow forage on their own land as priority is for food and cash crops. Limited availability of land for forage cultivation enhances this problem. The task of changing the attitude of the farmer and promoting more scientific forage management is a formidable one since the farmer's animal enterprise is generally a sideline.

Many farmers who have planted improved varieties under assistance schemes do not show sustained interest, and their plots show evidence of neglect after some time. When forage is introduced to paddy farmers, they expect the same growth rate in seed forage as in paddy. When this is not evident, they lose interest.

Planting materials (i.e., cuttings and seeds) are not readily available to the farmer at reasonable distances from farms. The current production of forage

seeds is concentrated in the private sector. A total of 78.5 tons per year is handled by these firms, and the level of production is determined by advance orders (Jayawarden, 1985). Although Sri Lanka could well produce its own requirements of pasture seeds, some climatic constraints indicate that levels of seed yields will be low (Humphreys, 1979).

A lack of strategic development centers and extension services is also an important contributing constraint for forage development in the country. Furthermore, manpower development for forage research has been rather low, and inadequate trained manpower is a major constraint. There has been a rapid decrease in effective funding for research in relation to the escalating cost of research materials. Therefore, the government allocation for research is fast becoming inadequate, even for infrastructure development and the maintenance of research-related support services.

Research priorities

Any research program aimed at defining nutritional limitations on forage production in Sri Lanka must pay particular attention to the incorporation of legumes into existing systems. Development of legume-based pasture can cut down on the cost of nitrogen fertilizers. Therefore, selection of pasture-fodder legumes suitable for various ecological zones with due regard to associated strains of Rhizobium should be made.

It is important to develop an appropriate integration of pasture-fodder production with crops as associations (coconut, maize, cowpea, etc.), rotations (paddy-legume), relays (legume into paddy toward the end of the latter), or partition (part of the farm to crops and the other to pasture-fodder), with due consideration to size of holding, labor, and type of livestock in the various ecological zones.

A continuous feed supply throughout the year for livestock through efficient utilization of pasture and fodder, crop residues, and agroindustrial byproducts, with minimum levels of concentrates, should be developed.

The efficiency of recycling farmyard manure and farm waste should be studied.

Research on agroforestry systems to be introduced under reforestation by including tree fodders and pastures as intermediate crops should be initiated.

Many of these programs should be carried out on small holdings under actual farming conditions with maximum participation by the farmer himself.

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FORAGE, PASTURE, AND GRASSLAND RESEARCH AND DEVELOPMENT PROGRAM OF THE PHILIPPINES*

Patricio S. Faylon and Elaine F. Lanting**

Introduction

Agriculture and natural resources have always played vital roles in the Philippine economy. However, the promise of bountiful harvests from these vast resources can only be realized if research and development (R & D) is efficiently and effectively managed to support production programs. Thus, the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD) was established and mandated to be the central planning, coordinating, and monitoring agency to administer the national R & D program in agriculture, forestry, and natural resources. As a central planning body, the major tasks of PCARRD are as follows:

> to formulate the national agriculture, forestry, and natural resources research and development program based on a multidisciplinary, interagency, and systems approach;
>
> to establish a system of priorities for crop, livestock, forestry, farming systems, and socioeconomic research and development, and to provide meaningful mechanisms for updating these priorities; and
>
> to program the allocation of all government revenues earmarked for agriculture, forestry, and natural resources R & D to implement a dynamic national R & D program.

Under PCARRD are five technical divisions (Figure 1) that implement the task of evaluating R & D project proposals, monitoring, and reviewing programs and projects implemented by agencies under the national network of R & D centers and stations. The technical divisions' functions also include manpower development, project development, workshop coordination, and technology packaging.

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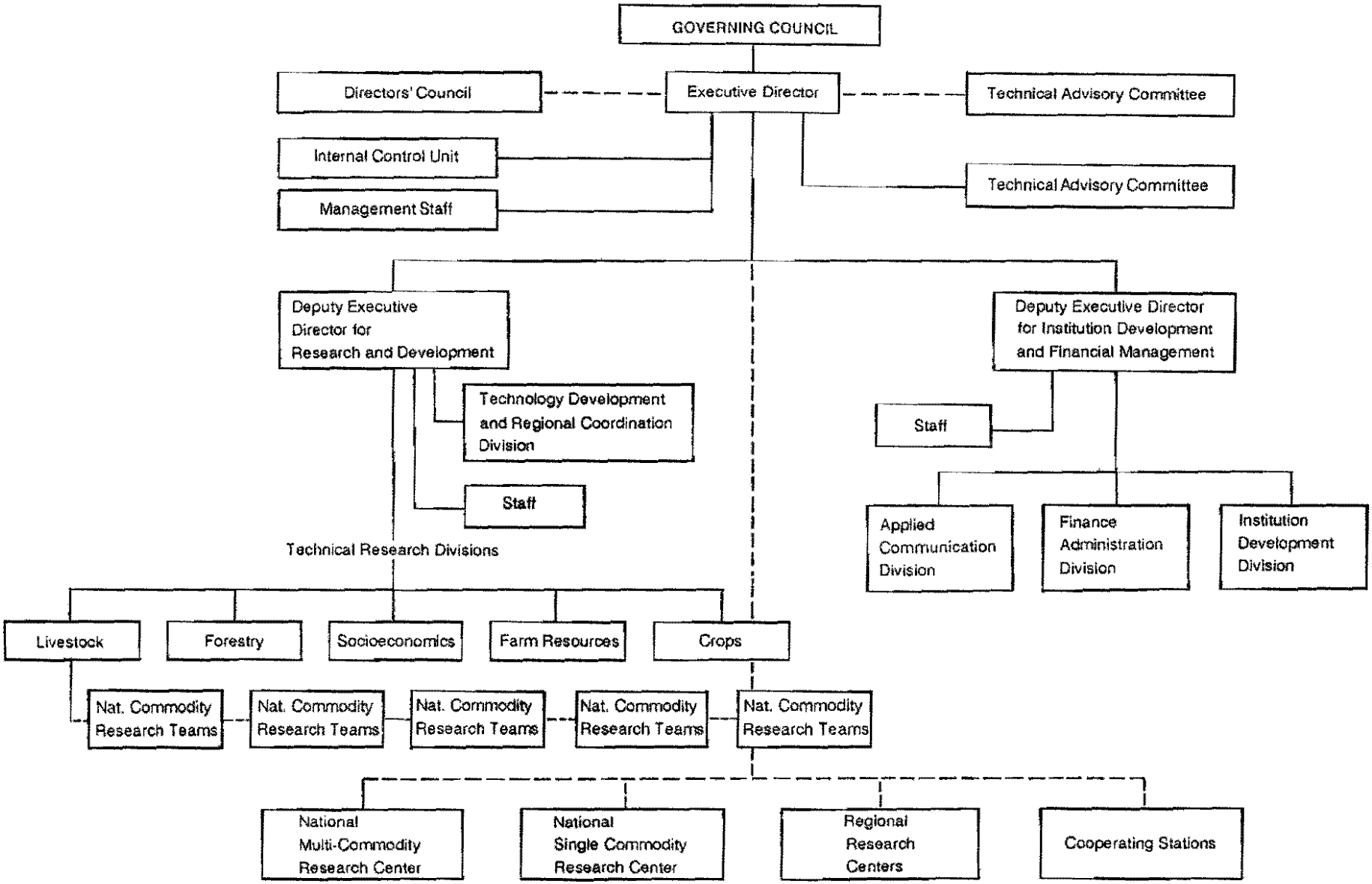

Figure 1. PCARRD's organizational structure.

The Livestock Research Division (LRD) is one of the technical divisions mentioned earlier. There are six national commodity programs under it, namely, carabeef, beef and dairy, small ruminants, forage, pasture and grassland, and pork and poultry. Each of these commodities has its R & D directions/thrusts and priority activities. Specifically, for forage and pasture, and grassland commodities, the thrusts are the production of quality forage crops and the development of efficient utilization schemes for cro presidues and agroindustrial byproducts as livestock feed.

