2791

Annual Report 1983

Tropical Pastures Program

Centro Internacional de Agricultura Tropical

TROPICAL PASTURES PROGRAM

ANNUAL REPORT 1983

INDEX

INTRODUCTION

INTRODUCTION

Beef and milk are staple food commodities of high nutritive value and of basic importance in the diet of the tropical American population. Consumption and preference of these commodities is highly independent of the income levels of the population. Table 1 shows expenditures in beef and milk, in relation to total food consumption of the lowest income strata. In the same manner, as an indication of preference, this Table shows the elasticity of income spent on these food commodities.

In general terms, the growth rate of demand for beef and milk increases more rapidly in the countries of tropical America than the production growth rate (Table 2). This disequilibrium leads to an increase in beef and milk prices which in turn affects the nutritional level and economic status of the lower income groups of tropical America. Cattle productivity in the tropics is low (Table 3) in comparison to that achieved by developed countries and under temperate conditions. This low productivity is due to the extensiveness of production systems, to racial factors related to climatic limitations, and primarily to edaphic limitations conditioning the low quality and availability of the primary resource (pastures) in production systems, especially in marginal areas where cattle production counts with favorable conditions in economic terms (low opportunity cost of the land).

Contrasting with the vast agricultural frontier areas (more than 300 million hectares in savannas and more than 600 million hectares in forests), where a clear misuse of the land is common and where cattle production constitutes an incipient and "pioneer" agricultural activity, a large part of cattle production in tropical America is found, even nowadays, competing with crops in fertile lands destined for agriculture.

These vast agricultural frontier areas can count with an excellent production potential since the solar radiation, the length of growing seasons and the predominantly good physical and topographical soil characteristics are not limiting. However, the predominant chemical characteristics (excessive acidity, aluminum toxicity, and low fertility) constitute the most important limiting factors explaining why these areas were not originally settled and used for food production.

THE PROGRAM'S AREA OF INTEREST

To date the Program's mandate has been concerned with the acid, infertile soil lowlands of tropical America, including the Caribbean countries, southern Mexico, Central and South America, between the tropics of Capricorn and Cancer, where more than 40% of the land of

Table 1. Proportional expenditures in beef and milk and income elasticity of the population in the lowest income quartile of some cities in Latin America.

Country	City	Percentage of expenditure assigned to		Income elasticity	
		Beef	Milk	Beef	Milk
COLOMBIA	Bogotá	18.6	9.6	1.09	0.91
	Cali	24.2	7.0	1.28	1.02
ECUADOR	Quito	12.9	8.7	1.28	0.87
PARAGUAY	Asunción	26.0	11.2	0.80	1.02
PERU	Lima	18.6	11.7	0.92	---
VENEZUELA	Caracas	12.4	13.1	0.80	1.06

CIAT, 1979 Annual Report.

Table 2 Annual demand and production growth rates for meat in various countries of Latin America, 1970-1981.

Region and Country	Growth rate	
	Demand	Production
	%	%
Tropical America	5.3	2.2
Bolivia	4.9	4.9
Brazil	6.1	1.5
Colombia	4.9	3.5
Dominican Republic	6.0	3.4
Ecuador	8.9	5.3
México	4.4	3.3
Paraguay	4.4	-1.1
Perú	3.0	-1.3
Venezuela	4.2	5.4
Central America	4.0	3.3
Caribbean	3.2	2.0
Temperate Latin America	1.7	3.2

Latin America: Trends in CIAT Commodities. CIAT, 1983.

a) Selection of pasture germplasm adapted to the prevailing environmental (climate and soil) and biotic constraints (pests and diseases).

b) Development of persistent and productive pastures.

c) Integration of new pasture technology into biologically, ecologically, and economically efficient animal production systems.

Organization

In accordance with the three strategies mentioned above, the Tropical Pastures Program is divided in three interdisciplinary units or research groups:

a) Germplasm Evaluation

b) Pasture Management and Evaluation

c) Pasture Evaluation and Production Systems

The Germplasm Unit centers its attention on the collection, selection, characterization, and development of legumes and grasses adapted to acid, infertile soils and tolerant to pests and diseases.

The Production Systems Unit analyzes production systems prevailing in a specific area, the socioeconomic conditions under which the systems operate and their implications to pasture technology. This team defines the improved pastures component needed to strategically solve and correct the critical constraints at the farm level, and evaluates the expected impact of improved pasture-technology alternatives on production systems.

The Pasture Management Evaluation Unit serves as a bridge between the two other units. Starting from characterized germplasm provided by the Germplasm Unit, it assembles pastures that fulfill the Production Systems Unit's requirements and concentrates its efforts on the development and evaluation of pastures under different management schemes, measuring animal productivity potential.

Figure 2 shows the flow of germplasm through the Program's structure, as well as the participation of national institutions collaborating with the development of new pasture technology.

As germplasm flows through the evaluation sequence, the number of introductions passing through different stages becomes smaller. Figure 2 also shows this decrease, depending on the intensity of the evaluation, starting from Category I - "Identification of germplasm with potential"; continuing to Category II - "Agronomic evaluation in small plots"; then to Category III - "Agronomic pasture evaluation"; followed by Category IV - "Evaluation of animal production potential and pasture management"; ending with Category V where pastures are evaluated in animal production systems. The final step of cultivar and technology

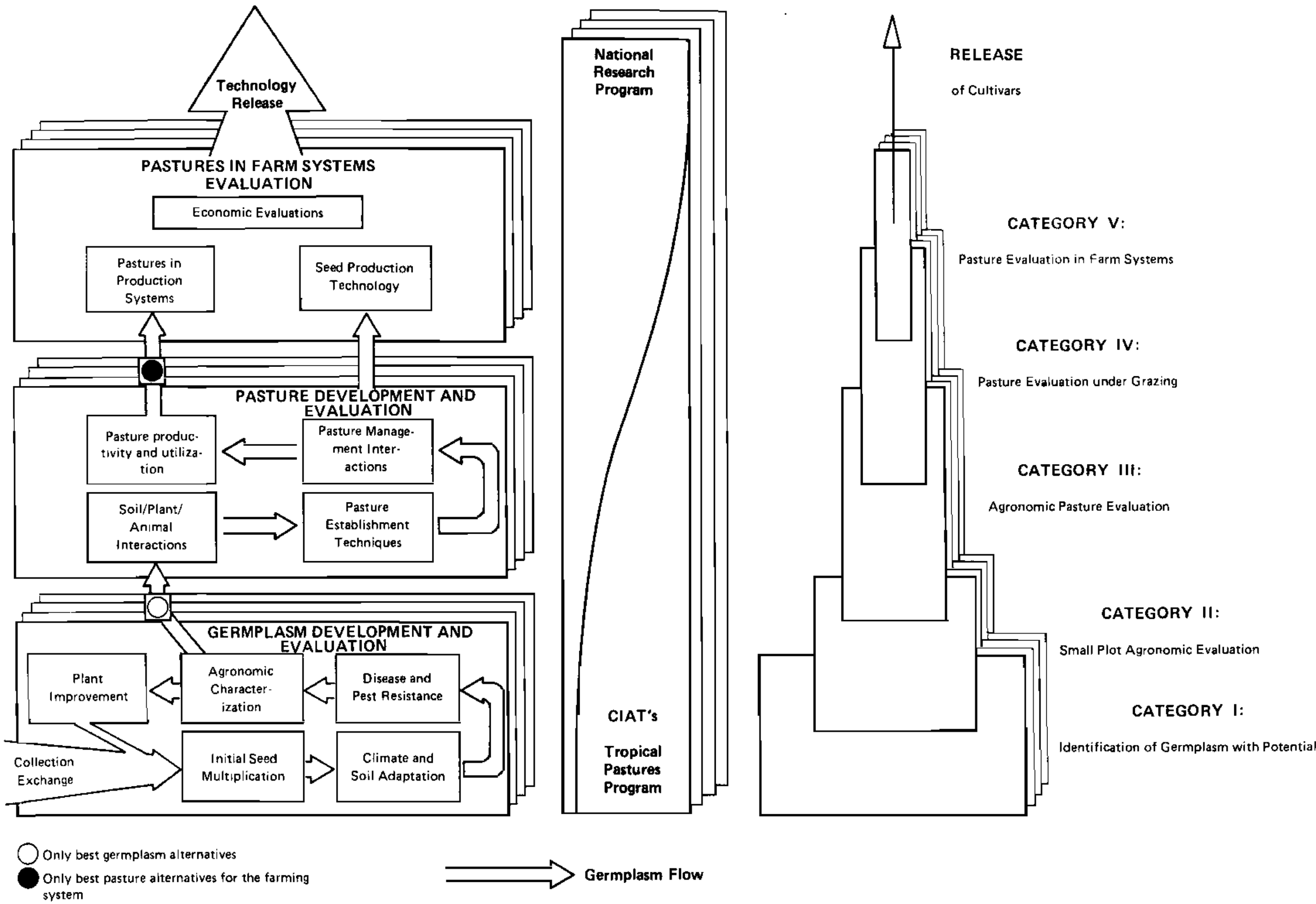


Figure 2. Organization of the Tropical Pastures Program: germplasm flow and participation of national programs in the evaluation process.

release to the public is a responsibility exclusive to the national institutions.

The Program's main screening sites are Carimagua (in the Llanos Orientales of Colombia), in collaboration with ICA (Instituto Colombiano Agropecuario), for the Llanos ecosystem; and CPAC (Centro de Pesquisa Agropecuaria dos Cerrados) in Brazil, in collaboration with EMBRAPA, for the Cerrados ecosystem. In addition, initial evaluation stages and seed multiplication take place at the FES-CIAT Quilichao station. Due to its proximity to headquarters, this station is also used for specific studies on such aspects as nutritional evaluation and methodology in addition to training activities.

A key activity within the Program's work is the International Network for the Evaluation of Tropical Pastures (RIEPT), a multi-institutional activity through which national programs evaluate tropical pasture germplasm (from national institutions and the CIAT germplasm bank). This network follows progressive steps for evaluating the adaptability and productivity of promising materials. This screening procedure complements the major screening work done in Carimagua and Brasilia.

Figure 3 shows the RIEPT structure. The information generated by the Tropical Pastures Program and national institutions belonging to this network is processed in data banks which constitute, in general terms, the Program's data base. This information is available to all members of the network. In this way, the use of available information is maximized; unnecessary duplication of efforts is avoided and horizontal technology transfer is achieved.

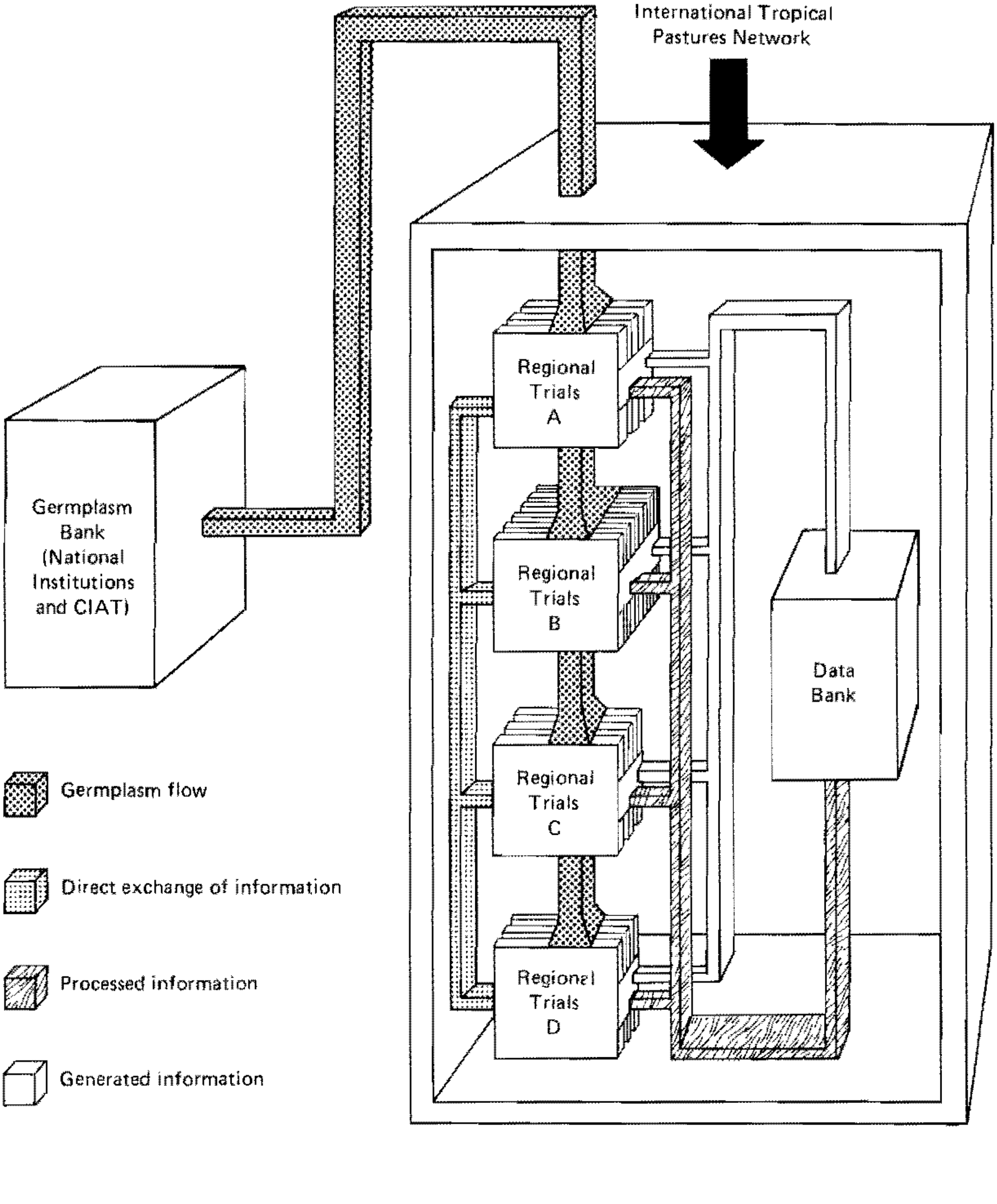


Figure 3. Organization of International Tropical Pastures Network.

GERMPLASM

During 1983 the Germplasm Section continued to concentrate on:

1) assembling of germplasm through direct collection and through exchange of material with other institutions;
2) multiplication and maintenance of legume germplasm;
3) characterization and preliminary evaluation of legume germplasm;
4) classification and documentation of germplasm.

COLLECTION AND INTRODUCTION OF GERMPLASM

Since the beginning of 1983 the responsibility for the collection and introduction of grass germplasm was gradually assumed by the Program's Forage Breeding/Agronomy Section (which has been handling the preliminary evaluation of grass material since 1981), while the activities of the Germplasm Section concentrated more on forage legumes.

Collection

During 1983, two major collection trips were conducted, both of them in regions with acid, infertile soils:

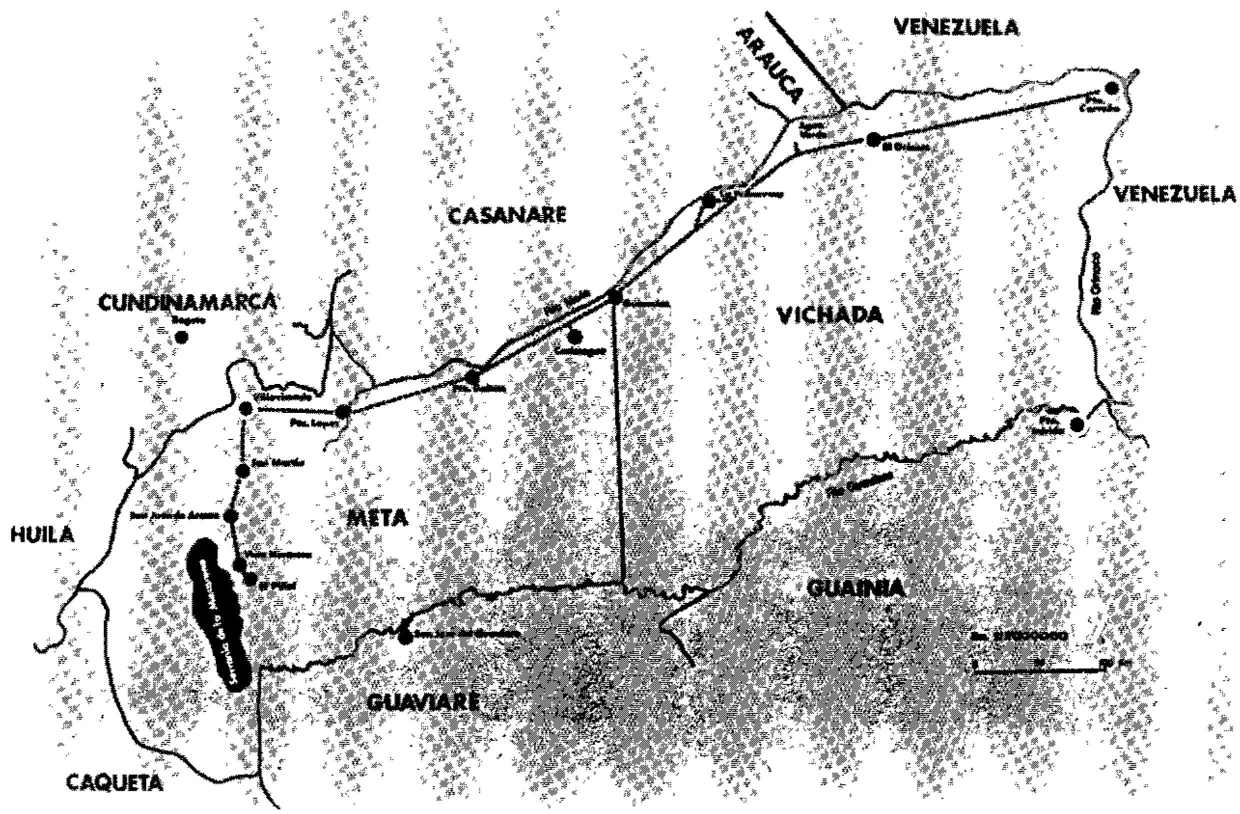
1. A collection expedition in the Colombian Llanos Orientales in February 1983, with the objective to increase the genetic base of *Centrosema* spp. (mainly *C. macrocarpum*) and *Zornia* spp. This trip covered the route from Villavicencio northeast to Puerto Carreño (Orinoco river) and from Villavicencio south to the Sierra La Macarena (Figure 1).

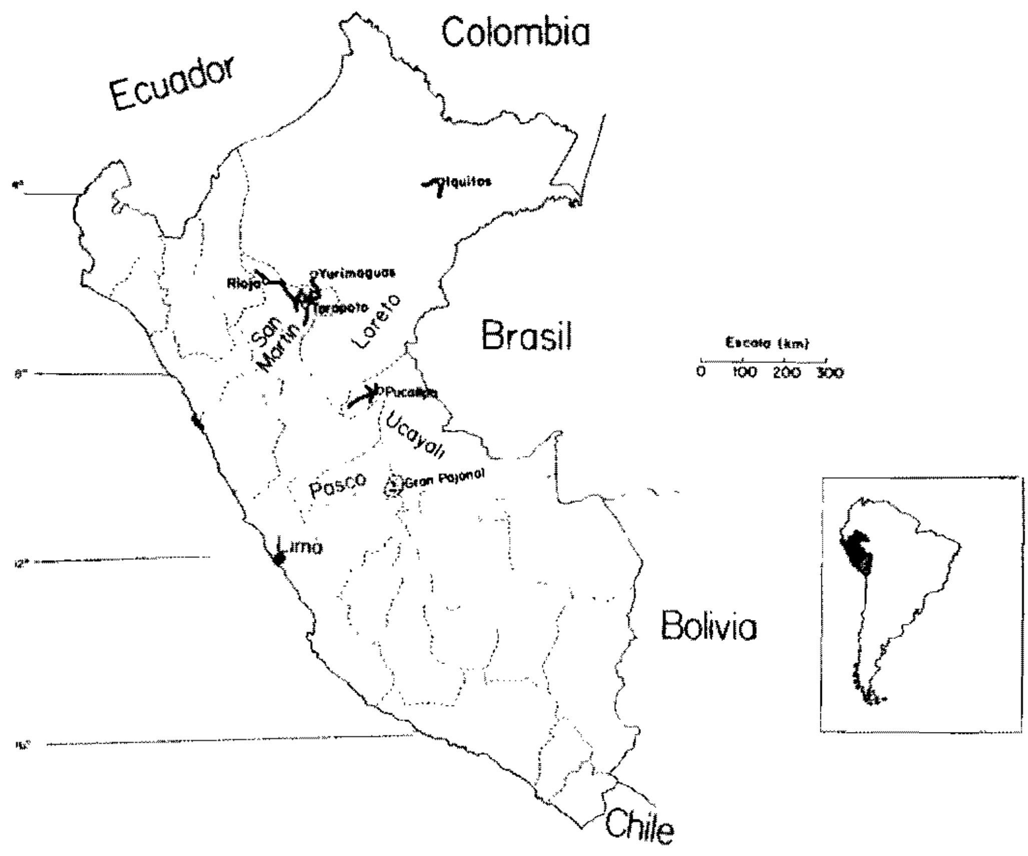
2. An exploratory collection trip in the humid tropics of Peru, where in August/September the regions of Tarapoto (Departamento San Martín), Yurimaguas, Iquitos and Pucallpa were sampled, as well as the Chequitavo and Obenteni area in the Gran Pajonal (Figure 2). These collections were made in collaboration with the Peruvian Instituto Nacional de Investigación y Promoción Agropecuaria (INIPA) and Instituto Veterinario de Investigaciones Tropicales y de Altura (IVITA).

The results of these collection trips are summarized in Tables 1 and 2.

Introduction

With respect to the introduction of germplasm through exchange with other institutions, an important achievement during 1983 has been the introduction of a *Panicum maximum* collection of 290 accessions donated by the French ORSTOM. Further important collections received from





Figures 1 and 2. Routes of systematic collection of tropical legume germplasm in the Llanos Orientales, Colombia and the humid tropics of Peru, respectively.

Table 1. Summary of tropical forage germplasm collected in the Llanos Orientales, Colombia (February 1983).

Species		No. of Samples
Stylosanthes guianensis		19
Desmodium		28
barbatum	14	
incanum	6	
scorpiurus	1	
adscendens	1	
distortum	1	
cajanifolium	1	
sp.	4	
Zornia		17
latifolia (?)	16	
guanipensis	1	
Aeschynomene		10
falcata	3	
brasiliana	2	
paniculata	2	
sp.	3	
Centrosema		35
macrocarpum	21	
acutifolium	7	
angustifolium	4	
pubescens	3	
Macroptilium/Vigna		20
Calopogonium		6
caeruleum	4	
sp.	2	
Miscellaneous legumes*		27
Paspalum plicatulum (grass)		2
Total		164

* *Crotalaria*, *Canavalia*, *Cassia*, *Clitoria*, *Dioclea*, *Eriosema*, *Galactia*, *Pueraria*, *Rhynchosia*, *Tephrosia*, *Teramnus* and unidentified genus.

Table 2. Summary of tropical forage germplasm collected in the humid tropics of Peru (August/September 1983).

Genera	No. of Samples Collected in: Dpto.San Martin and Yurimaguas region	Iquitos region	Pucallpa region	Gran Pajonal	Total Samples
Aeschynomene	11	1	5	-	17
Calopogonium	12	1	1	3	17
Canavalia	1	-	-	3	4
Centrosema	11	-	5	1	17
Chaetocalyx	-	-	-	1	1
Clitoria	4	-	-	-	4
Crotalaria	1	-	-	1	2
Desmanthus	4	-	-	-	4
Desmodium	28	2	9	6	45
Dioclea	2	-	4	-	6
Galactia	2	-	-	-	2
Macroptilium/*Vigna*	8	1	1	2	12
Rhynchosia	8	-	-	-	8
Stylosanthes	10	-	-	5	15
Tephrosia	1	-	-	-	1
Teramnus	13	-	-	2	15
Zornia	8	-	-	-	8
Total	124	5	25	24	178

other sources include legume material from INTA, Salta, Argentina (200 accessions, mainly Vigna, Galactia, Rhynchosia and Desmodium) and EMBRAPA-CENARGEN, Brasilia, Brazil (90 Stylosanthes accessions).

With the additions during the year, the collection of the CIAT Tropical Pastures Program increased to a total of 11,300 accessions (Table 3), the majority of which originate from regions with acid, infertile savanna and forest soils.

MULTIPLICATION AND MAINTENANCE OF LEGUME GERMPLASM

Multiplication of legume germplasm and its distribution to other sections within the Tropical Pastures Program as well as to collaborators outside CIAT, continued to be one of the section's important service functions. During 1983, the seed multiplication activities essentially consisted of:

- Germplasm multiplication from potted plants in the Palmira greenhouse and/or from individual plants in specific germplasm multiplication fields in CIAT-Palmira or CIAT-Quilichao (approximately 1350 accessions).
- Initial seed increase of all germplasm material under preliminary evaluation in CIAT-Quilichao (approximately 850 accessions).
- Seed rejuvenation of the collection of Stylosanthes guianensis (common forms) for long-term storage (approximately 800 accessions).

Distribution of germplasm during 1983. Approximately 2100 small seed samples were provided to members of the Tropical Pastures Program and to collaborators outside CIAT.

CHARACTERIZATION AND PRELIMINARY EVALUATION OF GERMPLASM

During the characterization and preliminary evaluation phase, germplasm of priority or "key" species and new, agronomically still unknown genera and species, is established in CIAT-Quilichao for seed increase as well as for observations of the most important plant descriptors (life form, growth habit, flowering time, perenniality, etc.). On the basis of monthly ratings during a total of 12-24 months germplasm adaptation to the Quilichao environment is assessed, in terms of (a) yield potential on a very acid, infertile Ultisol, including the regrowth after cutting and performance during the two rather short, but severe dry seasons that prevail in Quilichao; (b) disease and insect tolerance, and (c) seed production potential. Establishment and evaluation methodology is equivalent to the Category I evaluation in the Program's major testing sites, and is based upon unreplicated, space-planted rows (Figure 3). These preliminary evaluation observations assist in defining which materials should be given priority in the flow of germplasm to the Program's principal testing sites in Carimagua and Brasilia. Those species (Centrosema spp., Zornia spp.), for which CIAT-Quilichao edapho-climatic conditions can be considered representative of testing sites in other ecosystems or sub-ecosystems where, however, no major screening site

Table 3. Introduction of tropical forage germplasm through direct collection and exchange with other institutions during 1983 (No. of accessions).

Genera and Species	Collections			Exchange	Total	Total
	Colombia (Llanos O.)	Perú	Occasional		1983	Collection Nov.30, 1983
Stylosanthes	19	15	39	124	197	2556
Desmodium	28	45	29	33	135	1436
Zornia	17	8	14	3	42	824
Aeschynomene	10	17	21	-	48	551
Centrosema	35	17	21	9	82	1063
Macroptilium/*Vigna*	20	12	9	25	66	820
Calopogonium	6	17	4	-	27	174
Galactia	1	2	4	38	45	396
Miscellaneous legumes	26	45	37	114	222	2337
Total legumes	162	178	178	346	864	10157
Andropogon gayanus	-	-	-	1	1	66
Brachiaria spp.	-	-	-	2	2	198
Panicum maximum	-	-	-	290	290	668
Miscellaneous grasses	2	-	-	-	2	202
Total grasses	2	-	-	293	295	1134
Total	164	178	178	639	1159	11291

Figure 3. Characterization and Preliminary Evaluation (Category I) of legume germplasm in space-planted rows in CIAT-Quilichao.

Figure 4. Agronomic evaluation (Category II) of selected *Zornia* sp. germplasm in space-planted plots in CIAT-Quilichao.

is available, selected accessions undergo agronomic evaluation at a Category II level (cutting trials in replicated, space-planted plots; see Figure 4).

In preliminary evaluation experiments that were concluded in 1983, a series of new materials was identified as promising or particularly interesting within the priority species as well as within new, agronomically hitherto practically unknown material; in the subsequent evaluations at the Program's major screening sites, they merit priority and particular attention (Tables 4 and 5). It has to be pointed out that for the priority species Stylosanthes capitata, S. guianensis "tardío" and S. macrocephala, in view of ecosystem-specific disease problems, CIAT-Quilichao cannot be considered an appropriate selection site, and that the entire collections of these species warrant thorough evaluation in the principal testing sites representative of the two well-drained savanna ecosystems (Carimagua and Brasilia).

In preliminary evaluation experiments that were established in late 1982 or during 1983, approximately 500 accessions are currently being studied (Table 6). Preliminary observations indicate that:

- Centrosema macrocarpum: virtually all material without major disease problems. Accessions from Territorio Roraima/Brazil and Tolima/Colombia with tendency towards less seasonal-flowering. Considerable variability with regard to stoloniferous growth habit.
- Desmodium ovalifolium: considerable variability in flowering time and seed production potential. Several accessions with outstanding dry season performance.
- Desmodium heterocarpon: material extremely variable in adaptation to the Quilichao environment, growth habit, flowering time, leafiness, etc.
- Desmodium spp. and allied genera from S.E. Asia: Moghamia spp. germplasm outstandingly vigorous; some D. velutinum, Phyllodium spp. and Tadehagi spp. accessions very well adapted to Quilichao environment.

Table 7 informs about the agronomic evaluation experiments which are currently conducted in Quilichao at a Category II level with 6 species (262 accessions). One of the very promising species included is the yet unidentified 2-leaflet Zornia species which is native to the humid coastal strip of Eastern Brazil ("Zornia sp. type CIAT 7847"). The 15 accessions included are the result of systematic screening of approximately 700 accessions of 2-leaflet Zornia material during the past years in CIAT-Quilichao. Outstanding traits of this species are perenniality, disease tolerance and very good dry-season performance. Some of the data collected so far are shown in Table 8. There is not too much variation within the collection but the nutritive value of the species in terms of crude protein and phosphorus content in leaves, is very high. This trial forms part of a multilocational

Table 4. Characterization and preliminary evaluation of tropical forage legume species during 1983 in CIAT-Quilichao. Category I evaluations of priority species.

Species	No. of Evaluated Accessions	Observations
Stylosanthes capitata	121	In comparison with the 5 components of cv. Capica, no spectacularly outstanding accessions. Anthracnose incidence to a varying degree. All material recommended for further evaluations in the well-drained savanna ecosystems.
Stylosanthes guianensis "tardío"	76	Anthracnose seems to become a major problem with increasing plant age. A series of accessions with outstanding vigor and seed production potential considerably higher than control accessions CIAT 1280. However, entire collection warrants evaluation in principal testing sites Carimagua and Brasilia.
Stylosanthes macrocephala	40	All accessions anthracnose-tolerant. Entire collection warrants thorough evaluation in the well-drained savanna ecosystems. Late-flowering ecotypes CIAT 2133 and 2403 outstandingly vigorous during the first year but of all accessions poorest regrowth after cut.
Zornia spp. (2-leaflet)	130	Only the disease-tolerant accessions of the yet unidentified species represented by CIAT 7847, worthy for further evaluations. All other material susceptible to leaf and stem diseases, or too short-living annual.
Centrosema sp. (type 5112)	10	With exception of extremely bacterial blight-susceptible accession CIAT 5118 all materials within this new, yet undescribed species warrant further evaluation at Category II level; CIAT 5568 outstanding.
Total	377	

Table 5. Characterization and preliminary evaluation of tropical forage legume species during 1983 in CIAT-Quilichao. Category I evaluations of "new" species.

Species	No. of Evaluated Accessions	Observations
Centrosema spp.	40	Problems of adaptation to Quilichao soil conditions in Centrosema dasyanthum, C. fasciculatum, C. bifidum. C. coriaceum well adapted but flowering and seed-setting problems, furthermore due to very hard leaves doubtful potential as forage plant. C. brachypodum very interesting, further evaluation demanding new species; CIAT 5803 extremely stoloniferous. Profuse flowering of some C. brachypodum ecotypes, but seed production problems.
Centrosema acutifolium, Centrosema schiedeanum	26	All material of both species only deficiently adapted to Quilichao soil conditions and disease problems; poor vigor of most materials. C. schiedeanum CIAT 5201 (cv. Belalto) and 5161 and C. acutifolium CIAT 5601 the relatively most productive accessions.
Calopogonium caeruleum	17	No outstanding new germplasm; however, with respect to disease resistance, general adaptation, vigor and stoloniferous growth habit, 3 accessions superior to control.
Dioclea guianensis	16	Good adaptation of all material; 5 accessions outstandingly superior to control, with respect to vigor and general adaptation. No major disease problems.
Total	99	

Table 6. Characterization and preliminary evaluation of germplasm, 1983 CIAT-Quilichao. Category I evaluations not yet concluded.

A. PRIORITY SPECIES	
Stylosanthes guianensis "tardío"	111
Centrosema macrocarpum	101
Desmodium ovalifolium	72
B. "NEW" SPECIES	
Stylosanthes viscosa	60
Desmodium heterocarpon	72
Desmodium spp. and allied genera from S.E. Asia	80
Total	497

Table 7. Agronomic evaluation of selected germplasm, 1983 in CIAT-Quilichao. Category II evaluations not yet concluded.

A. PRIORITY SPECIES	
Centrosema brasilianum	130
Centrosema macrocarpum	12
Desmodium ovalifolium	85
Zornia sp. (type 7847)	15
B. "NEW" SPECIES	
Stylosanthes viscosa	14
Dioclea guyanensis	6
Total	262

Table 8. Multilocational variety trial with 15 accessions of *Zornia* sp. (type CIAT 7847) in CIAT-Quilichao: Cumulative dry matter yields of 3 cuts (8 months), % of leaves in total dry matter, and content of crude protein, phosphorus and calcium in leaves.

Accession CIAT No.	Cumulative Dry Matter Yields	Leaves in Total DM*	Content in Leaves * N x 6.25	P	Ca
	(g/plant)	%			
255	114	40	27	0.61	1.0
278	123	58	28	0.62	1.6
280	123	48	26	0.69	1.0
281	156	40	27	0.61	1.3
283	122	51	27	0.65	1.1
7847	154	51	28	0.52	1.3
8273	118	52	28	0.66	1.0
8278	162	41	28	0.53	1.0
8279	139	45	28	0.52	1.1
8283	145	47	28	0.58	1.3
8297	118	51	28	0.59	1.0
8307	133	42	26	0.60	0.9
8308	117	50	26	0.63	1.0
8343	113	48	29	0.58	1.3
8346	127	45	30	0.58	1.3
Mean	131	47	28	0.60	1.1

* 8-weeks old regrowth (rainy season).

experiment with replications in Carimagua, Brasilia, Sete Lagoas, Belém and Panama.

CLASSIFICATION AND DOCUMENTATION OF GERMPLASM

Within the objective to use electrophoretic patterns of seed proteins or enzymes from seed or other tissues, as a tool for germplasm classification including the very important aspect of identification of genetic duplicates in the collection, some methodological research proceeded during 1983.

Whereas total protein from seeds proved to be appropriate for species distinction within the genus Stylosanthes as well as Desmodium, it was not satisfactory at the species level. Since isoenzymes are known as proteins whose electrophoretic patterns can be genotype-dependent, a series of trials were conducted in order to identify within several Stylosanthes species and within Desmodium ovalifolium the most appropriate isoenzymes and the most appropriate tissues for accession separation. In Table 9 preliminary results are presented as to the identification of the concentration of 13 isoenzymes in different plant tissues. Accordingly, in the case of D. ovalifolium the most appropriate (because of highly enough concentrated) isoenzymes seem to be ADH (Alcohol Dehydrogenase), ME (Malic Enzyme) and PGI (Phosphogluco Isomerase), for Stylosanthes spp. α -EST (α -Esterase) and GOT (Glutamate Oxalacetate Transaminase). Roots seem to be the most appropriate tissue for both species.

Regarding germplasm documentation, in collaboration with CIAT's Genetic Resources Unit and Data Service Unit, the Germplasm Section has produced a computerized 719-page catalog which provides basic "passport" data for the 10,300 accessions which on March 1st, 1983 the CIAT collection of tropical forage germplasm consisted of.

Table 9. Presence* of 13 isoenzymes in different tissues of <u>Desmodium ovalifolium</u> and <u>Stylosanthes</u> spp.

	Roots		Shoot tips		Young leaves		Seeds	
Isoenzyme	D.oval.	Stylo	D.oval.	Stylo	D.oval.	Stylo	D.oval.	Stylo
AcP	3	4	3	3	4	3	1	3
ADH	5	1	3	–	1	1	5	2
DiAP	5	3	3	–	3	3	2	3
α -EST	3	5	4	4	1	2	4	5
G6PDH	2	2	1	–	1	1	2	3
GOT	4	5	2	5	2	–	4	4
MDH	4	3	3	3	3	3	3	3
ME	5	–	5	–	3	–	4	–
Prx	3	5	3	3	2	3	1	1
PGI	5	4	4	3	3	3	5	4
6PGDH	3	3	2	–	2	2	3	3
SKDH	–	2	–	2	–	2	–	2
GDH	–	1	–	–	–	1	–	1

* 5 : Very high concentration
4 : High concentration
3 : Intermediate concentration
2 : Difficult to distinguish
1 : No presence

AGRONOMY/FORAGE BREEDING

The Forage Breeding/Agronomy Section continues to have responsibility for the initial characterization and seed increase (Category I) of forage grass accessions and has begun to embark on some limited initiatives in the direct collection of grass germplasm. Plant breeding and related activities continue to receive the major portion of the Section's resources, with projects in *Andropogon gayanus* and *Stylosanthes guianensis*.

The main *S. guianensis* breeding project made a significant advance in 1983 with the first large-scale field plantings of progenies derived from controlled hybridizations. Complementary breeding and genetic studies continue to provide valuable information directly relevant to improving the efficiency and effectiveness of the main breeding project.

GRASS GERMPLASM

Activities in the initial characterization and seed multiplication of grass accessions increased significantly in 1983. A total of 289 unreplicated introduction plots (up from 176 in 1982) are now being maintained. These include 65 *A. gayanus* accessions (up from 51), 70 *Brachiaria* spp. accessions (up from 31), and 154 *Panicum maximum* accessions (up from 94).

The entire collection of *Brachiaria* spp. accessions has been delivered to the Forage Agronomy Section for evaluation at Carimagua and a large proportion of these materials has been delivered to the Entomology Section for regional evaluations of reaction to spittlebug.

A large and important collection of 290 accessions of *P. maximum* has recently been received from the ORSTOM Genetic Resources Service. This collection will greatly augment the genetic variation available in this species. Propagation of these materials has already begun.

A new initiative in the direct acquisition of forage grass germplasm was begun this year with a three country exploratory trip to Africa. While it was possible to obtain only a very limited amount of material on this trip, direct contacts established with forage researchers will facilitate future germplasm acquisition activities in Africa. The major priority in terms of African grass germplasm collection will be the perennial species of the genus *Brachiaria*.

BREEDING AND GENETICS

Selection in *Andropogon gayanus*

Nineteen clones obtained from 13 germplasm accessions are being evaluated in a replicated crossing block to select parents for a short-statured *A. gayanus* synthetic variety. The objective of this project is to improve the compatibility of *A. gayanus* with some of the less vigorous, but well adapted legumes (e.g. *Stylosanthes capitata* and *S. macrocephala*).

Stylosanthes guianensis breeding project

The major activity continues to be the breeding project in *S. guianensis* which seeks to develop persistent, productive genotypes with improved pest and disease resistance and seed yields (See Ann. Repts. 1981 and 1982).

F_2 Agronomic Trial

In April 1983, the 45 F_2 progenies of an initial, diallel series of crosses among 10 parental lines were established in a replicated, small-plot, agronomic trial at Carimagua. It is now anticipated that a preliminary selection of approximately 10 of the 45 crosses can be made towards year's end. Approximately 50 F_2 individuals within each of these selected crosses will be single seed descended through the F_3 generation during 1984 to produce approximately 500 F_4 families. On the basis of the second-year (1984) performance of the F_2 plots and observations on the F_3 plants, the number of F_4 families to be included in evaluation trials in 1985 ought to be reduced to approximately 200-250.

Bulk advance

A 960 m^2 plot was direct seeded in April, 1983, at Carimagua to a balanced bulk of F_2 seed from all 45 diallel crosses. A stand of approximately 10 plants/m^2 was achieved. This bulk plot was sub-divided into twelve 80 m^2 sub-plots. Every two weeks, beginning on 19 September, 1983, one of these 12 sub-plots is once-over harvested for seed. These harvests will continue until 6 February, approximately two months into the dry season.

The seed harvested from this plot will be used to plant at least three bulk plots in 1984 based on harvest date (early, mid-season, and late) for a second generation (F_3 to F_4), bulk advance.

Natural Selection

During 1983, we are continuing to harvest F_2 seed from replicated, F_1 plots established at Quilichao in 1982 (see Ann. Rept. 1982). This seed will be used to establish a 3-5 ha area under grazing at Carimagua in 1984 to study the effects of natural selection on a highly heterogeneous *S. guianensis* population, in one or more grass/legume associations, under one or more grazing managements.

New crosses

Approximately 100 new crosses (involving seven new parental accessions in addition to most of the 10 original parents) have already been made in 1983 (November). These are presently in the form of F_1 seedlings in the glasshouse. It is anticipated that about this many new crosses can be handled each year, providing a continuing flow of new breeding materials.

The present plan is to advance these and future crosses from F_1 to F_2 in the glasshouse, and handle each cross as a separate bulk from the F_2 to F_3 generation. Bulk F_3 populations will then be evaluated in replicated, direct seeded, agronomic trials primarily at Carimagua and perhaps at additional sites. The bulk advance through the F_2 generation ought to be an efficient means of enhancing seed production potential. A total of 24 parental accessions is currently involved in the crossing program.

OTHER STUDIES

Effect of establishment method in S. guianensis

An experiment to evaluate the effect of three different establishment methods (direct seeding, transplanted seedlings, or transplanted rooted cuttings) on 12 *S. guianensis* genotypes has been terminated with the completion of two full years' data on dry matter yield and flowering prolificacy (see Ann. Repts. 1981 and 1982). The first year's results (summarized in the 1982 Annual Report) suggested that the effect of establishment method disappeared with time. However, second year's data show a small but consistent yield difference among the three establishment methods (Figure 1). No persisting effect of establishment method on flowering prolificacy was detected. Survival was better for direct seeded than for transplanted plants (Figure 2). Striking differences in root morphology were found to persist up to 28 months following planting.

Transplanted seedlings or cuttings lack the strong tap root characteristic of direct seeded plants. It appears likely that under specific conditions (e.g. of high plant density, moisture stress, nutrient deficiency, etc.) this persisting modification of root system morphology due to establishment method could have larger effects on plant yield or persistence than were found in this experiment.

Estimation of outcrossing rate in S. guianensis

Open-pollinated seed was harvested on a single date in late 1982 from 12 white-flowered *S. guianensis* plants in a space planted (1 x 1 m) F_2 population segregating for flower color (1 white:3 yellow). One hundred fourteen plants from each of these 12 open-pollinated, single-plant progenies were transplanted to a field plot at Quilichao in May, 1983.

If no intercrossing had occurred among the white- and yellow-flowered F_2 plants, then all of the 1,368 plants ought to be white-flowered.

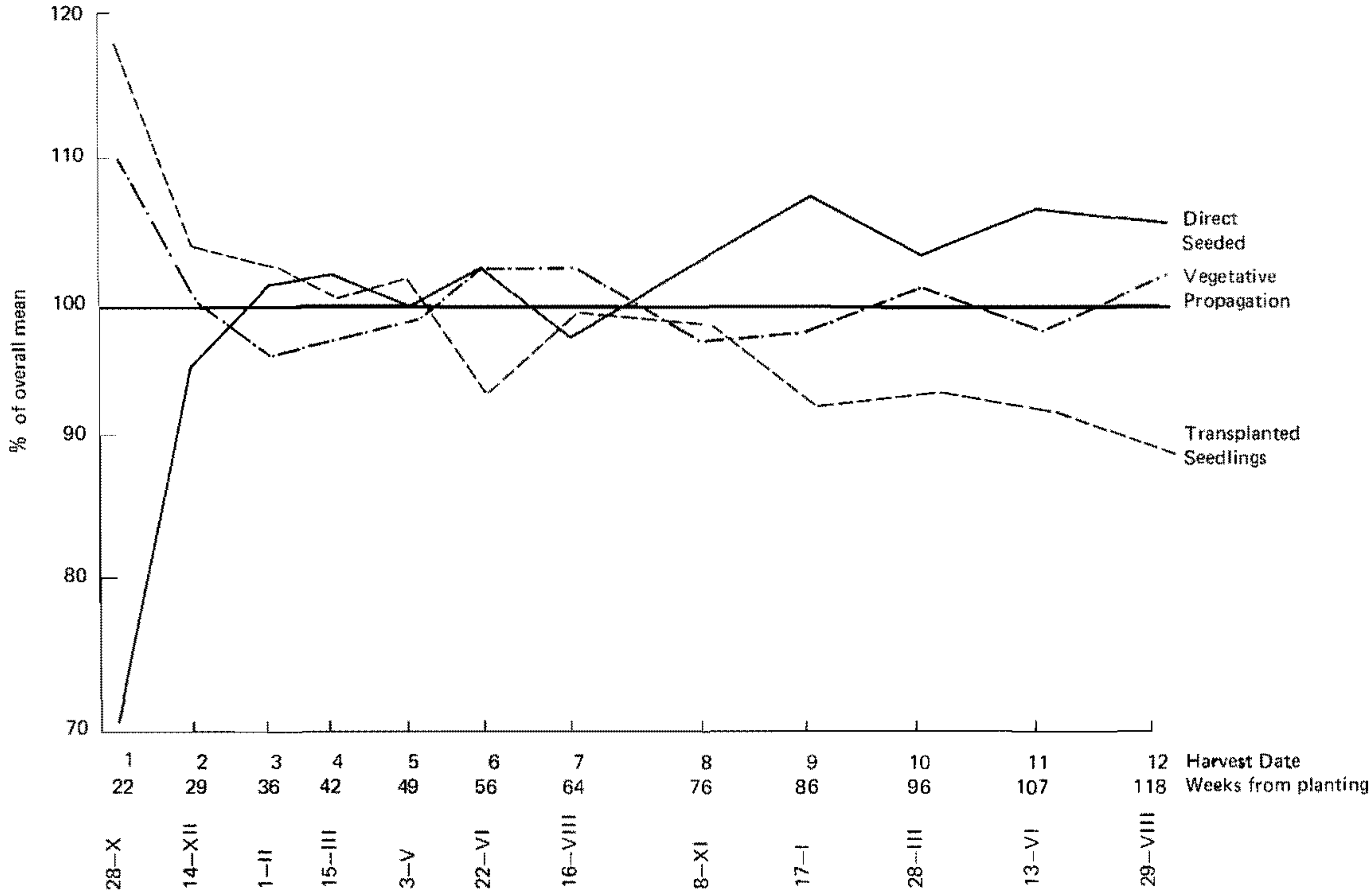


Figure 1. **Relative dry matter yield of *S. guianensis* plants established by direct seeding, transplanted seedlings or transplanted rooted cuttings on 12 harvest dates.**

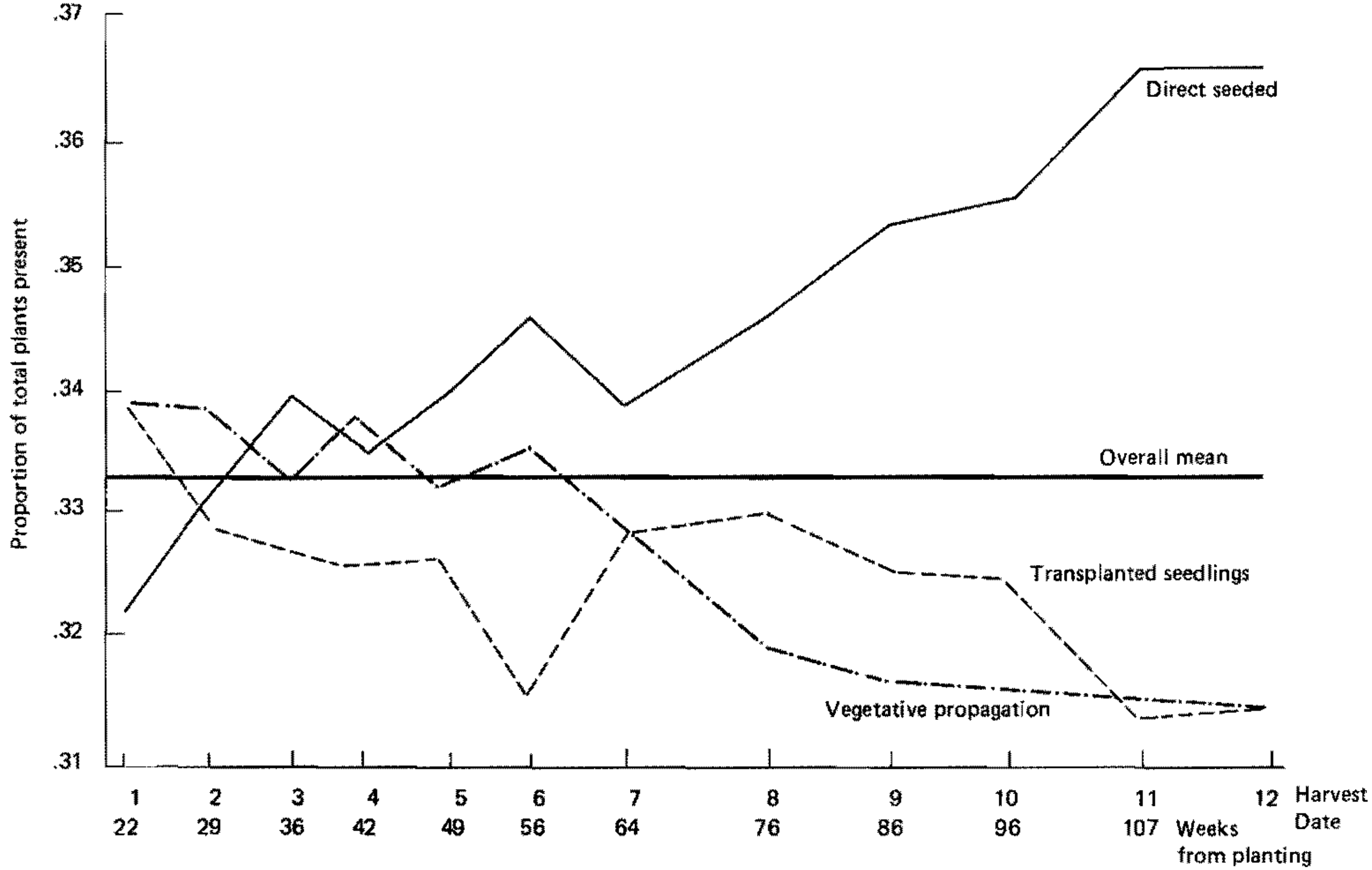


Figure 2. **Effect of establishment method on persistence: proportion of total plants present, by establishment method, over 12 harvest dates.**

These plants began flowering in mid-August. As of 12 November, 1983, 1,336 plants had flowered, of which 90 (6.7%) were yellow-flowered. Since approximately one-half the total number of outcrosses would be unidentifiable (due to the male gamete's carrying the recessive gene for white flower color) an estimate of total outcrossing rate is obtained by doubling the proportion of yellow-flowered progenies observed. This estimate of outcrossing rate (13.4%) applies, of course, only to the genotypes tested (a single F_2 population of the cross CIAT 1021 x CIAT 2160) and to the particular conditions under which the F_2 was grown. This is the first quantification of outcrossing rate in S. guianensis and suggests that appreciable outcrossing can occur in the species.

Restricted lesion reaction to anthracnose

The results of a seedling screening of the F_2 population of a cross between an anthracnose-susceptible S. guianensis line and a line (CIAT 1949) exhibiting a restricted lesion reaction to anthracnose indicated that the resistant reaction is probably of rather simple inheritance (Ann. Rept., 1982). The accession CIAT 1949 has been used in several additional crosses and progenies of these will be included in routine field evaluations to determine the real potential of this source of resistance.

Effect of defoliation frequency on anthracnose reaction in S. guianensis

An experiment at Quilichao in collaboration with the Plant Pathology Section designed to evaluate the effect of defoliation frequency (every 4, 8, or 12 weeks, plus uncut control) on the anthracnose reaction of 40 S. guianensis accessions (see Ann. Rept., 1982) is nearing the completion of 48 weeks of defoliation treatments. Although we are awaiting completion of this trial to analyze data, observations would suggest that those defoliation treatments which largely prevent flowering and seed set of particular accessions also reduce the severity of anthracnose on these same genotypes. These observations, if confirmed, have obvious relevance to the design of techniques for the reliable field evaluation of diverse S. guianensis genotypes for reaction to anthracnose: if plants are allowed to grow uninterruptedly, inherent reaction to anthracnose will be confounded with the effects of the natural senescence associated with flowering and seed set.

Genetic variation among and within 'Capica' component accessions

Ten random S_1 progenies in each of the five component accessions of the S. capitata cv. 'Capica' (component accessions CIAT 1315, CIAT 1318, CIAT 1342, CIAT 1693, and CIAT 1728) were sown in April, 1983, at Carimagua in a six-replicate trial.

Germination was uneven: poor germination seemed to be associated particularly with progenies from CIAT 1693 and CIAT 1728. This appears to be a real accession difference since seed of all progenies of all accessions was produced and processed (hand scarification) at the same time and under identical conditions in the glasshouse at Palmira. If this accession difference in seed quality (perhaps a difference in seed testa hardness or in embryo dormancy) is, indeed, real and consistent, it would appear to be of sufficient magnitude to cause very rapid diminution in the contributions of accessions CIAT 1693 and CIAT 1728 to the cv. 'Capica'.

Due to uneven stands, it will be impossible to fulfill the original objectives of this experiment which included determinations of dry matter forage yield and seed yield. However, ratings of flowering prolificacy and growth habit were made in September, 1983. For each trait, an independent rating (on a 0 to 9 scale) was given each progeny on three consecutive dates. The three values were averaged and analyzed (Tables 1 and 2). For both traits small, but significant, differences among component accessions were detected. For flowering prolificacy, variation among progenies within component accessions was as large as that among accessions. Only accessions CIAT 1315, 1318, and 1342 exhibit within-accession variability. CIAT 1693 and 1728 gave no evidence of containing genetic variation.

Table 1. Summary of the analysis of variance of flowering prolificacy score+ on single-plant progenies of the five "Capica" component accessions.

Source of Variation	Degrees of Freedom	Mean Square	F-Value
Replications	5	4.20	
Accessions	4	10.20	5.5**
Reps. x Acces. (Error a)	20	1.90	
Progenies (Accessions)	45	9.27	10.2**
Progenies (1315)	9	14.42	15.9**
Progenies (1318)	9	14.43	15.9**
Progenies (1342)	9	15.40	16.9**
Progenies (1693)	9	0.95	1.0
Progenies (1728)	9	1.18	1.3
Error b	221	0.91	

+ = Flowering prolificacy score is the mean of ratings taken on a progeny basis on a 0 (no flowering) to 9 (abundant flowering) scale on three consecutive dates in September, 1983.

** Effect significant at the $\alpha = 0.01$ probability level.

Table 2. Summary of the analysis of variance of growth habit score+ on single-plant progenies of the five 'Capica' component accessions.

Source of Variation	Degrees of Freedom		Mean Square		F-Value	
Replications	5		3.40			
Accessions	4		31.70		18.6**	
Reps. x Acces. (Error a)	20		1.70			
Progenies (Accessions)	45		5.52		5.5**	
Progenies (1315)		9		7.83		7.8**
Progenies (1318)		9		15.21		15.1**
Progenies (1342)		9		2.32		2.3*
Progenies (1693)		9		1.74		1.7
Progenies (1728)		9		0.50		0.5
Error b	221		1.01			

+ = Growth habit score is the mean of ratings taken on a progeny basis on a 0 (prostrate) to 9 (erect) scale on three consecutive dates in September, 1983.

** Effect significant at the $\alpha = 0.01$ probability level.

AGRONOMY–CARIMAGUA

PRELIMINARY EVALUATION OF FORAGE GERMPLASM (Category I)

Evaluation of a wide array of forage species was carried out during the current season. At present, 900 accessions of legumes and 200 grasses are in the preliminary evaluation stage. Of these, 674 were established in the wet season of 1983 (Table 1), the rest of the material was sown in late 1982.

LEGUMES

Centrosema spp.

New accessions of the *Centrosema macrocarpum* – *C. pubescens* – *Centrosema* (n. sp.) complex contain a great deal of variability and several lines exhibit desirable forage traits e.g.: strong stoloniferous root development and field resistance to fungal diseases and pests.

Accessions of *Centrosema brasilianum* currently under observation also exhibit useful characters (e.g. vegetative vigor, early flowering and high seed yield). Rhizoctonia during the wet season is still a major problem with this species

Desmodium ovalifolium

Sixty-six accessions of this important legume were established in a small plot experiment. At this early stage of evaluation this collection is showing considerable variability in vigor, yield, flowering time and intensity, and several morphological characters. Artificial inoculation of this collection with stem-gall nematode infested vegetative material has been carried out by Plant Pathology section and will allow preliminary selecting for nematode resistance.

Desmodium heterocarpon

Sixty accessions of this legume species are under evaluation and they show variation in gross morphological characters and growth habit ranging from small shrubs to dense leafy and prostrate forms. Many of the accessions are prolific seeders and an added advantage is that their seed pods are tightly closed and do not shatter very readily.

Desmodium heterophyllum

The cultivar tested at Carimagua (cv. Johnstone, CIAT 349) has marginal adaptation to the acid soils of the Llanos. The aim of the current evaluation of the entire collection is to find accessions with better tolerance to acid, infertile soils.

Table 1. Forage species introductions, established in Carimagua in 1983.

Species	Number of Accessions
Centrosema spp.	117
Desmodium spp.	148
Pueraria spp.	78
Stylosanthes spp.	120
Miscellaneous legumes	8
TOTAL LEGUMES	471
Andropogon gayanus	32
Brachiaria spp.	19
Panicum maximum	152
TOTAL GRASSES	203
TOTAL INTRODUCTIONS:	674

Pueraria spp.

One of the most interesting group of introductions is the 78 accessions of *Pueraria phaseoloides*. Commercially used cultivars of this legume are lacking variability, most likely due to the fact that the same cultivar has been traded around the tropical world, wherever this species is used as a cover legume in plantation agriculture.

The agronomic assessment of this collection of *Pueraria* is now in progress. The collection includes stoloniferous forms and many are distinctly different from the common cultivar of tropical kudzu. The main criteria for selection are: early flowering habit and high seed yields coupled with strong stoloniferous root development. Promising lines will be tested with various grass associates for palatability and persistence under grazing.

Stylosanthes capitata

In addition to new accessions, 29 hybrid derivatives of *S. capitata* were established along with the cultivar "Capica" and its five component accessions in row plots. Material for this experiment was selected on the basis of performance of F_6 generation hybrids during 1982-1983.

Stylosanthes viscosa

Some 123 accessions of this species are under preliminary observation. Of these, four accessions, 1074, 1544, 2123 and 2880 were resistant to both anthracnose and stemborer 12 months after establishment.

Zornia sp.

Fifteen accessions of Zornia sp. (type CIAT 7847) are being compared in a small plot clipping experiment. High yielding accessions so far are 280, 8308, 8307, 8278, 8279. These accessions yielded significantly more dry matter than the check, CIAT 7847. Slight infection of Sphaceloma was observed during the wet season of 1983.

GRASSES

The grasses best adapted to this environment are introductions and selected genotypes of Andropogon gayanus and species of Brachiaria. A small collection of 19 accessions of Brachiaria spp. was established during the wet season of 1983. One accession of Brachiaria humidicola is showing early promise with rapid establishment and spread by strong stolons.

The spittlebug attack during the current season was one of the heaviest observed in Carimagua for years. Accessions of the main species of Brachiaria under observation were susceptible in the following order: B. ruziziensis B. decumbens B. brizantha B. humidicola and B. dictyoneura (2 accessions, CIAT 6133 and 6369). Brachiaria dictyoneura CIAT 6369 is a short, leafy, very palatable accession; so far it is tolerant to spittlebug attack and is being used in grazing experiments with Desmodium ovalifolium and Arachis pintoi.

The grass evaluation program was expanded by the recent addition of 152 accessions of Panicum maximum. These new introductions were planted late in the season and no data are available on their performance. The aim of selection is to identify lines adapted to acid soil conditions with resistance to leaf diseases.

EVALUATION OF FORAGE GERMPLASM UNDER CUTTING (Category II)

Centrosema

C. pubescens is widely recognized as a tropical forage legume, but until recently, other species of the genus have not received attention as cultivated forages. To assess the agronomic value and adaptability of various species of Centrosema to the savanna ecosystem, a series of experiments was carried out. Results of a five-year study are summarized as follows:

A preliminary experiment was aimed at studying the agronomic variability of 9 species represented by 40 accessions. To characterize the material, data were collected from sward plots of 2.5 x 2.5 m. These plots were used later to measure dry matter yields over time.

In order to explore interspecific relationships, the forty accessions were scored for a range of agronomic attributes. A cluster analysis was then used to compute the data and to establish distinctive groups of species with similar agronomic characters.

As expected, with such heterogeneous material, much fragmentation occurred as shown in the dendrogram (Figure 1). However, it was relatively easy to identify adaptability and promising material on the basis of major agronomic attributes.

Certain agronomic types are immediately obvious, for example: group 5 with high yield and disease resistance, contains a group of desirable perennials for the isohyperthermic savannas. Seed-set in this group, however, was inadequate and insect damage was severe.

It is interesting to note that in group 5 the "best" overall accessions are mainly materials that originate from savanna habitats including Centrosema macrocarpum, Centrosema (n. sp.) CIAT 5278 and Centrosema pubescens CIAT 5189.

All five accessions of the annual Centrosema pascuorum fell into group 4. This group gave the lowest DM yields, but the best seed-set. The highest number of self-sown seedlings were recorded from these lines.

High leaf : stem ratio was measured for cluster 3 which contains a promising accession of Centrosema brasilianum (CIAT 5234).

Group 2 contains 3 Centrosema virginianum and 1 Centrosema acutifolium accessions; both are low yielding species with high leaf: stem ratio.

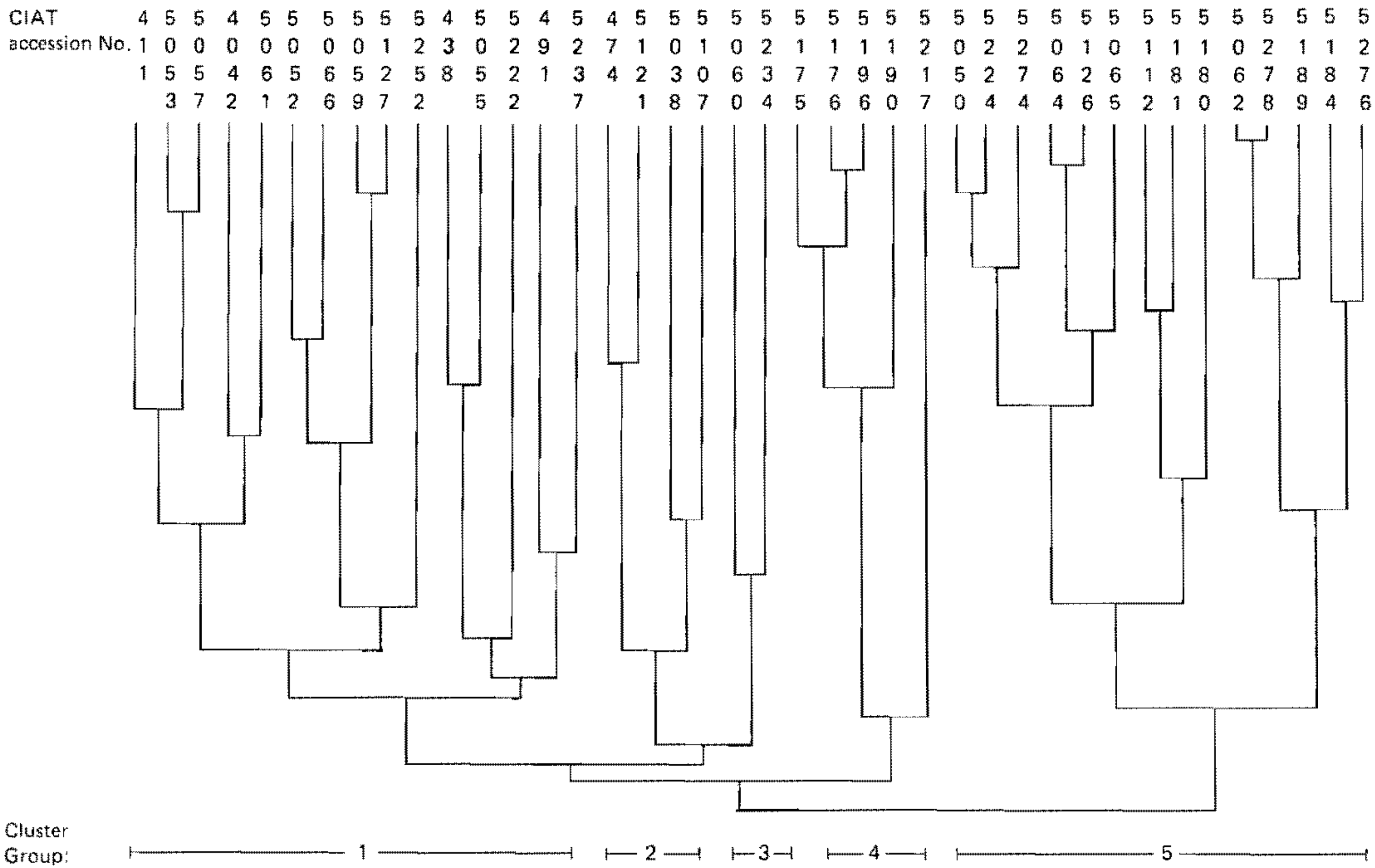
This cutting experiment, established in 1979, originally contained 40 accessions of Centrosema species. Treatments were reduced to 13 accessions of 5 species by the fourth year. Plant losses were largely due to fungal and bacterial diseases, and in some instances to lack of adaptation to acid soils. Yield data obtained in the last year of the experiment are summarized in Table 2.

Dry matter yields, and persistence under grazing and cutting indicate that Centrosema macrocarpum, C. pubescens, unidentified and specialized forms of the C. macrocarpum - C. pubescens complex and C. brasilianum contain accessions of potential value as forage cultivars for the isohyperthermic savanna ecosystem.

In view of the promise shown by C. macrocarpum, C. brasilianum and Centrosema (n. sp.) the variability in yield and stoloniferous root development among accessions of different geographical origin was compared in cutting only experiments.

Ten accessions of Centrosema representing 3 species exhibited significant differences in dry matter production and number of stoloniferous roots (Tables 3 and 4). Much variability was observed in insect and rhizoctonia resistance as well. Centrosema (n. sp.) 5277 significantly out-yielded the 3 accessions of C. macrocarpum in the trial. This result obtained under a seasonal cutting regime was consistent with data from previous experiments. CIAT 5277 was highly resistant to pests and diseases as well.

C. macrocarpum was found to be tolerant to major leaf diseases affecting most other species of the genus. It produced high yields of



1 = DM yield moderate

2 = DM yield low, highest leaf: stem ratio

3 = DM moderate, high leaf: stem ratio

4 = Annuals, DM yield lowest, highest seed yield

5 = DM yield highest, disease resistant, highly susceptible to insects. All *C. macrocarpum* and 5278 and 5112 *Centrosema* sp.

Figure 1. Dendogram of cluster analysis of some agronomic attributes of 40 accessions of Centrosema spp.

Table 2. Fourth year dry matter yields of 13 accessions representing 5 species of *Centrosema*. Carimagua, Llanos Orientales.

Species	CIAT No.	DM kg/ha/yr
Centrosema (n. sp.)	5278	3020 a *
C. macrocarpum	5064	2648 ab
C. macrocarpum	5062	2520 abc
C. macrocarpum	5065	2504 abc
C. macrocarpum	5276	2213 abcd
C. pubescens	5052	1833 bcde
C. macrocarpum	5274	1800 bcde
C. brasilianum	5055	1610 cde
C. pubescens	5189	1536 cde
C. pubescens	411	1387 de
C. pubescens	5126	1336 de
C. pubescens	5053	1280 de
C. acutifolium	5061	1133 e

* Means followed by a different letter are significantly different ($P < 0.05$) by Duncan's multiple range test.

Table 3. Dry matter yields (wet season) of 10 accessions representing 3 species of *Centrosema*. Carimagua, Llanos Orientales.

Species	CIAT No.	DM kg/ha/6 weeks
Centrosema (n. sp.)	5277	2273 a*
C. brasilianum	5487	1917 ab
Centrosema (n. sp.)	5610	1902 ab
Centrosema (n. sp.)	5118	1612 abc
C. brasilianum	5234	1538 abc
Centrosema (n. sp.)	5568	1297 bc
C. macrocarpum	5452	1181 bc
C. brasilianum	5712	1135 bc
C. macrocarpum	5065	1114 bc
C. macrocarpum	5434	1031 c

* Means followed by a different letter are significantly ($P < 0.05$) different by Duncan's multiple range test.

Table 4. Number of stolon roots in 'legume only' sward plots of 10 accessions of *Centrosema* spp. Carimagua, Llanos Orientales.

Species	CIAT Accession No.	Stolon roots m^{-2}
Centrosema (n. sp.)	5118	188
Centrosema (n. sp.)	5610	122
Centrosema (n. sp.)	5568	108
Centrosema (n. sp.)	5277	71
C. macrocarpum	5452	37
C. macrocarpum	5432	20
C. brasilianum	5234	6
C. macrocarpum	5065	2
C. brasilianum	5712	0
C. brasilianum	5487	0
s.e.		32.9
L.S.D. (0.05)		57.6

dry matter when harvested by cutting, but showed poor persistence under heavy grazing.

The low rate of survival of some C. macrocarpum lines under grazing is attributed to (a) non-stoloniferous habit of growth; (b) lack of seed-set under grazed pasture conditions; (c) high palatability of the legume relative to the associated grass, A. gayanus; (d) inadequate grazing management.

Significant differences were recorded in yield and number of stoloniferous roots among new accessions of Centrosema macrocarpum. Early introductions of this trailing, climbing legume (CIAT Nos. 5062, 5064, 5065, 5274 and 5276) show little tendency to root at the nodes. Among 17 new accessions of C. macrocarpum a range of 2.7 to 112 rooted stolons m^{-2} was recorded (Table 5). In four accessions of Centrosema (n. sp.) (CIAT No. 5277, 5568, 5610, 5118) the number of rooted stolons m^{-2} ranged from 71 to 188. Past experience with these species forms of the C. macrocarpum - C. pubescens complex indicates that strong stoloniferous root development is the key to long-term persistence.

The aim of a follow-up experiment, established in 1983, is to study yield and population dynamics of C. macrocarpum - A. gayanus associations under low (1 an/ha) and high (3 an/ha) stocking rates. Sub-plot treatments in the same experiment include one accession of each, C. brasilianum (CIAT 5234) and Centrosema n. sp. (CIAT 5568) and two lines of C. macrocarpum (CIAT 5062 and 5065).

EVALUATION OF FORAGE GERMPLASM UNDER GRAZING (Category III)

Desmodium incanum

This legume was tested in association with three species of Brachiaria and molasses grass (Melinis minutiflora). An inverse relationship was recorded between grass yields and that of D. incanum. Molasses grass produced the lowest dry matter yield of the four species, however, this mixture contained the highest percentage of legume (38%). The highest yielding and most aggressive of these grass species, Brachiaria dictyoneura, completely excluded the legume from the sward. A fair percentage of legume was maintained in association with the two Brachiaria brizantha accessions CIAT 665 and 664 (Figure 2).

Desmodium incanum showed considerable promise in association with these less aggressive grass species. It is free from major disease and insect problems, only moderately palatable and productive, but it is highly persistent under grazing.

Desmodium heterocarpon

One accession of this legume, CIAT 3787, is showing promise as a forage species. This low growing sub-shrub associates well with molasses grass and Andropogon gayanus. It is an exceptionally palatable Desmodium that yielded significantly better than two other Desmodium accessions under grazing (Figure 3).

Table 5. Variation in stoloniferous root development among 17 accessions of *Centrosema macrocarpum*. Carimagua, Llanos Orientales.

CIAT Accession No.	Stolon roots m^{-2}
5674	112.0
5396	107.0
5744	88.0
5392	84.0
5743	78.7
5731	70.0
5633	69.0
5411	60.0
5629	54.6
5741	53.0
5737	43.0
5734	42.0
5685	40.0
5335	28.0
5673	25.3
5738	14.0
5639	2.7
s.e.	30.82
L.S.D. (0.05)	49.41

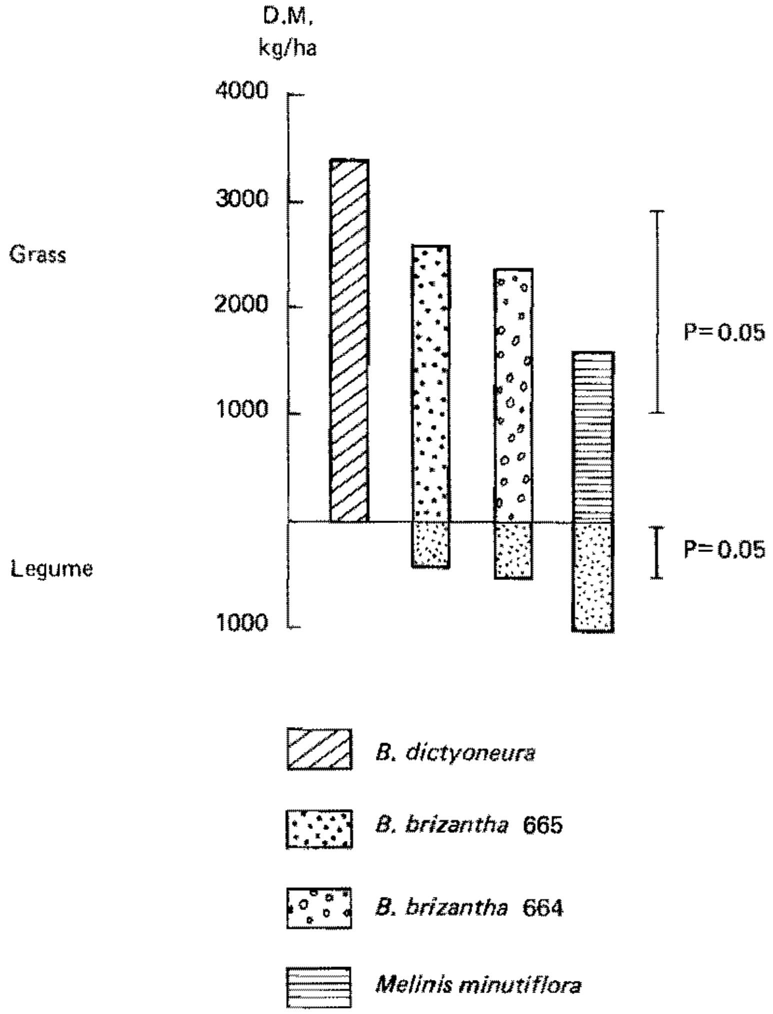


Figure 2. **Presentation yields of four grasses in association with *Desmodium incanum* in the second wet season.**

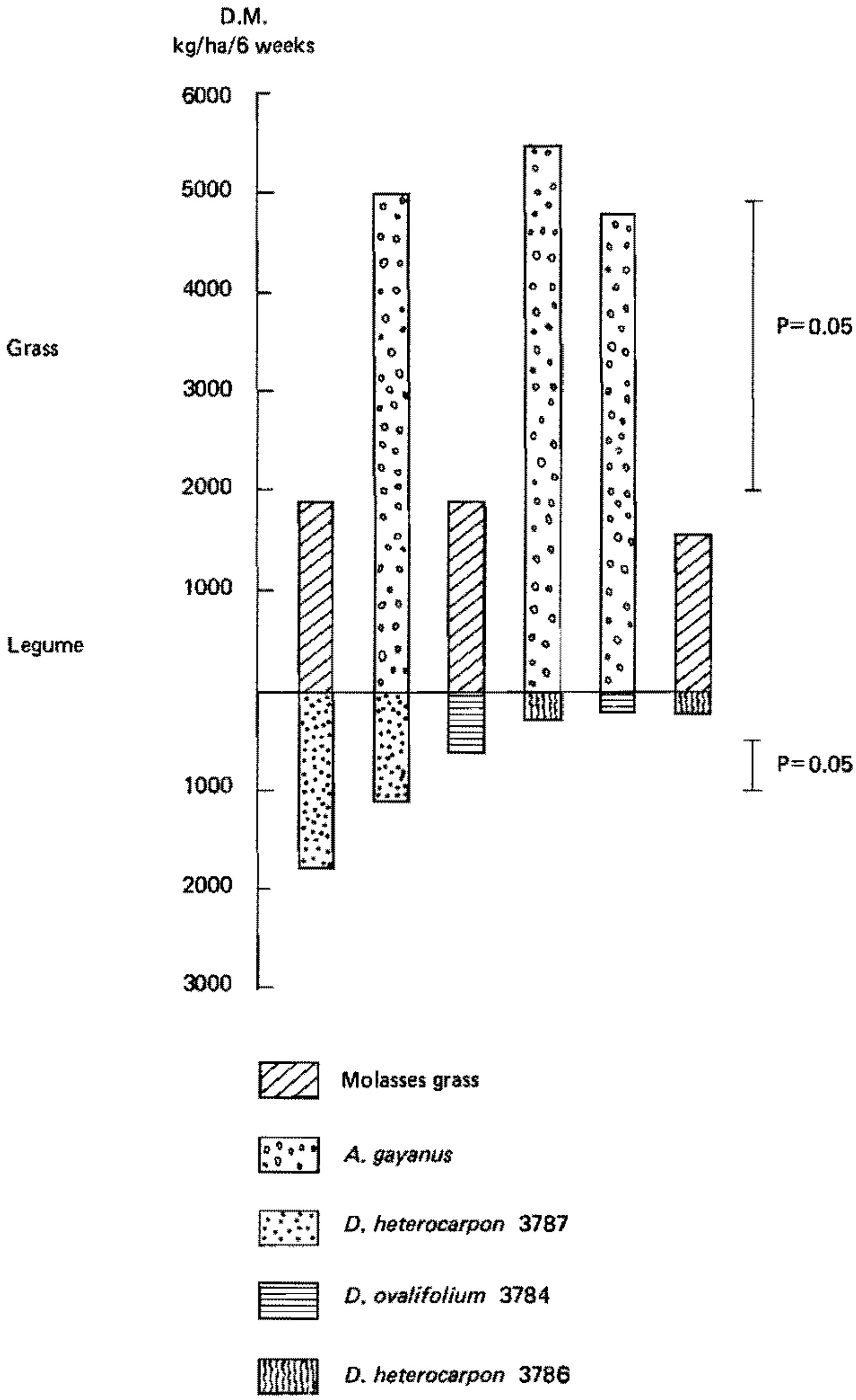


Figure 3. **Presentation yields of *Desmodium heterocarpon* and *D. ovalifolium* in association with *A. gayanus* and Molasses grass.**

Desmodium ovalifolium

New accessions of the Desmodium ovalifolium/heterocarpon complex are being studied in several trials. An early introduction of D. ovalifolium (CIAT 350), from Southeast Asia, showed high promise as a suitable forage legume for Oxisols. This accession was found susceptible to stem-gall nematode as well as false rust. A total of 66 accessions are now established in preliminary evaluation trials. The main selection criteria are resistance to nematodes, palatability, free seeding habit, and compatability with aggressive grasses e.g., species of Brachiaria.

Several accessions of this legume have been severely affected by stem-gall nematode during the past twelve months. In an experiment with 8 accessions, each grown in association with 5 accessions of Brachiaria spp. in a checker board design, 5 accessions yielded more dry matter than the standard cultivar, CIAT 350 (Table 6). The three high yielding accessions (CIAT 3793, 3794 and 3788), each with five Brachiaria spp., exhibited a mean legume content of 46-49%, dry matter basis (Figure 4).

Brachiaria humidicola was the highest yielding of the five grasses

Table 6. Mean legume content of 8 Desmodium ovalifolium accessions in association with Brachiaria spp. (means of five accessions) under grazing. Carimagua, Llanos Orientales.

Desmodium ovalifolium CIAT No.	% Legume (means of 10 harvest/grazing dates)
3793	49.02 a*
3794	48.85 a
3788	45.98 ab
3784	43.28 b
3652	37.87 c
3504	36.00 c
350 (control)	35.43 c
3780	22.60 d

* Means followed by a different letter are significantly different ($P < 0.05$) by Duncan's multiple range test.

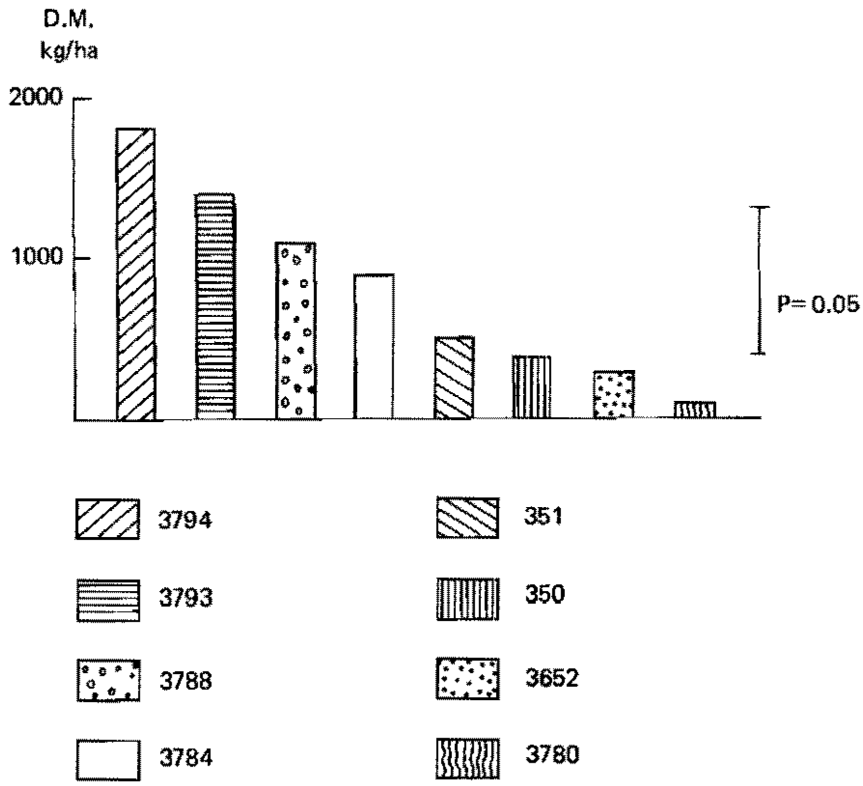


Figure 4. **Presentation yields of 8 accessions of *Desmodium ovalifolium* grown in association with 5 species of *Brachiaria* in the third wet season.**

(Table 7). D. ovalifolium accessions 3794, 3793 and 3788 in association with B. humidicola showed 29, 29 and 21% legume in the mixture, respectively, on a dry matter basis (Table 8).

In another experiment, 9 accessions of Desmodium ovalifolium are being evaluated under grazing. In this trial the legume was established with Brachiaria humidicola as the common grass in all treatments. The most persistent lines are 3788, 3776 and 3793. Accessions 350, 3652 and 3784 completely disappeared from this grazed sward.

Zornia spp.

Three grasses and three legumes were tested in a completely randomized field design. The grasses were Andropogon gayanus, molasses grass and Brachiaria sp. 6298, each in association with Stylosanthes capitata, Zornia brasiliensis and Zornia myriadena. These two Zornia species are the most resistant to fungal diseases and insect attack of the total collection tested in Carimagua. Both Zornia species were avoided by grazing animals and the mixture containing these legumes became legume dominant.

Stylosanthes capitata

CIAT 1441 was more compatible with molasses grass than with Andropogon. Andropogon was the highest yielding grass but the percentage of S. capitata was reduced to 11% in that association. The legume content in the molasses grass and Brachiaria sp. 6298 associations were 18% and 22% respectively.

Stylosanthes guianensis ("tardio")

Six accessions of S. guianensis were tested in small grazed plots in association with A. gayanus. Only two accessions (CIAT 2436 and 2362) persisted for two years, whilst the other accessions disappeared, mainly due to insect and disease attacks (Table 9). CIAT 10136 was moved to field scale grazing evaluation during the season. This accession is continuing to show fair tolerance to the insect/disease complex affecting the species and it was established in a mixture with A. gayanus to test persistence under three stocking rates (1, 1.7 and 2.4 an/ha).

Arachis pintoi CIAT 17434

This legume has performed very well in association with four Brachiaria species. It is very palatable and of exceptionally high quality. A particularly notable characteristic of A. pintoi is its high content of Ca and K (Table 10). It is compatible with both Brachiaria humidicola 679 and Brachiaria dictyoneura 6133, the two most aggressive species in the trial. These two species were little affected by spittlebug while both B. ruziziensis 6191 and B. brizantha 664 were heavily attacked during the July-August-September period.

Legume contents of B. humidicola and B. dictyoneura - A. pintoi mixtures gradually increased from 7% and 8% to 42% and 32% respectively by the end of the first year under grazing (Figure 5).

Table 7. Presentation yields (DM kg/ha/year) of 5 Brachiaria species grown in association with Desmodium ovalifolium (means of 8 accessions). Carimagua, Llanos Orientales.

Species CIAT Accessions No.	D.M. kg/ha/year
B. humidicola 679	14,502 a*
B. dictyoneura 6133	11,726 b
B. decumbens 665	11,548 b
Brachiaria sp. 6298	7677 c
Brachiaria brizantha 664	7335 c

* Means followed by a different letter are significantly different by Duncan's multiple range test.

Table 8. Legume content in five associations of Brachiaria humidicola CIAT 679 con Desmodium ovalifolium at the end of dry season in the first and second year under grazing. Carimagua, Llanos Orientales.

GRASS	LEGUME	Legume in dry matter Year 1	Year 2
		%	
B. humidicola CIAT 679 +	D. ovalifolium CIAT 3793	47.27	29.30
B. humidicola CIAT 679 +	D. ovalifolium CIAT 350	46.43	0.00
B. humidicola CIAT 679 +	D. ovalifolium CIAT 3794	38.97	29.35
B. humidicola CIAT 679 +	D. ovalifolium CIAT 3788	37.71	20.56
B. humidicola CIAT 679 +	D. ovalifolium CIAT 350A	37.33	1.72

Table 9. Presentation yields of 6 accessions of *Stylosanthes guianensis* "tardío" and 1 *S. capitata* accession associated with *Andropogon gayanus* in the 2nd wet season under grazing, Carimagua.

CIAT Accessions No.	DM kg/ha/6 weeks
S. guianensis CIAT 2436	2268.5 a*
S. guianensis CIAT 2362	310.5 b
S. capitata CIAT 2546	51.0 c
S. guianensis CIAT 2243	0.0
S. guianensis CIAT 2402	0.0
S. guianensis CIAT 2439	0.0
S. guianensis CIAT 2494	0.0

* Mean values followed by a different letter are significantly ($P < 0.05$) different by Duncan's multiple range test.

Table 10. Nutrient contents of grazed associations of *Arachis pintoi* - *Brachiaria* spp. Carimagua, Llanos Orientales.

SPECIES/MIXTURE	Dry season				Wet season			
	N	P	K	Ca	N	P	K	Ca
	%				%			
Brachiaria ruziziensis 6291	1.06	0.11	1.13	0.39	1.12	0.15	1.14	0.34
Arachis pintoi	2.28	0.21	1.40	1.82	2.46	0.21	1.91	2.35
Brachiaria brizantha 664	1.26	0.12	1.09	0.36	0.76	0.11	0.78	0.29
Arachis pintoi	2.34	0.22	1.71	1.68	2.24	0.17	1.06	2.68
Brachiaria dictyoneura 6133	1.23	0.08	1.01	0.26	0.95	0.11	1.10	0.27
Arachis pintoi	2.26	0.17	1.23	1.74	2.35	0.17	1.06	2.94
Brachiaria humidicola 679	1.02	0.08	1.11	0.26	1.06	0.11	1.09	0.29
Arachis pintoi	2.36	0.17	1.34	1.71	2.44	0.19	1.21	2.95

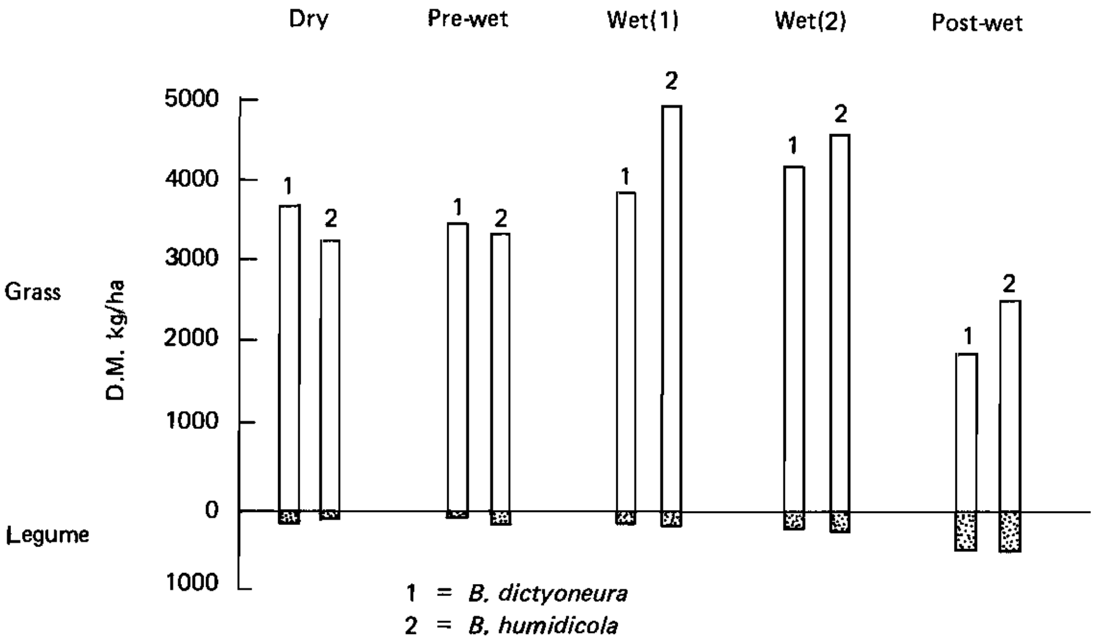


Figure 5. **Presentation yields of** ***B. dictyoneura*** **and** ***B. humidicola*** **in association with** ***Arachis pintoi*****.**

Centrosema macrocarpum CIAT 5065 in association with *Andropogon gayanus*. A trailing, climbing legume, highly palatable to stock. Grazed at 3 an/ha, before and after grazing.

Centrosema (n. sp.) CIAT 5277, a stoloniferous, persistent accesion native to the Colombian Llanos.