Commodity Industry Status

The development of the Philippine livestock industry, particularly cattle, water buffalo, goats, and sheep, depends largely on the production of good-quality forage crops and efficient utilization of crop residues/agroindustrial byproducts that remain the cheapest sources of feed for ruminants.

In general, two types of livestock production systems exist, that is, commercial or ranch type and backyard or smallholder type.

The commercial sector utilizes large, extensive grasslands on range areas of the country, which comprise more than 7 million hectares. According to the Bureau of Forest Development (BFD), of the Department of Environment and Natural Resources, the local area of grazing lands under lease in 1984 was about 468,509 hectares being grazed by 183,000 head of cattle, of which 21,600 were sold, at a value around P88 M. However, with the approval and implementation of the Comprehensive Agrarian Reform Law (CARL), these grazing areas will decrease tremendously.

Practically all goats and water buffalo and the majority of cattle are in the hands of the backyard farmer. They are integrated into cropping systems and subsist mainly on weeds, crop residues, and other byproducts from 3.5 million hectares of rice land, 3.1 million hectares of maize land, 3.0 million hectares of coconut land, and 425,000 hectares of sugarcane plantations. It is estimated that about 11 million cattle and water buffalo could easily be fed in small feedlots and in backyards by available farm waste products and byproducts. In 1988, there were only about 4.2 million head of cattle and water buffalo raised on backyard farms.

In addition to open grassland, there are about 15 million hectares of forested areas that are potentially available for commercial grazing.

Major Problems of the Livestock Industry vis-à-vis Forage, Pasture, and Grassland

The economically important problems that hinder the growth of the industry are as follows:

1. Low productivity and seasonal availability of native pastures. The native grass species (*Imperata* and *Themeda*) that dominate the open grassland produce dry matter of low quality and quantity. Their growth pattern is dependent on soil moisture/precipitation, thus making feed availability seasonal. Continuous utilization of pasture results in soil fertility depletion. It was estimated that a majority of the native grassland has a carrying capacity of only 0.25 AU/ha, and is capable of producing 15-25 kg of meat per ha annually.
2. Low quality of forage fed on a cut-and-carry basis.
3. Inefficient utilization of crop residues and farm byproducts.
4. A need for support services to lessen the constraints facing the livestock industry, such as lack of available seed stock, poor animal nutrition, and lack of trained manpower in forage, pasture, and grassland R & D.

R & D Thrusts/Directions and Priority R & D Areas for Forage, Pasture, and Grassland Commodities

PCARRD's mandate to develop a responsive and dynamic national research and development program necessitates that R & D directions and priority research and development areas be adequately identified. With established research priorities, researchers are given guidance on what areas of concern should receive emphasis in terms of efforts and resources. Likewise, both researchers and donor agencies are provided with criteria on the relevance, timeliness, and worth of proposed research activities.

Priority research areas for forage, pasture, and grassland commodities are presented in Table 1. As with priority research areas of other national R & D commodities, these priority areas were defined and identified by the National Commodity Team, in consultation with the regional R & D staff and private sector, taking into consideration both the national and regional development needs of the livestock sector.

Table 1. Priority research areas for forage, pasture, and grassland commodities (recommended by the National Forage, Pasture, and Grasslands Commodity Team, 6 October 1987).

Priority	Research area
1	Germplasm evaluation and seed production
2	Integration of fodder crops and utilization of farm byproducts in various cropping systems
3	Socioeconomics of fodder crop-livestock integrated farming systems
4	Crop protection
5	Management and utilization of pasture in open grassland and tree plantation
6	Policy studies

National Forage, Pasture, and Grasslands R & D Network

One of the major mandates of PCARRD is to establish, support, and manage the operation of a national network of centers of excellence for the various R & D programs.

Research centers were identified on the basis of: agroclimatic suitability of the area (where the center or station is located) to the production of pasture crops; accessibility of the center or station to the livestock industry and target clientele; availability of R & D expertise in the area; and other livestock industry-oriented considerations.

With this national R & D network, PCARRD envisions making an impact through relevant problem-oriented R & D projects to provide immediate solutions to problems encountered in the various regions where the agencies/institutions are strategically located.

The Forage, Pasture, and Grasslands R & D Network is shown in Figure 2 and Table 2. There are two national centers, namely, the University of the Philippines at Los Banos (UPLB) in Luzon, for smallholder production systems, and Central Mindanao University (CMU) in Mindanao, for ranch-type production systems. The Visayas State College of Agriculture in Baybay, Leyte, is identified as a regional center in the Visayas. There are 21 cooperating stations comprising the stations of the Department of Agriculture, state colleges and universities, and private farms.

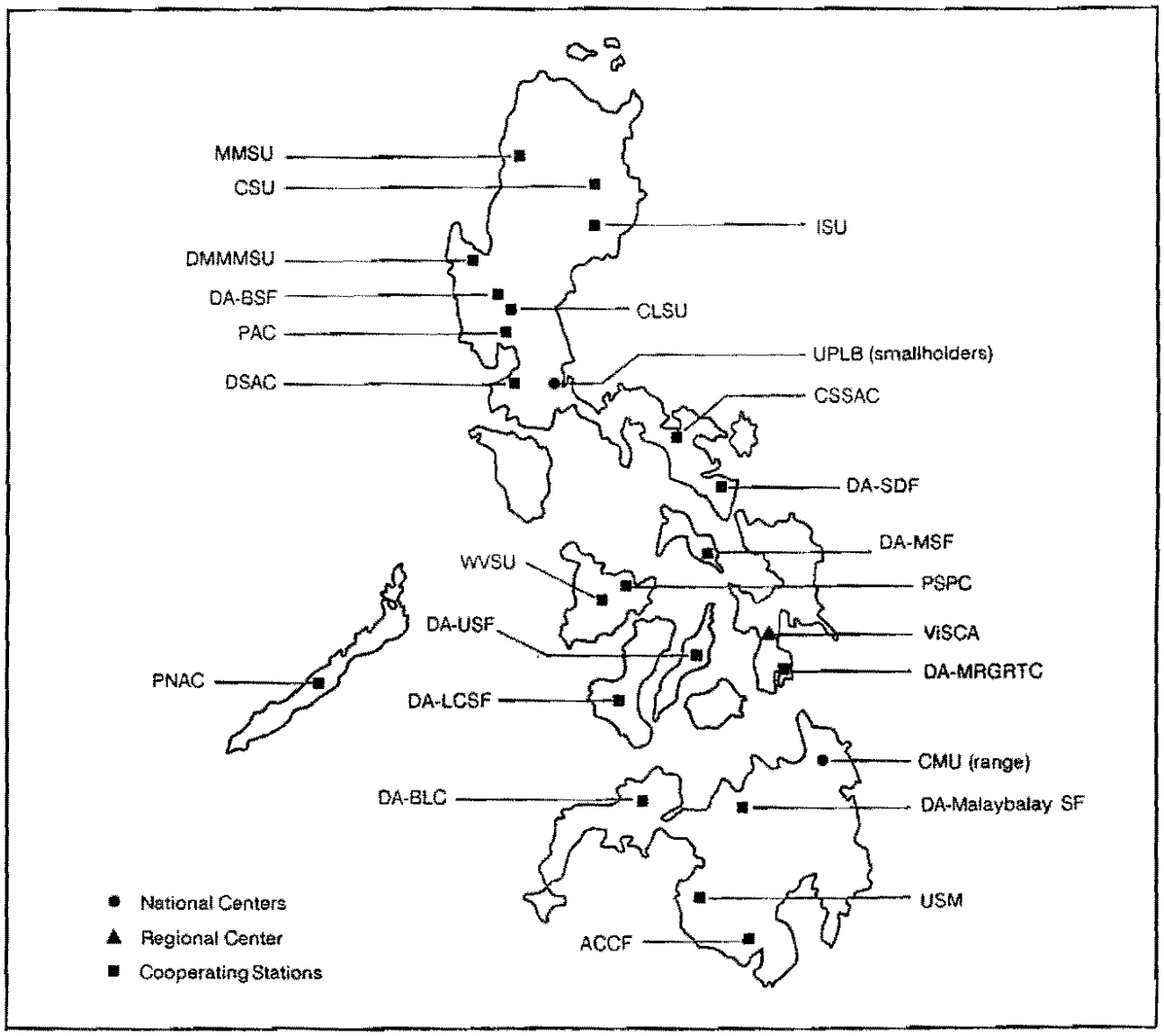

Figure 2. Forage, Pasture, and Grasslands R & D Network.