Arachis pintoi **CIAT 17434. A well-adapted new accession, compatible with *Brachiaria* spp. and well accepted by cattle.**

adaptation visualized, but also participants were interested in carrying out complementary germplasm evaluation trials under grazing, keeping in mind commercial exploitation as well. To achieve this objective, seed production of promising accessions must be emphasized at the regional and national levels, constituting a basic step in strengthening a forage germplasm evaluation program.

FAO's request to create the Regional Pasture and Forage Development Group for Central America and the Caribbean (GREDPAC) was strongly supported during the latter meeting. This will strengthen ties between the national institutions and member countries of the mentioned area, allowing CIAT to fulfill its coordinating activities.

Regional Trials by Ecosystems

A total of 35 seed sets for RTA and 109 for RTB were sent during 1979-82 . Considering that as of today 58% of the trials have been established and that participants' response has been enthusiastic, this activity can be evaluated as satisfactory and future participation promising.

At present, the RIEPT has 25 RTA, 65 RTB, 8 RTC and 9 RTD within the five main ecosystems of tropical America (Figure 1). Tables 2, 3, 4 and 5 show the country and location where regional trials are established, collaborating institutions and persons responsible for each trial.

Well Drained Isohyperthermic Savannas "Llanos"

Sufficient information is available and enough time has elapsed (July 1980-April 1982) for only the Regional Trials A located in "El Tigre", Anzoátegui, Venezuela as to allow for conclusions. Table 6 shows the list of the 15 accessions selected from 54 entries showing adaptation equal or superior to "good". It is interesting to note that all the legumes selected belong to the genus *Stylosanthes*. During the establishment period, *Aeschynomene*, *Centrosema* and *Desmodium* accessions were severely attacked by wild rabbits.

Information was reported from 8 RTB within the same "Llanos" ecosystem. These trials were located in Carimagua, El Paraíso, El Viento and Guayabal, in Colombia; Calabacito, Los Santos and El Chepo, in Panamá; and Atapirire, in Venezuela.

Table 7 shows average yields (DM kg/ha at 12 weeks regrowth) for grass and legume accessions common to all sites in the Llanos of Colombia. *A. gayanus* CIAT 621 and *B. decumbens* 606 yielded similarly in both evaluation periods within the ecosystem; however, yields of legumes common to all sites showed more variability. Both legumes and grasses show maximum productivity (91% and 86% of total production, respectively) during the rainy season. *Pueraria phaseoloides* and *Stylosanthes capitata*, yielded 5% of total production during the dry period, *Centrosema* spp. 15%, and *S. guianensis* "tardío" CIAT 1280 up to 20%.

Figure 1. INTERNATIONAL TROPICAL PASTURES EVALUATION NETWORK

R I E P T

Table 2. Regional Trials A in Tropical America.

COUNTRY	LOCATION	INSTITUTION/COLLABORATOR	ECOSYSTEM*	PLANTING DATE
BRAZIL	Bõa Vista I	EMBRAPA-UEPAT/V.Gianluppi	WDIS	VI-81
	Bõa Vista II	EMBRAPA-UEPAT/V.Gianluppi	WDIS	V-83
	Corumbá	EMBRAPA-UEPAE/A.Pott, J.A.Comastri	PDS	VI-81
	Itabela I	CEPLAC/M.Moreno, J.Marques Pereira	TRF	XI-80
	Itabela II	CEPLAC/M.Moreno, J.Marques Pereira	TRF	III-83
	Itajú	CEPLAC/J.M.Spain, M. Moreno	TRF	---
	Jataí	EMBRAPA-EMGOPA/E. Barbosa	WDTS	XII-80
	Paragominas	PROPASTO-CPATU/M.B.Dias Filho, E.A.Serrão	SESF	IV-81
COLOMBIA	Carimagua	CIAT/B.Grof	WDIS	XII-83
	Leticia	CIAT/A.Gómez-Carabaly, L.H.Franco	TRF	III-80
	Macagual I	ICA/A.Acosta, P.Cuesta	TRF	VI-80
	Macagual II	ICA/A .Acosta	TRF	IV-83
	Orocué	CIAT-HIMAT/A.Gómez-Carabaly,L.H.Franco	PDS	VI-80
COSTA RICA	Turrialba	CATIE/R.Borel	TRF	III-83
	Guapiles	MAG/J.Alpizar	TRF	---
HONDURAS	La Ceiba	CURLA/G.Valle	SESF	VII-83
NICARAGUA	Nueva Guinea	MIDINRA/C.Avalos, A.Cruz, A.Castro	TRF	VII-80
PANAMA	Calabacito	IDIAP	TRF	VII-83
	El Chepo	IDIAP	TRF	IX-83
	Los Santos	IDIAP	SESF	IX-83
	Soná	IDIAP	TRF	IX-83
PARAGUAY	Caapucú	PRONIEGA/R.Samudio	WDS	IX-82
PERU	Pucallpa	IVITA/H.Ordóñez, C.Reyes	SESF	III-80
VENEZUELA	El Tigre	FONAIAP/D.Sanabria, A. Flores	WDIS	VII-80
	Mantecal	FONAIAP/G.R. Torres	PDS	XII-80

* WDIS = Well drained isohyperthermic savanna; PDS = Poorly drained savanna; TRF = Tropical rain forest; WDTS = Well drained thermic savanna (Cerrados); SESF = Semi-evergreen seasonal forest.

Table 3. Regional Trials B in tropical America.

COUNTRY	LOCATION	INSTITUTION/COLLABORATOR	ECOSYSTEM*	PLANTING DATE
BOLIVIA	Chipiriri	IBTA/F. Saavedra	TRF	IX-81
	Valle del Sacta	UNIV.MAYOR S.SIMON/J.Espinosa	SESF	IX-80
BRAZIL	Barrolândia I	CEPLAC/J.Marques Pereira	TRF	XII-80
	Barrolândia II	CEPLAC/J.Marques Pereira	TRF	III-83
	Barreiros	EPABA/L.A.Borges de Alencar	WDIS	XI-82
	Bõa Vista	EMBRAPA-UEPAT/V.Gianluppi	WDIS	V-83
	Brasilia	EMBRAPA/CPAC/C.Campos da Rocha	WDS	XII-82
	Paragominas	PROPASTO-CPATU/M.B.Dias Filho	SESF	IV-80
	Porto Velho	EMBRAPA-UEPAE-PROPASTO/C.A.Gonçalves J.R.da C.Oliveira	SESF	XI-81
COLOMBIA	Bonanza	CIAT/A.Gómez-Carabaly,L.H.Franco	WDIS	IV-83
	Carimagua	CIAT/R.Gualdrón,C.Escobar	WDIS	V-80
	Paraíso	CIAT/A.Gómez,L.H.Franco	WDIS	V-80
	Orocué	CIAT-HIMAT/A.Gómez-Carabaly,L.H.Franco	PDS	IV-81
	El Viento	CIAT/A.Gómez-Carabaly,L.H.Franco	WDIS	V-80
	Las Leonas	CIAT/ " "	WDIS	IV-83
	Menegua	CIAT/ " "	WDIS	IV-83
	Pachaquiaro	CIAT/ " "	WDIS	IV-83
	Guayabal	CIAT/ " "	WDIS	V-80
	Villavicencio	CIAT-SEMILLANO/A.Gómez-Carabaly, L.H.Franco	TRF	IX-83
	Caucasia I	UNIV.ANTIOQUIA/L.A.Giraldo,H.J.Hoyos, L.F. Ramirez	SESF	VII-80
	Caucasia II	SEC.AGRIC.ANT./L.A.Giraldo	SESF	---
	Puerto Asís	FONGANADERO PUTUMAYO/P.Orozco	TRF	I-80
	Quilichao I	CIAT/A.Gómez-Carabaly,A.Ramirez	SESF	XI-79
	Quilichao II	CIAT/A.Gómez-Carabaly,L.H.Franco	SESF	XI-82
	Leticia	CIAT/Bat. Mixto, A.Gómez-Carabaly, L.H.Franco	TRF	XII-82
	Macagual	CIAT-ICA-UNIV.AMAZONIA/R.Angulo, G.Collazos	TRF	IV-83
COSTA RICA	San Isidro	MAG/J.L.Morales, V.M.Prado	TRF	VIII-80

-Continued

Table 3 (Cont'd).

COUNTRY	LOCATION	INSTITUTION/COLLABORATOR	ECOSYSTEM	PLANTING DATE
CUBA	Isla Juventud	MINAG/A. Gutiérrez	WDIS	II-82
ECUADOR	El Napo I	INIAP/K. Muñoz	TRF	IX-80
	El Napo II	INIAP/K. Muñoz	TRF	---
	El Puyo	ESPOCH/M. Freire	TRF	X-80
UNITED STATES	Hawaii	UNIV.DE HAWAII/A.S.Whitney	TRF	VI-80
GUYANA	Moblissa	CARDI/G.A.Nurse	SESF	IX-80
MEXICO	Arriaga	INIA/A. Ramos	WDS	VII-81
	Huimanguillo	INIA/A. Izquierdo Torres	WDS	IX-83
	Isla Veracruz	INIA/J.J. Pérez	WDS	IX-83
	Jalapa	INIA/A. Ramos	WDS	IX-83
	Jericó	INIA/A. Ramos	SESF	IX-83
	Loma Bonita	INIA/A. Ramos	SESF	IX-83
	Ocuilapa	INIA/A. Ramos	SESF	IX-83
NICARAGUA	El Recreo	MIDINRA-DGTA/C.Avalos,A.Cruz,A.Castro	TRF	XII-80
	Nueva Guinea	MIDINRA-DGTA/C.Avalos, A.Castro	TRF	VI-81
	Puerto Cabezas	MIDINRA-DGTA	TRF	-83
PERU	Alto Mayo-Calzada	INIPA/E.Palacios	SESF	X-81
	Moyobamba	INIPA/CIPA X/E.Palacios, W.López, G.Silva	SESF	X-82
	Pucallpa I	IVITA/L.Pinedo, C.Reyes	SESF	IV-78
	Pucallpa II	IVITA/H.Ordoñez	SESF	I-83
	Palcazu Pichis	NCSU/R.Schaus, P. Sánchez, K. Reátegui	TRF	---
	Puerto Maldonado	NCSU-INIPA/R.Schaus, P.Sánchez, K.Reátegui	TRF	X-82

-Continued

Table 3 (Cont'd)

COUNTRY	LOCATION	INSTITUTION/COLLABORATOR	ECOSYSTEM*	PLANTING DATE
	Tingo María	NCSU-INIPA/W.López	TF	---
	Tarapoto COPERHOLTA I	INIPA-CIPA X/W. López	SESF	II-81
	Tarapoto COPERHOLTA II	INIPA-CIPA X/W.López	SESF	XII-82
	Tarapoto ESEP I	INIPA-CIPA X/G. Silva	SESF	II-81
	Tarapoto ESEP II	INIPA-CIPA X/G. Silva	SESF	I-82
	Tarapoto Porvenir	INIPA-CIPA X/W.López	SESF	XI-81
	Yurimaguas	NCSU-INIPA/R. Schaus, K. Reátegui	TRF	XI-8
PANAMA	Calabacito	IDIAP/M.A.Avila	WDIS	X-80
	El Chepo	UNIV.DE PANAMA/J. Quintero	WDIS	VI-80
	David-Chiriquí	UNIV.DE PANAMA/J.Quintero	WDIS	VII-80
DOMINICAN REPUBLIC	Pedro Brand, D.N.	CENIP/M.Germán, Y.Soto	TRF	VIII-83
	Sabana de la Mar	CENIP/M.Germán, Y. Soto	TRF	VIII-83
	Miches-Seybo	CENIP/M.Germán, Y.Soto	TRF	IX-83
	-	CENIP/M.Germán, Y.Soto	TRF	IX-83
TRINIDAD	Centeno	CARDI/N.Persad	TRF	X-80
VENEZUELA	Guachí	UNIV.ZULIA/I.Urdaneta	SESF	V-80
	El Tigre-Atapirire	FONAIAP/D.Sanabria, A. Flores	WDIS	VII-80
	Mantecal	FONAIAP/G.R.Torres	PDS	VI-80

* TRF = Tropical Rain Forest; SESF = Semi-evergreen seasonal forest; WDIS = Well drained isohyperthermic savanna; PDS = Poorly drained savanna; TF = Tropical forest; WDS = Well drained savanna.

Table 4. Regional Trials C in tropical America.

COUNTRY	LOCATION	INSTITUTION/COLLABORATOR	ECOSYSTEM*	PLANTING DATE
BRAZIL	Río Branco	EMBRAPA-UEPAE/J.F.Valentim	SESF	X-83
	Porto Velho	EMBRAPA-UEPAE-P.Velho/C.A. Goncalves	SESF	80
	Porto Seguro	CEPLAC-CEPEC/J.Ribeiro, J.M. Pereira, J.M.Spain, M.Moreno	TRF	XII-83
COLOMBIA	Quilichao I	CIAT/J.M.Toledo, C.Lascano	SESF	80
	Quilichao II	CIAT/E.A.Pizarro,C.Lascano	SESF	XI-83
ECUADOR	El Napo	INIAP/K. Muñoz	TRF	VIII-83
PERU	Pucallpa	IVITA/H.Huamán	SESF	X-83
PANAMA	Gualaca	IDIAP/Carlos Ortega	SESF	IX-83

* TRF = Tropical Rain Forest; SESF = Semi-evergreen seasonal forest; WDIS = Well drained isohyperthermic savanna; PDS = Poorly drained savanna; TF = Tropical forest; WDS = Well drained savanna

Table 5. Regional Trial D in tropical America.

COUNTRY	LOCATION	INSTITUTION/COLLABORATOR	ECOSYSTEM*	PLANTING DATE
BRAZIL	Bõa Vista	EMBRAPA-UEPAT	TRF	V-82
	Macapá	EMBRAPA-UEPAT	TRF	82
	Paragominas	EMBRAPA-CPATU	TRF	82
ECUADOR	El Napo	INIAP/K.Muñoz	TRF	III-78
	El Napo	INIAP/K.Muñoz	TRF	VI-82
PANAMA	Calabacito	IDIAP/CIAT	TRF	---
	Gualaca	IDIAP/C.Ortega	WDIS	IX-83
PERU	Pucallpa I	IVITA/A.Riesco, C.Reyes, H.Huamán	SESF	II-83
	Pucallpa II	IVITA/A.Riesco, C.Reyes, H.Huamán	SESF	X-83
	Yurimaguas	INIPA/M.Ara,R.Schaus, K.Reátegui	TRF	-81

* TRF = Tropical Rain Forest; WDIS = Well drained isohyperthermic savanna; SESF = Semi-evergreen seasonal forest.

INTERNATIONAL TROPICAL PASTURES EVALUATION NETWORK

Introduction

The main objective of the Regional Trials Section is to evaluate new forage germplasm in the main ecosystems of the target area. This is achieved under the combined effort of national research institutions and CIAT.

The International Tropical Pastures Evaluation Network (RIEPT), follows a basic evaluation program made up of four basic stages called Regional Trials A, B, C and D (RTA - RTB - RTC - RTD) which allow for the introduction, agronomic evaluation, and evaluation under grazing of the most promising germplasm. The two first steps (RTA and RTB) essentially are an agronomic characterization of germplasm selected mainly for its tolerance to climate, soil, pests, and diseases. Regional Trials A evaluate the survival of a great number of entries (80-150) in a few representative sites within the five major ecosystems (well drained isohyperthermic savanna ["Llanos"]; well drained isothermic savanna ["Cerrados"]; poorly-drained savanna; semi-evergreen seasonal forest and tropical rain forest). Regional Trials B evaluate seasonal productivity under cutting as well as resistance to pests and diseases of the best entries selected in the previous stages (20-25 entries), in the largest possible number of sites within each ecosystem. Regional Trials C and D study the effect of the animal in order to evaluate characteristics such as pasture stability and persistence (RTC) and milk and/or beef production (RTD) under different herd management systems.

ADVANCES OF THE INTERNATIONAL TROPICAL PASTURES EVALUATION NETWORK

Coordination activities in the RIEPT

An Advisory Committee was established during the second meeting of the RIEPT, September 27-29, 1982, attended by all active members (Annual Report, Tropical Pastures Program, 1982). The first meeting of RIEPT's Advisory Committee was held in September 1983 at the Centro de Pesquisa Agropecuária dos Cerrados (CPAC) EMBRAPA with the participation of 28 members representing 12 countries of tropical America (Table 1). Each participant had the opportunity to explain how the national and regional networks were operating and to present for discussion their projects for regional trials C and D. This meeting's proceedings will be published during 1984. The good participation and critical spirit of the meeting without doubt contributes even further to the consolidation and integration of RIEPT's members. Not only were experimental support activities using materials selected for their

Table 1. Participants in the First Workshop of the Advisory Committee of the International Tropical Pastures Evaluation Network. EMBRAPA/CPAC, Planaltina, Brazil, September 19-22, 1983 (EMBRAPA/CIID/CIAT).

PARTICIPANTS	INSTITUTION	COUNTRY
Elmar Wagner	EMBRAPA/CPAC	Brazil
Carlos Magno da Rocha	EMBRAPA/CPAC	Brazil
Ronaldo de Andrade	EMBRAPA/CPAC	Brazil
Francisco Beni de Sousa	EMBRAPA/CPAC	Brazil
A. de Oliveira Barcellos	EMBRAPA/CPAC	Brazil
José Francisco Valls	EMBRAPA/CENARGEN	Brazil
Lidio Coradin	EMBRAPA/CENARGEN	Brazil
Armando Teixeira Primo	EMBRAPA/CENARGEN	Brazil
José Marques Pereira	CEPLAC/CEPEC	Brazil
Emanuel Adilson Serrão	EMBRAPA/CPATU	Brazil
Carlos Alberto Goncalves	EMBRAPA/UEPAE/P.Velho	Brazil
Derrick Thomas	CIAT/CPAC	Brazil
Pablo Mendoza	ICA	Colombia
José M. Toledo	CIAT	Colombia
Carlos Lascano	CIAT	Colombia
Esteban A. Pizarro	CIAT	Colombia
Héctor Hugo Li-Pun	IDRC	Colombia
Osvaldo Paladines	Univ.Católica de Chile	Chile
Juan José Paretas	Min. Agricultura	Cuba
Kleber A. Muñoz	INIAP	Ecuador
Angel Ramos Sánchez	SARH/INIA	México
Faustino Alguera	MIDINRA/DGTA	Nicaragua
Carlos Ortega	IDIAP	Panamá
Washington López	INIPA	Perú
Alfredo Riesco	IVITA	Perú
Yokasta Soto	CENIP	Dominican Republic
Paschal Osuji	CARDI	Trinidad
Santiago Rodriguez	FONAIAP	Venezuela

Table 6. Grass and legume accessions selected by FONAIAP with an average degree of adaptability[1] equal or superior to "good", in the Regional Trial A at "El Tigre", Anzoátegui, Venezuela (evaluation period: two years).

Species	CIAT No.
GRASSES[2]	
Andropogon gayanus	621
Andropogon gayanus	6053
Brachiaria decumbens	606
LEGUMES[3]	
Stylosanthes capitata	1097
Stylosanthes capitata	1342
Stylosanthes capitata	1686
Stylosanthes capitata	1693
Stylosanthes capitata	1728
Stylosanthes capitata	1943
Stylosanthes guianensis "tardío"	1280
Stylosanthes guianensis "tardío"	1283
Stylosanthes guianensis "tardío"	1523
Stylosanthes macrocephala	1582
Stylosanthes macrocephala	2133
Stylosanthes leiocarpa	2115

1/ Average of qualification after third evaluation
2/ 6 grasses evaluated (3 *A. gayanus* and 3 *Brachiaria* spp.)
3/ 48 legumes evaluated (24 *Stylosanthes* spp., 5 *Centrosema* spp., 5 *Desmodium* spp., 10 *Zornia* spp., 3 *Aeschynomene* spp. and 1 *Pueraria* sp.).

Table 7. Average yields of tropical grasses and legumes in the Colombian Llanos: 1980-82 (DM kg/ha at 12 weeks).

Accessions	Rainy season	Dry Season
GRASSES		
A. gayanus 621	1936	240
B. decumbens 606	1388	272
LEGUMES		
S. guianensis "tardío"1280	2159	495
S. capitata 1315	2266	120
S. capitata 1693	2192	160
S. capitata 1728	2159	161
S. capitata 2013	2019	165
S. capitata 1318	1827	131
S. capitata 1405	1760	100
S. capitata 1342	1760	91
S. capitata 1019	1352	90
S. capitata 1943	1349	95
D. ovalifolium 350	972	34
D. gyroides 3001	951	72
A. histrix 9690	949	97
P. phaseoloides 9900	892	43
Zornia sp. 9286	801	88
Z. latifolia 728	764	44
Z. latifolia 9199	749	34
C. macrocarpum 5065	685	60
Centrosema sp. 5112	345	39
C. pubescens 5126	251	47
C. pubescens 5053	147	31
C. brasilianum 5234	139	39

Data from Regional Trials B for the savana ecosystem was evaluated under a combined analysis across locations utilizing the methodology for the analysis of variance described in the Handbook for the Agronomic Evaluation of Regional Trials (1979), and the Proceedings of the II Meeting of the RIEPT (1982). Performance during the rainy season was evaluated in Carimagua, Guayabal, El Paraíso, El Viento in Colombia, and Los Santos in Panamá;performance during the dry period was considered for only Guayabal, El Paraíso and El Viento. Results are shown in Table 7.

The results of the analysis of yield variance (DM kg/ha at 12 weeks of regrowth) for the different grass and legume accessions evaluated are shown in Table 8. Highly significant values ($P < 0.01$) were found for the effects of location and accession, and their interaction, for grasses and legumes during the rainy season. This confirms environmental differences existing among locations, differences in productivity among accessions, and differences in adaptation to different locations among accessions.

For the dry season the analysis of variance for legumes shows highly significant values ($P < 0.01$) for location and accession, and their interaction; grasses only showed differences ($P < 0.05$) among accessions and for the interaction location x accession, but not among locations. This shows that the productivity of grasses (*A. gayanus* and *B. decumbens*) in the locations considered was equally low during the dry season.

Several accessions (*C. pubescens* CIAT 5050, 5053 and 5126 as well as *D. ovalifolium* CIAT 350) showed no production during the dry season in El Paraíso, Guayabal, and El Viento locations, possibly due to the more sandy soils at these sites. This explains the large coefficient of variation (cv) (69%) for legume DM production during the dry period, in contrast with the corresponding cv (35%) found during the rainy season.

An analysis to evaluate the range of adaptability of common accessions to the different locations was performed using the method of Eberhart and Russell (as described in the Tropical Pastures Program Annual Report 1981 [pp. 57-66]) and in the Proceedings of the II Meeting of the RIEPT (pp. 429-447). Table 9 shows slope "b" values, representing the adaptability index of accessions to the different environments within the ecosystem; intercept "a" values, representing the mean productivity of accessions for the ecosystem, as well as standard error values of the slope(S_b) and the regressions' coefficient of determination (r^2). The information summarized in this table only includes results of the regression analysis for the rainy season because results of the regression analysis made during the dry period were not significant, possibly due to the reduced number of locations and to a higher relative error in the yields obtained. During the rainy season *S. capitata* CIAT 1019, 1315*, 1318*, 1342*, 1405, 1693*, 1728*, 1943 and 2013 presented the highest yields, almost doubling the productivity of *Zornia latifolia* CIAT 728 and 9199 and *P. phaseoloides* CIAT 9900. The adaptability index ("b") values

* Components of CAPICA cultivar.

Table 8. Analysis of variance for grass and legume dry matter yields (kg/ha) at 12 weeks after regrowth in the tropical well drained isohyperthermic savanna ecosystem.

Source of Variation	Rainy season DF	Rainy season F	Dry season DF	Dry season F
GRASSES				
Location	3	7.5**	2	2.2^NS
Rep. (Location)	9		6	
Accession	1	15.2**	1	10.4*
Location x Accession	3	16.2**	2	9.8*
Error	9		6	
Corrected total	25		17	
Yield	2793		276	
CV (%)	21		26	
LEGUMES				
Location	4	45.4**	2	7.3**
Rep. (Location)	11		6	
Accession	15	16.4**	22	20.1**
Location x Accession	56	3.8**	44	3.8**
Error	147		122	
Corrected total	233		196	
Yield	1868		127	
CV (%)	35		69	

* Significant effect with $0.01 < P \leqslant 0.05$.

** Significant effect with $P \leqslant 0.01$.

NS = not significant

Table 9. Ecosystem of tropical well drained isohyperthermic savannas.

Adaptability Index of accessions during the rainy season.

SPECIES and CIAT No.	a DM kg/ha (12 weeks)	b	S_b	r^2
LEGUMES				
Aeschynomene histrix 9690	1315	-	-	0.04 NS
Centrosema pubescens 5126	169	-	-	74.4 NS
Desmodium gyroides 3001	1483	-	-	23.5 NS
Pueraria phaseoloides 9900	1089	0.85	0.17	89.2*
Stylosanthes capitata 1019	1618	1.28	0.23	91.1*
Stylosanthes capitata 1315	2872	1.81	0.39	87.8*
Stylosanthes capitata 1318	2228	1.21	0.18	95.5*
Stylosanthes capitata 1342	2323	1.61	0.16	96.8*
Stylosanthes capitata 1405	2358	1.64	0.31	90.1*
Stylosanthes capitata 1693	2597	1.73	0.23	95.0**
Stylosanthes capitata 1728	2622	1.61	0.19	95.6**
Stylosanthes capitata 1943	2096	-	-	48.6 NS
Stylosanthes capitata 2013	2877	0.93	0.31	82.0*
Zornia latifolia 728	1112	-	-	61.1 NS
Zornia latifolia 9199	1260	1.05	0.34	83.0*
Zornia sp. 9286	1225	-	-	59.4 NS
GRASSES				
Andropogon gayanus 621	3021	-	-	37.0 NS
Brachiaria decumbens 606	2282	-	-	37.0 NS

90% confidence interval of b around 1: Legumes (including only significant regressions): (0.6, 1.4).

* Significant at 95% confidence
** Significant at 90% confidence

shown in Table 9 indicate a variation in productivity of each material throughout the different "qualities of the environment". Pueraria phaseoloides with an "a" value of 1089 kg DM/ha at 12 weeks of regrowth and a "b" value of 0.85 shows less response to a better environment within the range of sites tested, possibly due to unfavorable environmental factors (soil, climate and/or biotics) which have the tendency to standardize its behavior. On the other hand, most S. capitata accessions with yields close to 2500 kg DM/ha and with mean "b" values of 1.5 show a more marked response to improvements in the environment. The classification of legumes according to their degree of adaptability ("b") and their potential productivity ("a") are shown in Figure 2.

As mentioned above, S. capitata, located in the upper right quadrant, showed high productivity and a marked response to improvements in the environment; while P. phaseoloides CIAT 9900, in the lower left quadrant was less productive and presented little response to improvements in the environment.

These results are consistent with those obtained and presented by the participants of the second meeting of the RIEPT within the ecosystem of tropical, well-drained isohyperthermic savanna suggesting that the method of analysis is satisfactory in spite of its limitations in providing explanations on the superior or inferior behavior of any accession.

Evaluations of damage caused by diseases show that the most important are: for Stylosanthes, anthracnose; for Zornia, Sphaceloma scab and Dreschlera leaf spot; for Centrosema, Cercospora leaf spot and Rhizoctonia leaf blight; for Desmodium, nematodes.

Based on the analysis it can be tentatively concluded that the most disease resistant legume and grass accessions are:

S. capitata (1315 - 1318 - 1342 - 1693 - 1728)
S. guianensis "tardío" (2031 - 10136)
S. macrocephala
C. macrocarpum (5065)
P. phaseoloides (9900)
Z. brasiliensis (7485)
A. gayanus (621)
B. humidicola

Results show significant damage due to sucking insects for the genera Stylosanthes, Zornia, Centrosema and Brachiaria; next in importance were chewing insects attacking Centrosema, Desmodium, Pueraria and Brachiaria and budworms, feeding on Stylosanthes.

A new set of Regional Trials A and B has recently been established in Brazil, Colombia, Ecuador, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru and Dominican Republic (Figure 1 and Tables 2 and 3).

WELL DRAINED ISOHYPERTHERMIC SAVANNA ECOSYSTEM

Maximum Precipitacion Period

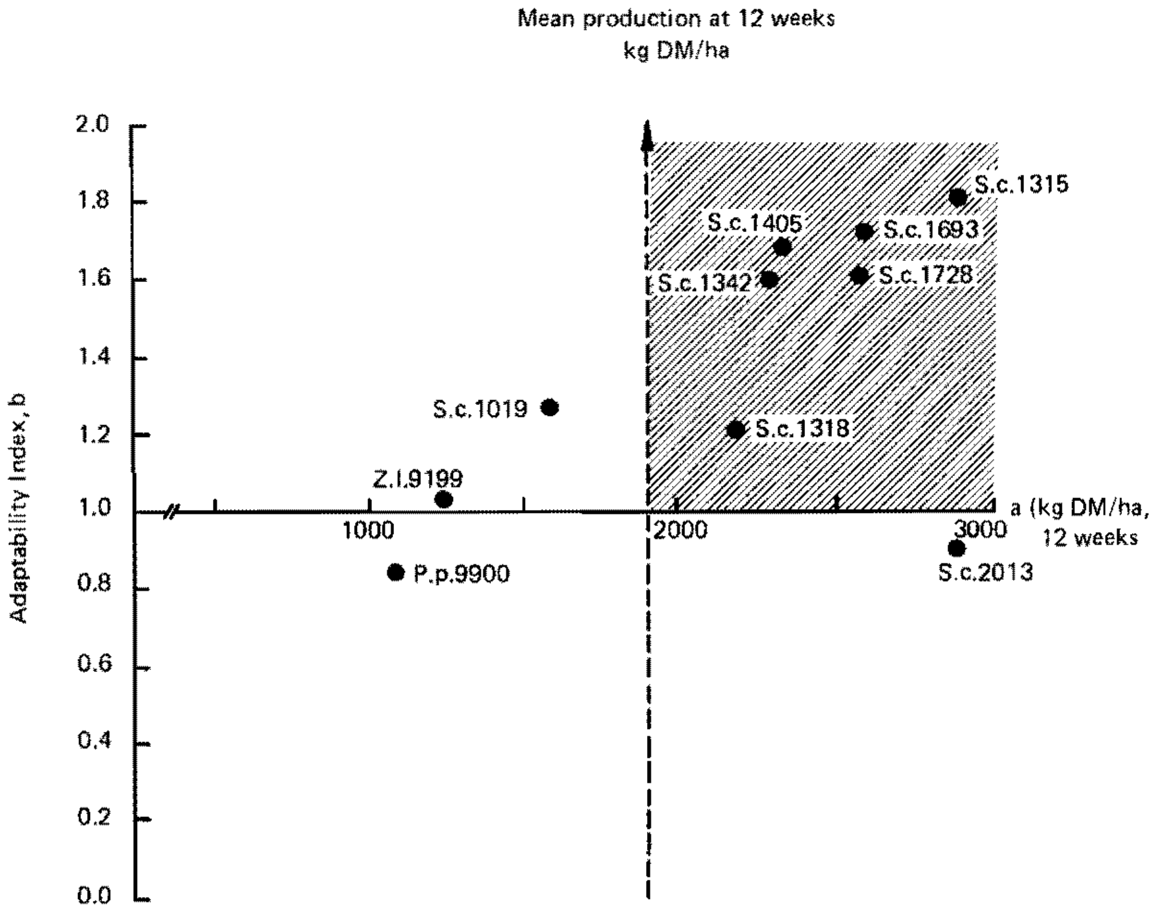


Figure 2. **Accumulated mean production at 12 weeks and Adaptability Index of tropical legumes. Shaded area shows ecotypes with production higher than the mean of the ecosystem.**

Well Drained Isohyperthermic Savannas "Cerrados"

It is impossible to define germplasm performance in this ecosystem due to the reduced number of agronomic regional trials established here. One of the more important advances during 1983 was the organization and establishment of regional trials in the "Cerrados" region of Brazil using germplasm selected at CPAC-EMBRAPA.

The location of these new regional trials A and B, to be established in the Cerrado area, and the most important characteristics of the locations (latitude, altitude, annual rainfall and soil type) are shown in Tables 10 and 11, respectively.

Poorly drained savannas

Two Regional Trials A (ERA) have been established in this ecosystem. Enough information (August 80-February 82) is available on the ERA located in Orocué, Casanare, Colombia in order to arrive at certain conclusions.

Out of 11 grasses and 20 legumes evaluated, only B. humidicola CIAT 679 and D. ovalifolium CIAT 350 showed an average adaptation, equal or superior to "good". It is important to point out that pastures in trial plots located under higher water saturation and flooding conditions were lost, probably due to the combined effect of an early flood and/or low germplasm adaptation.

Germplasm selected for the well-drained savanna conditions in Carimagua were evaluated in "bank"* areas in Mantecal, Apure, Venezuela (FONAIAP), and Orocué, Casanare, Colombia (HIMAT/CIAT).

Results of a Regional Trial B (RTB) conducted in a "bank"* area in Orocué are shown in Table 12. Mean dry matter production was drastically reduced from the first to the second year for both grasses and legumes during the period of maximum precipitation. B. humidicola 679 and D. ovalifolium 350 were the ecotypes with the lowest yield reduction during the first and second year: 58 and 38%, respectively. Preliminary observations show that anthracnose, Cercospora leaf spot, and Rhizoctonia foliar blight are the most important diseases. Thrips, mites, flea beetles, suckers, and spittlebugs were the main insects observed in the area.

Tropical Forest Ecosystems

The two major forest ecosystems (rainy and semi-evergreen seasonal) have 16 RTAs and 44 RTBs. Regional Trials A, established for more than one year, are located in Itabela, Brazil; Leticia and Florencia, Colombia; Nueva Guinea, Nicaragua; and Pucallpa, Peru.

The sites and grass and legume accessions, evaluated in RTB and included in a combined analysis for this ecosystem appear in Table 13.

* "Banks" - areas that do not flood in the poorly-drained savannas, known in Brazil as "Teso".

Table 10. Network of Regional Trials in the Cerrados of Brazil
EMBRAPA-CPAC-CIAT.

LOCATION	LATITUDE		ALTITUDE (m)	PRECIPITATION (mm)	SOIL TYPE
Macapá-AP	0°3'	N	15	2500	OXISOL
Bõa Vista-RR	3°15'	N	90	1740	OXISOL
Balsas-MA	7°21'53"	S	190	1566	OXISOL
Eliseu Martins-PI	8°12'30"	S	210	900	OXISOL
Barreiras-BA	11°50'	S	479	1020	ENTISOL
Vilhena-RO	12°44'	S	600	2000	OXISOL
Planaltina-DF	15°35'30"	S	1170	1570	OXISOL
Jaciara-MT	15°35'36"	S	219	1700	OXISOL
Goiânia-GO	16°41'	S	730	1443	OXISOL
Felixlândia-MG	18°45'52"	S	614	1100	OXISOL
Camapua-MS	20°28'00"	S	559	1396	ENTISOL
São Carlos-SP	22°01'	S	854	1495	OXISOL

Table 11. Network of Regional Trials in the Cerrados of Brazil.

LOCATION	STATE	RESPONSIBLE	INSTITUTION	TYPE OF TRIAL	PLANTING DATE
Felixlândia	MG	Nuno Sousa Costa	EPAMIG	RTB	October, 1983
Campo Grande	MS	Arae Boock	EMBRAPA	RTB	October, 1983
Vilhena	RO	Carlos A. Gonçalves	EMBRAPA	RTB	October, 1983
Barreiras	BA	Luis Alberto Borges de Alencar	EPABA	RTB	November, 1982
São Carlos	SP	Favio Teotonio de Olivera	UEPAE	RTB	October, 1983
Goiânia	GO	Marcelino Sobrinho	EMGOPA	RTB	October, 1983
Jaciara	MT	Gonçalo Sabino Lobo	EMPA	RTB	October, 1983
Bõa Vista	RR	Vicente Gianluppi	EMBRAPA/UEPAT	RTA/RTB	May, 1983
Planaltina	DF	Carlos Magno Campos Da Rocha	EMBRAPA	RTB	December, 1982
Macapá	AP	Francisco José Camara Figueiredo	UEPAT	RTA/RTB	October, 1983
Balsas	MA	Carlos Alberto Dos Santos	EMAPA	RTB	October, 1983
Valença	PI	Gonçalo Moreira Ramos José Carlos Machado Pimentel	UEPAE	RTB	October, 1983
Capinópolis	MG	Claudio Prates Zago	CEPET-UFV	RTB	October, 1983

Table 12. Mean production (DM kg/ha at 12 weeks) of grasses and legumes in the poorly drained savanna ecosystem planted in higher well drained terrace, Orocué, Colombia.

SPECIES and CIAT No.	Maximum Precipitation		Minimum Precip.
	1o.Yr.	2o.Yr.	1o.Yr.
GRASSES			
Andropogon gayanus 621	3462	673	600
Brachiaria decumbens 606	1897	361	240
Brachiaria decumbens 6131	-	-	450
Brachiaria dyctioneura 6133	2725	959	430
Brachiaria humidicola 679	4340	1820	293
LEGUMES			
Centrosema arenarium 5236	891	-	383
Centrosema brasilianum 5055	1025	248	370
Centrosema brasilianum 5184	2219	309	443
Centrosema brasilianum 5234	1853	200	396
Centrosema brasilianum 5247	683	-	230
Centrosema macrocarpum 5065	2105	133	282
Centrosema pubescens 5050	266	185	166
Centrosema pubescens 5053	326	120	148
Centrosema pubescens 5126	126	170	100
Centrosema sp. 5112	2544	685	310
Desmodium gyroides 3001	3581	742	146
Desmodium ovalifolium 350	3796	2340	256
Pueraria phaseoloides 9900	3378	926	240
Stylosanthes capitata 1019	1358	270	120
Stylosanthes capitata 1315*	2046	547	140
Stylosanthes capitata 1318*	3486	817	133
Stylosanthes capitata 1342	2010	640	96
Stylosanthes capitata 1405	2260	576	273
Stylosanthes capitata 1441	2252	606	156
Stylosanthes capitata 1693*	2944	690	143
Stylosanthes capitata 1728*	2009	765	83
Stylosanthes capitata 2044	1844	496	115
Stylosanthes capitata 2310	1120	626	326
Stylosanthes leiocarpa 1087	2080	-	206
Stylosanthes guianensis "tardío" 1283	1617	511	800
Stylosanthes macrocephala 1281	1627	170	150
Stylosanthes macrocephala 1643	1627	-	93
Stylosanthes macrocephala 2039	1597	-	73
Stylosanthes macrocephala 2061	1976	150	45
Stylosanthes macrocephala 2093	753	-	65
Stylosanthes macrocephala 2133	949	140	225
Zornia brasiliensis 7485	1255	-	270

* Components of "CAPICA" cultivar.

Table 13. Locations and ecotypes considered for the combined analysis in the RIEPT's trials, in tropical forest ecosystem (1979-1982).

COUNTRIES AND LOCATIONS	COMMON ECOTYPES
BOLIVIA	GRASSES
Valle del Sacta	*Andropogon gayanus* 621
Chipiriri	*Brachiaria decumbens* 606
BRAZIL	*Panicum maximum* 604
Barrolândia	LEGUMES
COLOMBIA	*Aeschynomene histrix* 9690
Quilichao	*Centrosema pubescens* local
Caucasia	*Centrosema pubescens* 438
Puerto Asís*	*Calopogonium mucunoides*
COSTA RICA	*Desmodium gyroides* 3001
San Isidro	*Desmodium heterophyllum* 349
ECUADOR	*Desmodium ovalifolium* 350
El Puyo	*Pueraria phaseoloides* 9900
El Napo	*Stylosanthes guianensis* 136
PERU	*Stylosanthes guianensis* 184
Tarapoto, COPERHOLTA	*Stylosanthes capitata* 1097
Tarapoto, Porvenir	*Stylosanthes capitata* 1405
Tarapoto, ESEP	*Zornia latifolia* 728
Pucallpa*	
Yurimaguas*	
TRINIDAD	
Centeno	
UNITED STATES	
Hawaii	
VENEZUELA	
Guachí	

* Considered only for the dry season.

Table 14 shows the results of the analysis of yield variance for grasses and legumes during maximum and minimum precipitation periods. For the maximum precipitation evaluations, the grasses (A. gayanus CIAT 621, B. decumbens CIAT 606 and P. maximum CIAT 604) show differences ($P < 0.05$) in productivity. Differences were also detected among locations ($P < 0.01$). However, the interaction was not significant, indicating relative grass performance is consistent throughout the different locations. On the other hand, legumes showed differences ($P < 0.01$) during this period, among locations, among accessions ($P < 0.01$), and different relative performances ($P < 0.01$) from one location to another, showing greater performance specificity than grasses in this ecosystem.

The analysis of variance for the minimum precipitation period shows differences ($P < 0.01$) among locations for grasses and legumes. Furthermore, differences among accessions and location x accession interactions ($P < 0.05$) were found. These results suggest that during this period, even grasses exhibited different relative performances among locations, and indicate the presence of conditions throughout the range of locations and within the dry period, affecting in different ways the legumes and the three grasses evaluated.

Table 15 shows yield averages by location, separating maximum and minimum precipitation periods for grasses and legumes.

In these ecosystems, with overall climatic conditions during the maximum and minimum precipitation periods less extreme than those in savanna ecosystems, forage plants can grow throughout the year. Reduction in productivity from the rainy season to the minimum precipitation period was approximately 24%. In specific locations such as Napo and Puyo in Ecuador, for example, yield during the minimum precipitation period was superior to that during the maximum precipitation period. This was partly due to the excessive precipitation and lower radiation during the rainy season and contrasts strongly with performance in the savannas.

Mean yield values "a" of the accessions under study are recorded by locations in Table 16 for the maximum and minimum precipitation periods. These values were taken from the adaptability analysis, obtained by regression between the adaptability index* and yield (kg DM/ha, 12 weeks after regrowth). As expected, grass yields were higher, being A. gayanus CIAT 621 the outstanding accession.

The most productive legumes were S. guianensis CIAT 136 and A. histrix CIAT 9690, with 12 weeks regrowth yields close to 3000 kg DM/ha. D. gyroides CIAT 3001, D. ovalifolium CIAT 350, P. phaseoloides CIAT 9900 S. capitata CIAT 1097, and Z. latifolia CIAT 728 rated next with 12 weeks regrowth yields of approximately 2200 kg DM/ha.

Adaptability indexes "b" are also shown in Table 16, for the maximum and minimum precipitation periods. With the exception of A. histrix

* Adaptability Index = "productivity potential for each location" (see Tropical Pastures Program 1981 Annual Report, pp. 57-66; and Memorias II Reunión de la RIEPT, pp. 429-447).

Table 14. Analysis of variance for the dry matter production (kg/ha) at 12 weeks of regrowth of grasses and legumes in the tropical rain forest ecosystems

Source ot Variation	Rainy season DF	F	Dry season DF	F
GRASSES				
Location	13	4.3**	17	23.0**
Rep. (Location)	37		47	
Accession	2	3.2*	2	3.8*
Location x Accession	20	1.6NS	26	2.3*
Error	57		67	
Corrected total	129		159	
Mean	6356		4820	
CV (%)	63		37	
LEGUMES				
Location	15	32.2**	17	18.1**
Rep. (Location)	42		47	
Accession	12	18.6**	12	14.9**
Location x Accession	152	3.7**	166	3.6**
Error	406		436	
Corrected total	627		678	
Mean	2294		2004	
CV (%)	53		72	

* Significant effect with $0.01 < P \leq 0.05$.

** Significant effect with $P \leq 0.01$.

NS = Not significant.

Table 15. Mean production by location in the tropical forest ecosystem.

Location	Dry Matter Production (kg/ha), 12 weeks			
	Maximum precipit.		Minimum precipit.	
	Grasses	Legumes	Grasses	Legumes
BRAZIL				
Barrolândia	5873	1612	2529	1061
BOLIVIA				
Chipiriri	3493	1090	4185	1098
Valle de Sacta	9158	3448	1803	1539
COLOMBIA				
Caucasia	5679	1869	2211	1251
Quilichao	10084	2309	6036	2331
Puerto Asís	-	-	1193	836
COSTA RICA				
San Isidro	-	590	2733	1495
ECUADOR				
El Napo	5618	4221	8879	4810
El Puyo	8712	3646	7868	4365
NICARAGUA				
Nueva Guinea	10450	1443	10316	1130
El Recreo	-	1586	-	-
PERU				
Tarapoto, COPERHOLTA	2631	1354	1350	821
Tarapoto, ESEP	5437	1226	3610	1911
Tarapoto, Porvenir	938	682	702	526
Pucallpa	-	-	791	823
Yurimaguas	-	-	2809	1393
TRINIDAD				
Centeno	6976	3943	11742	3086
UNITED STATES				
Hawaii	1497	566	5717	2198
VENEZUELA				
Guachi	9796	5203	6094	1809
Mean	6356	2294	4820	2004
$LSD_{Loc, 5\%}$	4461	760	2014	814

Table 16. Adaptability Index, b, of the legumes and grasses accessions in the tropical forest ecosystem[a]. RIEPT's trials, 1979-1982.

Ecotype	Period of maximum precipitation				Period of minimum precipitation			
	a (kg DM/ha)[b]	b	S_b	r^2 (%)	a (kg DM/ha)	b	S_b	r^2
LEGUMES								
A. histrix 9690	2911	1.83	0.24	83**	3412	-	-	2^{NS}
C. mucunoides común	1233	0.41	0.12	51*	1341	0.71	0.13	75**
C. pubescens común	1080	0.28	0.09	49*	1084	0.44	0.14	46*
C. pubescens 438	1450	0.40	0.11	48*	1165	-	-	9^{NS}
D. gyroides 3001	2237	0.78	0.20	57*	1710	1.21	0.23	69**
D. heterophyllum 349	1303	0.55	0.16	46*	834	0.42	0.13	40*
D. ovalifolium 350	2296	0.78	0.16	63*	2093	0.68	0.23	34*
P. phaseoloides 9900	1992	0.53	0.14	50*	1713	0.70	0.13	63*
S. capitata 1097	2033	1.29	0.14	89**	2297	1.51	0.19	85**
S. capitata 1405	1889	1.16	0.14	84**	1259	1.06	0.23	59*
S. guianensis 136	3497	2.07	0.37	72**	2769	1.46	0.33	57*
S. guianensis 184	3344	1.62	0.09	97**	3296	1.89	0.48	54*
Z. latifolia 728	2778	1.39	0.21	77**	1903	1.15	0.32	47*
GRASSES								
A. gayanus 621	7413	0.70	0.29	32*	4582	0.74	0.13	66**
B. decumbens 606	5321	0.44	0.18	33*	4764	1.11	0.11	87**
P. maximum 604	5452	1.02	0.42	49*	3785	0.82	0.17	72**

a/ 95% confidence interval of b around 1:
Legumes, max. precipitation = (0.69, 1.31)
Legumes, min. precipitation = (0.63, 1.37)
Grasses, max. precipitation = (0.54, 1.46)
Grasses, min. precipitation = (0.78, 1.22)
See equation (3).

b/ At 12 weeks of regrowth.

* Significant regression at 95% of confidence ($0.01 < P \leq 0.05$).

** Significant regression at 90% of confidence ($P \leq 0.01$).

NS = Not significant.

CIAT 9690 and C. pubescens CIAT 438 all yields were significantly different during the dry period. These "b" values, as was the case in the savanna and only during the rainy season, tend to be greater when the average productivity reached by the ecotype is higher. For example S. guianensis CIAT 136 and 184, registering the highest yield levels, also have greater "b" values during both periods. Instead, materials with lower productivity (D. heterophyllum CIAT 349, C. pubescens "common") have relatively low "b" values. This suggests, once more, that for this type of germplasm, adaptability and productivity are positively related.

Figure 3 shows the classification of legumes by forest ecosystems, using the same method by quadrants. As mentioned previously, ecotypes S. guianensis CIAT 136 and 184 show greater productivity and a marked response to environment changes during the maximum and minimum precipitation periods. Z. latifolia CIAT 728 and S. capitata CIAT 1097 are legumes with intermediate performance. The latter maintains its productivity throughout both seasons and increases its response to the environment during the rainy season and less productive during the period of minimum precipitation, when its response to the environment is reduced. P. phaseoloides CIAT 9900, D. ovalifolium CIAT 350, C. pubescens "common", are consistently found in the left quadrant during the maximum and minimum precipitation periods, with productivities below average and low response to environmental changes.

Evaluation of damage caused by diseases indicates that the most important are: Cercospora leaf spot and Rhizoctonia foliar blight, for Centrosema; small leaf and root nematode, for Desmodium spp.; Sphaceloma scab and Drechslera leaf spot for Zornia latifolia; and rust for Zornia spp.

From the information collected, it can be tentatively concluded that the legume and grass accessions with higher resistance to diseases are:

P. phaseoloides
S. guianensis (136 - 184 - 1175)
D. heterophyllum (349)
C. macrocarpum (5065)
A. gayanus (621 - 6053 - 6054)
B. humidicola (679 - 682)
B. brizantha

With respect to pests, the insect groups most frequently present in this ecosystem are: sucking insects, chewing insects, budworms, stemborers, and flea beetles, attacking mainly species of Stylosanthes, Zornia, Centrosema, Desmodium, Pueraria, and Brachiaria.

Combined analysis for germplasm common to the tropical savanna and the tropical forest ecosystems

In order to obtain information on the performance of germplasm tested in the RIEPT, not only within each major ecosystem but also in the ecosystems considered (isohyperthermic tropical savanna and tropical forests), dry matter production (kg/ha, 12 weeks after regrowth) was

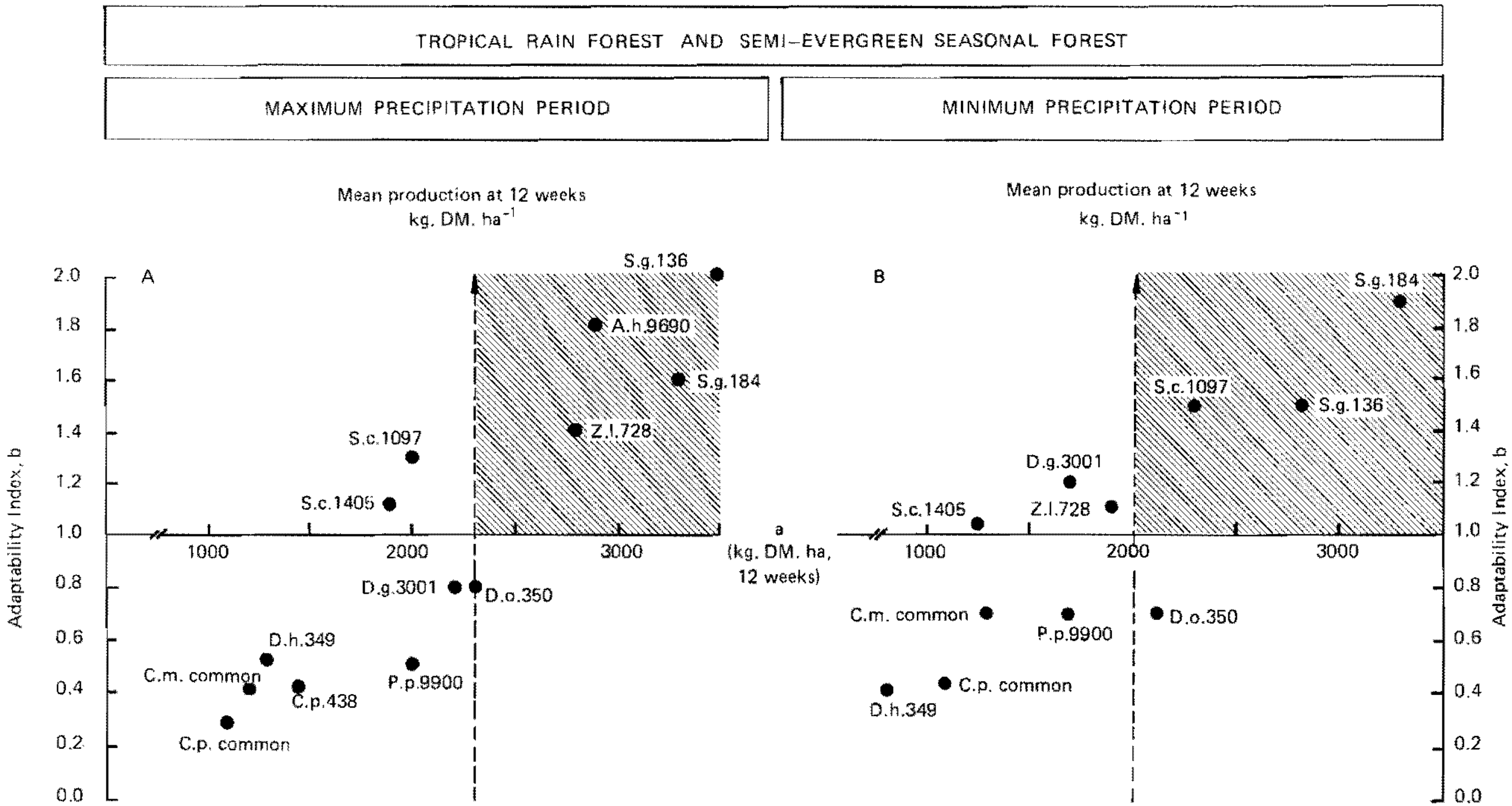


Figure 3. Accumulated mean production at 12 weeks and Adaptability Index of tropical legumes. Shaded area shows accesions with production higher than the mean of the ecosystem.

measured for two grass ecotypes (*A. gayanus* CIAT 621 and *B. decumbens* CIAT 606) and six legumes (*A. histrix* CIAT 9690, *D. gyroides* CIAT 3001, *P. phaseoloides* CIAT 9900, *S. capitata* 1405, *D. ovalifolium* CIAT 350 and *Z. latifolia* CIAT 728) i.e., those ecotypes common to the trials conducted in both ecosystems (Table 17).

This analysis indicated that for grasses (Table 18), average productivity in both ecosystems differs ($P < 0.05$); during the maximum as well as during the minimum precipitation periods, with yield means during the latter period of 5120 and 276 kg DM/ha, 12 weeks after regrowth, for the tropical forests and tropical savannas, respectively. During the maximum precipitation period, these means were 6742 and 2040 kg DM/ha, after 12 weeks. Undoubtedly, these results partially explain the higher productivity levels obtained in the tropical forest ecosystems, even with minimum technology and management levels. To explain this greater productivity in the tropical forests the following production factors must kept in mind: (a) tendency towards better soil fertility in the forest ecosystems, (b) less severe minimum precipitation period, and (c) less pressure due to biotic factors.

For legumes, however, the statistical analysis (Table 17) does not detect differences in productivity among ecosystems during maximum precipitation periods, even though production averages were 2463 and 1469 kg DM/ha, 12 weeks after regrowth, for tropical forests and savannas, respectively. This may possibly be due to the very marked difference ($P < 0.01$) between locations within each ecosystem. On the contrary, during minimum precipitation periods, significative differences ($P < 0.05$) were observed in the overall productivity of the two ecosystems: 2061 and 91 kg MD/ha, 12 weeks after regrowth, for tropical forests and savannas, respectively.

The fact that the differences found among locations within ecosystems are, in all cases, equal to or greater than those among ecosystems, and that these differences sometimes are covering up the effect of the ecosystem on the statistical analysis, suggests that other factors such as soil, drainage, topography, biotic elements, in addition to the climate parameter currently considered, should be used to better define the ecosystems and their subecosystems.

The accession x ecosystem interaction was not significant in all cases, except for legumes during the rainy season; this significant interaction indicates performance among the legumes to be relatively different when exposed to the different ecosystems.

Future Activities

A new list of RTA and RTB has been made official during this year. This will allow the RIEPT to increase the number of regional trials in order to evaluate the range of germplasm adaptation with a solid extrapolation basis.

With respect to Regional Trials C and D (RTC, RTD), the first steps have been taken to establish a methodological basis to estimate characteristics such as pasture stability and persistence in small

Table 17. Mean production (DM kg/ha at 12 weeks) of grasses and legumes in both the ecosystems of tropical forest and tropical savanna.

Ecotypes	Rainy Season		Dry Season	
	Forest	Savanna	Forest	Savanna
GRASSES				
A. gayanus 621	7845	2089	4771	220
B. decumbens 606	5574	1990	5486	331
LEGUMES				
A. histrix 9690	2984	1523	3664	171
D. gyroides 3001	2304	1229	1801	83
D. ovalifolium 350	2323	1228	2068	0
P. phaseoloides 9900	1979	1116	1698	34
S. capitata 1405	2247	2593	1427	161
Z. latifolia 728	2969	1072	2062	97

Table 18. Analysis of variance for the dry matter production (kg/ha) at 12 weeks of regrowth of germplasm tested in both the ecosystems of tropical forest and tropical isohyperthermic savanna.

Source of Variation	Rainy season DF	Rainy season F	Dry season DF	Dry season F
GRASSES				
Ecosystem	1	5.7*	1	4.9*
Location (Ecosystem)	16	4.1**	19	18.5**
Rep. (Ecosystem x Location)	45		52	
Accession	1	4.3*	1	3.5NS
Ecosystem x Accession	1	0.7NS	18	0.4NS
Location x Accession (Ecosystem)	15		18	
Residue	43		46	
Corrected Total	122		138	
Mean	6054		4493	
CV (%)	68		30	
LEGUMES				
Ecosystem	1	1.2NS	1	3.9*
Location (Ecosystem)	18	18.6**	19	8.8*
Rep. (Ecosystem x Location)	50		53	
Accession	5	3.5**	5	5.6**
Ecosystem x Accession	5	5.7**	5	1.2NS
Location x Accession (Ecosystem)	81		81	
Residue	212		212	
Corrected total	372		376	
Mean	2276		1800	
CV (%)	50		98	

* Significant effect with $0.01 \leq P \leq 0.05$
** Significant effect with $P < 0.01$
NS= Not significant.

plots and to evaluate the presentation and discussion of project proposals on the recently established RTCs and RTDs in the RIEPT (Figure 1 and Tables 4 and 5).

A work meeting sponsored by INIPA-CIID-CIAT will be held (October, 1984) to define the general objectives for the RTDs, the experimental variables to be measured, and their analysis.

In addition, a course will be held in November-December, 1984 in Gualaca, Panamá on introduction, evaluation, and production of forage germplasm seed for México and countries in Central America and the Caribbean.

ENTOMOLOGY

During 1983, the Entomology Section of the Tropical Pastures Program has continued its research activities consistent with the objectives proposed since 1977:

a) germplasm evaluation in the different categories, in search of resistance and/or tolerance to the insect pest attack including germplasm under evaluation in the regional trials; and

b) development of specific research projects in relation to those pests considered limiting to forage production.

GERMPLASM EVALUATION

Germplasm evaluation for resistance and/or tolerance to the insect attack continued in Carimagua and various regional trial sites. Evaluations produced an insect inventory for CPAC, CEPLAC and in a *S. capitata* trial in collaboration with EPAMIG, in Acauã, MG, Brazil (Table 1).

SPECIFIC STUDIES

Spittlebug

During 1983, efforts were intensified to understand better the spittlebug complex, the most important pest affecting grasses in the American tropics. To this effect, research was organized in the following manner: (1) greenhouse and laboratory studies; (2) studies at the farm level in the Colombian Llanos Orientales; and (3) studies on the performance of grass germplasm in relation to the attack of different spittlebug species in various ecosystems of Central and South America.

Greenhouse and laboratory studies

An intensive evaluation of grass germplasm of the genus *Brachiaria* was initiated during the 1983 and studies were carried out on (a) feeding preference of adults, (b) oviposition preference, (c) capacity to recover after damage, and (d) effect of spittlebug attack on nutrient concentration.

Feeding preference of adults

Based on results from previous years, demonstrating that the insect causes more severe damage in the adult stage than during its nymphal

Table 1. Insects registered in Brazil (Acauã, CPAC, CEPLAC, 1982-1983).

LEGUMES

Insect-Pest	Order-Family	Host	Habit	Site
Lagria villosa	Coleoptera-Lagriidae	*S. capitata*	Predator	Acauã
Diabrotica pos. (*viridula*)	Coleoptera-Chrysomelidae	*S. capitata* *S. macrocephala*	Foliage eater	Acauã-CEPLAC CPAC
Diabrotica sp.	Coleoptera-Chrysomelidae	*Zornia* sp.	Foliage eater	CEPLAC
Pachibrachis sp.	Coleoptera-Chrysomelidae	*S. capitata*	Foliage eater	Acauã
Cerotoma sp.	Coleoptera-Chrysomelidae	*D. gyroides* *Zornia* sp.	Foliage eater	CEPLAC-CPAC
Gynandrobrotica lacta	Coleoptera-Chrysomelidae	*Zornia* sp.	Foliage eater	CPAC-Acauã
sp.	Coleoptera-Coccinellidae	*S. capitata*	Predator	Acauã
Apion sp.	Coleoptera-Curculionidae	*Zornia* sp.	Seed borer	CEPLAC
Helochara communis (F)	Homoptera-Cicadellidae	*S. capitata*	Sucker	Acauã
Plesiommata molicella	Homoptera-Cicadellidae	*Centrosema* sp.	Sucker	CPAC
Tylosigus fasciatus	Homoptera-Cicadellidae	*S. macrocephala* *Centrosema* sp.	Sucker	Acauã
Ceresa ustulata	Homoptera-Membracidae	*D. gyroides*	Sucker	CEPLAC
Euschistus crenator	Hemiptera-Pentatomidae	*S. capitata*	Sucker	Acauã
Euschistus sp.	Hemiptera-Pentatomidae	*S. capitata*	Sucker	Acauã
Banasa lenticularis	Hemiptera-Pentatomidae	*Zornia* sp.	Sucker	CPAC
Bracon sp.	Hymenoptera-Braconidae	*S. capitata*	Parasite	Acauã
Polibia	Hymenoptera-Vespidae	*S. capitata* *S. macrocephala*	Predator	Acauã
sp.	Diptera-Muscidae	*S. macrocephala*		Acauã
sp.	Neuroptera-Chrysomelidae	*S. macrocephala*	Predator	Acauã

Table 1. Continued.

Insect-Pest	Order-Family	GRASSES Host	Habit	Site
Diabrotica pos. (*viridula*)	Coleoptera-Chrysomelidae	*B. decumbens*	Foliage eater	Acauá-CEPLAC
Diabrotica sp.	Coleoptera-Chrysomelidae	*B. decumbens*	Foliage eater	CEPLAC
Cerotoma sp.	Coleoptera-Chrysomelidae	*B. decumbens*	Foliage eater	Acauá
Lagria villosa	Coleoptera-Lagriidae	*B. decumbens*	Predator	CEPLAC
Deois flavopicta	Homoptera-Cercopidae	*B. decumbens*	Sucker	CEPLAC
Deois schach	Homoptera-Cercopidae	*B. decumbens* *B. humidicola*	Sucker	CEPLAC
Ceresa vistolus	Homoptera-Membracidae	*B. humidicola*	Sucker	CEPLAC
Ceresa sp.	Homoptera-Membracidae	Native pasture	Sucker	CEPLAC
Plesiommata molicella	Homoptera-Cicadellidae	*B. humidicola*	Sucker	CEPLAC
Hortensia similis	Homoptera-Cicadellidae	*B. humidicola* *B. decumbens*	Sucker	CEPLAC
Apagonalia germana	Homoptera-Cicadellidae	*B. decumbens*	Sucker	CEPLAC
Tetragonia cribata	Homoptera-Cicadellidae	*B. decumbens*	Sucker	CEPLAC
Helochara communis	Homoptera-Cicadellidae	Pasto nativo	Sucker	Diamantina
Euchistus sp.	Hemiptera-Pentatomidae	*B. decumbens*	Sucker	Acauá
sp.	Hemiptera-Rhodolidoe	Pasto nativo	Sucker	CEPLAC
sp.	Hymenoptera-Formicidae	*B. decumbens*	Foliage eater	CEPLAC
sp.	Neuroptera-Chrysopidae	*B. decumbens*	Predator	Acauá

stage, it was decided to start by studying adult feeding preference. The trial was carried out under greenhouse conditions in CIAT-Palmira, using fine-screen cages and giving the insect the opportunity to select freely. Each cage had 200 adults. After ten days, the insects were removed to measure the respective damage using the following scale: (1) without damage, (2) slight damage, (3) moderate damage, (4) severe damage, and (5) plant death.

Results in Table 2 show variation regarding damage caused by adults among different accessions of Brachiaria spp. These results are considered promising in the search for germplasm resistant and/or tolerant to the insect. As a result, field studies have been established in different locations in order to complement the information obtained in the greenhouse.

Capacity of several accessions of Brachiaria spp. to recover after damage caused by adults

One of the most important characteristics of a grass, besides its resistance to the pest, is its capacity to recover after damage, measured by biomass production after insect damage. This experiment was carried out in screenhouses at CIAT-Palmira. Results indicated (Table 2) that those accessions selected as promising, in general, show a "good" capacity to recover, with the exception of B. humidicola 6709, which showed a "regular" capacity, very similar to the control, B. decumbens 606. The best response was given by B. brizantha 6688. It is worth noticing that of the Brachiaria species being evaluated, B. brizantha represents 67% of the total species selected for this preliminary screening trial.

Oviposition preference

This study was conducted under greenhouse conditions using nine accessions selected as promising with respect to resistance to spittlebug (Table 3). Results indicate considerable variation with respect to oviposition preference. Brachiaria brizantha CIAT 6686 was least preferred; while B. brizantha 6294, which under field conditions is not damaged by the insect, was the most preferred. This situation seems contradictory. It is possible that the capacity of this grass to produce foliage could offer a microclimate favorable for oviposition. Specific trials are currently in progress to characterize each accession selected in relation to oviposition preference.

Chemical analysis and study of the effect of spittlebug attack on concentration of nutrients in the grass

This study (Table 4) showed that the plant's nutrient concentration apparently does not seem to be affected by the damage caused by the adult spittlebug. According to observations under field conditions, forage is not consumed by cattle in pastures where the grass presents "moderate" to "severe" damage. This suggests that toxins injected by the insect while feeding affect the plant's palatability.

Table 2. Feeding preference of adult spittlebug and regrowth capacity of *Brachiaria* spp. accessions under controlled greenhouse conditions (CIAT-Palmira, 1983).

Accession	CIAT No.	Damage/ Adult[1]	Capacity to Recover[2]
B. humidicola	6707	1.3	2.7
B. brizantha	6424	1.6	2.3
B. brizantha	6688	1.7	1.7
B. brizantha	6297	2.0	2.0
B. brizantha	6686	2.0	2.3
B. brizantha	6687	2.0	2.3
B. humidicola	6709	2.0	3.3
B. dictyoneura	6369	2.0	2.3
B. brizantha	6294	2.0	2.7
B. humidicola[3]	679	3.0	2.7
B. decumbens[3]	606	3.7	3.5

1/ Damage evaluation scale: 1 = no damage, 2 = slight damage, 3 = damage, 4 = severe damage, 5 = plant death.

2/ Evaluation scale of the plant's regrowth capacity: 1 = excellent; 2 = good; 3 = average; 4 = bad; 5 = plant death.

3/ Control.

Table 3. Oviposition preference of adult spittlebug registered on Brachiaria spp. accesions under controlled greenhouse conditions, CIAT-Palmira.

Accessions	CIAT No.	Oviposition preference (%)
B. brizantha	6686	1.7
B. humidicola	6709	2.7
B. dictyoneura	6369	2.7
B. brizantha	6424	3.0
B. brizantha	6687	3.0
B. decumbens	606	6.3
B. brizantha	6297	9.7
B. humidicola	6707	10.3
B. humidicola	679	10.3
B. brizantha	6688	14.7
B. brizantha	6294	20.0

Evaluation of spittlebug populations on farms in the Colombian Llanos Orientales

Research was started during 1983 with the objective of studying the incidence and distribution of spittlebug in the Llanos of Colombia. Results obtained indicate (Table 5) that spittlebug incidence in B. decumbens pastures is related to a certain extent with grass height and with the use of some management practices. The smallest insect populations were registered in farms where land preparation was done with a turbotiller and maintenance fertilization was applied, in addition to adequate grazing treatments to keep the grass between a height of 25-35 cm. These results suggest that if "genetic resistance" is obtained, use of the above mentioned management practices in addition to use of efficient strains of the fungus Metarhizium anisopliae (see previous annual reports), could be ideal complements for integrated control of this pest.

The effect of several management systems and different grazing pressures on spittlebug populations in Carimagua

The trial was started in 1983 using four stocking rates and four treatments including different occupation and resting periods in addition to continuous grazing. Results (Table 6) showed different insect populations that could be attributed to the effect of the various grazing treatments; however, the evaluation period was considered to be relatively short (5 months) for making conclusions. For the continuous grazing treatment with a stocking rate of 1.2 an/ha, the average insect

Table 4. Nutrient concentration in Brachiaria spp. accessions attacked and not attacked by adult spittlebug (*Zulia colombiana*) under controlled greenhouse conditions (CIAT, 1983).

	Ecotype CIAT No.	Visual Evalu. of damage[1] X	Chemical Analysis N(%) A[2]	N(%) NA[3]	K(%) A	K(%) NA	P(%) A	P(%) NA	S(%) A	S(%) NA
RESISTANT										
B. humidicola	6707	1.33	1.28	1.88	1.00	1.03	0.11	0.18	0.20	0.23
B. brizantha	6424	1.60	1.37	1.71	1.79	1.79	0.16	0.17	0.16	0.19
B. brizantha	6688	1.66	1.16	1.62	1.60	2.54	0.11	0.19	0.14	0.18
B. brizantha	6297	2.00	2.43	2.94	2.69	2.68	0.24	0.27	0.21	0.26
B. brizantha	6686	2.00	1.87	1.60	2.12	1.76	0.13	0.13	0.15	0.19
B. brizantha	6687	2.00	1.64	1.68	2.40	2.04	0.16	0.13	0.14	0.15
B. humidicola	6709	2.00	1.69	1.48	1.07	1.29	0.11	0.22	0.17	0.23
B. dictyoneura	6369	2.00	1.66	1.82	1.06	1.28	0.13	0.24	0.23	0.26
B. brizantha	6294	2.00	1.72	1.46	1.36	1.15	0.24	0.24	0.23	0.27
MEAN		1.84	1.65	1.80	1.68	1.73	0.15	0.20	0.18	0.22
SUSCEPTIBLE										
B. ruziziensis	655	4.00	2.08	1.74	1.75	2.17	0.22	0.35	0.35	0.34
B. radicans	6020	4.00	1.46	1.57	1.50	1.46	0.21	0.30	0.30	0.34
Brachiaria sp.	6008	4.00	1.75	1.82	1.96	2.50	0.18	0.32	0.25	0.23
B. ruziziensis	660	4.00	1.41	1.65	1.40	0.89	0.21	0.23	0.34	0.36
B. decumbens	6131	4.33	2.08	1.57	1.83	1.48	0.23	0.31	0.28	0.26
B. ruziziensis	6419	4.33	1.59	0.90	1.35	1.09	0.21	0.22	0.40	0.41
B. ruziziensis	656	4.33	1.35	1.65	1.34	1.89	0.23	0.28	0.36	0.36
MEAN		4.14	1.67	1.56	1.59	1.64	0.21	0.28	0.32	0.32

1/ Damage evaluation scale: 1 = no damage; 2 = slight damage; 3 = moderate damage; 4 = severe damage; 5 = Plant death

2/ Attacked

3/ Not attacked

Table 5. Evaluation of spittlebug populations found in *B. decumbens* in several farms (Llanos Orientales, Colombia, 1983).

Farm	1st. Evaluation (June)			2nd. Evaluation (October)		
	Nymphs/m^2	Adults/m^2	Height of pasture (cm)	Nymphs/m^2	Adults/m^2	Height of pasture (cm)
Brasil 1	0.0	0.0	35-40	5.2	2.9	35-40
Guayabal	0.0	0.0	25-30	0.0	0.0	40-50
Margaritas	0.0	0.0	35-40	0.1	0.0	30-40
La Plata	0.0	0.0	35-40	0.3	0.1	25-30
El Viento	1.8	1.5	10-15	7.3	1.7	20-25
Altagracia	1.9	1.4	30-35	0.9	0.5	35-40
Brasil 2	3.3	1.7	30-35	3.4	2.6	40-50
El Paraíso	18.2	11.7	25-30	6.8	5.8	20-25

Table 6. Effect of management and grazing pressure on spittlebug populations in *B. decumbens*, 1983.

Treatment/ Grazing System	Stocking Rate (an/ha)	Adults/m^2	Nymphs/m^2	Height of pasture (cm)
Continuous	1.2	2.5	16.3	40-50
Rotational 7/35[1]	2.5	2.6	13.1	30-40
Rotational 14/28	2.5	2.8	12.4	35-40
Alternate 21/21	2.5	3.0	18.7	50-60
Rotational 14/28	2.0	3.1	16.2	35-40
Rotational 14/28	2.5	2.1	11.5	30-35
Rotational 14/28	3.0	1.2	3.5	35-40

1/ Occupation days/resting days.

population was unexpectedly high as was grass height. These results seem to suggest that 1.2 an/ha is not adequate to maintain the grass height low (25-35 cm). At the beginning of the trial, the pasture had a height of 60-70 cm.

Rotational grazing treatments of 14/28* at a 2.5 an/ha stocking rate showed similar results with regard to insect population and grass height. However, within the same grazing system, the lowest stocking rate (2.0 an/ha) resulted in a higher spittlebug population, while the highest stocking rate (3.0 an/ha) was accompanied by lower insect populations, and, grass height was maintained at an acceptable level. As mentioned before, although there remain many unanswered questions concerning appropriate management systems and adequate grazing pressures, these preliminary results indicate that with the 14/28 system, the highest stocking rate (3.0 an/ha) gave the lower spittlebug populations in comparison to the rest of the treatments in this trial. This trial will continue during 1984 in an attempt to define the actual effect of management systems and grazing pressures on the regulation of spittlebug populations.

Introductions II

Since 1980 the Pasture Management and Productivity Section's Introduction II trial has been under evaluation. Two pasture systems with *Brachiaria decumbens* and *Pueraria phaseoloides* as compared with the grass alone have been studied. Results in Tables 7 consistently show

* Occupation days/Resting days.

low spittlebug nymph and adult populations after the fifth year of evaluation, when the pasture have been managed at an average height of 25 cm. However, it is interesting to note that pure *Brachiaria decumbens*, under the same management conditions, was observed to always present the lowest insect populations; while the protein bank treatment showed intermediate populations. The association with *P. phaseoloides* planted in strips hosted the highest populations, even though animal production has been consistently higher in this pasture, as compared with the other treatments. These results and results from farm evaluations, indicate that maintaining grass height between 25 and 35 cm by using adequate management systems and stocking rates, along with the use of some regenerative cultural practices (turbotiller, maintenance fertilization, etc.) may constitute the components of an integrated spittlebug control system in the Llanos Orientales of Colombia. More work is presently in progress.

Evaluation of the Brachiaria spp. germplasm

Studies were initiated during 1983 on the performance of the *Brachiaria* spp. collection in relation to spittlebug attack in several sites in Central and South America. The main objective of this study is the identification of tolerant and/or resistant germplasm.

In view of the importance of this type of evaluation, trials have been established in different ecosystems and locations: Colombia (6), Perú (4), Bolivia (1), Brazil (1), Cuba (1), Ecuador (1), and Panamá (1), and further trials are planned. The first results, which include evaluation of nutrient concentration in the plants, are expected for 1984.

Table 7. Spittlebug populations in *B. decumbens* alone and with *P. phaseoloides* in blocks and strips (Carimagua).

B. decumbens	Mean (1980-1982)		1983		
Pasture	Nymphs/m^2	Adults/m^2	Nymphs^2	Adults/m^2	Height of pasture (cm)
Gramínea sola	0.54	0.47	0.39	0.32	22.5
+ *P. phaseoloides* - blocks	1.58	1.27	1.29	0.84	21.9
+ *P. phaseoloides* - strips	2.47	1.57	3.11	1.44	27.4

PLANT PATHOLOGY

As in previous years, the responsibilities of the Plant Pathology Section continued during 1983 in:

1. The evaluation of all germplasm for reaction to diseases in major screening and regional trial sites in all ecosystems.

2. The identification and assessment of diseases of germplasm under pasture evaluation.

3. The evaluation and development of control measures for the most important diseases of promising pasture species.

GENERAL STUDIES

Disease Survey

Two new diseases were detected during 1983. Firstly, rust of *Stylosanthes aurea* in a native population of several *Stylosanthes* species near Diamantina, Minas Gerais, Brazil. The rust is a species of Puccinia; its full identity is presently under review. Secondly, witches broom, probably caused by a mycoplasma, was detected on several accessions of *Centrosema brasilianum* in Carimagua.

Selection within the *Zornia latifolia* CIAT 728 population for resistance to Sphaceloma scab

During 1980-1981, observations made in CIAT 728 plots found considerable variation in reaction to Sphaceloma scab. Individual plants were surveyed for twelve months and selections made for further evaluations. Seedling reaction of progeny collected from resistant and susceptible plants correlated well with parent field reactions. Field reactions of these selected progeny in Quilichao during 1982-1983 also correlated well with the field reactions of the parents during 1980-1981 with FP* 2, 4 and 5 being susceptible and FP 1 and 3 remaining resistant (Table 1). Field evaluations in Carimagua will made during 1984-1985 with the aim of selecting a Sphaceloma scab resistant *Zornia latifolia*.

Studies on the seed microflora of *Stylosanthes capitata*

A student thesis project** on the microflora of seed of *S. capitata* found 23 genera of fungi and 12 different bacteria associated with seed harvested from Carimagua and Santander de Quilichao, Colombia (Tables 2 and 3). Fourteen fungal genera were common to both sites; five genera -*Bipolaris*, *Eurotium*, *Gloeocercospora*, *Humicola* and

* FP = Plant Pathology selection

** Diego Fernando Orozco.

Table 1. Reaction of selected progenies from Zornia latifolia CIAT 728 to Sphaceloma scab during 1982 - 1983 in Quilichao.

Selection	Reaction[1] to Sphaceloma	Survival %	Yield per Plot g	Yield per Plant g
FP 1	0.9	57	2767.8	687.2
FP 2	1.9	42	2453.2	452.8
FP 3	0.7	43	2797.4	774.3
FP 4	3.9	36	2545.7	1094.0
FP 5	1.6	58	2532.8	313.8

1/ Reaction to Sphaceloma: 0 = No disease; 5 = Dead plant.

Trichothecium- were found in Santander de Quilichao only while four genera -Leptosphaerulina, Myrothecium, Pleospora and Ulocladium- were specific to Carimagua. Treatments including disinfection with sodium hypochlorite; low and high temperatures; scarification and chemicals were successful in significantly reducing the percentage of fungi associated with seed, however, bacterial contamination was reduced more by treatment with sodium hypochlorite and scarification than by other treatments. Seed germination was considerably increased by scarification and temperature treatments.

Collaborative screening for resistance to Meloidogyne spp. among the Desmodium ovalifolium germplasm collection

The International Meloidogyne Project (IMP) based at the North Carolina State University in Raleigh is in the process of evaluating the reaction of the D. ovalifolium collection to major species and races of Root-knot nematode (Meloidogyne). Results from evaluations of 17 accessions have found more resistance to M. hapla (Table 4). There was no accession highly resistant to all populations, however. CIAT 350 may have a desirable level of resistance to all except M. arenaria, CIAT 3666 and 3780 were very resistant to M. arenaria Race 2 and CIAT 3666 was also very resistant to M. javanica. Further screening is in progress with M. incognita Races 1, 2 and 3, and M. javanica from South America. Evaluation of the whole collection of D. ovalifolium will be completed during 1984.

STUDIES IN THE WELL-DRAINED ISOHYPERTHERMIC SAVANNAS - LLANOS

Diseases of Stylosanthes species

Anthracnose

Since July 1982, 140 accessions of S. guianensis "tardio" have been under evaluation for resistance to anthracnose in Carimagua. By

Table 2. Percentage of fungi and bacteria* associated with seed of Stylosanthes capitata harvested in Santander de Quilichao.

Accessions / Microorganisms	*Ascochyta* sp.	*Aspergillus* spp.	*Bipolaris* sp.	*Colletotrichum* spp.	*Coniothyrium* sp.	*Curvularia* spp.	*Chaetomium* spp.	*Eurotium* sp.	*Fusarium* spp.	*Gloeocercospora* sp.	*Gonatobotryum* sp.	*Humicola* sp.	*Mucor* spp.	*Penicillium* spp.	*Pestalotiopsis* sp.	*Phoma* sp.	*Rhizopus* spp.	*Trichoderma* sp.	*Trichothecium* sp.	Fungus (Total)	(Total)
1019-78		0.66						0.33					1.0				0.33			2.32	32.66
SS**		0.33																		0.33	2.66
1019-79	1.33	0.33		2		1	1	0.33	2.0				0.33			0.66				8.98	23.32
SS	1.0			1.66		0.33		0.33	1.66							0.66				5.64	3.0
1019-80		1	0.66		0.33	1.33			4.66		1.66	0.33		0.33		0.33		0.33	0.66	11.29	35.66
SS		1			0.33	0.33			0.66							0.33				2.65	4.0
1318-82		2.33			0.66	0.66	0.33		1.33				12.32	31.3			2.0			50.93	73.33
SS		1.33		0.33	1.33	1.0			2.66	1.0			0.33	0.33	0.33		0.33			8.97	13.0

* Mean percentage associated with 400 seeds in each case.

** SS = Surface Sterilized

Table 3. Percentage of fungi and bacteria* associated with seed of *Stylosanthes capitata* harvested in Carimagua.

Accessions / Microorganisms	*Ascochyta* sp.	*Aspergillus* spp.	*Colletotrichum* spp.	*Coniothyrium* sp.	*Curvularia* spp.	*Chaetomium* spp.	*Fusarium* spp.	*Gonatobotryum* sp.	*Leptosphaerulina* sp.	*Mucor* spp.	*Myrothecium* sp.	*Penicillium* spp.	*Pestalotiopsis* sp.	*Phoma* sp.	*Pleospora* sp.	*Rhizopus* spp.	*Trichoderma* sp.	*Ulocladium* sp.	Fungus (Total)	Bacteria (Total)
1019-79		1.0			0.33	0.33	1.0			1.0	0.33	0.33		0.33					4.65	83.33
SS**					0.33	0.66	1.0							0.33					2.32	19.0
1019-80-A					4.66	1.33	2.33		0.33	1.0		0.66	0.33	0.33		0.33			11.3	37.33
SS	1.0	0.33	0.33		1.33	1.0	2.66							0.66		0.33			7.64	9.0
1019-80-B			0.33	4.0			3.33	2.0		0.66					0.66		0.33	1.0	12.31	32.0
SS				2.0			0.33												2.33	1.0
1318-81		3.66		0.33			17.65			40.29		0.33				4.0			66.26	35.33
SS		0.33					8.32		0.66										9.64	99.0

* Mean percentage associated with 400 seeds in each case.

** SS = Surface Sterilized.

Table 4. Reaction[1] of 17 accessions of Desmodium ovalifolium to major species and races of root-knot nematode - Meloidogyne[2].

CIAT No.	M. incognita Race 4	M. arenaria Race 1	M. arenaria Race 2	M. javanica	M. hapla
			Nematode Populations		
350*	HR	HR	MR	VR	HR
3607			S		
3608	MR	S	S	S	HR
2652	S	S	S	S	SR
3663	S	S	S	S	VR
3666	SR	S	VR	VR	HR
3668	S	S	S	S	VR
3673	S	MR	S	S	HR
3674	S	S	S	S	VR
3776	S	MR	MR	S	HR
3780	S	SR	VR	S	HR
3781	S	S	S	S	VR
3784	S	SR	S	MR	MR
3788	MR	SR	MR	MR	HR
3793	S	S	S	S	SR
3794	SR	MR	SR	MR	HR
350A	S	S	S	S	VR

1/ Degree of resistance is based on percent reproduction.
* Insufficient replication, test is being repeated.
Scale of evaluation: 1 = 0% reproduction; HR = 0-1%; VR = 1-10%; MR = 10-25%; SR = 25-50%; S = 50-100%

2/ Collaborative project with the International Meloidogyne Project of the University of North Carolina, Raleigh, U. S. A.

October 1983, 23.6% of accessions remained resistant to anthracnose (Table 5). These included CIAT 2031, 2127, 2326, 2357, 2362, 2373, 2436, 2646, 2684, 2709, 2734, 2981 and 10136 as the most promising accessions. Evaluations of both anthracnose and stemborer will continue through 1984.

Table 5. Reaction to anthracnose of 107 accessions of *S. guianensis* "common" and 140 accessions of *S. guianensis* "tardio" in Carimagua from September 1982 to October 1983.

SPECIES	ACCESSION No.	REACTION TO ANTHRACNOSE[1] % ACCESSIONS 5	4	3	2	1	0
S. guianensis common	107	78.8	14.7	5.3	0.9	0.3	0
S. guianensis "tardio"	140	19.5	31.7	25.2	13.5	8.3	1.8

A collection of 107 accessions of *S. guianensis* "common" from Australia was planted in Carimagua late in 1982. After one year, 98.8% of the collection were found susceptible to anthracnose (Table 5). Resistant accessions were found to be mistakenly identified "tardios".

The higher anthracnose resistance of "tardio" types of *S. guianensis* in the llanos ecosystem is now well recognized and further evaluation of "common" types is not warranted.

A large collection of *S. capitata* has been under evaluation in Carimagua since 1979. During the past four years, both the 181 accessions and the associated *Colletotrichum* spp. isolates have been monitored. Eighty-four percent of the collection remained free of anthracnose during four years while the remainder were slightly affected by both C. gloeosporioides and C. dematium (Table 6). Other diseases detected included blight (Sclerotium rolfsii) and some dieback due to Botryosphaeria ribis and Macrophomina phaseolina (Table 6). It's clear that no significant changes have occurred in the virtually disease-free status of promising accessions of S. capitata in Carimagua during the past four years.

Table 6. Evaluation of diseases of 181 accessions of Stylosanthes capitata from 1979 to 1983 in Carimagua.

DISEASE	REACTION 0	1	2	3	4	5
Anthracnose (Colletotrichum spp.)	84.5	12.2	1.7	1.1	0.5	0
Blight (Sclerotium rolfsii)	98.3	0	1.7	0	0	0
Others	98.8	0.6[1]	0.6[2]	0	0	0

1. Macrophomina phaseolina.

2. Botryosphaeria ribis.

The effect of anthracnose on susceptible S. guianensis CIAT 13 (cv. Endeavour) and resistant CIAT 10136 was evaluated in pure stand at different planting densities and in association with A. gayanus. At all evaluations, more anthracnose was found in CIAT 13 in association with A. gayanus than in pure stand and there was no difference between planting densities (Figure 1). No anthracnose was found on CIAT 10136 in any treatment. The greater susceptibility of CIAT 13 in association with A. gayanus was thought to be due to the maintenance of a more humid microclimate in association with the grass which could favour anthracnose development and the increased shading by the grass which could increase spore production by C. gloeosporioides and subsequent dissemination and anthracnose spread. More associations with grasses of varying morphology will be evaluated next year.

Studies on the use of accession mixtures of S. guianensis to control anthracnose continued during 1983. By April 1983, the advantage of the mixture in control of anthracnose in the susceptible "commons" CIAT 136, 1875 and 1949 had been virtually lost but was still evident in the susceptible "tardio" CIAT 1927, with the mixture being responsible for 60.5% improvement in live plant yield and a slight

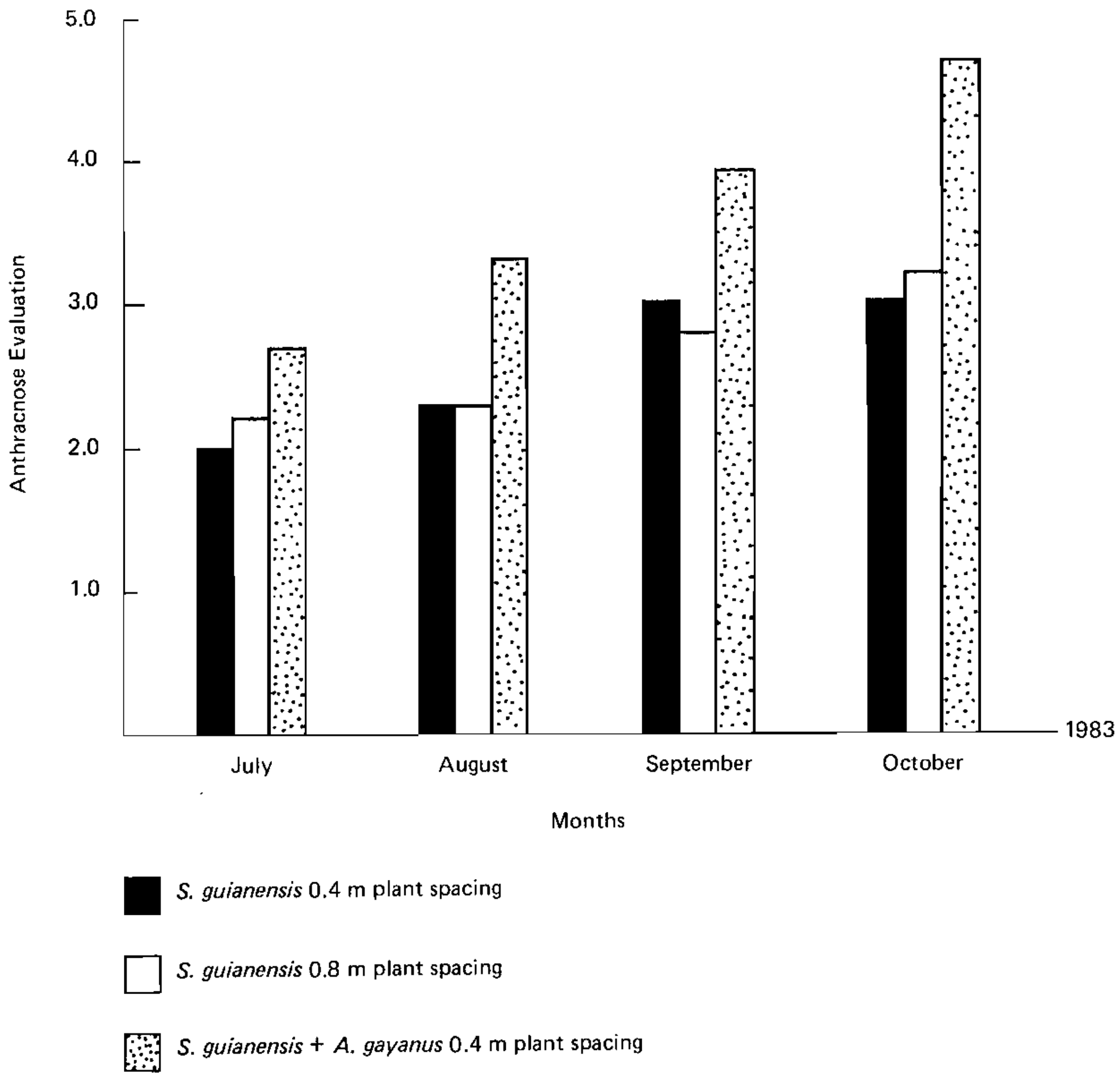


Figure 1. Effect of anthracnose on *S. guianensis* cv. Endeavour planted with and without *A. gayanus*.

(13.8%) improvement in survival (Table 7), with anthracnose levels of 4.0 in the mixture and 4.7 in the pure stand (Figure 2).

Results of studies on variation in pathogenicity among isolates of C. gloeosporioides collected from this experiment during 1982-1983 clearly show the occurrence of three "races" pathogenic to two of the three "common" components, CIAT 136 and CIAT 1875; one "race" pathogenic to all three components; and one "race" specific to CIAT 1875. In contrast, although the most susceptible "tardio" CIAT 1927 was affected by four "races", only one "race" was pathogenic to "tardio" CIAT 2031 and no "races" were found pathogenic to CIAT 10136 (Table 8).

The results for the "tardios" are encouraging and a new experiment looking at the effect of mixtures of different proportions of three accessions of S. guianensis "tardio" CIAT 1927, 2031 and 10136 has been established in Carimagua for evaluation during 1984.

Diseases of Desmodium species

Stem-gall nematode

The Commonwealth Institute of Parasitology, England confirmed the identity of stem-gall nematode as the new genus, Pterotylenchus, of the family Anguinidae, unique in the females having large vulval flaps. The specific name cecidogenus means gall-forming.

Preliminary studies on host range found that P. cecidogenus was pathogenic to Desmodium spp., including D. ovalifolium, D. heterocarpon and one accession of D. distortum (Table 9), but did not affect a wide range of promising tropical pasture legumes and several accessions of Phaseolus vulgaris. Results to date suggest that among promising tropical pasture legume genera, P. cecidogenus is restricted to Desmodium.

Seed of D. ovalifolium CIAT 350 was harvested from stem-gall nematode infested plots. The presence of galls and nematodes associated with inflorescences and inflorescence stems was confirmed and seed transmission of the nematode was evaluated in seedlings produced from seed from these inflorescences. No galls were found in the resulting 360 plants although nematodes were found in 10% of plants from mechanically scarified seed germinated in the presence of pods and in 5% of plants from mechanically scarified seed germinated in the absence of pods (Table 10). At the same time, however, any natural infection was eliminated by chemical scarification (H_2SO_4) and Furadan (Table 10).

The effect of artificial infection of germinating seeds with stem-gall nematode was studied by germinating acid scarified seed of CIAT 350 in a nematode suspension of 200 nematodes per milliliter for 4, 8, 16 and 32 hours (Table 11). Percentage of dead plants ranged from 13.3 to 22.9 and percentage of plants with galls from 8.8 to 14.8 (Table 11). These results suggest that stem-gall nematode could reduce seedling populations in the field which could have a long-term effect on persistence of D. ovalifolium CIAT 350 pastures.

Table 7. Percentage improvement in survival and live plant yield of each component accession of *Stylosanthes guianensis* due to the mixture.

	ACCESSIONS					
	10136*	2031*	1949	1875	1927*	136
	R					S
% Improvement In Survival	0[1]	0.5	-4.4	40.1	82.2	88.5
	5.2[2]	1.4	9.1	22.7	13.8	0
% Improvement In Live Plant Yield	-20.8[1]	30.4	33.7	-17.0	30.3	66.5
	45.1[2]	40.3	0	0	60.5	0

* *S. guianensis* "Tardío"

1/ Harvest 1 - October, 1982

2/ Harvest 2 - April, 1983

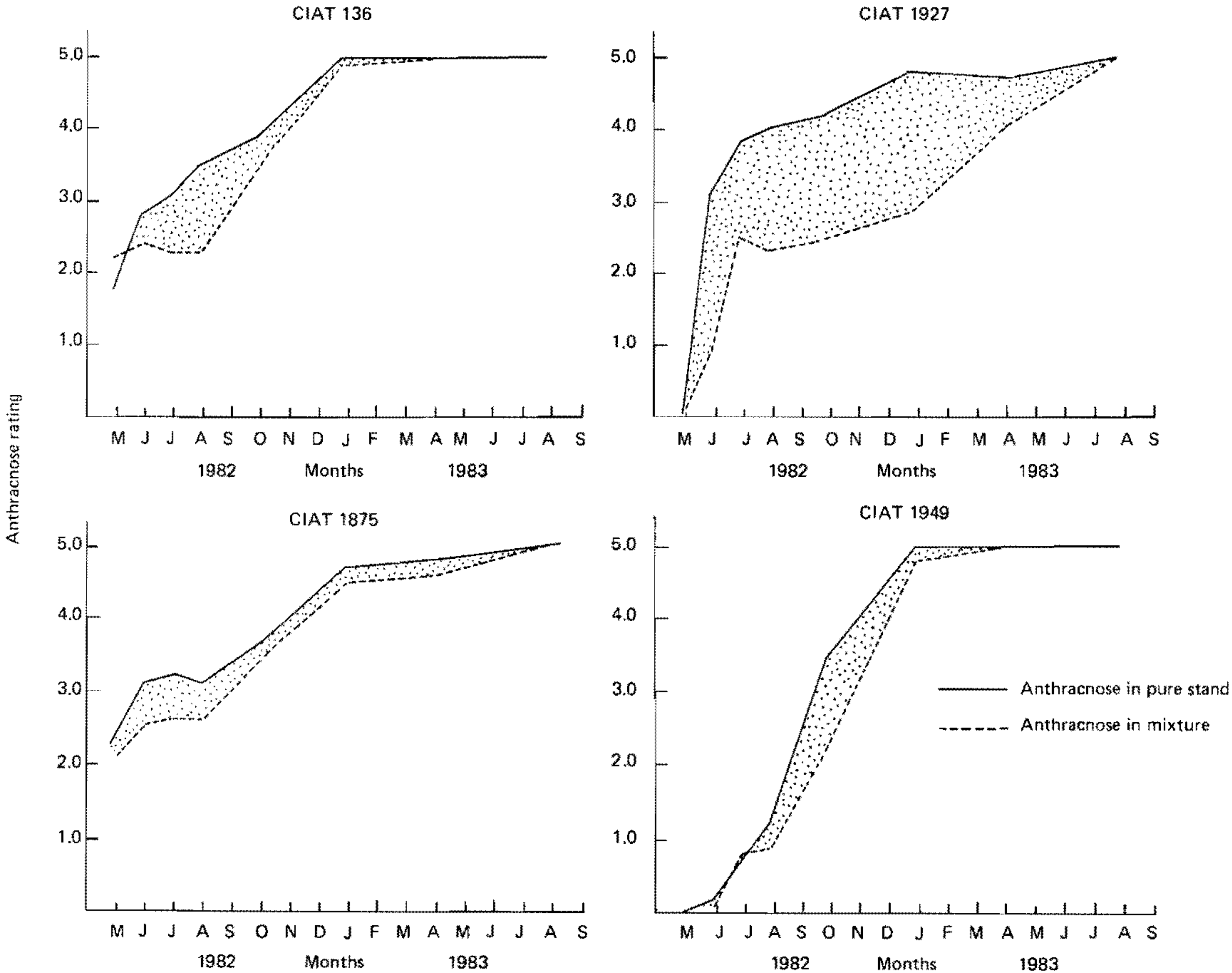


Figure 2. **Anthracnose development in pure stands and mixtures of four susceptible accessions of *Stylosanthes guianensis* in Carimagua during 1982 - 1983.**

Table 8. Variation in pathogenicity among isolates[1] of *Colletotrichum gloeosporioides* collected from the mixture experiment in Carimagua - 1982 to 1983.

	PATHOGENICITY					
"RACE"	136	1875	1949	1927	2031	10136
1	+	+	-	-	-	-
2	+	+	-	+	-	-
3	+	+	+	+	-	-
4	-	+	-	-	-	-
5	-	-	-	+	-	-
6	-	-	-	+	+	-

1/ All isolates collected from CIAT 2031 and 10136 were not pathogenic.

+ = Susceptible

- = Resistant

Table 9. Preliminary studies on the host range of stem-gall nematode of *Desmodium ovalifolium*.

I. *Desmodium* spp.

CIAT	Plant	Occurrence and Degree of Galling	Occurrence and Degree of Nematodes
350	*D. ovalifolium*	++	++
350 A	*D. ovalifolium*	++	++
3666	*D. ovalifolium*	+++	+++
3784	*D. ovalifolium*	+	+
365	*D. heterocarpon*	+	-
3669	*D. heterocarpon*	++	+
3670	*D. heterocarpon*	+++	+++
3671	*D. heterocarpon*	++	+
3672	*D. heterocarpon*	++	++
3675	*D. heterocarpon*	++	++
3094	*D. barbatum*	+	-
3063	*D. barbatum*	-	-
3129	*D. barbatum*	+	-
3001	D. *gyroides*	-	-
335	*D. distortum*	+	+
13032	*D. canum*	-	-
3291	*D. intortum*	-	-

- (no); + (few); ++ (moderate); +++ (abundant).

Table 10. Effect of natural infection[1] of inflorescences by stem-gall nematode on infection of resulting plants of *Desmodium ovalifolium* CIAT 350.

Treatment[2]	Plants No.	Dead[3] Plants %	Presence of Galls %	Presence of Nematodes %
Mech. Scarification + Pod	90	5.5	0	10
Mech. Scarification - Pod	90	3.8	0	5
Chem. Scarification	90	0	0	0
Chem. Scarification + Furadan	90	10.0	0	0

1/ Seed harvested from infected plants that were surveyed for presence of galls and nematodes in inflorescences.
2/ Seeds germinated for 48-72 hours under the various treatments.
3/ Plants that died during the 8 week experiment.

Table 11. Effect of various treatments on the colonization by stem-gall nematode[1] of germinating seed and seedlings.

TREATMENT[2]	Dead Plants %	Plants with Galls %
NS 4 H	22.9	14.8
SDW 4 H	0	0
NS 8 H	21.4	11.1
SDW 8 H	0	0
NS 16 H	20.7	8.8
SDW 16 H	0	0
NS 32 H	13.3	6
SDW 32 H	0	0
NS 4 H + NaOCl	13.3	0
NS 8 H + NaOCl	8.8	0
NS 4 H + Furadan	7.4	0
NS 8 H + Furadan	0	0

1/ Seed scarified with concentrated H_2SO_4
2/ Treatments: NS = Nematode suspension approx. 200 Nematodes/ml
SDW = Sterile distilled water

Table 12. Effect of burning on stem-gall nematode of *Desmodium ovalifolium* in Carimagua.

1. Effect of burning on soil seed reserves and seed germination

Treatment	Soil Seed Reserves[1] No/m²		Germination %	
	BB[2]	AB	BB	AB
HSR[3]	1413	1160	42.2	40.9
MSR	2672	876	37.5	41.4
LSR	1293	1058	26.0	23.9

1/ Seed sampled to a depth of 5 cm.
25 samples (15 x 15 cm) per plot.

2/ BB = Before burning; AB = After burning.

3/ HSR = High SR (4.5 AU/ha); MSR = Medium SR (3.5 AU/ha);
LSR = Low SR (2.5 AU/ha)

Table 13. Effect of burning on stem-gall nematode of *Desmodium ovalifolium* in Carimagua.

2. Seedling population two months after burning and cutting

Treatment	Soil seed[1] Reserves No./m^2	Germination %	Seeds with Potential to Germinate No./m^2	Seedlings[2] No./m^2
Burning				
- HSR	1160	40.9	474	288
- MSR	876	41.4	363	276
- LSR	1058	23.9	252	138
Cutting				
- HSR	1320	30.7	405	203
- MSR	4865	23.2	1129	264
- LSR	7941	19.1	1517	185

1/ Seeds sampled to a depth of 5 cm
25 samples (15 x 15 cm) per plot

2/ 25 one m^2 quadrats per plot

During 1984-1985, the main objectives of studies on P. cecidogenus will be to develop reliable and efficient screening methods to evaluate the D. ovalifolium germplasm collection for resistance and/or tolerance under glasshouse and field conditions. Studies will also be made on the relationship between animal trampling and resistance and the host range of the nematode.

The effect of burning on control of stem-gall nematode of D. ovalifolium CIAT 350 in association with B. humidicola was studied in collaboration with the Animal Management Section in Carimagua during 1983. The effect of burning on CIAT 350 and on the plant nematode association was assessed. Burning was found to reduce soil seed reserves, especially in one treatment due to destruction of surface seed, however it did not affect germination (Table 12). Seedling emergence and establishment was variable, averaging $226/m^2$, and there was no apparent relationship with stocking rate (Table 13). In contrast, cutting x stocking rate treatments showed considerably higher soil seed reserves and lower seed germination at lower stocking rates which possibly reflected the deposition of much immature seed on the soil surface during cutting (Table 13).

Assessment of the occurrence and abundance of galled young plants of D. ovalifolium CIAT 350 began 2 months after burning and cutting in April, 1983. By May, low percentages (1.3-2.7) of galled plants were found in the cutting treatments which increased to 24% of galled plants by September (Table 14). Galled plants were not detected in the burnt treatments until July, 5 months after burning. However, by October, the abundance of galled plants was equal to the cutting treatments (Table 14). Due to the design of this experiment, it was not possible to avoid contamination by animals moving between treatments. At the same time, the occurrence and build-up of nematode affected young plants in the cages, suggests that the nematode was present in the soil and that burning was only a short-term means of control.

Table 14. Occurrence and abundance of galled young plants of Desmodium ovalifolium after burning and cutting in Carimagua during 1983.

TREATMENT	% Young Plants with Galls and Nematodes[1]						
	April	May	June	July	August	September	October
Burning							
HSR	0	0	0	5.3	28.0	14.7	24.0
MSR	0	0	0	6.7	33.3	5.3	20.0
MSR Burning+Cage	0	0	0	0	1.3	9.3	29.3
LSR	0	0	0	3.3	25.3	12.0	22.7
Cutting							
HSR	0	1.3	6.7	14.7	12.0	32.0	25.3
MSR	0	2.3	4.3	12.0	16.0	30.7	20.0
LSR	0	2.7	12.0	9.3	10.7	5.3	26.7

1/ Sampled 75 plants per plot. All galled plants were checked for the presence of nematodes.

In February 1983, all pastures of D. ovalifolium and B. humidicola were legume dominant (Figure 3). By August 1983, due to burning, cutting and especially the effect of stem-gall nematode and false rust on seedlings and young plants, the pastures had become grass dominant (Figure 3).

False rust

The development and spread of False-rust Synchytrium desmodii throughout pastures of D. ovalifolium CIAT 350 in Carimagua during the past year has necessitated screening of the germplasm collection for resistance in 1984. It was confirmed that the fungus is not borne on the seed but that resting spores are embedded in the leaf and stem material in association with seed harvested from infected plots. As acid scarification will not destroy such embedded spores, seed from infected plots must be cleaned of all debris before use.

Other Studies

Effect of different levels of fertilizers on reactions of tropical pasture plants to diseases (Annual Reports 1981-82)

Evaluations continued during 1983 on C. pubescens CIAT 438 and D. ovalifolium CIAT 350 only. The reaction of CIAT 438 to both Cercospora leaf spot and Rhizoctonia foliar blight was surveyed across treatments. During 1983, the severity of both diseases decreased during July-August, the period of maximum precipitation (Figure 4). During 1982, this was observed for Rhizoctonia foliar blight only, and found to be related to the build-up of native populations of antagonists. Results from 1983 suggest that these antagonists may also reduce Cercospora leaf spot.

During 1982-1983 no significant difference between treatments was found for Rhizoctonia foliar blight of CIAT 438. However less Cercospora leaf spot overall was found in comparison to 1981-1982 and there was significantly less recorded in the -Mg treatment (Figure 5). At the same time however, this finding has no practical application as the plants were Mg deficiency.

It was interesting to note that the level of galling and dieback due to stem-gall nematode was considerably less in CIAT 350 in the high Ca treatment (Figure 6). This will be monitored throughout 1984 to determine the stability of the reaction.

STUDIES IN THE WELL-DRAINED ISOTHERMIC SAVANNAS - CERRADOS

Diseases of Stylosanthes species

Multilocational Stylosanthes capitata Screening Trials

Two multilocational screening trials were planted in 1981 to evaluate the reaction of a large collection of S. capitata to anthracnose and other pests and diseases in their native habitat in Brazil and Venezuela. Firstly, in collaboration with EPAMIG, the multilocational screening trial progressed well during 1983 at Acauã, Minas Gerais,

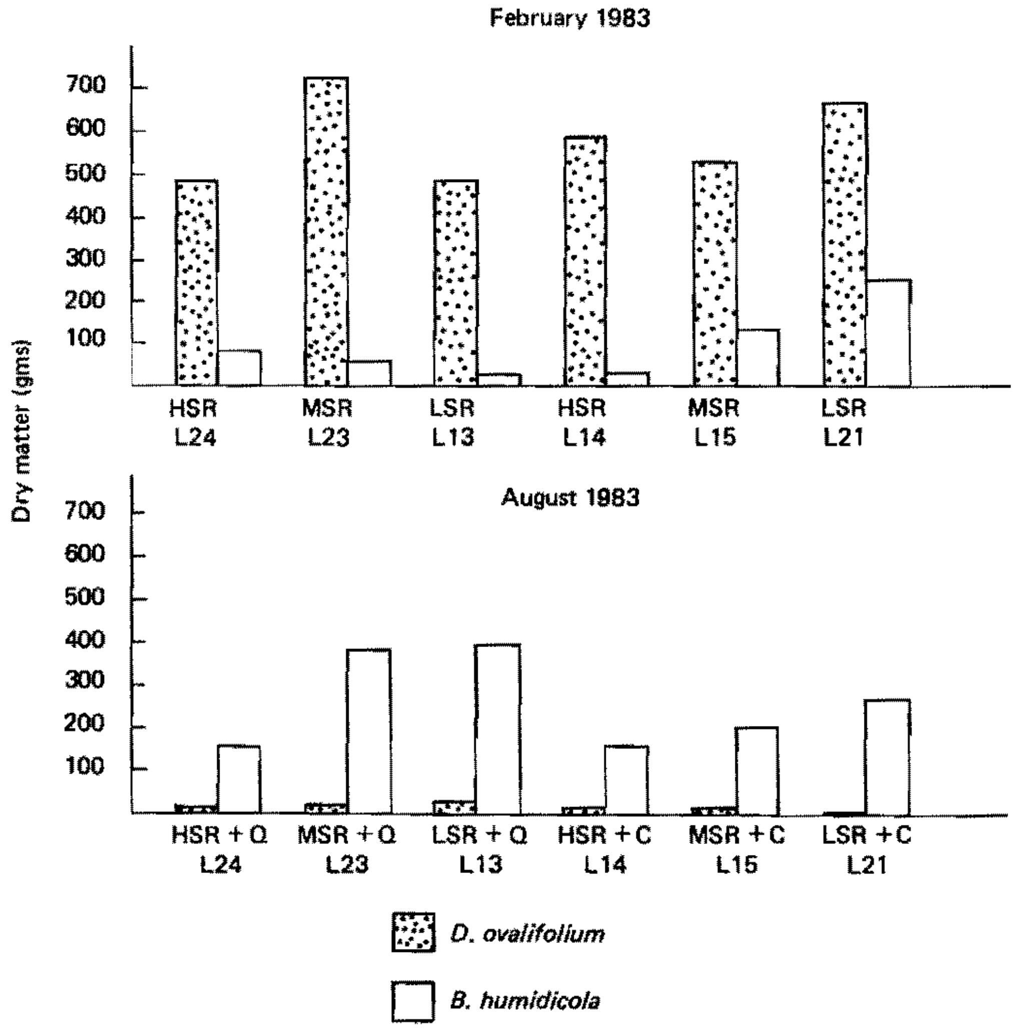


Figure 3. **Effect of burning, cutting and diseases on the biomass of *D. ovalifolium* and *B. humidicola* in Carimagua during 1983.**

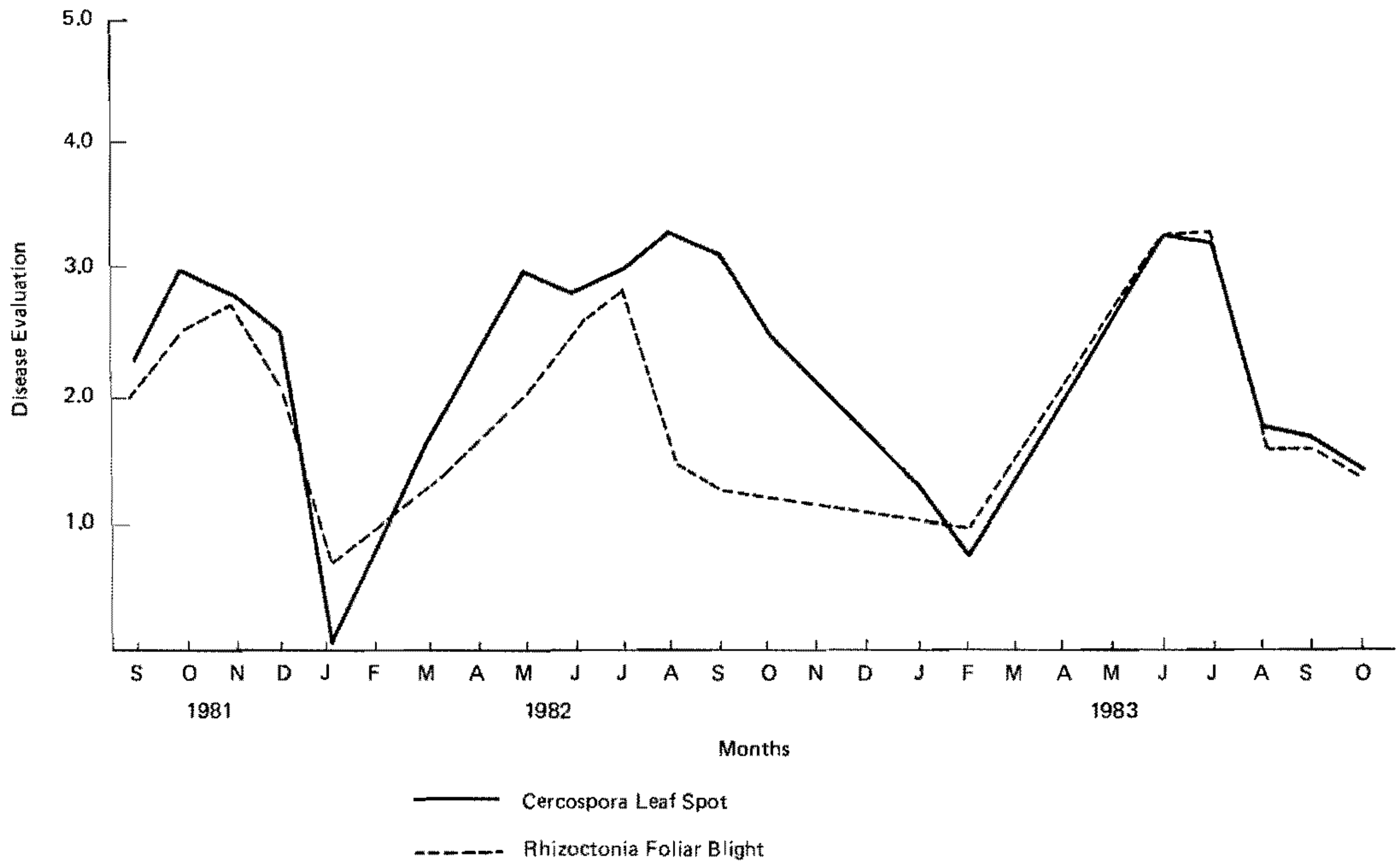


Figure 4. **Reaction of *Centrosema pubescens* CIAT 438 to Cercospora leaf spot and Rhizoctonia foliar blight in Carimagua 1981 - 1982.**

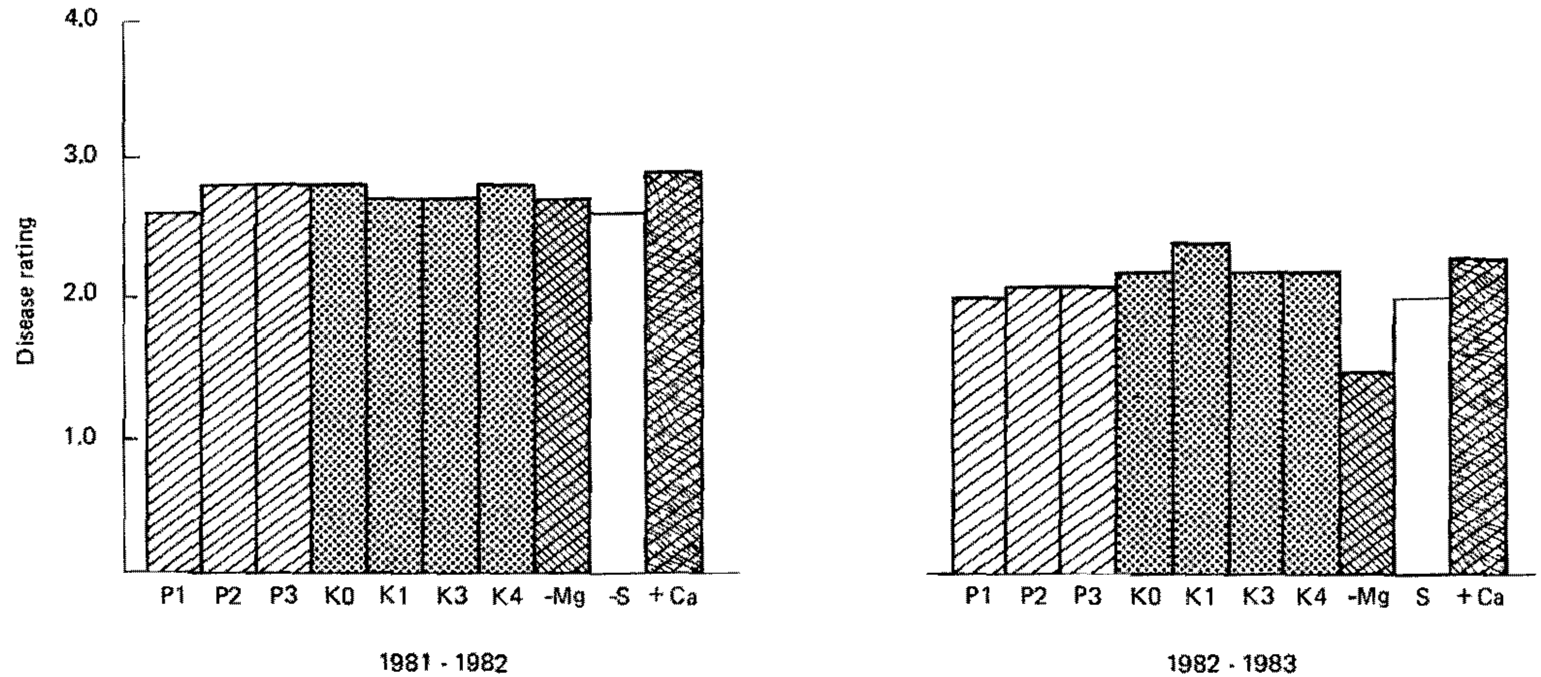


Figure 5 **Effect of various nutrients on development of Cercospora leaf spot in** *Centrosema pubescens* **CIAT 438 in Carimagua.**

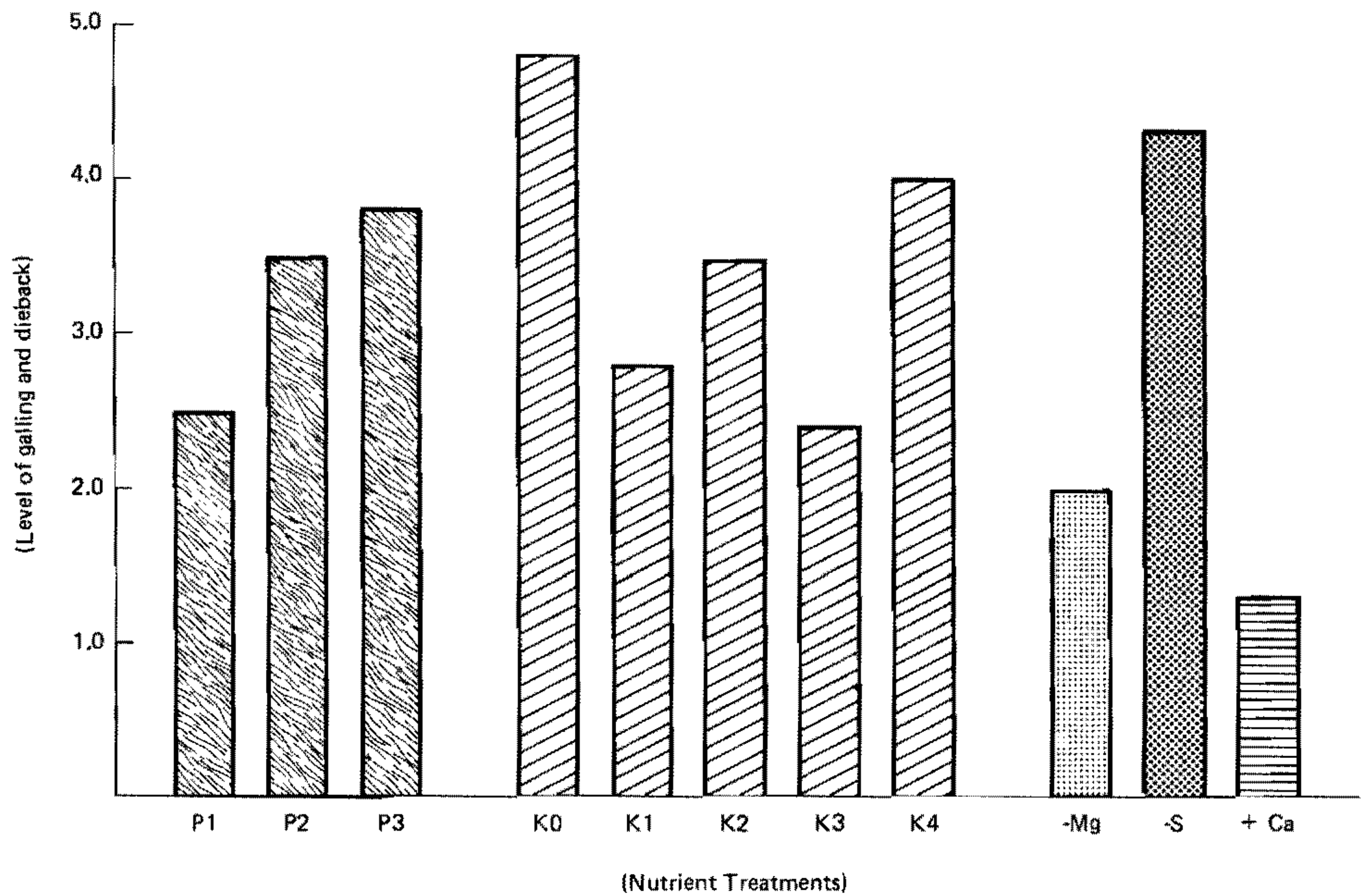


Figure 6. **Reaction of *Desmodium ovalifolium* CIAT 350 to stem gall nematode under various fertilizer treatments during 1983 in Carimagua.**

Brazil. By May 1983, 23 accessions were rated susceptible; 17 of the originating from Minas Gerais (Table 15). The most susceptible accessions were therefore those native to the region in which the trial was located as was hypothesized. At the same time, several accessions from Ceará and Bahía were most promising not only with respect to resistance to anthracnose but also with respect to dry matter production including CIAT 2251, 2138, 2253, 2254, and 2044 (Table 16). In this environment, these accessions were more promising than the components of CAPICA, the most promising group in the isohyperthermic savannas.

Table 15. Multilocational screening trials.

1. Acauã, Minas Gerais, Brazil.

Reaction of 100 accessions of Stylosanthes capitata to anthracnose during 1981 - 1983.

Anthracnose Reaction					
0	1	2	3	4	5
% of Accessions					
2	37	38	20[1]	3[1]	0

1/ Of the 23 susceptible accessions, 17 accessions originated from Minas Gerais and 3 accessions (CIAT 2035, 2049 and 2068) are S. pilosa from Bahia.
Other susceptible accessions include CIAT 2013 (Goiás), 2092 (Bahia), 2250 (Pernambuco).
Correlation coefficients - RI/RII - r = 0.63
RI/RIII - r = 0.61
RI/RIII - r = 0.82

Secondly, in collaboration with FONAIAP, the multilocational screening trial at El Tigre has continued during the past two years. Although this trial is located in the isohyperthermic savannas in the native habitat of S. capitata, it is more meaningful to compare it directly with the trial located in Brazil. By August 1983, 98% of the surviving accessions of S. capitata remained resistant to anthracnose (Table 17). However, at least 60% were susceptible to a new stemborer (Coleoptera - Curculionidae) which must now be recognized as the most important pest of S. capitata in this region. Results to date from this trial and others suggest that anthracnose is not a limiting factor for S. capitata in the savannas of Venezuela but that the Coleoptera stemborer represents a new pest whose potential warrants intensive evaluation.

Studies of native populations of S. capitata

Studies of a natural S. guianensis - C. gloeosporioides host-pathogen population at Lago Calima, Colombia during 1981-82 found considerable

Table 16. Most promising accessions of *Stylosanthes capitata* in Acauã, Minas Gerais, Brazil.

CIAT No.	Origin	Anthracnose[1] Evaluation	Dry matter[2] Production g/plot
2251	Ceará	1.0	511.0
2138	Bahia	1.5	449.8
2253	Ceará	1.0	407.2
2254	Ceará	1.0	374.8
2044	Bahia	1.5	367.3
2221	Sel. 2044	1.5	355.2
2252	Ceará	1.5	352.0
2200	Fed. Dis.	1.5	351.1
2125	Bahia	2.0	343.0
1315[3]	Maranhao	2.0	249.0[4]
1318[3]	Maranhao	1.5	251.0
1342[3]	Piaui	2.0	190.6
1693[3]	Mato Grosso	2.5	158.6
1728[3]	Mato Grosso	2.5	231.9

1/ Rating scale 0 = No disease

5 = Dead plant

2/ Mean of 5 harvests - June 1982-June 1983

3/ Components of Capica

4/ Mean yield of components of CAPICA - 216.2 g/plot pathogenic, cultural and sexual variability in the pathogen and genetic and morphological variability in the host. These results supported the hypothesis that persistence of such natural populations of Stylosanthes species in South America in the presence of indigenous populations of Colletotrichum species is due to their heterogeneity.

During 1983, further studies were made of S. capitata populations near Diamantina, Minas Gerais, Brazil. Seed was collected from ten plants from one m^2 quadrats and these progenies were inoculated with one pathogenic isolate of C. gloeosporioides. Comparison of results from two quadrats 2F and 4F clearly showed variability in anthracnose reaction among progenies from the single plants; among plants from the same site; and among sites (Figures 7 and 8). That the extent of the variation was apparently not related to site proximity was seen by comparing sites within ten meters of each other and sites separated by 50 kilometers. Although the mean anthracnose reactions of S. capitata populations from sites 2 and 2F, separated by ten meters, were similar, the mean reactions of populations from sites 4 and 4F, also separated by ten meters, were very different (Table 18). At the same time, mean anthracnose reactions of populations from sites 2 and 4, separated by 50 kilometers, were also different (Table 18). Results suggest that natural diversity in anthracnose resistance within S. capitata populations also contributes to their stability and persistence in the presence of the pathogen. And these findings further supported the importance of maintenance of diversity within improved Stylosanthes pastures.

STUDIES IN THE FOREST ECOSYSTEMS

Diseases of Stylosanthes Species

Multilocational Stylosanthes guianensis "common" Screening Trials

Several trials were established during 1982-83 to determine whether high resistance to anthracnose among accessions of S. guianensis "common" was a general character through forest ecosystems. The majority of accessions have remained resistant at three sites in Peru and one site in Brazil with CIAT 21, 64, 128, 136, 184, 1175, and 1875 being resistant at all sites (Table 19). The greater severity of anthracnose at Tarapoto, Peru is thought to have been stimulated by the record dry year causing greater development of latent infections. Two further trials will be planted in 1984 at Moyobamba and Iquitos, Peru.

Comparison of isolates of C. gloeosporioides from various locations within forest ecosystems

Previous studies have shown that isolates of C. gloeosporioides from slightly anthracnosed S. guianensis collected from various forest sites were just as pathogenic as those from savanna ecosystems. During 1983, we compared 48 isolates from Brazil, Peru, Ecuador and Colombia. Pathogenic isolates were found at all sites (Table 20); those from El Napo, Ecuador, and Leticia and Macagual, Colombia, were

Table 17. Multilocational screening trials.

2. El Tigre, Venezuela

Reaction of 90 accessions of *Stylosanthes capitata* to anthracnose and stemborer during 1981 to 1983.

Disease or Pest	Reaction 0	1	2	3	4	5[2]
	% of Accessions					
Anthracnose (*Colletotrichum* spp.)	4.7	35.9	57.8	1.6	0	0
Stemborer (Coleoptera: Curculionidae)	30.9[1]	0	18.5	22.2	16.2	22.2

1/ Only young plants in plots; adults may have died from stemborer damage.
2/ Rating scale: 0 = No disease
5 = Dead plants

Table 18. Mean reaction to anthranose of populations collected from native stands of *Stylosanthes capitata* in Minas Gerais, Brazil.

Site	Mean Reaction to Anthracnose 5	4	3	2	1	0
2	-	62.2[1]	27.7	8.4	1.7	-
2F	-	47.8	35.9	13.5	2.2	0.6
4	1.3	36.8	41.0	16.2	4.6	0.1
4F	-	-	87.4	11.1	0.9	0.6

1/ Percentage of plants in each reaction group for each site.

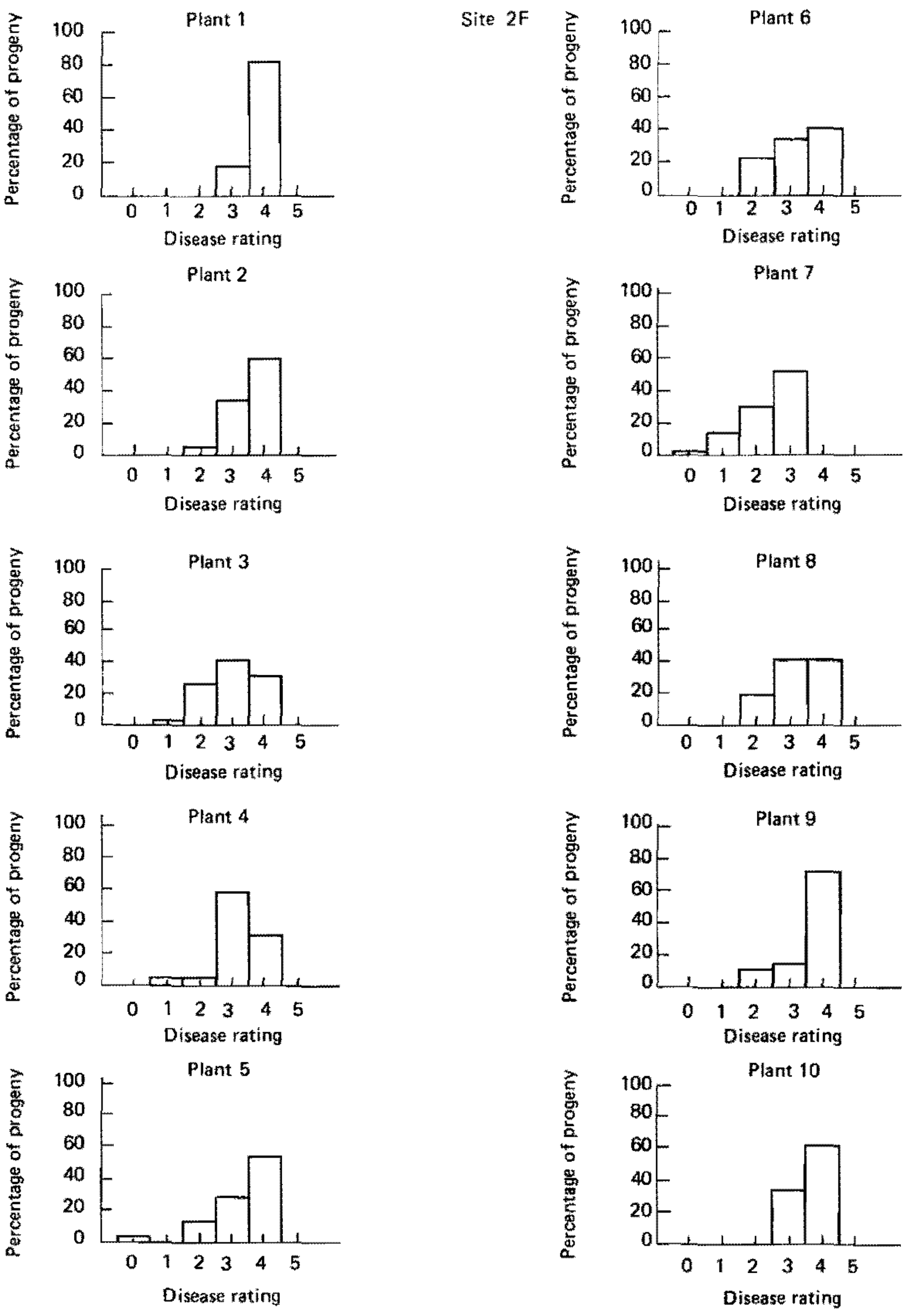


Figure 7. Reaction to anthracnose of progeny from single collected from native stands of *Stylosanthes capitata* in Minas Gerais, Brazil.

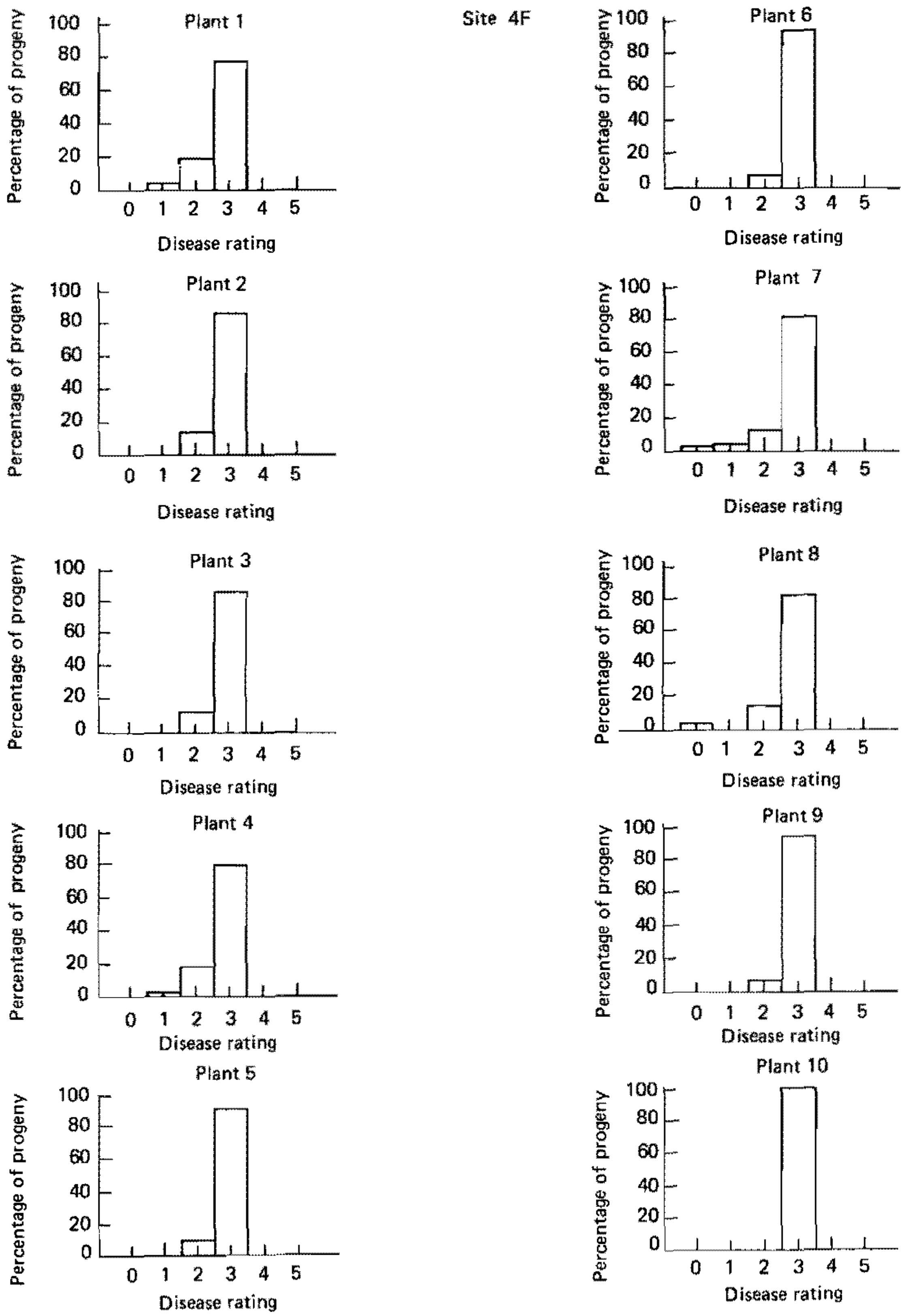


Figure 8. **Reaction to anthracnose of progeny from single plants collected from native stands of *Stylosanthes capitata* in Minas Gerais, Brazil.**

Table 19. Reaction of accessions of *Stylosanthes guianensis* common to anthracnose in various sites in forest ecosystems from 1982 to 1983.

Site	Planting Date	Anthracnose Reaction 0	1	2	3	4	5
		% of Accessions					
Tarapoto, Peru	Jan., 1983	0	38.7	16.1	41.9	3.3	0
Yurimaguas, Peru	Jan., 1983	0	96.8	3.2	0	0	0
Pucallpa, Peru	May, 1982	0	42.9	25.0	10.7	14.3	7.1
Itaju do Colonia, Brazil	Jan., 1983	47.1	41.1	5.9	5.9	0	0

Accessions resistant in all sites: 21, 64, 128, 136, 184, 1175, 1875.

Table 20. Comparison of isolates[1] of Colletotrichum gloeosporioides collected from forest ecosystems throughout tropical South America.

CIAT No.	Cultivar Name	Brazil		Peru		Ecuador	Colombia		
		Bahia[2]	Pará[1]	Pucallpa	Yurimaguas	El Napo	Leticia	Macagual	Quilichao
13	Endeavour	+++	+++	++++	++++	+++	+++	+++	++++
15	Graham	+	+	+/++	+	-	-	-	+/+++
17	Schofield	++++	+++	++++	++++	+++	+++	+++	++++
136		++++	+++	++++	++++	++	++	++	++++
184		++++	+++	+++	++++	++	++	++	+++
1950	Cook	++	+	+/+++	++	-	-	-	+/+++
1283		+++	+	+/++++	-	-	-	-	-/+++
10136		-	-	-	-	-	-	-	-

1/ All isolates were collected from common S. guianensis.

2/ Number of isolates tested: Bahia (7); Para (8); Pucallpa (18); Yurimaguas (2); El Napo (2); Leticia (9) Macagual (2).

less virulent than those from other sites; while variation in pathogenicity was identified within and among sites (Table 20).

Collection and comparison of C. gloeosporioides isolates from new and already sampled sites will continue throughout 1984 as a major activity to further understand anthracnose in forest ecosystems.

Further studies on anthracnose of S. guianensis in forest ecosystems

Importance of antagonistic phylloplane bacteria.

Studies carried out in 1982 identified several groups of bacteria isolated from the phylloplane of S. guianensis "common" in Pucallpa, Peru that were antagonistic to spore germination and appressorium formation of local C. gloeosporioides isolates and that significantly reduced anthracnose under glasshouse conditions. During 1983, surveys of the phylloplane bacteria associated with S. guianensis continued in Pucallpa, Peru to determine if antagonistic bacteria were present throughout the year. In addition to the four groups identified in 1982, four different groups were found and at all sampling dates throughout 1983, antagonistic bacteria made up a considerable proportion of the phylloplane population (Table 21). These bacteria could have a significant effect on the infection process of C. gloeosporioides and their presence may explain partly the reduced severity of anthracnose in forest ecosystems.

Table 21. Survey of the presence of bacteria antagonistic to Colletotrichum gloeosporioides on plant surfaces of Stylosanthes guianensis in Pucallpa, Peru, during 1982-1983.

Bacterium	Antagonistic		Percentage of Population			
Group	In vitro	In vivo	May/82	Jan/83	Mar/83	May/83
I[1]	+	+	5.8	-	-	-
II	+	+	17.6	-	34.5	14.4
III	+	+	11.8	13.9	-	27.3
IV	+	+	5.8	-	-	-
V	–	?	-	5.1	-	-
Va	+	?	-	-	-	9.1
VI	+	?	-	30.7	16.4	-
VII	+	?	-	-	3.1	-

1/ I = I_2; II = I_5; III = I_{10}; IV = I_{12}.

Occurrence and abundance of latent infection.

Further intensive surveys of latent infection in *S. guianensis* at various sites in Peru confirmed the wide-spread occurrence and great abundance of latent infection in CIAT 136 and 184. During 1984, more detailed histopathological studies will be made on the type of infection. Resistance that operates by increasing the latent period of the pathogen is considered one of the most effective forms of resistance in decreasing the infection rate. Therefore, the abundance of latent infection in forest ecosystems may explain partly the reduced severity of anthracnose.

Studies on the effect of physiological stresses on anthracnose development

It was hypothesized that physiological stresses, such as water, temperature and light stresses, often more severe in savanna ecosystems than in forest ecosystems, increase the natural susceptibility of *Stylosanthes* to anthracnose. Therefore, the general lack of severe stresses in forest ecosystems may explain the reduced severity of anthracnose. To date, several studies have been completed; others are in progress.

In general, there was no effect of water stress on development of latent anthracnose infection in a range of accessions of *Stylosanthes* species. This experiment will be repeated looking at the effect of water stress on non-latent anthracnose development rather than latent infection.

Studies on the effect of diurnal temperature fluctuations on the development of latent infection, however, showed significantly greater development of latent infections in two ecotypes of *S. guianensis* CIAT 1283 and 2243 at temperature fluctuations of 18°C (24/6°C) than at 12°C (24/12°C) or no fluctuations (24/24°C) (Figure 9). At the same time, the effect was greater in CIAT 1283 which originated from 6°S where diurnal temperature fluctuations are smaller than at 16°S, the origin of the less responsive CIAT 2243 (Figure 9). In savanna ecosystems, diurnal temperature fluctuations are often greater than in the forests due to distance from the equator; degree of cloud cover; etc. Results to date, strongly suggest that smaller diurnal temperature fluctuations may explain the reduced severity of anthracnose in forest ecosystems due to lack of development of latent infections. Further studies are in progress.

The effect of various levels of light interception on anthracnose development was studied under greenhouse conditions with various accession of *Stylosanthes* species. Anthracnose severity was generally not affected until 80% light interception after which it increased rapidly (Figure 10). Results generally showed that there is no effect on anthracnose severity within the range of light interception commonly encountered in grass-legume pastures. In contrast, light interception or shading considerably increased spore production from anthracnose lesions in both *S. capitata* (Figure 11) and *S. guianensis* (Figure 12). Therefore, under higher % light interception there is greater potential for spore dissemination and anthracnose spread.

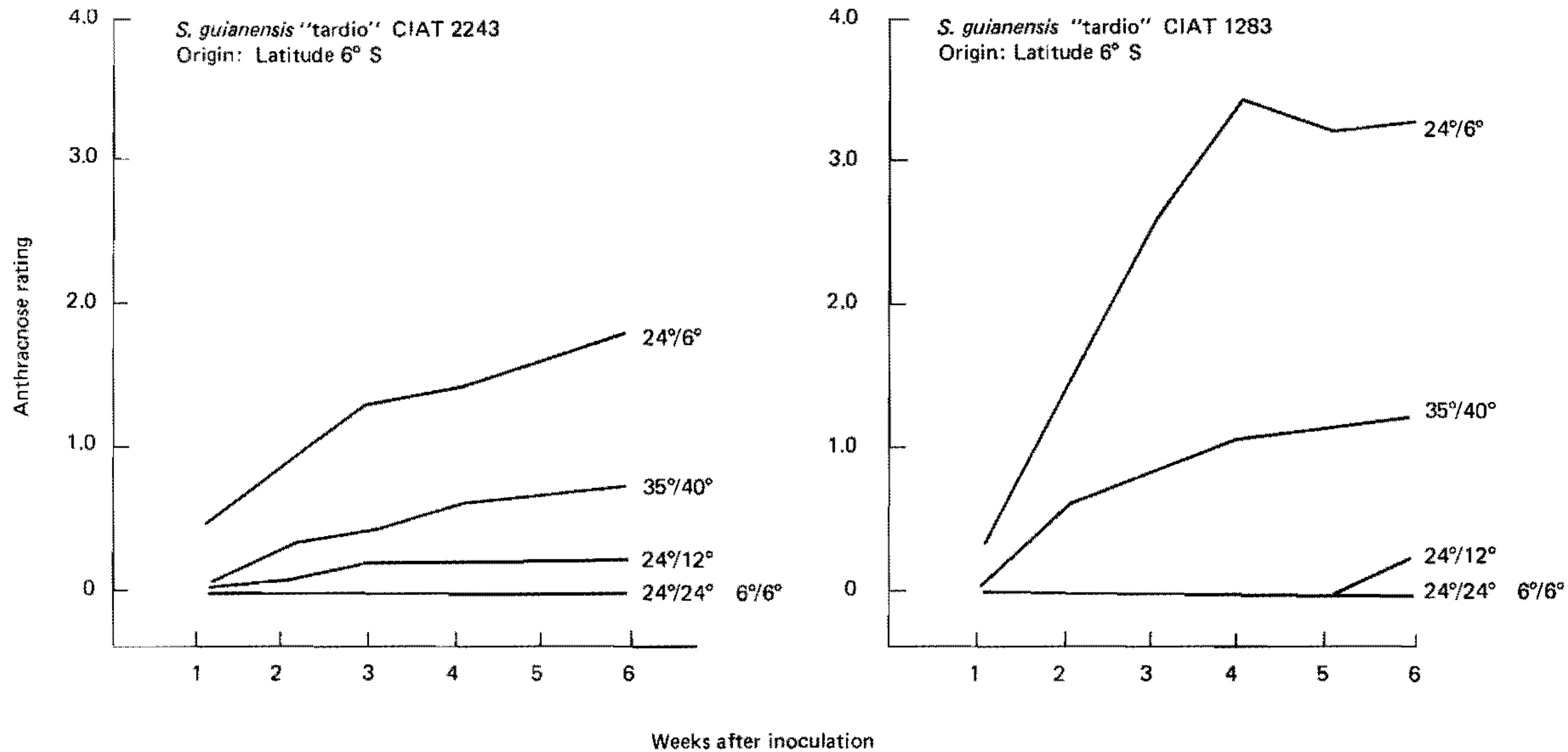


Figure 9. **Effect of diurnal temperature fluctuations on the development of latent infection by *Colletotrichum gloeosporioides* in two ecotypes of *Stylosanthes guianensis* "tardio".**

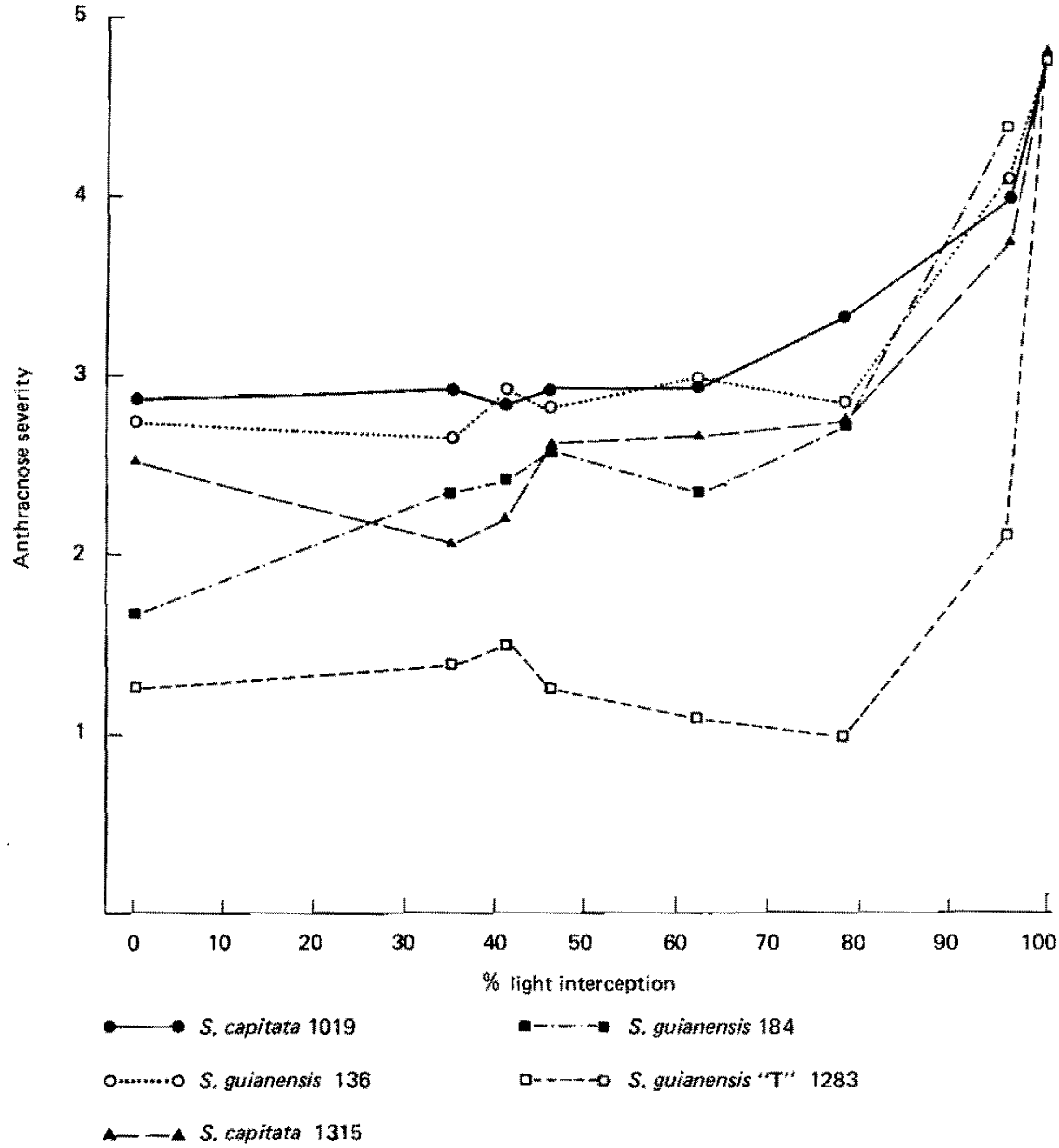


Figure 10. Effect of light interception on anthracnose severity.

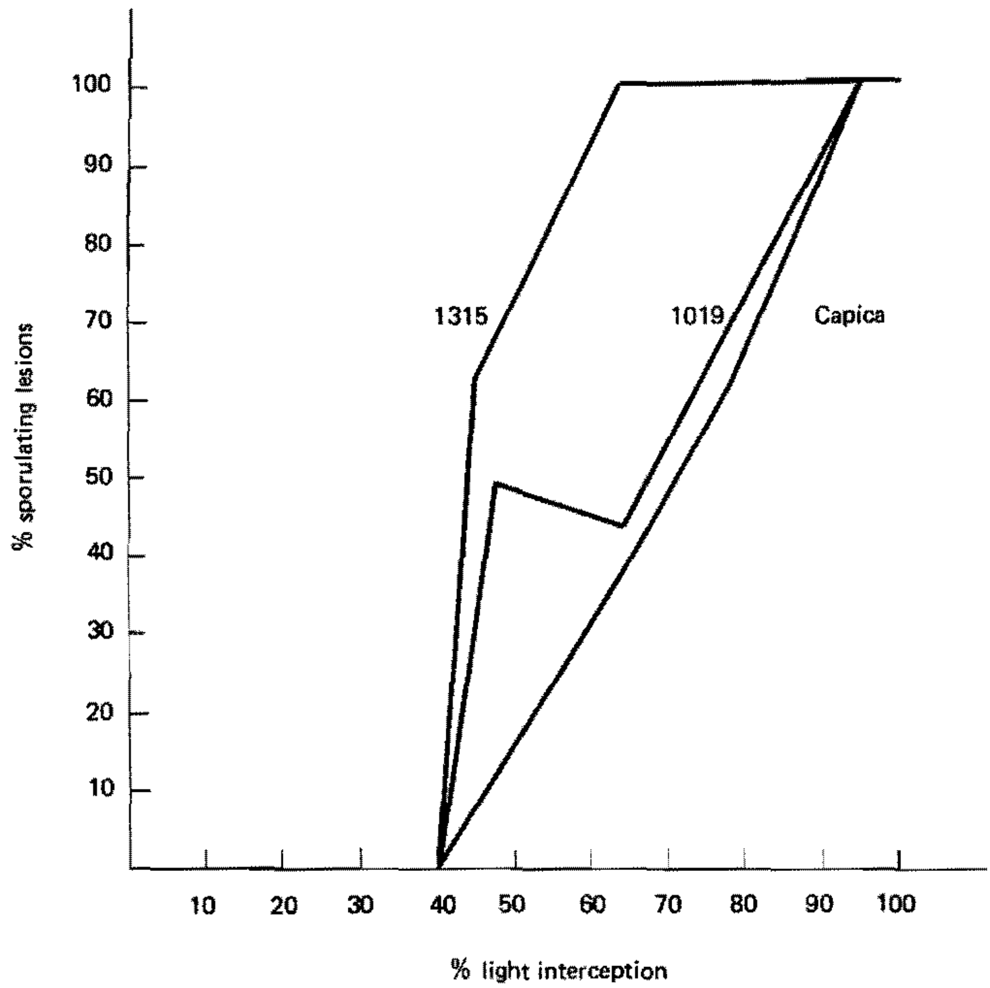


Figure 11. **Effect of light interception on spore production by anthracnose lesions on two accessions of *Stylosanthes capitata* and Capica.**

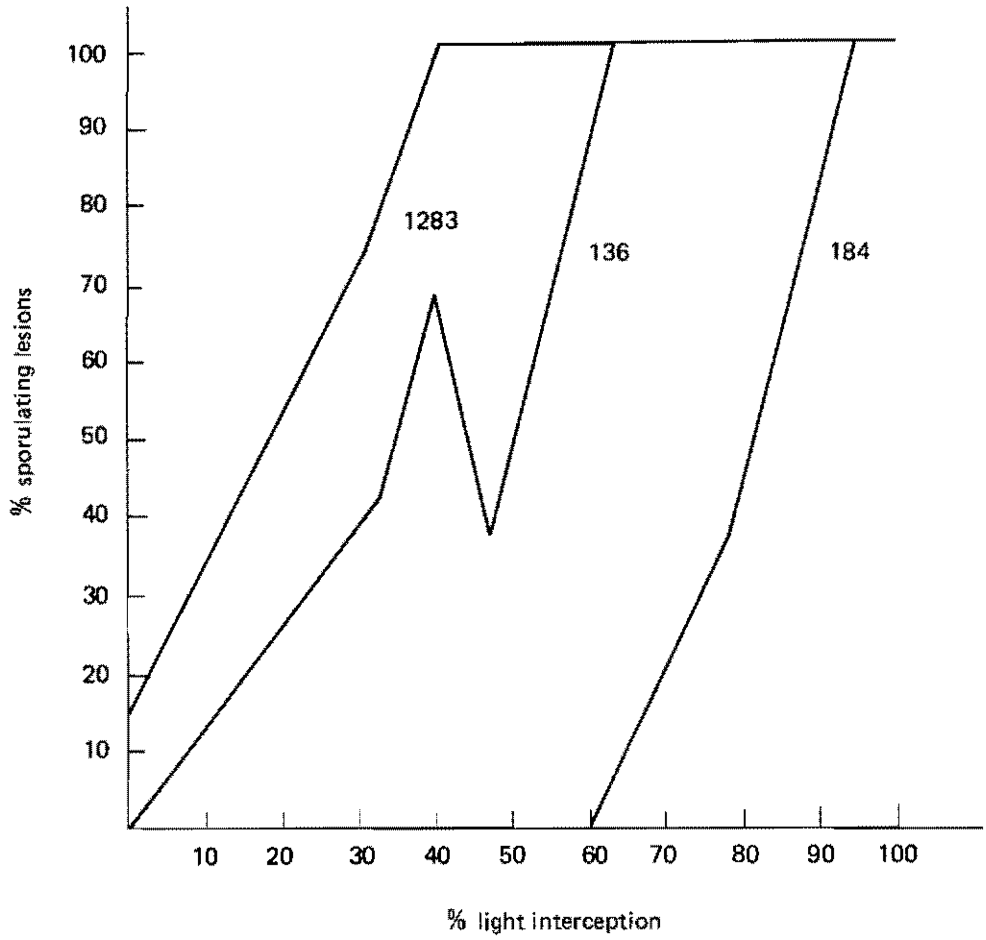


Figure 12. Effect of light interception on spore production by anthracnose lesions on three accessions of *Stylosanthes guianensis*.

This could be important in associations of tall grasses and less resistant accessions of Stylosanthes species.

Additional information was obtained from this study on the effect of light interception on relative dry matter production of several accessions of Stylosanthes species. Stylosanthes capitata represented by CIAT 1315 was more sensitive to increased light interception than ecotypes of S. guianensis some of which were not affected in dry matter production until 40% light interception. For example CIAT 1283 and others such as CIAT 184 produced more dry matter at moderate levels of light interception (40%) than under full light (Figure 13). The importance of these findings to choosing the most productive grass-legume associations are clear and further experiments are in progress.

The effect of environmental factors on disease development in tropical pasture plants has been somewhat neglected in the past. Their importance with respect to understanding the ecosystem x anthracnose severity differential reactions is becoming clear. More detailed studies in this field are planned for 1984.

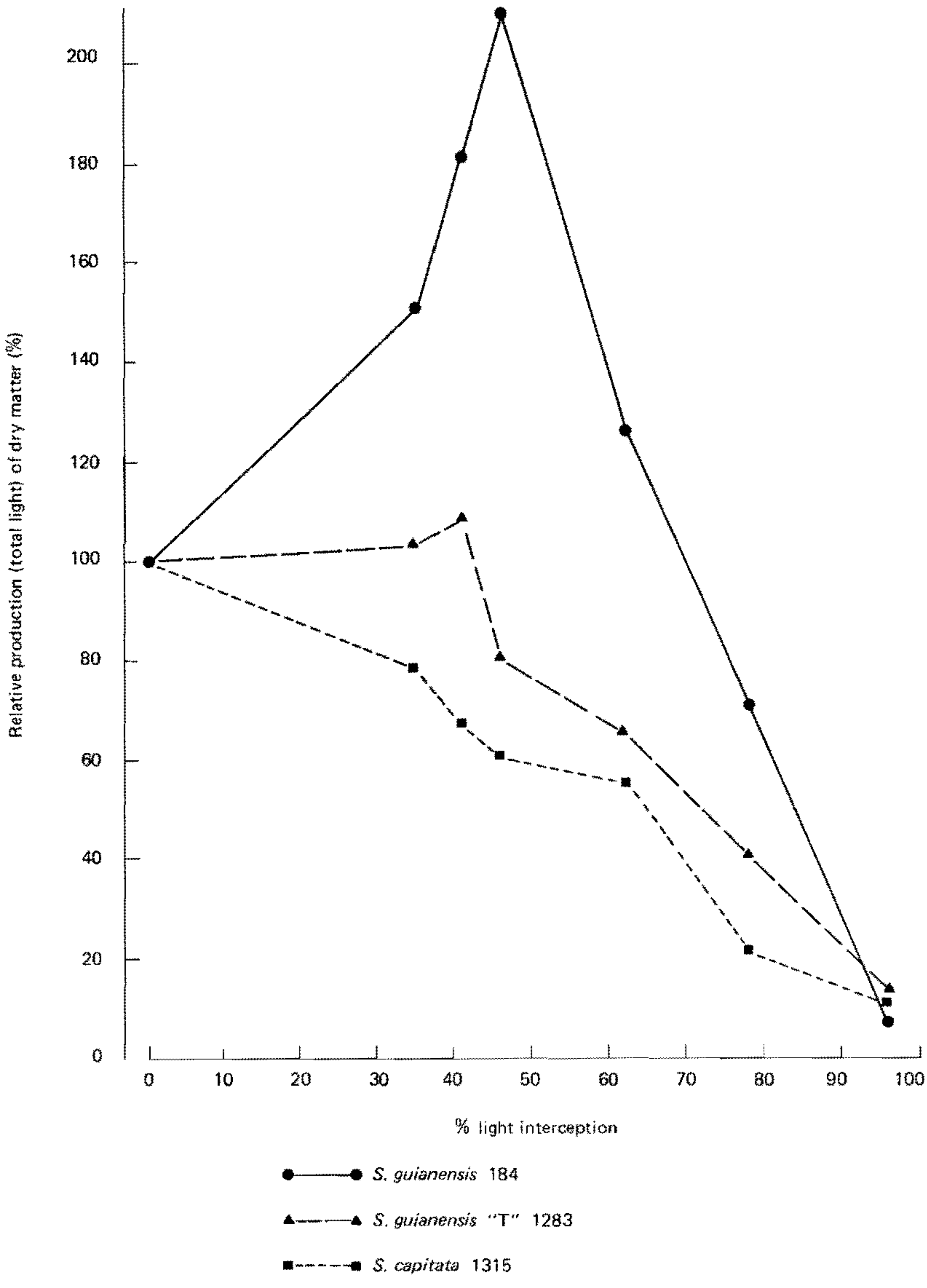


Figure 13. Effect of light interception on dry matter production.

COLLABORATIVE WORK IN PANAMA

Through an agreement with the University of Rutgers and the Instituto de Investigación Agropecuaria de Panamá (IDIAP), the Tropical Pastures Program started its activities in Panama with the following basic objectives: (a) selection of germplasm of promising species for the different ecosystems prevailing in the country; (b) agronomic studies on fertilizer response of adapted species; (c) seed multiplication of promising species; and (d) management and evaluation under grazing of selected species in terms of their persistence in the pasture and of animal production.

The activities during 1983 concentrated on the selection of sites, establishment of species, and preliminary evaluation management.

GERMPLASM

Table 1 shows the different type A regional trials established in various sites in Panama during 1983. Selected germplasm is characterized by its adaptation to acid, infertile soils; however, in the Los Santos area, the main stress is drought, about six months of the year. For this reason, reason species of the genera Cenchrus and Macroptilium and ecotypes of Stylosanthes hamata and S. humilis were included.

With the exception of Chepo, where the site selected has serious drainage problems, the other trials have been successfully established. An equalizing cut was carried out in Calabacito and the evaluation of dry matter production will soon be started.

In all sites, introduced germplasm has been complemented with native or naturalized species prevailing in the area. Thus, information on adaptation and agronomic performance of comparable genera will be obtained in the future.

AGRONOMY

Response to P, K, Mg, and S of Andropogon gayanus alone and in association with Stylosanthes capitata cv. 'Capica', will be measured in an Ultisol in Calabacito in a cutting experiment . Fertilizer treatments are: 0, 15, 30 and 60 kg P_2O_5/ha; 0, 50 of K_2O; 0, 20 of MgO; and 0, 20 of elementary S, all applied at planting time. Soil characteristics at the site of the trial are the following: pH 5.0; 1.0 meq Al; 3.0 meq Mg; traces of P; and 0.5 meq Ca.

The experiment was established in September 1983 and preliminary visual observations indicate a marked response of both species to phosphorus

Table 1 Regional trials type A established for germplasm evaluation in Panama during 1983.

Site	Predominant ecosystem*	No. of accessions established (grasses and legumes)	Establishment date
Chepo	Tropical rain forest	45	September 26
Los Santos	Tropical dry forest	63	September 15
Calabacito	Tropical rain forest (derived savanna)	48	July 4
Soná	Very humid tropical forest	34	September 10

* Holdridge Classification.

applications. The major response was observed within the 15 and 30 kg/ha levels. An equalizing cut has been programmed for December--beginning of the dry season--and evaluations will be done every eight weeks, once the rains have stabilized in the following wet season.

SEEDS

Seed multiplication of promising species has been considered as an activity of high priority, not only to increase the availability of seed for experimental purposes but also to demonstrate techniques of seed production. Table 2 illustrates the species and production sites selected.

Brachiaria spp.

Areas for seed production were separated from grazed pastures. The management consisted in a uniformity cut and weed control at the beginning of the rainy season, followed by the application of 50 kg/ha of ammonium sulphate. Flowering started at the beginning of June and harvesting was carried out in mid July. A total of 5 ha of *B. humidicola* were harvested since an additional area, which was not

Table 2. Promising forage species and areas of seed multiplication, in Panama, 1983.

Species	Area (ha)	Site	Initiation of flowering	Harvest
Brachiaria decumbens "Comercial"	2.00	Fca.Chiriquí	10-12 June	20-21 July
Brachiaria humidicola "Comercial"	1.00	Fca.Chiriquí	10-12 June	16-17 July
Andropogon gayanus CIAT 621	2.00	Gualaca	26 September	21 November
Andropogon gayanus CIAT 621	1.00	Calabacito	28 September	18 November
Andropogon gayanus CIAT 621	2.00	Chepo	15 November	10 Jan.84
Pueraria phaseoloides CIAT 9900	1.00	Chepo	Vegetative	
Pueraria phaseoloides CIAT 9900	1.00	Gualaca	5-10 December	February 84
Stylosanthes capitata "Capica" CIAT 10280	0.33	Gualaca	26 September	10 Jan.84
Stylosanthes guianensis CIAT 136	0.15	Gualaca	7 November	30 Jan.84
Centrosema macrocarpum CIAT 5065	0.40	Gualaca	28 November	February 84

initially programmed, was harvested as well. Table 3 illustrates the results of this harvest.

Yields of combine-harvested seed were relatively high, indicating the species' seed production potential in the area. The lower yield obtained by manually harvesting was due to a low inflorescence density in the area harvested.

Yields of B. decumbens could not be estimated due to lack of uniformity in the plot and to weed problems. Of 26 kg of crude seed harvested, 0.5 kg of pure seed were obtained, indicating a low caryopsis content and seed formation. This contrasts with B. humidicola seed which had 52% caryopsis content at harvest and 82% after processing.

Andropogon gayanus

This species initiated flowering with relative good flower synchronization at the end of September in Calabacito and in Gualaca; in the region of Chepo, flowering started in November due to late planting.

Harvesting has been completed in Gualaca and Calabacito and crude seed yields are estimated to be acceptable. Seed has yet to be trashed and cleaned.

PASTURE EVALUATION AND PRODUCTIVITY

Grazing experiments to study persistence and animal production have been planned with the Agronomy Faculty (University of Panama) and IDIAP in Chiriquí (western region), and Calabacito (central region).

Table 4 illustrates the type of trial and the sites where the experiments will be carried out. The areas have been prepared and the experiments will be established in the forthcoming rainy season.

Table 3. *B. humidicola* harvest- Finca Chiriquí - July 1983.

Harvest method	Yield (kg/ha)	Total harvest (kg)	Purity (%) (processed seed)
Manual	53.0	15.0	--
Mechanical (conventional combine)	75.0	286.8	97.6*

* Irish or modified purity.

Table 4. Grazing trials to be established in Panama (1983-1984)

Type of trial	Site	Collaborator	Financing	Current status
C	Fca.Chiriquí	Fac.Agronomía	University	Land prepared
C	Gualaca	IDIAP	CIID (Canadá)	Site chosen
D	Gualaca	IDIAP	CIID	Land prepared and partially established
D	Calabacito	IDIAP	IDIAP	Land prepared

The objective is to select persistent, disease-resistant germplasm adapted to the soils and climate of the Brazilian cerrados. This is accomplished by CPAC/EMBRAPA scientists, in close collaboration with CIAT staff stationed at CPAC.

AGRONOMIC SMALL-PLOT EVALUATION OF LEGUME GERMPLASM (CATEGORIES I/II)

The total number of accessions sown since 1978 is listed in Table 1. In the 1982-83 wet season 324 accessions were introduced. Dioclea guyanensis was the only new species tested. There was a major increase in the number of accessions of Stylosanthes viscosa. Observations continue to be made on phenology, plant vigour, resistance to pests and diseases. Of accessions studied to date 63 per cent are Stylosanthes species.

The seven key species hitherto identified are Stylosanthes guianensis, S. capitata, S. macrocephala, S. viscosa, Zornia brasiliensis, Centrosema macrocarpun and C. brasilianum.

Stylosanthes guianensis

Twenty-four lines have been selected as promising for Cerrados conditions (Table 2). The accessions are more productive, more resistant to disease and of higher quality than cv. Cook. Most of the accessions belong to the "Tardio" group and are of Brazilian origin. No "common" types have been selected because of a high susceptibility to anthracnose. Brazilian "tardío" accessions have proved to be more productive, more resistant to anthracnose and of higher digestibility than those from Venezuela (Table 3). Nitrogen and calcium contents were found to be similar. Accession CIAT 2243 has now been released in Brazil as the cultivar Bandeirante.

The major problem with the "tardio" group is the relatively low seed yield when compared to "common" types or other Stylosanthes species. Attempts are being made to increase seed yield through management and breeding. Forty-five F_2 populations coming from the breeding project in CIAT Palmira are being compared. Early observations on performance indicate that 8 lines are particularly promising. No anthracnose was observed in these promising lines.

Stylosanthes capitata

Four lines have been selected as promising for cerrados conditions. Accessions CIAT 1019 (from Minas Gerais) and CIAT 1097 (from Bahia) are in advanced stages of testing in Category IV. Accessions CIAT 2853 (from Maranhao) and 2935 (from the Federal District) are showing promise in preliminary testing. All ecotypes evaluated at CPAC have

Table 1. Legume germplasm under preliminary evaluation in Category I at CPAC, Brazil.

	1978-1982	1982-1983	Totals
Stylosanthes			
S. guianensis	195	17	212
S. capitata	167	32	199
S. scabra	171	-	171
S. viscosa	60	100	160
S. macrocephala	70	17	87
S. humilis	22	-	22
Others	21	-	21
Totals	706	166	872
Other genera			
Centrosema	84	133	217
Zornia	119	14	133
Desmodium	30	-	30
Calopogonium	29	-	29
Galactia	20	-	20
Leucaena	18	-	18
Aeschynomene	17	-	17
Macroptilium/Vigna	11	-	11
Dioclea	-	11	11
Others	23	-	23
Totals	351	158	509
Grand Total			1381

Table 2. Introductions of *Stylosanthes guianensis* "tardio" selected in Category I at CPAC, Brazil.

CIAT No.	Sub-origin	CIAT Introduction No.	Sub-origin
1095	Bahia	2315	Bahia
1286	Maranhao	2326	Maranhao
1317	Maranhao	2328	Bahia
1808	Minas Gerais	2750	Bahia
2046	Bahia	2950	Minas Gerais
2078	Bahia	2951	Minas Gerais
2146	Bahia	2953	Minas Gerais
2191	Bahia	2973	Goiás
2203	Goiás	2976	Bahia
2243*	D.F.	2981	Bahia
2244	Goiás	2982	Bahia
2245	Piaui	2993	Espirito Santo

	Anthracnose Reaction (0-5.0)**	DM Yield (g/plant)	DDM "in vitro" (%)	N Content (%)
Tardio Selections	0-1.5	100-400	41-58	1.57-1.84
cv. Cook	4.0	75	41	1.59

* cv. Bandeirante
** 0 = no disease, 5.0 = plant death

Table 3. Means for dry matter yield chemical composition and reaction to anthracnose of two groups each of 21 ecotypes of "tardio" stylo from Brazil and Venezuela evaluated at CPAC, Brazil.

GROUP	DM Yield (g/plant)	DDM "in vitro" (%)	N Content (%)	Ca Content (%)	P Content (%)	Anthracnose Reaction (0-5.0)*
Brazil	12.5	42.75	1.83	0.77	0.13	2.0
Venezuela	6.5	37.17	1.96	0.74	0.18	4.5
F Ratio Significance	***	***	NS	NS	***	***

N.S. = Not statistically significant.

* 0 = no disease; 5.0 = plant death.

*** = Significance at 0.001 level of probability.

shown excellent adaptation to acid, infertile soils and have produced large amounts of seed. The major problem has always been anthracnose. Recently, the root-knot nematode (Meloidogyne javanica) has been observed affecting CIAT 1019 in field plots (R. D. Sharma, pers. comm.).

Stylosanthes macrocephala

Seven accessions have been selected as showing excellent performance under the "Cerrados" conditions. These are CIAT 1281 (from the Federal District); 2039, 2053, 2133 (all from Bahia); 2280 (from Minas Gerais); 2732 (from the Federal District) and 2756 (from Goiás). Accessions CIAT 2039 and 2053 are being tested in Category III and CIAT 1281 has now been released in Brazil as the cultivar Pioneiro. This species has proved the most outstanding in terms of anthracnose resistance, with 80 per cent of accessions resistant to the disease.

Stylosanthes viscosa

Several accessions were attacked by anthracnose. However, 8 accessions showing good vigour and resistance were selected. These were CIAT 1094 (from Bahia), 2872 (sub-origin not known), 2879 and 2914 (both from Bahia) and 2919 (from Espirito Santo). Accession CIAT 1094 is already under seed multiplication for Category III evaluation.

Zornia species

Four accessions of Z. brasiliensis have been selected. These are CIAT 7485 (from Goiás); 8023, 9472 and 9473 (all from Bahia). The first accession CIAT 7485 is already under evaluation in Category III together with CIAT 8025 (from Ceará). The species has shown good adaptation to cerrados conditions, is very vigorous, flowers well and shows good resistance to the complex of diseases that attack other Zornia species. However, serious acceptability problems have been observed in Category III. Animals refuse to consume the species in both the wet and dry seasons. This species is no longer considered as key for the "Cerrados" ecosystem.

Centrosema macrocarpum

Accessions CIAT 5062, 5065, 5274, 5275, 5276 (all from Colombia), CIAT 5854 (from Bahia) and 5391 (from Belize) have all shown excellent adaptation to cerrados conditions and good resistance to Rhizoctonia Foliar Blight and Cercospora Leaf Spot. The major problem has been seed production. Many accessions failed to flower or produced little seed. This would be a serious limitation to the commercial use of these accessions. However, the breeding program of Dr. E. M. Hutton, initiated in Colombia, has shown that crosses with C. pubescens produce excellent quantities of seed. The progeny also retain the good adaptation to acid soils and disease resistance of C. macrocarpum. Table 4 shows the 7 breeding lines that have performed best this season. Seed yields are also markedly higher than the parental lines. These lines are to be multiplied for Category III evaluation.

Table 4. Promising F_4 and F_5 progenies selected from a series of crosses between *Centrosema pubescens* and *Centrosema macrocarpum* at CPAC, Brazil.

PARENTAL LINES (CIAT No.)		SEED YIELD (g/3 m line)
C. pubescens	*C. macrocarpum*	
5189	5275 (-21)	24.6
5052	5062 (-65/1)[1]	37.6
5052	5065 (-1)	43.4
5189	5062 (-15)	44.9
5189	5276 (-15)	52.1
5189	5062 (-22)	63.6
5189	5062 (-26)	70.5
C. macrocarpum	5062	1.6
C. pubescens	5052	3.1
C. pubescens	5189	3.0

Data supplied by Dr. E. M. Hutton and F. B. de Sousa.

1/ F_5 plants.

Centrosema brasilianum

Accessions CIAT 5234, 5487, 5824, 5825, 5826 (all from Bahia) and 5523 (from Rio Grande do Norte) are all promising for cerrados conditions. Unlike C. macrocarpum, C. brasilianum lines flower well and are better seed producers. The main problem has been the incidence of diseases especially Rhizoctonia Foliar Blight. The selected accessions show good resistance and low disease scores were recorded this season.

New Species

Three new species have been evaluated in the last few years. These are Cassia rotundifolia, Dioclea guyanensis and Rhynchosia species, Cassia shows little potential and accessions are badly attacked by anthracnose and Cercospora Leaf Spot, Rhynchosia accessions have established well, flower profusely and produced seed. Information is now required on the effects of defoliation. Dioclea lines have also established well but appear nutrient deficient. It is too early to comment on the potential of this species.

AGRONOMIC SMALL-PLOT EVALUATION OF GRASS GERMPLASM (CATEGORIES I/II)

In earlier years genera of African origin namely Andropogon, Brachiaria, Melinis and Panicum have been evaluated. Accessions of Brachiaria brizantha and Panicum maximum have been selected for the dark-red latosol, and Andropogon gayanus var. bisquanulatus CIAT 621 released as the cultivar Planaltina. Problems were encountered on the red-yellow latosol.

Attention has turned to the genus Paspalum, native to Latin America. The genus contains up to 250 species and a small nursery collection at EMBRAPA-CENARGEN indicates considerable variation in types. This wet season a small preliminary observation trial was established vegetatively on the red-yellow latosol with 8 Paspalum species and A.gayanus cv. Planaltina as a control. P. guenuarum and especially P. conspersum are impressive, producing considerably more growth than A. gayanus. Next season the number of accessions will be increased and will include some lines collected at CPAC which have been observed to be highly acceptable and selected by fistulated steers.

AGRONOMIC EVALUATION OF LEGUMES UNDER GRAZING (CATEGORY III)

Promising accessions from Category I/II are evaluated in this category in small, individually-grazed, and replicated plots. Associations are grazed intermittently in both the wet and dry seasons at two stocking rates. During the wet season, to control the growth of Andropogon, grazing was every 3 weeks for 2 days duration. In the dry season this was extended to 4 days every 6 weeks. Plot sizes are 480 or 320 m^2 to give the two stocking rates, and enable accessions to be evaluated under high and low grazing intensities. The existing trial is in its second season, but grazing only commenced this season. Fistulated steers were used periodically.

Eight legumes were associated with A. gayanus cv. Planaltina. The legumes were Stylosanthes macrocephala cv. Pioneiro (= CIAT 1281) and

10138 (both controls), S. macrocephala CIAT 2039 and 2053; Zornia latifolia CIAT 728 (control), Z. brasiliensis CIAT 7485 and 8025; Centrosema macrocarpum CIAT 5065.

At the start of the second season in early November 1982 the total dry matter on offer in the treatments ranged from 1036 to 1879 kg/ha. In the S. macrocephala and Zornia plots legume contents ranged from 17 to 67 per cent. C. macrocarpum failed to establish. Weeds were at a low level (5 per cent). The total dry matter on offer and legume contents at the end of the wet season (early June 1983) and mid-dry season (late August 1983) are shown in Table 5.

S. macrocephala CIAT 2039 and 2053 are two promising lines and their contents have increased appreciably since November. Z. latifolia CIAT 728 has associated well at both stocking rates and a good grass-legume balance has been achieved. In November 1982 the plots of Z. brasiliensis CIAT 7485 were legume-dominant and the content of the legume has increased further. Animals have grazed Andropogon to ground level but the legume was not accepted neither in the wet season nor the dry season. A strong odour is associated with this legume. In the dry season, it was the only legume which had an appreciable amount of green leaf. The dry season yields quoted in Table 5 for this accession are total yields. The accession is a shrub-type with a large amount of woody material. "Edible" dry matter yields were only 12 per cent of these values. The plots containing Z. brasiliensis CIAT 8025 had a lower legume content in November 1982 than those of CIAT 7485. There is now a good grass-legume balance in the plots of CIAT 8025 particularily at the low stocking rate. CIAT 8025, unlike CIAT 7485, is semi-prostrate, less woody with a lower total dry matter yield and does not retain green leaf in the dry season. Unfortunately, animals have also refused to consume CIAT 8025 in both the wet and dry seasons. C. macrocarpum has virtually disappeared from the plots with only a trace remaining. Weed contents in August 1983 were insignificant.

Differences in dry matter between stocking rates became visible at the end of the wet season except in the plots containing CIAT 7485. These differences increased markedly in the dry season. Legume contents tended to be higher in the dry season in the high stocking rate treatments because of preferential grazing of Andropogon. Disease incidence was low. In the wet season there was slight Sphaceloma Scab and Drechslera Leaf Spot in Z. latifolia and slight virus-fungus complex in Z. brasiliensis lines. No anthracnose was found in Stylosanthes.

Fistulated animals were used during one grazing period in early March in the plots of Z. latifolia, Z. brasiliensis CIAT 8025, S. macrocephala cv. Pioneiro, and C. macrocarpum CIAT 5065. The animals were used again in one grazing period in late August in the plots of Z. latifolia, Z. brasiliensis CIAT 7485 and 8025, S. macrocephala cv. Pioneiro and 2053. In March, in every treatment, over 95 per cent of consumption was accounted for by Andropogon, of which 85 per cent was green leaf. In August, the animals consumed between 60 and 70 per cent dry Andropogon, most of which was dry leaf material. Small quantities of green Andropogon regrowth were selected. The only

Table 5. Total dry matter on offer and legume contents at end of wet season and in mid-dry season in Category III evaluation at CPAC, Brazil.

ACCESSION/ORIGIN	TOTAL DM ON OFFER (kg/ha)			
	LOW SR[1]		HIGH SR[1]	
S. macrocephala	WET	DRY	WET	DRY
CIAT 10138[2] DF	3848 (11)[3]	2443 (3)[3]	1455 (25)[3]	330 (2)[3]
CIAT 1281[2] DF (cv. Pioneiro)	4858 (11)	1743 (3)	2428 (11)	1326 (13)
CIAT 2039 Bahia	3538 (57)	1123 (59)	2348 (38)	645 (66)
CIAT 2053 Bahia	3451 (80)	958 (67)	2711 (93)	710 (87)
Z. latifolia				
CIAT 728[2] Colombia	2935 (38)	1088 (34)	1625 (36)	445 (69)
Z. brasiliensis				
CIAT 7485 Goiás	4208 (98)	1920 (100)	4820 (99)	2110 (100)
CIAT 8025 Bahia	4982 (28)	1853 (49)	1960 (83)	988 (66)
C. macrocarpum				
CIAT 5065 Colombia	6167 (1)	2868 (0)	3500 (1)	1430 (0)

1/ SR = Stocking rate.
2/ Controls.
3/ Legume content (% DM basis).

legume consumed was *S. macrocephala*, which accounted for approximately 5 per cent of the total material eaten.

Next season, depending on seed supplies, another Category III evaluation will commence with selected lines of *Panicum maximum* and *Stylosanthes guianensis* "tardio".

SEED PRODUCTION

In addition to conducting research on problems of seed production in adapted species considerable effort is concentrated in the process of seed multiplication; seed is required for pasture evaluation and other programs at CPAC. When new cultivars are released by CPAC it is the CPAC Program responsibility to produce foundation seed for the Basic Seed Unit of EMBRAPA to commence large-scale production.

SEED MULTIPLICATION

Multiplication of seed of selected species continues to expand and new areas were established in 1982-83. The pure seed yields of 7 accessions of *S. guianensis* "tardio" in the establishment year ranged from 12 to 35 kg/ha, with a mean of 21 kg/ha. The highest yield was recorded in CIAT 2243 released by EMBRAPA as cv. Bandeirante which approximated yields obtained in previous experiments.