Table 2. The Forage, Pasture, and Grasslands R & D Network.

R & D centers	Institutions
National center	UP at Los Baños (smallholder farm)
	Central Mindanao University (ranch type)
Regional center	Visayas State College of Agriculture
Cooperating stations	Central Luzon State University
	Mariano Marcos State University (smallholder farm)
	Isabela State University
	Cagayan State University-Piat
	Palawan National Agricultural College
	Camerines Sur State Agricultural College
	University of Southern Mindanao
	Don Mariano Marcos Memorial State University
	DA-Baguio Stock Farm
	Pampanga Agricultural College
	Don Severino Agricultural College
	DA-Milagros Stock Farm
	DA-Sorsogon Dairy Farm
	DA-La Carlota Stock Farm
	DA-Ubay Stock Farm
	DA-Malitbog Regional Goat Research and Training Center
	DA-Baglupa Livestock Complex
	DA-Malaybalay Stock Farm
	ANSA Cattle and Crop Farm
	Panay Polytechnic State College
	Western Visayas State University

Forage, Pasture, and Grasslands Research and Development Program

Completed and ongoing activities

Forage, pasture, and grasslands R & D outputs generated by the national research system cover such disciplines as grassland ecology, soil fertility and legume bacteriology, crop improvement, seed production technology, culture and management, and fodder integration with existing cropping systems.

For the purpose of this consultation meeting, this paper deals largely with what has been done and has to be done as far as pasture crop improvement and utilization are concerned.

Introduction of pasture species was started in 1904 by the defunct Bureau of Agriculture. Since then, the University of the Philippines at Los Baños, the

Bureau of Animal Industry, and other state colleges and universities have taken an active interest in pasture development.

In 1972, the National Cooperative Pasture R & D Program (NCPRDP) was launched to support the national livestock program through the development of improved pastures. The program consisted of pasture seed production, applied research, graduate training, and extension, among other aspects.

A total of 65 grass species and 27 legume species that are being used as livestock feed were identified and evaluated. Twenty-one grass species and 4 legume species showed potential as forage crops.

Accessions of different pasture grass and legume species from international organizations had been evaluated and tested by various government agencies. As a result, 12 species/cultivars of grasses and legumes were initially recommended for pasture improvement and development. Grasses included: Napier grass (*Pennisetum purpureum*), Guinea grass (*Panicum maximum*), Para grass (*Brachiaria mutica*), Kennedy ruzi (*Brachiaria ruziziensis*), Signal grass (*Brachiaria decumbens)*, African Star grass (*Cynodon plectostachyus*), and Alabang x *Dichanthium aristatum.* Legumes included: Centro (*Centrosema pubescens*), Ipil-ipil (*Leucaena leucocephala)*, Stylo (*Stylosanthes guianensis*), Siratro (*Macroptilium atropurpureum*), and Townsville stylo (*Stylosanthes humilis*). The same species are still being recommended up to the present, except for *S. guianensis*, because of its susceptibility to anthracnose.

Vast efforts were also invested in collection, screening, and adaptability trials of leucaena. However, in mid-1985, leucaena plants were severely infested with jumping plant lice (psyllids), resulting in drying and defoliation of most of these trees throughout the country. The infestation brought detrimental effects to the Philippine livestock and poultry industry.

Performance trials for pasture crops were established in five ecological zones that showed the potential of *Brachiaria decumbens* and *B. humidicola*, along with traditional grass species such as Napier, Guinea grass, Star grass, and Para grass for pasture development. The trials also showed outstanding performance of Cook and Seca stylos over other legume species. Detailed results and progress of forage and pasture crop performance trials in different agroclimatic conditions of the country, as well as germplasm collection and evaluation, will be reported by another author.

In the past, results of forage and pasture performance trials conducted in different areas of the country were very difficult to integrate to come up with one "package" recommendation. This is due to the absence of standardized R & D verification/evaluation procedures to follow, unlike in other crops being tested or evaluated for performance under the National Crop Testing Program (NCT). Starting in 1989, however, researchers involved in forage and pasture performance trials will be using one and the same set of criteria. A prepared manual identified the research leader and the lead implementing agencies of the various R & D activities.

Proposed activities

Germplasm evaluation and development of seed production technology are the current priority research areas in forage, pasture, and grassland commodities. At least for the next five years, researchers will focus their attention on these areas of concern. Specifically, the following activities shall be undertaken:

The collection and evaluation of germplasm to improve the existing gene pool of Philippine forage, pasture, and grassland species.

The conducting of performance/adaptability trials of new varieties or species in the different ecological zones or different production systems to determine their performance under these varied conditions. The immediate concern is to identify forage/pasture crops of outstanding performance under plantations and even in problem or marginal soils for cut-and-carry (semi-confinement) and grazing production systems.

Screening for disease resistance of the different forage and pasture species.

Generation of seed production technology to ensure availability of seed stocks for distribution to farmers.

Setting up of seed production centers at strategic locations to produce commercial volume of high-quality seeds of each recommended forage and pasture crop.

All of the above major tasks of the national forage, pasture, and grassland commodity program seek to improve the stability and productivity of the livestock industry.

REGIONAL PERFORMANCE EVALUATION TRIALS FOR PASTURE CROPS IN THE PHILIPPINES

F. A. Moog*

Introduction

The introduction of improved pasture species to the Philippines was started by the now defunct Bureau of Agriculture in 1904, and until the sixties pasture species introduction received great attention. However, there had been no systematic effort to screen and evaluate introductions with the exception of work at the Dairy Training and Research Institute (DTRI) at the University of the Philippines at Los Banos (UPLB) in the late sixties.

The introductions, however, managed to spread around at various government stations and among more progressive farmers, either intentionally or by chance. No records were kept of adaptability, production, reaction to pests and diseases, and the like.

Nevertheless, in spite of the lack of a formal system of regional variety trials, both government workers and farmers have identified over the years (largely through empirical observations) the pasture species which are more adapted and productive under local growing conditions.

In 1973, the Bureau of Animal Industry (BAI) began to take an active interest in developing a pasture improvement program and planted on a much larger scale the most promising species from its small-plot trials at its major stock farms.

Earlier recommendations in the selection of species were mainly based on studies conducted in conditions isolated from UPLB, results of which had limited applications.

Existing Regional Evaluation Trials

In 1985, PCARRD (Philippine Council for Agriculture, Foresty and Natural Resources Research and Development) initiated regional performance

* Philippine Council for Agriculture, Forestry and Natural Resources Research and Development.

evaluation trials for forage crops which are implemented by the Bureau of Animal Industry. Their primary objectives are to set up permanent sites for the national crop trials on forage and pasture; thus, the major criterion considered in site selection is the presence of regular staff who will handle the project long term or on a continuing basis.

Project Sites

The trials were set up in different ecological regions with major livestock concentrations (Figure 1). Characteristics of the sites are shown in Table 1.

Procedure and methodology

The project was the first attempt to have standardized methodology in forage evaluation trials.

Plots measuring 3 x 5 meters were made and laid out in randomized complete block designs with three replications at all sites.

Grass species/cultivars were planted using root stocks and seed at 50 x 50 cm. Legume seeds were drilled in rows 50 cm apart. Species/cultivars tested are shown in Tables 2 and 3. Planting was done at the onset of the rainy season in 1985.

Fertilization was done at the rate of 100-50-50 and 0-50-50 kg N-P-K/ha/year for grasses and legumes, respectively. Weeding was done whenever necessary.

Number of days to seeding and herbage yield were recorded. Incidence of insect and pest attack was also noted.

All grass species were initially cut in October and December 1985 and every 45 days thereafter. Initial harvest of legumes was made in December 1985 and March and April 1986 at Sorsogon, Masbate, Bohol, and Isabela sites, respectively. Initial cutting of both grasses and legumes in Bukidnon was done in April 1986.

Summary of Results

Variations in the performance of the various species at different locations were observed. Table 4 shows the high-yielding species or varieties at different locations arranged according to their performance.

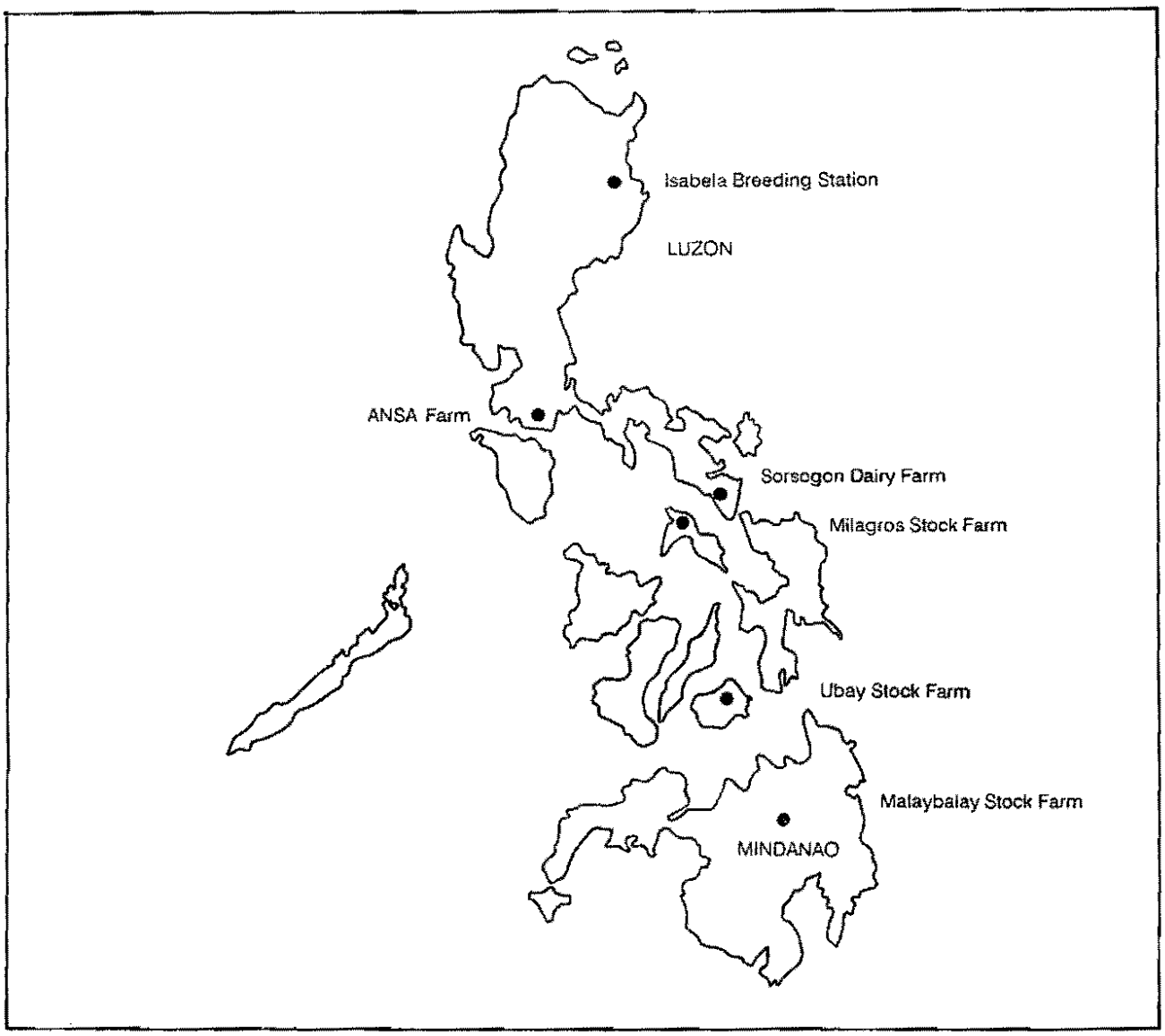

Figure 1. Locations of existing regional evaluation trials for pasture crops.

Table 1. Site descriptions.

Factor	Site					
	Ilagan, Isabela	Milagros, Masbate	Sorsogon, Sorsogon	Ubay, Bohol	Malaybalay, Bukidnon	Lipa, Batangas
Climate	Distinct wet and dry period	No pronounced maximum rain period	No dry season but very pronounced maximum rain period	No pronounced maximum rain period	No pronounced maximum rain period	Distinct wet and dry period
Rainfall						
Annual mean (mm)	1574	2000	2810	1800	2300	2632
No. of dry months	6	1-3	0	1-3	1-3	5
Soils						
Type	Ilagan clay	Ubay clay	Castilla clay	Ubay clay	Adtuyon clay	Lipa clay
pH	5-6	4.9	5-5.9	6.1-6.4	4.6-5.4	5.8
OM (%)	low	5-5.75 sufficient	3	4 sufficient	sufficient	--
P (ppm)	sufficient	15 deficient	10 deficient	16 deficient	12 deficient	sufficient
K	sufficient	deficient	deficient	deficient	deficient	deficient

The trials show the potential of Signal grass (*B. decumbens*) and *B. humidicola* as well as the Setarias in the wet areas of Sorsogon, Masbate, Bohol, and Bukidnon. Their production is comparable to commonly grown Napier and Guinea grass.

Table 2. Grass tested at different locations in the Philippines.

Grass	Location					
	Isabela	Sorsogon	Bohol	Masbate	Bukidnon	Batangas
Guinea grass	x	x	x	x	x	x
Napier	x	x	x	x	x	x
Paragrass	x	x	x	x	x	x
Stargrass	x	x	x	x	x	x
Signal grass	x	x	x	x	x	x
Pangola	x	x	x	x	x	x
USA Buffel	x	x	x	x	x	x
Kennedy ruzi	x	x	x	x	x	x
Nandi	x	x	-	x	-	x
Narok	-	x	-	-	-	x
Kazungula	x	x	x	x	-	-
Splendida	x	-	x	-	x	-
Humidicola	x	x	x	x	-	x
Rhodes (pioneer)	x	x	x	x	-	x
Rhodes (Callide)	x	x	x	x	x	x
Rhodes (Samford)	-	x	-	-	-	x
Rhodes (local)	x	-	x	x	x	-
P. plicatulum	x	x	x	-	x	x
P. notatum	-	x	-	-	-	-
Rodd's Bay	x	x	x	x	x	-
Gayndah	x	x	x	x	-	-
Urochloa (Sabi)	x	x	x	x	x	-
Dallis	-	-	-	x	-	-
S. anceps	-	-	-	-	x	-
Kikuyu	-	-	-	-	x	-
B. brizantha	-	-	-	-	x	-
P. repens	-	-	-	-	x	-
Taiwan Napier	-	-	-	-	x	-

Table 3. Legume species tested at different locations in the Philippines.