S. macrocephala and *S. capitata* lines continue to produce good seed yields, although anthracnose can be a problem in the latter in susceptible accessions in the second year. The pure seed yields of 5 selected lines ranged from 164 to 612 kg/ha in the establishment year, with a mean of 381 kg/ha. The *S. macrocephala* CIAT 1281 released by EMBRAPA as cultivar Pioneiro produced 413 kg/ha. Yields for 4 selected lines of *S. capitata* in the same period ranged from 139 to 1000 kg/ha, with a mean of 564 kg/ha. The only accession of *S. viscosa* under multiplication is CIAT 1094 which gave a yield of 136 kg/ha.

As a consequence of the problems in producing seed of *Centrosema macrocarpum*, future efforts will be directed towards the accessions of *C. pubescens* x *C. macrocarpum* from the breeding program. *Z. brasiliensis* accessions flower profusely but there are problems of lack of uniformity in seed maturation and seed shedding. Animal acceptability problems in the species cast a shadow over future seed multiplication at CPAC.

EFFECTS OF CUTTING AND IRRIGATION ON SEED PRODUCTION OF *Stylosanthes guianensis* CV. BANDEIRANTE

To determine whether seed yield could be increased agronomically in this cultivar by defoliation and/or supplementary irrigation, a trial was established in the 1981-82 wet season. Two irrigation treatments were factorially combined with two defoliation treatments. The two irrigation treatments were supplementary irrigation up to peak flowering (July) and no irrigation. The two defoliation treatments were no cutting and cutting in late February (4 weeks before estimated flower initiation based on Australian experience with commercial cultivars of the species). A further irrigation treatment was included for observation purposes i.e. irrigation through the dry season. No defoliation treatment was imposed in 1981-82 in the establishment year. The results for that season are shown in Table 6. Irrigation until peak flowering time increased appreciably the number of inflorescences although seeds per inflorescence were reduced by 15 per cent. However, pure seed yield was increased by 41 per cent. Continuous irrigation reduced all parameters, particularily seed yield.

In February 1983, in the second season, the defoliation treatments were applied and plots cut to 30 cm above soil level. Defoliation killed all the plants leaving only dry stems. Further research is to be conducted on this aspect.

EFFECTS OF CUTTING AND DEFERRED GRAZING ON SEED PRODUCTION IN ANDROPOGON

1982-83 was the third and last season for both these trials. The aim was to determine when seed crops of A. gayanus cv. Planaltina could be cut or grazed in the wet season without reducing seed yield. Defoliation is necessary to prevent lodging under conditions of relatively high fertility. The treatments were no cutting or grazing, grazing until or cutting at 15th January, 15th February and 15th March in each season. After cutting or deferring the grazing, 50 kg N/ha was applied.

Seed yields are presented in Table 7 for both cut and grazed treatments. The yields are given as means of 3 years data for the cutting experiment and 2 years (1st and 3rd years) for the grazing experiment. In the 2nd year fire swept through the latter trial and it was decided to ignore the variable results obtained.

Under cutting the highest seed yields were obtained by defoliating in mid-January. There was a 51 per cent increase over the uncut control. Cutting in mid-February only increased seed yield by 7 per cent whilst delaying until mid-March reduced appreciably seed yield. Under grazing the results were different. Deferring grazing in mid-January increased seed yields by 41 per cent. However, deferring grazing in mid-February gave a further 15 per cent increase in yield. In both trials there was a tendency for defoliation to increase tiller number, the number of fertile tillers and seed size at the optimum dates of cutting or deferred grazing.

There was evidence that reduced plant height at harvest and the lack of lodging decreased harvesting and post-harvest labour requirements. Comparing the ungrazed and deferred grazing in mid-February treatments there was a 60 per cent reduction in cutting time, a 43 per cent reduction in carrying time and required for making the piles for "sweating", and a 66 per cent reduction in time necessary for threshing and clearing.

Table.6 Components of seed production in undefoliated stands of *S. guianensis* cv. Bandeirante in 1982 with or without irrigation at CPAC, Brazil.

Treatment	Inflorescence No./m^2	Seeds/Inflorescence	Pure Seed Yield (kg/ha)
No Irrigation	3732	1.50	24.3
Irrigation until peak flowering	6172	1.27	34.3
Irrigation through dry season	2796	1.19	5.4

Table 7. Effects of cutting and deferred grazing on seed production in *Andropogon gayanus* cv. Planaltina at CPAC, Brazil.

Treatment	Plant Height At harvest (m)	Seed Yield (kg/ha) [1]	Plant Height At harvest (m)	Seed Yield (kg/ha) [2]
No cutting or grazing	3.0	107	3.0	98
Cut or Grazed until 15.01	2.0	162	2.25	140
Cut or Grazed until 15.02	1.75	115	1.75	153
Cut or Grazed until 15.03	1.25	40	1.25	108

1/ Mean of 3 years data.
2/ Mean of 2 years data.

REGIONAL TRIALS

Now that a large base of information has been established at CPAC on promising germplasm, and key species identified there is a need to test this material at other sites in the region particularily those outside the "central core" where rainfall is higher or lower. Twelve sites have been selected for regional trials of the Type B (Table 8). These sites vary from north of the equator down almost to the sub-tropics of Brazil. There is considerable variation in altitude and rainfall, and major soil types are included. Regional trials already exist in Roraima and Barreiras. In 1982-83, a regional trial type B was established at CPAC on the red-yellow latosol. Sites at Goiania and Felixlandia already have a history of pasture evaluation. A provisional list of germplasm to be included in these trials is presented in Table 9. This list is based mainly on experience obtained over 5 years at CPAC. Collaborators are encouraged to include their own promising germplasm in the trials and, where possible, to send seed to CPAC to distribute to other sites in the Brazilian network. Of particular interest will be the anthracnose reaction of Stylosanthes species; whether Centrosema macrocarpun and S. guianensis "tardio" flower and produce higher seed yields at lower or higher latitudes than CPAC. When seed of other introductions and breeder's material is available at CPAC the list will be expanded.

PASTURE PRODUCTIVITY EVALUATION (CATEGORY IV)

With the objective of assessing animal potential productivity of promising pastures coming from Category III, in 1981-82 a grazing trial was established with four highly promising legumes. The legumes were Stylosanthes guianensis cv. Bandeirante (CIAT 2243), S. capitata CIAT 1019 and 1097; S. macrocephala cv. Pioneiro (= CIAT 1281). The legumes were sown with A. gayanus cv. Planaltina (CIAT 621). Three stocking rate treatments 1.0 animal unit per ha (low), 1.4 animal units per ha (medium) and 1.8 animal unit per ha (high) were included in the design. One animal unit is ≐ 400 kg liveweight. Each paddock is continuously grazed by four animals (two steers and two females) and stocking rate treatments were obtained by varying paddock size. Animals will be changed annually at the start of the dry season. Fistulated steers will be used periodically to monitor diet selection. Pastures will be analysed by the sampling and computing procedure "BOTANAL". This combines estimates of relative species composition (Dry-Weight Rank Method of 't Mannetje and Haydock 1963) and of pasture yield (Comparative Yield Method of Haydock and Shaw 1975).

The paddocks were not grazed in 1981-82 to allow the species to produce seed. In the 1982-83 wet season paddocks were pregrazed to uniformize the treatments. Grazing treatments were imposed in May 1983. Initial liveweight of the animals was 150 kg.

The dry matter on offer and botanical composition of the paddocks at the start of the experiment is presented in Table 10. The highest legume contents were in the Andropogon - S. guianensis associations and ranged from 29 to 52 per cent. Weed contents were less than 5 per cent, except in the Andropogon - S. capitata CIAT 1019 association at the high stocking rate. Here the weed content was 8 per cent due to invasion of Brachiaria ruziziensis from an adjoining paddock.

Table 8. Regional trial sites in the cerrados of Brazil.

Macapa/AMAPA	0°3'N	15	2500	Red Yellow latosol
Boa Vista/RORAIMA	3°15'N	90	1740	Yellow latosol
Balsas/MARANHAO	7°21'S	190	1566	Red Yellow latosol
Amarante/PIAUI	8°12'S	210	900	Red Yellow latosol
Barreiras/BAHIA	11°50'S	479	1020	Quartz sand
vilhena/RONDONIA	12°44'S	600	2000	Red Yellow latosol
Planaltina/DF	15°35'S	1170	1570	Red Yellow latosol
Jaciara/MATO GROSSO	15°35'S	219	1700	Dark Red latosol
Goiania/GOIAS	16°41S	730	1443	Dark Red latosol
Felixlandia/MINAS GERAIS	18°45'S	614	1100	Red Yellow latosol
Camapua/MATO GROSSO DO SUL	20°28'S	559	1396	Quartz sand
Sao Carlos/SAO PAULO	22°01'S	854	1495	Red Yellow latosol

Table 9. A provisional list of germplasm to be distributed to the Brazilian Regional Trial Network from CPAC, Brazil.

Species	CIAT Accession No.
S. guianensis "tardio"	1095, 2191, 2203, 2243, 2244, 2245
S. capitata	1019, 1097, 1318, 2252
S. macrocephala	1582, 2039, 2053, 2133, 2280, 2732
S. viscosa	1094
C. macrocarpum	5062, 5065
Z. latifolia	728
Zornia glabra	7847

Animal performance during the first 90 days of the dry season is shown in Table 11. Small gains were made in nearly all the treatments and were highest in the *Andropogon* - *S. guianensis* associations. This legume species remained green in the dry season.

Fistulated steers were introduced in April towards the end of the wet season and again in June 1983 in the early dry season. Diet selection data are summarized in Table 12. In the first sampling period, in eleven out of twelve treatments, *Andropogon* was almost exclusively consumed. The exception was at the high stocking rate in the *Andropogon* - *S. capitata* CIAT 1019 treatment where animals selectively grazed the area of the invading *B. ruziziensis*. In April more than 80 per cent of consumption was green *Andropogon* leaf. In the July sampling the trend was similar, although the intake of *S. guianensis* increased markedly and the amount of green *Andropogon* leaf consumed fell to less than 50 per cent. The chemical composition of fistula samples for three of the four associations in June is shown in Table 13. The highest crude protein levels selected were in the *Andropogon* - *S. guianensis* association.

Slight to moderate anthracnose was found in *S. guianensis* and *S. capitata* CIAT 1097 at the start of the experiment. Only a few lesions were detected in *S. capitata* CIAT 1019 and none in *S. macrocephala*.

Table 10. Dry matter on offer and botanical composition of associations at start of dry season in Category IV evaluation at CPAC, Brazil.

Andropogon Association	Stocking Rate	*Andropogon* on Offer GREEN (kg/ha)	*Andropogon* on Offer DEAD (kg/ha)	Legume on Offer (kg/ha)
S. capitata	Low	4131 (48)[1]	2735 (32)	1317 (15)
CIAT 1019	Medium	4071 (46)	3716 (42)	728 (8)
	High	2976 (39)	2741 (36)	1294 (17)
S. capitata	Low	4099 (43)	3729 (39)	1473 (15)
CIAT 1097	Medium	4343 (46)	3501 (37)	1489 (16)
	High	4805 (50)	2779 (29)	1888 (20)
S. guianensis	Low	4009 (37)	4023 (34)	3401 (29)
CIAT 2243	Medium	2531 (27)	1657 (18)	4882 (52)
(cv. Bandeirante)	High	3316 (32)	2628 (25)	4093 (40)
S. macrocephala	Low	4822 (54)	2585 (29)	1107 (12)
CIAT 1281	Medium	4716 (52)	2725 (30)	1383 (15)
(cv. Pioneiro)	High	4169 (44)	3996 (42)	1053 (11)

1/ Botanical composition values (% DM) in parenthesis.

Table 11. Liveweight performance of animals after 90 days of dry season (late August) in Category IV evaluation at CPAC, Brazil.

Association with *Andropogon*	Actual Stocking Rate (animal units/ha)	Animal Gain (kg/an/day)
S. capitata	0.81	0.101
CIAT 1019	1.01	-0.020
	1.31	0.036
S. capitata	0.75	0.098
CIAT 1097	1.05	0.065
	1.34	0.053
S. guianensis	0.77	0.247
CIAT 2243	1.08	0.220
(cv. Bandeirante)	1.37	0.164
S. macrocephala	0.75	0.095
CIAT 1582	1.05	0.122
(cv. Pioneiro)	1.33	0.053

Table 12. Selection of sward components by fistulated steers in the late wet season and early dry season in Category IV evaluation at CPAC, Brazil.

Andropogon Association	Stocking Rate	Grass (%) April	Grass (%) July	Legume (%) April	Legume (%) July	Weed (%) April	Weed (%) July
S. capitata	Low	98	98	2	0	0	2
CIAT 1019	Medium	99	96	1	0	0	4
	High	10	69	3	0	87	31
S. capitata	Low	100	99	0	1	0	0
CIAT 1097	Medium	99	99	0	0	1	1
	High	100	100	0	0	0	0
S. guianensis	Low	99	92	1	7	0	1
CIAT 2243	Medium	99	92	1	8	0	0
(cv. Bandeirante)	High	96	79	4	20	0	1
S. macrocephala	Low	49	100	0	0	1	0
CIAT 1281	Medium	88	93	0	0	12	7
(cv. Pioneiro)	High	97	99	0	0	3	1

Table 13. Chemical composition of fistula samples collected in early June in Category IV evaluation at CPAC, Brazil.

Andropogon Association	Crude Protein (%)	"In vitro" Dry Matter Digestibility (%)
S. guianensis		
CIAT 2243	13.61	39.70
(cv. Bandeirante)		
S. capitata		
CIAT 1097	10.43	49.45
S. macrocephala		
CIAT 1281	9.37	54.18
(cv. Pioneiro)		

PASTURES DEVELOPMENT–CERRADOS

The identification of new forage legume ecotypes tolerant to diseases and adapted to the soil conditions and climate of the Cerrados, offers a wide range of alternatives for pasture development and renewal in the region.

The selection of new germplasm under acid soil conditions with low levels of available nutrients assures its adaptation to these conditions. Thus its use for improving native pastures and renewing degraded pastures is made possible within a minimum input system. Preliminary results on the inclusion of these new materials in degraded Brachiaria pastures are presented in this report. In addition, the knowledge of their potential response to higher fertility levels is necessary to broaden their possible use in previously cropped Cerrado areas, where high levels of phosphorus and lime have been applied. Experimental results obtained under these conditions with five legumes that are presently in the most advanced evaluation phase are presented in this report. Finally, new results are discussed in relation to the use of alternative phosphorus sources, showing the long residual effect and increasing efficiency of some phosphoric rocks available in the region.

New experiments to determine the need of applying fertilizers for the maintenance of grass and legume pastures have been initiated. The information to be obtained from these experiments, under grazing conditions, will allow the development of techniques that assure long-term persistence of stable associations and enhance an optimum recycling of nutrients in the soil-plant-animal system.

RESPONSE OF FIVE LEGUME SPECIES TO INCREASING LEVELS OF PHOSPHORUS AND LIME

In a field experiment initiated in 1980, the productivity of Stylosanthes guianensis "tardío" CIAT 2243, S. capitata CIAT 1019, S. macrocephala CIAT 1281, Zornia brasiliensis CIAT 7485 and Centrosema macrocarpum CIAT 5065 under various conditions of available phosphorus and lime applications was studied. Preliminary results corresponding to the first harvest were presented in the 1982 Annual Report. Cumulative results are presented in Figure 1 and show that Centrosema macrocarpum CIAT 5065, as well as Stylosanthes guianensis CIAT 2243, respond to levels of 220 kg P_2O_5/ha, while S. macrocephala CIAT 1281, Zornia brasiliensis CIAT 7485, and S. capitata CIAT 1019 showed a response only at the 120 kg P_2O_5/ha level, with production levels well under those of the former species. The response to lime above the minimum 120 kg/ha level applied, was limited in all species; with exception of S. capitata CIAT 1019, dry matter production of all introductions increased up to 800 kg/ha. The favorable effect of lime applications was observed primarily at levels of up to 120 kg P_2O_5/ha, with a slightly unfavorable effect above this level in the majority of the introductions (Figure 1).

These results indicate the possibility of including S. guianensis CIAT 2243 or C. macrocarpum CIAT 5065 under variable fertility conditions, while the other species could be used for those areas receiving smaller appli- cations of phosphorus and lime.

Furthermore, it has been confirmed that although the fertilizers applied last year had a very high residual effect in terms of plant response to applied phosphorus, available P in the soil was considerably lower in those plots that at the same level of applied P received higher levels of lime. The data available do not indicate whether this is the result of a minor extraction of P by the extractor used (Mehlich) due to the presence of lime, or if it corresponds to a lower real availability of P for plants under those conditions. The chemical analyses of the aerial parts of the plants showed that while P contents of C. macrocarpum CIAT 5065 and S. capitata CIAT 1019 were 0.20% at the species highest yields, S. guianensis CIAT 2243 and S. macrocephala CIAT 1281 showed maximum yields at P contents of 0.16%.

RELATIVE EFFICIENCY OF PHOSPHORUS SOURCES FOR PASTURES

The extreme phosphorus deficiency and high P-fixing capacity is a well known characteristic of the Oxisols. Using laboratory methods a number of studies have documented the high P-fixing capacity of these soils. Nonetheless, the proportion of the phosphorus fixed under these conditions which, however, can be used by the plants, is not well known. Previous studies showed that certain tropical pasture species are able to efficiently use several years after application those fertilizers that contain a high proportion of water-soluble phosphorus (superphosphate), suggesting that a good portion of these, although already fixed, can be used by the plants. In any case, the use of non-water soluble sources of phosphorus may be attractive in order to avoid an initial high fixation and to enhance the gradual release of phosphorus over many years. Results obtained with three phosphorus sources, during a period of four years, are presented in this section. The products used were Araxá phosphate, Yoorin thermophosphate, and triple superphosphate. The first is a finely ground phosphate rock, and Yoorin is a phosphate treated at high temperatures, both having a very low content of water soluble phosphorus.

Figure 2 shows the results obtained during a period of four years in an experiment carried out with Andropogon gayanus CIAT 621 and Stylosanthes capitata CIAT 1078. Results are presented in relative yield percentages, 100 being the yield obtained with equal amounts of applied phosphorus in the form of triple superphosphate. All treatments received basic applications of S (50 kg/ha), dolomitic lime (1000 kg/ha), K (83 kg/ha), Zn (5 kg/ha) and ammonium molibdate (0.5 kg/ha).

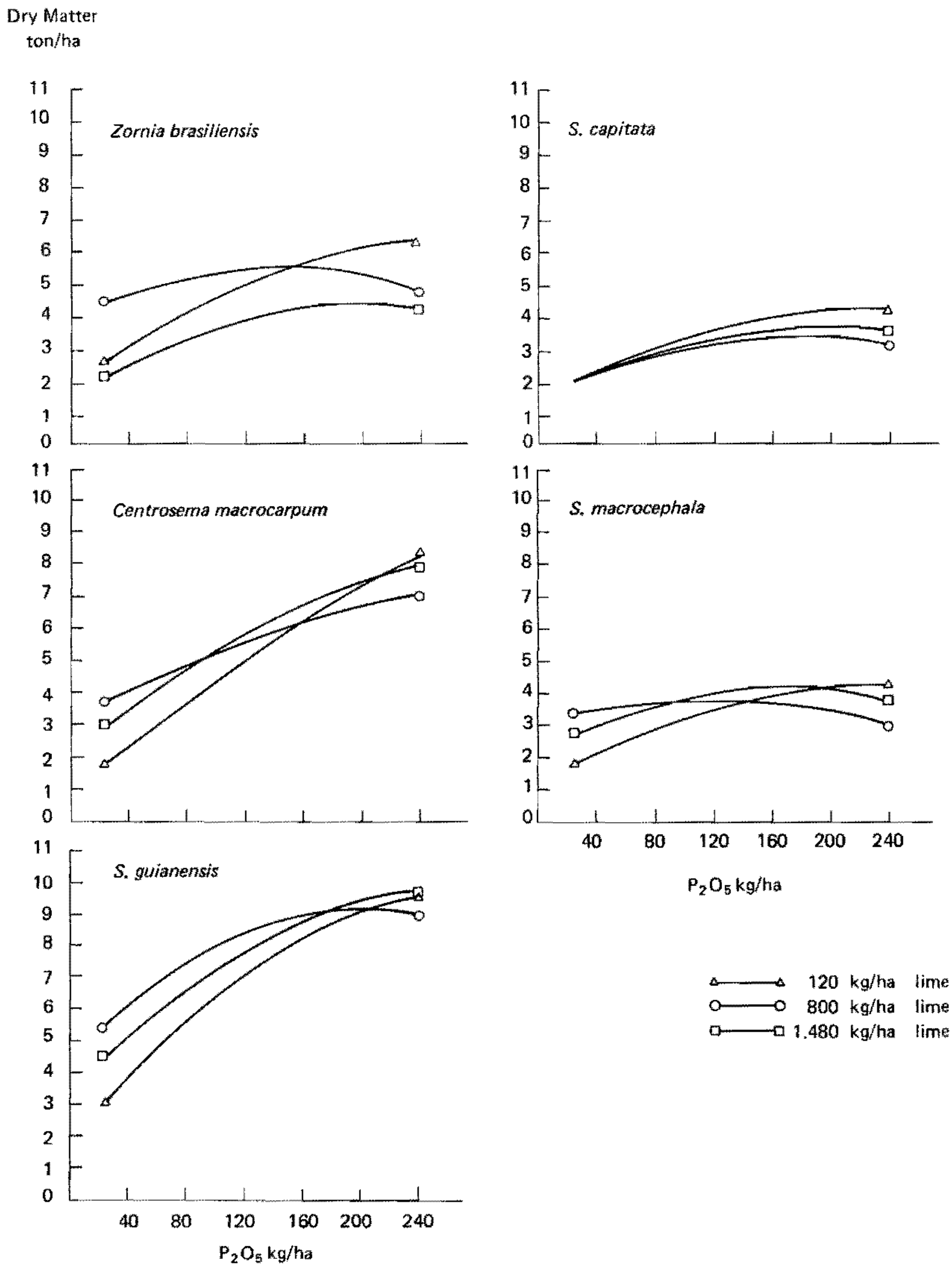


Figure 1. Response of 5 forage legumes to increasing levels of P and lime. Sum of 2 cuts.

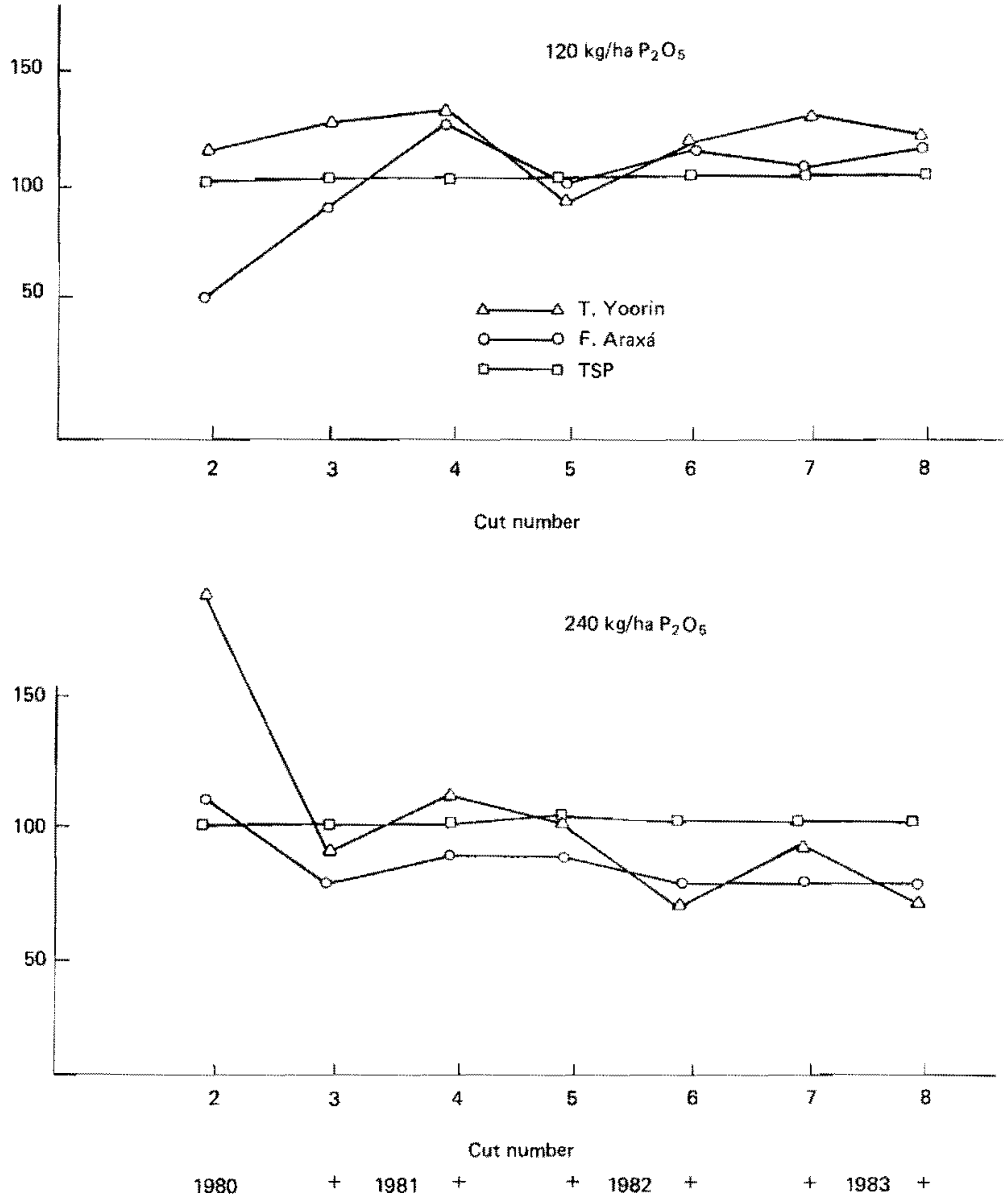


Figure 2. **Relative yield (TSP = 100%) of *A. gayanus* and *S. capitata* under 3 sources and at 2 levels of P, during 4 years.**

Results show that at the 120 kg P_2O_5/ha level Araxá phosphate initially was not very effective but that its effectivity increased with time and after the third year was similar to triple superphosphate. The effectivity of Yoorin thermophosphate was as high as or higher than that of triple superphosphate. When the level applied was 240 kg P_2O_5/ha, the efficiency of these two sources compared with triple superphosphate decreased with time, being inferior to triple superphosphate at the beginning of the third year. This has been interpreted as the result of a minor phosphorus solubility in the non-soluble sources, when levels of application were higher, as well as a higher residual effect of higher triple superphosphate doses. The possibilities of using Araxá and Yoorin phosphate seem to be limited to levels of up to 120 kg P_2O_5/ha under experimental conditions; the convenience of using these sources, however, will be determined by their relative prices.

RENEWAL OF *Brachiaria* spp. PASTURES

Large areas of the Cerrados region have been planted to pastures of various *Brachiaria* species. In most cases, pastures that in the beginning were highly productive, now present lower productivity levels, a decrease in the number of persisting plants, only partial ground coverage, and the consequent surface erosion of the soil. Though it is true that the causes that lead to the gradual decline of grass pastures are multiple, the low capacity of the soil to provide nitrogen in mineral form a few years after establishment can be considered as one of the pasture degrading factors. This is confirmed by the response to N fertilizers of grass pastures which have been for several years under grazing (CIAT, Annual Report 1979).

The introduction of legumes into degraded pastures as a means of incorporating nitrogen into the system and improving the forage quality during the dry season, offers a more viable alternative from the economic point of view. Previous experiments showed the viability of this alternative using techniques that include scarification of the soil surface (CIAT, Annual Report 1979). New forage legume ecotypes identified by selecting plants adapted to the Cerrados soils offer new alternatives for the renewal of *Brachiaria* pastures, advantageously substituting the commercial varieties tested before. A new experiment was initiated in 1980, comparing various renewal methods for a *Brachiaria ruziziensis* pasture which had been established six years ago. The experiment included the following treatments: (a) soil surface scarification with a turbotiller, (b) fertilization, (c) the combination of (a) and (b), (d) introduction of legumes into the pasture by sowing in rows with a chisel seeder, and (e) introduction of legumes by broadcast seeding after some light disking with a turbotiller. Four legume species were tested: *Stylosanthes guianensis* CIAT 2243, *Stylosanthes macrocephala* CIAT 1281, *Stylosanthes capitata* CIAT 1019 and *Stylosanthes capitata* CIAT 1097. The plants established well with either method, but their contribution to total production was very low in the first year. During the second year, their contribution was in some cases superior to 50% of the total dry matter, total forage production being five times higher than the control plot (Figure 3).

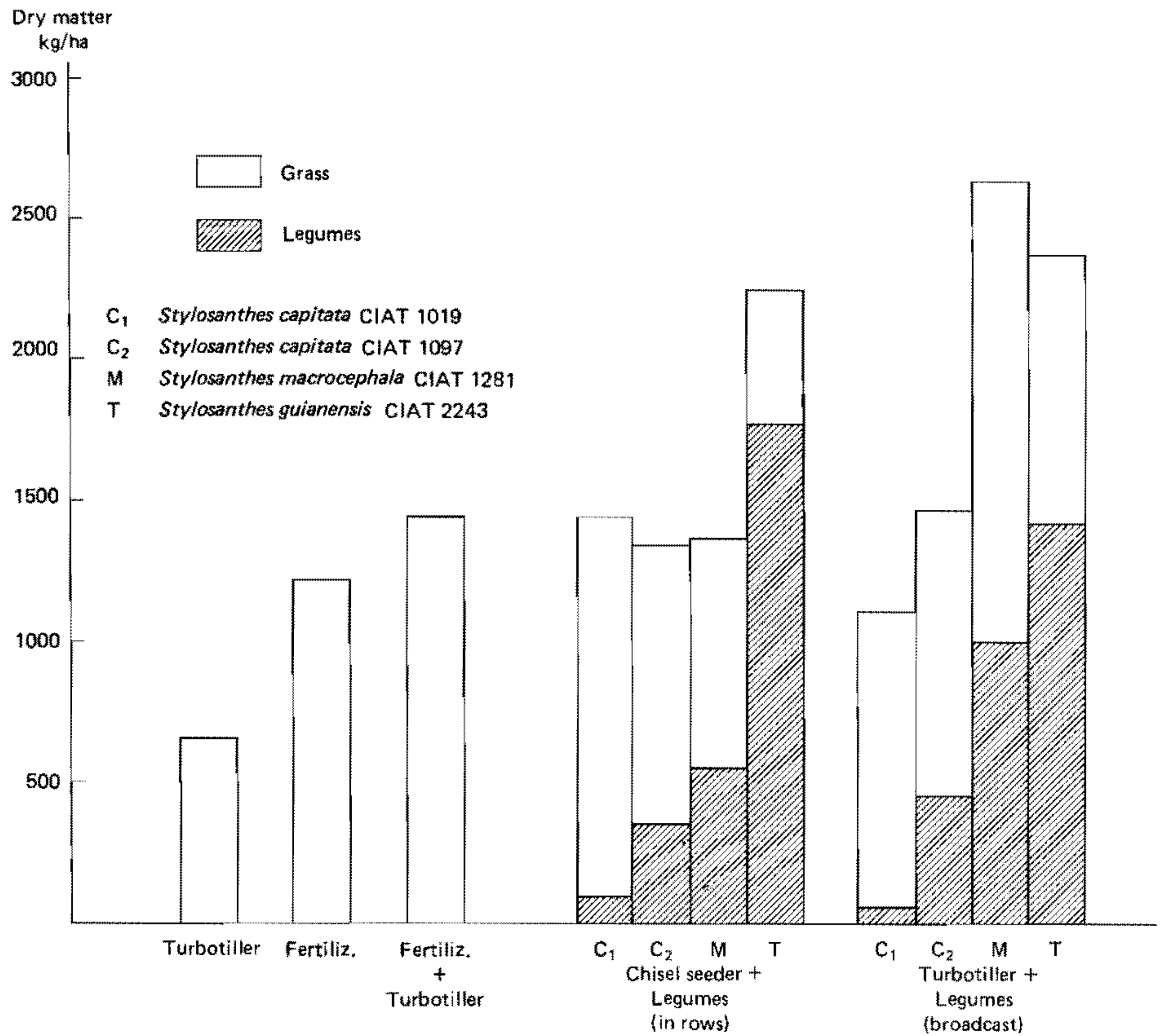


Figure 3. **Dry matter yield of *B. ruziziensis* under different pastures renovation methods in the Cerrados (Brazil).**

From Figure 3 it is evident that the increase in forage production obtained with the best treatments (renewal with turbotiller, fertilization, and planting Stylosanthes macrocephala or Stylosanthes guianensis), is the result of the contribution of each of the factors considered in the experiment, and their interaction. The application of fertilizer contributed with a 100% increase in forage production, while additional soil surface scarification contributed only modestly to a further yield increase. However, previous experiments showed that this superficial mechanical treatment of the soil was necessary for the better establishment of the legumes. The inclusion of legume introduction into the renewal process doubled forage production in comparison with the fertilization treatment.

During 1983 the Section has focused research work in four main areas: (1) Nutrient competition in grass-legume mixtures; (2) Studies on the recovery of degraded pastures; (3) Evaluations of nutrient cycling in the soil-plant-animal system, and (4) Use of mineral rocks as alternative sources of fertilizers.

NUTRIENT COMPETITION IN GRASS-LEGUME MIXTURES

Andropogon gayanus - Stylosanthes capitata mixture

In the 1982 annual report, preliminary information was presented on the effect of P and basic fertilization on the performance of a mixture of *A. gayanus* 621 and *S. capitata* 1019. Table 1 summarizes the dry matter production of *A. gayanus* and *S. capitata* during the first year in response to 3 sources and 2 rates of P in the presence and absence of basic fertilization applied during the establishment period.

It can be seen that P fertilization mainly favored the grass, whether or not it received basic fertilization. Independent of the P source, *A. gayanus* showed an approximately 50% increase in dry matter production with the first 20 kg P/ha applied without basic fertilization and 100% with basic fertilization in relation to the control. The response to an additional 20 kg P/ha was not so great. Basic fertilization alone did not improve growth of *A. gayanus*. These results show that the presence of other nutrients in the soil produces positive and interactive effects with certain amounts of P (20 kg P/ha). The effect of basic fertilization, in combination with P independent of sources and rates, caused a 25% increase in dry matter production over the treatments without basic fertilization.

In contrast to the *A. gayanus* response, the dry matter production of the legume (*S. capitata*) was increased with basic fertilization, even in the absence of P. The effect of this fertilization was equivalent to a 63% increase in the amount of dry matter produced in comparison with the controls. Increments of about 92 and 60% with 20 and 40 kg P/ha, respectively were observed. The main effect of P was to increase the dry matter production of the legume by about 30% but only with the first 20 kg P/ha added.

A differential performance of the grass and legume in terms of persistence in the forage production (Figure 1), was also observed in this experiment. *Stylosanthes capitata* showed a gradual reduction in forage production with time which was independent of the fertilizer treatment applied. This fact was related to previous results which

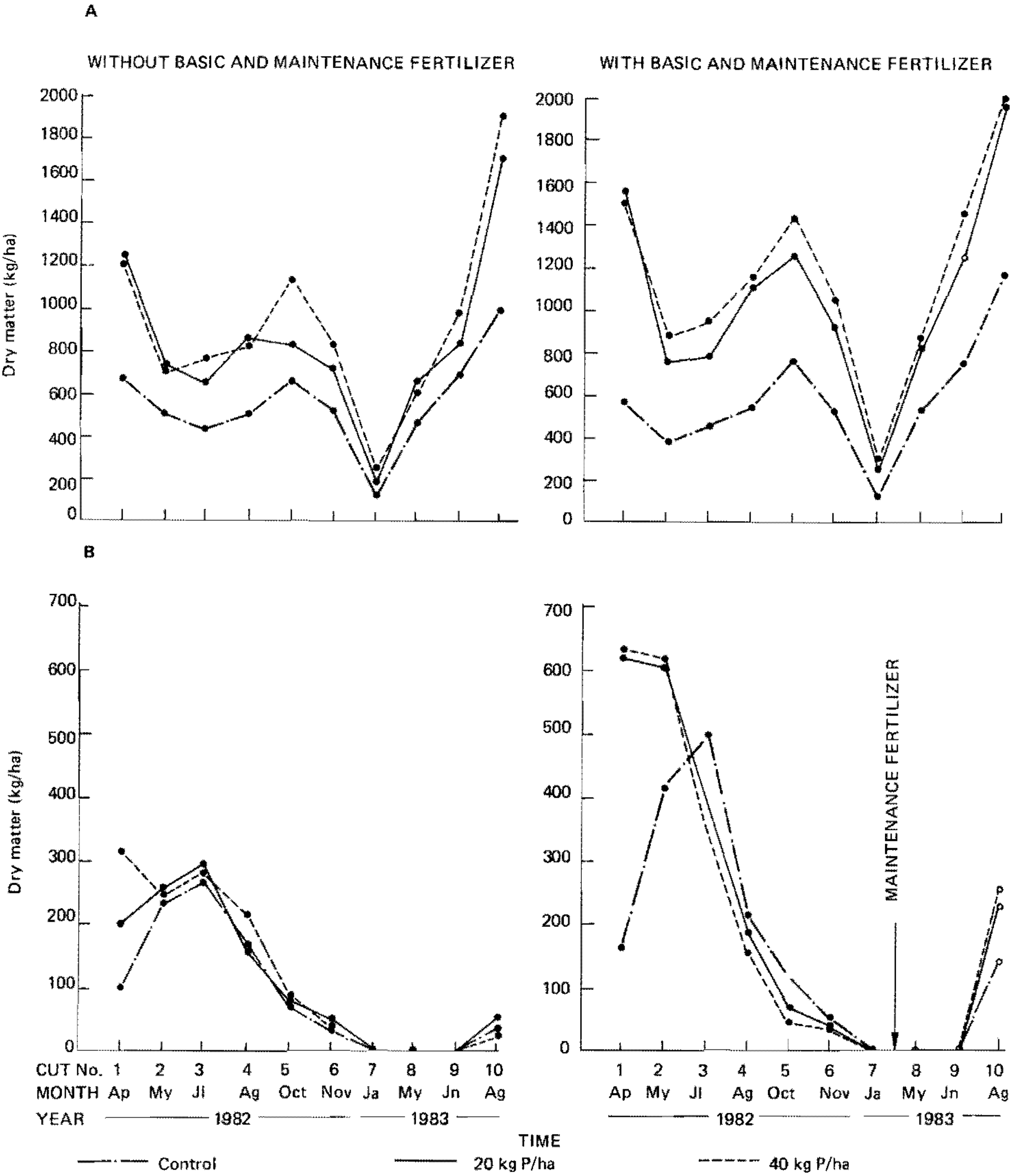


Figure 1. Dry matter production of *Andropogon gayanus* 621 (A) and *Stylosanthes capitata* 1019 (B) grown in association as a function of time and phosphorus fertilizer rates with and without basic fertilization (May, 1981) and maintenance fertilizer (March, 1983).

Table 1. The effect of P application and basic fertilization[1] on the dry matter production (kg/ha/yr) of A. gayanus (A.g.) and S. capitata (S.c) grown in association.

P Application		Without Basic Fertilization		With Basic Fertilization	
Source S.c.	P Rates (kg P/ha)	A.g.	S.c	A.g.	S.c.
Control	0	3380	880	3176	1433
Triple Superphosphate	20	5198	927	6414	1957
	40	4966	1148	6080	1874
Calfos	20	5012	890	6796	2014
	40	6359	1043	7548	1562
Phosphate Rock (Huila)	20	5027	1104	6001	1732
	40	5416	1150	7132	1936

Planting date: May 7, 1981

1/ Basic fertilization (kg/ha): 33 K; 111 Ca; 24 Mg; 14 S; 5 Zn; 1 B

have suggested that S. capitata is a weakly perennial species, that the productivity of mother plants decreases with time and the persistence of the legume depends on new generations of seedlings.

Several experiments carried out in the Program (Annual Reports 1981 and 1982) have consistently shown lack of vigor in seedlings of S. capitata and this poor growth is accentuated when the legume is associated with perennial and aggressive grasses such as A. gayanus. In experiments in which A. gayanus was not defoliated and plastic cylinders were introduced to the soil to eliminate nutrient competition between roots of both species (A. gayanus and S. capitata), a maintenance fertilizer application (mainly K) stimulated growth of the legume seedlings.

Considering the above mentioned results, the present experiment was modified submitting the grass to a defoliation process and applying maintenance fertilization (30 kg K, 20 kg Mg, and 20 kg S/ha), at the beginning of the rainy season. Fifteen days after the fertilizer was applied, the seedlings of S. capitata showed excellent recovery of vigor and Figure 1 shows this response, in terms of dry matter production at the first cut. Subsequent evaluations have also shown better growth and dry matter production of the legume plants associated with A. gayanus, as compared with that obtained without maintenance fertilization (Table 2).

These results and several observations made in pastures under grazing with this mixture (A. gayanus and S. capitata), have suggested new experiments for 1984, mainly based on the interactions between defoliation of grass and maintenance fertilizer (specific nutrients and amount applied).

The main hypothesis is that a certain degree of grass defoliation (plant height and time of defoliation) would result in a lower nutrient competition with the seedlings of S. capitata which can take advantage of the fertilizer applied for their recovery.

Importance of Potassium and Cation Exchange Capacity of Roots

In spite of the complexities of mutual competition for several external factors in grass-legume pasture mixtures, it is known that nutrient competition is one of the key factors in the stability and persistence of such mixtures. Among the nutrients, potassium is considered to be important, in the sense that grasses are more efficient than legumes in removing K from the soil and that the efficiency of the grasses decreases as the K fertilization increases. The differential efficiency for potassium between grasses and legumes has been well correlated with the cation exchange capacity of their roots (CEC_r).

In general, the CEC_r of legumes is higher than that of grasses, and this determines greater divalent cation absorption (Ca, Mg) by legumes. On the other hand, grasses absorb greater amounts of monovalent cations (K, Na) than the legumes (Figure 2). A differential CEC_r and cation absorption rates between the components in pasture associations would therefore influence their stability and dominance.

This differential cation uptake will increase at low levels of exchangeable soil K. Therefore, the more nearly equal the CEC of the grass and legume roots growing in association, the more compatible the mixture would be in absorption of nutrient cations. Tables 3 and 4 present relationships between CEC_r and K absorption rates by different grass-legume mixtures on an Oxisol of Carimagua, Colombia. Table 3 shows that all the grasses have lower CEC_r than the two legumes (S. capitata and Zornia sp.) when the K fertilizer supplied is low (20 kg K/ha), results which indicate a favorable differential K uptake for the grasses. When the K supplied was increased to 80 kg K/ha, a better compatibility among certain species of grasses and legumes was observed. This is the case for A. gayanus and S. capitata which present similar CEC_r values and, therefore, a substantial increase in K uptake by the legume. This situation is not the same for the other grasses and, thus, indicates less compatibility in the mixture for K uptake. Table 4 also shows similar trends with the same grasses associated with other legumes. It can be seen that in the case of P. phaseoloides associations, the grasses and legume were more compatible when the K supplied to the mixture was increased. However, Desmodium ovalifolium showed the opposite effect at high K supplies. This implies that it is more adapted to low K levels than P. phaseoloides.

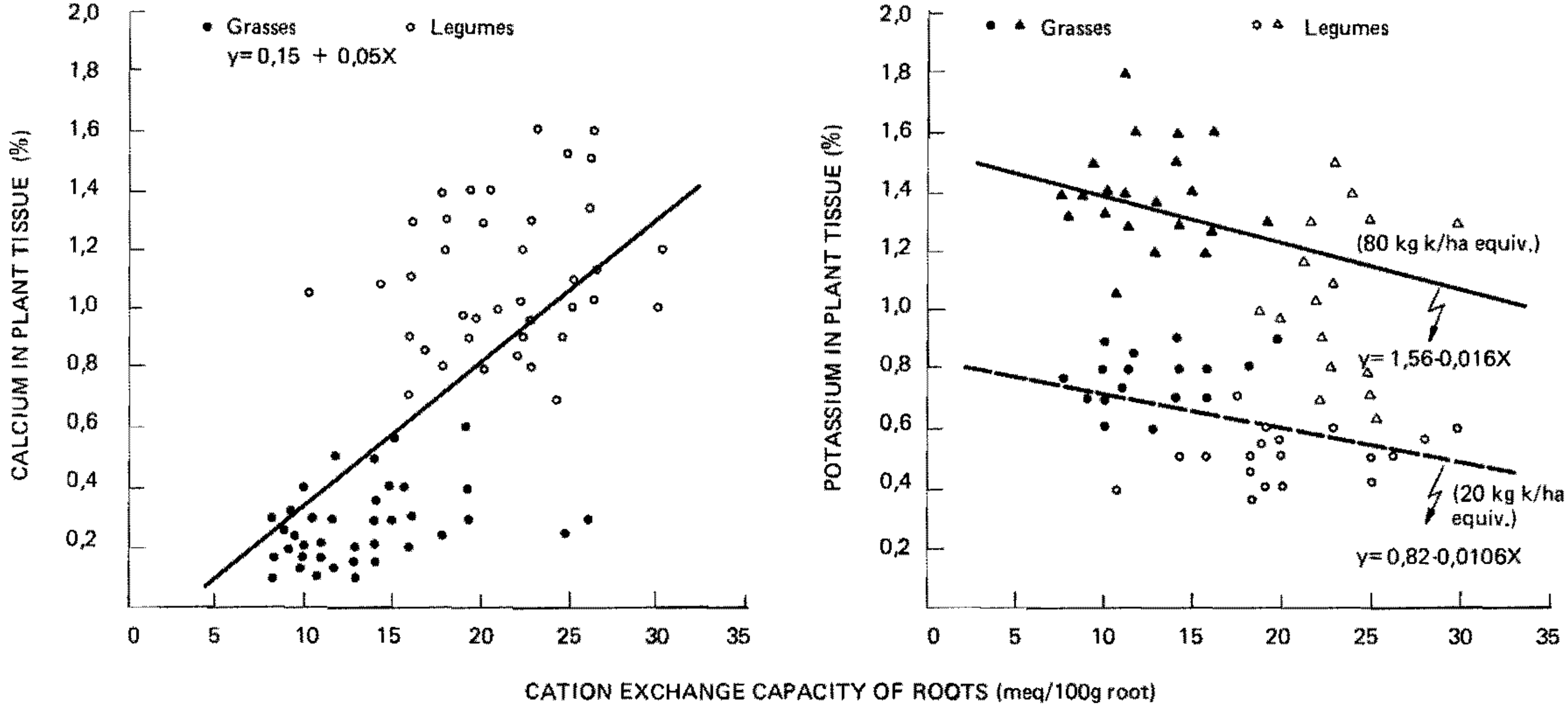


Figure 2. Calcium and potassium content in the plant tissue of several tropical forage grasses and legumes grown in association as a function as a function of the cation exchange capacity of their roots.

Table 2. Dry matter production[1] (kg/ha) of *A. gayanus* 621 (A.g.) and first generation of *S. capitata* 1019 (S.c.) grown in association as affected by P and maintenance[2] fertilization.

P Applied		Without Maintenance Fertilization			With Maintenance Fertilization		
Source	P Rate (kg P/ha)	A.g.	S.c.	Legume %	A.g	S.c.	Legume %
Control	0	4540	177	3.9	5279	407	7.8
Triple Superphosphate	20	7345	179	2.4	7943	732	9.2
	40	6230	108	1.7	7936	954	12.0
Calfos	20	6343	172	2.7	7575	620	8.2
	40	6471	120	1.8	8839	502	5.7
Phosphate Rock (Huila)	20	6121	157	2.6	7934	544	6.9
	40	6915	133	1.9	8390	589	7.0

1/ Dry matter production of *A. gayanus*, sum of 6 cuts and *S. capitata*, sum of 3 cuts.

2/ Maintenance fertilization (kg/ha): 30 K, 20 Mg, 20 S (March 22/83).

Table 3. The effect of 2 potassium fertilizer rates on the Cation Exchange Capacity of Roots (CEC_r) and potassium uptake by 4 grasses and 2 legumes grown in association in an Oxisol of Carimagüa, Colombia.

K Applied		Variable	Grass-Legume Association[1]			
(mg/pot)	(kg/ha eq.)		A.g.x S.c.	B.dyc.x S.c.	B.dec.x S.c.	P.max.x S.c.
25	20	CECr (meq/100 g root)	14-19	10-21	10-25	9-23
		K Uptake (mg/pot)	21- 7	38- 2	33- 5	29- 5
100	80	CECr (meq/100 g root)	25-26	12-18	12-25	15-26
		K Uptake (mg/pot)	56-28	79- 6	79- 5	64- 8
			A.g.x Z.sp.	B.dyc.x Z.sp.	B.dec.x Z.sp.	P.max.x Z.sp.
25	20	CECr (meq/100 g root)	16-19	11-19	10-18	8-20
		K Uptake (mg/pot)	21- 7	43- 2	32- 3	28- 2
100	80	CECr (meq/100 g root)	21-24	13-22	9-22	14-22
		K Uptake (mg/pot)	42-33	73- 1	91- 2	73- 4

1/ A.g.= *Andropogon gayanus* 621' B.dyc.= *Brachiaria dictyoneura* 6133; *B. dec.* = *Brachiaria decumbens* 606; P.max.= *Panicum maximum* 604' S.c.= *Stylosanthes capitata* 1315; Z.sp.= *Zornia* sp. 7847.

Table 4. The effect of 2 potassium fertilizer rates on the cation exchange capacity of roots (CEC_r) and potassium uptake by 4 grasses and 3 legumes grown in association in an Oxisol of Carimagua, Colombia.

K Applied		Variable	Grass-Legume Association[1]			
(mg/pot)	(kg/ha eq)		A.g.x C.m.	B.dyc.x C.m.	B.dec.x C.m.	P.max.x C.m.
25	20	CECr (meq/100 g root)	16-19	14-16	18-20	12-30
		K Uptake (mg/pot)	23- 6	34- 3	28- 7	28- 3
100	80	CECr (meq/100 g root)	14-16	10-23	8-25	12-26
		K Uptake (mg/pot)	47-23	87- 3	73- 7	81- 4
			A.g.x P.p.	B.dyc.x P.p.	B.dec.x P.p.	P.max.x P.p.
25	20	CECr (meq/100 g root)	10-12	13-24	12-25	14-26
		K Uptake (mg/pot)	18-15	29- 7	28- 7	27- 4
100	80	CECr (meq/100 g root)	19-23	10-16	13-20	9-23
		K Uptake (mg/pot)	22-42	61-24	72-10	66-23
			A.g.x D.o.	B.dyc.x D.o.	B.dec.x D.o.	P.max.x D.o.
25	20	CECr (meq/100 g root)	10-26	19-20	16-18	19-28
		K Uptake (mg/pot)	28- 3	39-21	37-22	35- 3
100	80	CECr (meq/100 g root)	14-30	8-16	11-20	16-22
		K Uptake (mg/pot)	30-10	99- 1	89- 2	90- 2

1/ A.g. = Andropogon gayanus 621; B.dyc.= Brachiaria dictyoneura 6133; B.dec.= Brachiaria decumbens 606; P.max.= Panicum maximum 604; C.m.= Centrosema macrocarpum 5065; P.p.=Pueraria phaseoloides 9900; D.o.= Desmodium ovalifolium 350.

This type of information has promise for further evaluation of new forage germplasm, since it would indicate compatibility between pairs of grasses and legumes during their initial characterization.

RECOVERY OF DEGRATED PASTURES

Brachiaria humidicola

Fertilizer requirements for pasture maintenance in Brachiaria humidicola have been evaluated since 1981 in close collaboration with the Section of Productivity and Pastures Management. This grass has shown a repid decline in terms of biomass production and forage quality. Initially a diagnostic fertilization based on N, P, S and Mg applications was carried out. These fertilizer treatments were applied to small plots, localized in a degraded Brachiaria humidicola pasture which was under grazing with 3 stocking rates (high, medium and low) (Tropical Pastures Program, Annual Report 1982). The results of this study are presented in Table 5, in terms of dry matter production and crude protein. N fertilization increased the grass forage production, without increasing the protein. The interactive effects of the other nutrients on pasture recovery were not significant. However, dry matter production increased when Mg was applied alone, which may be related to the low cation ratios in this acid soil.

In view of the fact that chisel tines are commonly used in the Eastern Plains of Colombia for pasture recovery (Brachiaria decumbens), the fertilized plots and a new area (control) were treated with chisel tines a year after the above study was initiated. Table 6 shows the results of the experiments which indicate that the use of the chisel tines alone caused a dry matter production similar to that obtained with 50 kg N/ha. The mechanical disturbance of the soil apparently increase the rate of mineralization of the organic matter favoring the release of nutrients such as N, P and S and, therefore, their utilization by the plant. These results also indicate that pasture recovery in similar soils may be possible using only chisel tines and, therefore, avoiding N fertilization. However, neither N applications nor the use of chisel tines improved forage quality in terms of higher protein contents (Table 7). Future objectives would be to introduce a legume compatible with this grass to compensate the protein deficit or to look for a substitute for this grass with better forage quality.

Utilization of Nitrogen by Brachiaria spp.

It is reported in the literature that many forage species present differential uptake and utilization of nitrogen forms. It has also been suggested that grass species may inhibit the nitrification process in the soil. This has been observed with Brachiaria humidicola (ref. Soil Microbiology Report). Based on these observations, a greenhouse experiment using a nutrient solution culture to grow plants of three Brachiaria species (B. decumbens 606, B. dictyoneura 6133 and B. humidicola 679) during 90 days was carried out. The treatments applied consisted of 4 N rates (0, 15, 30 and 60 ppm N) and 2 forms of nitrogen ($N\text{-}NO_3^-$ and $N\text{-}NH_4^+$). The evaluations were in terms of dry matter production, N content in the

Table 5. Nutritional status of <u>Brachiaria</u> humidicola 679 for maintenance fertilization.

Fertilizer Treatment				High ST*		Medium ST		Low ST		Mean	
N	K	S	Mg	DM**	CP**	DM	CP	DM	CP	DM	CP
0	0	0	0	876	5.7	771	5.2	937	4.9	861	5.2
25	0	0	0	1055	5.3	1078	5.2	1182	5.7	1105	5.4
50	0	0	0	1416	5.9	1287	5.6	1424	5.4	1365	5.6
25	0	10	0	910	5.3	1075	5.6	1100	5.2	1028	5.4
50	0	10	0	1204	5.6	1143	5.6	1243	4.9	1200	5.4
0	30	0	0	921	5.7	910	5.4	1021	4.8	951	5.3
25	30	0	0	1102	5.9	1128	5.2	1393	5.1	1207	5.4
0	30	10	0	847	5.2	802	5.4	883	4.4	844	5.0
25	30	10	0	1192	4.9	1120	5.4	1141	5.2	1151	5.2
25	30	10	10	1069	5.0	1083	5.6	1338	5.6	1163	5.4
0	0	10	0	852	5.4	895	5.6	907	4.6	885	5.2
0	0	0	10	1243	5.4	1050	5.4	1254	5.2	1182	5.3

* ST = Stocking Rate

** DM = Dry matter (kg/ha); CP = Crude Protein (%).

Table 6. The effect of residual fertilizer treatment and chisel tine cultivation in the forage dry matter production (kg/ha) of _Brachiaria humidicola_ 679. Carimagua, Colombia.

Residual Fertilizer Treatment[1]				Mechanical Treatment[2]	Rainy Season 1983		
N	K	S	Mg		First cut Jun.8/83	Second cut Aug.8/83	Sum of 2 cuts
---------- kg/ha ----------					-------Dry Matter kg/ha -------		
0	0	0	0	Chisel tine[3]	406	1317	1723 bc[5]
25	0	0	0	"	513	1189	1699 bc
50	0	0	0	"	521	1312	1820 ab
25	0	10	0	"	471	1116	1587 cd
50	0	10	0	"	58	1438	1997 a
0	30	0	0	"	378	928	1306 e
25	30	0	0	"	421	1213	1634 cd
0	30	10	0	"	421	1253	1674 bcd
25	30	10	0	"	445	1294	1739 bc
25	30	10	10	"	515	1435	1951 a
0	0	10	0	"	490	1002	1493 de
0	0	0	10	"	448	1201	1649 bc
0	0	0	0	Chisel tine[4]	602	1331	1933 a

1/ Applied in April 1982.
2/ Applied in April 1983.
3/ Control under previous cuttings.
4/ Treatment without cutting regime.
5/ Values followed by the same letter are not significantly different (P 5%).

Table 7. The effect of residual fertilizer treatments and chisel tine cultivation on the nutrient concentration and crude protein of Brachiaria humidicola 679. Carimagua, Colombia.

Fertilizer Treatment					Nutrient Content and Crude Protein									
N	K	S	Mg		N_1	N_2	PC_1	PC_2	K_1	K_2	S_1	S_2	Mg_1	Mg_2
------kg/ha----------					---------------- % ----------------									
0	0	0	0		0.85	0.78	5.3	4.8	1.04	0.98	0.04	0.19	0.19	0.12
25	0	0	0		0.87	0.74	5.4	4.6	0.80	0.84	0.04	0.19	0.19	0.07
50	0	0	0		0.91	0.76	5.6	4.7	0.88	0.96	0.05	0.20	0.22	0.13
25	0	10	0		0.86	0.77	5.3	4.8	0.88	0.90	0.04	0.18	0.19	0.08
50	0	10	0		0.86	0.78	5.3	4.8	0.97	0.86	0.04	0.19	0.21	0.12
0	30	0	0		0.85	0.76	5.3	4.7	1.08	1.11	0.04	0.16	0.17	0.06
25	30	0	0		0.87	0.77	5.4	4.8	0.98	1.02	0.04	0.18	0.18	0.07
0	30	10	0		0.80	0.78	5.0	4.8	0.95	1.02	0.04	0.18	0.16	0.09
25	30	10	0		0.83	0.74	5.1	4.6	1.01	1.00	0.04	0.18	0.17	0.08
25	30	10	10		0.87	0.80	5.4	5.0	0.89	0.87	0.05	0.21	0.23	0.13
0	0	10	0		0.83	0.77	5.1	4.8	1.05	1.01	0.05	0.18	0.18	0.09
0	0	0	10		0.86	0.81	5.3	5.0	1.01	1.06	0.05	0.19	0.19	0.12
0	0	0	0	Chisel tines	--	0.74	--	4.6	--	1.10	--	0.17	--	0.11

1/ July/82, without soil remotion.
2/ August/83, with soil remotion (chisel tines).

plant tissue, and final concentration of nitrate and ammonium in the nutrient solutions.

Dry matter production in each treatment expressed as percentage of maximum yield is shown in Figure 3. All three grasses showed better performance when the N form supplied was nitrate ($N-NO_3^-$). However, when the N supply was as ammonium ($N-NH_4^+$), the growth of B. decumbens and B. dictyoneura was inhibited at higher levels, whereas showed increased production at higher NH_4 levels. Figure 4 shows the N content in the plant tissue of the 3 Brachiaria species grown under both N treatments. B. humidicola shows similar N uptake and utilization in both N treatments, when compared with the other two Brachiaria species. These results indicate that B. humidicola absorbs and utilizes both N forms ($N-NO_3^-$ and $N-NH_4^+$).

The final contents of N as nitrate, ammonium and total in the nutrient solutions, are presented in Table 8. A comparison between them shows that when the N supply was as ammonium ($N-NH_4^+$) the ranking in N uptake and utilization by the 3 grasses was: B. humidicola > B. dictyoneura > B. decumbens. The oxidation of $N-NH_4^+$ was very low in these treatments which may indicate that the N availability as ammonium was total. When the N supply was as nitrate ($N-NO_3^-$), the N uptake and utilization by the 3 Brachiaria species was quite similar.

USE OF NATURAL ROCKS AS FERTILIZER: POTASSIUM FELDSPARS

Rocks-potassium feldspars, magnesium serpentine or carbonates, and gypsum or elemental sulfur could, in the near future, be more economical sources of K, Mg, and S, respectively, for pasture fertilization in the acid soils of low fertility in Latin America. These fertilizers could be compatible with the improved germplasm and low input, low cost technology that is being developed by the Tropical Pastures Program in marginal areas.

As an initial step in the study of such natural sources of fertilization, the case of potassium will be considered. To establish and maintain improved pastures in acid soils, potassium fertilization is necessary, which implies, in the present conditions, the use of traditional sources of potassium fertilizers (KCl, K_2SO_4, KNO_3) that are soluble in water, susceptible to quick leaching, expensive, and which have to be imported to Tropical America (Table 9). The use of native sources of potassium is, therefore, necessary and it appears that of these native sources the K-feldspars and the micas are the main ones which contain slow release potassium. Most countries in Tropical America have numerous areas with an abundance of the mentioned minerals, mainly K-feldspars and the existence of these in Latin America provides a large incentive for fertilizer production.

In the evaluation process of K-feldspars research priorities are being considered and partial results are mentioned as follows.

Composition

K-feldspars are made up of SiO_4 and AlO_4 tetrahedra linked in

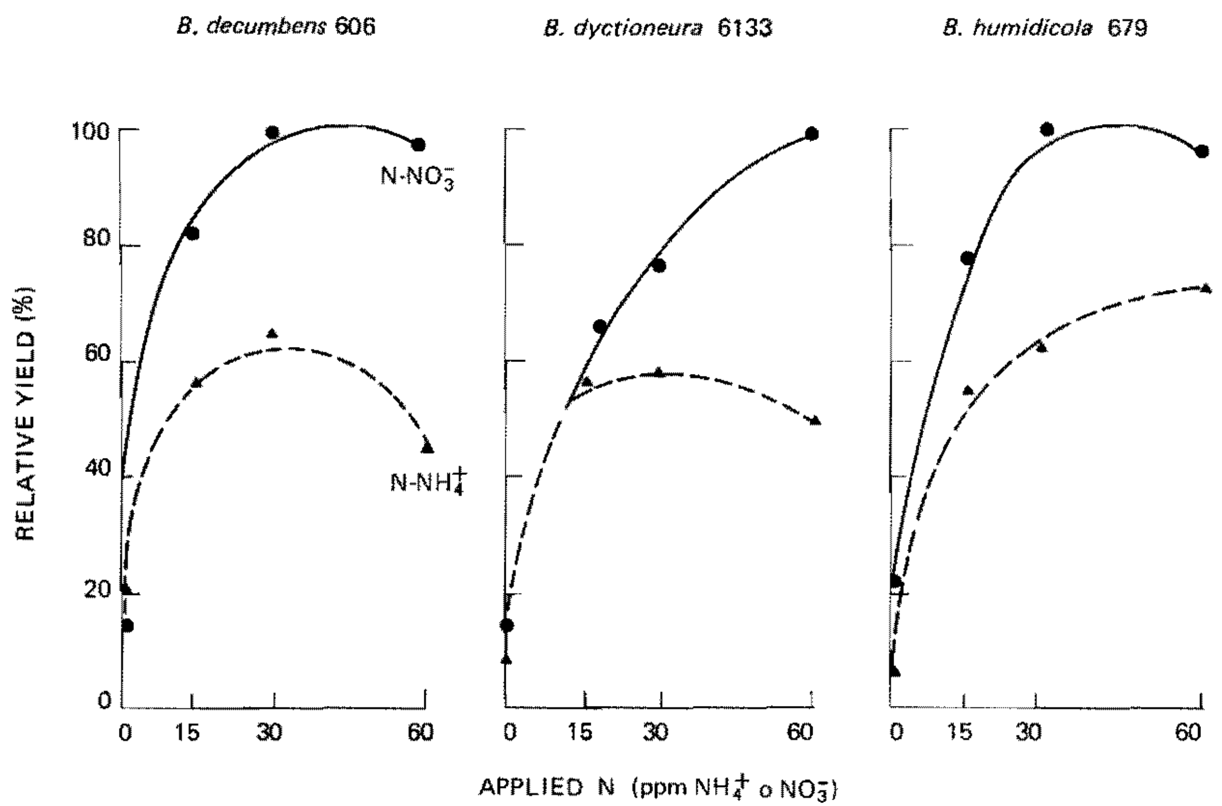


Figure 3. Relative yield of three *Brachiaria* species as affected by the rate of nitrogen applied in the form of ammonium and nitrate in nutrient solution.

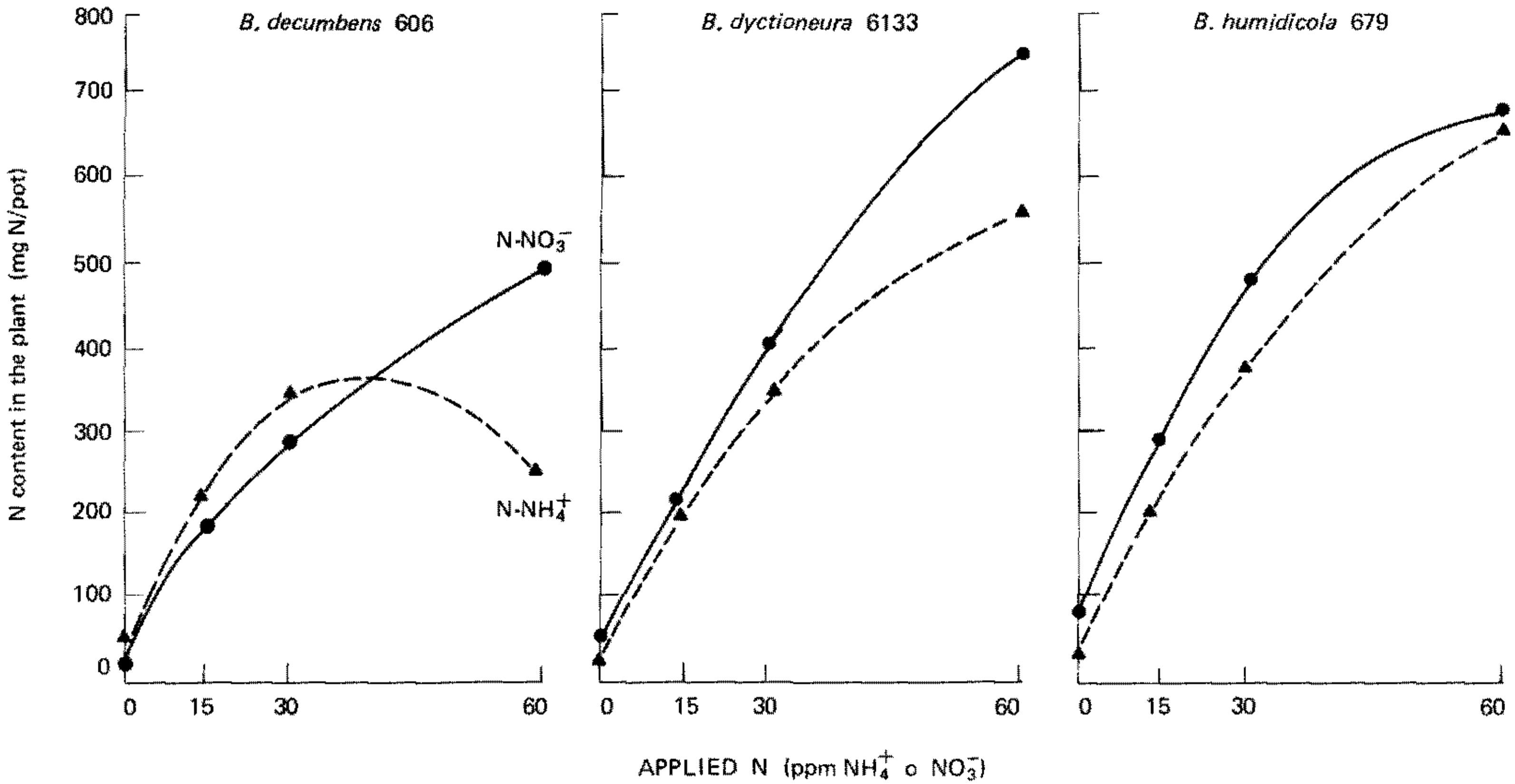


Figure 4. **Nitrogen content in the tissue of three *Brachiaria* species as affected by the doses of nitrogen applied as ammonium and nitrate in nutrient solution.**

Table 8. Final content of nitrate, ammonium, and total nitrogen in a nutrient solution as a function of the N rate applied as nitrate and ammonium to three *Brachiaria* spp.

Species	Form of N applied	N Rates applied	Final Content of N in the Nutrient Solution		
			$N\text{-}NH_4^+$	$N\text{-}NO_3^-$	Total N
		ppm	ppm		
B. decumbens 606	$N\text{-}NH_4^+$	0	0.00	0.00	0.00
		15	1.85	0.04	2.25
		30	4.50	0.16	4.80
		60	26.10	0.44	27.00
	$N\text{-}NO_3^-$	0	0.00	0.00	0.00
		15	0.00	0.39	0.41
		30	0.08	1.16	1.30
		60	0.04	2.90	3.00
B. dictyoneura 6133	$N\text{-}NH_4^+$	0	0.00	0.00	0.00
		15	1.20	0.34	1.60
		30	2.10	0.58	2.80
		60	11.00	0.44	12.10
	$N\text{-}NO_3^-$	0	0.00	0.00	0.00
		15	0.00	0.46	0.50
		30	0.00	0.76	0.83
		60	0.08	1.94	2.10
B. humidicola 679	$N\text{-}NH_4^+$	0	0.00	0.00	0.00
		15	2.30	0.33	2.80
		30	2.40	0.58	3.00
		60	2.90	0.68	3.70
	$N\text{-}NO_3^-$	0	0.00	0.00	0.00
		15	0.5	0.78	1.20
		30	0.30	0.52	1.10
		60	0.36	2.49	4.10

$N\text{-}NH_4^+$ absorption : *B. humidicola* *B. dictyoneura* *B. decumbens*.

Table 9. Production and use of fertilizers in several tropical american countries during 1980-1981 (thousands of metric tons = N-P-K).

Country	N		P		K	
	Production	Use	Production	Use	Production	Use
Brazil	384	906	708	867	0	1089
Colombia	42	152	20	33	0	63
Ecuador	2	41	3	6	0	15
Perú	74	82	1	7	0	9
Venezuela	145	113	10	34	0	42

Source: FAO, Fertilizer Yearbook, 1982.

three dimensions by sharing all their vertices with adjacent tetrahedra. The tetrahedra accomodate the K ions inside their framework. The structure of the feldspars is more difficult to weather than that of the micas, but their abundance is much greater and their potassium contents are generally higher. Literature reports that when weathering K-feldspars in the lab, the Al of the structure goes into solution, but it precipitates before concentrating and, therefore, is not toxic to the plants.

Potassium feldspars are, therefore, not very susceptible to being leached and release K slowly; the mechanisms of dissolution are independent of the weathering environment, and different types of feldspars can weather in different ways.

The dissolution rate of K-feldspars is controlled by pH, being higher in acid environments (pHs < 5.5) with lower concentrations of K^+ in the soil (exchangeable K < 0.1 meq/100 g of soil). An example of the typical mineral composition of a K-feldspar can be seen in Table 10.

Development of Methods

The determination of the total contents of cations (K, Ca and Mg) in the K-feldspars can be carried out by means of fusion of ground samples at 1000°C in the presence of Na_2CO_3 which acts as a fusing and solubilizer agent (Table 11). Once the composition of total cations is known, the procedure is to select extractants in order to study the availability and rates of release of K. In Figure 5 it can be seen than when the acidity of the extractant is increased, the potassium extraction increases and, in addition, if fluoride is present in the extractant (Bray II), the K extracted increases even more. This last increase is possibly due to the fluoride (F^-) retention by the Al hydroxide in the rocks; at the same time the potassium (K^+) is able to go into solution.

The next step is to determine the quality of several K-feldspars

Table 10. Typical mineral composition of K feldspar rocks from Huila, Colombia.

Mineral Component	Content %
SiO_2	72.63
Al_2O_3	15.69
Fe_2O_3	0.21
TiO_2	0.14
P_2O_5	0.26
CaO	0.78
MgO	0.42
MnO	0.01
Na_2O	1.78
K_2O	7.61
SO_3	0.47
K Feldspars ($K_2O.Al_2O_3.6SiO_2$)	45.01
Na Feldspars (Na_2O $Al_2O_3.6SiO_2$)	15.05
Other minerals	39.94

Table 11. K-feldspars fusion (1000°C in the presence of Na_2CO_3 as a fusing and solubilizer agent) to determine the total content of K, Ca and Mg.

Potassium Feldspars	K	Ca	Mg
	---------- mg/g Rock	----------	----------
Hobo	64	2.7	0
Algeciras 1	41	13.2	0.3
Algeciras 2	87	14.2	0.1
Ospina	56	4.7	0
Rio Blanco	92	12.6	0
Rivera	59	13.1	0

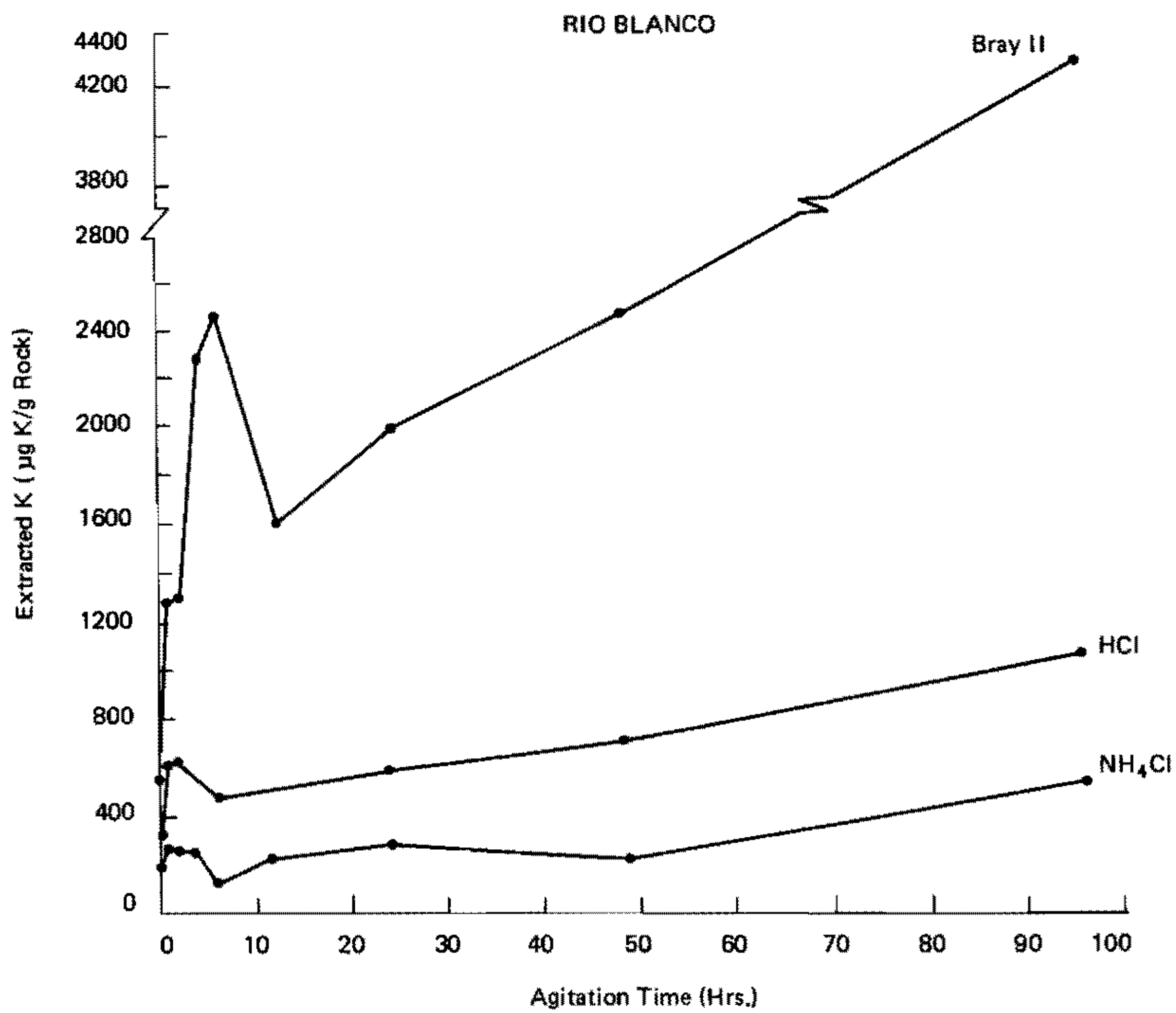


Figure 5. The effect of agitation time on the quantity of K extracted from feldspars with three different extractants.

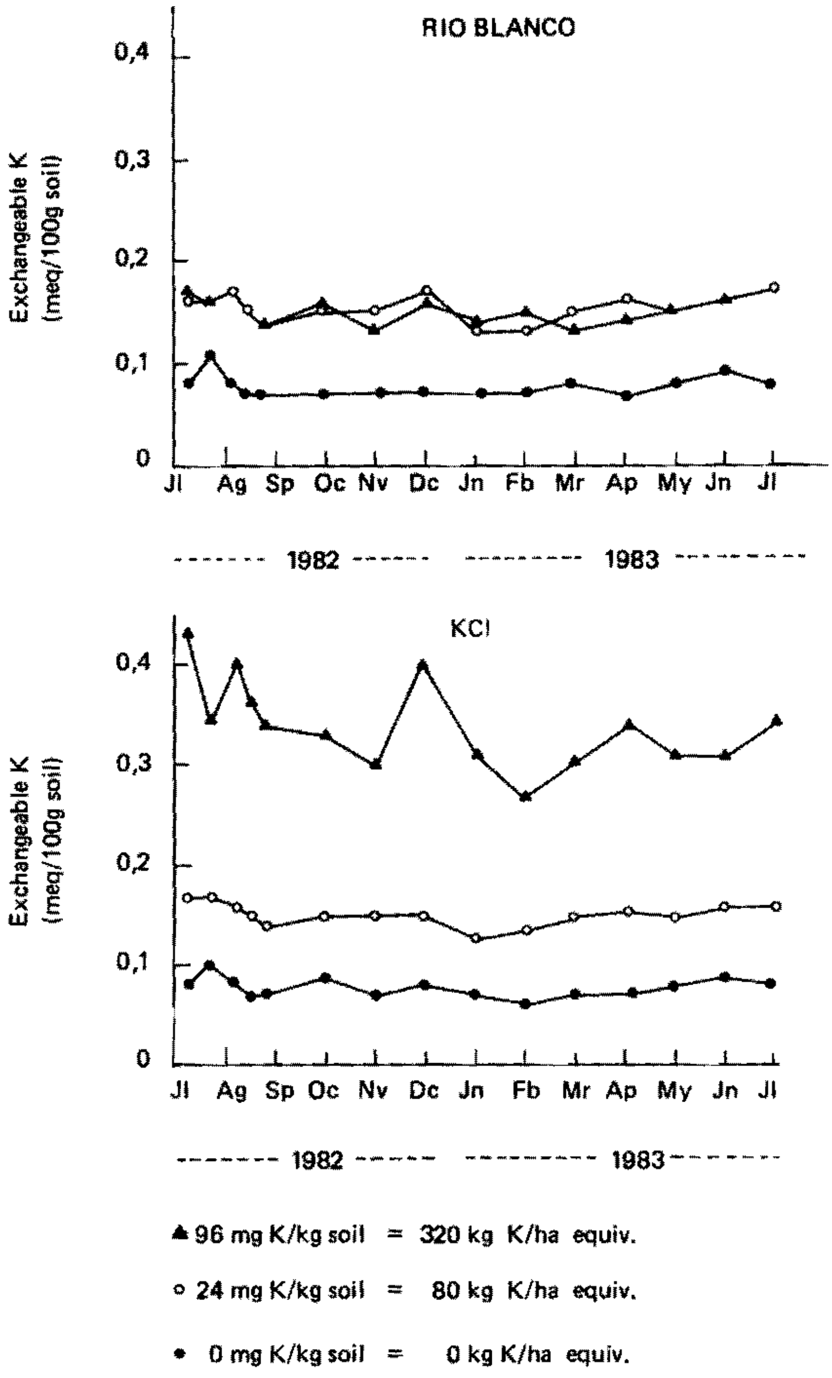


Figure 7. Exchangeable potassium dynamics from two sources and three rates of application of K as a function of time.

Table 12. Relative agronomic effectivity of several K feldspar rocks as determined by the yield of *Brachiaria decumbens* grown in a Carimagua Oxisol, under greenhouse conditions.

	Rates (kg K/ha eq.)			
	10	20	40	80
	(7.6)	(7.8)	(7.7)	(8.6)
KCl*	100a	100a	100a	100a
Algeciras 1	64c	91a	91a	97a
Rio Blanco	95a	87b	95a	107a
Algeciras 2	90a	90a	96a	77b
Ospina	101a	85b	95a	87b
Hobo	86b	87b	80b	94a

Control: (4.0)

Means in the same column and with the same letters are not significantly different (P 0.05).

* The yields of KCl treatments are assumed to be 100% for each rate of K; the number in parenthesis shows yield in g/pot.

MICROBIOLOGY

During 1983, the activities of the Soil Microbiology concentrated on: a) Rhizobium inoculation trials, b) nitrification studies, and c) VA mycorrhizal inoculation trials.

RHIZOBIUM INOCULATION TRIALS

Stylosanthes

Figure 1 shows the results of a Rhizobium screening trial with Stylosanthes capitata 1019 carried out in undisturbed cores of three soils (for soil analyses see Table 1). In this experiment all treatments were inoculated with mycorrhizae. In the least sandy soil ('Microbiología') less nodules were formed than in the more sandy soils ('Alegría' and 'Guayabal'), and greater increases in N yield due to inoculation and N fertilization were observed. Strains 2304 and 2400 showed significant increases in N yield over the uninoculated control. Strains 1460, 71 and 1238, which have been recommended for inoculation of S. capitata on the basis of previous trials in sterile sand and nutrient solution, did not perform well in this soil type, although in the sandier soil type strain 1460 performed relatively well. Strain 2304, on the other hand, did not perform well in sandy soil.

The results imply that the plants have a relatively high N yield potential (i.e. N yield in the N fertilized control) in less sandy soil, but the native strains (i.e. in the uninoculated control) do not even support even half of this potential N yield. In the sandier soils, although the N yield potential was not so high, the native strains in the uninoculated control came nearer to reaching it. This may mean that native strains are effective in sandy soil but not in clayey soil.

Figure 2 shows the results of a field experiment which supports this hypothesis. The overall production of 'Capica' was much greater in clayey ('Reserva') soil than at the other sites. However, responses to N fertilization occurred in the clayey ('Reserva') and medium sandy ('Hato 3, Lote 3') soils but not in the very sandy soil ('Rincón').

The native strains (uninoculated control) in the very sandy soil yielded more N and came nearer to reaching the potential N yield than in the medium sandy soil. Strain 1460 did not improve N yield in any of the soils even when applied with molybdenum. This implies that although strain 1460 may be effective in sandy soil, the native strains were equally effective, at least at the sites and under the conditions used in this experiment. Growth and N yield of S. capitata are apparently limited by factors other than N or Rhizobium strain in the very sandy soil. Since 'Capica' is recommended for sandy soils, a

Table 1 Analyses of the soils at the sites mentioned in this report.

Site*	Depth	%	ppm	%	P		meq/100 g			
	cm	OM	N	Sand	Bray II	pH	Ca	Al	Mg	K
1. Microbiologia	0-10	4.09	1176	12	1.8	4.7	.19	2.6	.06	.07
	10-20	3.18	784	11	1.0	4.5	.09	2.4	.03	.04
2. Reserva	Similar to 1.									
3. Hato 3 (Yopare)	0-10	3.63	952	30	2.4	4.8	.29	2.2	.11	.07
	10-20	3.41	784	28	2.1	4.7	.17	2.2	.06	.04
4. Lote 3	Similar to 3.									
5. Rincon	0-10	1.82	448	61	1.3	4.7	.16	1.0	.05	.05
	10-20	1.13	280	57	1.1	4.5	.11	1.0	.03	.03
6. Guayabal	Similar to 5.									
7. Alegria (Hato 5)	0-10	1.13	336	66	2.7	4.8	.16	0.8	.06	.04
	10-20	1.13	280	64	2.5	4.5	.13	.08	.05	.03
8. Quilichao	0-20	7.30	2062	21	2.8	4.4	1.39	3.4	.54	.26

* 1 and 2 = "clayey"
3, 4 and 8 = "medium sandy"
5, 6 and 7 = "sandy" or "very sandy"

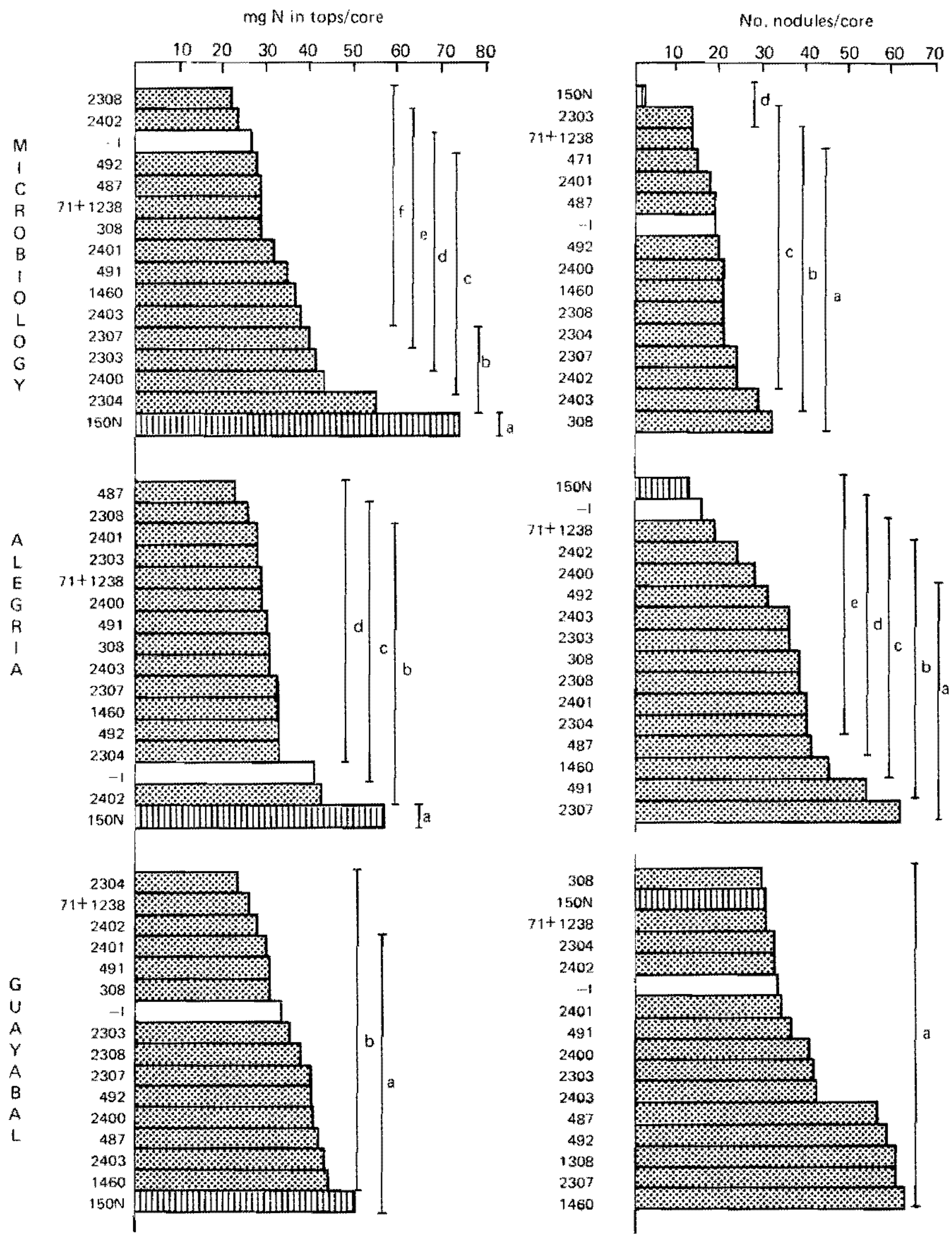
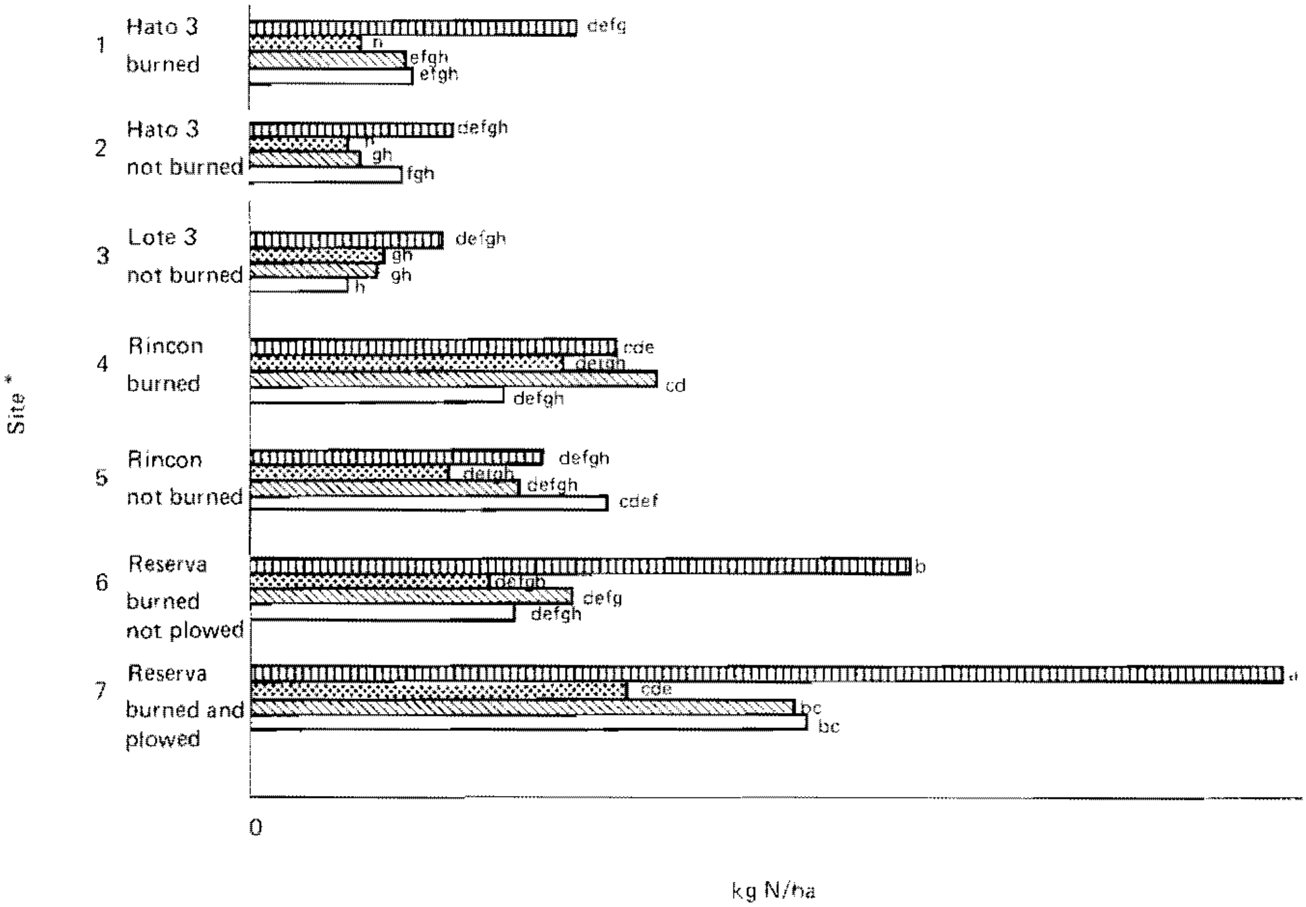


Figure 1. Effect of inoculation with *Rhizobium* strains ( ) and N fertilization ( ) on N in tops and nodulation of *S.capitata* 1019 in undisturbed cores of three soils.