Species	Location					
	Isabela	Sorsogon	Bohol	Masbate	Bukidnon	Batangas
Graham	x	x	x	x	x	x
Cook stylo	x	x	x	x	x	x
Seca stylo	x	x	x	x	x	x
Greenleaf	x	x	x	x	x	-
Highworth	x	x	x	x	x	-
Rongai	x	x	x	x	x	-
Siratro	x	x	x	x	x	-
Tropical kudzu	x	x	x	x	x	-
Ipil-ipil	x	x	x	x	x[a]	x
M. axillare	x	x	x	x	x	x
Tinaroo	x	x	x	x	x	-
Cooper	x	x	x	x	x	x
Centrosema	x	x	x	x	x[b]	x
Ovalifolium	-	-	x	x	x	-
Indigofera	-	-	x	x	-	-

a. Three varieties: Cunningham, K-28, and K-8.

b. Two varieties: CIAT line 438 and local.

Among the legumes, Cook and Seca stylos are most outstanding. *Desmodium ovalifolium* also shows potential.

Application of Results

Evaluation trials gave us the opportunity to test a wide range of species/varieties at six locations and their results gave us confidence on what species/varieties to evaluate further in the context of animal utilization and grazing management. Further studies on grass-legume combinations and fertilizer and defoliation requirements could be made among the promising and high-yielding species identified.

Table 4. High-yielding pasture grasses and legumes at different locations in the Philippines.

Type	Location					
	Isabela	Sorsogon	Masbate	Ubay	Bukidnon	Ansa (Lipa)
Grasses	Rodd's Bay Plicatulum	Napier	Guinea	Signal	Signal	Napier
	Napier	Signal	Humidicola	Humidicola	Guinea	Signal
	Humidicola	Humidicola	Napier	Guinea	Napier	Kazungula
	Guinea	Kazungula	Rodd's Bay Plicatulum	Para	Splendida	Humidicola
	Pangola	Narok	Nandi	Splendida	Callide Rhodes	Guinea
	Signal	Guinea	Signal	Pangola	Humidicola	Stargrass
				Kazungula		
Legumes	Cook Stylo	Seca Stylo	Cook Stylo	Seca Stylo	Seca Stylo	
	Seca Stylo	Graham Stylo	Archer	Ovalifolium	Greenleaf Desmodium	
	Centro	Seca Stylo	Seca	Cook Stylo	Cook Stylo	
	Siratro	Ovalifolium	Kudzu	Siratro	Centro	
	Graham Stylo	Kudzu	Graham Stylo	Centro	Siratro	
					Ovalifolium	

New Directions in Forage and Pasture Species Performance Trials

A "Manual on the Regional Performance Trials for Forage and Pasture Crops" had been designed during the PCARRD-sponsored consultation workshop held March 16-17, 1989, involving a number of concerned forage and pasture researchers in the country. During the workshop, research centers and institutions were assigned tasks to concentrate on. Figures 2, 3, and 4 show the different testing sites for three production systems (i.e., cut-and-carry, integration with plantation crops, and grazing). Testing sites have narrowed down the genera researchers will be working on under each production system.

The main feature of the manual is the standardized methodology to be adopted by researchers or institutions involved. In addition, the Institute of Plant Breeding (at UPLB) is given the principal task of handling the observational nursery and the preliminary performance trial (everybody tried to do these before).

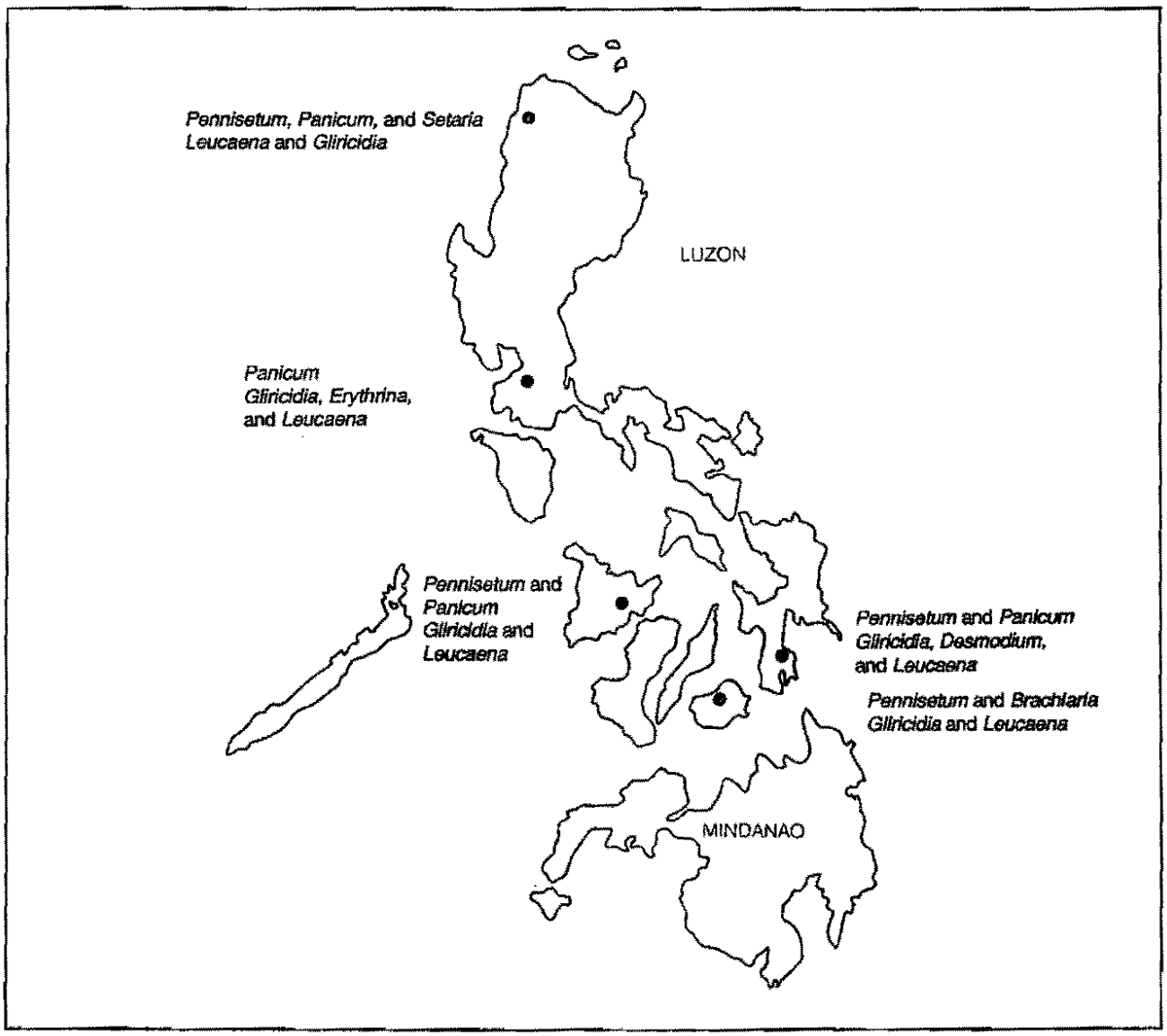

Figure 2. Regional performance testing sites for cut-and-carry production system.