* 1 Established in furrows in 1 year old *M. minutiflora* sward (29% sand).

2 Established in furrows in 1 year old *M. minutiflora* sward (29% sand).

3 Established in furrows in 1 year old *B. decumbens* pasture (29% sand).

4. Established in furrows in 1 year old *M. minutiflora* pasture (60% sand).

5. Established in furrows in 1 year old *M. minutiflora* pasture (60% sand).

6. Established in furrows in savanna (12% sand).

7. Established in plowed soil (12% sand).

Figure 2. Effect of uninoculated (▭), uninoculated and pelleted with Mo (▨), inoculated with CIAT 1460 and pelleted with Mo (▩) and 112.5 kg N/ha (▥) treatments on production (kg N/ha) of "Capica" under different establishment conditions in the field at Carimagua 14 weeks after establishment.

study of nutrient requirements of S. capitata in sandy soils, to determine whether increased fertilization or mycorrhizal inoculation could improve growth and N_2 fixation, should be carried out.

Although 'Capica' is recommended for sandy soils, it is likely to be planted also in clayey soils, especially in pure stands to be used as protein banks. The results show that in clayey soils the potential N yield of 'Capica' is high but nodulation and N_2 fixation by native strains and by strain 1460 are limited relative to this potential. This may be due to the inhibition of nodulation by mineral N, which is more abundant in clayey than sandy soils, and appears to be sufficient to inhibit nodulation but not for the plants to express their potential N yield. This may be an energy-saving strategy since at low soil P levels energy is scarce, and utilization of NO_3 is thought to require less energy than N_2 fixation. A project to select NO_3 tolerant Rhizobium strains for S. capitata in clayey soils, and to inoculate them in combination with mycorrhizae, which would increase P availability, is necessary.

Meanwhile, strains 2304 and 2400 which were effective on S. capitata 1019 in clayey soil, should be tested on 'Capica', and if effective, should be recommended for inoculation of 'Capica' in clayey soils. It is probably safe to recommend that S. capitata does not need inoculation in very sandy soils (i.e. 60% sand) although if its nutrient requirements in sandy soils are found to be other than the levels used in the experiments described here, further need-to-inoculate trials with the new nutrient levels would be necessary.

Figure 3 shows that in a strain screening trial in soil cores for S. guianensis 'tardío' 1283, no significant response to N fertilization or inoculation was observed. Nodulation was much more abundant than that of S. capitata. This lack of N-response implies that in this soil type the native strains are effective and this legume does not need inoculating.

Desmodium

Figure 4 shows a series of screening trials of Rhizobium strains for Desmodium spp. It can be seen that D. ovalifolium nodulated more with native strains in the uninoculated control than D. canum or D. heterophyllum. However, all four legumes showed increases in N yield due to inoculation of some strains, which shows that even though there may be abundant rhizobia in the soil which nodulate Desmodium, they are not as effective as some of the inoculated strains. It can be seen that some of the inoculated strains are more specific in their range of effectivity than others. For example, strain 2469 was effective on D. heterophyllum and both D. ovalifolium ecotypes, whereas strain 2487 was effective on D. canum but not on D. ovalifolium. There is also some difference in specificity of strains between the two D. ovalifolium ecotypes, e.g. strain 2284 was effective on D. ovalifolium 3784 but not on 3666, whereas several other strains were effective on both ecotypes. The most effective strains on D. heterophyllum originated from a field at Carimagua where D. heterophyllum had been growing for four years. Initially its development was slow and it was poorly nodulated, but after four years abundant nodulation developed, apparently due to adaptation of native strains. The previously recommended strain for D. heterophyllum, No.31, was not effective in this trial, although it caused an increase in the number of nodules.

The results show that some Desmodium spp. and ecotypes do need inoculation in Carimagua soil, and that strains with differing specificity ranges exist. Further work should be carried out to select strains for Desmodium spp. with as wide a specificity range as possible. However, since there are so many native strains able to nodulate Desmodium spp. ineffectively, it is also important to ensure that inoculated strains are able to compete for nodule sites with the native strains. Therefore, once strains with a wide specificity range have been selected in soil cores it will be important evaluate their ability to compete with native strains under field conditions.

Centrosema and Pueraria

In Figure 5 it can be seen that in soil core screening trials C. brasilianum 5234, C. macrocarpum 5065 and Centrosema hybrid 5931 showed significant increases in N yield due to inoculation with some strains when compared with the uninoculated control. Strains 1670 and 3334 appeared to be particularly effective for both C. brasilianum and C. macrocarpum and strain 3196 for all three legumes. Strain 1780 which is currently recommended for inoculation of C. macrocarpum was only the twelfth most effective strain in this trial. The number of nodules in the uninoculated control was less for C. macrocarpum and Centrosema hybrid 5931 than for C. brasilianum which implies that more of the native strains are able to nodulate C. brasilianum, i.e. it is a more promiscuous legume under these conditions, but the native strains are ineffective relative to the potential N yield. On the other hand, C. pubescens 5052, which is one of the parents of Centrosema hybrid 5931, apparently nodulated effectively with native strains. It seems that the hybrid did not inherit this ability but rather the more specific characteristic of its other parent C. macrocarpum.

Figure 6 shows the response of C. pubescens 438 to inoculation in Quilichao soil, Carimagua soil, and Leonard jars. In both soils strains 1670 and 1780 caused the greatest increase in N yield. It is interesting to note that strain 3250 which was the most effective strain in Leonard jars, was not so effective in the soil cores, possibly due to lack of tolerance of soil conditions. Strain 590, previously recommended for inoculation of C. pubescens, did not perform well in this trial. Strain 49, originally CB 1923 and recommended in Australia for inoculation of C. pubescens, can be seen to be effective in all three treatments. These results imply that Centrosema spp. except possibly C. pubescens 5052, need inoculating in Carimagua soil, and C. pubescens 438 needs inoculating in Quilichao soil.

Table 2 shows the result of a field trial where C. macrocarpum 5065 and P. phaseoloides 9900 were established in 1982 in pure stands in plowed soil at two sites at Carimagua, either uninoculated or

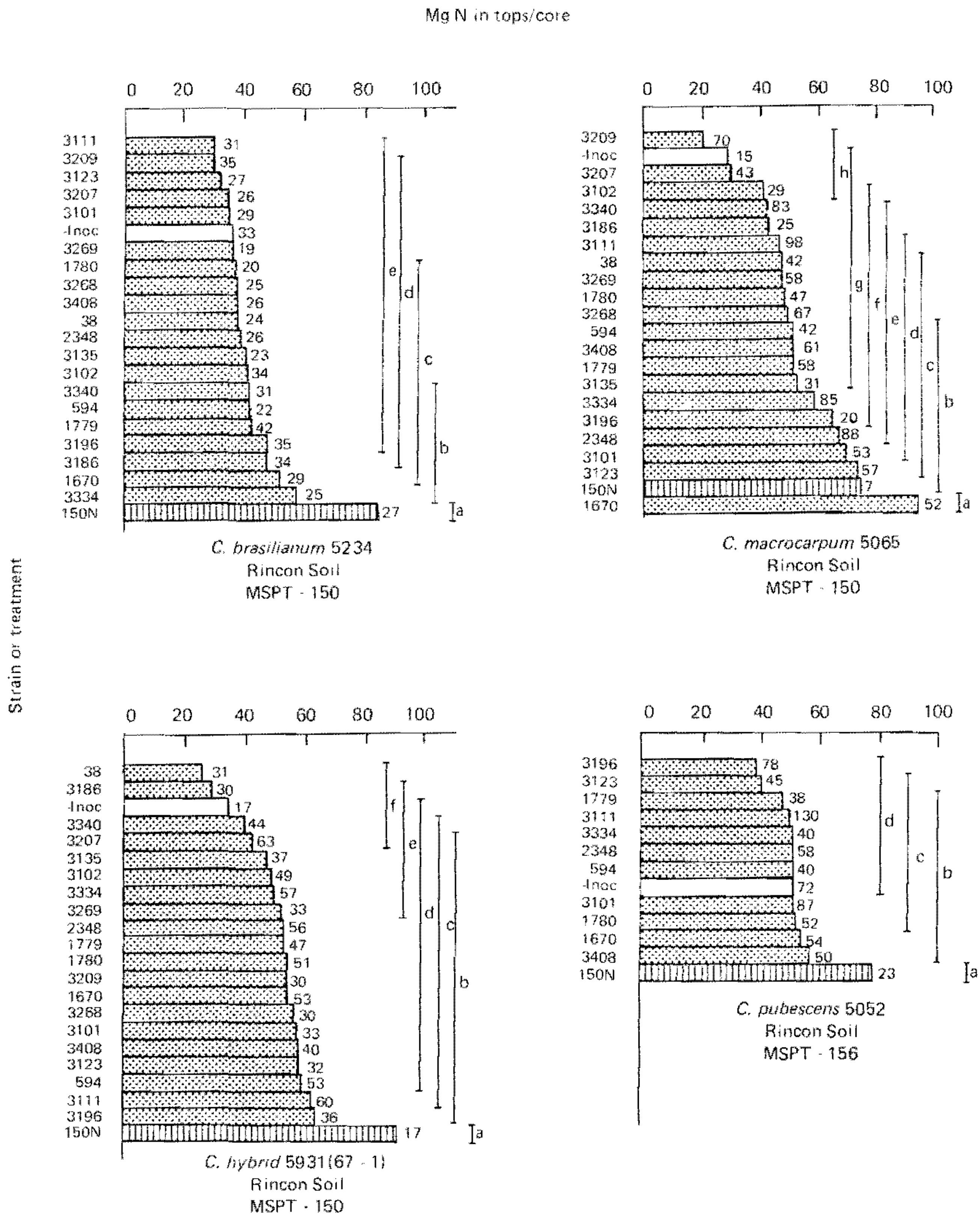


Figure 5. **MgN in tops and number of nodules/core of undisturbed Carimagua soil produced by *Centrosema* spp. uninoculated (▭), inoculated with different strains (▩) or fertilized with 150 kg N/ha (▥).**

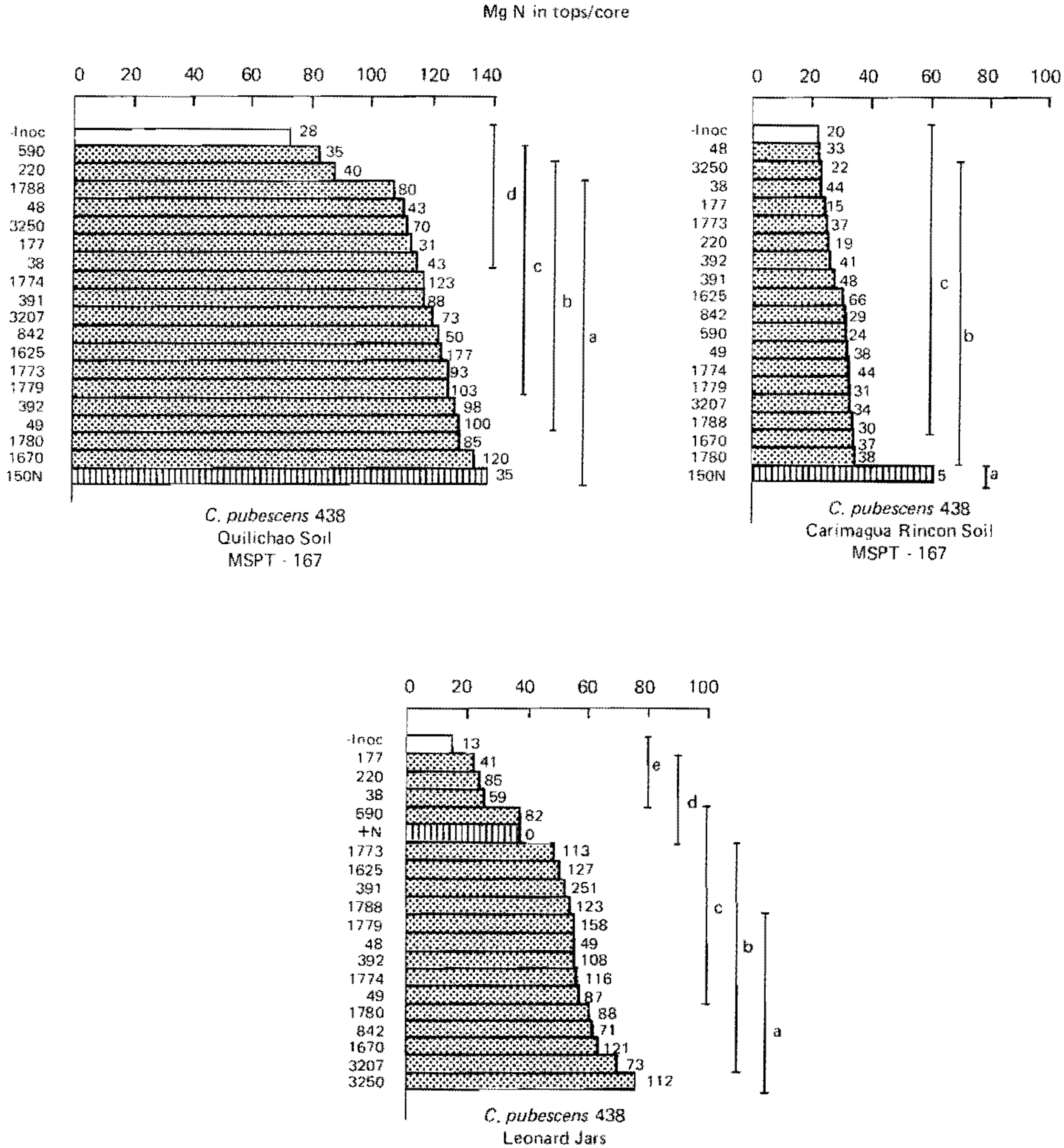


Figure 6. **MgN in tops and number of nodules/core of undisturbed Quilichao or Carimagua soil and Leonard jars produced by *Centrosema pubescens* 438: uninoculated (▭); inoculated with different strains (▩); fertilized with N (▥). (Work carried out by Miguel Tang, visiting Researcher from Matanza, Cuba.)**

Table 2. Effect of inoculation and site (soil type) on kg N produced/ha per cut from March till July of *Centrosema macrocarpum* 5065 and *Pueraria phaseoloides* 9900 in the second year after planting at Carimagua.

Treatment	*C. macrocarpum*	*P. phaseoloides*
Site 1 (Hato 3)	243.88 a	314.57 a
Site 2 (Rincon)	203.50 b	364.97 a
-Inoculant	179.86 b	305.87 b
+Inoculant	267.53 a	374.17 a
	% increase in kg N/ha due to inoculation	
C. macrocarpum	85.79 a	
P. phaseoloides	29.42 b	

(Different letters represent significant differences between vertical pairs of numbers only)

Table 3. Effect of time of land preparation on production (kg DM/ha) of two rice varieties and pasture grasses sown in April 1983 (Carimagua).

Variety or Species	Date of Land Preparation	
	December 1982	April 1983
	(kg DM/ha)	
Metica (rice panicle)	1129	1043
Bluebonnet 50 (rice panicle)	506	594
M. minutiflora	2495	1832
A. gayanus	1797	956
B. decumbens	3270	1576
B. humidicola	1940	1606
P. maximum	1206	431

inoculated with strains 1780 and 2434 respectively. In the second year after establishment (1983) a significant inoculation response was still observed in both legumes. The percentage increase in N yield due to inoculation was greater in C. macrocarpum than P. phaseoloides. The interaction of site with inoculation treatment was not significant for either legume, i.e. the inoculation effect was generalized over both sites. This is an important result, since it shows not only that strains selected in soil cores are able to cause inoculation responses in the field but also that they are able to do so at different sites, and to survive over the dry season and continue to cause increased N yield in the second year. This occurred even in the case of P. phaseoloides, normally considered to be a "promiscuous effective", legume. Thus P. phaseoloides is in fact "promiscuous ineffective" under Carimagua conditions, and responds to inoculation, contrary to the commonly expressed view that it does not.

RHIZOBIUM STRAIN CATALOGUE

The Rhizobium strain catalogue has been computerized including results of screening trials so that users can request data on strains for a given legume, whether they have been screened and the increase in N yield obtained due to inoculation under given conditions.

NITRIFICATION STUDIES

It was suggested from previous results that land preparation before the previous dry season would stimulate N mineralization due to drying and subsequent wetting, whereas preparing the land at the beginning of the wet season would not result in such high N mineralization rates. This would consequently affect the growth of grasses or rice planted at the beginning of the wet season. Table 3 shows that there was a marked effect of time of land preparation on growth of pasture grasses but not on production of rice. In fact there was a very clear visual effect of the two treatments on the early development of the rice, but the difference later disappeared. This may be because rice is more N-demanding than pasture grasses and therefore requires N fertilization even in the first year after plowing savanna, whereas pasture grasses do not. The results show that there is a marked advantage in preparing the land before the dry season for establishment of pasture grasses. Possibly the N fertilization requirements of rice would be reduced by preparing the land before the dry season.

Table 4 shows the results of an experiment designed to test the effect of plants on soil nitrification. Legumes had no effect on nitrification as compared to plowed soil kept free of plants. However, when grasses were grown without N fertilization, no NO_3^--N accumulated. This could be caused by a lower rate of production of NO_3 by microorganisms associated with the roots of grasses than legumes, but it could also be due to a higher rate of immobilization of the NO_3^- produced. When the grasses were fertilized with N (urea), NO_3^--N did accumulate, except in the case of B. humidicola. This implies that the lack of NO_3^--N accumulation observed without N fertilization was due to lack of NH_4 substrate, or immediate uptake of any NO_3^--N produced, except in

Table 4. Effect of plant and N fertilization (150 kg N/ha/year) on nitrification and C/N ratio in Carimagua soil (Hato 3) 15 months after establishment (ppm NO_3^--N produced after 3 weeks incubation, in 0-10 cm depth of soil removed from under the plants).

	No N Fertilization		With N Fertilization	
	ppm NO_3 -N	C/N	ppm NO_3 -N	C/N
Bare plowed soil	4.8	17.55	-	-
S. capitata	3.5	19.52	-	-
P. phaseoloides	5.7	17.93	-	-
C. macrocarpum	5.1	21.83	-	-
A. gayanus	0.1	18.43	11.2	18.10
M. minutiflora	-1.8	18.20	6.6	17.96
B. decumbens	-1.2	18.20	8.8	18.97
B. humidicola	-0.5	20.17	-0.3	18.24

the case of B. humidicola. It can be seen that the C/N ratio associated with non-N-fertilized B. humidicola was high in comparison with the other grasses, but when fertilized with N it was as low as that associated with the other grasses. The C/N ratio associated with C. macrocarpum was suprisingly high, but even so NO_3^--N accumulated. Further work is needed to determine whether the lack of NO_3-N accumulation associated with B. humidicola is due to high availability of C substrates for microbial growth and N uptake or to direct inhibition of nitrification by root exudates.

The results imply that soils under grasses without N fertilization become N deficient during the first year after sowing, whereas with legumes nitrification continues for more than a year. Therefore grasses may become dependent on legumes for N during the first year after establishment.

MYCORRHIZAL STUDIES

En 1982 mycorrhizal studies were centered on the evaluation of the vesicular-arbuscular mycorrhizal (VAM) association in tropical pasture plants under different field conditions. The effects of season, soil type, vegetation cover, grazing and fertilization on infection by native VAM were evaluated. In 1983 various experiments were conducted under greenhouse and field conditions in order to determine whether mycorrhizal inoculation of unsterilized soil would stimulate the growth and mineral uptake of tropical pasture plants.

Field infection of cultivars with indigenous mycorrhiza and *Rhizobium*

Twenty-two accessions of six genera of tropical pasture legumes and grasses were sown at Carimagua to study their capacity to form associations with the indigenous mycorrhizal fungi and rhizobia. One hundred and eight accessions of the genera *Stylosanthes*, *Centrosema*, *Zornia* and *Brachiaria* were also evaluated for their VAM associations with native endophytes.

Table 5 and Figures 7 to 12 show that pasture legumes had marked differences in their capacity to establish good VAM association and to nodulate with native strains not only among species but also among ecotypes within species. In order to evaluate the large numbers of different indigenous mycorrhizal fungal strains in these soils capable of infecting these plants, it is necessary to isolate and test them against various ecotypes of the pasture plants under sterile conditions and in different unsterilized soils. In this way native strains can be assessed for their effectivity and for their potential as inoculants.

Mycorrhizal inoculation response of eight pasture plants

This pot experiment was conducted in an unsterilized Oxisol from Carimagua. The test plants were: *Stylosanthes capitata* 1315; *Centrosema macrocarpum* 5065; *Pueraria phaseoloides* 9900; *Desmodium ovalifolium* 3780; *Zornia* sp. 7847; *Andropogon gayanus* 621; *Brachiaria dictyoneura* 6133 and *B. humidicola* 679, using mycorrhizal inoculation with a mixture of *Acaulospora* sp.; *Enthrophospora* sp. and *Glomus manihotis*.

Figures 13 to 21 clearly show that total dry matter production of all the test plants was increased significantly by mycorrhizal inoculation. Among the five legumes tested *S. capitata* and *Zornia* sp. showed the greatest increases in dry weight due to inoculation. Total uptake of P, N, C, Ca and Mg was also significantly increased by mycorrhizal inoculation.

In another small greenhouse experiment the efficiency of three mycorrhizal fungi used in the above experiment was tested with *D. ovalifolium*. Figure 22 shows the difference in efficiency of the endophytes used. This indicates the necessity of such experiments with other pasture plants to find out the best host-fungus combinations. It is quite possible that a VAM endophyte which is efficient with one host may not be so effective with another.

Table 5. Percentage of root length mycorrhizal and number of nodules/plant of 22 accessions of pasture plants grown for 15 week in the Reserva at Carimagua.

Species	Accesión No.	Percentage root length mycorrhizal	No. of nodules per plant Mean of 15 plants
LEGUMES			
Centrosema macrocarpum	5065	50 ± 5	1
C. brasilianum	5234	64 ± 9	4 ± 3
C. brasilianum	5247	64 ± 8	6 ± 6
C. brasilianum	5236	65 ± 10	4 ± 3
C. brasilianum	5190	43 ± 5	15 ± 8
C. pubescens	5189	43 ± 3	5 ± 3
Desmodium ovalifolium	350	56 ± 3	21 ± 18
D. ovalifolium	350A	56 ± 3	18 ± 18
D. ovalifolium	3784	49 ± 5	15 ± 11
Pueraria phaseoloides	9900	67 ± 10	6 ± 4
Stylosanthes capitata	1019	85 ± 4	6 ± 4
S. capitata	1315	71 ± 7	10 ± 6
S. capitata	1693	71 ± 7	6 ± 6
S. guianensis	1020	84 ± 3	6 ± 4
S. leiocarpa	1087	62 ± 6	8 ± 5
S. macrocephala	1643	64 ± 4	6 ± 4
S. macrocephala	2133	72 ± 7	8 ± 4
Zornia sp.	7847	73 ± 5	40 ± 4
Zornia sp.	9199	52 ± 5	26 ± 15
GRASSES			
Brachiaria dictyoneura	6133	67 ± 4	
B. humidicola	679	50 ± 5	
B. decumbens	606	51 ± 4	

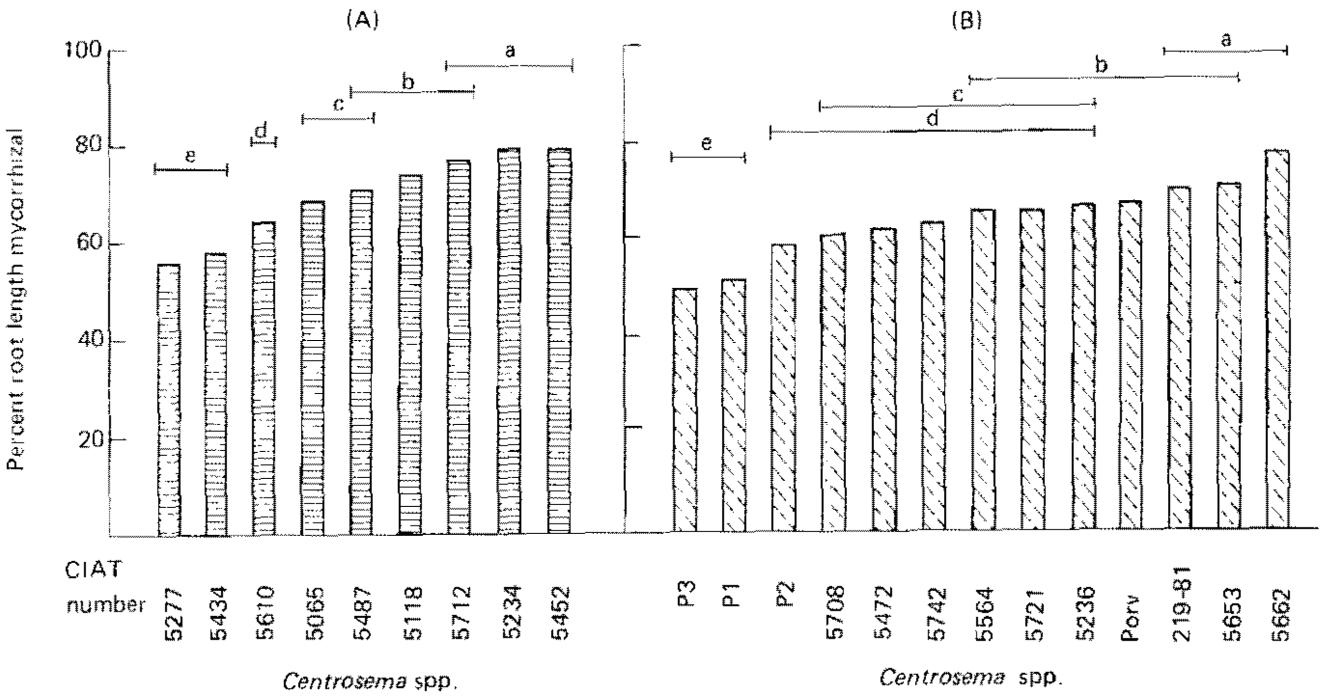


Figure 7. Percentage root length mycorrhizal of *Centrosema* spp., A) 3 months and B) 5 months after sowing. The plants were grown under field conditions in the Llanos Orientales, Carimagua. Different letters represent significant differences in percentage root length mycorrhizal.

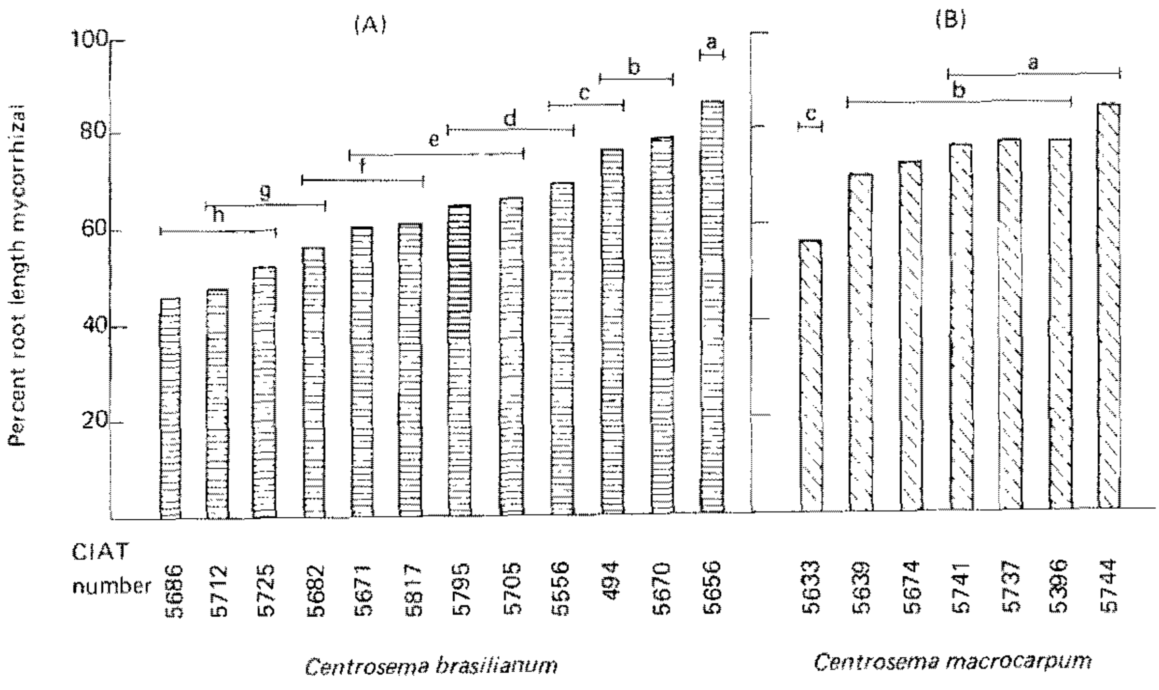


Figure 8. Same as Figure 7., but for A) *Centrosema brasilianum*, 3 months B) *Centrosema macrocarpum*, 5 months after sowing.

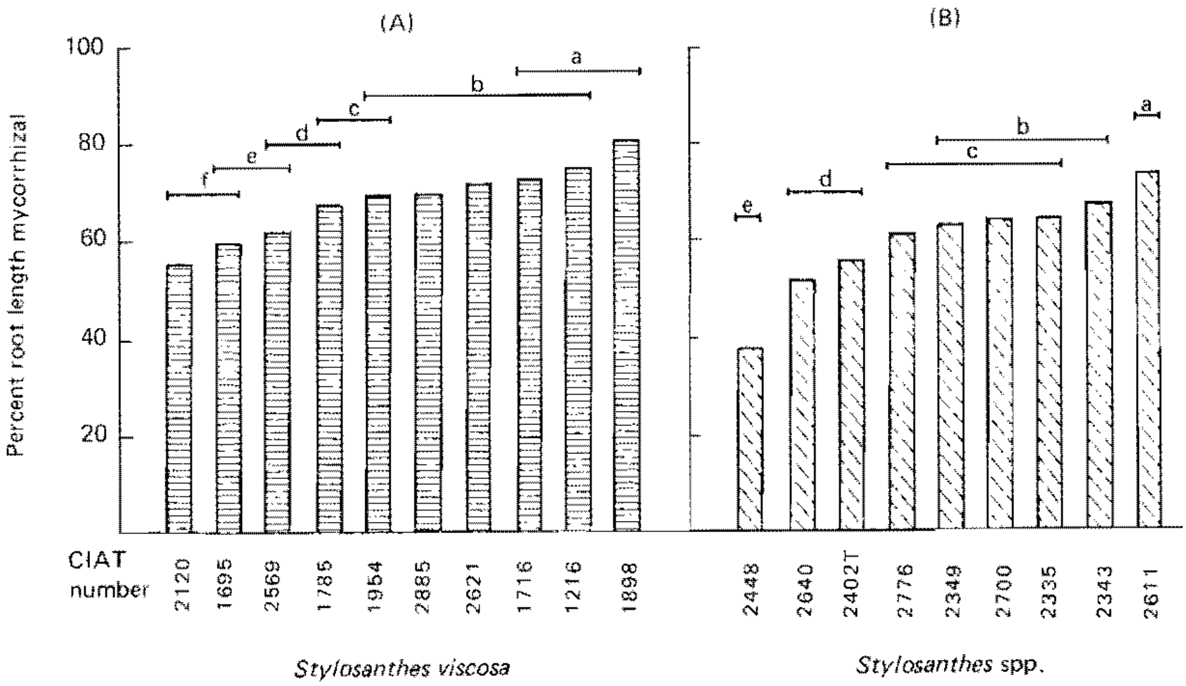


Figure 9. Same as Figure 7., but for A) *Stylosanthes viscosa*, 3 months B) *Stylosanthes* spp., 5 months after sowing.

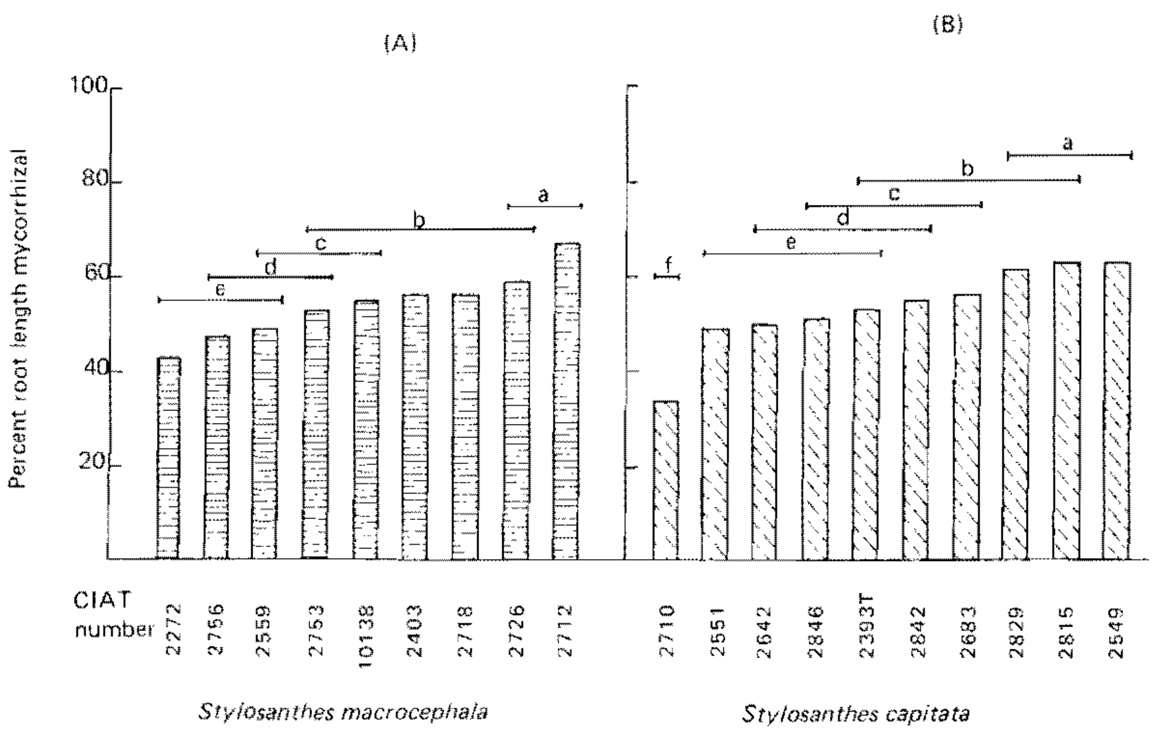
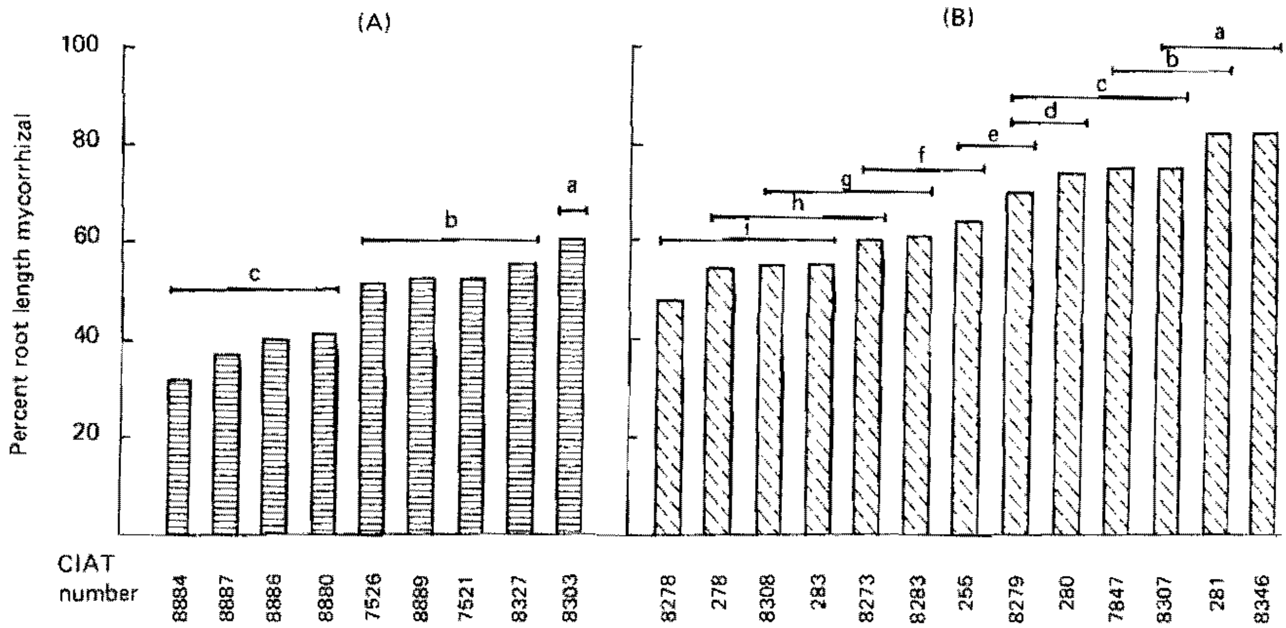
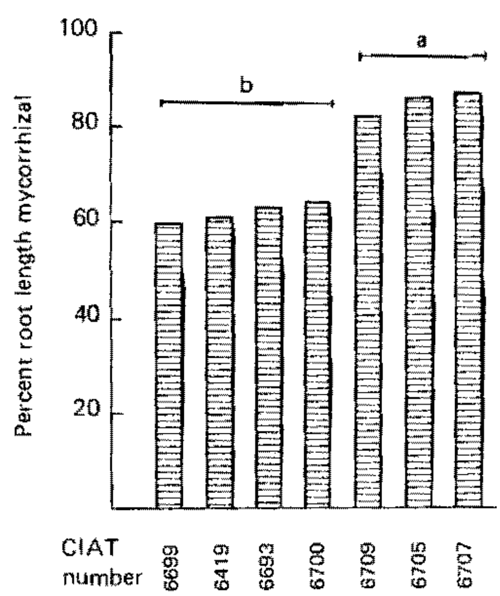


Figure 10. Same as Figure 7., but for A) *Stylosanthes macrocephala*, 3 months B) *Stylosanthes capitata*, 5 months after sowing.



Zornia spp.

Figure 11. Same as Figure 7., but for *Zornia* spp., A) 5 months and B) 2 months after sowing.



Brachiaria spp.

Figure 12. Same as Figure 7., but for *Brachiaria* spp., 3 months after sowing.

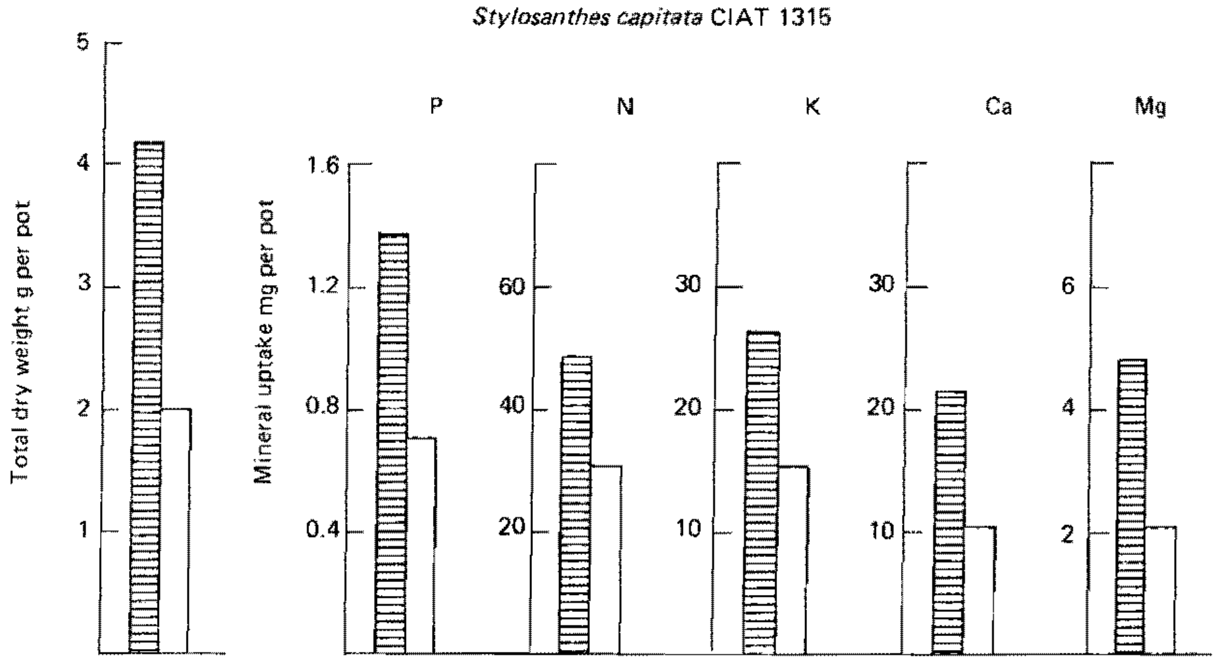


Figure 13. Total dry weight (g per pot) and mineral uptake (mg per pot) of *Stylosanthes capitata* CIAT 1315 inoculated with a mixture of three mycorrhizal fungi and grown in an unsterilized Oxisol. [hatched box], inoculated; [open box], non-inoculated. The values for inoculated and non-inoculated plants are significantly different at $P < 0.01$.

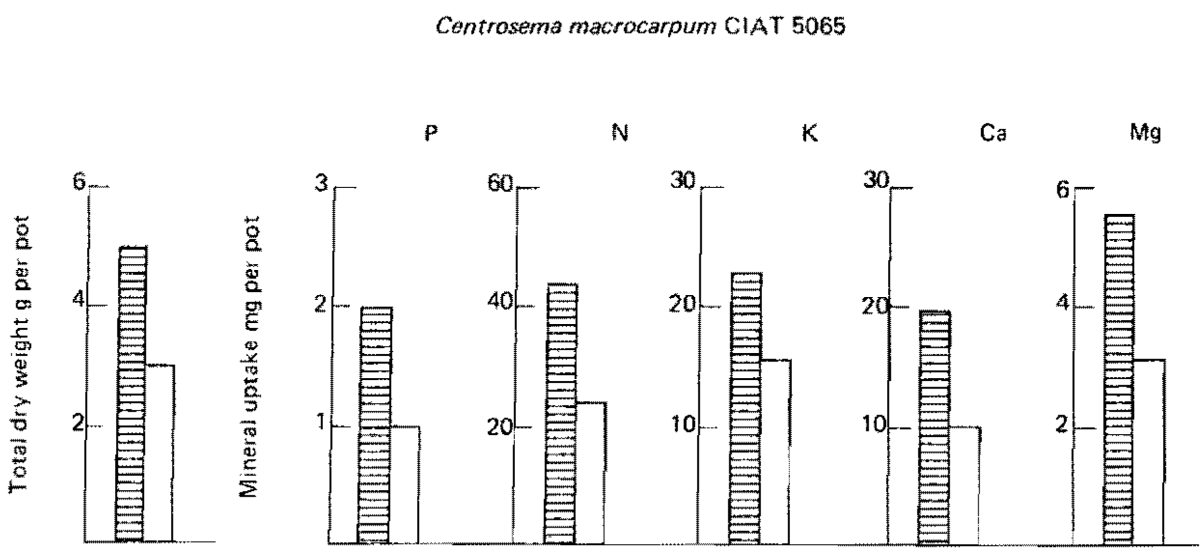


Figure 14. Same as Figure 13., but for *Centrosema macrocarpum* CIAT 5065.

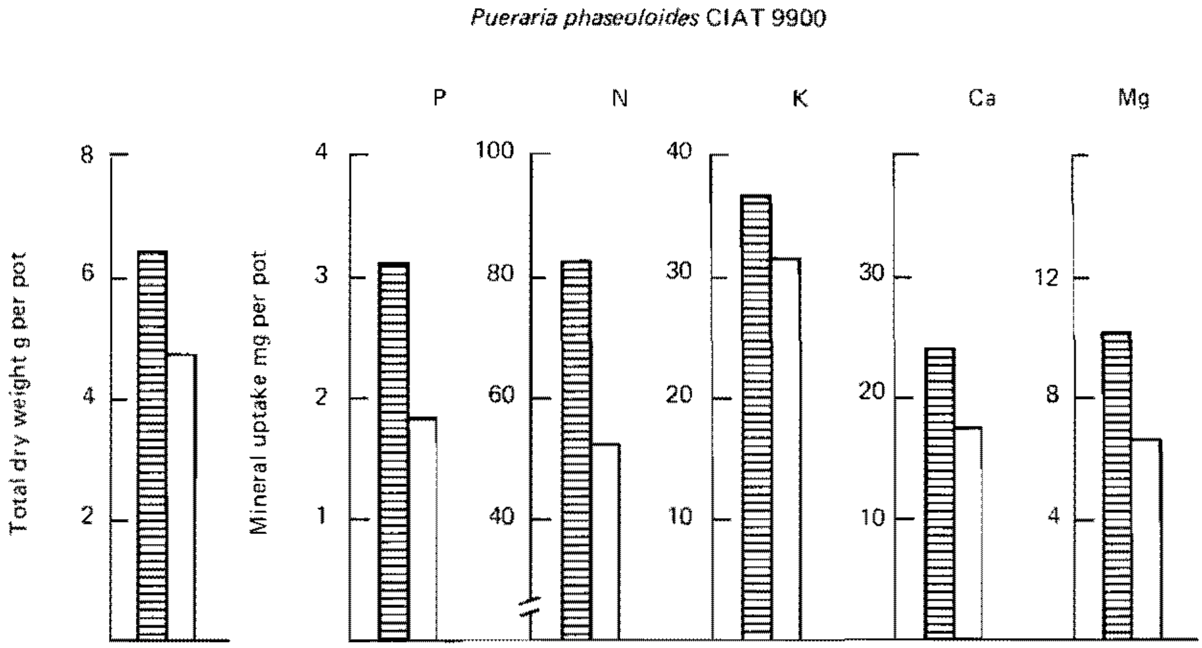


Figure 15. **Same as Figure 13., but for** *Pueraria phaseoloides* **CIAT 9900.**

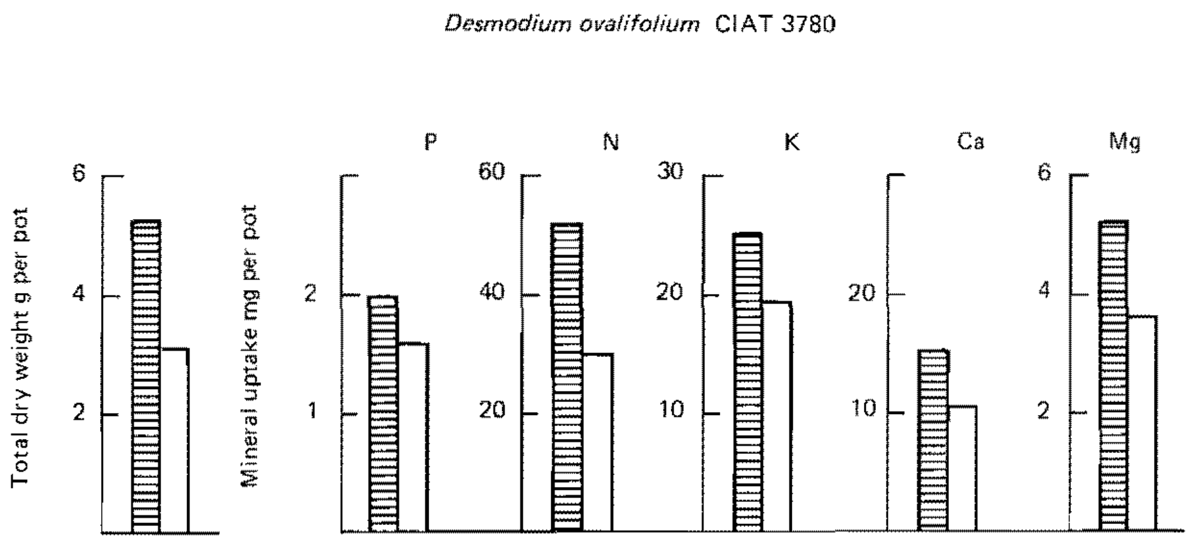


Figure 16. **Same as Figure 13., but for** *Desmodium ovalifolium* **CIAT 3780.**

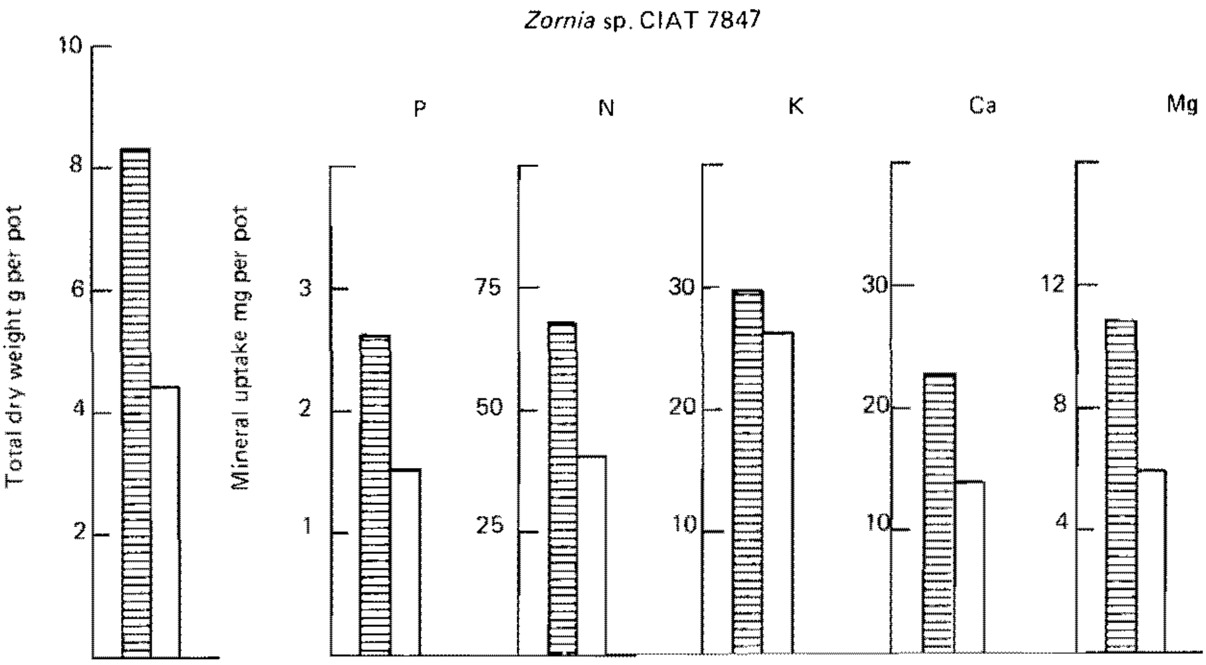


Figure 17. Same as Figure 13., but for *Zorni[illegible] sp* CIAT 7847.

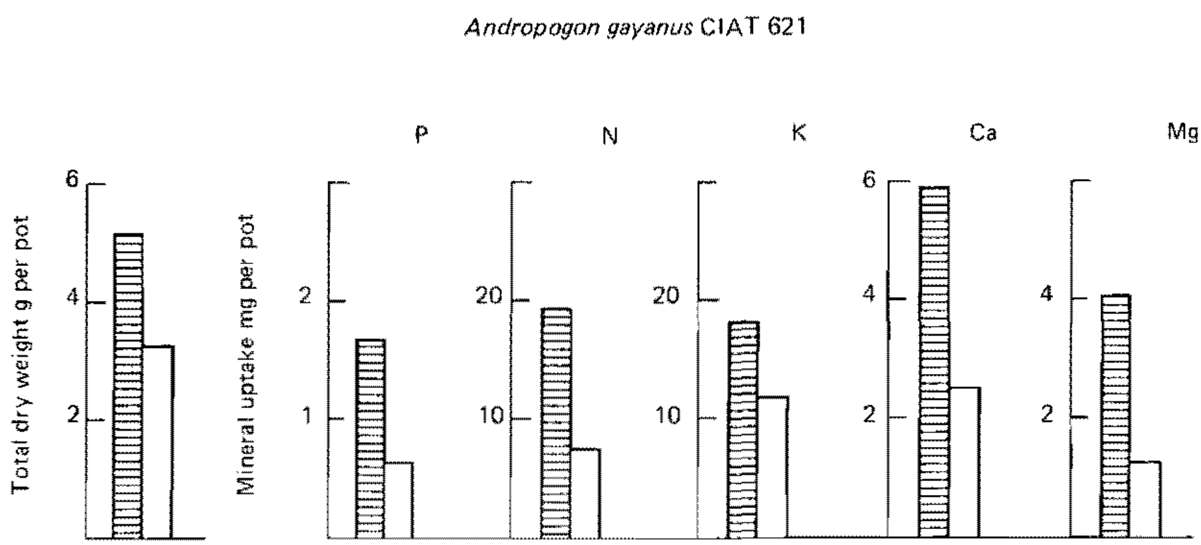


Figure 18. Same as Figure 13., but for *Andropogon gayanus* CIAT 621.

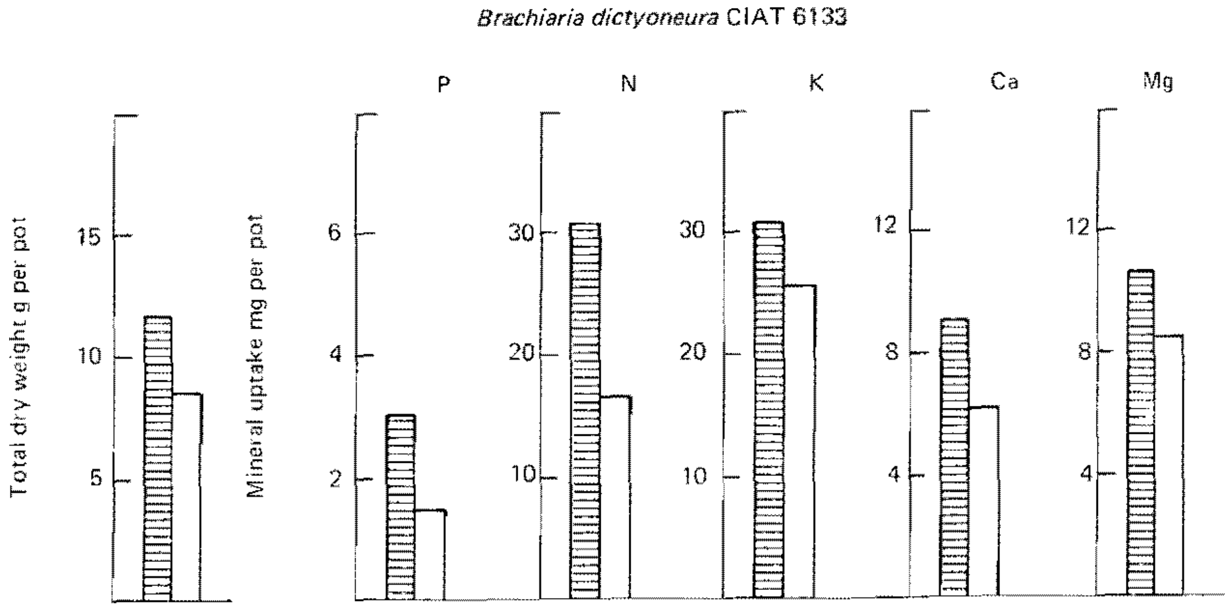


Figure 19. Same as Figure 13., but for *Brachiaria dictyoneura* CIAT 6133.

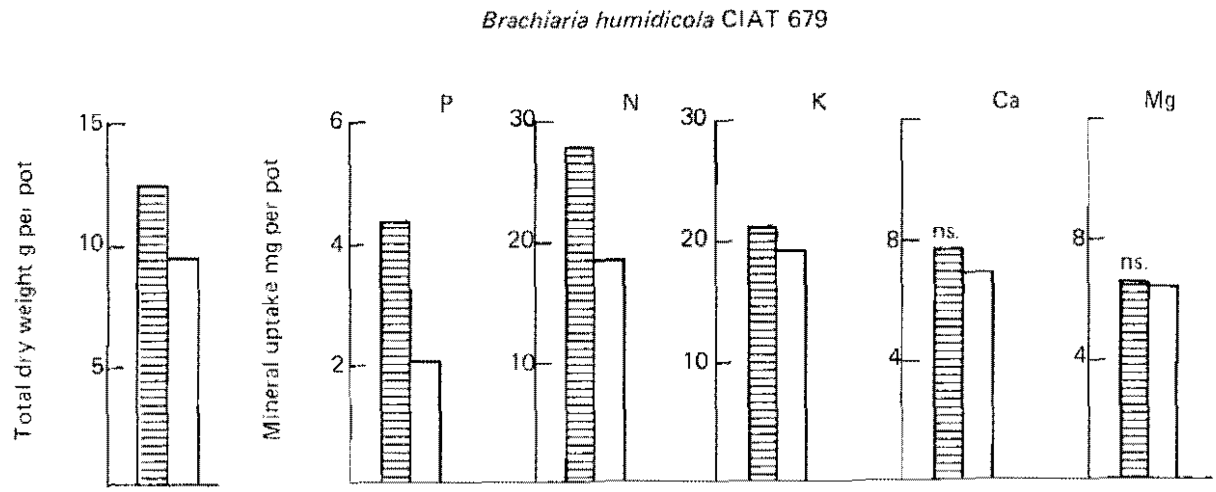


Figure 20. Same as Figure 13., but for *Brachiaria humidicola* CIAT 679.

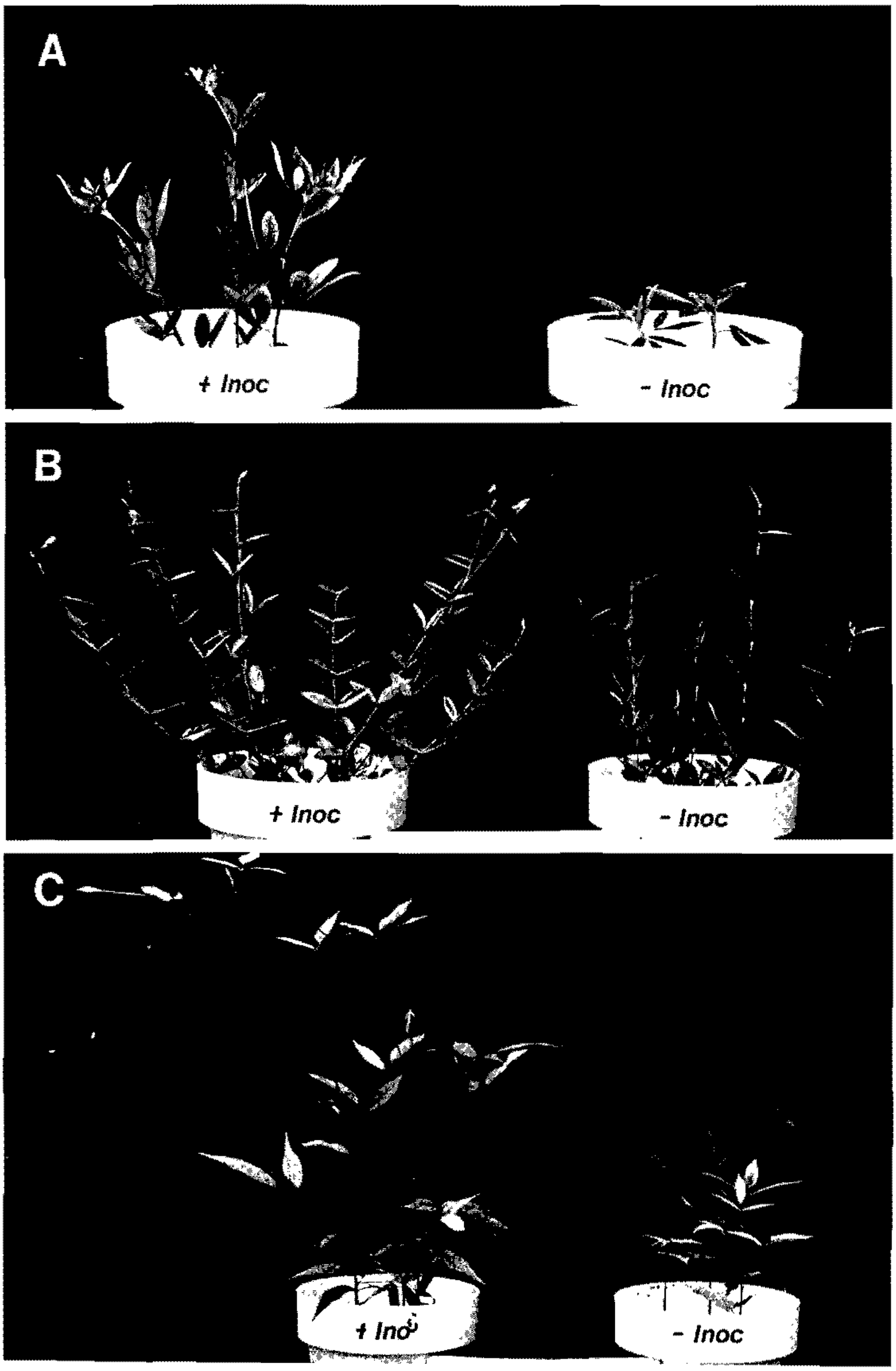


Figure 21. Effect of mycorrhizal inoculation on the growth of A) *Stylosanthes capitata*, B) *Zornia* sp and C) *Centrosema macrocarpum* grown in unsterilized Oxisol.

DESMODIUM OVALIFOLIUM CIAT 3780

Figure 22. Effect of three mycorrhizal fungi on the growth of *Desmodium ovalifolium* grown in sterile Oxisol. M_1, *Glomus manihotis*; M_2, *Acaulospora* sp; M_3, *Enthophospora* sp; NM, non-inoculated.

Comparison of P sources and application rate

This experiment was also conducted in an unsterilized Oxisol from Carimagua with the objective of seeing whether rock phosphate from Huila is as good a P source as Calfos (basic slag) and if inoculated plants require the same amount of P fertilizer or less to give the same yield as those of uninoculated plants. Figures 23 to 24 demonstrate that the both P sources were equally good for the growth and P uptake of P. phaseoloides, C. macrocarpum and B. decumbens. In the legumes, mycorrhizal inoculation and 10 kg P/ha gave the same amount of dry matter as that of non-inoculated plants with 20 kg P/ha. This means that at low P application rates mycorrhizal inoculation of pasture legumes may help to reduce the amount of P fertilizer needed by about 50%. This should be verified under field conditions. These data also imply that in such Oxisols rock phosphate can be used as P fertilizer as successfully as more soluble P sources.

Field inoculation response

This experiment was established in an Oxisol at Carimagua, Llanos Orientales, Colombia. The aim of the experiment was to see if field inoculation with VAM fungi would increase the establishment rate of seedlings, growth and mineral uptake of S. capitata, P. phaseoloides and A. gayanus and if so how long the effect of inoculation would last.

There were four treatments: NIL, no addition of mycorrhizal inoculum or phosphate; M, with mycorrhizal inoculum; RP, with rock phosphate from Huila; and RP + M, rock phosphate and mycorrhizal inoculum. Phosphorus was applied at the rate of 20 kg P/ha.

Mycorrhizal inoculation (M) significantly increased the seedling establishment and plant cover (%) but did not affect plant height of Pueraria compared to non-inoculated (NIL) plants (Figure 25). Rock phosphate (RP) alone caused significantly higher values for these growth parameters than the mycorrhiza alone (M) and the effect was further increased when rock phosphate was combined with mycorrhizal inoculum (RP + M). Fresh and dry matter production was also significantly increased by mycorrhizal inoculation (M) (Figure 26). When the M and NIL treatments are compared, mycorrhizal inoculation doubled the dry matter production (Table 6). When combined with rock phosphate, mycorrhizal inoculation increased the dry matter production by 67% over RP treatment. When compared to NIL treatment RP increased dry matter production 7 times more, and RP + M 11.67 times more (Table 6).

The total mineral uptake was also increased significantly by mycorrhizal inoculation (M) (Figure 27). All treatments showed highly significant differences. The efficiency of treatments when compared with each other followed the patterns of dry matter production however, the extent of increase varied among mineral elements (Table 6).

Not only the dry matter production and mineral uptake was increased by mycorrhizal inoculation but also the nodulation by Pueraria plants.

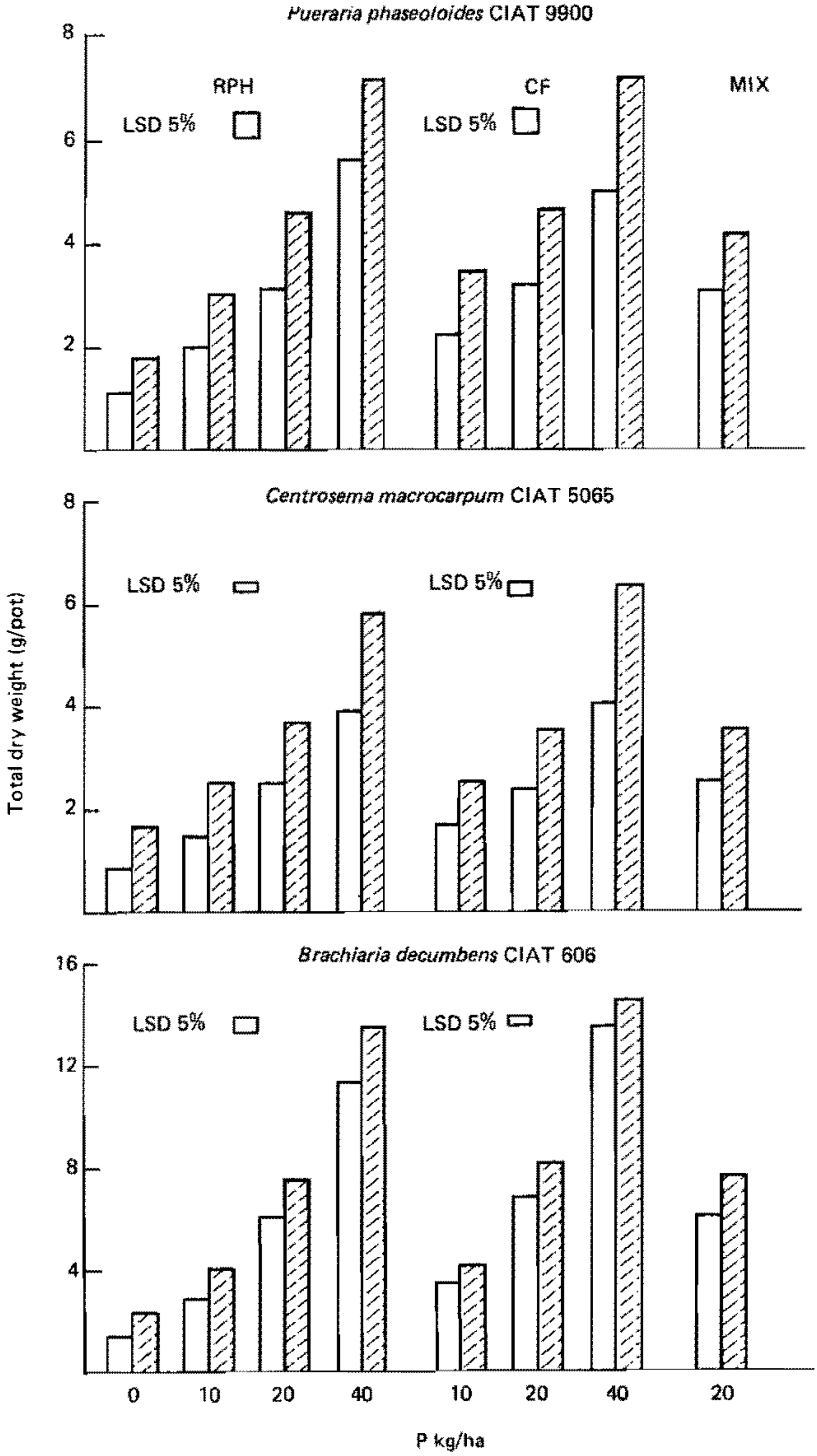


Figure 23. **Total dry weight (g/pot) of *Pueraria*, *Centrosema* and *Brachiaria* grown in unsterilized Oxisol in pots. RPH, rock phosphate Huila: CF, calfos; MIX, 1:1 RPH and CF. ▭, non-inoculated; ▨, inoculated with mycorrhiza.**

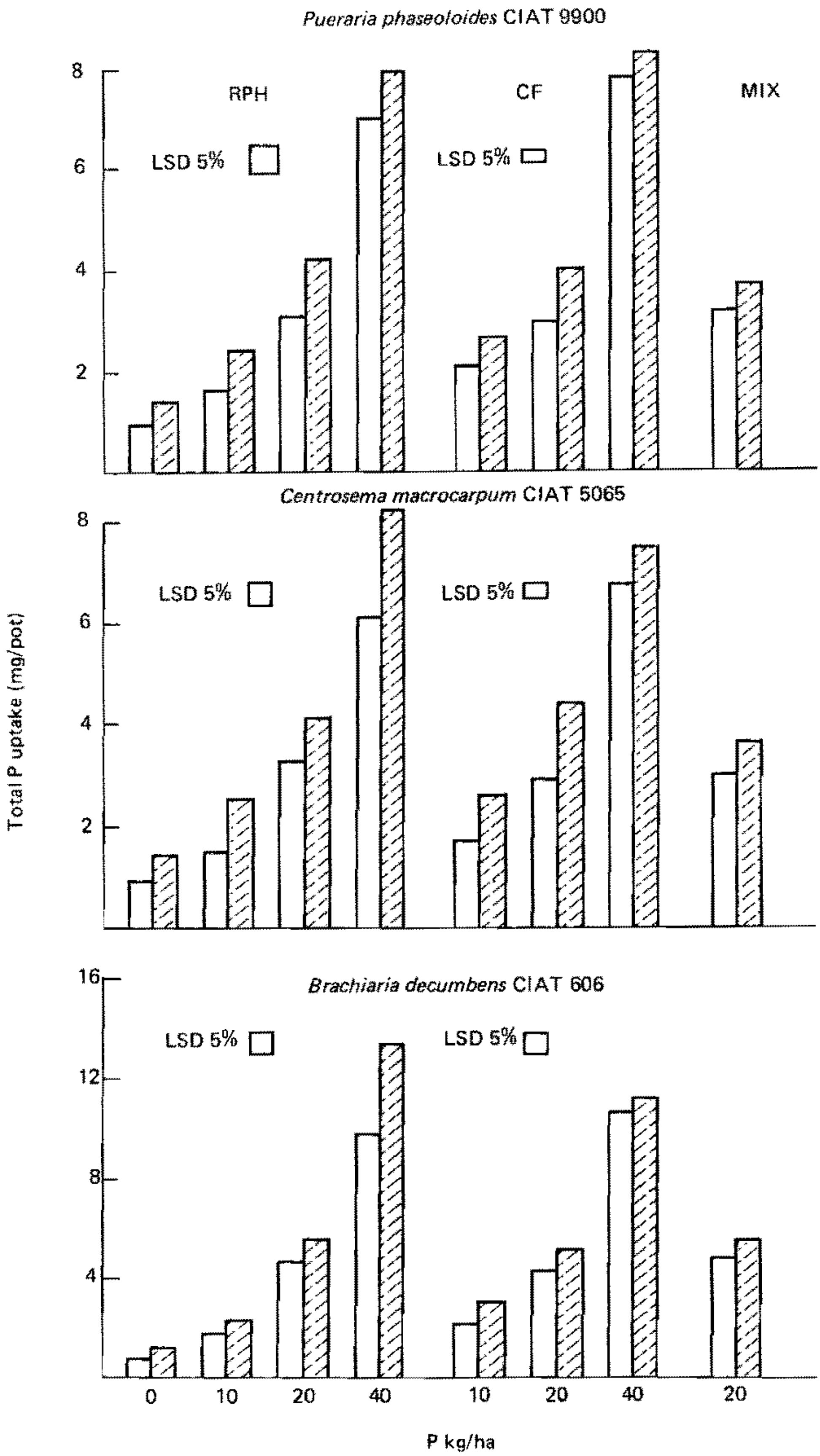


Figure 24. **Total P uptake (mg/pot) of *Pueraria, Centrosema* and *Brachiaria* grown in unsterilized Oxisol in pots. For explanation see Figure 23.**

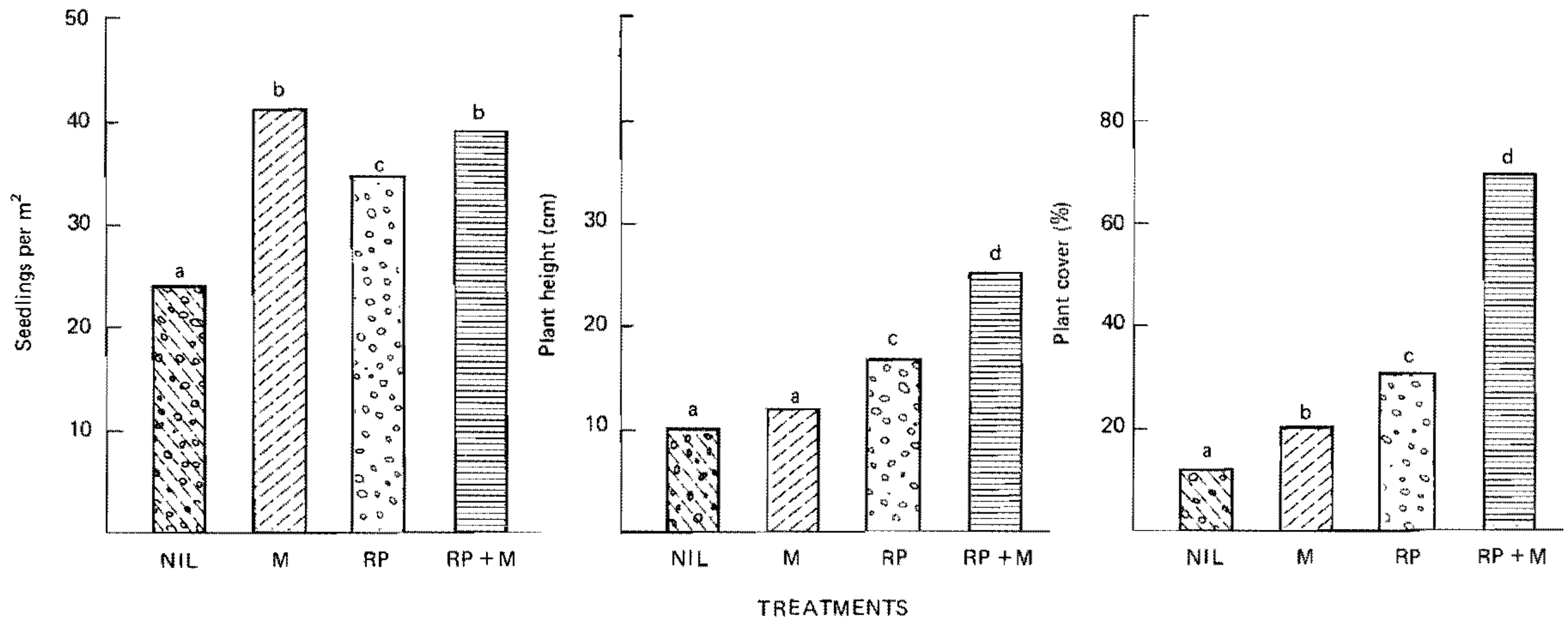


Figure 25. Number of seedlings established, plant height (cm) and plant cover (%) of *Pueraria phaseoloides* CIAT 9900, 10 weeks after sowing. NIL, cheek; M, inoculated with mycorrhiza; RP, rock phosphate from Huila and RP+ M, rock phosphate plus mycorrhiza. Phosphate was applied at a rate of 20 kg P/ha. Different letters represent significant differences ($P < 0.05$).

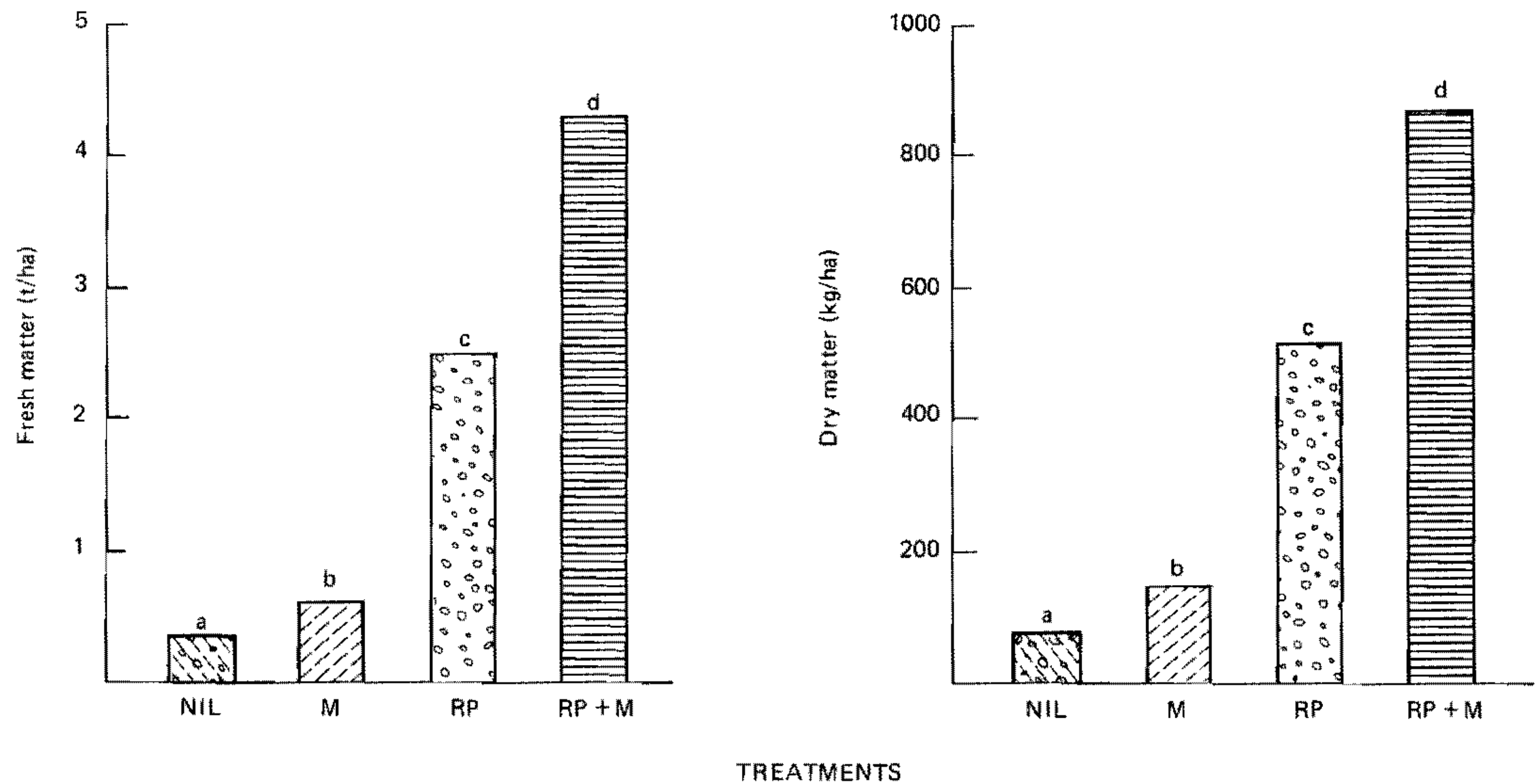


Figure 26. Fresh and dry matter production of *Pueraria phaseoloides* CIAT 9900 grown in unsterilized Oxisol under field conditions at Carimagua. Data are of Ist cut after 3 months of sowing. For explanation see Figure 25.

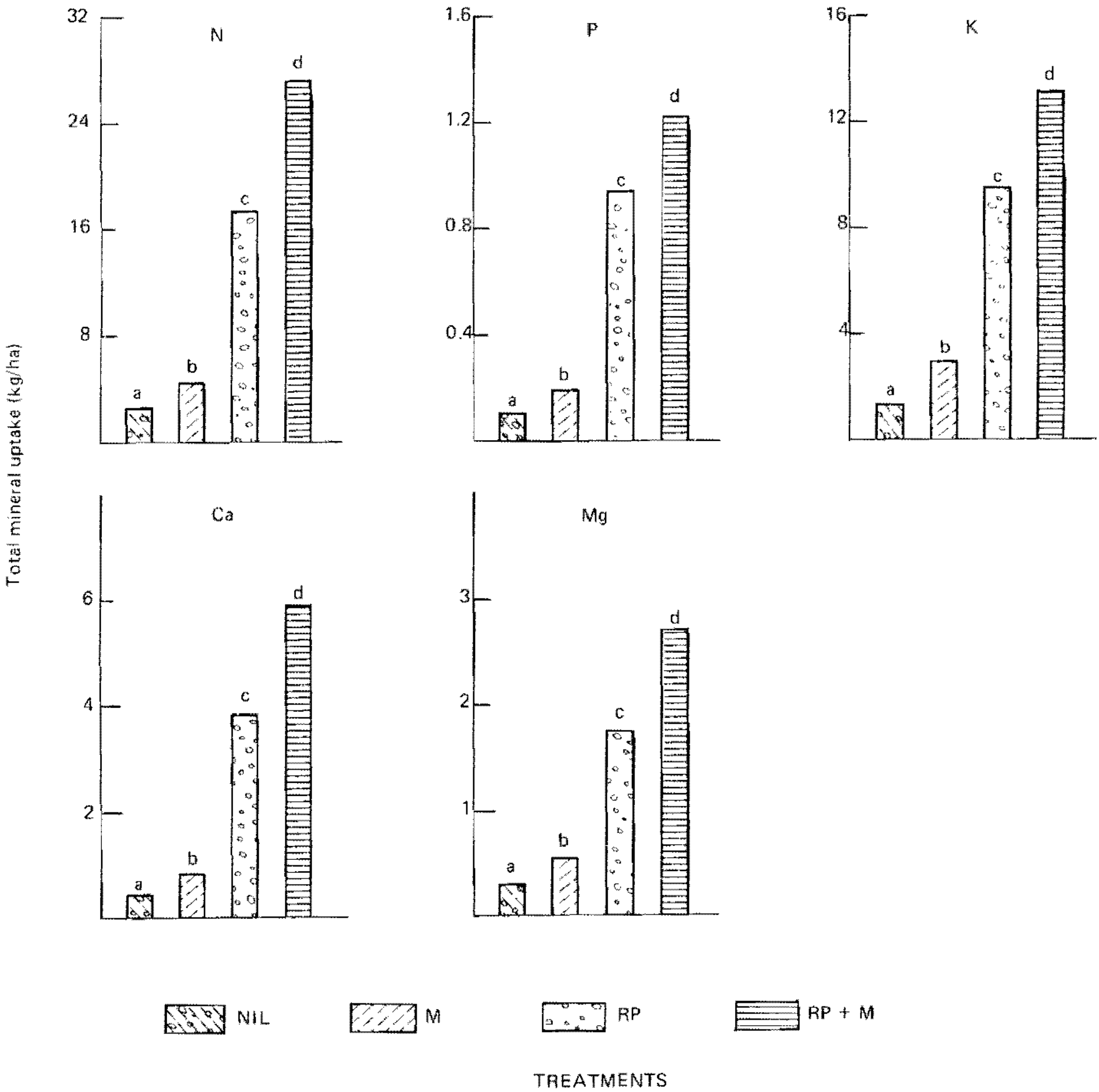


Figure 27. Total mineral uptake (kg/ha) of *Pueraria phaseoloides* CIAT 9900 grown in unsterilized Oxisol under field conditions at Carimagua. For explanation see Figure 25.

Mycorrhizal inoculation (M) doubled the number of nodules/plant (Figure 28). Similarly RP + M treatment had also higher number of nodules than the RP treatment. The nodules of M and RP + M treatments were much bigger than those in RP treatment.

Figure 29 shows that also in the case of Stylosanthes capitata fresh and dry matter production increased significantly by mycorrhizal inoculation (M). This effect was further increased when mycorrhizal inoculum was combined with rock phosphate (RP + M). Total mineral uptake of Stylosanthes was also increased by mycorrhizal inoculation (M) (Figure 30) and all the treatments showed significant differences. When compared with the NIL treatment, RP increased P uptake by 7.7 times, and RP + M by 13.3 times (Table 7), which was a greater increase than that of the dry matter and uptake of other mineral nutrients.

Although Stylosanthes was supplied with 50 kg N/ha after one month of sowing, nodulation still showed differences among treatments. Mycorrhizal inoculation increased the nodule number/plant. The number of nodules produced/plant in each treatment was as follows: NIL, 4.74; M, 8.02; RP, 14.99 and RP + M, 24.69 (mean of 15 plants).

Similarly to legumes, A. gayanus also showed a marked response to inoculation. The dry matter production of five treatments, i.e. NIL, M, RP and RP + M, were 0.27, 0.38, 2.3 and 3.04 t/ha at the first cut after 3 months of planting respectively. All these treatments were significantly different. Similar results were obtained for total uptake of P, N, K, Ca and Mg.

These data confirm the response to inoculation observed in the pot experiments conducted in the same low MIP soil and with the same plants. This experiment is being continued to determine how long the effect of mycorrhizal inoculation will persist.

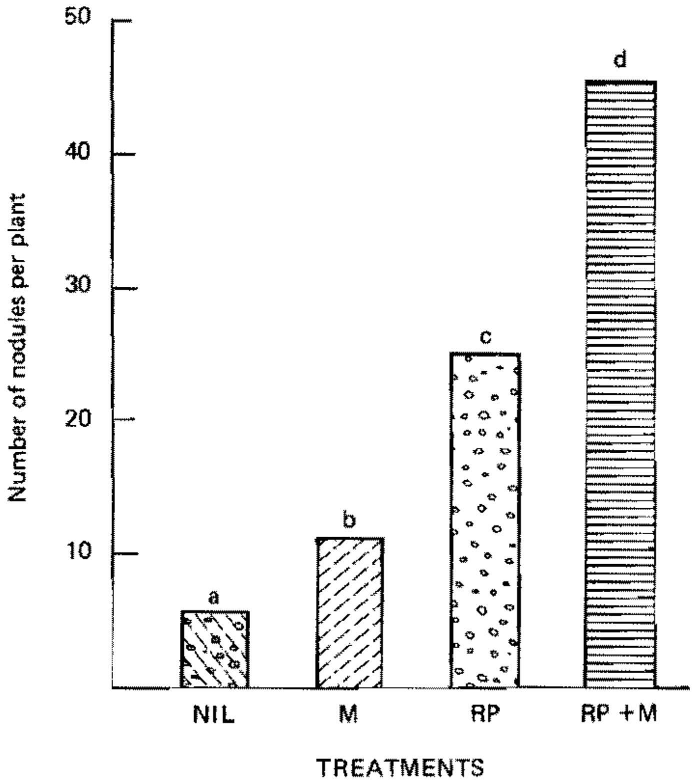


Figure 28. **Number of nodules per plant of *Pueraria* grown in unsterilized Oxisol under field conditions at Carimagua. For explanation see Figure 25.**

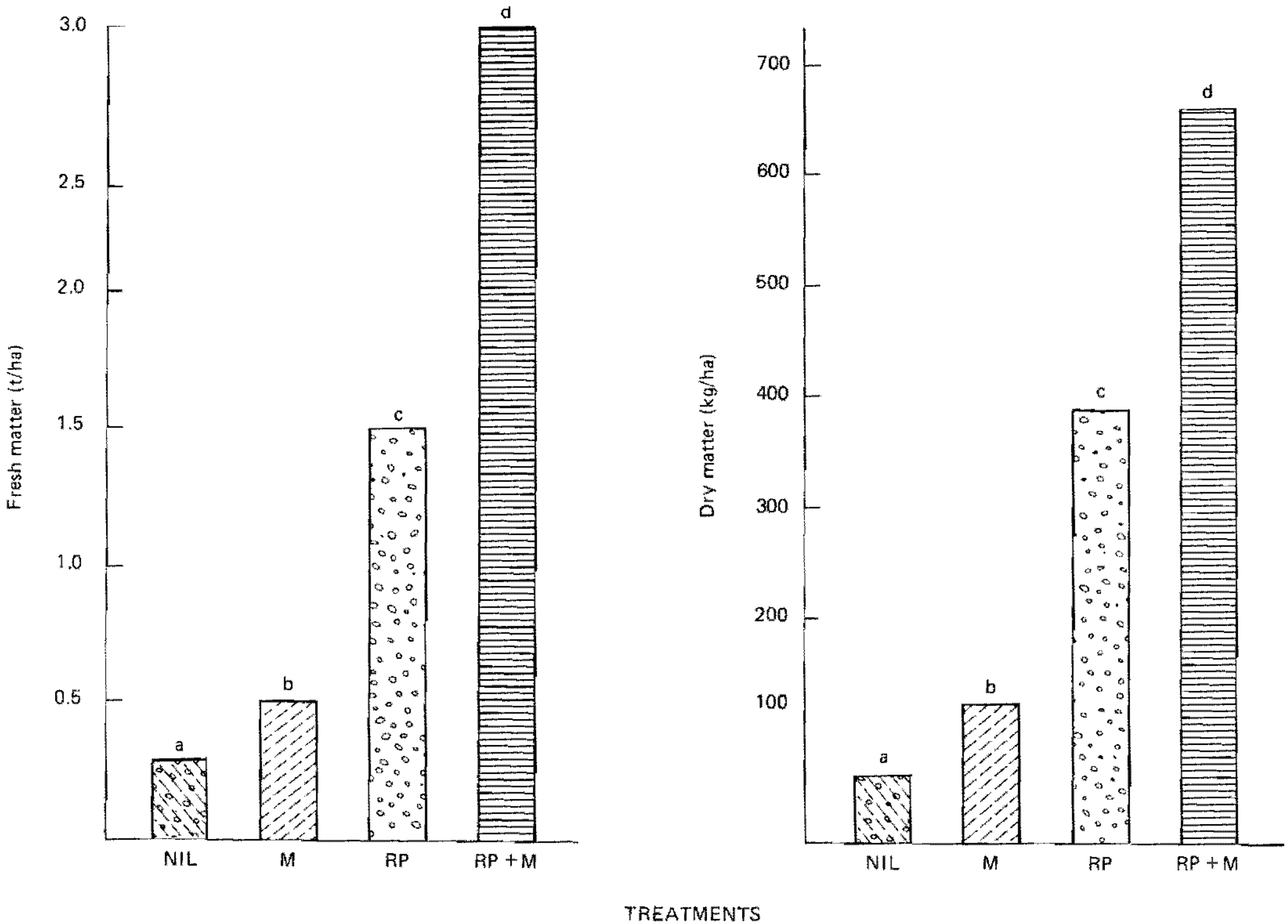


Figure 29. Fresh and dry matter production of *Stylosanthes capitata* CIAT 1315 grown in unsterilized Oxisol under field conditions at Carimagua. Data are of Ist cut after 3 months of sowing. For explanations see Figure 25.