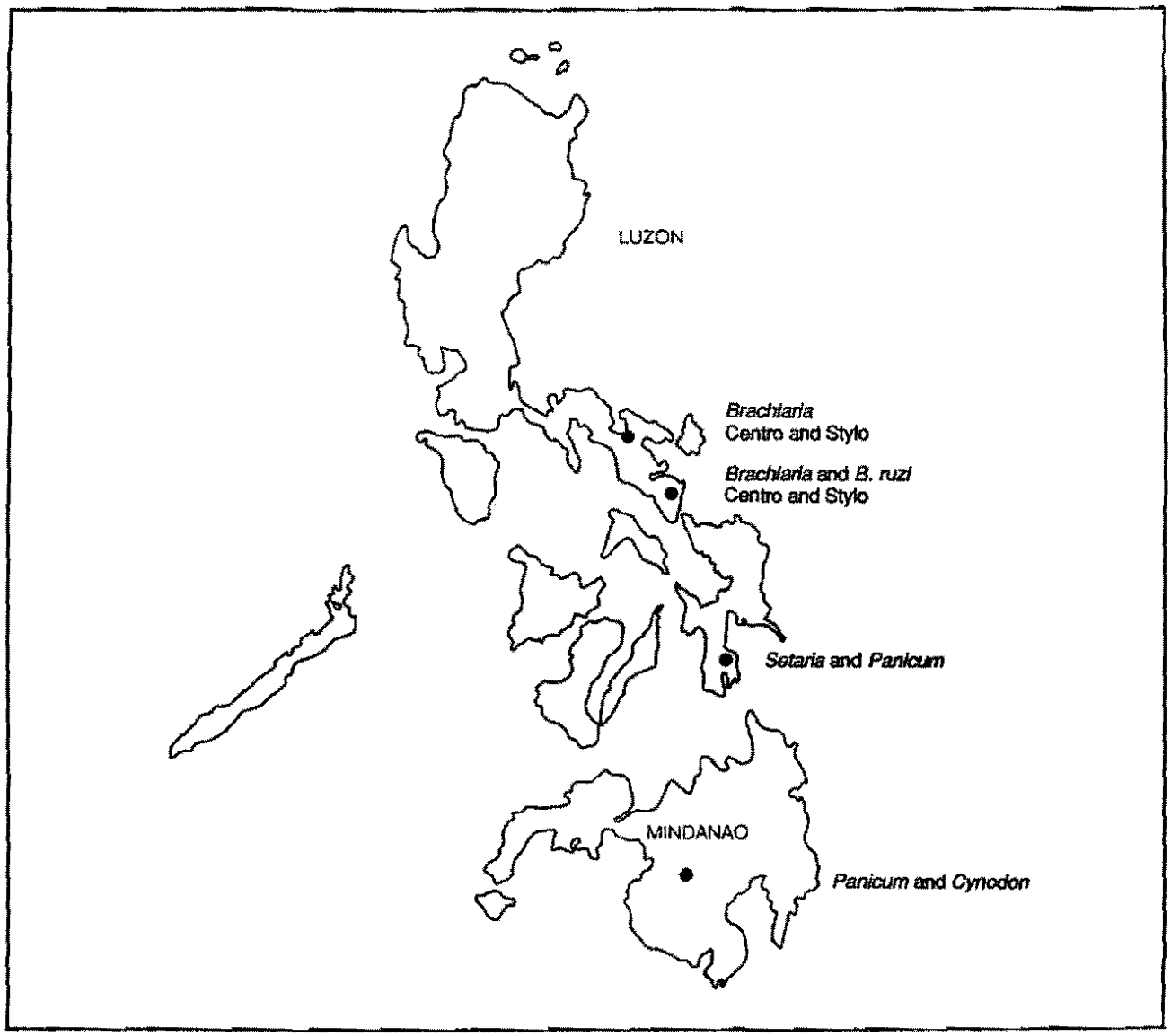

Figure 3. Regional performance testing sites under plantation crops.

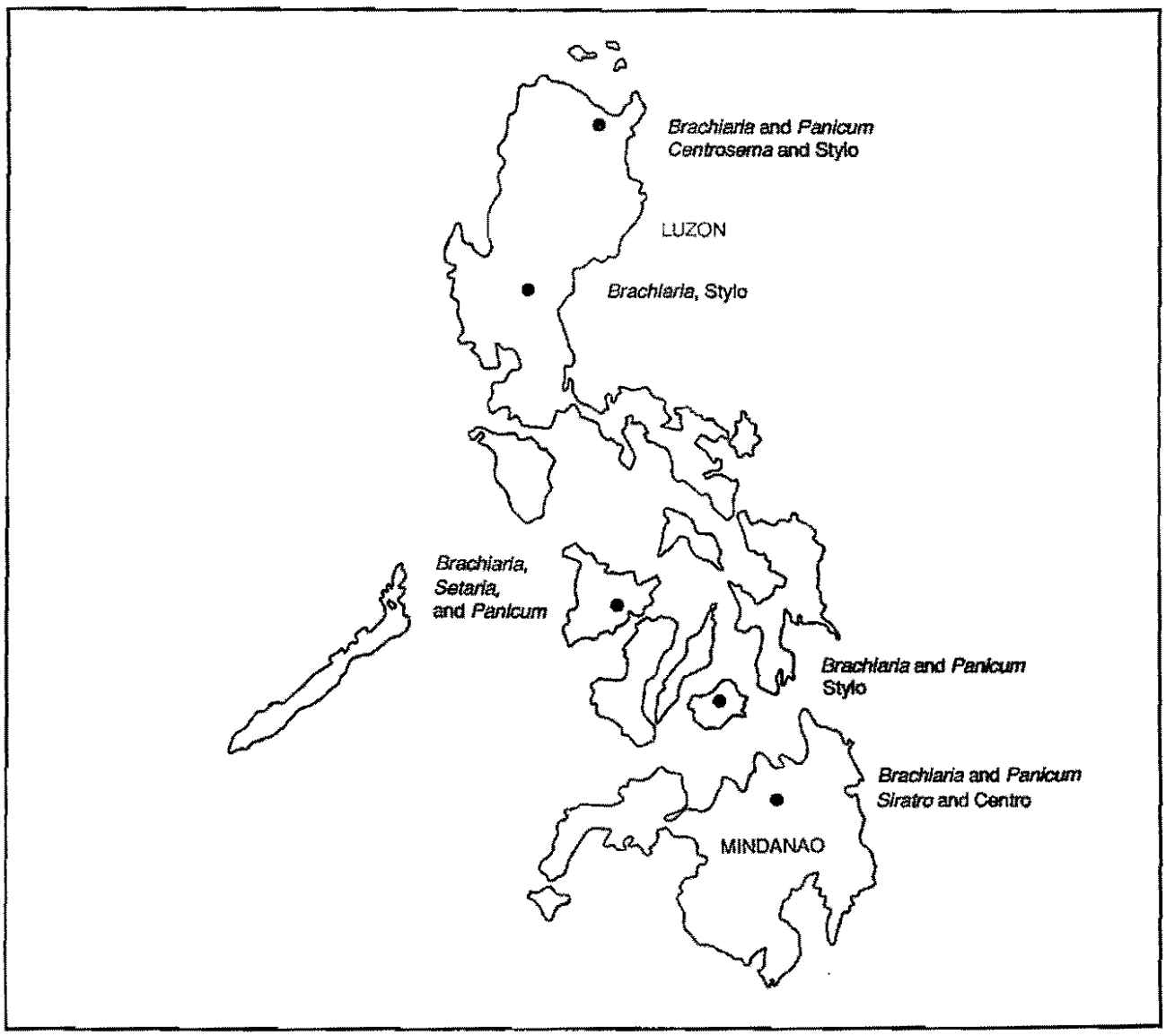

Figure 4. Regional performance testing sites for range/grazing production system.

TROPICAL PASTURE RESEARCH IN CHINA: PRESENT AND FUTURE

He Chaozu and Jiang Houming*

In tropical and subtropical China, there are about 7,000,000 ha of natural grassland, mainly scattered over the hilly area and having very low productivity (2-3 ha of grassland can only carry 1 head of cattle), whose annual meat production is 30-40 kg/head. Recently, the Chinese government has paid attention to grassland development in South China and 30,000 ha of natural grassland have been improved in the region. As a result, 1 ha of improved grassland can carry 1 head of cattle and annual meat production is 120-140 kg/head.

In recent years, because of a shortage of grain and foodstuffs, using forage meal as feed is another important way to improve pasture production in tropical and subtropical China. In Guangdong Province, 5000 ha of forage legumes have been intercropped with fruit trees for forage meal production.

Tropical pasture research is now conducted mainly on introduction and evaluation, forage agronomy, selection, and cultivation techniques. Several varieties have been selected and recommended for commercial use. Advances have also been made in pasture development.

Current Research

The South China Academy of Tropical Crops (SCATC) first conducted tropical pasture research in China in the late 1950s, with introduction and evaluation of tropical pastures being carried out at the institution. SCATC has directly or indirectly released most cultivars used for tropical pasture production in China. In 1986, a Tropical Pasture Research Center was set up at SCATC and provided with instruments and devices by the Ministry of Agriculture. The Tropical Pasture Research Center has 12 researchers, including 2 senior research fellows and 2 research associates, carrying out the following research projects on tropical pastures.

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1. Tropical pasture germplasm collection, introduction, evaluation, and selection.

In collaboration with the Centro Internacional de Agricultura Tropical (CIAT), the Tropical Pasture Research Center has collected native pasture germplasm in tropical China (mainly on Hainan Island) and introduced exotic germplasm, maintaining over 700 accessions of grasses and legumes. Regional trials were conducted with some superior grasses and legumes in different ecosystems after preliminary evaluation. Besides the Australian varieties, *Stylosanthes guianensis* CIAT 184 was released to farms in 1987, and over 1000 ha were established by 1988, mainly by intercropping with fruit trees for forage meal production. Some promising accessions, *Brachiaria decumbens* CIAT 606, *Andropogon gayanus* CIAT 621, and Kinggrass, among others, are under trials.

2. Cultivation and utilization of *Leucaena leucocephala*.

Research has been done on introduction, evaluation, ecology, biology, and cultivation techniques of *L. leucocephala*. Superior varieties have been screened with suitable cultivation techniques (rhizobia nodulation, planting density, cutting, fertilizer application, etc.). A germplasm garden of *Leucaena* (including 72 accessions of *L. leucocephala* and another 8 species of the genus) was set up for maintenance. Over 2000 ha of *L. leucocephala* were established by 1988, for forage, reforestation, firewood production, and shade trees for coffee.

3. Tropical pasture development.

Research on tropical pasture development at the Tropical Pasture Research Center is aimed at 700,000 ha of natural grassland in Hainan, where cattle and goats graze with poor management and low productivity. Developing techniques of establishment and management of artificial grassland and selecting suitable grass-legume associations are under way in research. On Hainan Island, there are about 4000 ha of artificial grassland, yielding 4.5-9.0 t/ha of DM annually, offering a productivity 3-6 times higher than that of a natural one, and its carrying capacity can be double.

4. Tropical pasture seed production.

Tropical China, located on the north edge of the tropics, has low winter temperatures, which affect pasture seed production seriously. But southern Hainan is an ideal place for pasture seed production because of its year-round high temperature and good condition of illumination. Research on tropical

pasture seed production seeks to promote techniques (including seeding, establishment, fertilizer, weed and disease control, harvesting, and cleaning) to increase productivity and quality. In 1988, 20,000 kg of tropical pasture seed were produced in southern Hainan (Table 1), and most of it was sold to mainland China.

5. Research on utilization of tropical forage meal.

After the successful intercropping of forage legumes with fruit trees in Guangdong Province, great importance has been attached to the utilization of tropical forage meal, and the area has increased to 1000 ha. The forage legumes are only varieties of the genus *Stylosanthes,* of which forage meal contains 12%-16% crude protein, and mineral nutrition and vitamins, used as feed for pigs and chickens. Experiments have shown that prepared feed that contains 15% forage meal does not have any significant difference from normal ones, so that large amounts of feed grain are saved, and the cost of foodstuffs is lowered. Ten thousand tons of forage meal were produced in Guangdong Province in 1988. Research emphasized cultivation techniques of forage legume intercropping with fruit trees, along with forage meal processing, feed mixing, and feeding effect.

Highlights and Strategies of Tropical Pasture Research

By 2000, highlights of tropical pasture research in China will be the following:

1. Collection, introduction, maintenance, and identification of tropical pasture germplasm; evaluating, screening, and extending high-yielding, good-quality, and disease-tolerant varieties.

2. Research on ecology and edaphology of tropical grasslands to direct grassland improvement and management toward boosting its productivity.

3. Development of tropical forage meal.

4. Techniques of tropical pasture seed production.

Although the output value of improved tropical grassland is 120-150 Chinese yuan/ha, the average of all grasslands in China is only 15 Chinese yuan/ha, and that of tropical grassland is 30 Chinese yuan/ha. Through strengthening tropical pasture research to improve tropical pasture varieties and grassland management, the following achievements will be made by 2000:

Table 1. Seed yield of tropical pastures (Ledong, Hainan, China, 1988).

Varieties	Area (ha)	Yield (kg/ha)	Total yield (kg)
Stylosanthes guianensis cv. Graham	25	315	7875
S. guianensis CIAT 184	14	300	4200
S. scabra cv. seca	4	450	1800
S. hamata cv. verano	2	975	1950
Melinis minutiflora	6	450	2700
Total	51	--	18,525

1. To screen 5-10 high-yielding, good-quality varieties with high tolerance to climatic, edaphic, and biotic constraints, whose yield will increase 20%-30%.

2. To increase stocking rate to 1.5 AU/ha and annual meat production to 300 kg/ha.

3. Yield of tropical forage meal will be raised to 10 t/ha and forage meal prepared feed will be produced commercially.

Constraints

Because of poor management, improved grasslands degrade seriously on Hainan Island and economic benefits are low. Weeds and shrubs (*Eupatorium odoratum, Vitex trifolia, Harrisonia perforata*, and *Erioglossum rubiginosum*, etc.) for rapid recovery are difficult to control economically.

Large-scale experiments, such as grassland improvement and grazing systems, cannot be conducted because funds are limited.

Since there is no tropical pastures discipline in universities in China, human resources are poor.

Suggestions

Government should increase funds for tropical pasture research and strengthen human resources of the Tropical Pasture Research Center in order to build it up as a multidisciplinary institution in this research area.

International collaboration should be strengthened through exchanging germplasm and information. We hope that international organizations and institutions will support our tropical pasture research with funds and by training researchers.

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PASTURE AND FORAGE CROP RESEARCH WORK IN THAILAND*

Chanchai Manidool**

Introduction

Traditionally, pastures and forage crops have not appeared to play a leading role in Thai agriculture, which is characterized by crop dominance. Rice, cassava, corn, sugarcane, pineapple, and rubber are the main crops that provide the major part of income from the agricultural sector. Most ruminant animals are kept for a farm power source and farming is mainly subsistence type. Thus, the chance to adopt and maintain improved pasture is very low. Growing grass is considered less attractive than other types of farming.

However, appreciable change has occurred over the last few years when price depression of important crops was felt. Since that time, thought has been given to the important role of livestock, especially for ruminant animals, to serve as a buffer or preventive measure against crop failure and price risk. Improvement of stock breeds and provision of necessary services such as artificial insemination, animal health, and pasture seed distribution were urgently made. At the same time, dairy development is rapidly progressing. All these happenings have direct impact on the work of pastures and forage crops in Thailand, and the trend of pasture development is favorable. This can be seen from the trend of forage seed production, which has increased from a few tons in 1975 to 505 tons in 1988, not to mention vegetative planting materials, which account for several thousand tons.

Organization and Resources

Forage research

There is no official national body to coordinate, supervise, or administer research work. Different institutions have their own research programs and

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* Consultation meeting organized by CIAT in Los Banos, Philippines, 11-12 May 1989.

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facilities, and the capacity to perform pasture research depends on the availability of funds, which always fall below par.

Recently, through the Australian Center for International Agricultural Research (ACIAR) program in Australia, the forage research network was established and an in-country coordinator set up with representatives from several institutions being nominated to become core members. The members meet regularly to discuss the research plan. But, problems of financial support still were not solved.

The most active institution doing research on pastures is the Department of Animal Science of Khon Kaen University in the northeast. It is well equipped with both personnel and research facilities. It is interested in plant selection, ley farming, and nutritive-value studies. It also offers postgraduate study on pastures.