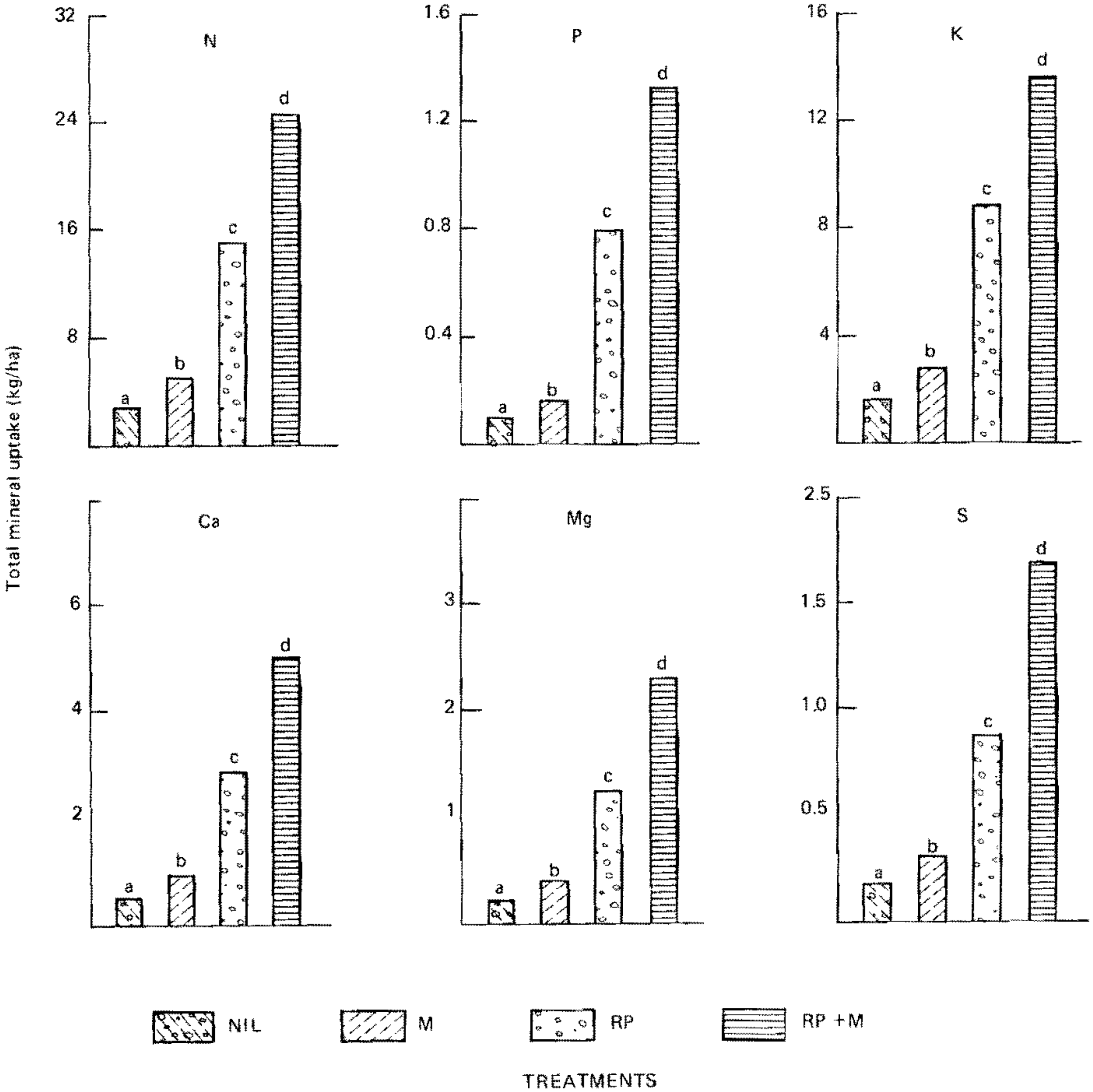


Figure 30. **Total mineral uptake (kg/ha) of *Stylosanthes capitata* CIAT 1315 grown in unsterilized Oxisol under field conditions at Carimagua. For explanation see Figure 25.**

Table 6. Effect of mycorrhiza and phosphate rock on DM yield and mineral uptake of *Pueraria phaseoloides* CIAT 9900, expressed as treatment ratios.

Treatments	DM*	Mineral uptake				
		N	P	K	Ca	Mg
M :NIL	2.02	1.88	1.90	2.10	1.95	1.93
RP+M : RP	1.67	1.59	1.32	1.37	1.52	1.55
RP : NIL	7.00	7.12	9.40	7.00	10.51	6.21
RP+M : NIL	11.67	11.33	12.40	9.59	16.00	9.64

* Dry matter.

Table 7. Effect of mycorrhiza and phosphate rock on DM yield and mineral uptake of *Stylosanthes capitata* CIAT 1315, expressed as treatment ratios.

Treatments	DM*	Mineral uptake					
		N	P	K	Ca	Mg	S
M : NIL	1.81	1.77	1.50	1.75	1.77	1.84	1.72
RP+M : RP	1.69	1.63	1.73	1.52	1.71	1.86	1.93
RP : NIL	5.70	5.48	7.70	5.69	6.17	5.68	4.77
RP+M : NIL	9.66	8.93	13.30	8.65	10.52	10.59	9.22

* Dry matter.

PASTURE DEVELOPMENT–CARIMAGUA

The objectives of the section are the development of (a) simple pasture establishment systems to minimize cost and reduce risk during the establishment phase, and (b) management and maintenance systems for pastures which result in high productivity consistent with long term persistence and stability. In the last three years emphasis has been given to the use of native savanna supplemented with introduced species planted in strips. In one case, the object has been to gradually replace native savanna with planted legumes and grasses over a period of 5 years, grazing the savanna during the replacement phase without burning and with gradually increasing stocking rate. In a new trial, the strategy followed is to supplement the native savanna with planted legumes, attempting to find a stable and productive association without burning and with relatively high stocking rates. In other experiments the effect of management factors on animal productivity balance and stability of associations is being studied.

ESTABLISHMENT

It is generally thought that pasture establishment in remote areas of the tropics is more costly because of the lack of adequate infrastructure which results in high costs for inputs at the farm. Nevertheless, one of the principal cost components in pasture establishment: the opportunity cost of land, is almost always less in frontier areas. For that reason, the section has given more attention to methods which require relatively more time for completion than do traditional establishment methods. A savanna replacement study has produced especially interesting results since 1980 when the experiment was established. The basic philosophy and methodology used were presented in the annual report of that year. Four associations were planted in strips, occupying 20% of the total area. The area fertilized has been increased by an additional 20% each year, thus favoring the advance of the planted species which gradually invade and replace the intermediate savanna strips. In Table 1 the advance of planted species during the first three years of the experiment can be observed. There is a marked effect of initial strip width and of species. The narrow strips of all associations have covered 20% or more of the total area each year. Associations with P. phaseoloides have covered more than the projected 20% even in the 5 m strip width until 1983, with one exception when the legume failed to advance, probably due to heavy grazing pressure on the legume due to the high proportion of savanna to planted grass in that treatment. (Proportion of planted species is a function of the number of interfaces between planted species and native savanna thus a function of strip width.)

Table 1. The effects of planting pattern and association on the advance of strip- planted, introduced species in native savanna. 1980-83.

	Initial strip width		Mean width of the strips of planted species and % total area covered					
	1980		1981		1982		1983	
Association	Planted	Savanna	m	%	m	%	m	%
	m							
B. humidicola	0.5	2	1.7	67	2.5	100	2.5	100
x	2.5	10	6.0	48	7.2	58	7.2	58
D. ovalifolium	5.0	20	8.4	34	10.4	42	9.1	36
B. humidicola	0.5	2	2.5	100	2.5	100	2.5	100
x	2.5	10	7.7	62	12.5	100	12.5	100
P. phaseoloides	5.0	20	8.3	33	15.0	60	14.0	56
A. gayanus	0.5	2	1.7	67	2.5	100	2.5	100
x	2.5	10	6.0	48	6.3	50	7.2	58
D. ovalifolium	5.0	20	7.8	31	12.4	50	9.3	37
A. gayanus	0.5	2	2.5	100	2.5	100	2.5	100
x	2.5	10	8.1	64	12.5	100	12.5	100
P. phaseoloides	5.0	20	10.7	43	16.3	65	18.3	73

Desmodium ovalifolium performed very well in the associations tested during the first year but suffered a serious attack of nematodes in 1982, which severely reduced stand and cover. The legume has partially recovered in 1983. Andropogon gayanus has not performed well in the experiment, due in part to problems of establishment and subsequently to a very high grazing pressure which did not permit flowering nor seeding and led to a rapid reduction in the original stand. Thus the associations with this grass are in reality associations of legumes with savanna. The best association continues to be B. humidicola x P. phaseoloides. In Figure 1, the performance of this association can be seen. In the 0.5 m strips, P. phaseoloides had covered all of the area in the first year; in 2.5 m strips, the entire area was covered in two years. The 0.5 m strip planting could be considered a form of low density sod planting which could easily be mechanized to permit the simultaneous preparation of land, fertilization and planting in a once-over operation.

In Figures 2 and 3 botanical structures of each pasture at the beginning of the 4th year after planting are shown. It can be seen that the savanna continues to play an important role in the widest strips but is rapidly disappearing in the medium width strips and its almost gone in the 0.5 m strips.

Stocking rates are adjusted depending on forage availability. At the end of 1983, the B. humidicola x P. phaseoloides association was carrying two animals per hectare; the other associations are stocked with one animal ha^{-1}. All of the associations resulted in liveweight gains of 450-500 g animal day^{-1} during the 1983 wet season with the exception of D. ovalifolium x (A. gayanus) x savanna in which gains were inferior to 200g $animal^{-1}$ day^{-1}.

In summary, the most important result of this experiment to date has been the validation of a strategy to gradually replace native savanna by planting strips of aggressive species and annually increasing the area fertilized. It has also been feasible to manage the associations between savanna and planted species without need for burning, and animals have continued to consume native savanna when adequately supplemented by introduced legumes.

The preliminary results of this experiment have served as a basis for a new trial in which savanna has been supplemented by planted legumes in a range of 2.5 to 30% of the total area, with stocking rates ranging from 0.33 to 1.33 animals ha^{-1}. Grazing of this experiment will begin at the end of the present dry season (1983-84). It is hoped that this experiment will provide information on the long term effects of management of savanna supplemented with strip-planted legumes, without burning and at relatively high stocking rates. The dynamics of both native and introduced species and animal performance will be monitored.

Pasture establishment in "zural" type flooding savannas

In some flooding savannas such as those found in Casanare, and to a lesser extent in the high plains of Meta and Vichada, Colombia the

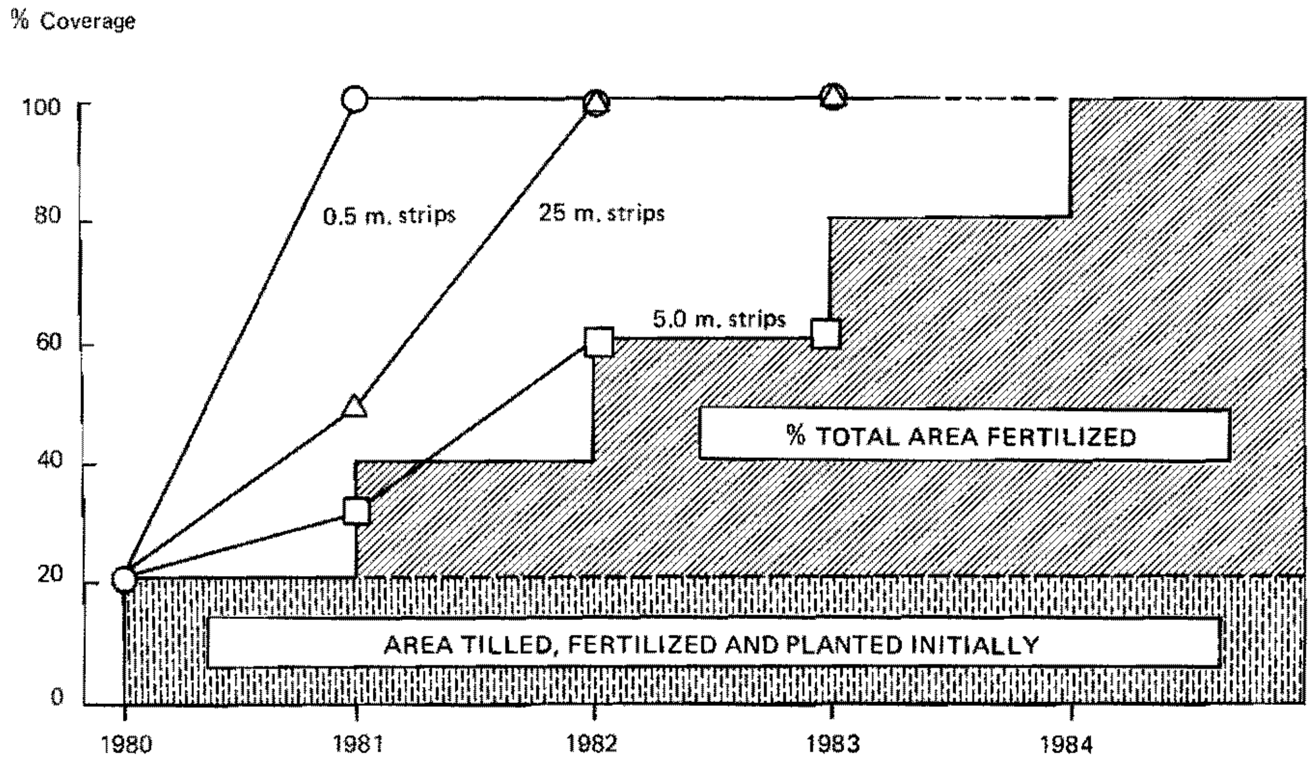


Figure 1. The effect of initial strip width and time on the % of total area covered by *Brachiaria humidicola* and *Pueraria phaseoloides* in the savanna replacement trial.

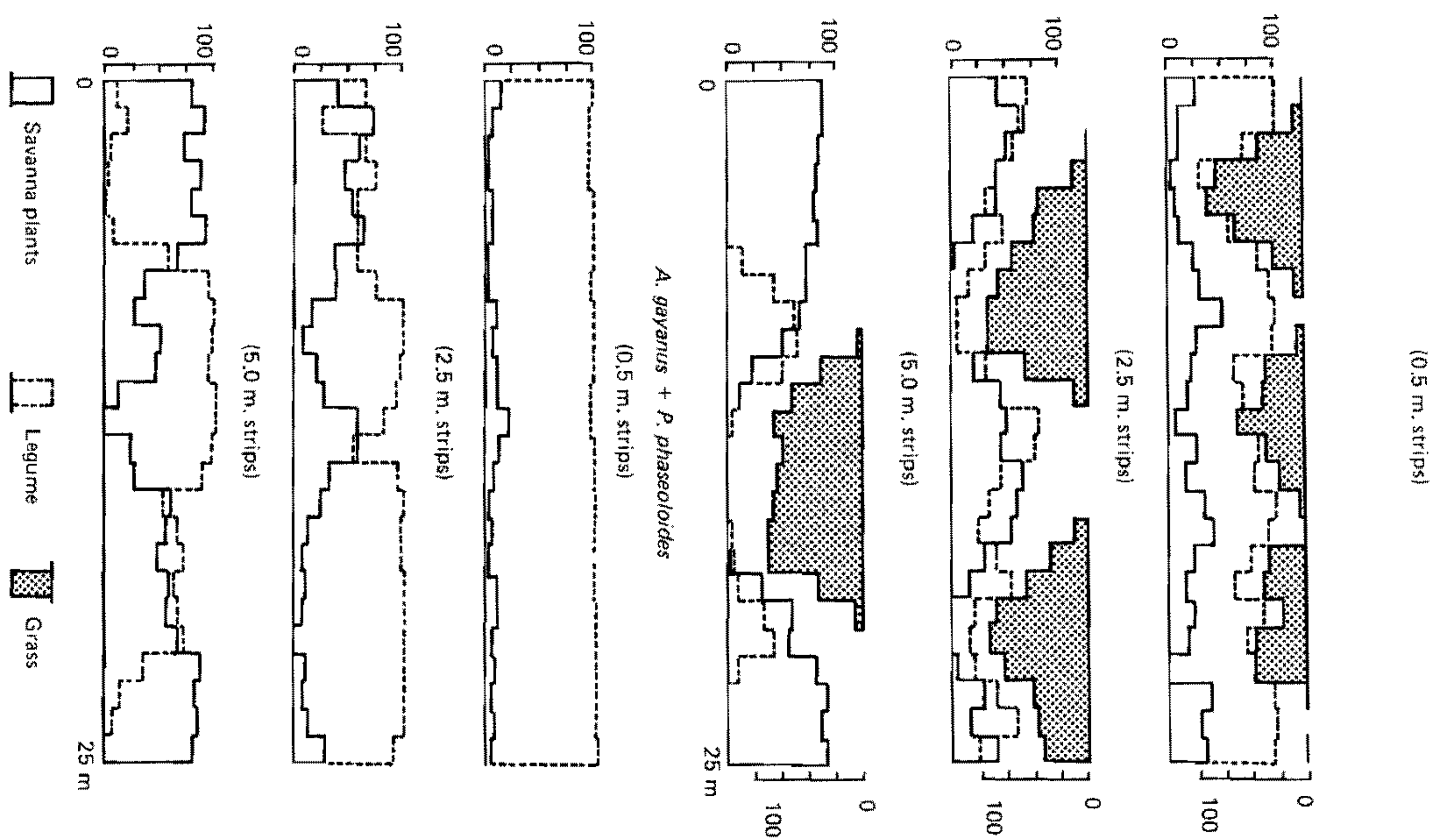


Figure 2. The effect of strip width in associations of *Pueraria phaseoloides* with two grasses on the botanical structure of pastures formed by the gradual replacement of savanna by introduced species; fourth year after planting.

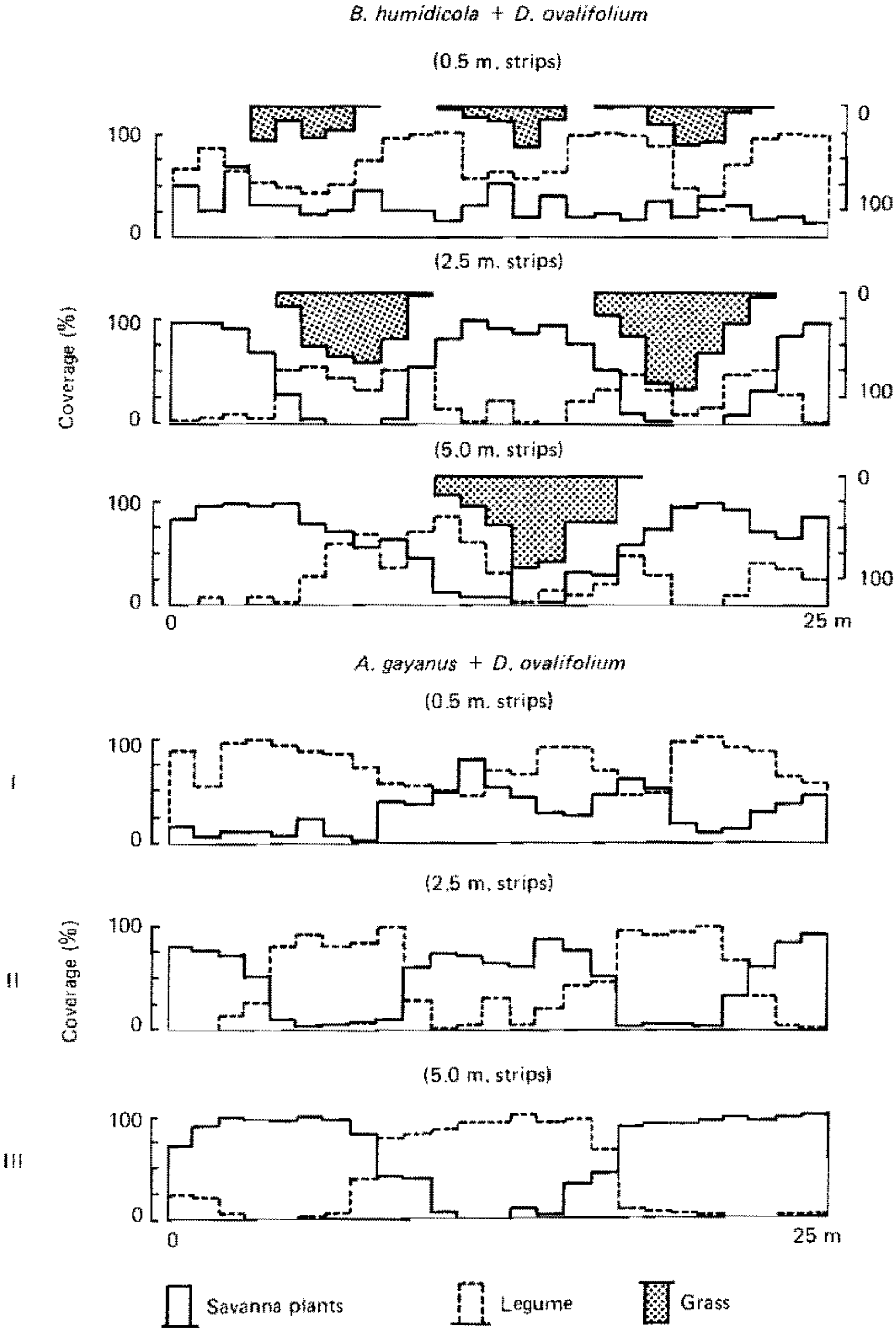


Figure 3. The effect of strips width in association of *Desmodium ovalifolium* with two grasses on the botanical structure of pastures formed by the gradual replacement of savanna by introduced species; fourth year after planting.

occurrence of "zurales" is common. This is a formation in which mounds 40 to 60 cm high and 1.5 to 2 m diameter occur every 3 to 5 m in the landscape (Figure 4). Preliminary studies indicated the possibility of establishing introduced species on the "zurales", following manual preparation of the planting site, based on a low density planting pattern. The vegetation on the balance of the "zural" was controlled either with herbicide or manually. In Figure 4 the effect of method and degree of vegetation control on the production and botanical composition of forage of associations between B. humidicola, P. phaseoloides, D. ovalifolium and Echinochloa polystachya can be seen. In general, forage availability was high during the dry season. The use of herbicide for controlling the native savanna "zural" vegetation gave much better results than manual control of weeds, primarily because of the effect during the establishment phase. The chemical control resulted in much more rapid and vigorous establishment than manual control. It appears that the exposure of the soil resulting from manual control had a strong negative effect. Once established, the introduced species were efficient in invading and displacing native vegetation in the entire area, even though weed control was limited to the high part of the "zural". The percentage legume is greater in the high part of the zural where it is not subjected to flooding, supporting the hypothesis that it should be feasible to maintain legumes in a flooding environment taking advantage of well drained niches for the legume and leaving the "floor" for grasses adapted to such conditions. D. ovalifolium is much more tolerant to temporary flooding and saturation than P. phaseoloides, due to the mechanical damage suffered by the latter as a result of trampling by grazing animals. The problem of trampling is minimized in well-drained Oxisols characterized by very stable structure, even in periods of high rainfall. The "zural" soils become quite plastic when wet.

Echinochloa polystachya ("Pasto Alemán") is well adapted to poorly drained conditions but it appears to be less well adapted to the chemical soil conditions in this environment. In contrast, B. humidicola is very well adapted not only to poor drainage but also to soil chemical conditions. These differences can be clearly seen in Figure 5. The best balance between legume and grass was achieved in the B. humidicola x P. phaseoloides association.

MAINTENANCE

Planting patterns

In previous annual reports, the problem of lack of seedling vigor in second and subsequent generations of S. capitata associated with A. gayanus has been discussed. All of the results to date indicate that the principal problem is the strong competition of the grass for nutrients, with potassium probably being the most limiting factor in Carimagua Oxisols. A planting pattern experiment (S. capitata x A. gayanus) was established in 1982 and grazing began in 1983. Animal performance has been excellent, with gains of over 600 g animal^{-1} day^{-1} during the first 215 days of grazing. Forage availability and botanical composition of the association are shown in Figure 6. The

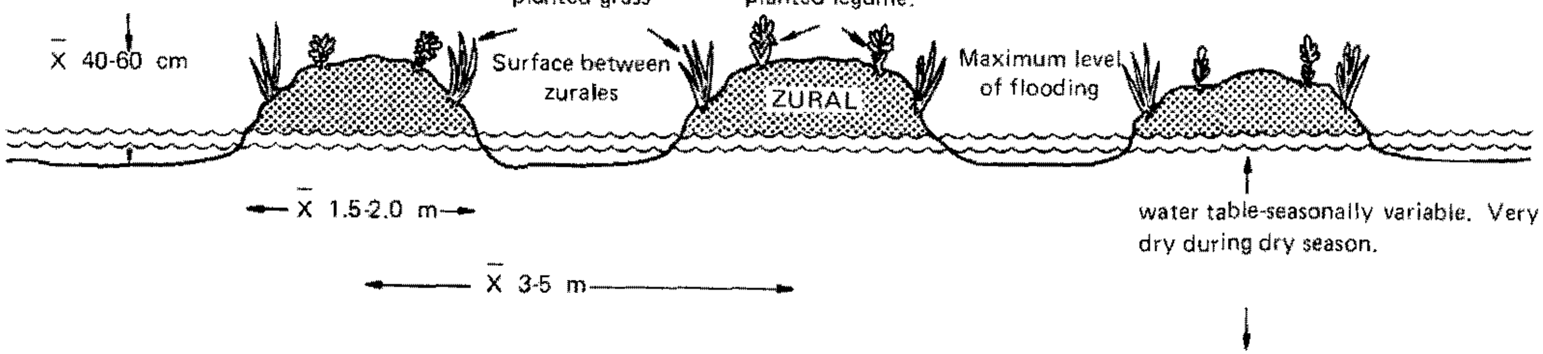


Figure 4. **Transverse section of a zural formation.**

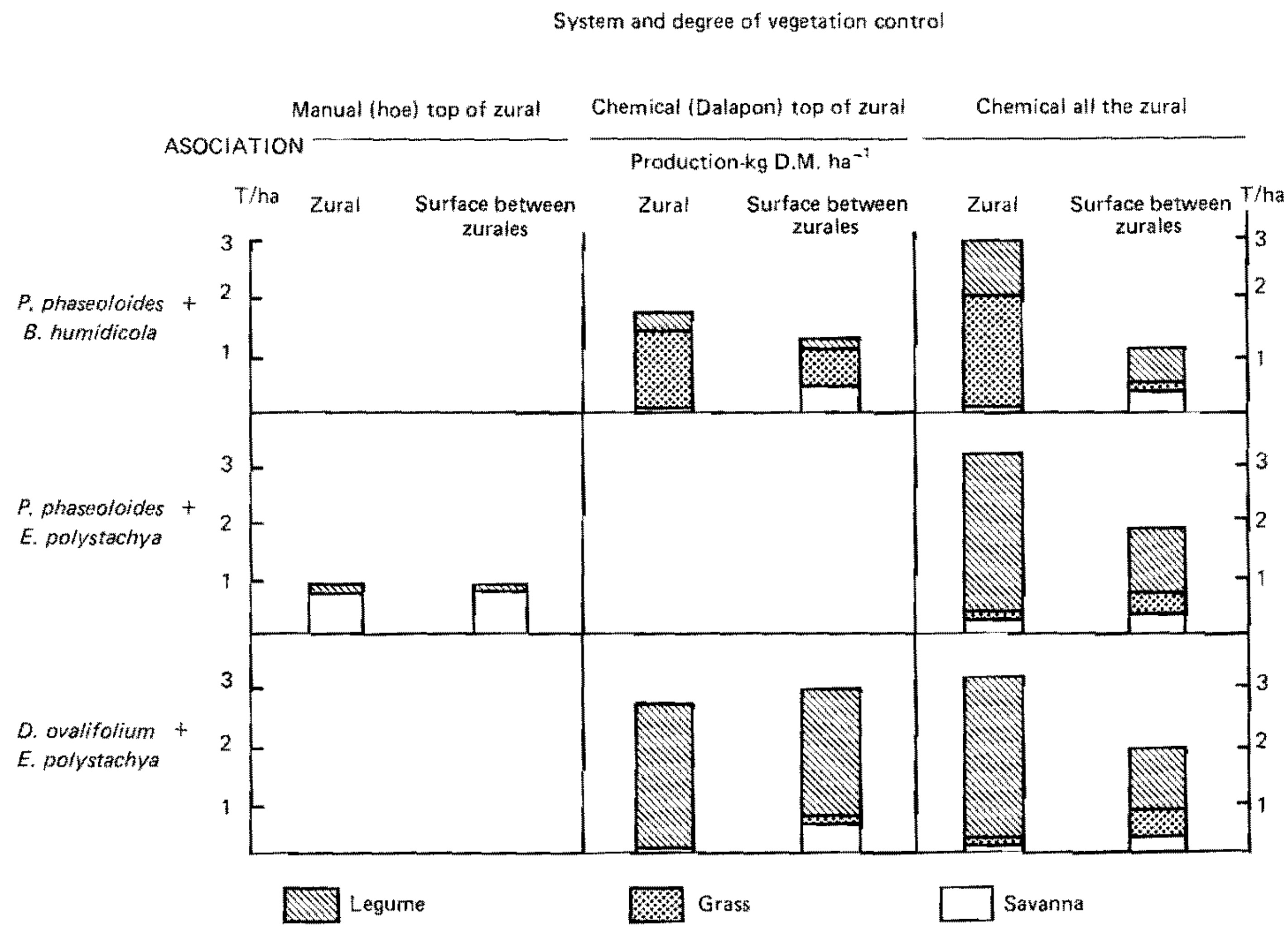


Figure 5. **The effect of system and degree of control of native vegetation on zurales on the productivity and botanical composition of forage in the second dry season after low density planting of the introduced species.**

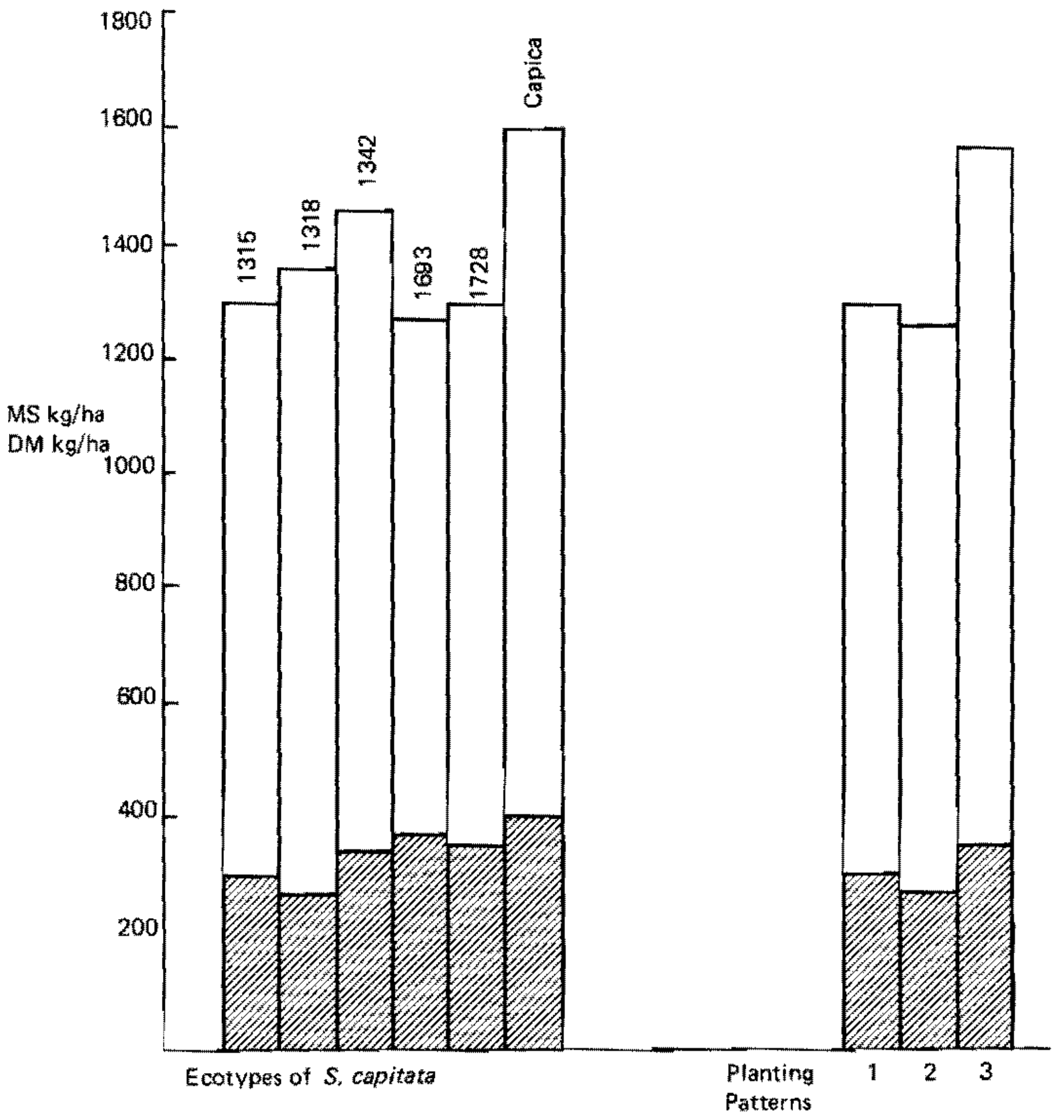


Figure 6. **The effect of ecotype and planting pattern on total forage production and botanical composition in associations of *A. gayanus* and the different components of *Stylosanthes capitata* cv. 'Capica'.**

legume accounts for 20 to 30% of the forage available, independent of planting pattern.

The purpose of the different planting patterns was to vary the distance between grass and legume, leaving more space for the development of the legume with less competition for the grass. Previous studies indicate that the effect of the grass extends approximately 1 m from the base of the plant. In the pattern of 1 row of grass to 1 row of legume (1:1) with 0.75 m between rows, the distance between rows of grass is 1.5 m; in the 2:2 and 3:3 patterns, the distances are 2.25 m and 3 m. Observations to date indicate that one of the limitations to the strategy is the development of a new population of A. gayanus seedlings in the midst of the legume rows. If this stand develops, the potential advantage of greater separation between the original grass rows will be lost all too soon.

NEW EXPERIMENTS

The effect of pasture management on botanical composition, persistence and productivity of associations

Old pastures from trials just terminated were used for initiating four small, preliminary experiments to study the effect of stocking rate and grazing system on two associations.

P. phaseoloides x A. gayanus. At the end of 4 years of grazing, one of the most productive pastures in the Introductions II experiment was in very poor condition due to over-grazing and the use of a grazing system which appears to be inappropriate for the association at the stocking rate employed. The pasture had essentially no harvestable forage when the previous experiment was terminated in December 1982. Nonetheless, it responded markedly to a dry season rest period after having controlled ants and applying maintenance fertilizer. The grass recuperated very rapidly at the beginning of the rainy season in April and when grazing was initiated in June there was more than 6,000 kg of forage available, 95% grass, 5% legume. Under rotational grazing with heavy stocking rates of over two animals ha^{-1}, the legume-grass balance rapidly improved and by September there was 60% grass and 40% legume, with approximately 2.5 tons of green forage (dry matter) available.

The most important aspect of this experience to date is the remarkable ability of both species to recover from a very degraded state after severe over-grazing, without the need for controlling weeds nor replanting; the only cultural practices being the control of ants and the application of maintenance fertilizer. The effects of grazing management will be reported in the future.

B. decumbens x P. phaseoloides. This pasture was formed over a period of 4 years under continuous grazing, beginning with the "triangle" experiment. The pasture has been severely affected during the last two years by an increasing incidence of spittlebug. The grass almost disappeared in 1982, but responded to a dry season rest (1983-84) and maintenance fertilizer, without need for ant nor weed control. Before initiating grazing in April, there was three tons of forage with a botanical composition of 65% grass, 35% legume. Under continuous grazing, the botanical composition changed drastically; by September there was only 3% grass and 97% legume with over two tons of forage available. This is largely due to the effect of spittlebug. Under rotational grazing, the grass performed somewhat better with a range of 10 to 20% grass, 80 to 90% legume. The future of this experiment is doubtful due to the drastic effect of spittlebug on the grass.

FUTURE PLANS

1. To expand studies on the effects of grazing systems on the productivity, persistence and balance of species in association

2. To expand studies on direct planting systems for introducing legumes into degraded pastures and native savanna. Equipment developed for this purpose may also serve for the study of direct planting of grasses using vegetative material, both in traditionally prepared seed beds and in minimum tillage systems.

3. To continue studying alternatives for pasture establishment on the sandy soils found on more sloping sites in Carimagua. These soils are structurally much less stable and subject to greater erosion hazard than the dominant fine-textured soils found on the smooth landscapes of Carimagua.

Activities during 1983 were centered around (a) the evaluation of the quality and palatability of promising germplasm; (b) measurement of forage quality attributes and their relationships with animal production; and (c) identification of alternate uses of germplasm based on quality attributes.

What follows is a report on the results of experiments that have been completed or are in progress, many of them in collaboration with other sections of the program.

QUALITY AND PALATABILITY MEASUREMENTS IN LEGUMES

Protein ruminal degradation

In previous work a negative correlation had been found between tannins in legumes and protein solubility in pepsin. It was of further interest to evaluate the effect of tannins in legumes on protein degradability in the reticulo-rumen. Six legumes with different *in vitro* digestibility, protein and tannin content (Table 1) were weighed into nylon bags and placed *in situ* in the rumen of fistulated steers grazing *A. gayanus* and *B. decumbens*. Bags were taken out from the rumen at different times (2, 4, 8, 12, 24, 48 and 144 hours) and after drying, residues were weighed and crude protein was determined. Curves of percentage protein degraded vs. time were adjusted with the model:

$Y = Bo\ (i - e^{-B_1\ (X-B_2)})$, where:

Bo = maximum potential degradation when time of fermentation tends towards infinity.

B_1 = degradation rate.

X = time of degradation.

B_2 = time delay or lag time.

The data were well adjusted by the model used, as can be seen in Figure 1.

The maximum proportion of protein degraded ranged between 62 and 75%, with a higher proportion been degraded in the *A. gayanus* diet as compared with *B. decumbens*. Large differences were found between legumes in the rate of degradation (B_1) (Table 2) and in the lag time (B_2), thus resulting in different half lives. In general, legumes with tannins (*Desmodium ovalifolium* 350, *Dioclea guianensis* 9311 and *Rhynchosia reticulata* 8173) had significantly slower rates of

Table 1. Chemical analyses of legumes used in a study of *in situ* ruminal protein degradation.

Legume	Crude Protein	IVDMD	Tannins	Soluble Nitrogen in Pepsin	Soluble Nitrogen in Protease
	%	%	%	%	%
Desmodium ovalifolium 350	17.2	44.2	22.5	46.7	52.2
Rhynchosia reticulata 8173	22.3	45.7	7.1	59.8	53.9
Dioclea guianensis 9311	18.3	43.3	24.3	45.7	59.0
Centrosema arenarium 5236	24.4	60.3	1.2	84.6	76.4
Centrosema macrocarpum 5065	29.9	65.7	1.0	78.5	76.4
Calopogonium caeruleum 9247+8159	26.6	57.5	0.9	74.2	66.5
Mean				63.3	64.1

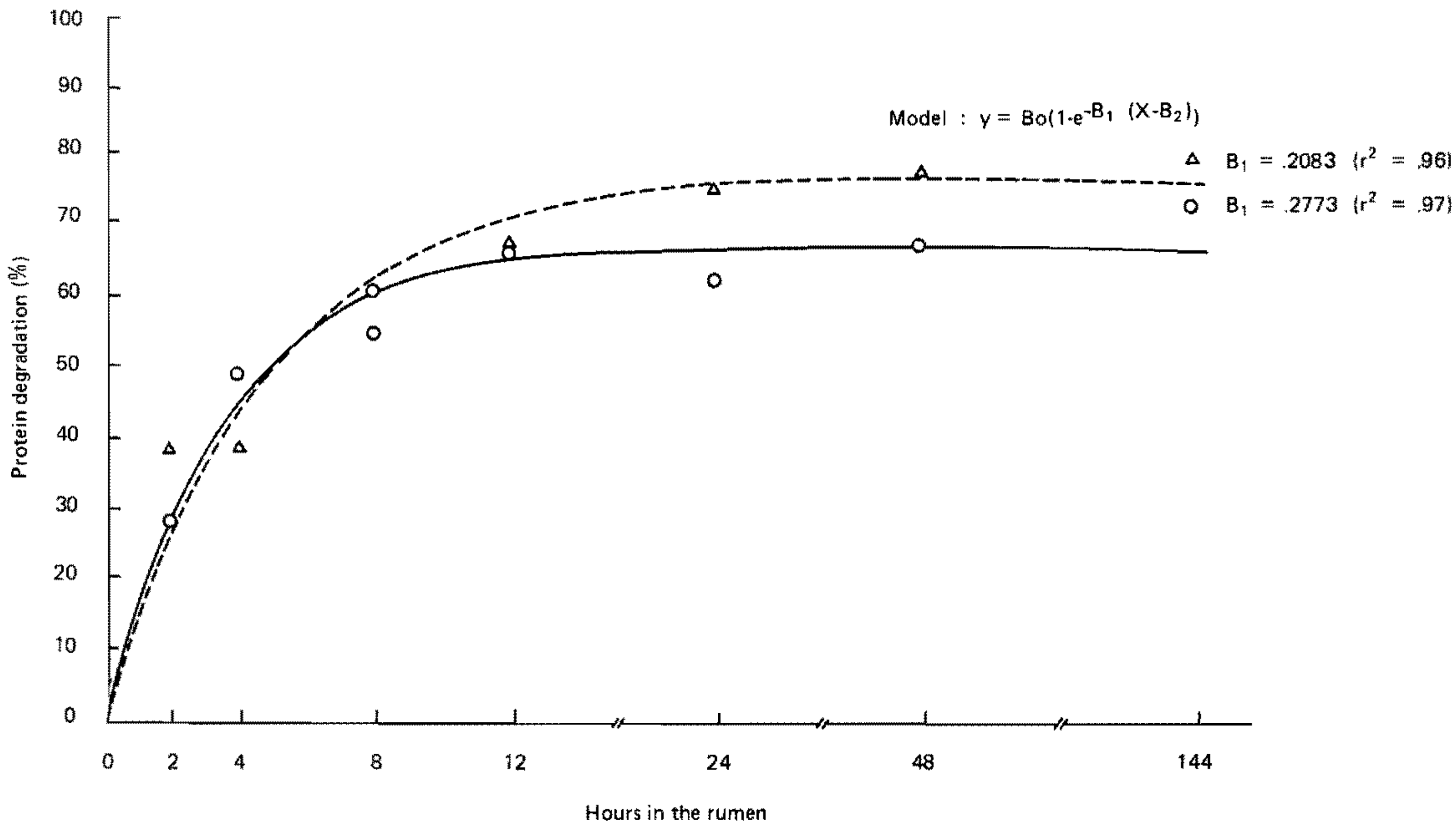


Figure 1. *In situ* **ruminal protein degradation of** *C. macrocarpum* **5065 using** *B. decumbens* **(o — o) and** *A. gayanus* **(△ — △) as basal diets (Quilichao).**

Table 2. *In situ* ruminal rates of protein degradation of legume leaves with two basal diets (Quilichao).

Legume	Rate of Degradation (Rumen)		
	Basal Diet		
	B. decumbens	*A. gayanus*	Mean
	---------------- B^{a} (hr^{-1}) ----------------		
C. arenarium 5236	.2752	.3475	.3114
C. macrocarpum 5065	.2773	.2083	.2428
C. caeruleum 9247 + 8159	.1171	.1573	.1372
D. guianensis 9311	.0541	.0552	.0547
R. reticulata 8173	.0284	.0373	.0329
D. ovalifolium 350	.0161	.0474	.0318
Mean	.1280[b]	.1422[b]	

a/ B_1 in model $y = Bo\ (i-e^{-B_1\ (X-B_2)})$

b/ Means with the same letter are not different ($P < .05$)

protein degradation and greater lag times (7.4 and 12.5 hours). Tannin content was significantly ($P < 0.05$) and negatively correlated r (= -.72) with ruminal protein degradation.

These results could either indicate that tannin containing legumes may be inadequate in terms of nitrogen for rumen bacteria or that they have a high proportion of potential by-pass protein, which could be a possitive attribute provided that the protein is digested in the lower tract. Future studies should be aimed at determining the exact amount of by-pass protein reaching the lower tract when animals are fed with legumes of a high tannin content.

Palatability of D. ovalifolium accessions

In 1982 it was reported that the accessions 3673, 3666, 3788 and 3784 had higher protein contents and less tannins than the accession 350, which was used as a control. Thus, it became of interest to determine if there were differences in palatability among accessions of D. ovalifolium. A "cafeteria" type trial including 18 accessions of D. ovalifolium and 1 accession of D. heterocarpon cv. Florida Carpon Desmodium was conducted in Quilichao in collaboration with the Germplasm section. The test was carried out using 6 animals in two blocks, with observations grazing time every 5 minutes (9AM-3PM) for two consecutive days. In the analysis of variance the difference due to accessions was not significant ($P < .160$). However, when the data were tabulated (Table 3) it was evident that accessions 3673, 3666 and 3784 had a tendency of being more preferred than the accession 350, which is consistent with the chemical analysis data.

Animal variability was large in this "cafeteria" test, as indicated by coefficients of variation ranging from 33.5% to 105.3%. It is suggested that observed animal variability may have resulted from great competition for more palatable accessions, particularly since plots per accession were small (18 m^2) and were not replicated in each block.

Palatability of S. guianensis "tardio" accessions

From observations made in small plot grazing trials in Carimagua it was suggested that S. guianensis "tardio" could have some palatability problems. In collaboration with the Legume Breeding section a "cafeteria" trial was conducted in Quilichao, including 10 accessions of S. guianensis "tardio", a positive control (S. capitata cv. Capica) and a negative control (S. scabra cv. Seca). The two controls were chosen on the basis of results included in the 1981 CIAT Annual Report. Accessions in the test were previously characterized in terms of yield, growth habit and degree of viscosity (Table 4). Yields ranged from 181 and 490 g DM/m^2 and growth habits from prostrate to very erect. Only the accession 1280 was found to be of low viscosity.

The palatability evaluation was carried out during 7 days after a 7 day adjustment period, making observations every 5 minutes on 8 animals in 2 blocks. In the analyses of variance the interaction accession x day was highly significant ($P < .0001$), so the data were analysed for each day (Figure 2). As expected, day 1 was the most

Table 3. Palatability ratings of accessions of *Desmodium ovalifolium* (Quilichao)

Accession No.	Preference Index (PI)
3673	1.66
3666	1.52
3784	1.52
3793	1.48
3608	1.27
3663	1.13
3674	1.04
3788	1.04
3794	1.04
350A	1.00
3781	0.86
365[2]	0.81
3607	0.75
3778	0.75
3668	0.65
350	0.61
3652	0.61
3776	0.61
3780	0.57

1/ PI = % observed grazing each accession / % expected grazing each accession with no preference (0.44)

2/ *Desmodium heterocarpon* cv. Florida Carpon Desmodium

Table 4. Attributes of accessions of *S. guianensis* "tardio" used in a palatability study (Quilichao).

Accession CIAT No.	Initial forage on offer g/m^2	Growth habit [1]	Viscosity [2]
1633	490	1	3
1280	422	2	1
2031	364	2	2
1283	360	3	2
2127	318	3	2
2812	315	3	3
1317	314	3	3
1009 (C-) [3]	287	1	3
10136	283	3	2
1062	255	3	3
10280 (C+) [4]	241	3	1
1808	181	3	2

1/ 1 = Erect 2 = Semi-erect 3 = Prostrate

2/ 1 = No viscosity 2 = Intermediate in viscosity 3 = High viscosity

3/ *S. scabra* cv. Seca (negative control)

4/ *S. capitata* cv. Capica (Positive control)

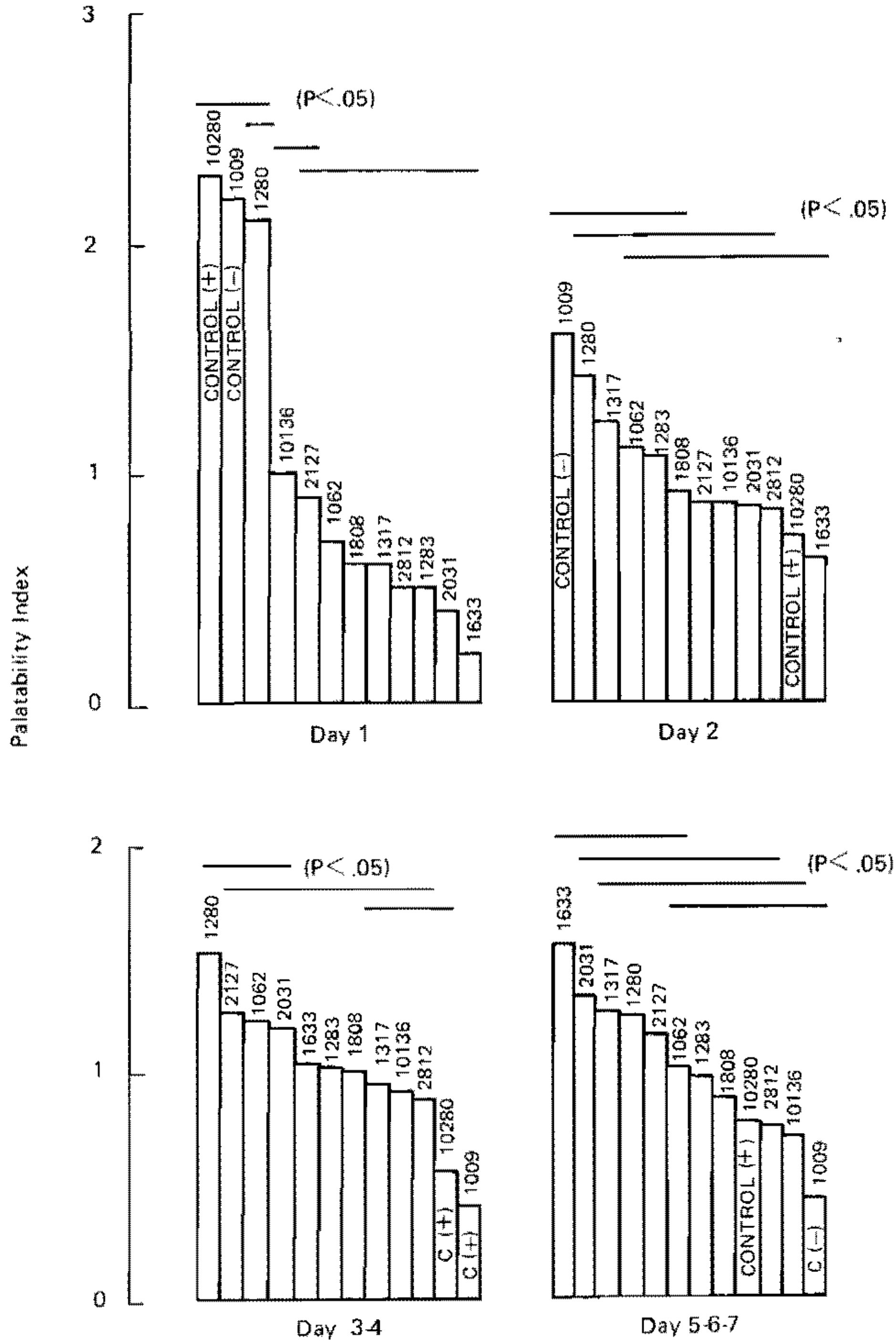


Figure 2. Palatability ratings of accessions of *S. guianensis* "tardío" in several days of evaluation (Quilichao).

sensitive to detect differences in palatability. The two controls were more palatable than 9 of the 10 accessions of S. guianensis "tardio". The accession 1280 was similar in palatability to accession 10136, but more palatable than the rest of introductions. The lack of difference between controls on the first day may have been due to low initial availability of S. capitata cv. Capica, in addition to a high rate of intake of this legume, as suggested by its low palatability index on the second day. On the following days (3, 4, 5, 6 and 7) differences between accessions were not consistent.

From the results of this trial it may be inferred that the S. guianensis "tardio" accession 1280 is more palatable than the rest of introductions evaluated. However, its rate of intake appears to be low, particularly when compared with the S. scabra cv. Seca (negative control). The better acceptability of 1280 may be related to its lower viscosity, eventhough it is not clear why it was as palatable as S. scabra cv. Seca which is very viscous.

In general, it may be stated that the legume S. guianensis "tardio" seems to be of low palatability. This characteristic combined with its high drought resistance may be a positive attribute in ecosystems like the Cerrados of Brazil with prolonged dry seasons. In addition, this legume could be of great value to supplement unburnt native grasses in the Llanos of Colombia. On the other hand, it is expected that associations of S. guianensis "tardio" with improved grasses such as A. gayanus in ecosystems with little drought stress, may require grazing managements that favor the grass (some form of rotational grazing).

Nutritive value and intake of some legumes

As a complement to studies on legume palatability the section has continued evaluating the nutritive value and voluntary intake of promising introductions.

During 1983 C. macrocarpum 5065, S. macrocephala 1643, S. guianensis "tardio" 1283 and Z. brasiliensis 7485 were fed green to crated sheep. The legumes fed had variable leaf-stem ratios, but in all cases with higher stem proportions (Table 5). The crude protein was highest in the leaves of C. macrocarpum 5065 and lowest in the leaves of S. guianensis 1283, with the other two legumes having intermediate values (Table 6). Higher and less variable dry matter intakes were recorded for C. macrocarpum 5065 and S. macrocephala 1643 as compared with the other two legumes which had very low and variable intakes. (Table 7). Animals fed with Z. brasiliensis 7485 exhibited digestive problems such as loss of feces, which was indicative of alcaloid problems. An analysis for alcaloids was carried out in Z. brasiliensis 7485 and in other 15 introductions of Zornia sp. Thin layer cromatography was used for detecting alcaloids together with the Dragendorff reagents (violet coloration = + reaction). Of the introductions included in the tests, only Z. brasiliensis 7485 was positive, which is consistent with the low intake and digestive problems found with this legume.

Table 5. Plant part composition of 4 legumes offered to sheep housed in metabolism crates (Quilichao).

Legume	Plant part		
	Leaf	Stem	Flower
	%		
C. macrocarpum 5065	43.4	56.6	-
S. macrocephala 1643	17.5	70.8	11.7
S. guianensis 1283	34.6	65.4	-
Z. brasiliensis 7485	12.9	79.3	7.8

Table 6. Chemical composition of 4 legumes offered to sheep housed in metabolism crates (Quilichao).

Legume	Whole plant		Plant part					
			Leaf		Stem		Inflorescence	
	CP[1]	NDF[2]	CP	NDF	CP	NDF	CP	NDF
	%							
C. macrocarpum 5065	17.0	60.3	25.1	46.1	12.4	69.4	-	-
S. macrocephala 1643	11.1	68.1	15.9	40.8	9.4	74.0	15.1	59.2
S. guianensis 1283	11.2	57.1	12.5	51.7	8.3	61.1	-	-
Z. brasiliensis 7485	10.4	58.1	17.9	34.7	9.2	69.0	19.4	30.6

1/ CP = Crude protein (N x 6.25)
2/ NDF = Neutral detergent fiber.

Table 7. Dry matter intake of 4 legumes offered to sheep housed in metabolism crates (Quilichao).

Legume	Intake ($gDM/kg^{.75}/day$)[1]					
	Animal					
	1	2	3	4	X	CV(%)
Z. brasiliensis 7485[2]	36.3	16.9	8.2	3.0	16.2	89.8
S. guianensis 1283	57.5	26.4	39.2	23.6	36.7	42.1
S. macrocephala 1643	43.3	58.7	63.2	53.7	54.7	15.6
C. macrocarpum 5065	67.3	56.2	73.7	56.4	63.4	13.6

1/ Measurements done for 7 days with a 10 day adjustment period.
2/ Animals exhibited diggestive problems.

In general, these results are in agreement with the total rejection of Z. brasiliensis when in association with grasses in small plot grazing trials in Carimagua, Colombia and CPAC, Brazil. In addition, the low intake of S. guianensis "tardio" 1283 is in agreement with the interpretation given to the results of the "cafeteria" trial with this legume.

SELECTING AND INTAKE STUDIES UNDER GRAZING

Legume selection in associations

Cafeteria type trials with legumes in pure stand are complemented by selectivity studies of legumes in association with a grass. During 1983 a small plot grazing trial was established in Quilichao to study the effect of three stocking rates on the selection of C. macrocarpum 5065, S. guianensis "tardio" 1283, S. macrocephala 1643, D. ovalifolium 3784, Z. brasiliensis 7485 and Zornia sp. 7847 in association with A. gayanus cv. Carimagua 1. Each paddock of different size, to generate stocking rates, is grazed for 3.5 days every 28 and 42 days in the wet and dry season, respectively. Up to this point several grazing have been done to generate differences in the pastures. During 1984 selectivity evaluations will be made, including measurements of botanical composition of the forage on offer and selected by esophageal fistulated steers.

Intake of B. humidicola

In the 1982 Annual Report it was indicated that in Carimagua the voluntary intake of B. humidicola was low as a result of a protein deficiency in the grass, which resulted in extremely low animal performance. To further confirm those results, a series of measurements were done in Quilichao with B. humidicola under grazing. Small plots were grazed at 3 different stocking rates, every 42 days. Results averaged across stocking rates are presented in Table 8. Intake in period I was greater than in periods II and III, eventhough

Table 8. Forage on offer and quality attributes of *B. humidicola* under grazing measured in three periods[1] (Quilichao).

Time of Measurement (month-year)	Forage on offer kg MS/ha	Crude Protein Diet %	Dry matter Digestibility %	Dry matter Intake g/kg$^{.75}$/day
Period I (12-81) + Water balance	2104	6.7 ± .4	53.6 ± 2.6	58.6 ± 9.8
Period II (2-82) - Water balance	1684	5.7 ± .4	50.6 ± 2.7	43.9 ± 10.3
Period III (8-82)[2] - Water balance	4315	4.9 ± .3	50.3 ± 1.4	43.2 ± 9.7

1/ Values reported are the average of 6 animals in each period.

2/ Fertilized with Mg, K, and S.

digestibility was similar in the three periods. The differences in intake between periods were more related to crude protein in the diet than to forage on offer. In addition, it is clear that B. humidicola looses quality rapidly, particularly in terms of crude protein.

The intake of B. humidicola and B. dictyoneura was measured in (Table 9) Quilichao with crated sheep. The results indicate that in both grasses, protein declined with time, but the reduction was greater in B. humidicola. The reduction in crude protein was accompanied by a considerable reduction in digestibility in both species and of intake in B. humidicola. Differences between species, particularly over time, could possibly be related to a higher leaf proportion in B. dictyoneura (Table 10).

A future research priority is to determine under grazing if real differences exist in quality between the two Brachiaria species, particularly over time. It is also of high priority to find a compatible legume for B. humidicola, since data obtained in Quilichao under cutting suggest a positive effect of D. ovalifolium in the quality of this grass. The crude protein of B. humidicola was always above 7% when the grass was associated with D. ovalifolium 350, which was not the case with nitrogen applications (100 kg/ha) or with an incompatible legume such as S. capitata (Figure 3). The lack of response of B. humidicola to nitrogen applications in terms of increasing nitrogen in the tissue was also found in cutting trials in Carimagua (see Soil Fertility and Plant Nutrition Section).

INTAKE OF B. decumbens WITH AND WITHOUT LEGUMES

In collaboration with the Pasture Productivity and Management section a series of measurements are being made in a grazing experiment with B. decumbens alone and associated with Kudzu in Carimagua. The experiment was established in 1978 and since 1979 it has been managed under continuous grazing with variable stocking rates (2 A/ha rainy season, 1 A/ha dry season). Animal performance during the dry season has been consistently better in the grass-legume pastures, but little differences have been found between pastures in the rainy season, up to the fourth year.

During 1983, intake measurements were made in the dry season and at the beginning of the rainy season. In both periods the pastures had more legume (61-68%) than grass. Legume selection was greater in the dry season (20%) than in the beginning on the rainy season (5%), which is consistent with results obtained in other grass-legume pastures.

The grass on offer in the legume based pasture showed a higher crude protein content than in the pure grass stand, particularly at the beginning of the rains (Table 11). This difference could be attributed to nitrogen transfer from the legume and to a younger grass regrowth in the association. Differences in crude protein due to the season of the year and pasture were also detected in the diet and faeces of the grazing animals (Table 12). The crude protein level in the diet was greater in the association in both sampling periods. Differences in quality between the grass and grass-legume pastures were not reflected in voluntary intake (Table 13). It is suggested

Table 9. Quality attributes of *B. humidicola* and *B. dictyoneura* offered to sheeps housed in metabolism crates (Quilichao).

Grass	First evaluation[1]			Second evaluation[2]		
	Crude Protein in the diet %	Dry matter digestibility %	Intake $gDM/kg^{.75}/day$	Crude Protein in the diet %	Dry matter digestibility %	Intake $gDM/kg^{.75}/day$
B. humidicola	11.3	59.1 ± 1.8	75.2 ± 2.0	4.8	50.0 ± 3.0	53.9 ± 7.0
B. dictyoneura	9.3	58.2 ± 1.9	68.4 ± 1.9	5.7	50.5 ± 4.5	63.3 ± 6.6

1/ Trial conducted in February 1982, using 8 week-regrowth material.

2/ Trial conducted in August 1982 using 6 week-regrowth material.

Table 10. Leaf-stem proportion of *B. humidicola* and *B. dictyoneura* used in feeding trial with crated sheep.

Grass	Forage Offered		Forage Consumed	
	Leaf	Stem	Leaf	Stem
	%		%	
B. humidicola	49 ± 6.9	51	69 ± 6.4	31
B. dictyoneura	64 ± 5.9	36	85 ± 8.4	15

Table 11. Crude protein in *B. decumbens* alone and in association with legumes (Carimagua).

Pasture	Season	Forage on offer			
		Whole plant	Leaf	Stem	Dead matter
		Crude protein (%)			
B. decumbens	Dry[1]	2.6 ± .3	4.7 ± .2	2.3 ± .1	1.8 ± .1
	Initial rains[2]	3.7 ± .2	6.9 ± .6	3.6 ± .6	2.3 ± .3
B. decumbens + legumes	Dry	3.2 ± .5	6.0 ± .3	3.4 ± .3	2.6 ± .3
	Initial rains	6.7 ± 1.7	9.0 ± 2.0	5.7 ± .6	3.2 ± .6

1/ February/83.
2/ April/83.

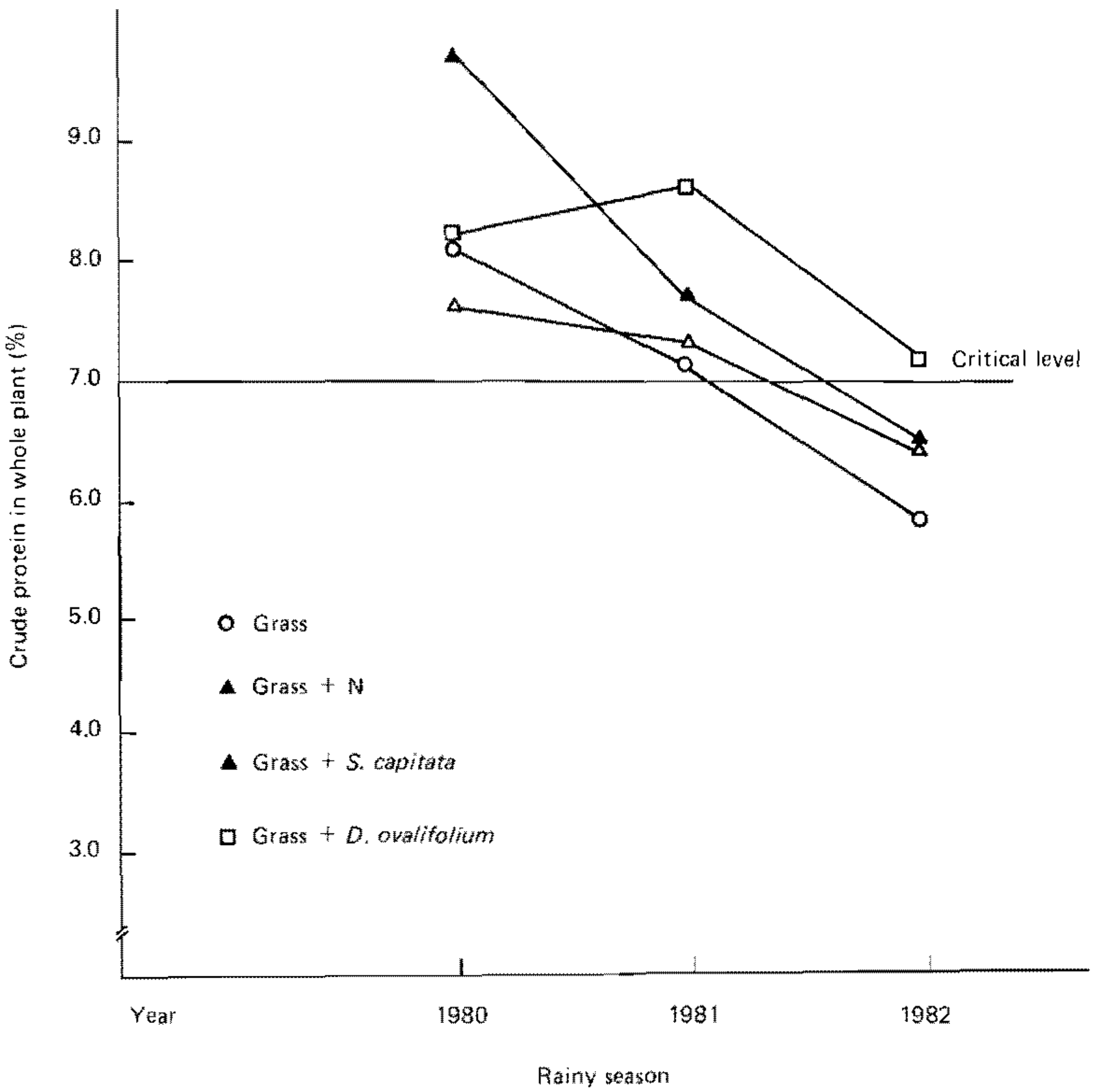


Figure 3. Crude protein content of *B. humidicola* under cutting with nitrogen application and in association with legumes.

Table 12. Crude protein content in forage on offer, forage selected and feces of animals grazing *B. decumbens* alone and in association with legumes.

Pasture	Season	Crude Protein			
		Forage on offer		Diet	Feces
		Grass	Legume		
		------------ % ------------		%	%
B. decumbens	Dry[1]	2.6 ± .3	-	5.0 ± .3	5.3 ± .6
	Initial rains[2]	3.7 ± .2	-	7.3 ± .4	8.4 ± .6
B. decumbens + legumes[3]	Dry	3.2 ± .5	8.8 ± 1.1	7.6 ± 1.0	7.0 ± .4
	Initial rains	6.7 ± 1.7	12.3 ± 2.2	10.0 ± 1.2	9.8 ± .4

1/ February/83.

2/ April/83

3/ Mixture of *P. phaseoloides* and *D. ovalifolium*

Table 13. Green dry matter on offer, digestibility (DMD) and intake of cattle grazing B. decumbens alone and in association with legumes (Carimagua).

Pasture	Dry season (February/83)				Initial rains (April/83)			
			Intake[3]				Intake	
	Grass[1] on offer kg/ha	DMD[2] %	DM g/kg$^{.75}$/day	CP g/kg$^{.75}$/day	Grass on offer kg/ha	DMD %	DM g/kg$^{.75}$/day	CP g/kg$^{.75}$/day
B. decumbens	1037 ± 236	30.9 ± 5	39.4 ± 7	2.0	1546 ± 271	60.7 ± 3	53.1 ± 9	3.9
B. decumbens + legumes[4]	268 ± 3	39.2 ± 4	43.1 ± 5	3.3	457 ± 51	60.8 ± 3	57.7 ± 9	5.8

1/ Includes leaves and stems of the grass.
2/ Estimated with indigestible neutral detergent fiber as internal marker.
3/ Estimated with chromium oxide paper as extense marker.
4/ Legumes: Mixture of P. phaseoloides 9900 and D. ovalifolium 350.

that the superior animal performance in the association during the dry season is due to a higher protein intake. In addition, it appears that in both periods grass availability may have limited intake in the legume based pasture (Table 13).

Measurements will continue to be made in these pastures in an attempt to explain differences in animal performance.

ALTERNATE USE OF GERMPLASM

Intake of S. capitata and P. phaseoloides

The Program has been testing the idea of using legumes in pure stand as a complement to native savanna. More recently legumes have been introduced in savanna with no burning management. In both systems, it is believed that in order for the legume not be grazed out, it should be, to a certain extent, of low palatability and rate of intake. Therefore, it was considered important to measure intake under grazing of two commercial legumes (S. capitata cv. Capica and P. phaseoloides). Mesurements were done in the rainy season (June 1983) in pure stand legume blocks. Both legumes were mature, but Kudzu had a greater leaf proportion than Capica. In order to keep a similar grazing pressure (16 kg DM/100 kg BW/day) in both blocks, number of grazing animals were adjusted according to size of block and forage on offer. Digestibility and intake were considerably greater in Capica than in Kudzu (Table 14).

The low voluntary intake of Kudzu explains the poor animal performance usually observed when this legume becomes dominant in association with grasses. This points out the importance of managing associations with Kudzu in such a manner as to favor the grass, particularly in ecosystem with little drought stress. On the other hand, the low intake rate of Kudzu and its high crude protein content seem to be positive factors for the use of this legume as a supplement of native savanna. In contrast, Capica would not appear to be a good option to supplement savanna since it would rapidly be grazed out due to its high rate of intake. In this respect some experience was gained in Carimagua during 1983.

The legume S. capitata was used as a protein bank to complement native savanna, using 2000 m^2 of legume per animal and two stocking rates (0.25 and 0.50 $A.ha^{-1}$). The native savanna was managed with traditional burning and animals had free access to the legume all year round. The forage on offer on the bank was reduced drastically in an 8 month period (Figure 4), due to heavy grazing in both the dry and wet seasons (Table 15). In both the low and high stocking rates animals substituted grass for legume, eventhough the native grass was managed with burning. The experience with Kudzu as a protein bank has been somewhat different, since animals heavily graze the legume only during the end of the rainy season and dry season.

The high quality of S. capitata could be of great value for raising early weaned calves in programs directed towards improving reproductive performance of breeding cows.

Table 14. Fecal production, digestibility (DMD) and intake of cattle grazing *S. capitata* and *P. phaseoloides*[1] (Carimagua).

Legume	Fecal production g MS/kg$^{.75}$/day	DMD %	Intake g MS/kg$^{.75}$/day
P. phaseoloides	21.4 ± .60	39.8 ± 1.5	35.7 ± 1.9
S. capitata	33.0 ± 4.3	46.5 ± 1.2	61.7 ± 9.1
Diference (%)	35.1	14.4	42.0

1/ Values are the mean of 3 animals in each legume.

Table 15. Grazing frequency in native savanna supplemented with a *S. capitata* bank (Carimagua).

Stocking rate (A/ha)	Season	Grazing frequency (5am - 7pm) Savanna	Bank
	Dry	%	%
0.25	January	67	33
	March	65	35
0.50	January	58	42
	March	60	40
Mean		62.5	37.5
	Rainy		
0.25	May	53	47
	July	69	31
	September	53	47
0.50	May	39	61
	July	64	36
	September	57	43
Mean		55.8	44.2

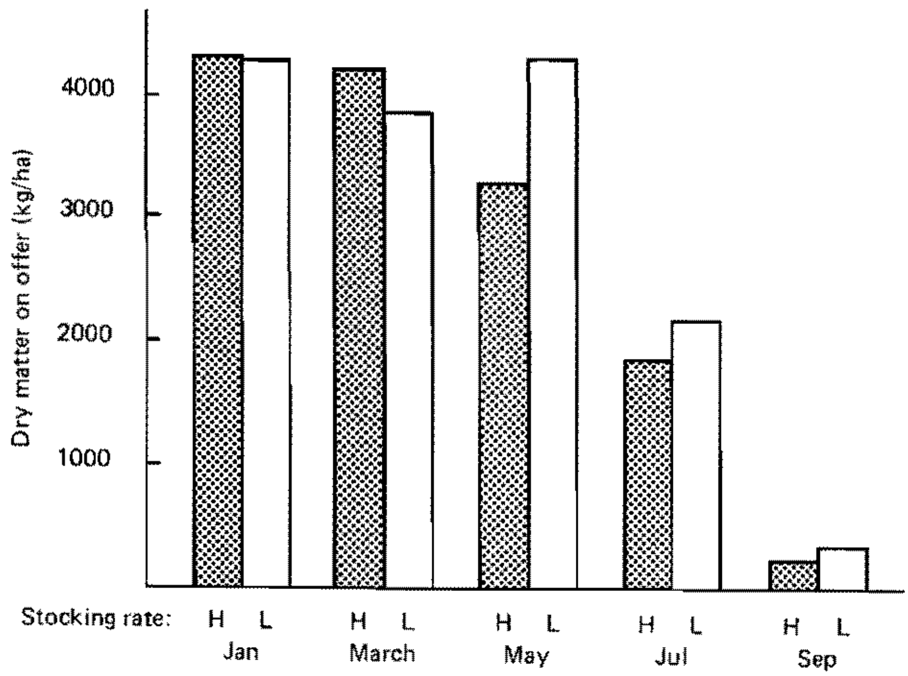


Figure 4. **Legume on offer on a *S. capitata* bank complementing native savanna under two stocking rates (H = 0.5 A/ha L = 0.25 A/ha) (Carimagua).**

PASTURE PRODUCTIVITY AND MANAGEMENT

The following objectives of this section have been maintained during 1983:

1. to determine the potential animal productivity of promising germplasm adapted to the well-drained isothermic savanna ecosystem represented by Carimagua; and

2. to determine the appropriate management for persistence and stability of the desirable pasture components.

PROTEIN BANKS

Stylosanthes capitata

In view of the good results obtained during 4 years on burned savannas with complementary grazing on Pueraria phaseoloides as a protein bank, a similar experiment with S. capitata CIAT 1315 was initiated. In September 1981 an area of 1.6 ha was established with fertilization with 50 kg P_2O_5, 22 kg K_2O, 11 kg MgO and 22 kg S per hectare, and in May 1983 a maintenance fertilization was applied with 1/3 the amount used for establishment. Grazing was initiated in January 1983 with free access of animals to the bank offering 2000 m^2 per animal. Stocking rates were 0.25 and 0.50 animals/ha, and the savanna was managed by burning 1/3 of the area at the beginning and end of the dry season. First year results (Table 1) show that the mean daily liveweight gains during the dry season were greater than those obtained during the previous years with P. phaseoloides (78 and 183 g/an/day at stocking rates of 0.25 and 0.50 an/ha, respectively), with no significant differences ($P < 0.05$) between stocking rates.

During the rainy season the mean liveweight gains were not different from those obtained during the dry season, and there were no significant differences ($P < 0.05$) between stocking rates. The animal productivity at the end of the year was slightly lower than the mean obtained with P. phaseoloides during the 4 previous years (109 kg/animal). This was due to deficient persistence of S. capitata under the conditions of free access to the bank (Figure 1) because of the relatively high palatability of the species. Even though the savanna was burned at the beginning of the rainy season, the animals continued grazing the bank intensively throughout the year, contrary to the experience with P. phaseoloides.

Desmodium ovalifolium

The evaluation of this species in a protein bank was initiated last year with accession CIAT 350, but had to be suspended in 1983,

Table 1. Mean liveweight gains of steers on burned savanna and complementary grazing on *Stylosanthes capitata* banks[1] in Carimagua, 1981-83.

Stocking Rate	Dry season 110 days		Rainy season 242 days		Total Annual 352 days	
an/ha	g/an/day	kg/an	g/an/day	kg/an	g/an/day	kg/an
0.25	247 N.S.	27	314 N.S.	76	291 N.S.	103
0.50	283	31	322	78	309	109
Average	265 N.S.	29	318 N.S.	77	300	106

1/ 2000 m^2/animal, free access.

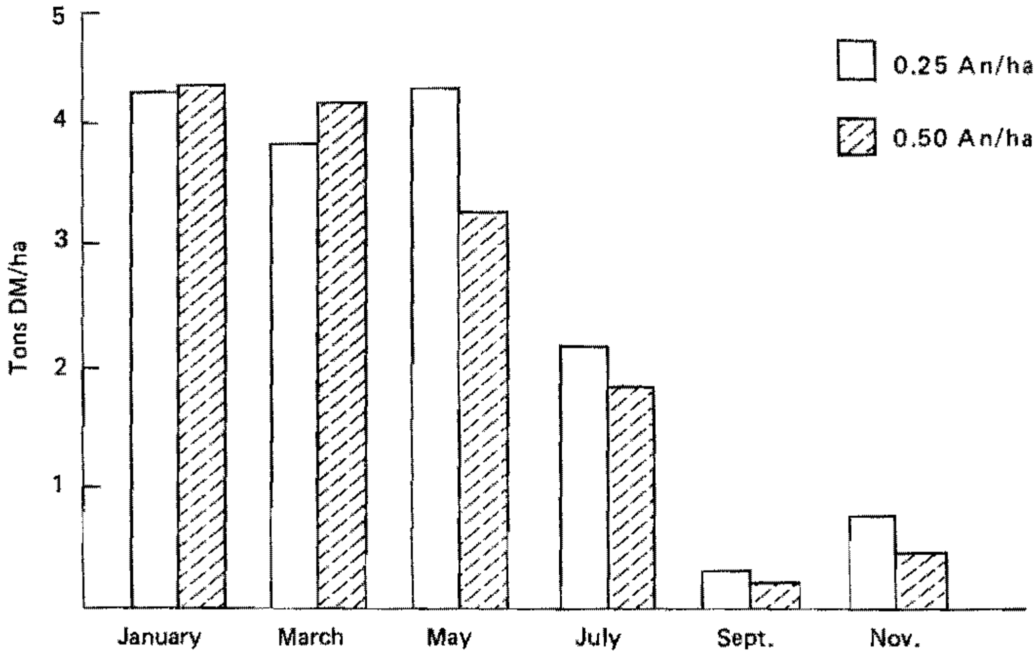


Figure 1. Availability of total forage of *S. capitata* in protein banks on savanna with two stocking rates in Carimagua during 1983.

due to a severe attack of stem gall nematode, which practically destroyed the stand. It is expected that with new resistant materials a similar experiment can be initiated in a near future.

Pueraria phaseoloides

The evaluation of this legume established in blocks and strips, for complementary grazing on Brachiaria decumbens, was continued in the fifth year of continuous grazing after maintenance fertilization at the beginning of the rainy season with 15 kg K_2O, 8 kg MgO and 18 kg S per hectare, and light disking of the B. decumbens stand. The best results (Table 2) were obtained in the strips treatment which were significantly greater ($P < 0.05$) than the others during both seasons of the year. The annual animal productivity on the strips treatment was higher than the mean obtained during the 4 previous years (170 kg/animal); contrary to this in the blocks and grass alone treatments, the means were remarkably inferior (157 and 145 kg/animal, respectively). This was probably due to the fact that disking of the pure grass stand apparently did not have any effect on improving forage on offer. In the strips treatment the forage on offer was maintained with an adequate grass-legume balance (Figure 2).

LEGUME ASSOCIATIONS

Brachiaria decumbens - Desmodium ovalifolium

This experiment was established in 1982 with the objective to determine the potential animal productivity under different stocking rates and grazing and to determine proper management including maintenance fertilization with sulfur. The design consisted of a split plot with continuous, alternate and rotational (14 days of occupation and 42 days rest) grazing in the main plots and three stocking rates (1.15, 2.30 and 3.45 animals/ha) in the subplots; furthermore, a treatment without maintenance fertilization with sulfur was included at the medium stocking rate level. The pastures were established with commercial B. decumbens and D. ovalifolium CIAT 350 fertilized with 50 kg P_2O_5, 44 kg K_2O, 22 kg MgO and 44 kg S per hectare. In 1981 and 1982 a maintenance fertilization was applied with 20 kg S/ha as gympsum. Until the experimental stocking rates were imposed in December 1982, the pastures were grazed intermittently at low stocking rates (1-2 animals/ha). First year results of liveweight gains (Table 3) show that there was no significant difference ($P < 0.05$) between grazing systems, and neither there was a significant difference ($P < 0.05$) between the means for the low and medium stocking rates. However, liveweight gains were significantly lower ($P < 0.05$) in the high stocking rate treatment. Besides, there was an interaction between stocking rate and grazing system: At the highest stocking rate, the alternate and rotational systems produced more than the continuous grazing system (Figure 3). The annual animal productivity mean of all systems at the medium stocking rate (2.30 animals/ha), reach levels which exceed the best results obtained in Carimagua with B. decumbens pastures (Table 4), except in the above reported experiment with P. phaseoloides. In regard to maintenance fertilization with sulfur (Table 5), there were no significant effects

Table 2. Mean liveweight gains of steers in *Brachiaria decumbens* alone and with complementary grazing[1] on *Pueraria phaseoloides* (Kudzu) in blocks and strips during the fifth year[2] of continuous grazing in Carimagua, 1983.

Treatment	Stocking Rate[3]	Dry season 110 days		Rainy season 242 days		Total Annual 352 days		
	an/ha	g/an/day	kg/an	g/an/day	kg/an	g/an/day	kg/an	kg/ha
Grass alone	1.0/2.0	359 c	39	310 b	75	325 c	114	189
Grass + *Pueraria phaseoloides* in blocks	1.0/2.0	488 b	54	364 b	88	402 b	142	230
Grass + *Pueraria phaseoloides* in strips	1.0/2.0	611 a	67	533 a	129	557 a	196	325
Average		486	53	402	97	428	151	248

1/ 30% of the area, free access.
2/ Maintenance fertilization: 15 K_2O, 8 MgO, 15 S, kg/ha. Disking of the grass stand.
3/ Dry/wet seasons, respectively.

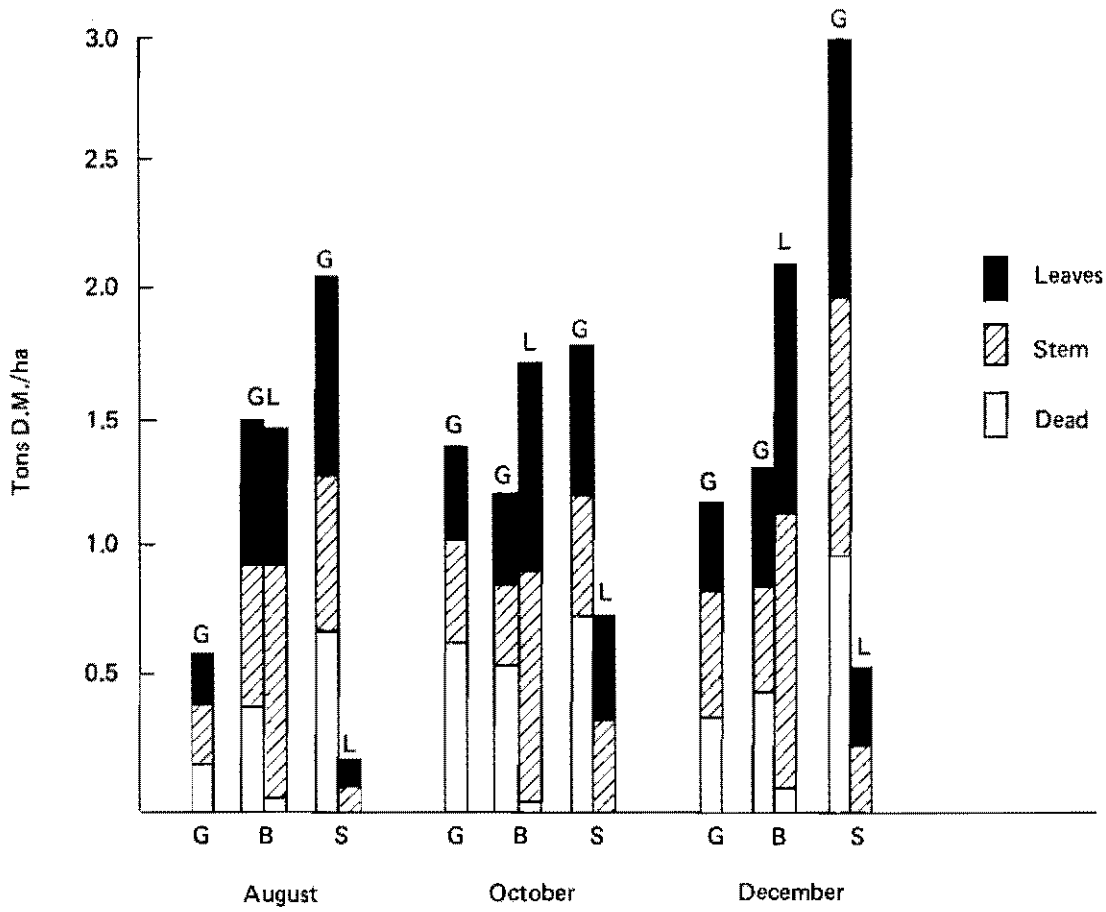


Figure 2. **Availability of forage and plant part composition of *B. decumbens* alone (G) and with complementary grazing on *P. phaseoloides* in blocks (B) and strips (S) during the fifth year of continuous grazing in Carimagua, 1983. (G = grass; L = legume).**

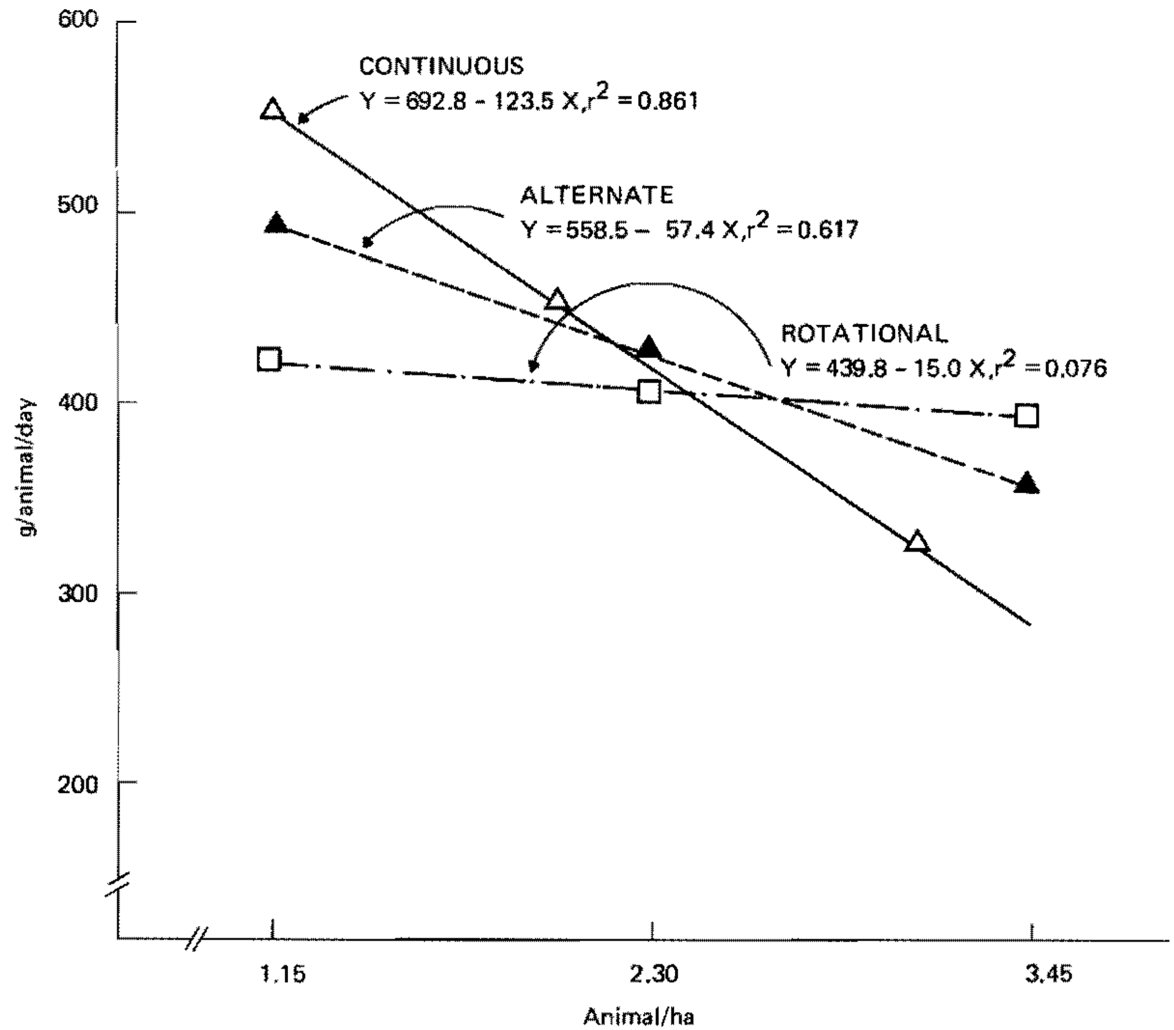


Figure 3. Interaction between stocking rates and grazing systems in *B. decumbens* + *D. ovalifolium* in Carimagua, 1982-83.

Table 3. Mean liveweight gain of steers in *Brachiaria decumbens* - *Desmodium ovalifolium* CIAT 350 with different grazing systems in Carimagua[1], 1982-83.

System	Stocking rate (an/ha) 1.15	2.30	3.45	Average
		g/an/day		
Continuous	521	469	237	409 a
Alternate	463	486	331	427 a
Rotational	414	422	379	405 a
Average	466 a	459 a	316 b	413

1/ Maintenance fertilization 20 kg S/ha.

Table 4. Annual animal productivity of *Brachiaria decumbens* - *Desmodium ovalifolium* CIAT 350 with different grazing systems in Carimagua[1], 1982-83.