Kasetsart University, situated in the low plain of the central region, is also doing some research work on tropical pastures. Its main interests are forage for dairy cattle and high-quality beef fattening. It has established close cooperation with the Dairy Farm Promotion Organization (DPO), which provides necessary facilities for research and dairy training courses. Land and laboratory resources are available, but with limited research personnel. In addition to offering postgraduate courses on pastures, it also accommodates facilities for the International Buffalo Information Center, which disseminates international research information to interested researchers.

The Faculty of National Resources of Prince of Songkla University in the south takes a keen interest in pastures under plantation crops and goat production. One staff member with a Ph.D. in shade tolerance of forages has undertaken a research program on pastures under plantation crops. However, research facilities are inadequate for large-scale programs.

The Department of Agronomy of Chiang Mai University in the north had sometimes engaged in studying forage in highland areas, but could not continue the work after Australian aid terminated. Personnel resources are limited but other facilities are available. Topographically, there is a good opportunity for research on forage for dairy farms and the improvement of highland grazing areas.

The Department of Livestock Development (DLD) of the Ministry of Agriculture and Cooperatives does both research and development and extension work, with the latter activity being the main interest. This institution

is a focal point for pasture work in Thailand. It has large land areas that are used for experimental and seed production purposes, but is handicapped by the rather low caliber of its staff working in the field of forage research. The majority of forage research workers have inadequate training in pasture courses. Most of them are animal husbandry graduates with no or only one course on pastures. They will need further training or education in pasture research techniques. Nevertheless, this institution has performed quite an important role in pasture development of the country, particularly in forage seed production and backyard pastures.

Achievements

The following are considered points of achievement regarding works in pasture research and development.

Species selection and evaluation

Research along this line has resulted in obtaining adaptable forage species. Common Guinea, Hamil, colonial Guinea, ruzi, signal, molopo buffel, sabi, pioneer Rhodes, napier, humidicola, Guatemala, seca stylo, hamata, Graham stylo, Khonkaen stylo, Endevour stylo, centro, leucaena, *Sesbania grandiflora, Erythrina*, and pigeonpea are among the selected and recommended species for upland areas; Plicatulum and Para for the lowland; and centro, *Desmodium ovalifolium*, and cori for plantation crops. *Desmanthus* is under investigation, because it appears to be susceptible to white ant damage at several locations. On the whole, ruzi and hamata are the most important species that are widely utilized.

Backyard pasture program

This program is carried out through the package livestock development program in which animal health, artificial insemination, and forage seed distribution services are started in village areas.

Seed and planting materials are given free to the small farmers who are organized to form cattle-raising groups. Backyard forage growing is mandatory for villagers who wish to receive the mentioned service. Small farmers are encouraged to raise cattle or buffalo for sale and this is treated as a means to generate supplementary income. In order to help the small farmers sell their animals, the Department of Livestock Development has organized several village stock sale yards, which operate weekly. The forage species in use are

Hamil, ruzi, hamata, and leucaena. Backyard pastures are commonly grown in the northeast.

Forage seed production

Considering the difficulty in promoting forage growing in villages where livestock are produced by means of subsistence agriculture, forage seed production is viewed as a most successful operation. Most pasture seed produced at present is from small farmers. This is planned using the concept that a forage crop be treated as a cash crop. That is, seeds are produced for sale similar to other cash crops. Villagers are encouraged to produce forage seeds for sale at a guaranteed price on a contract basis. Seeds and fertilizer are loaned to them in the first year. A production method is demonstrated and extension officers make frequent visits. In 1988, 505 tons of forage seed were produced by 3228 small farmers, and 6000 families are expected to cooperate in the 1989 growing season. The main species produced on a contract basis are ruzi and hamata.

Communal grazing land improvement

For small farmers who own limited land areas, an inadequate supply of green feed is always a problem during the growing season. This is because arable lands are planted in cash crops and limited areas are available for grazing. Therefore, a large number of ruminants are raised on small areas of public grazing land. The government approach to this problem is to improve these areas by oversowing the land with hamata stylo either by hand broadcast for small areas or by helicopter in the case of large areas. Approximately 80,000 ha were improved. Hamata was selected for this purpose because of its superior characteristics (e.g., adaptation to low-fertility soils, better self-regeneration, and tolerance to grazing). The productivity from such improved areas is not high because of very low inputs (e.g., no cultivation and no fertilizer, with seeding rate at 3.5 kg/ha). But the presence of this legume in the areas for a long period is quite satisfactory.

Constraints

Financial problem

At present, forage research is given a low priority and not many government funds are provided to support research programs. The amount available each year is either low or nil for a number of institutions. Recently, three universities that used to be involved in one or two forage programs did

not carry out any research because of a shortage of funds. A small amount could be obtained from the National Research Council, and some universities are seeking funds from this source, but no long-term funds are available. Several researchers gave up and took on another line of crops for their research. For these reasons, grazing trials that will need larger amounts of money are rarely undertaken.

Research personnel

Researchers with an adequate background in pasture research techniques are another problem that makes it rather difficult to meet the needs of pasture development at its greatest potential. In the case of the Ministry of Agriculture, a number of researchers have not had courses on pastures, although some may have had one course. But, in general, they need more thorough training on pasture work. On the other hand, there are quite competent and qualified scientists at the university, but they lack research funds, as stated earlier.

National forage research program

A group of forage workers has made several attempts to establish a core body to carry out the task of coordinating and formulating a national forage program, but this has never been implemented. In addition, funds from the Australian government, through ACIAR, are available for coordination under the forage research network, but funds for carrying out research are not available from the Thai government. My view is that in Thailand no coordination will work without having a central body such as the National Pasture Research Institute to operate the entire research program through its own budget. This institute should allocate research funds for individual organizations depending on their capacity to do research work. For this reason it is recommended to establish the National Pasture Research Institute for this country.

Research Priorities

Selection and evaluation of species

This priority is to be continued and strengthened through plant introduction and testing for specific conditions, such as plantation crops, ley farming, backyard forage for small dairy farms, and management of communal grazing land. The most adaptable varieties should be tested under grazing conditions before release to farmers.

Increasing forage seed yields

At present, very low seed yields of forage crops, particularly for grasses, are obtained. Detailed studies will be needed regarding management, fertilization, harvesting time, and techniques.

Fodder tree program

Although small farmers can afford to grow pastures, they prefer to grow cash crops on their land. These farmers are encouraged to grow fodder trees along hedges or fallow areas. There is particular interest in obtaining varieties that bear some green leaves during the dry season of the year.

APPENDIX

Resolution

It is resolved that the participants at the consultation meeting on tropical pastures from the People's Republic of China, Malaysia, Sri Lanka, Thailand, and the Philippines, collectively referred to as the Southeast Asian countries, recognize the need to establish a regional network for forage and pasture R & D; that the participants strongly recognize the constraints on accelerating R & D in forage and pasture to support livestock production; and that the participants recognize the need to link with regional and international organizations to overcome the following specific constraints:

(1) Lack of trained manpower to implement R & D projects in forage and pasture; (2) need for standardized R & D methodology on forage and pasture; and (3) need for systematic germplasm evaluation to identify appropriate materials for various forage and pasture production systems existing in the region.

Therefore, it is hereby resolved that the participants agree to establish the Southeast Asian Forage and Pasture R & D Network, referred to as the SEAFRAD Network, initially operating within the respective national agriculture and resources R & D systems. Furthermore, the regional network agreed to strongly link with CIAT's TPP and AIDAB/CSIRO on the following activities:

(1) Training; (2) development of R & D methodology; (3) germplasm collection, introduction, and evaluation; and (4) information exchange.

Signed this 12th day of May 1989 at Los Baños, Laguna, Philippines.

CHANCHAI MANIDOOL, Thailand

VAJIRA LIYANAGE, Sri Lanka

HE CHAUZU, China

CHEN CHIN PENG, Malaysia

PATRICIO S. FAYLON, Philippines

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