System	Stocking rate(an/ha) 1.15		2.30		3.45	
	kg/an	kg/ha	kg/an	kg/ha	kg/an	kg/ha
Continuous	187	215	167	384	85	293
Alternate	166	191	175	402	119	410
Rotational	149	171	152	350	136	469
Average	168	193	165	379	114	393

1/ Maintenance fertilization 20 kg S/ha.

($P < 0.05$) between treatments. However, there was an interaction between grazing system and fertilization related to daily liveweight gains per animal (Figure 4). The availability of forage decreased throughout the year due to stocking rate effects (Figure 5); regarding the legume on offer, its decrease was also due to defoliation caused mainly by stem nematode and the fungus Synchytrium desmodii.

Initially, the maintenance fertilization with 20 kg S/ha did not have any effect on forage availability in the different grazing systems. However, later in the year, especially during the rainy season, interactions between S fertilization and grazing system appear (Figure 6). Naturally, in view of the decrease of the legume component because of pathogens, it is not possible to explain the effect of sulfur on the stability of pasture components.

Brachiaria humidicola - Desmodium ovalifolium

At the end of the dry season and in collaboration with the Plant Pathology Section, burning and mowing treatments were imposed on all replications in this experiment, in order to possibly reduce the damage caused by the stem gall nematode to mature D. ovalifolium plants, at the same time as new seedlings develop from seeds accumulated during the dry season. After a maintenance fertilization with 22 kg K_2O, 11 kg MgO, and 22 kg S per hectare, grazing was re-initiated with stocking rates of 2.5, 3.5, and 4.5 animals/ha, alternating between the burning and mower treatments. Results in terms of daily liveweight gains during the rainy season (Table 6) were similarly high to those obtained with B. decumbens - D. ovalifolium at similar stocking rates (Table 3). This was due to the abundance of leafy forage on offer during the first part of the season (Figure 7) including legume material since initially D. ovalifolium responded positively to the treatments. However, the same figure shows that towards the end of the season most of the forage on offer was made of dead material and that the legume component had disappeared due to pathogenic effects, combining the stem nematode and the fungus Synchytrium desmodii. Furthermore, for the first time in Carimagua these pastures presented a severe attack of "spittlebug" which caused considerable damage on B. humidicola.

LIVEWEIGHT GAINS WITH DIFFERENT CATEGORIES OF ANIMALS

Grazing started in 1983 in a former Melinis minutiflora pasture into which an association of A. gayanus/ S. capitata was established. Treatments consisted of continuous grazing at 3 stocking rates (initially 1.09, 1.46 and 1.83 A.U./ha (=350 kg/ha), then adjusted to 1.38, 1.85, and 2.32 A.U./ha, respectively), and 4 different categories of animals: culled cows, growing heifers, fattening steers, and growing steers. The objective is to evaluate animal performance in relation to sex, weight, age and stocking rate effect. Preliminary results from part of the rainy season (Table 7) show a general tendency for the male animals to gain weight at a higher rate than females, especially at low and high stocking rates. At the medium stocking rate this tendency does not become evident because of some of the females being pregnant when the groups of animals were

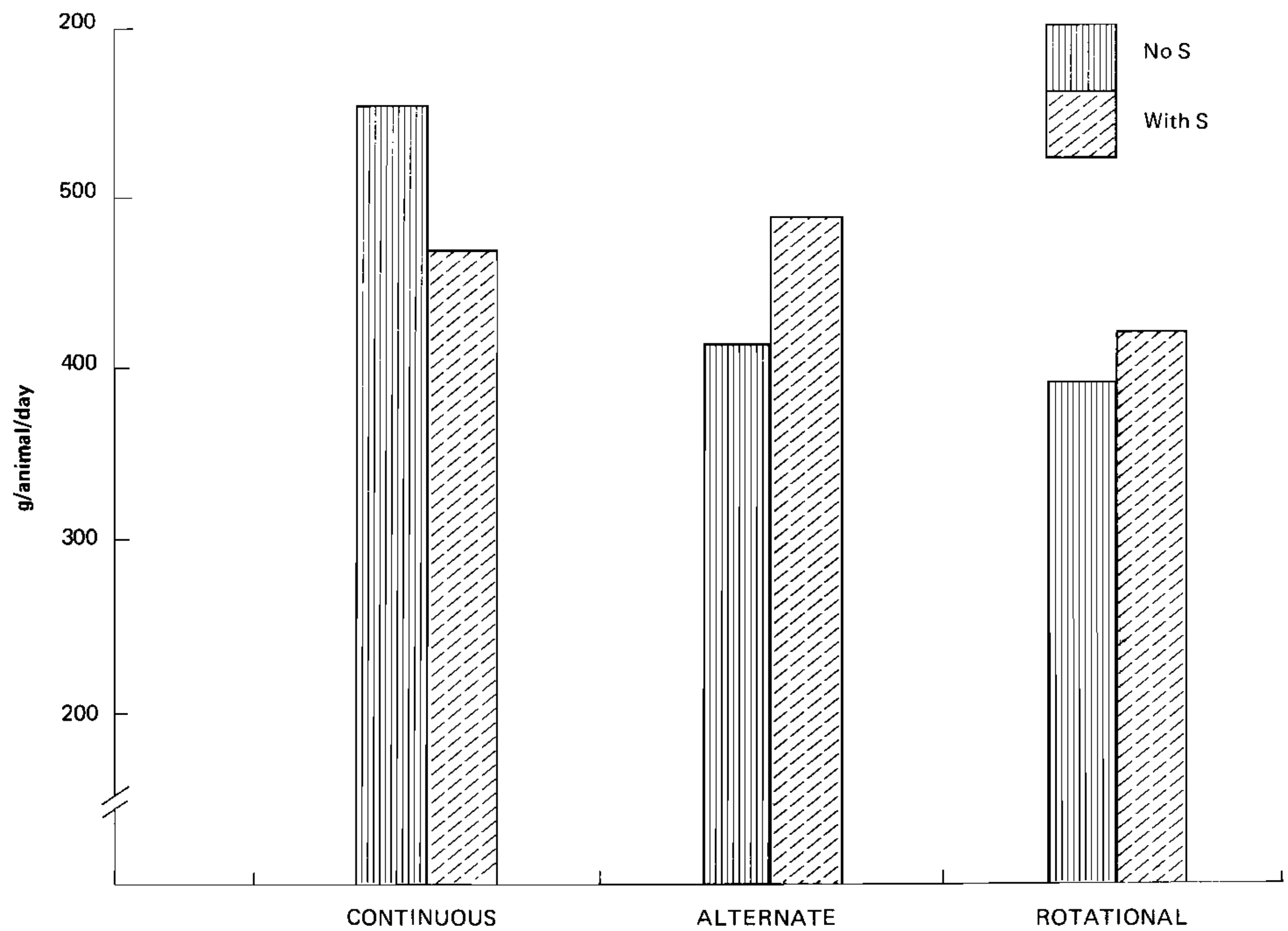


Figure 4. Interaction grazing system-maintenance fertilization with 20 kg S/ha in *B. decumbens* + *D. ovalifolium* in Carimagua, 1982-83.

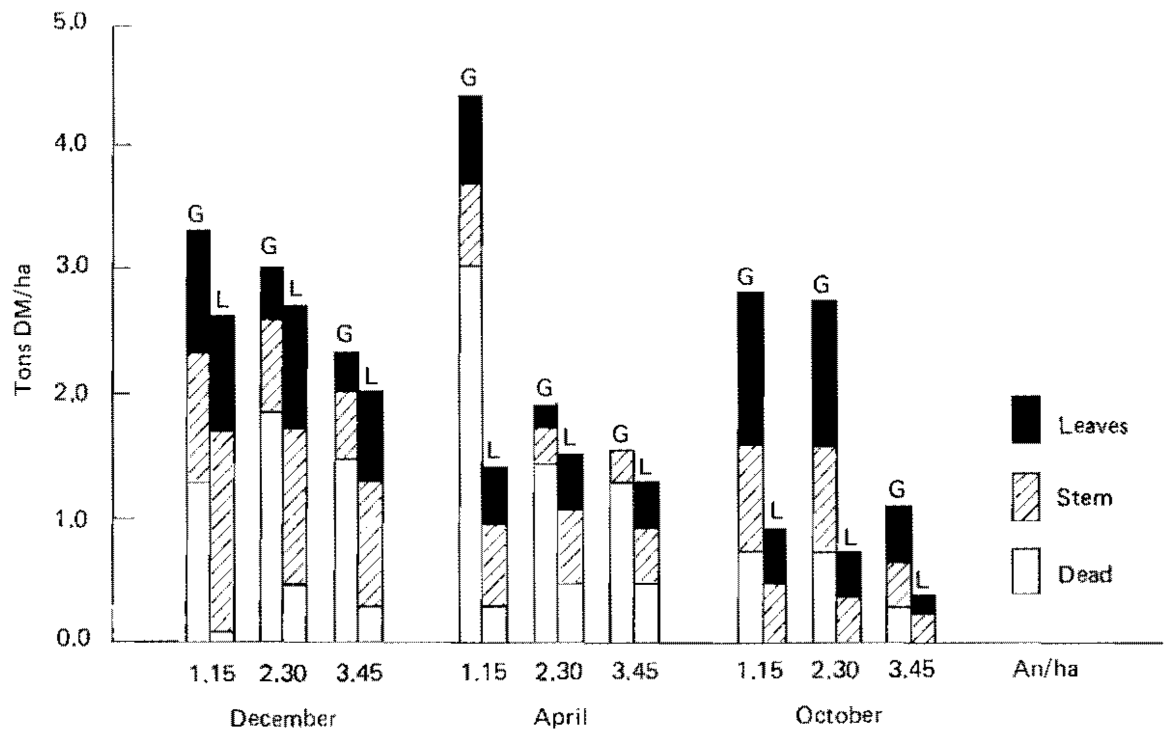


Figure 5. Availability of forage and plant part composition of *Brachiaria decumbens* (G) and *Desmodium ovalifolium* (L) (average for the three grazing systems) at three stocking rates during the first year of grazing in Carimagua, 1982-83.

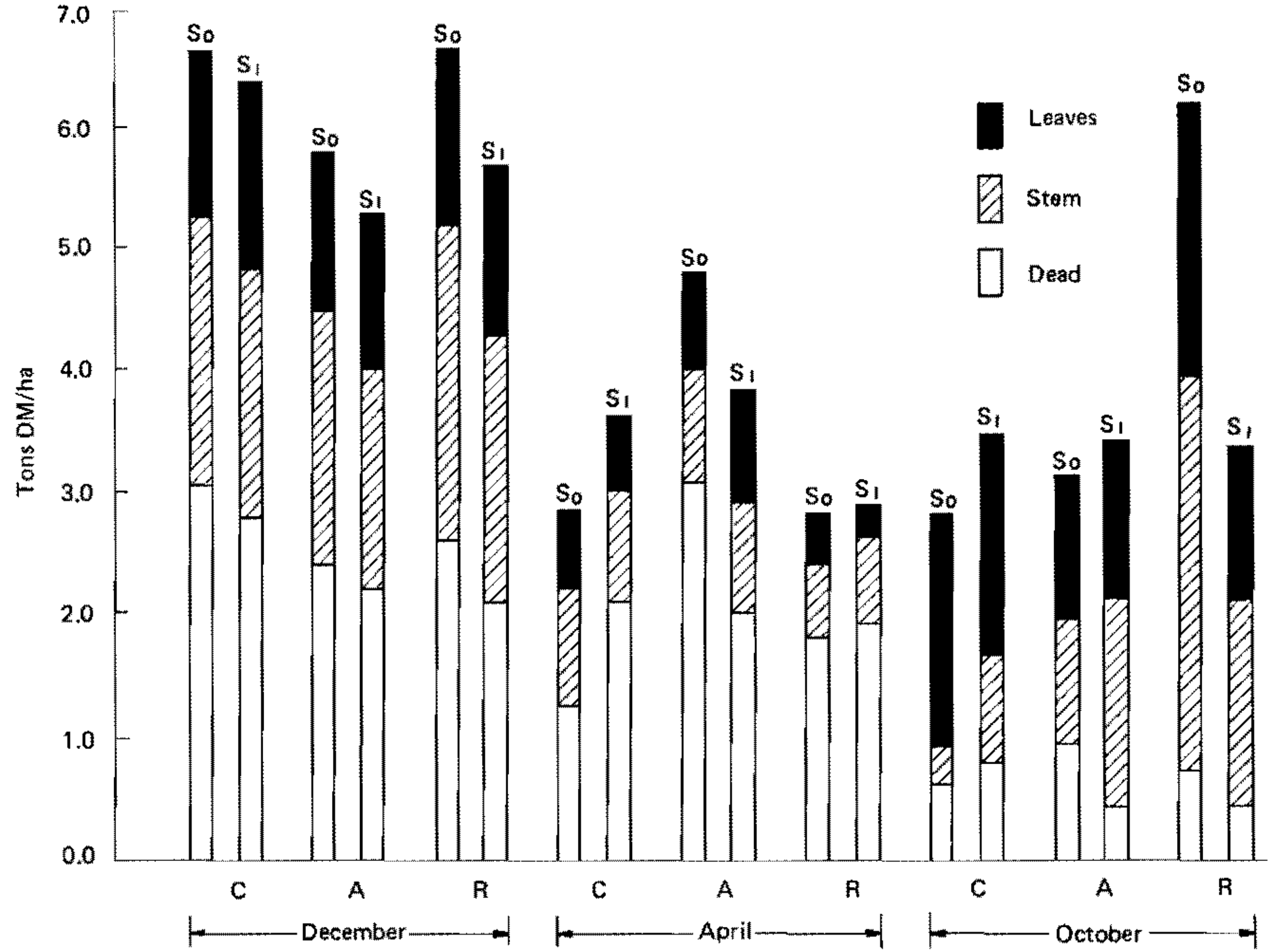


Figure 6. Effect of maintenance fertilization with sulphur (S_1) on the total availability of forage and plant part composition of *B. decumbens - D. ovalifolium* on continuous (C), alternate (A) and rotational grazing (R) at a stocking rate of 2.3 animales/ha in Carimagua during 1982-83 (S_0 = no S fertilization).

Table 5. Effect of maintenance fertilization on liveweight gains of steers on *Brachiaria decumbens* - *Desmodium ovalifolium* CIAT 350 under different grazing systems[1] in Carimagua, 1982-1983.

System	Maintenance Fertilization		Average
	Control	20 kg S/ha	
		g/an/day	
Continuous	551	469	510 a
Alternate	417	486	451 b
Rotational	390	422	406 c
Average	453 a	459 a	456

1/ Fixed stocking rate (2.30 an/ha).

Table 6. Mean liveweight gains of steers in *Brachiaria humidicola* - *Desmodium ovalifolium* CIAT 350 at different stocking rates in Carimagua. Rainy season[1], 1983.

Stocking Rate	Liveweight gains		
	Per animal		Per Area
an/ha	g/an/day	kg/an	kg/ha
2.5	434 a	103	258
3.5	361 a	86	301
4.5	329 a	78	352
Average	374	89	303

1/ 238 days.

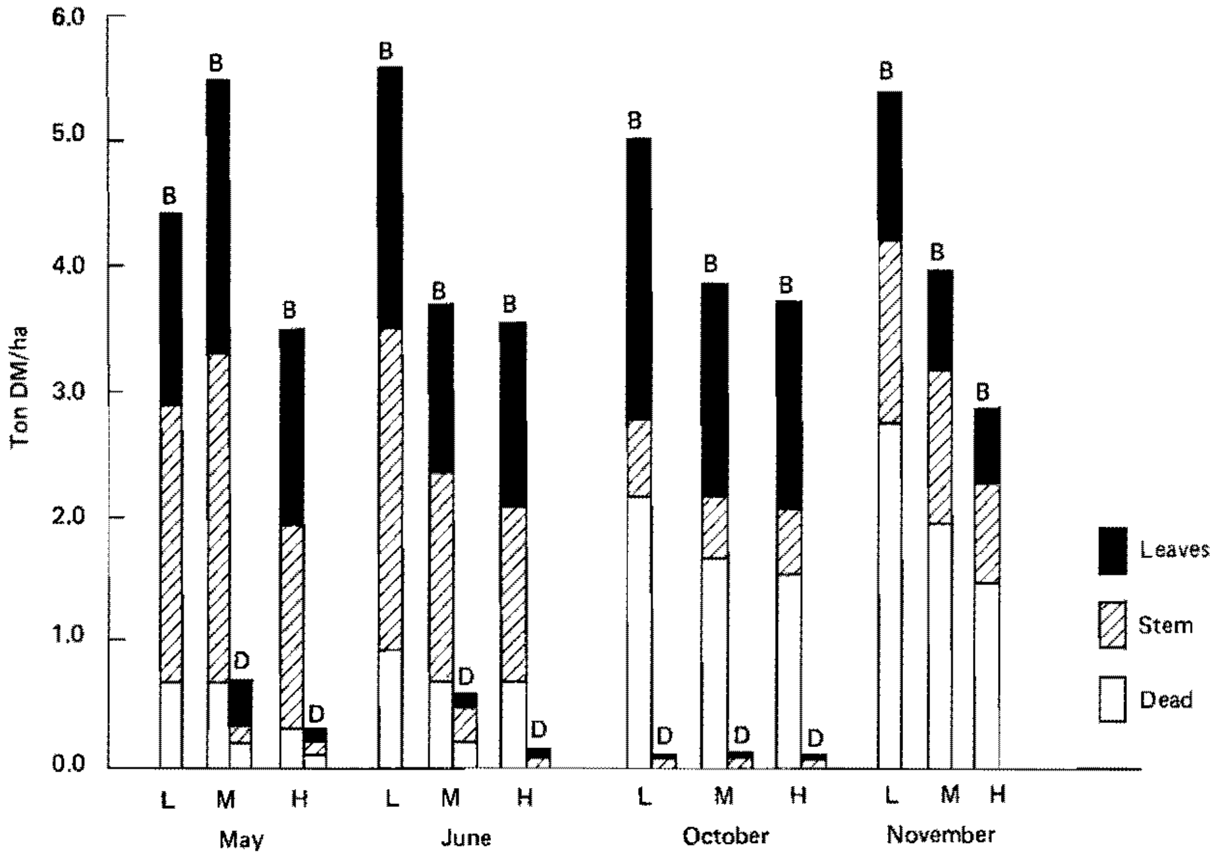


Figure 7. **Forage availability and plant part composition of *B. humidicola - D. ovalifolium* at three stocking rates (L= 2.5, M= 3.5 and H= 4.5 animals/ha, respectively) after burning in Carimagua during 1983 (B = *B. decumbens*; D = *D. ovalifolium*).**

Table 7. Mean liveweight gains of different animal categories at different stocking rates an *A. gayanus* - *M. minutiflora* - *S. capitata* association in Carimagua, rainy season[1], 1983

Type of Animal	Low Stocking Rate 1.09/1.38 A.U.[2]/ha		Medium Stocking Rate 1.46/1.85 A.U./ha		High Stocking Rate 1.83/2.32 A.U./ha	
	g/an/day	kg/an	g/an/day	kg/an	g/an/day	kg/an
Culled cows	300	54	357	44	247	44
Growing heifers	258	46	552	68	351	63
Fattening steers	364	65	552	68	511	92
Growing steers	372	67	302	37	475	85
Average	323	58	440	54	396	71

1/ 180 days for low and high stocking rates, 123 days for medium stocking rate.

2/ A.U. = 350 kg.

formed. It was not possible to observe in this first year of grazing a significant tendency related to age of animals, by comparing culled cows with growing heifers, and fattening with growing steers.

Figure 8 shows that there was no decrease of forage availability with time, but that after the August sampling a very substantial reduction of the amount of leaves on offer occurred. This may affect liveweight gains during the next dry season, although stocking rates will be considerably reduced by then, since the culled cows and fattening steers remain in the experiment only during the dry season.

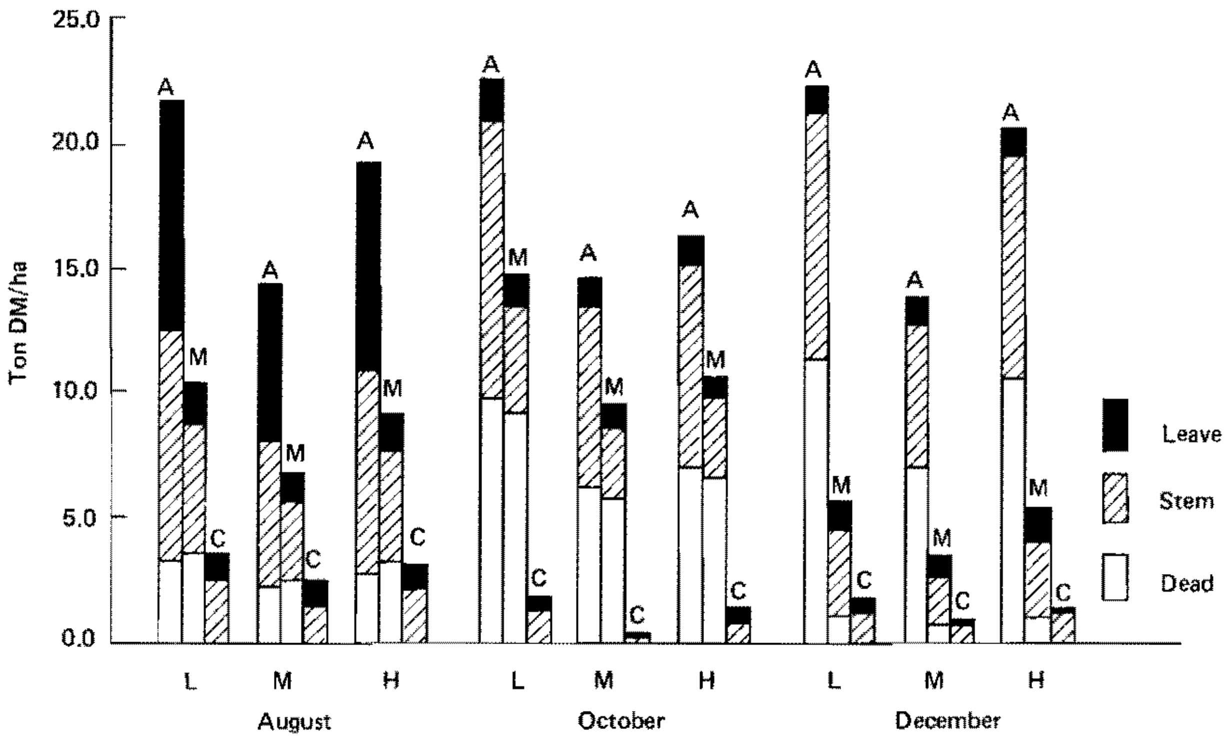


Figure 8. Availability of forage and composition of plant parts of *A. gayanus* (A), *M. minutiflora* (M) and *S. capitata* (C) under continous grazing by different animal categories at 3 stocking rates, low (L), medium (M) and high (H) in Carimagua, rainy season 1983.

STUDIES ON NATIVE SAVANNA OF LLANOS OF COLOMBIA

Observations and measurements of burning and grazing effects on native savanna vegetation were continued in Carimagua in 1983. In addition, measurements of the savanna were carried out in the Yopare site.

INTRODUCTION II SAVANNA

Objectives

To investigate the effects of burning date on the savanna vegetation under different grazing intensities.

Materials and Methods

Savanna vegetation was investigated using a modified line interception method was ten one-meter lines in each plot (Figure 1).

Results and Discussions

Recovery of the savanna is more rapid on the area burnt at the end of the dry season than at the beginning of dry season. Plant coverage is always higher at the high stocking rate than at the low stocking rate, but the pattern of recovery is the same for both stocking rates. Plant coverage during the second year after burning is lower than the first year (Figure 2).

Trachypogon vestitus predominates at site I and II at both stocking rates. At site III, it is competitive with *Paspalum pectinatum* at high stocking rate but *P. pectinatum* predominates at the low stocking rate. Last year the same tendency was observed even before the first burning. It was thought that there were gradual changes in soil texture from site I to site III which might result in the differences in distribution of these species among sites (Figures 3a, 3b). Even though, Blydenstein (1967) concluded that the geographical distribution of savanna vegetation is primarily due to soil conditions, no clear evidence to explain the *Paspalum* predominance is given in the Table 1. Clay content is very high and there is no significant difference among the sites. *T. vestitus* is generally thought to predominate in these soils as indicated by Blydenstein (1967).

In summary, burning time has little effect on the basic structure of savanna vegetation but does affect the speed of recovery of plants in the stable savanna like the Llanos.

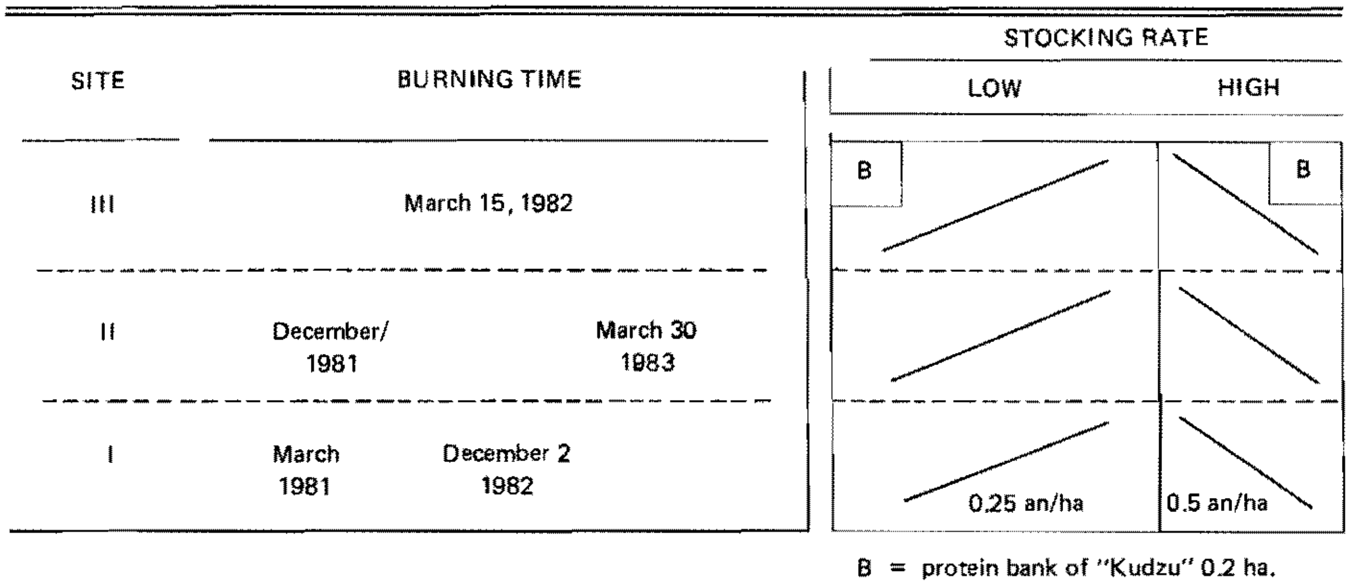


Fig. 1. Outline of the area studied - Carimagua, (Introduction II).

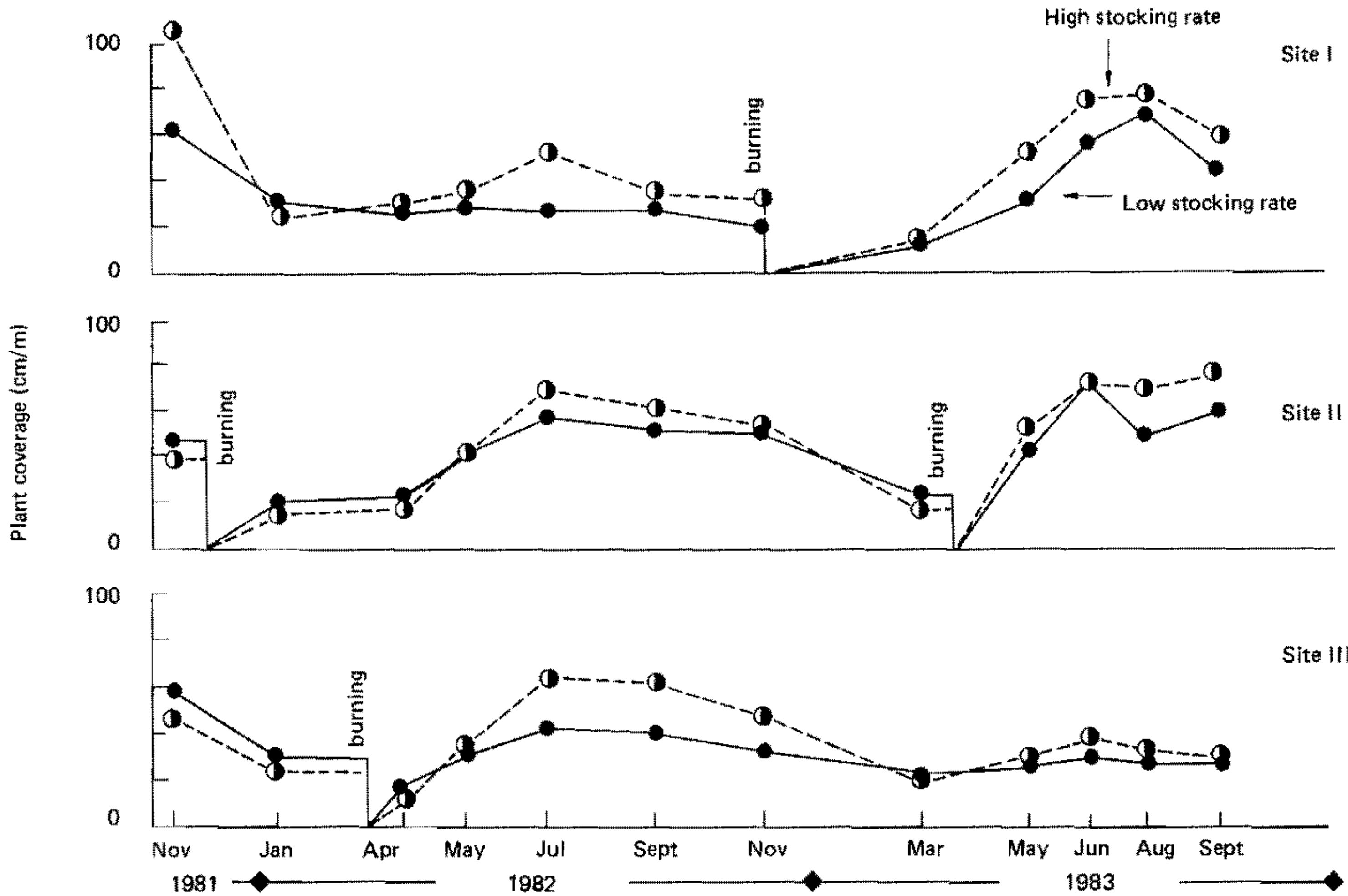


Fig. 2. **Seasonal changes of the plant coverage of the savanna with different burning times, (Introduction II).**

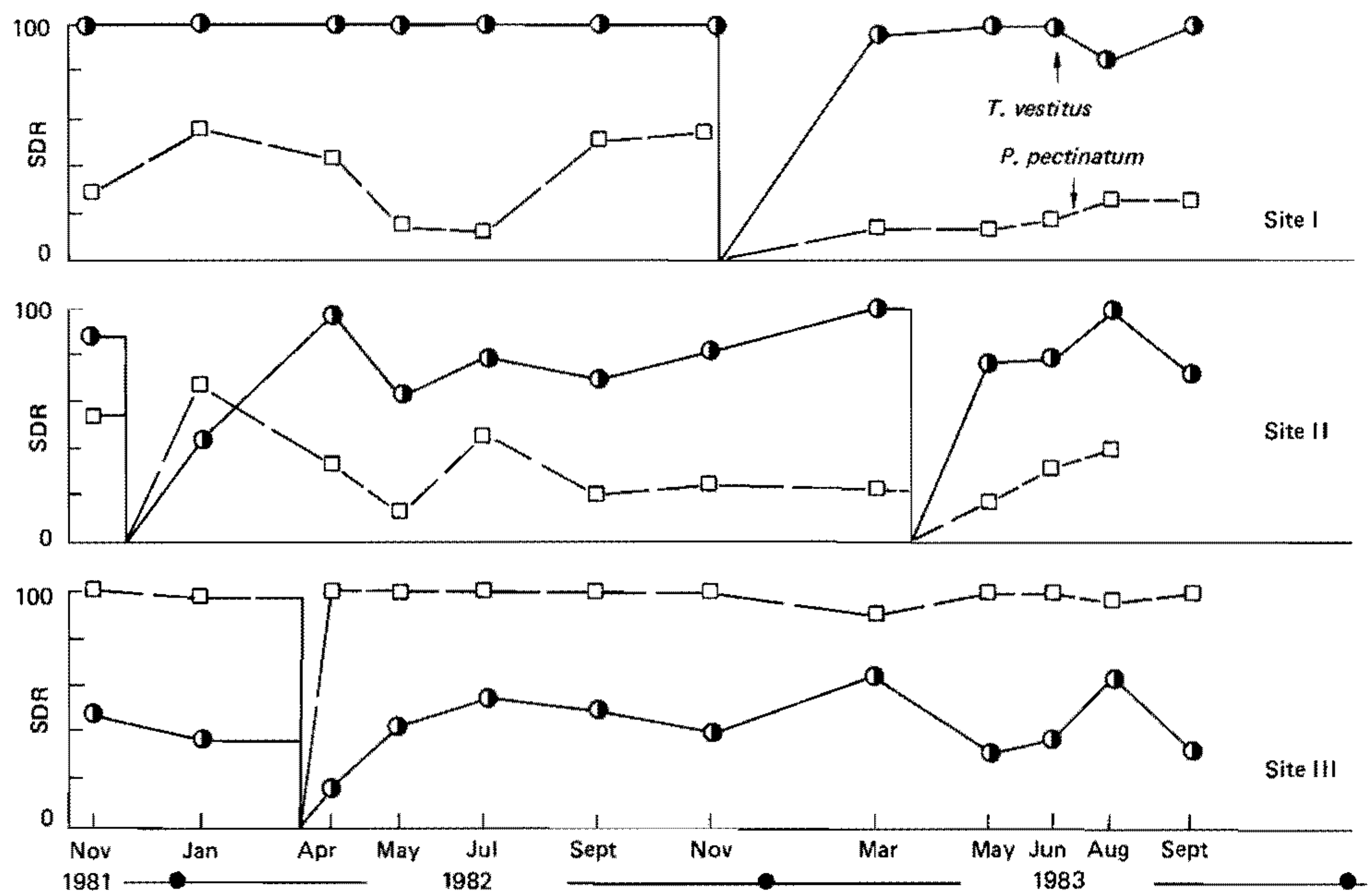


Fig. 3a. **Seasonal changes of the SDR of *T. vestitus* and *P. pectinatum* with different burning times - low stocking rate. (Introduction II).**

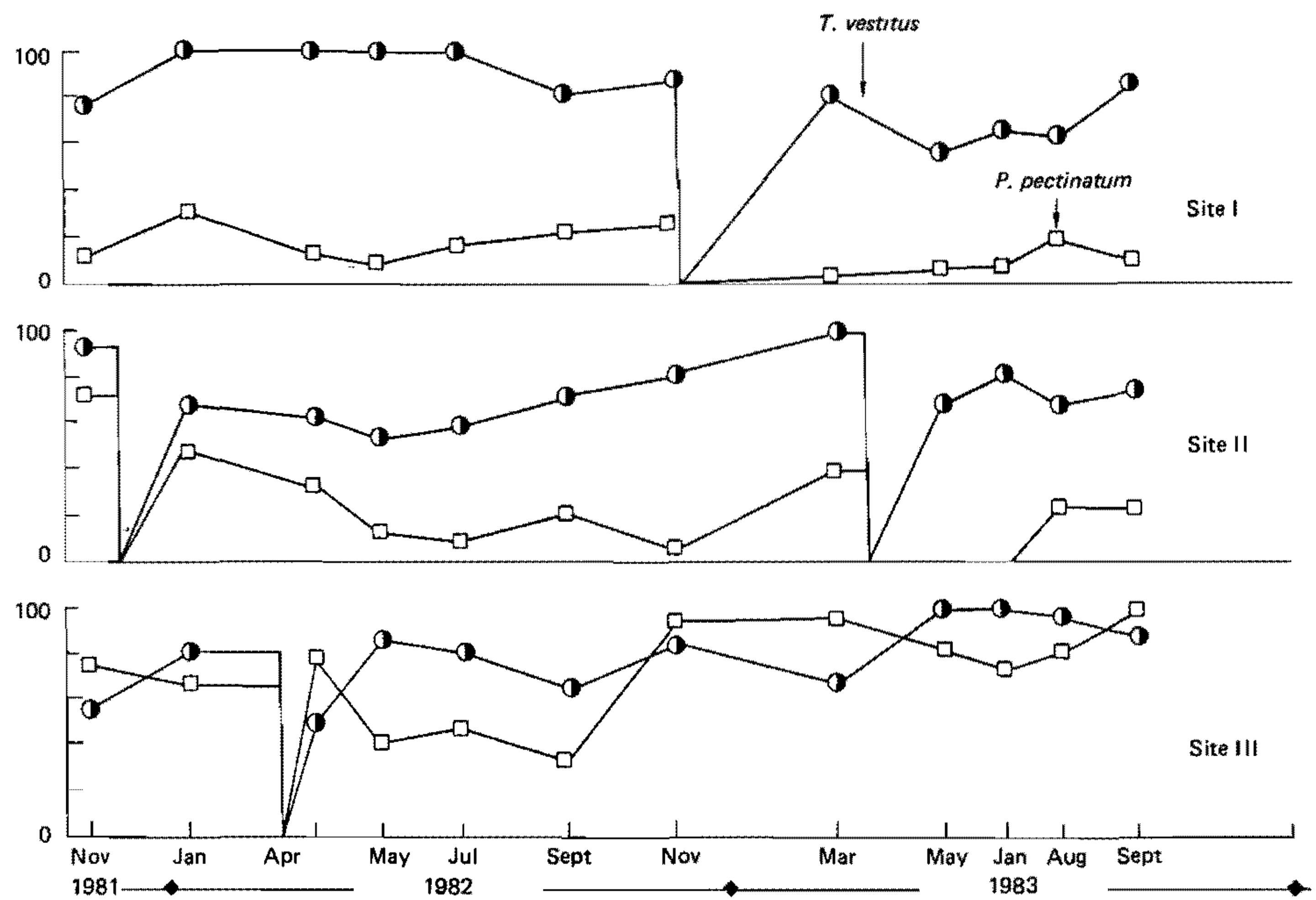


Fig. 3b. **Seasonal changes of *T. vestitus* and *P. pectinatum* with different burning times - high stocking rate. (Introduction II).**

Table 1. Physical and chemical characteristics of the Introduction II soil (0-20 cm), February 1983.

Site	I		II		III	
Stocking rate	L	H	L	H	L	H
Sand (%)	2.24	4.33	2.89	2.36	2.51	4.08
Clay (%)	50.4	50.7	52.0	50.9	50.2	50.1
Mud (%)	47.4	45.0	45.1	46.8	47.3	45.8
pH (H_2O)	4.56	4.53	4.54	4.42	4.46	4.54
P (Bray II, ppm)	2.34	1.83	2.08	1.66	1.86	1.68
S (ppm)	14.7	10.7	10.5	13.2	12.0	8.44
Ca (me/100g soil)	.152	.193	.192	.180	.210	.240
Mg (me/100g soil)	.070	.055	.058	.058	.076	.066
K (me/100g soil)	.090	.075	.076	.078	.082	.088
Al (me/100g soil)	3.22	3.45	3.60	3.60	3.52	3.66

"YOPARE" SAVANNA

Objectives

1) to investigate the succession processes of the savanna vegetation with or without burning under different grazing intensities.
2) to measure standing forage on offer in savanna; and
3) to evaluate the nutritional value of the savanna plants.

Materials and Methods

The savanna vegetation was investigated on 10 one-meter transects by a modified line-interception method (Figure 4). All savanna plants were cut at about 3 cm above ground on five one-square meter quadrats in each treatment and then were hand-separated in plant species as follows: T. vestitus, P. pectinatum, other grasses, legumes, herbs including bushes, other grasses, dead matter and litter. The dry weight was determined after 2 days oven drying. Nutritional analysis of the plants was done in the CIAT laboratory for crude protein.

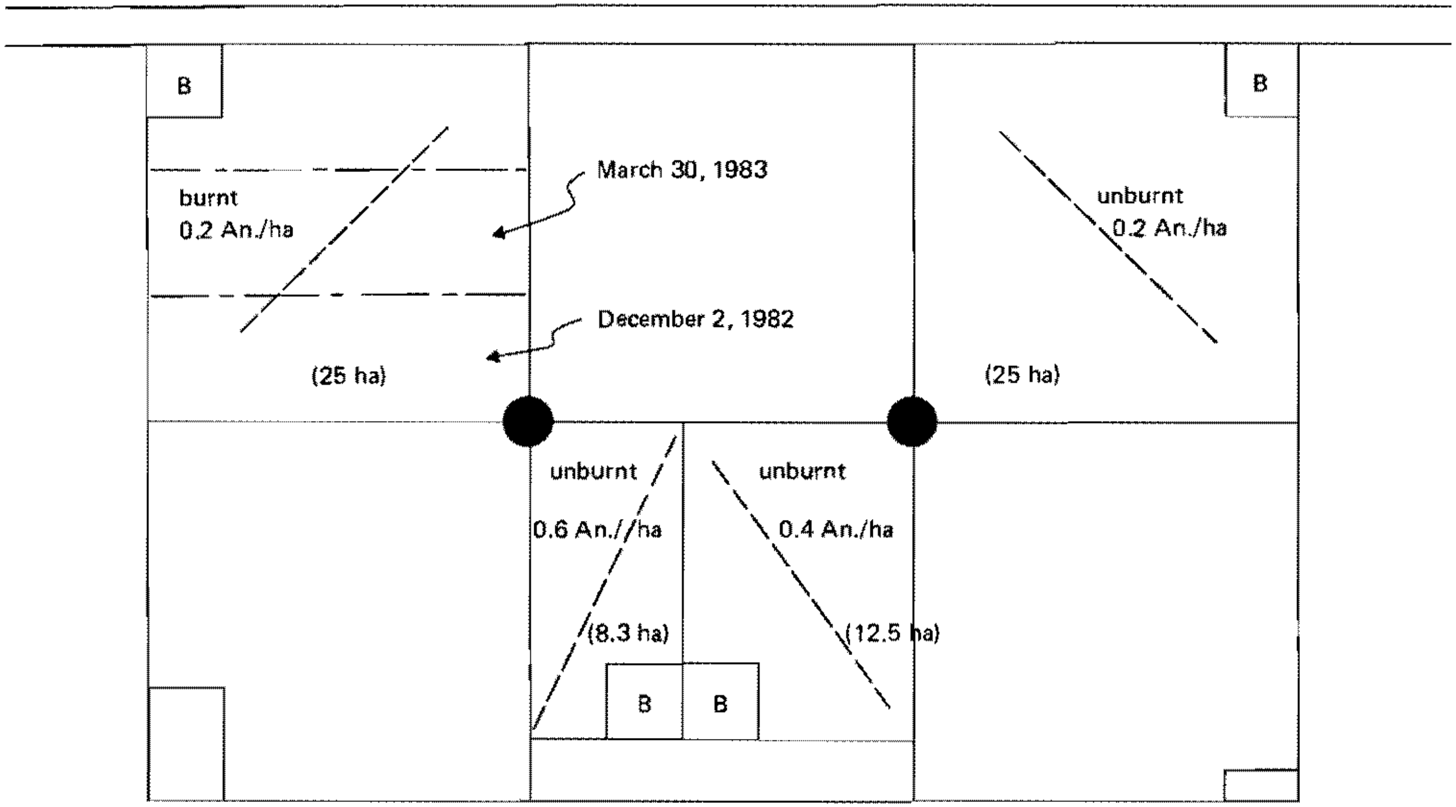
Results and Discussions

Plant coverage of the savanna slightly declined with time of year and was highest at the low stocking rate with burning because there is a large amount of standing dead matter in the plots without burning (Figure 5).

Paspalum pectinatum consistently predominates in unburnt plots. On the burnt plots, T. vestitus predominated during almost all the last rainy season. In the case of this year, the first one-third of the plot was burnt on December 2nd of 1982, the second one-third was burnt on March 30th of 1983 and another one-third has not been burnt yet. However, T. vestitus continues to predominate this year and at the same time P. pectinatum also codominates possibly related to the presence of Paspalum on the unburnt part of the paddock (Figure 6).

Since the soil of the Yopare savanna usually is very high in sand, P. pectinatum generally predominates in this site. However, T. vestitus codominates in the burnt plot. The SDR of T. vestitus was obviously raised by burning. On the other hand, there seems to be a relationship between the distribution of T. vestitus and the physical characteristics of soil in such a way that its distribution seems to be correlated with high clay contents of the soil (Table 2). In conclusion, the dominancy of T. vestitus appears to be naturally related to burning, but also to soil structure.

The standing forage on offer of green plants was not greatly affected by treatments. In burnt plot, standing crop of green plants rapidly increased with time after burning. At the same time, dead matter also increased with time in all plots. Litter increased at the end of rainy season in the unburnt plots. The general growth rate of each plot is very similar except in the low stocking rate without burning (Figure 7). The standing crop of T. vestitus was about 40 g/m^2 on the burnt plot during the growing period and reached about 95 g/m^2



B : protein bank of *Desmodium ovalifolium* is each 1 ha.
( ) : total area ● : water basin

Fig. 4. Treatments and transects measured in savanna vegetation (Yopare).

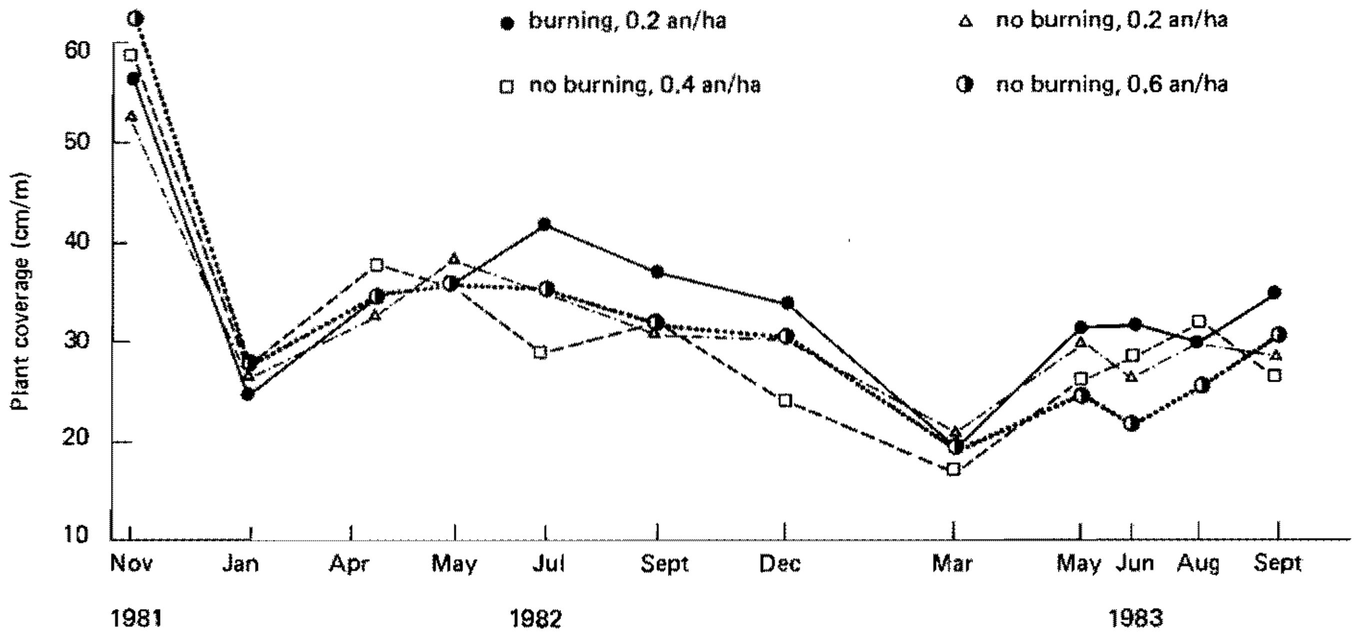


Fig. 5. Seasonal changes of plant coverage at savanna with and without burning and different stocking rates (Yopare).

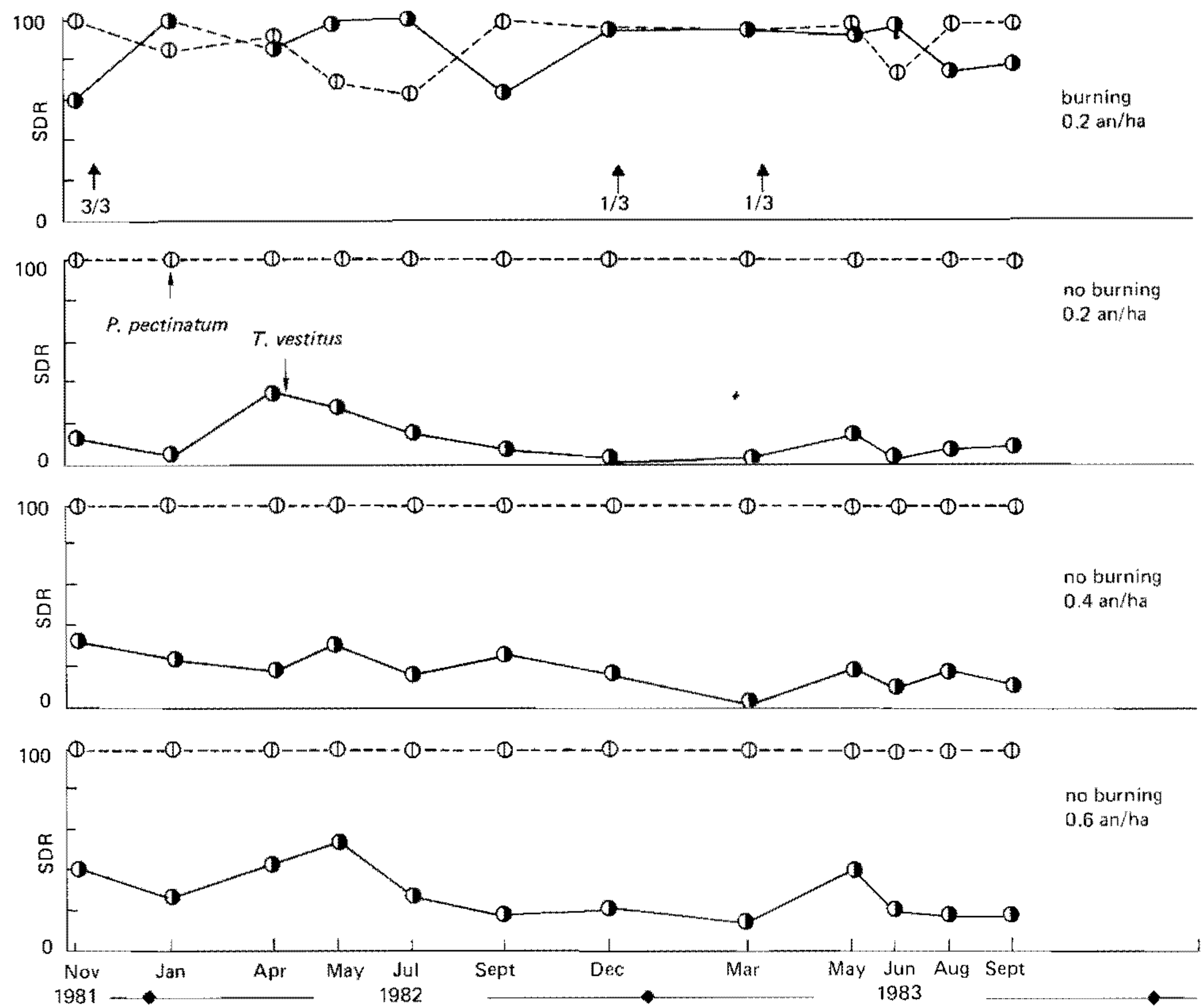


Fig. 6. **Seasonal changes of the SDR of *T. vestitus* and *P. pectinatum*, (Yopare).**

Table 2. Physical and chemical characteristics of the Yopare soil (0-20 cm), February 1983.

Stocking Rate	Burning	No Burning		
	0.2	0.2	0.4	0.6 an/ha
Sand (%)	27.06	42.98	43.38	34.64
Clay (%)	34.50	27.76	29.14	33.46
Mud (%)	38.44	29.26	27.48	31.91
pH (H_2O)	4.60	4.52	4.58	4.50
P (Bray II, ppm)	1.70	1.94	1.90	2.12
S (ppm)	11.12	12.48	12.00	14.04
Ca (me/100g soil)	.092	.106	.105	.088
Mg (me/100g soil)	.028	.026	.025	.030
K (me/100g soil)	.050	.052	.055	.060
Al (me/100g soil)	2.20	1.34	1.68	2.26

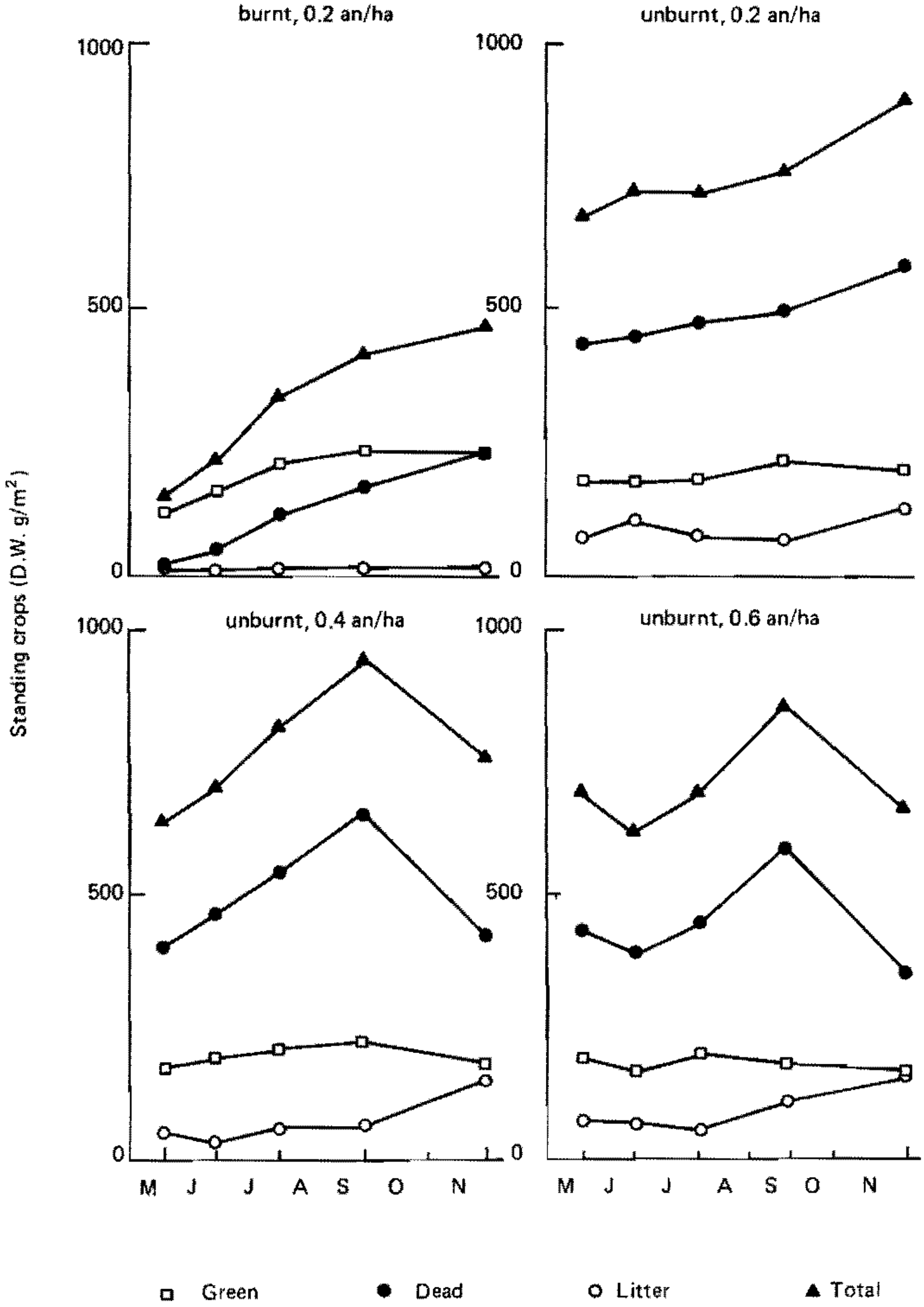


Figure 7. **Seasonal changes of the standing crops of savanna, (Yopare).**

at the end of the rainy season. It was sometimes negligible at both low and middle stocking rates without burning and it was 6 to 11 g/m^2 at high stocking rate without burning. P. pectinatum increased with time on the burnt plot and it was stable on the unburnt plots. The other grasses also show similar tendency. The legumes and herbs are negligible on all plots (Figure 8).

Legumes including some Cassia spp., Desmodium spp., Eriosema spp., etc. had the highest protein content of all species analyzed. Herbs including Hyptis brachiata, Sipanea colombiana, Palicourea rigida (bush), etc., also show high protein content relative to other plants but their contribution to total biomass is negligible as previously indicated. Protein content in T. vestitus is slightly higher than P. pectinatum which is similar with other grasses found in the savanna. In general and as expected, protein content tends to decline with time (Figure 9).

Summary

1. Burning times has not affected the basic structure of vegetation of the stable savanna. Major effects have been on the speed of plant recovery.
2. Dominance of T. vestitus was increased by burning on the Paspalum savanna but it is also related to soil conditions.
3. The standing crop of green plants is similar among the unburnt plots, yielding on the average 200 g/m^2.
4. The standing crop on the burnt plot increased rapidly after burning and reached more than 200 g/m^2.
5. The protein content of legumes is the highest of all plants but makes little contribution to total biomass.

AN EVALUATION OF THE ADVANCE OF PLANTED SPECIES IN THE SAVANNA REPLACEMENT TRIAL

Objectives

- To evaluate the displacement of native savannas by introduced species in the third year of grazing.
- To evaluate the persistence of savanna under very high stocking rate.

A detailed description of the treatments is given in the 1980 Annual Report (Pasture Development in the Iso-hiperthermic savannas).

In 1983, the crown coverage and plant height of the introduced species and the savanna plants including weeds, which invaded after cultivation, were evaluated on fifty 1 m^2 quadrates and two 25 m transects in each paddock (Figure 10). The percentage of bare soil and the main savanna species were also recorded.

Results and Discussions

Frequency of occurrence and plant height of each component is shown in Table 3. The distribution pattern of coverage for each plant is shown in Figures 11a, 11b, 11c, and 11d. In this report the wider (5 m),

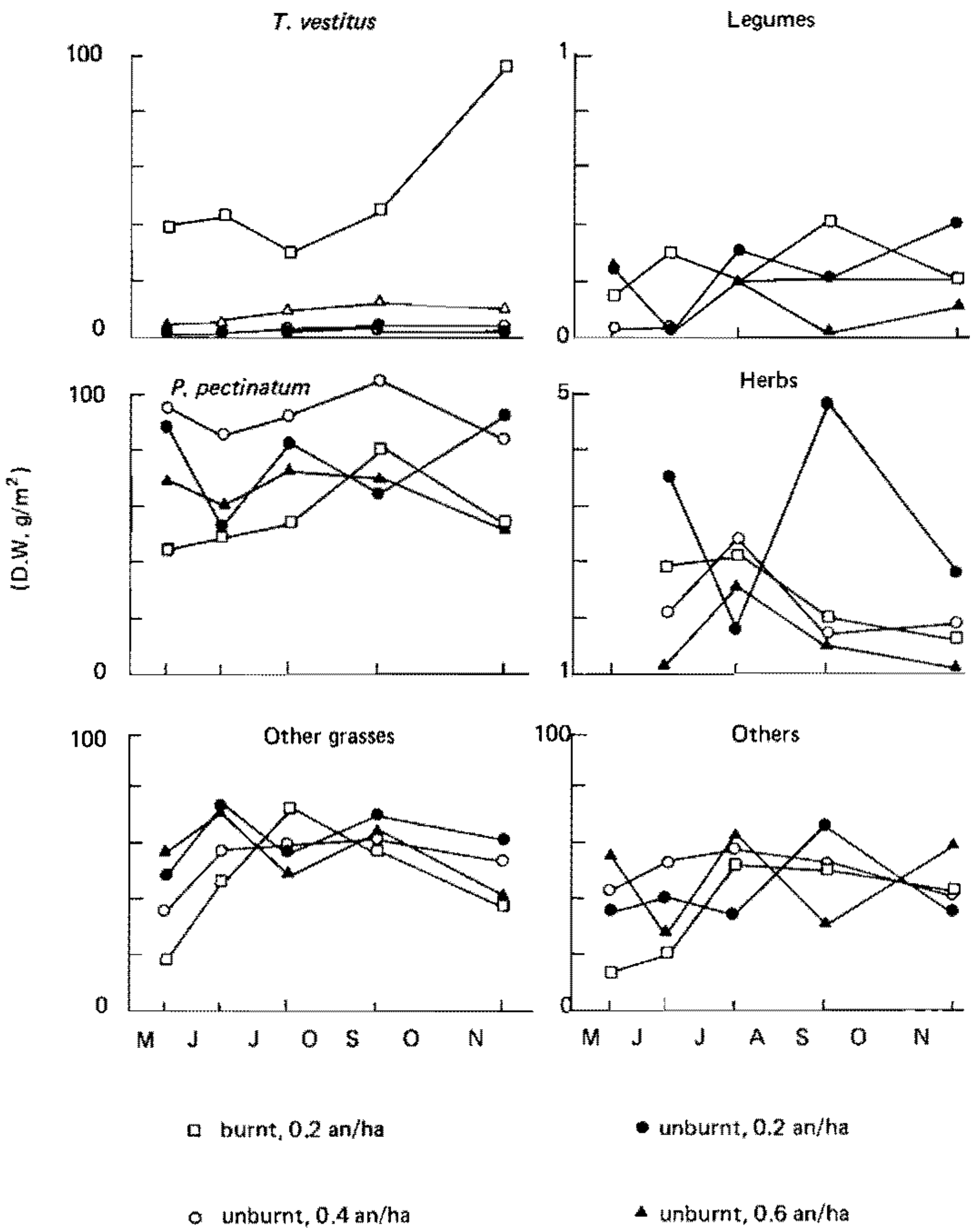


Fig. 8. Seasonal changes in dry matter on offer of the green plants in savanna, (Yopare).

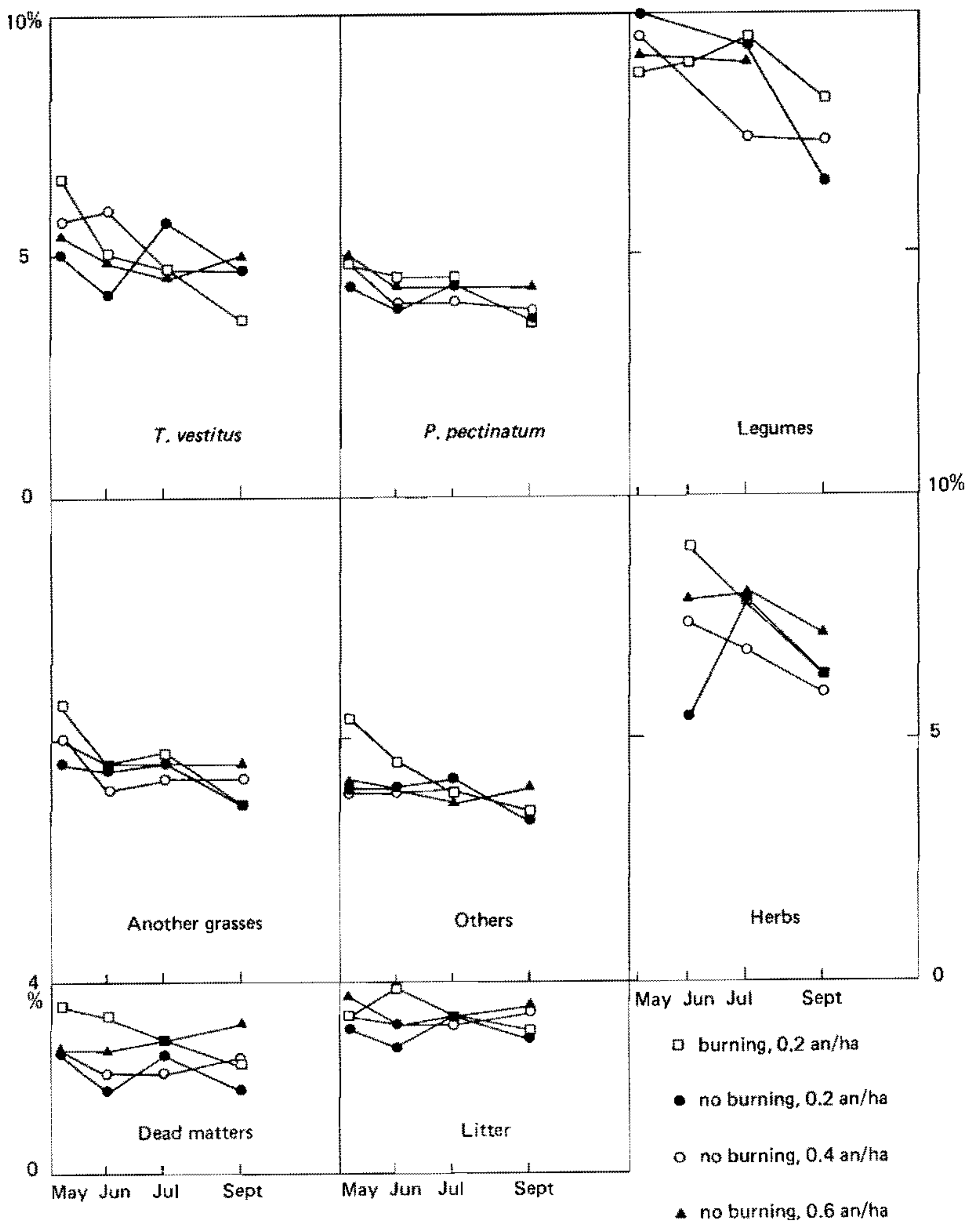


Fig. 9. Seasonal changes of protein content of the savanna plants, (Yopare).

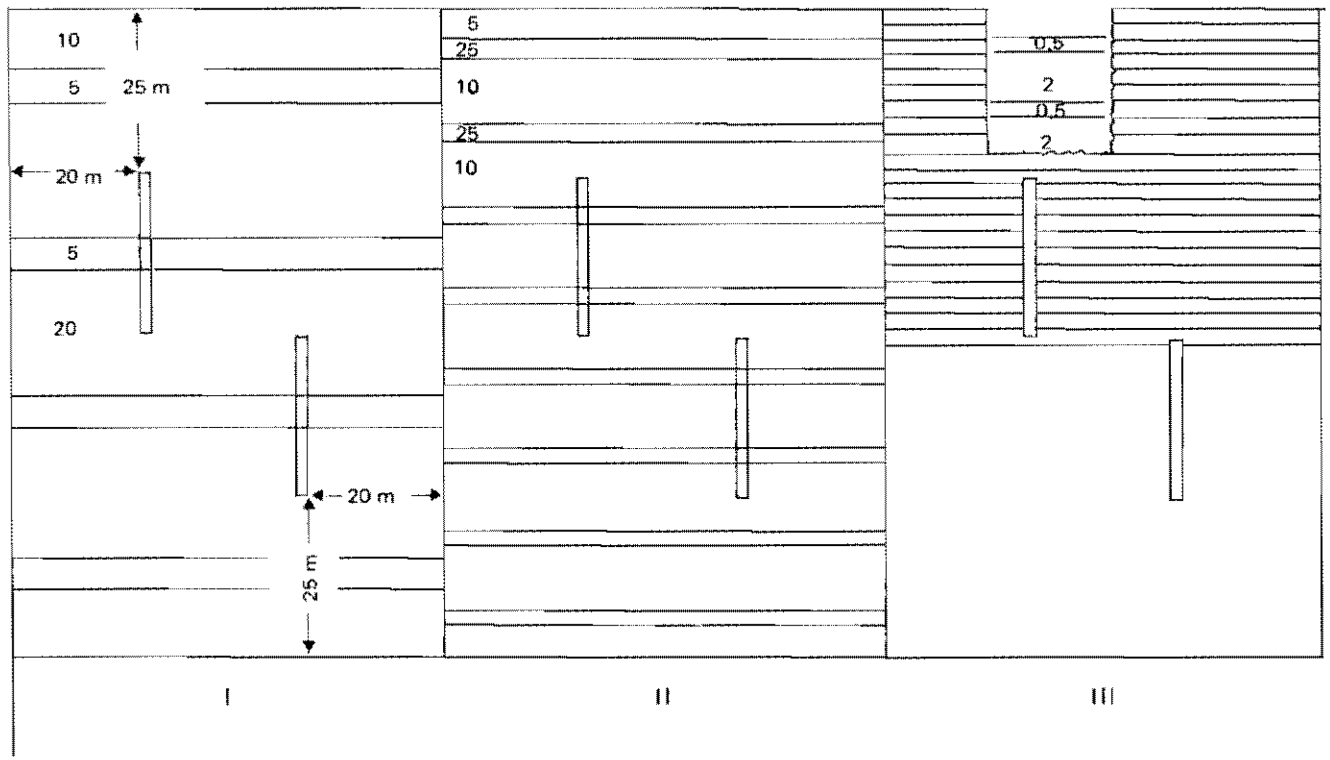


Fig. 10. Sites of the two observation transects (1 m x 25 m) in each system in the savanna replacement trial.

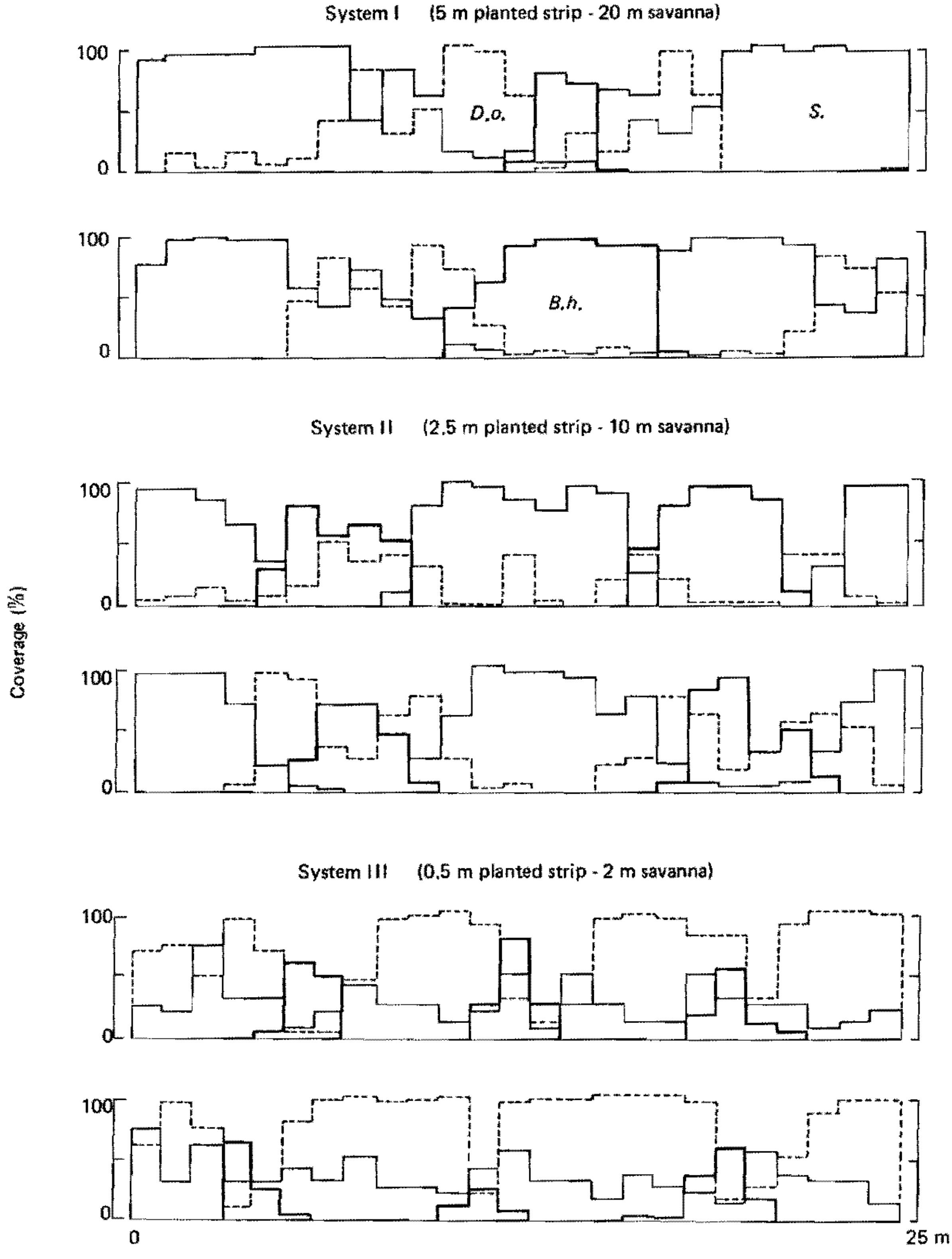


Fig. 11a. **Distribution patterns of the savanna plants and the improved plants on the differents planting systems, (savanna replacement trial).**

a) *B. humidicola* **x** *D. ovalifolium* **association.**

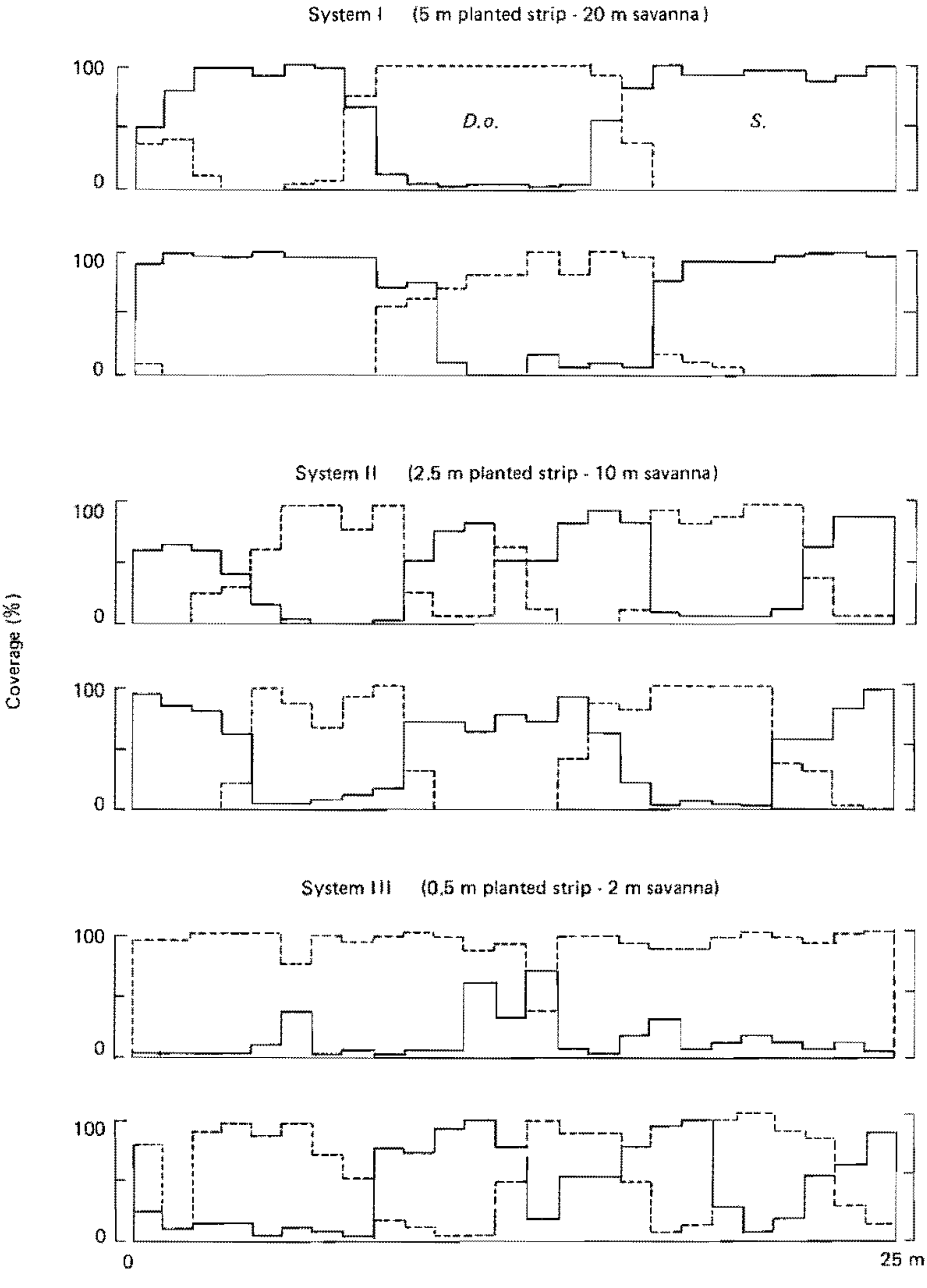


Fig. 11b. *A. gayanus* x *D. ovalifolium* **association.**

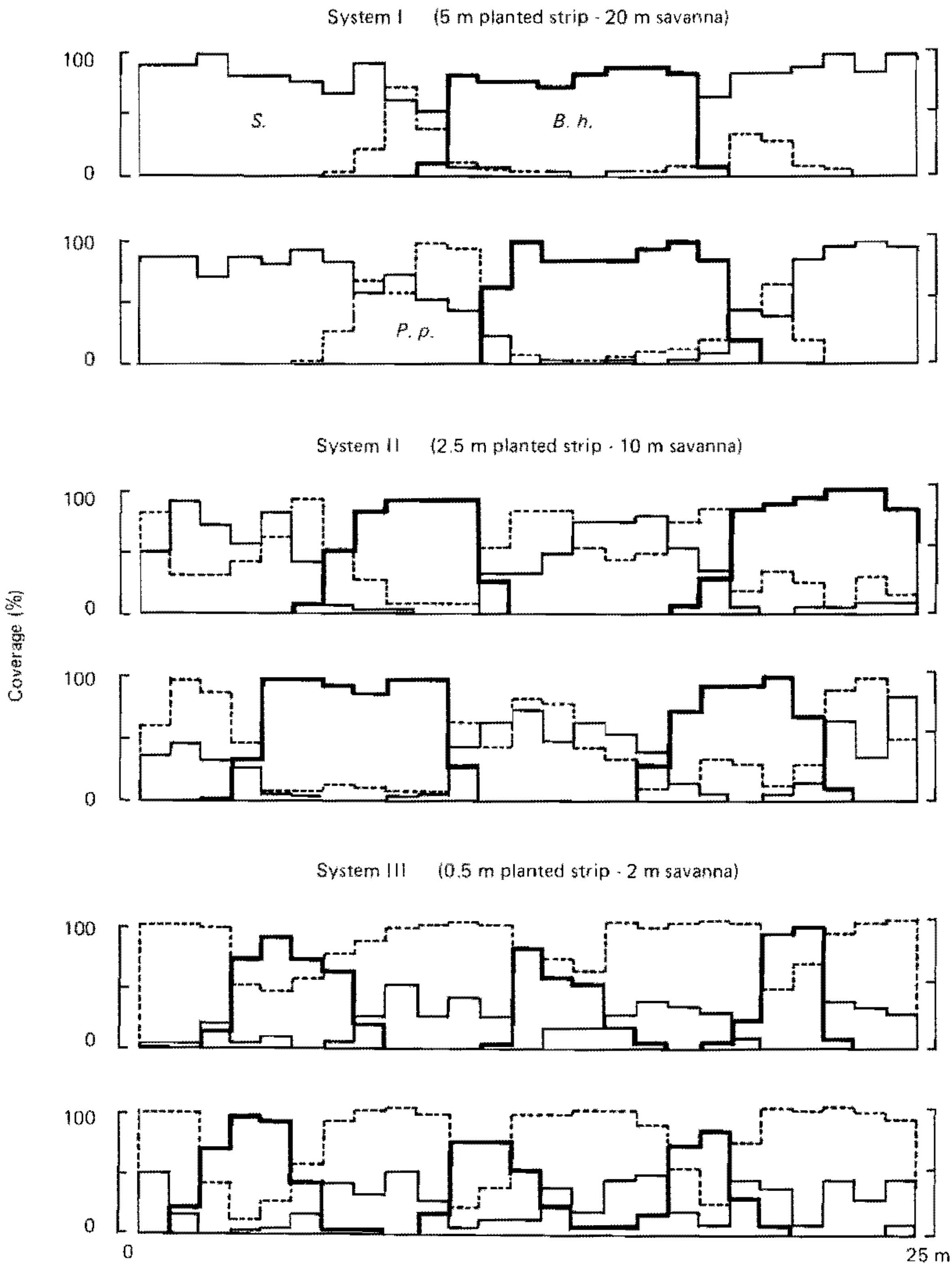


Fig. 11c. *B. humidicola* **x** *P. phaseoloides* **associations.**

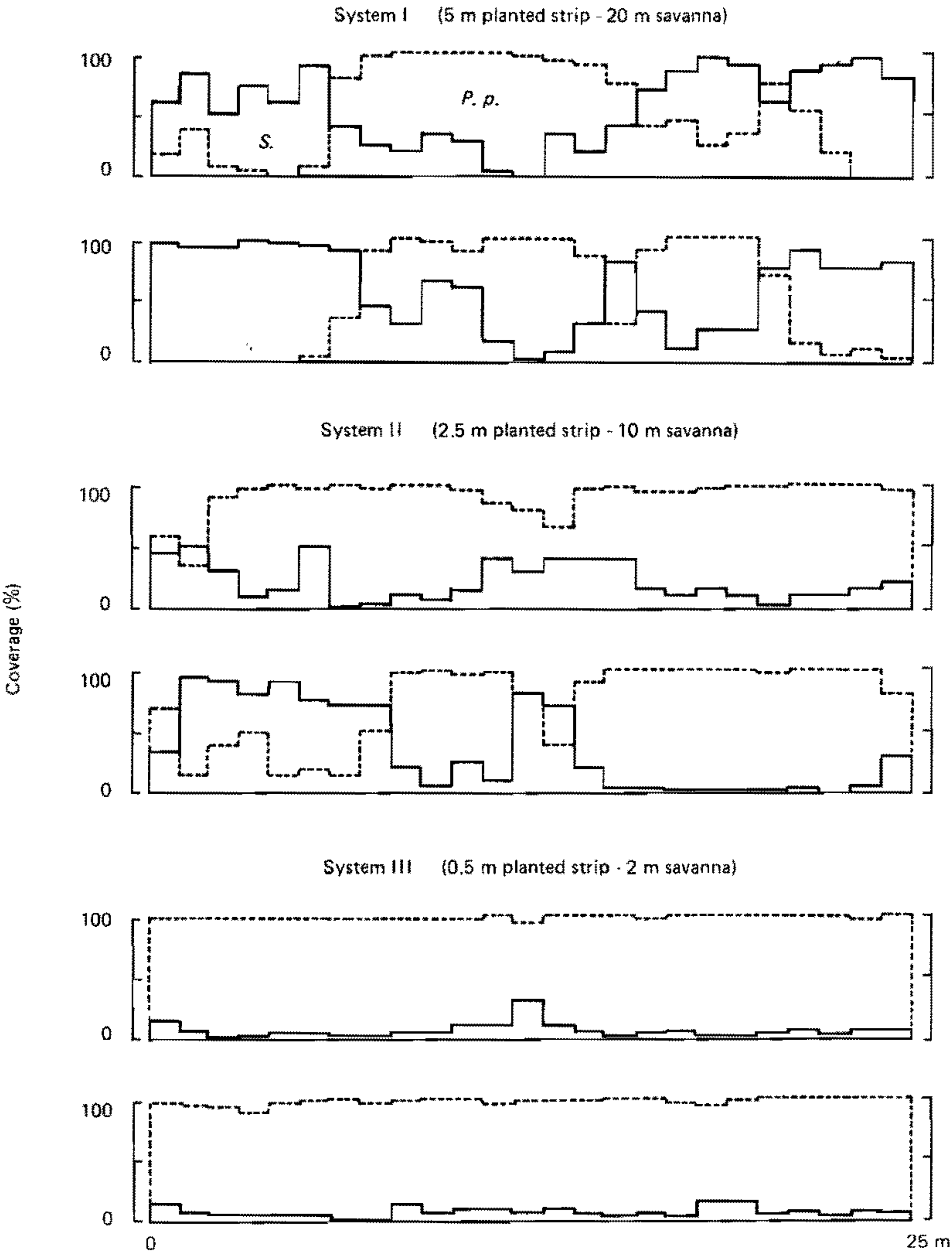


Fig. 11d. *A. gayanus* x *P. phaseoloides* **association.**

Table 3. The frequency of occurrence (F), crown coverage (C) and plant height (H), in the savanna replacement trial (July 11-12, 1983, Carimagua).

Planting System	I (20-5)			II (10-2.5)			III (2-0.5)		
	F	C	H	F	C	H	F	C	H
	%	%	cm	%	%	cm	%	%	cm
Savanna plants	94	60.34	33.6	86	49.36	31.3	100	29.50	35.9
Brachiaria humidicola	24	14.46	14.6	44	23.30	12.1	44	11.40	25.9
Desmodium ovalifolium	76	27.92	20.9	88	24.62	14.2	100	72.70	19.5
Denuded	72	13.32	-	98	12.90	-	68	6.70	-
Savanna plants*	100	65.16	28.9	100	44.66	21.2	100	29.04	18.2
Desmodium ovalifolium	66	35.12	13.4	78	44.78	9.6	100	73.22	10.6
Denuded	82	5.84	-	90	15.70	-	90	8.76	-
Savanna plants	90	52.38	27.0	88	29.98	26.5	92	20.86	35.2
Brachiaria humidicola	38	26.34	17.9	62	40.64	21.0	76	29.76	27.9
Pueraria phaseoloides	60	14.24	19.3	100	39.82	18.7	100	79.06	25.5
Denuded	100	13.90	-	96	11.14		-	3.70	-
Savanna plants**	100	58.38	31.1	100	28.36	20.1	100	6.08	28.4
Pueraria phaseoloides	86	52.80	18.7	100	82.78	16.3	100	98.88	24.0
Denuded	60	6.22	-	62	4.82	-	28	0.56	-

* *Andropogon gayanus* essentially disappeared after the first grazing year because of establishment problems and incompatibility with the grazing system.

intermediate (2.5 m) and narrow (0.5 m) planted strip treatments are referred to as systems I, II and III, respectively.

The original planting width of the introduced pastures were 5.0 m in system I, 2.5 m in system II and 0.5 m in system III. The present width of B. humidicola (50% coverage or more) ranged from 2 to 6 m (about two times the original width) in system I, 2 to 4 m (about 4 times) in system II and 1 to 2 m (about 3 times) in system III. The distribution of D. ovalifolium was so disperse that the present widths are not as defined as with B. humidicola. However, frequency of occurrence of D. ovalifolium was two or three times B. humidicola which indicates the ability of D. ovalifolium to invade savanna. The frequency reached 100% when the distance between was narrow, as in system III. In general, in the association of B. humidicola + D. ovalifolium the coverage by savanna species was highest in system I. B. humidicola had more coverage in system II and D. ovalifolium covered more in system III.

In the association of A. gayanus x D. ovalifolium, the coverage by savanna species was also highest in system I and D. ovalifolium had more coverage in this association than in the association with B. humidicola, because D. ovalifolium invaded the area originally occupied by A. gayanus, since this grass failed to persist. The D. ovalifolium strip is wider with A. gayanus than with B. humidicola and it is 8 to 9 m (about 5 times the original width) in system I and 5 to 6 m (about 7 times) in system II.

In the association of B. humidicola x P. phaseoloides, the coverage by savanna species was highest in system I, but it was only around 50%. B. humidicola was highest in system II and reached about 40% coverage whereas, P. phaseoloides showed about 80% coverage in system III, but showed only 14% in system I in spite of 60% frequency of occurrence. The frequency of P. phaseoloides was higher than D. ovalifolium as a consequence of the more aggressive stoloniferous growth habit of P. phaseoloides. B. humidicola has spread 7 to 8 m in width and has formed a dense strip in system I.

The distribution of B. humidicola was generally wider in the association with P. phaseoloides than with D. ovalifolium, probably as a result of the stoloniferous growth of P. phaseoloides and from a barrier formed by D. ovalifolium in the first year. In addition, a higher consumption of B. humidicola in the association with D. ovalifolium as compared with P. phaseoloides could have also contributed to the observed differences.

In the association of A. gayanus x P. phaseoloides, A. gayanus also failed. The coverage by savanna species was highest in system I and the lowest in system III in spite of 100% frequency of occurrence. The coverage by savanna species in this association was the lowest among all associations. P. phaseoloides had 99% coverage in system III and 50% coverage even in system I.

The advance of introduced species with planting systems and with times is shown in Table 4. According to earlier data , the replacement of

Table 4. The advance of the introduced pastures with planting systems over time[a].

Association	System	Initial Strip Width			Width (m) Coverage (%)		Width (m) Coverage (%)[b]		
		Planted	Savanna	1980 Total	1981	Total area	1982	Total area	1983
		m	m	m	m	%	m	%	%
B.h.	I	5.0	20.0	25.0	8.4	34	11.0	44	42
x	II	2.5	10.0	12.5	6.0	48	7.5	60	48
D.o.	III	0.5	2.0	2.5	2.5	100	2.5	100	84
(A.g.)[c]	I	5.0	20.0	25.0	7.8	31	10.0	40	35
x	II	2.5	10.0	12.5	6.0	48	8.0	64	45
D.o.	III	0.5	2.0	2.5	2.5	100	2.5	100	73
B.h.	I	5.0	20.0	25.0	8.3	33	15.0	60	41
x	II	2.5	10.0	12.5	7.7	62	12.5	100	80
P.p.	III	0.5	2.0	2.5	2.5	100	2.5	100	109
(A.g.)[c]	I	5.0	20.0	25.0	10.7	43	19.0	76	53
x	II	2.5	10.0	12.5	8.1	64	12.5	100	83
P.p.	III	0.5	2.0	2.5	2.5	100	2.5	100	99

a) Adapted from the CIAT Internal Program Review 1982, Annual Report of Tropical Pasture Program, Vol.I, p. 17, Table 5, December 1982, by Dr. James Spain. % cover = (Present width/Total width [1980]) x 100.

b) Cover was calculated from 50 x 1 m^2 quadrate observations on the two 25 m x 1 m belts and summed each coverage (%) of B.h. and D.o. or P.p.

c) Andropogon gayanus disappeared after the end of 1980 because it had not established well. So, only legume is available now.

the native savanna was succeeded in all associations with system III after one year. In the case of P. phaseoloides, complete coverage was achieved in system II after two years. But the coverage by improved species in the fourth year reached 100% only in system III in the P. phaseoloides associations. In the case of D. ovalifolium associations, the coverage was 73% with A. gayanus and 84% with B. humidicola in system III. The expected coverage (60%) by introduced species by the end of the third year, was not accomplished with any association in system I or in associations with D. ovalifolium in system II, possibly as a result of a nematode attack on the legume. On the other hand, in the association of the savanna and P. phaseoloides, a coverage of 53% was achieved even in system I.

Carrying capacity of the savanna is usually 0.2 an/ha in the Llanos Orientales of Colombia. Although, carrying capacity was over ten times in this experiment, the savanna persisted in some cases. The coverage by savanna species associated with D. ovalifolium was 60 or 65% in system I, 45 or 49% in system II and 27 or 30% in system III.

THE VEGETATION OF THE SAVANNA BURNING AND WITH DIFFERENT LEGUME PROPORTIONS IN ROWS (PRIMARY EVALUATION OF THE VEGETATION BEFORE GRAZING

Objectives

To investigate the succession of the savanna vegetation with introduced legumes.

Materials and Methods

This grazing experiment, UEP-3-82, has fifteen treatments with two replications. But, in this case, only six pastures were sampled. The legume, P. phaseoloides and S. capitata, were sown each 5 m, 10 m, 20 m rows to get 20%, 10%, 5% sown area, respectively.

Since the legume failed to establish in 1982, the savanna was not grazed during 1983.

Measurements of coverage and plant height of the legumes, the savanna plants, T. vestitus, P. pectinatum and herbs were on 1 m x 50 m transects on the center of each plot. Bareland percentage also was recorded.

Results

Table 5 shows the frequency, coverage and plant height of each component. In the association of the savanna and P. phaseoloides, coverage by the legume was 14.7% on the 20% sown plot, 23.3% on the 10% sown plot and 2.9% on the 5% sown plot respectively. T. vestitus predominates on the 20% and 10% plots and P. pectinatum predominates on the 5% plot. In the savanna plus S. capitata, the coverage by legume was 19.2% on the 20% plot, 4.7% on the 10% plot and 7.9% on the 5% plot respectively. P. pectinatum predominates on the 10% and 5% plots.

Table 5. Initial structure of pastures oversown with different legume proportions. Carimagua, Yopare, November 21-December 1, 1983.

Species	Legume proportion (%) + Stocking rate (A/ha)								
	20%-1.33 A/ha			10%-0.67 A/ha			5%-0.33 A/ha		
	F	C	H	F	C	H	F	C	H
	%	%	cm	%	%	cm	%	%	cm
P. phaseoloides +	86	14.7	24.1	90	23.3	31.4	28	2.9	27.1
Savanna plants	100	68.2	28.0	100	66.6	30.6	100	91.3	29.8
T. vestitus	100	14.1	33.2	96	26.2	35.8	16	0.6	43.1
P. pectinatum	44	0.8	23.9	84	3.2	26.9	90	40.0	29.7
Herbo	46	0.5	22.2	28	0.3	24.6	64	1.3	26.8
Bareland	72	10.0	-	74	3.4	-	58	1.2	-
S. capitata +	70	19.2	44.9	28	4.7	34.3	28	7.9	52.5
Savanna plants	100	50.8	25.5	100	74.1	24.3	100	79.9	28.4
T. vestitus	68	4.6	32.5	10	0.1	26.0	32	2.1	29.7
P. pectinatum	68	3.9	25.4	92	14.9	24.0	96	27.0	28.3
Herbo	58	1.4	24.1	76	1.8	30.7	66	1.4	32.4
Bareland	84	15.3	-	74	5.7	-	68	3.8	-

SEED PRODUCTION

The objectives of the section have continued as (a) multiplication and distribution of seed of both experimental lines and basic seed; and (b) the investigation of some of the limitations to the commercial seed supply of new cultivars.

During the year within the internal organization of the Tropical Pastures Program, the section was moved from the Germplasm Unit to the Systems Unit. This move indicated a transition in activities towards more emphasis upon applied research and training. This change of focus has been made in response to an increasing awareness of seed related issues concurrent with progress being made in many countries in germplasm evaluation, cultivar release and initial activities in commercial seed supply.

SEED MULTIPLICATION

Activities in seed multiplication involved propagation at the Palmira plant house and field production plots at Quilichao and Carimagua.

The number of legume accessions under multiplication was 108, principally from the genera Centrosema, Desmodium and Stylosanthes and a total of 1.146 kg of seed was produced (Table 1). The number of grass accessions under multiplication was 22, involving principally the genera Andropogon, Brachiaria and Panicum, and a total of 1.082 kg of graded seed was produced (Table 2).

Table 3 provides a summary of multiplication activities indicating 28 ha under seed multiplication: the total number of accessions involved was 130, a significant increase over previous years. As a consequence of this number of accessions, the majority under early and small scale multiplication, the total volume of seed produced, 2.228 kg, was less than in previous years.

SEED DISTRIBUTION

The section responded to a total of 340 composite seed requests. The vast majority were requests by Program members to conduct forage evaluation experiments and for the conduction of the network of regional trials. There were a small number of requests by National Programs for seed to use for seed multiplication. Total volume of seed distributed amounted to 1.670 kg (Table 4).

An increasing number of countries are requiring the prior issue of an Import Permit before seed can be imported. This perfectly reasonable requirement, however, does add to the logistical coordination required to conduct seed distribution.

Table 1. Summary of legume seed multiplication between October 1982 and October 1983.

Species	Total Accessions No.	Field Area New ha	Field Area Total ha	Seed Produced kg
Arachis pintoi	1	0.20	0.20	0.00
Centrosema arenarium	1	0.16	0.16	18.65
Centrosema brasilianum	6	0.02	0.32	80.26
Centrosema macrocarpum	7	0.10	0.47	92.27
Centrosema pascuorum	1	0.00	0.01	0.39
Centrosema pubescens	2	0.19	0.19	21.49
Centrosema rotundifolium	1	0.01	0.01	0.01
Centrosema schiedeanum	3	0.01	0.01	0.50
Centrosema sp.	4	0.27	0.19	3.20
Centrosema (hybrids)	6	0.02	0.02	19.46
Desmodium incanum	1	0.20	0.24	1.10
Desmodium heterophyllum	2	0.15	0.15	0.67
Desmodium heterocarpon	1	0.02	0.02	0.00
Desmodium ovalifolium	8	0.11	3.91	289.37
Galactia spp.	2	0.01	0.01	0.00
Pueraria phaseoloides	1		3.09	2.66
Stylosanthes capitata	12	3.00	6.14	532.34
Stylosanthes guianensis c*	20	0.33	0.33	12.73
Stylosanthes guianensis t	18	0.44	0.66	13.18
Stylosanthes hamata	1	0.01	0.01	0.00
Stylosanthes macrocephala	6	1.25	1.50	41.50
Zornia brasiliensis	2	0.03	0.18	9.87
Total	108	6.42	17.88	1,146.17

* c = common type.
t = "tardío" type.

Table 2. Summary of grass seed multiplication between October 1982and October 1983.

Species	Total Accessions	Field Areas		Seed Produced
		New	Total	
	No.	ha	ha	kg
Andropogon gayanus	4	0.13	3.73	1,009.90
Brachiaria brizantha	4	0.06	0.17	0.67
Brachiaria decumbens	2	0.03	1.13	1.24
Brachiaria dictyoneura	1	2.02	4.32	58.76
Brachiaria humidicola	1	0.02	0.32	1.64
Brachiaria ruziziensis	3	0.05	0.05	0.27
Panicum maximum	5	0.30	0.40	8.12
Paspalum plicatulum	2	0.10	0.10	1.37
Total	22	2.71	10.22	1,081.97

Table 3. Summary of grass and legume seed multiplication between October 1982 and October 1983.

Species	Total Accessions	Field Areas		Seed Produced
		New	Total	
	No.	ha	ha	kg
All legumes	108	6.42	17.88	1,146
All grasses	22	2.69	10.20	1,082
Total	130	9.11	28.08	2,228

Table 4. Seed distribution between October 1982 and October 1983.

Request Basis	Recipient	Requests No.	Seed Weight (kg) Grasses	Legumes	Total
Forage Evaluations	Members Pastures Program	122	502	378	880
	Network Regional Trials	92	112	72	184
	National Institutions	87	187	150	337
	Other CIAT Programs	13	24	19	43
	Others	11	20	5	25
Seed Multiplication	Seed Unit, CIAT	11	12	28	40
	National Institutions	4	101	60	161
Total		340	958	712	1.670

A computerized seed inventory system has been developed and is revised monthly. Each seed lot is described by provenance, age, volume and amounts reserved for specific purposes (such as basic seed or a particular experiment).

APPLIED RESEARCH

Seed quality of Andropogon gayanus

Colleagues of EMBRAPA at Brasilia have frequently commented upon high germination values for seeds harvested in that area. In view of possible methodological differences in analyses conducted in different laboratories, seed samples harvested in the Brasilia region were sent to CIAT Palmira for analysis in comparison with samples of a comparable age harvested at Quilichao and Carimagua in Colombia. Results are presented in Table 5 and confirm higher germination values of pure seed spikelets and greater caryopsis size of samples from Brasilia. The reason for these difference requires further investigation but may reflect a greater synchronization of flowering and a higher proportion of caryopses attaining full physiological maturity at higher latitudes.

Table 5. A comparison of some quality components in seed samples of *Andropogon gayanus* from CIAT, Colombia and EMBRAPA, Brasilia.

Quality Component	Units	AVERAGE VALUE (n=6) CIAT	EMBRAPA
Pure Seed Spikelets	%	37	45
Unit Weight of:	mg/100		
Pure Seed Spikelets		295	317
Caryopsis		85	105
Germination	%	27	68

An overview of the release process of new cultivars

The development and distribution of germplasm resources along with sequential germplasm and pasture evaluations has advanced to the stage where national institutions are beginning to release promising experimental lines as cultivars. Many countries, however, do not have any tradition of a formal release process for tropical forages as the majority of existing common type cultivars came into commercial use by seed merchants importing seed independently of any local evaluation mechanism. An attempt has been made, therefore, to increase attention to and understanding of the release process. By so doing it is intended to benefit the perspective of all participants in lowland asture development and to assist in the rapid and effective release of valuable new cultivars.

The term "release process" is proposed to emphasize the dynamic and complex nature of converting an experimental line into a commercially available cultivar. A concept, or model, of the release process has been described in terms of the main interacting components and also in terms of the sequence of major events which occur. Very briefly, the major components are: (a) the concept of a cultivar in the genetic sense; (b) what constitutes merit for a new cultivar; (c) what body, committee, commission (or authority), makes the decision on release and then coordinates the various events of the release process; (d) what are the ways by which basic seed can be multiplied; (e) what are the relevant roles of seed certification, cultivar registration and cultivar recommendation for each cultivar; (f) what non-technical forces can influence the release process. In the case of each particular cultivar, the sequence of major events, or phases, which take place during its release process are (a) the presentation of a release proposal; (b) the review of the proposal by a release authority; (c) the decision to release; (d) the multiplication of basic seed; (e) the actual release; (f) and the post-release follow-up. Each of these events or phases involves one or more aspects of the aforementioned components and many have a short or prolonged duration or may even overlap.

It is important to realize that the release process has to integrate and coordinate a number of highly contrasting and dynamic components. This is not easy and each case is different. In addition, the release process is not complete until seed is becoming available to farmers. A decision by researchers "to release" should carry with it the obligation to promote and assist the development of a commercial seed supply. Unfortunately the latter obligation is often overlooked or not provided with sufficient resources or stimulus. Without a seed supply graziers have no way to utilize or adopt a new cultivar.

Release and adoption of particular cultivars

A collaborative project with other Program members has been initiated to monitor the release process, the development of commercial seed supplies and the subsequent adoption by graziers of new cultivars (such as 'Carimagua 1' and 'Capica'). In so doing it is hoped to identify both the impact of these cultivars, and the factors which accelerate or hinder the release and adoption processes.

While these studies are incomplete and will be continued, the following limitations have been identified:

- the lack of a clearly defined release authority in many countries with the necessary composition to make key decisions and coordinate the overall process;
- insufficient resources (of trained personnel, equipment and funds) to provide adequate amounts of basic seed and to provide technical assistance to new seed growers;

- the sheer novelty of the first cultivar of an unknown forage species, especially a legume. This requires additional research, seed supplies and extension efforts to make its character and potential known to researchers, extension agents, graziers and seed-growers in the post-release follow-up phase. This 'novelty factor' is in marked contrast to the situation with traditional grain crop species;
- the lack of existing seed enterprises or a lack of conviction by the existing seed enterprises, to initiate commercial seed production of the new cultivar. While part of the 'novelty factor', it requires that special attention be focused on potential seed growers to promote their rapid awareness of the potential of the new cultivar so the challenge to produce seed is initiated without delay.

CATTLE PRODUCTION SYSTEMS

During 1983 the Section continued its activities of on-station and on-farm germplasm evaluation of accessions in categories IV and V, in the context of production systems. Component research was also continued, with the objective of detailed evaluation of important subsystems. Part of the latter work was performed in cooperation with other sections of the program and therefore, some of these activities are reported elsewhere.

Description and documentation of prevailing cattle production systems in the Eastern Plains of Colombia was continued; the results of a survey conducted in 1982 are described below. Also, and in cooperation with the sections of Economics and Seed Production, a survey was made in Colombia during 1983 with the objective of estimating the current uses of, and area planted with, Andropogon gayanus; the study is reported by Economics and forms part of a larger project aimed at estimating the impact of recently released forage cultivars in countries of tropical America.

Lastly, two new activities were incorporated to the section: the Animal Health Laboratory, that will constitute a support activity for all experimental work with animals, and the prototype Family Farm Unit.

Evaluation of cow-calf systems with improved pastures

This experiment, began in April 1982 and was described in detail in that year's report; the treatments are listed in Table 1. Changes in body weight and body score during the first year are shown in Table 2. Calving rates for the first year are not included because they were affected by residual effects related to treatment prior to the initiation of the trial, and origin and physiological condition of the animals. Initial results (Table 2) suggest a slight improvement in liveweight and score, although the small improvement in score of lactating cows in Treatment 4 is surprising. The trend is supported by examination of the data for the three treatments that have field replicates (Table 3). In either case, the lack of correlation among changes in body weight and score is obvious; the implications of these changes on reproductive performance shall be examined in the future. No differences between treatments have been observed so far in terms of calf birth weights (Table 4), but the lack of complete mineral supplementation in Treatments 2 and 3 induced high abortion and neonatal death rates during the first semester of 1983 (38.7% vs. 2.4% without and with mineral supplementation respectively). Periodic sampling of soils, native savanna and sown pastures was made with the aim of clarifying the status of mineral nutrition in the experiment. Also, liver biopsies and rib bone samples were obtained in six cows of

Table 1. Description of treatments in cow-calf systems with improved pastures experiment.

Treatment	Sown Pastures sq.m./AU	Mating System	Pasture Management	Type of Mineral Supplement
1	0	Continuous	-	Complete
2	900	Continuous	Minimum	Common Salt
3	1800	Continuous	Minimum	Common Salt
4	900	Seasonal	Intensive	Complete
5	1800	Seasonal	Intensive	Complete

Table 2. Changes in liveweight and body score of cows under five management treatments in the first year of the experiment (April 82-April 83).

Treatment		Percent change in	
		Weight	Score
1	CONTROL		
	All cows	12	12
	Nursing cows*	11	12
2	MINIMUM MANAGEMENT		
	All cows	15	16
	Nursing cows	16	22
3	MINIMUM MANAGEMENT		
	All cows	16	9
	Nursing cows	3	18
4	INTENSIVE MANAGEMENT		
	All cows	17	27
	Nursing cows	23	7
5	INTENSIVE MANAGEMENT		
	All cows	17	25
	Nursing cows	22	31

Means of replicate I.
* Lactating-empty cows.

Table 3. Changes in liveweight and body score of cows under different management treatments in the first year of the experiment (April 82 - April 83).

Treatment		Percent change in	
		Weight	Score
1	CONTROL		
	All cows	5	-4
	Nursing cows*	9	15
4	INTENSIVE MANAGEMENT		
	All cows	7	5
	Nursing cows	9	1
5	INTENSIVE MANAGEMENT		
	All cows	7	4
	Nursing cows	15	24

Weighted means of two replicates.
* Lactating-empty cows.

Table 4. Mean calf birthweight in five different systems.

Treatment	Replicate	
	I	II
1	26 $\pm$ 5	27 $\pm$ 4
2	26 $\pm$ 5	-
3	25 $\pm$ 5	-
4	27 $\pm$ 4	26 $\pm$ 4
5	27 $\pm$ 4	25 $\pm$ 4

each treatment that, in February, were in the third trimester of pregnancy. The same animals were sampled at three months intervals until weaning in December. Samples of feces and serum were also collected. The analyses are made in cooperation with Dr. L. R. McDowell, of the University of Florida, U. S. A.

Preliminary results confirm the known mineral deficiencies of the savanna and suggest that 30-60 days after burning, the available forage is deficient in several elements, some of which are shown in Figure 1. So far, the value of fecal mineral analysis to estimate the nutritional status of the animals appears to depend upon the element under consideration. No consistent differences have been observed in fecal nitrogen (Table 5), in contrast with fecal phosphorus (Table 6). Analyses of animal tissues have shown a marked influence of physiological condition on mineral concentration, particularly in the case of phosphorus, but the results obtained in different tissues are not necessarily consistent (Figures 2 and 3). This is to be expected if it is considered that they may represent different pools.

The data continues to be analyzed, but there is sufficient evidence to suggest that nursing cows in Treatments 2 and 3 (supplemented with common salt) were not able to satisfy their mineral requirements in spite of continuous access to small areas of well fertilized grass-legume pastures; therefore, these two treatments shall be modified in the near future.

Reproductive performance on improved pastures

This ancillary experiment represents a positive control to the previously described trial. The objective is to estimate the reproductive performance of herds representative of those commonly found in the Eastern Plains, when the nutritional constraints typical of the savanna are removed. A *B. decumbens* pasture, supplemented by a *S. capitata* protein bank is being used. Since the beginning of the experiment with 22 month old heifers and until the beginning of the calving season, the stocking rate was 1.02 animals/ha, with a mean daily liveweight gain of 0.462 ± 0.076 kg/head. The growth curve of the animals is shown in Figure 4, which includes the mean liveweight corrected for the effect of gestation (dotted line). The weight correction was based on the formula utilized by A.R.C. (1980), adjusted for birthweight of each calf; the mean birthweight was 31 ± 4 kg. Figure 4 suggests that cow liveweights began to stabilize at a weight of about 100 kg above those commonly observed in savanna. Rate of conception in the first year was 97%.

In some newly born calves, symptoms similar to those of photosensitization were occasionally observed; these were confirmed by high serum titres of gamma-glutamyl-transferase (GGT), shown in Table 7. Nevertheless there was some evidence that these levels tend to decrease with age and, therefore, the meaning of these observations is still subject to confirmation. It should be noted that the photosensitization syndrome was, until now, believed to occur mostly in young animals following weaning.

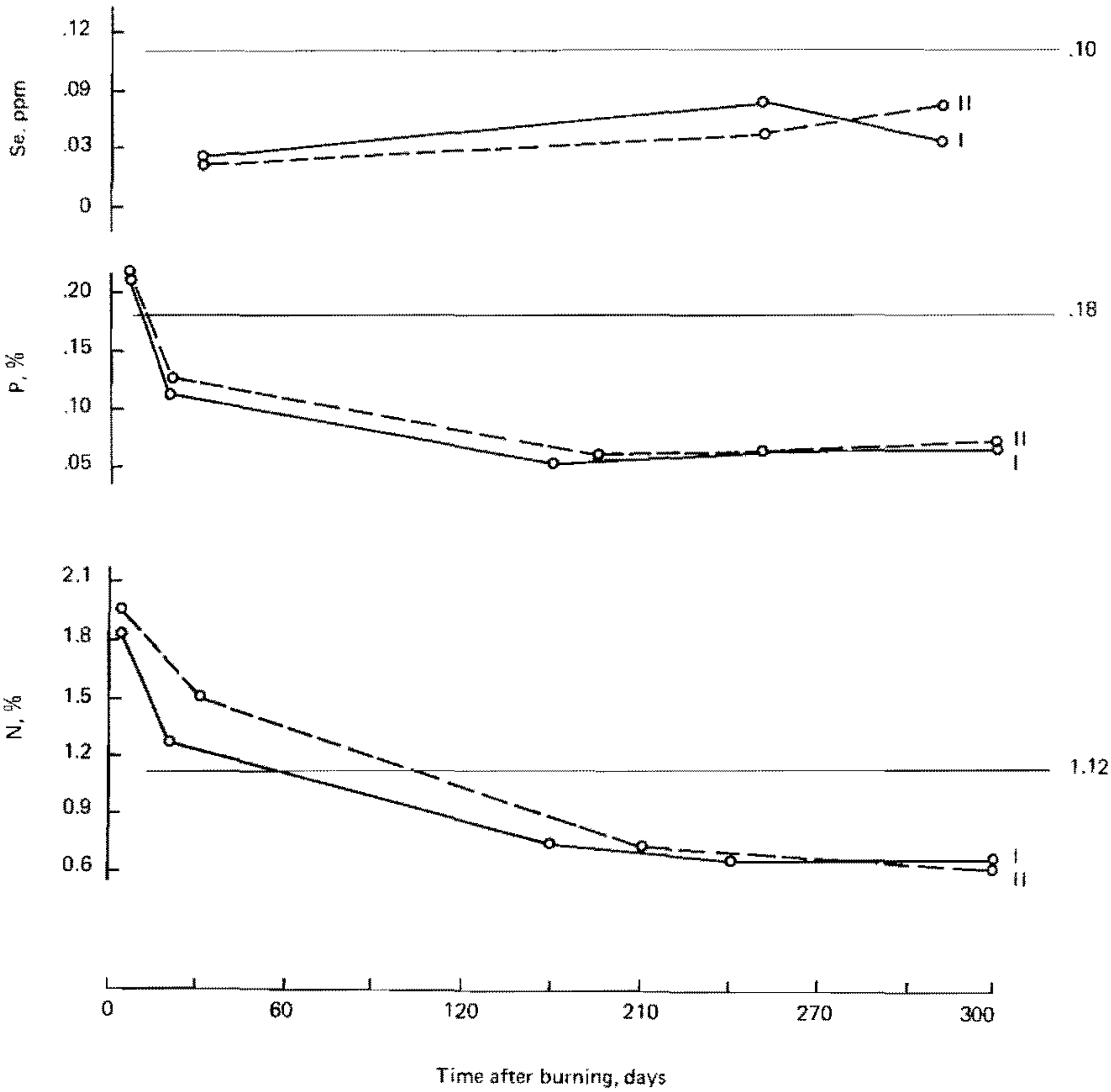


Figure 1. Mineral concentration of savanna vegetation, in two replicates. (I and II).

Table 5. Fecal nitrogen concentration (% DM).

Year, and days of Lactation	Savanna + Minerals	Savanna + Sown Pastures -Minerals	Savanna + Sown Pastures +Minerals
1982:			
49	....	1.09 ± .13[a]	....
190	1.22 ± .11	1.40 ± .07	1.18 ± .07
274	1.08 ± .10	1.40 ± .30	1.07 ± .10
1983:			
-60	1.18 ± .08	1.29 ± .10	1.23 ± .12
20	1.50 ± .17	1.39 ± .13	1.35 ± .08
120	1.29 ± .12	1.31 ± .11	1.34 ± .21

a/ Mean of all animals at beginning of experiment.

Table 6. Fecal concentration of phosphorus (% DM).

Year, and days of Lactation	Savanna + Minerals	Savanna + Sown Pastures -Minerals	Savanna + Sown Pastures +Minerals
1982:			
49	....	.35 ± .09[a]	....
190	.31 ± .08	.19 ± .01	.21 ± .03
274	.32 ± .11	.19 ± .02	.37 ± .12
1983:			
-60	.26 ± .03	.18 ± .03	.33 ± .10
20	.29 ± .05	.23 ± .03	.24 ± .05
120	.29 ± .08	.21 ± .03	.35 ± .13

a/ Mean of all animals at beginning of experiment.

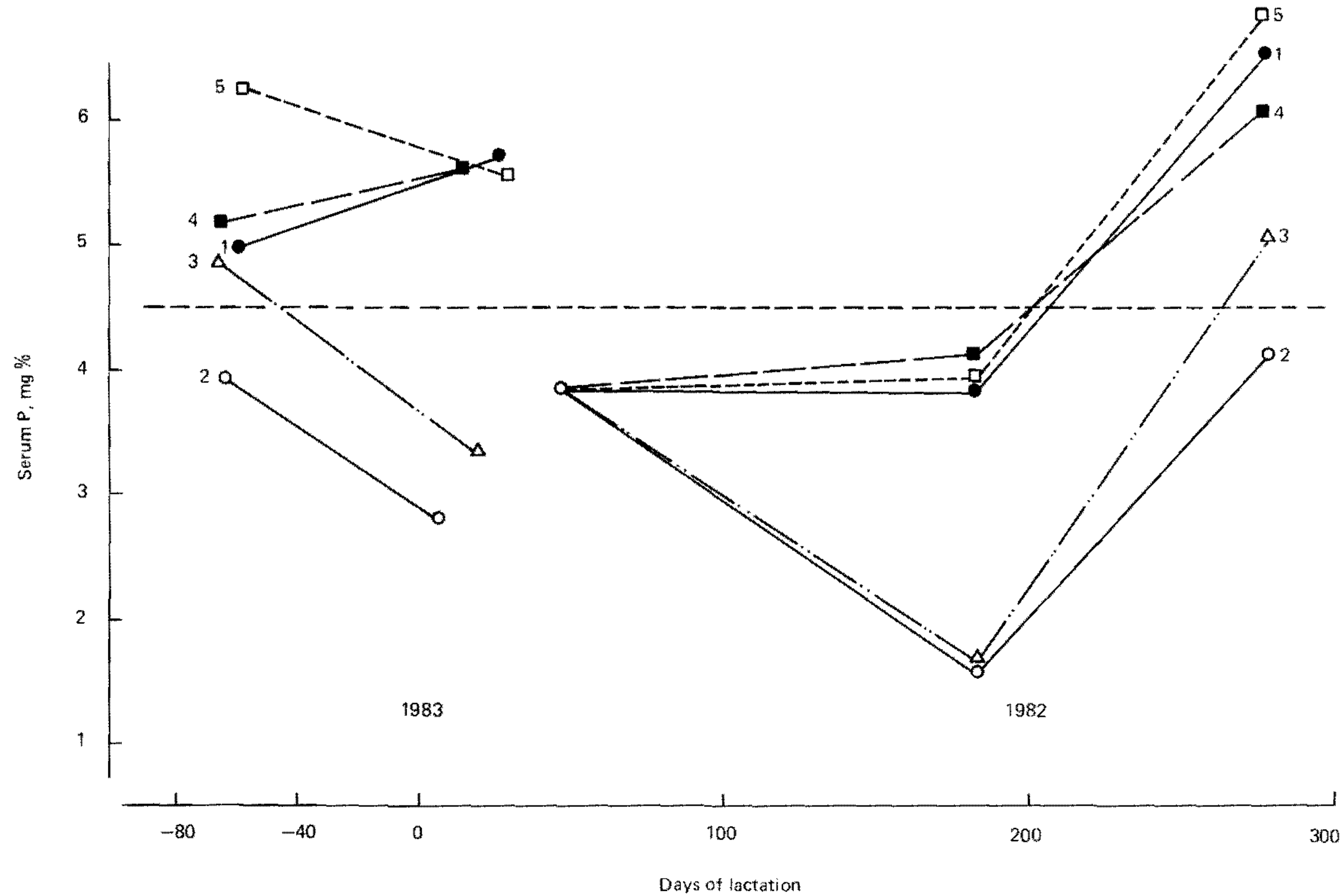


Figure 2. Influence of lactation on serum phosphorus concentration of cows under five management treatments (1 - 5).

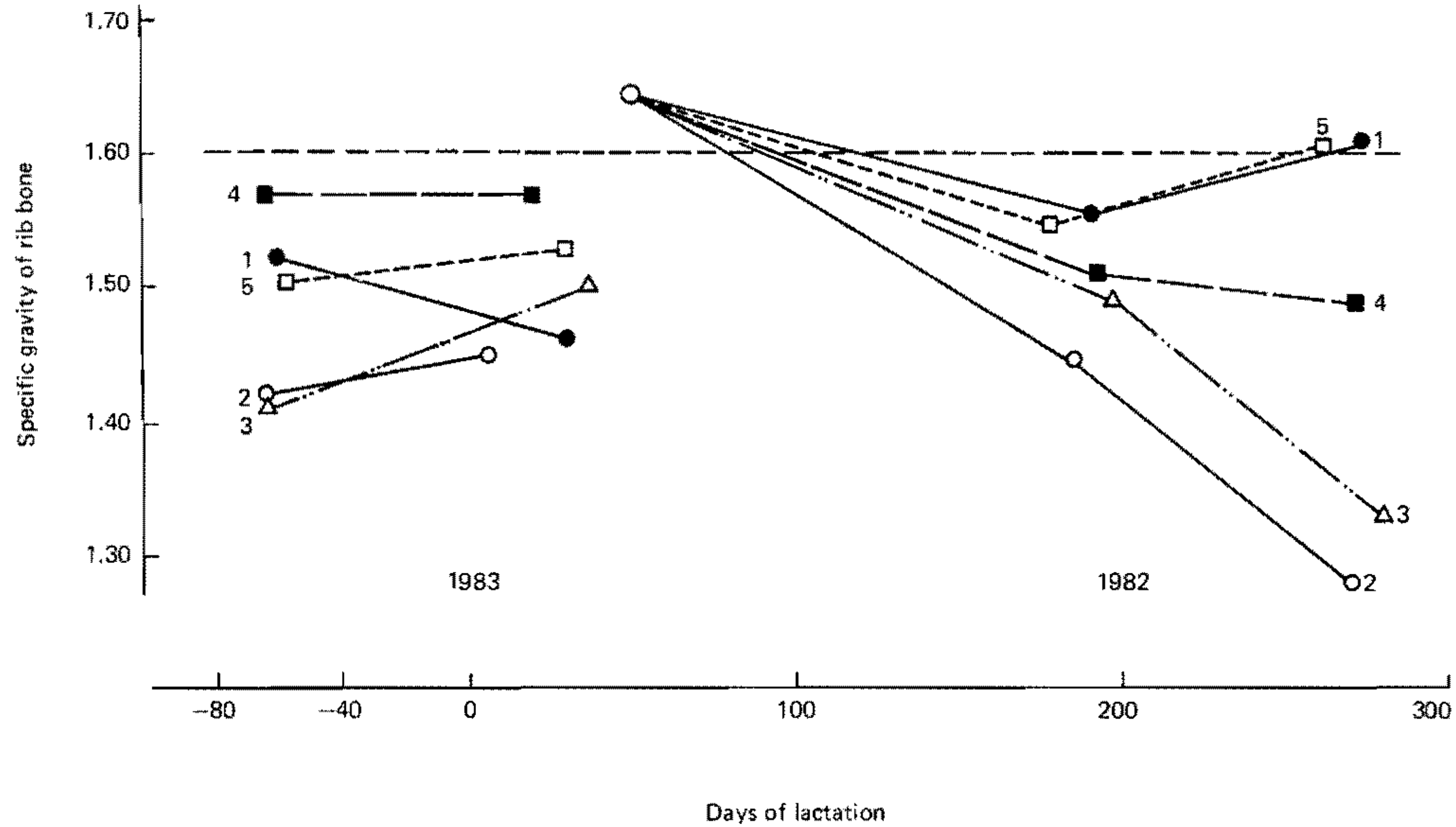


Figure 3. **Effect of lactation on rib bone specific gravity of cows under hoe management treatments (1 - 5).**

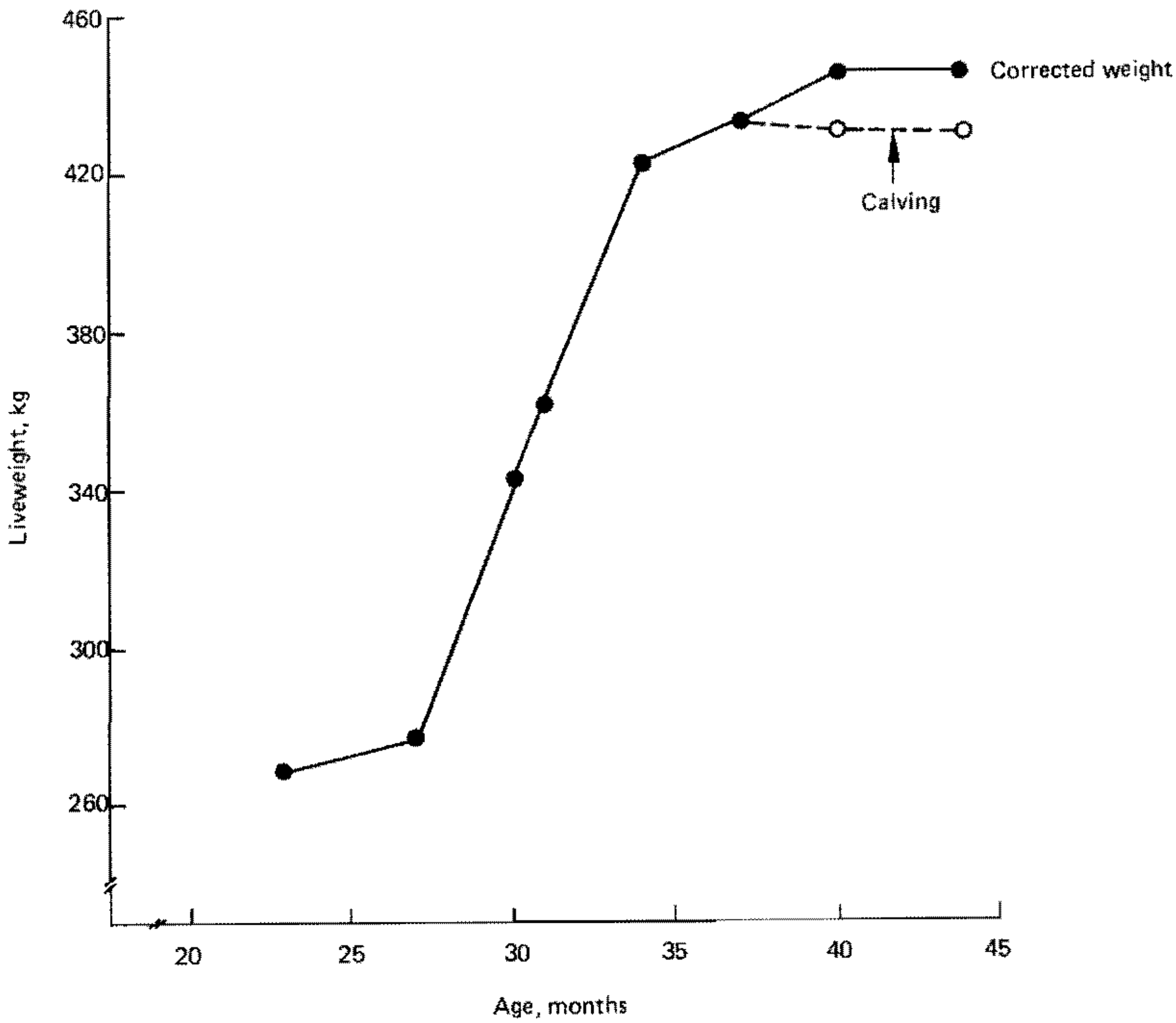


Figure 4. Growth curve of heifers.

Reproductive performance in heifers.

A general characteristic of the extensive ranching systems of tropical America is the very low rate of growth of replacement heifers. Thus, an experiment was initiated with the sections of Pasture Productivity and Management, Pasture Quality and Nutrition, and Economics, with the aim of evaluating the effect of low rates of growth on the occurrence of heat, based on the hypothesis that there may exist a weight-by-age interaction.

Considerable differences between treatments were obtained through the use of three stocking rates in a B. humidicola-M. minutiflora-D. ovalifolium pasture (Table 8). The range of liveweight gains observed were similar to those reported under extensive conditions. Animals are removed from the experiment at a liveweight of 270 kg, but their reproductive performance will continue to be estimated.

Photosensitization in B. decumbens.

It has been speculated that zinc may have a hepatoprotective role in the occurrence of this syndrome. An experiment was therefore begun to evaluate the role of Zn and of the fungus Pithomyces chartarum. It includes a factorial combination of fungal presence, through spraying spores on the pasture (absence vs. presence), and Zn application to the soil (0 vs. 5 kg/ha). The performance of, and appearance of symptoms in, weaners is being measured. The experiment, made in cooperation with the sections of Pasture Productivity and Management, and Pasture Quality and Nutrition, includes measurements in soil, pasture and animal samples to determine the status of Zn, counts of spores and serum chemistry.

The family farm prototype.

This prototype was described in detail in the 1982 Annual Report. Following a detailed study of the available results, and after an ex-ante economic analysis, the animal inventory of the unit was modified with the objective of including dual-purpose animals. Since no information is available on levels of milk production of pastures based on CIAT's germplasm, it was considered that this prototype may provide some preliminary data under semi-commercial conditions.

On-farm testing of improved pastures.

The objectives and main characteristics of these activities were listed in the 1982 Annual Report.

The results of the two first years on the use of improved pastures for rearing young heifers are shown in Tables 9 and 10. The data confirm the superiority of the A. gayanus-S. capitata association in terms of weight gains, carrying capacity and reproductive performance, relative to the native savanna. A consistent difference of 100 kg in mean liveweight, at the same age, was observed, but it is interesting that in farm 07, the use for only 6 months per year of the improved pasture, resulted in only a slight decrease in performance, when

Table 7. Serum concentration of gamma-glutamyl-transferase (GGT) of animals on a *Brachiaria decumbens* pasture.

Sampled Animals	n	GGT IU/ml	No. Animals with GGT > 16 IU
Cows	30	17.53 ± 4.82	15/30
Calves	22	48.71 ± 78.35	13/22

Table 8. Effect of stocking rates on liveweight gains and age and weight at first heat of heifers on a *B. humidicola*/*M. minutiflora*/*D. ovalifolium* pasture.

Stocking rate	LWG kg/d	Age at heat days	Weight at heat kg
Low	0.289 ± 0.028	793 ± 89	268 ± 25
Medium	0.207 ± 0.026	824 ± 37	249 ± 27
High	0.051 ± 0.016	-	-

Table 9. Liveweight gains of heifers grazing different types of pastures, in on-farm experiments.

Type of Pasture	Farm 15		Farm 07	
	LWG $g.d^{-1}$	SR $an.ha^{-1}$	LWG $g.d^{-1}$	SR $an.ha^{-1}$
Savanna	195 ± 33[b]	-	118 ± 27[c]	-
Brachiaria humidicola/ *Desmodium ovalifolium*	150 ± 60[c]	1.69	-	-
Andropogon gayanus/ *Stylosanthes capitata*	330 ± 72[a]	1.04	245 ± 36[a]	1.33
Andropogon gayanus/ *Stylosanthes capitata* + Savanna [1]	-	-	218 ± 23[b]	1.33

Means with different superscripts, within farms, differ significantly ($P < 0.05$).

1/ Sown pasture during the rainy season and savanna in the dry season.

Table 10. Conception rate of heifers in on-farm experiments. Data for May 83.

Type of Pasture	Farm 15			Farm 07		
	Conception %	LW kg	Age months	Conception %	LW kg	Age months
Savanna	0	200 ± 26	29 ± 1	0	222 ± 18	34 ± 2
Brachiaria humidicola/ *Desmodium ovalifolium*	21.0	220 ± 36	29 ± 3	-	-	-
Andropogon gayanus/ *Stylosanthes capitata*	45.1	298 ± 48	29 ± 3	87.5	340 ± 32	34 ± 1
Andropogon gayanus/ *Stylosanthes capitata* + Savanna[a]	-	-	-	85.0	322 ± 28	34 ± 1

a/ Sown pasture in rainy season, savanna in dry season.

compared to year-round use of the pasture. The influence of liveweight on conception rate is shown in Figure 5.

It is well known that fattening is the most profitable enterprise in these extensive ranching systems, but it only becomes possible when improved pastures are available. In this case, fattening of old steers (3 or more years of age) and of culled cows is common. Thus, it is of interest to compare the performance of these types of animals with the younger categories traditionally used in research (Tables 11 and 12). The preliminary data shown, suggest that a pasture by animal category interaction may exist.

The most difficult aspect to document on the integrated use of forage resources, is the effect of improved pastures on long-term reproductive performance. Farm 04 specializes in the production and sale of weaners; in this farm, 170 ha of improved pastures were sown between 1979 and 1980. This area represents 5.5% of the ranch, and is strategically used by the breeding herd. Mating was reduced from the traditional 12, to 8 months, coinciding with the rainy season. Weaning continues to be performed at 9 months of age.

Changes in mean uncorrected liveweight of the whole herd and of nursing cows, in stocking rate (referred only to cows/ha) and in the proportion of lactating cows are shown in Figure 6. If the stocking rate is expressed in terms of animal units (1 AU = 300 kg), it can be estimated that from an initial 0.13 AU/ha in 1979, the stocking rate rose to 0.24 AU/ha in 1983, an 85% increase, accompanied by a 29% increase in mean liveweight. The latter is an underestimate of the true increase, since there was a simultaneous change in age structure and physiological condition of the herd. If ages are adjusted to a mean of 6-7 years, and to the empty-dry physiological condition, the increase in mean liveweight was 42% (Table 13), with a highly significant effect of year ($P < 0.001$). Similarly, weaning weights increased from 109 kg in 1979, to 162 kg in the first semester of 1983. The weaning rate in 1979 was 50%. In 1982 the rate had increased to 57 to 63%, depending upon the method used to calculate it; over the four year period considered, and due to the use of records, it was possible to cull cows for fertility, which resulted in an actual weaning rate of 63% for the group of cows that remained in the ranch during four consecutive years. On the other hand, and using the more conservative hypothesis that the low fertility cows remain unidentified, the weaning rate would have been 57%. In either case, these percentages are an underestimate of the potential of the system because, as stated above, the new heifers and cows incorporated to the ranch during the intervening years were not considered, although they constitute an increasing proportion of the herd. This also indicates that the herd has not yet stabilized and therefore more years of observation are required.

It is obvious that the situation examined in farm 04 is only one of many strategies available for the development of the breeding herd. Some of the alternatives, such as improved feeding of heifers, have already been mentioned, while still others will be the subject of

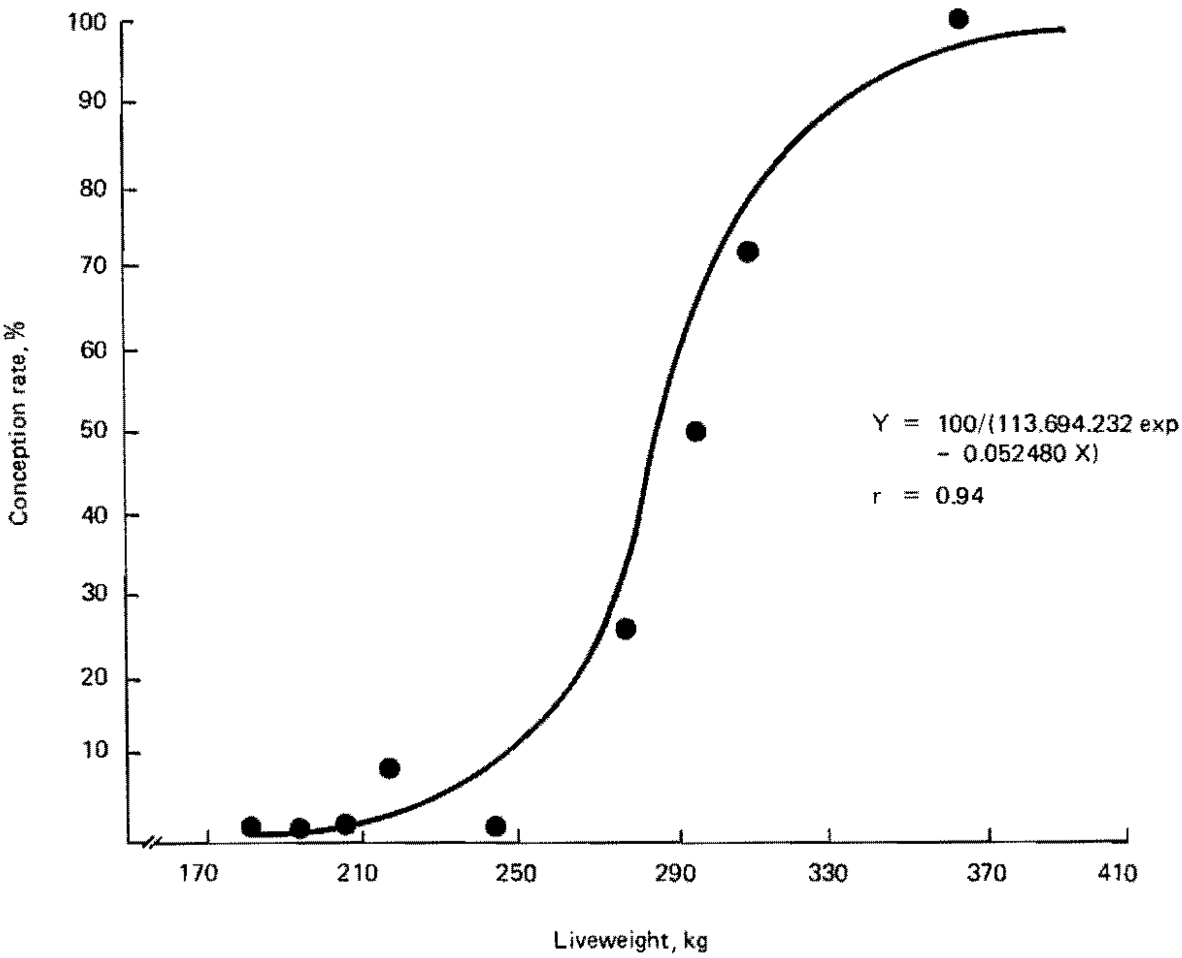


Figure 5. Relationship between liveweight and conception rate in heifers. Farm 15.

Table 11. Liveweight gains of heifers and mature steers grazing *Andropogon gayanus/Stylosanthes capitata*, farm 15.

Season	Mature Steers		Heifers		F
	$g.d^{-1}$	n	$g.d^{-1}$	n	Test
Dry Season 162 d,	209 ± 127	19	270 ± 94	24	N.S.
Whole year 351 d	376 ± 82	11	376 ± 111	23	N.S.

Table 12. Comparative liveweight gains of several animal categories on a *Brachiaria humidicola/D. ovalifolium* pasture. Rainy season of 1982; Farm 25.

	LWG, $g.d^{-1}$
Heifers	159^{b} ± 96
Adults steers	343^{a} ± 119
Cull cows	292^{a} ± 124

* 138d for steers; 227d for cows and heifers.

Means with different superscripts differ significantly ($P < 0.05$).

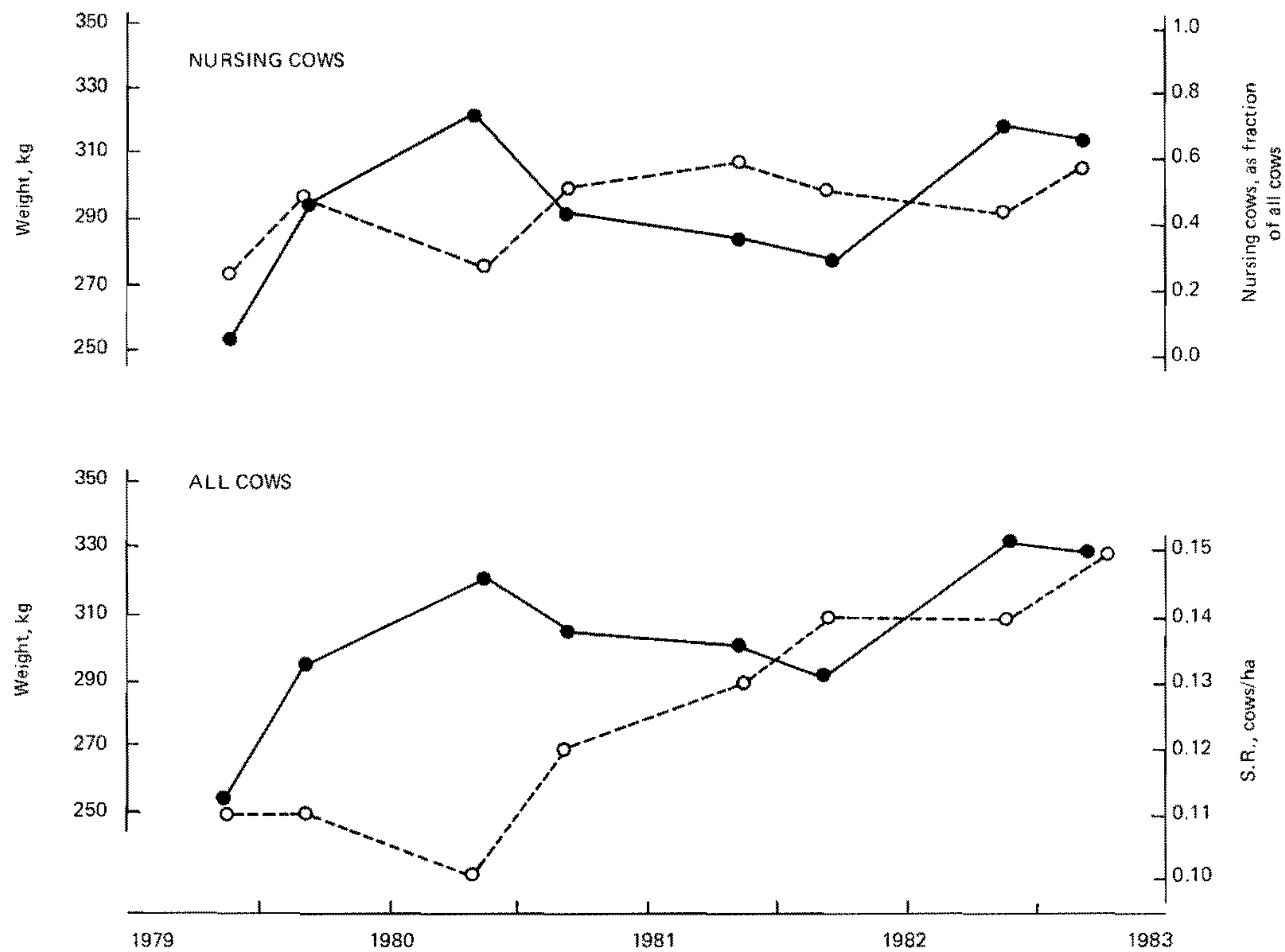


Figure 6. **Mean cow liveweight and stocking rate in Farm 04.**

Table 13. Mean cow liveweights, adjusted to an average age of 6-7 years and to the dry-empty condition. Farm 04.

Year	n	LW[3], kg
1979[1]	261	229[e]
1980	618	267[d]
1981	730	299[c]
1982	771	306[b]
1983[2]	465	326[a]

1/ Second semester of 1979
2/ First semester of 1983
3/ Means with different superscripts differ significantly (P <0.001).

simulation studies. The economic consequences of several of these strategies are reported by the Economics section.

Survey in livestock ranches of the Meta Department, Colombia.

A survey of 54 ranches involved with the Fondo Ganadero del Meta, was conducted in 1982 with the objective of identifying areas potentially suitable for continued on-farm testing of advanced germplasm. Ranches were located in the Andean Piedmont of the Eastern Plains, the well-drained savanna and the undulated or dissected ("serrania") savanna regions. Their location is shown in Figure 7. Information was collected regarding availability of forage resources, animal inventory, labour use, machinery and soil resources. Data on the latter is still being analyzed by the Soil Fertility and Plant Nutrition section, and shall be related to topography and vegetation.

Table 14 shows some of the characteristics of the ranches surveyed, while Table 15 includes data on sown forage species. The latter clearly shows the marked decrease in sown pastures as one progresses from the Piedmont region towards the "serrania". Table 16 shows the frequency of fertilizer use and of mineral salt supplementation of cattle, as well as the type of enterprise.

The data clearly indicates the dominance of *B. decumbens* among sown pastures, together with the incipient use of newer species such as *A. gayanus* and *B. humidicola*. On the other hand, traditional species such as *M. minutiflora* and *H. rufa* contribute very small areas in the savanna regions, but continue to be important in the Piedmont. Independently of the region considered, sown pastures are present in relatively small paddocks (Table 14) which probably implies that they are subject to some degree of management. Also, it is clear that in the more developed regions there is an important percentage of sown

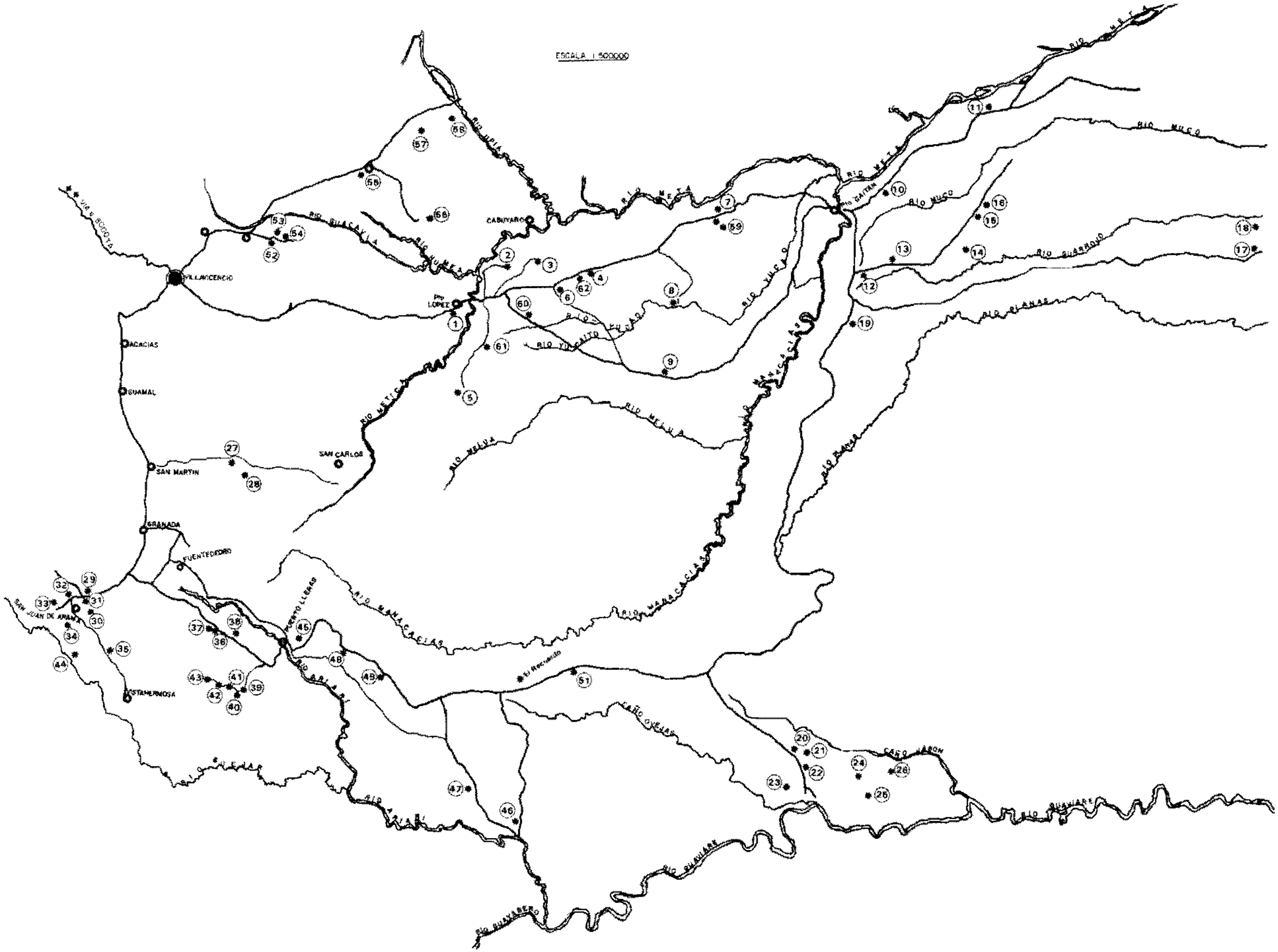


Figure 7. Survey in Ranches of the Meta Department.

Table 14. Forage species and areas planted in ranches surveyed in 1982 in the Meta Department.

REGION	No. of ranches	Mean size, ha	No. ranches with sown pastures	Sown pastures (%)*	Frequency of Occurrence: *Brachiaria decumbens*	*Hyparrhenia rufa*	*Melinis minutiflora*	*Brachiaria humidicola*	*Andropogon gayanus*	Other grasses	Grass-legume mixtures	Legume	No. of paddocks sown	Mean size, ha
TOTAL	54	2437 ± 3020 (65-15000)	52	22 ± 27 (.03-97.5)	43/50 (.5-1300)	23/50 (2-500)	7/50 (.5-41)	5/50 (.5-20)	12/50 (.5-105)	6/50 (.5-105)	4/50 (8-50)	1/50 (3)	2.7 ± 2.0 (1-10)	64.5 ± 76.7 (.5-1300)
Villavicencio-Río Upía	7	1482 ± 2074 (250-6000)	7	37 ± 40 (7-98)	5/7 (8-100)	4/7 (70-400)	2/7 (150-360)	0 -	2/7 (2-40)	0 -	0 -	0 -	1.7 ± 0.8 (1-3)	140 ± 123 (40-400)
San Juan de Arama to Río Ariari	17	1077 ± 2324 (65-10000)	17	38 ± 25 (3-82)	16/17 (20-380)	9/17 (30-500)	0 -	0 -	0 -	1/17 -	1/17 -	0 -	3.3 ± 3.0 (1-10)	73 ± 71 (19-290) (19-290)
Serranía:Río Manacacías-Río Ariari-Río Guaviare	7	5386 ± 5106 (800-15000)	7	.93 ± .98 (.01-2.75)	5/17 (.5-45)	4/7 -	2/7 -	0 -	0 -	0 -	0 -	0 -	1.7 ± 0.9 (1.3)	39 ± 72 (.5-200)
Well-drained savanna/ Serranía: Pto.López-Planas	23	2834 ± 2261 (302-10000)	21	8.1 ± 11.5 (.03-41)	17/21 (1-1300)	6/21 (2-30)	3/21 (.5-41)	5/21 (.5-10)	10/21 (1-20)	5/21 (.5-200)	3/21 (20-50)	1/21 (3)	2.8 ± 1.5 (1-5)	33 ± 35 (1-117)

* Percent sown, in ranches with improved pastures.

( ) Numbers between parentheses are the respective ranges.

Table 15. Total area of sown pastures found in 52 ranches surveyed in early 1982.

	REGION			
	Villavi- cencio- Río Upía	San Juan Arama Río Ariari	Serranía: Ríos Manacacías, Ariari, Guaviare	Well-drained Savanna/ Serrania: Pto.López- Planas
Area surveyed (ha)	10377	18316	37700	65178
Area sown with:				
H. rufa	650	1865	265	85
M. minutiflora	510	-	12	44
B. decumbens	308	1949	12	2566
B. humidicola	-	-	-	68
A. gayanus	42	-	-	83
Other grasses	-	50	-	314
Grass/Legume mixtures	-	8	-	120
Improved pastures, % total area	15	21	1	5

pastures that were fertilized at planting time (Table 16). Lastly, the large percentage of this group of ranches that uses some degree of mineral supplementation is surprising (36 out of 44, Table 16).

Table 16. Type of enterprise and frequency of use of some inputs.

REGION	Fertilization[1]					Supplementation				Activity								
	Lime	Phosphorus	Urea	Others	None	Common salt	Mineral suppement	Mixture[2]	None	Cow-calf only	Cow-Calf + yearling	Cow-calf + fattening	Complete cycle	Fattening	Cow-calf	Yearling	Fattening	Stocking rate (head/ha)
TOTAL	7/50	15/50	2/50	2/50	30/50	8/44	18/44	18/44	0/44	8/54	22/54	2/54	20/54	2/54	52/54	42/54	4/54	.34±.25 (.05-1.11)
Villavicencio-Río Upía	-	4/7	-	1/7	2/7	1/6	2/6	3/6	0/6	0	2/7	1/7	2/7	2/7	5/7	4/7	3/7	.49±.25 (.12-.70)
San Juan de Arama al Río Ariari	4/17	5/17	2/17	1/17	8/17	4/17	7/17	6/17	0/17	0	4/17	0	13/17	0/17	17/17	17/17	13/17	.54±.19 (.12-.91)
Serranía: Río Manacacías-Río Ariari-Río Guaviare	1/7	1/7	-	-	5/7	0/6	1/6	5/6	0/6	0	6/7	0	1/7	0	7/7	7/7	1/7	.16±.05 (.09-.25)
Well-drained savanna/ Serranía: Pto.López-Planas	2/21	5/21	-	1/21	16/21	3/15	8/15	4/15	0/15	8/23	10/23	1/23	4/23	0	23/23	14/23	1/23	.17±.10 (.05-.40)

1/ In several cases, more than one fertilizer was used.

2/ Mixtures of common salt + complete mineral supplement.

ECONOMICS

During 1983 economics research in the Tropical Pastures Program covered the areas of demand analysis for different meats and input: output price relations in different regions of the program's area of interest as rather macro-level topics. The major effort was in production economics. An ex-ante feasibility analysis of small scale family-run farms was undertaken for the Eastern Plains of Colombia. For the same region the competitiveness of three different strategic uses of improved pastures in cow-calf operations was assessed.

The monitoring of dual purpose (beef and milk) operations in the central provinces of Panama was completed and presently the potential impact of improved pasture technology is being assessed within a linear programming frame.

An ex-post analysis was undertaken on the marginal productivity of improved pastures used strategically in commercial cow-calf operations formerly belonging to the ETES (systems monitoring) project. Fifty-seven early adopters of *Andropogon gayanus* were surveyed in several regions of Colombia. The survey is presently being analyzed.

MEAT CONSUMPTION (BEEF, PORK AND POULTRY) IN THE LATIN AMERICAN TROPICS AND SUBSTITUTION POTENTIALS

For decision making on resource allocation of research funds for food products, such as meats, it is necessary to understand consumer attitudes to these commodities and reactions to be expected to relative price changes. These variables influence total benefit to be achieved from the investment in research and the distribution thereof among different groups of the population.

In collaboration with FAO's Regional Office for Latin America a study on demand of beef, pork and poultry in the Latin American tropics is underway. Particular attention is being given to the evolution of the relative participation of different meats in total consumption and the potential for consumers to substitute among them.

Up to date time-series analyses have been completed for Colombia, Venezuela and Brazil. Similar work is underway for selected countries of Central America, the Caribbean and the Southern Cone. In addition, livestock policies of the selected countries are being reviewed. For the Colombian case, a cross-sectional analysis of meat consumption and its determinants based on a representative nutritional survey of 10,000 households is being undertaken. This survey was undertaken by DANE/DRI and kindly made available to CIAT.

In the following paragraphs the early results of the time-series analysis for Brazil, Colombia and Venezuela are given.

The levels of total meat consumption and their structure (Table 1) document somewhat higher total consumption in Venezuela than in the other two countries and quite different structural patterns. In Venezuela, poultry contributes to more than one third of the total consumption while in Colombia its contribution is only 14%. These differences in consumption patterns are related to different policies and relative prices. The latter clearly support a higher consumption of poultry in Venezuela (Table 1).

Table 1. Consumption parameters of beef, pork and poultry meat in Brazil, Colombia and Venezuela. 1982.

Meat	Consumption		
	Brazil	Colombia	Venezuela
	------------	(kg/capita)	------------
Beef	17	25	22
Pork	8	5	6
Poultry	9	5	16
Total	34	35	44
Relative price (kg/kg)			
Beef/Poultry	2.2	1.5	2.9
Beef/pork	0.9	0.9	1.5

The econometric analysis of the time-series data rendered estimates of the price and cross-price elasticities for the three types of meats and the respective income elasticities (Table 2). Double-log or Cobb Douglas functions were estimated; thus coefficients directly represent elasticities. Problems such as administration of prices in Venezuela and difficulties inherent in time-series analysis induced some biases into the estimations.

The results show income per capita to be a significant variable to explain consumption in all three countries and for the three types of meat, all of which respond as superior goods, i.e. demand grows with increasing incomes. Nevertheless the magnitude of this positive income elasticity varies between type of meat and country. In general, poultry presents the highest income elasticities followed by beef and pork (Table 2). Colombia is the exception with a slightly higher income elasticity for beef than for poultry.

Within the same type of meats, various cases of similar income elasticities were found:

Table 2. Demand equations for meats in Brazil, Colombia and Venezuela (dependent variable - per capita demand in kg/year).

Variable	Brazil	Colombia	Venezuela
Beef			
Slope	4.67	-2.93	9.67
Price beef	-0.23 (2.33)	-0.71 (4.63)	-0.01 (0.11)
Price pork	0.09 (1.17)	-0.51 (4.63)	0.11 (0.89)
Price poultry	0.50 (4.66)	0.37 (2.67)	-0.33 (8.59)
Income per capita	0.32 (4.34)	0.79 (2.93)	0.34 (15.26)
R^2	0.69	0.54	0.94
R^2	0.60	0.47	0.93
SSE	0.0355	0.0915	0.0372
DW	2.41	0.75	1.65
Pork			
Slope	1.53	-4.53	7.22
Price beef	0.06 (0.89)	0.66 (3.09)	0.62 (2.97)
Price pork	-0.26 (3.92)	-0.48 (2.83)	-0.12 (0.41)
Price poultry	-0.007 (1.29)	-0.15 (4.50)	-0.09 (0.99)
Income per capita	0.02 (1.71)	0.29 (5.30)	0.27 (5.37)
R^2	0.57	0.68	0.82
R^2	0.48	0.63	0.80
SSE	0.0278	0.0956	0.1848
DW	1.10	1.07	0.69
Poultry			
Slope	6.27	-5.45	6.97
Price beef	0.03 (0.09)	0.62 (2.49)	0.33 (18.59)
Price pork	0.01 (0.05)	-1.14 (5.49)	0.01 (0.12)
Price poultry	-1.26 (10.82)	-0.46 (9.64)	-0.52 (47.12)
Income per capita	1.62 (12.12)	0.73 (10.14)	0.61 (51.79)
Año	0.11 (1.42)		0.02 (54.30)
Dummy	-0.36 (2.52)	0.30 (4.68)	0.29 (28.09)
R^2	0.97	0.94	0.99
R^2	0.96	0.93	0.99
SSE	0.7868	0.1226	0.1283
DW	0.71	1.27	1.73

In brackets "t" values.

1) For beef, those of Brazil and Venezuela (0.32 and 0.34) are similar and lower than the one for Colombia (0.79).

2) For pork, those of Colombia and Venezuela (0.29 and 0.27) are also similar and higher than the one for Brazil (0.02).

3) For poultry, those of Colombia and Venezuela (0.73 and 0.61) are much lower than the one for Brazil (1.62).

The price of each of the considered meats affects the consumption in the opposite direction as expected beforehand, but in Venezuela neither beef nor pork show a direct price elasticity significantly different from zero. This can be explained in part by the rigorous price controls at consumer level in this country. In beef, Colombia presents the highest price elasticity (-0.71), which is three times higher than the estimated value for Brazil (-0.23) (Table 2). Colombia also presents the highest price elasticity of pork (-0.48), 1.8 times higher than the estimation for Brazil (-0.26). The highest price elasticity of poultry meat occurs in Brazil (-1.26), compared to -0.52 estimated for Venezuela and -0.46 for Colombia.

The substitution effects between the meats are rather different among the countries, although a common feature can be detected: a substitution exists between beef and poultry in Brazil and Colombia (Tables 2 and 3). In the case of Venezuela the situation is not all that clear, because even though price increases of beef determine the substitution of beef by poultry, the reverse effect does not happen.

Table 3. Direction of the substitution-complementarity and income effects by type of meat in Brazil, Colombia and Venezuela.

Country	Type of meat demanded	Price			Income per capita
		Beef	Pork	Poultry	
Brazil	Beef	-	o	+	+
	Pork	o	-	o	+
	Poultry	o	o	-	+
Colombia	Beef	-	-	+	+
	Pork	+	-	-	+
	Poultry	+	-	-	+
Venezuela	Beef	o	o	-	+
	Pork	+	o	o	+
	Poultry	+	o	-	+

\+ = Changes in the value of the variables (prices or incomes) influence demand in the same direction.
o = No significant change.
\- = Changes in the value of the variables (prices or incomes) influence demand in the contrary direction.

In Brazil only one of the six possible relationships of substitution-complementarity is significant: the substitution of beef by poultry. Venezuela, as mentioned before, is the country of least consistency in relation to the behavior of prices. In this country a substitution of beef by poultry and of beef by pork can be observed. Colombia is the most consistent country in terms of price behavior, and all relationships of substitution-complementarity are significant, showing substitution of poultry by beef, of beef by poultry and beef by pork. The complementary relationship between pork and poultry is clear-cut and of symmetric type.

Based on this information, projections of meat demand assuming different scenarios of producers prices and incomes are being elaborated.

ANALYSIS OF PRODUCT AND AGRICULTURAL INPUT PRICES IN THE AREA OF INTEREST OF THE TROPICAL PASTURES PROGRAM

In order to design technologies adapted to farmer conditions in an area as heterogeneous as the savannas and forests of tropical America, the Tropical Pastures Program requires information on the biological and economic frame of the different regions.

The RIEPT (International Network of Tropical Pasture Evaluation) is the instrument of the national programs in cooperation with CIAT to measure the response of germplasm to environmental conditions across locations. To additionally measure the variability of the economic frame, an annual survey on product and input prices of all participants in the network has been conducted, with a response rate of 21% in 1982 and 36% in 1983.

The analysis includes price comparisons between countries and regions in terms of US$ prices and relative cattle prices with regard to some inputs (fertilizers, labour, machinery, land and fuel) and products (milk, rice). For analyzing the aggregate effect of various inputs, a basket of basic inputs for pasture establishment on acid soils was designed. The value of this basket is expressed in kilograms of beef liveweight in order to make comparisons between countries possible. Figure 1 presents the result of the comparative analysis of the establishment cost index for 1983 based on the information of 15 locations. An ample range of variation of the index can be observed, indicating the variability of the adoption potential for improved pastures. It has to be emphasized, however, that for decision-making this analysis has to be expanded over time to include the variation of prices caused by the cattle cycle. It is therefore hoped to continue counting on the collaboration of the RIEPT members for this type of analysis.

MONITORING OF DUAL PURPOSE FARMS IN THE CENTRAL PROVINCES OF PANAMA

In 1982 account was given of this joint project with the National Bank of Panama, presenting information about resource availability, physical characteristics and farm management. This year, the monitoring activities were brought to an end and a linear programming model for the analysis of alternatives was developed.

Table 4 ETES-PANAMA: main technical coefficients (June 81-May 82).

Coefficients	Farm 01	02	03	04	05	06	Average
Calving rate[1]	70.0	73.2	79.1	63.3	57.7	98.9	73.1
Mortality rate adult cattl.	0.0	0.0	6.9	5.2	0.0	0.0	3.3
Mortality rate calves	11.8	0.0	25.3	58.8	3.3	2.7	19.5
Age first calving	30.1	34.7	42.4	41.4	38.8	30.6	37.5
Weight (kg)							
Cow	392	341	310	343	327	372	337
Weaner	98	145	133	89	165	163	132
Milk production							
Mean lactation length (days)	354	407	288	240	293	240	304
Litres per:							
. lactating cow	1247	890	1484	783	584	662	1156
. cow in the herd	751	560	578	344	418	425	509
. hectare/year	608	259	260	326	208	220	276
Beef production							
kg/AU/year	63	55	45	25	55	50	46
kg/ha/year	100	67	57	53	61	65	62
Equivalent beef production[2]							
kg/AU/year	102	77	67	40	74	66	67
kg/ha/year	161	92	83	85	81	87	89
Stocking rate (AU/ha)[3]	1.8	1.2	1.2	2.1	1.1	1.3	1.3

1/ June 1981-May 1982: heifers not included.

2/ 10 litres milk - 1 kg beef.

3/ Only cattle.

Table 5. ETFS-PANAMA: Economic indicators.

Coefficients	Farm 01	02	03	04	05	06	Average
Gross income (US$):							
Sale of milk	3714	4004	9081	2798	2943	2904	4241
Salf of beef	1310	4220	17314	4804	7810	7281	7123
Change in inventory	1537	-1853	-7284	-3309	-4616	-1404	-2820
Total	6561	6371	19119	4293	6137	8781	8544
Expenditure (US$):							
Herd management	37	407	4479	1601	778	0	1217
Weed control	238	491	213	244	555	30	295
Pasture short term rent	359	312	30	0	80	150	155
Pasture maintenance	0	518	1095	464	0	56	355
Animal health and supplementation	109	186	709	215	576	465	377
Others	399	383	2440	111	333	638	718
Total	1142	2297	8966	2635	2322	1340	3117
Net income (US$) (Return to family labor + capital)	5419	4074	10153	1658	3815	7441	5472
Returns (US$/day)[1]:							
Family labor	25.3	13.6	121.6	2.0	39.5	12.6	20.6
Total labor	18.0	8.4	9.5	4.8	10.6	12.6	10.1
Total capital[2] (%)	15.6	7.0	6.9	2.5	7.2	11.0	7.6

1/ Assuming 3% return to capital.

2/ Inputing a wage of US$5/day to family labor.

weed control. The strenuous jobs like weeding are carried out by hired labourers while the owner tends to look after the administration and cattle management.

The short-term renting of pastures is another important expenditure in some farms, indicating the importance of this adjustment mechanism for the seasonal availability of fodder. The fact that inputs bought from other sectors, as veterinary products, wire, etc. are of little incidence, shows the high value added generated for the region by these systems in spite of their moderate physical productivity levels.

The average return to total labour almost doubles the average salary of the region, indicating the relatively efficient use of the labor of this system. Furthermore, the system represents a rational use of the resources resulting in a return to total capital of 7.6% annually on the average.

In order to evaluate different options of technological change for this system with special emphasis on the improvement of the fodder base, a linear programming model for a representative farm was developed. The model included the following activities:

a) Fodder production in terms of DM, metabolizable energy and digestable protein per trimester, for a number of grasses and legumes with changing fertilizer levels and soil requirements.

b) Transfer of fodder between periods according to the type of fodder (grass or legume, three types).

c) Utilization of fodder by different types of animals. Two separate blocks of fodder balances for each of the seasons are considered to properly represent the high requirements of milking cows.

d) Included are cows in production, rearing of males and females, cows of different production levels as well as calving seasons, periods of weight gains and losses. In order to obtain the requirements of each type of cow, a small nutritional budgeting model was previously developed.

e) A number of activities for buying feed supplements, using credit, family and hired labor, etc. are included.

The present model quite realistically describes the actual organization of the above described farms. Preliminary results of simulations with the model indicate:

a) The rather high establishment costs of pastures in Panama (particularly fertilizers, land preparation) as well as the relatively low product prices (meat and milk) presently limit the attractiveness of a massive use of improved pastures, particularly due to the production level of presently used pastures like Hyparrhenia rufa, which is considerably higher than that of the savannas of South America.

b) Leucaena leucocephala seems to have a high potential in this system because of its high production, and protein content as well as considerable concentration of metabilizable energy. Its principal limiting factor is the high establishment cost. A rapid expansion of the area of this legume could be expected if Leucaena could be established together with crops like maize and/or if weeding costs in the establishment phase could be reduced by using herbicides.

c) Given the production level of H. rufa and the management of milking cattle, there seems to be a potential role for legume banks both to supplement milking cows and calves.

These conclusions are preliminary and based on information available to date. More data is needed on the production under grazing during each season of the year for the majority of the materials as well as the possibility to transfer these standing forage crops to the dry season. Finally, these results refer to an average situation. The marked drought in various Panamanian regions brings up the idea that the role of legumes should additionally be analyzed as a mechanism to reduce risk.

EX-ANTE ANALYSIS OF ALTERNATIVE STRATEGIC USES OF IMPROVED PASTURES IN COW-CALF OPERATIONS IN THE EASTERN PLAINS, COLOMBIA

The use of pastures for early weaning, rearing of heifers and improved feeding of cows was evaluated ex-ante by using information provided by the Program and assumptions based on the literature and qualified informants. The main parameters used are to be found in Table 6. The weaning strategies differ in the age at weaning causing different impact on the cows' weight, calving rate and pasture requirement. The alternatives of strategic nutrition of the cows differ according to the duration of the period on improved pasture influencing the cows' weight, calving rate and due to the better feeding of female calves, their age at the first mating. Increases in the period on improved pasture imply a reduction in the number of cows fed per hectare of improved pasture.

The Alternative I of improved heifer feeding corresponds approximately to the results of on-farm trials reported by the Cattle Production Systems Section.

The alternative II refers to similar stocking rates, but higher weight gains. Alternative III, finally implies stocking rates and weight gains similar to those obtained with males under experimental conditions in Carimagua. In all cases it is supposed that the only effect of a better feeding of heifers consists in the younger age at first calving, without affecting the later reproductive life during which traditional management exclusively on savannas is assumed.

Based on these parameters and on prices of 1983 a marginal analysis of the impact of each of the strategies for an initial herd of 100 cows and their respective followers is made. Table 7 indicates the evolution of the areas in improved pastures for each strategy and the implications in terms of percentage of the total farm area with sown pastures.

Table 6. Strategic use of improved pastures in cow-calf operations: technical coefficients.

Coefficients	Traditional	Early Weaning			Improving Feeding of Cows			Improved feeding of Heifers		
		I	II	III	I	II	III	I	II	III
Calf mortality (%)	4	4	4	4	4	4	4	4	4	4
Adult mortality (%)	2	2	2	2	2	2	2	2	2	2
Mating of heifers (%):										
2-3 years	0	0	0	0	0	20	60	5	40	40
3-4 years	20	20	20	20	40	40	100	90	100	100
+ 4 years	100	100	100	100	100	100	100	100	100	100
Calving rate (%)	50	60	75	100	60	75	100	50	50	50
Culling rate (%)	16	16	16	16	16	16	16	16	16	16
Cow weight (kg)	310	340	400	500	340	400	500	310	310	310
Improved pasture requirements (head/ha)):										
Calves		10	7	7						
Heifers								1.33	1.33	2.00
Cows					10	2.77	1.05			
Pasture persistence (years)		6	6	6	6	6	6	6	6	6
Refertilization frequency (years)		3	3	3	3	3	3	3	3	3
Mineral supplementation (kg/AU)		15	15	15	15	15	15	15	15	15

Table 7. Evolution of the required areas of improved pastures.

Type of use[1]	Required areas of improved pastures			Relative Area[2]
	Initial	10 years	20 years	
	ha			(%)
Early weaning:				
I	5	7	13	0.30
II	7	16	36	0.50
III	7	32	92	0.69
Improved feeding of cows:				
I	10	15	25	0.65
II	36	73	173	2.19
III	128	391	950	6.02
Improved feeding of heifers:				
I	20	27	50	1.42
II	27	41	60	2.09
III	18	27	40	1.38

1/ Alternatives I, II and III correspond to the coefficients reported in Table 6.

2/ Area of improved pastures year 10/total farm area (5 ha/AU).

Various efficiency indicators, the marginal rate of return, the relative increase of the cash-flow and the relative increase of the herd's value in the 25th year are shown in Table 8. Early weaning and strategic nutrition of cows always dominate the alternatives of strategic use for rearing heifers. Ever under conservative assumptions, attractive rates of return are obtained.

A large share of the production increase is capitalized in herd growth. This is the reason why the indicator of final value of the herd presents a higher variation among alternatives than the cash-flow in the years 10-15. Early weaning has the advantage of requiring only a very small investment in improved pastures while the growth of the herd constitutes the major investment. As cattle can easily be sold, this alternative offers a higher flexibility and less investment risk in pastures. On the other hand, early weaning requires more sophisticated management.

These results reveal the potential of the new germplasm, but at the same time document the importance of continuing systems experiments to evaluate these alternatives with more reliable data.

Table 8. Expected performance of various strategic uses of improved pasture in cow-calf operations (100 cow unit).

Type of Use	Marginal internal rate of return	Incremental cash flow	Final value of herd[2]
Early weaning:			
I	37.96	54.45	73.16
II	45.50	146.07	236.31
III	51.71	403.40	707.72
Improved feeding of cows:			
I	34.87	60.20	75.81
II	29.02	172.70	297.50
III	22.22	359.16	787.50
Improved feeding of heifers:			
I	17.39	21.98	17.09
II	19.74	34.29	23.60
III	30.76	45.28	23.60

1/ Average of the years 10 to 15:

$$\frac{\text{Improved - traditional cash flow}}{\text{traditional cash flow}} \times 100$$

Traditional cash flow = $382.000

2/ $$\frac{\text{Improved herd value - traditional herd value}}{\text{traditional herd value}} \times 100$$

Traditional herd value (25 years) = $Col.8'901.000

FEASIBILITY OF ESTABLISHING FAMILY FARMS IN THE EASTERN PLAINS, COLOMBIA

The high productivity levels in terms of beef production which were obtained in experiments with grass-legume associations, as well as the results of the Family Farm Unit in Carimagua led to the evaluation of the technical and economic feasibility of family-sized cattle farms for the region of the Eastern Plains of Colombia.

The ex-ante study undertaken by the Visiting Scientist Dr. Bruce Davidson, of the University of Sydney, Australia, included different options of pasture use: native savanna, pure grasses and grass-legume associations. Different uses of the pastures were considered: breeding and rearing, fattening and dual purpose. Alternatives based on results of experimental weight gains and alternatives discounting 20 and 40% of the experimental yield level to simulate farm level results, were included.

The main results of the study were:

- The development of small scale cattle farms in the Eastern Plains is feasible by using the improved pasture technology.

- The orientation towards dual purpose cattle, cheese making and pig rearing based on whey and cassava markedly increased the profitability reaching 18.9% on the total capital and reduced the initial years of negative cash-flow. Using grass-legume associations with dual purpose cattle it is feasible to obtain positive accumulated cash-flows from the 8th year onwards and achieve annual net incomes of Col$1.7 millions after 18 years.

- The necessary capital to establish a farm of this type amounts to approximately Col$1.6 millions. Taking advantage of the credit facilities for small cattle farms, a model was developed with grass-legume associations, with milking and production of beef at 60% of the experimental weight gains. The credit could be paid in eight years, obtaining an inflation corrected rate of return of 22% annually on farmer equity.

EX-POST ANALYSIS OF THE PROFITABILITY OF STRATEGIC USE OF IMPROVED PASTURES IN BREEDING SYSTEMS. CASE STUDY

The report of the Cattle Production Systems Section presents the results in terms of cows' weight gains, calving rates, weaner weights and stocking rate achieved on this farm by introducing improved pastures on 5.5% of the farm area.

A marginal analysis of the profitability of this technical change is presented here, using prices of 1979 when this project started. Table 9 shows the gross benefits and the evolution of their structure overtime. The increased carrying capacity contributes an important part of the benefits achieved in spite of the low percentage of the area improved and the emphasis laid on the improvement of the reproductive performance. The increased weight of the weaners was more important than the improvement of the calving rate, although the

Table 9. Marginal benefits of strategic use of improved pastures on a cow-calf operation - case study. Eastern Plains of Colombia (US$).

	1980	1981	1982	1983
1. Sale of cull cows (No.of cows sold x kg incremental weight x price per kg)	(70)(70)(.96) = 4.704	(70)(70)(.96) = 4.704		
2. Incremental weaner weight (No.of weaners x incremental weight x price per kg)	(165)(20)(1.07) = 3.531	(165)(20)(1.07) = 3.531	(165)(35)(1.07) = 6.179	(165)(53)(1.07) = 9.357
3. Incremental weaning rate (No.of cows x increment x price per calf)	(330)(.03)(126.5) = 1.252	(330)(.03)(126.5) = 1.252	(330)(.07)(154.3) = 3.564	(330)(.07)(173.6) = 4.010
4. Reduction of mortality (No.of cows x reduction x value of cow)	(330)(.02)(235.0) = 1.551	(330)(.02)(235.0) = 1.551	(330)(.02)(235.0) = 1.551	(330)(.02)(235.0) = 1.551
5. Additional calves due to stocking rate increase (No.of additional cows x weaning rate x price per calf*)			(100)(.57)(154.3) = 8.795	(134)(.57)(173.6) = 13.259
T O T A L	11.038	11.038	20.089	28.177

* Net value of a calf after deducting variable costs (minerals and drugs).

importance of the latter is growing.

The marginal cash-flow analysis (Table 10) shows that when selling weaners, a three-year negative cash-flow can be expected. Afterwards, however, an annual net cash income of US$26,500 is achieved. This is reflected in attractive marginal rates of return which fluctuated between 19 and 35% p.a. depending on the assumed persistence and refertilization regime of the pastures.

SURVEY OF EARLY-ADOPTERS OF *Andropogon gayanus* IN COLOMBIA

In order to provide feedback to the Program on the performance of the grass *A. gayanus* at the farm level, a survey of 57 adopters was undertaken in cooperation with the Seed Production and Systems sections.

As it was not feasible to draw a random sample, given the incipient diffusion of this material, purchasers of *A. gayanus* seed were contacted through the seed dealers. Further users were identified through adopters and other qualified informants.

The survey included general information about the farm, evolution of areas of *A. gayanus*, management practices for the grass, estimated productivity levels and value judgements on merits and drawbacks of the cultivar. This information is presently being processed.

On 57 farms comprising a total area of 64,524 ha, an area of *A. gayanus* of 5,002 ha was encountered. The geographical distribution and evolution of these areas overtime are shown in Table 11.

It can be noticed that substantial areas of *A. gayanus* were found outside the Eastern Plains, the region where the cultivar was originally developed. Certain characteristics of the cultivar such as its tolerance to pests and diseases, particularly spittlebug, its dry season productivity and performance on poor soils seem to give it an important role in other regions, particularly some areas of the Colombian North Coast.

Given the fact that the survey documents the almost exclusive use of pure *Andropogon*, a marked increase in adoption is to be expected, once the productivity of this cultivar in association with legumes becomes well-known and these legume cultivars are actually made available to farmers.

Table 10. Marginal cash flow (US$ 1979 prices) and internal rate of return.

	1979	1980	1981	1982	1983
Investment::					
a) Pasture establishment	24347	11374			
b) Infrastructure	2679				
c) Cattle			23501	7990	
Inflows:					
a) Production increase		11038	11038	20089	28177
b) Residual value pastures					28202
c) Residual value infrastructure					1598
d) Residual value additional cows					31492
Outflows:					
a) Mineral feeds				116	164
b) Drugs				116	164
c) Pasture maintenance					1433
Net cash flow:	-27026	-336	-12463	12331	87708

Marginal internal rate of return:

a) Residual value of the pasture zero in year 5 = 19%

b) Residual value of the pasture 80% of initial value in year 5= 31%

c) Persistence 12 years refertilizing every third year at 1983 levels = 35%

Table 11. Evolution of the area of *Andropogon gayanus* on farms of 57 early adopters in Colombia. 1979-1983.

Region	1979	1980	1981	1982	1983
Eastern Plains	5	191	560	1682	2087
Middle Magdalena	8	36	205	705	1013
North Coast	29	129	624	1208	1902
Total	42	356	1389	3595	5002

SCIENTIFIC TRAINING

In 1983, 34 visiting researchers from 12 countries, included in the categories of visiting associates (2), visiting researchers (29), and visiting researchers in intensive courses (3), received scientific training (Tables 1 and 2).

Most researchers participated in the Postgraduate Training Program in tropical pastures production. This program has the following main objectives: 1) up-date, in an integrated manner and with a multidisciplinary focus, existing technology and technology being generated, for the solution to the main problems in tropical pastures production. 2) contribute in strengthening research and liaison networks in extension research in order to carry out collaborative projects.

The first objective can be achieved by means of conferences, presentations, workshops, and seminars carried out at CIAT-Palmira and field practices in the main ecosystems where the program conducts its research. The second objective is fulfilled primarily through multilocational regional trials carried out by national institutions and the Tropical Pastures Program. Table 3 presents trials established by 1983 which are being managed by professionals trained in the Program.

More than 50% of the visiting researchers came from Colombia, Panama, and Peru (Figure 1). These countries have a high percentage of their total land as acid infertile soils.

Eight researchers, from the universities of New Mexico (USA), Costa Rica, Reading (England), and Berlin (West Germany), carried out their thesis work toward the obtention of their Ph.D. (2) and M.S. (6) titles.

Table 1. Number of researchers, by countries, trained in the Tropical Pastures Program during 1983.

Country of origin	No. of researchers	Percentage of total participants
Bolivia	1	2.94
Brazil	2	5.88
Chile	1	2.94
Colombia	7	20.59
Cuba	2	5.88
Dominican Republic	2	5.88
Ecuador	2	5.88
Honduras	1	2.94
Nicaragua	3	8.83
Panama	6	17.65
Peru	6	17.65
West Germany	1	2.94
Total	34	

Table 2. Professionals trained in the Tropical Pastures Program during 1983, by category in each section of the Program.

Program or unit	Visiting research associates: PhD thesis		Visting researchers: MS thesis		Visting researchers: Specialization		Intensive multidisciplinary phase			
	No.	Months	No.	Months	No.	Months	No.	Months	No.	Months
Germplasm					1	0.43			1	0.43
Agronomy-Carimagua					1	4.30			1	4.30
Economics			1	5.06	1	5.66			2	10.72
Entomology					2	13.13			2	13.13
Forage breeding			1	1.20					1	1.20
Seed Production			1	3.20	3	15.20			4	18.40
Soil Microbiology					2	6.53			2	6.53
Pasture Quality	1	12.00	1	4.40	2	11.79			4	28.19
Production Systems			1	5.70	3	17.93	1	9.00	5	32.63
Pasture Productivity and Management			1	3.96	1	5.03			2	8.99
Soil and Plant Nutrition	1	3.66			2	14.13			2	17.79
Regional Trials					4	17.66			4	17.66
Plant Pathology					1	6.36			1	6.36
TOTAL	2	15.66	6	23.52	23	118.15	1	9.00	31	166.33

Table 3. Regional trials established by professionals that participated in the Tropical Pastures' training programs at CIAT (1979-1983).

Country	Institution/Collaborator	Type of regional trial
Brazil		
Jatai	Emgopa/E. Barbosa	A
Paragominas	Propasto/M.D. Filho	B
Paragominas	Propasto/B. Filho	A
Boa Vista	Propasto/V. Gianluppi	A
Bolivia		
Valle del Sacta	U. San Simón/J. Espinosa	B
Chipiriri	IBTA/Félix Saavedra	B
Colombia		
Florencia	ICA/A. Acosta	A
Florencia	ICA/P. Cuesta	B
Caucasia	U. de A/A. Giraldo	B
Puerto Asís	Fonganadero/D. Orozco	B
Costa Rica		
Buenos Aires	MAG/V. Prado	B
Cuba		
La Habana	MINAG./A. Gutiérrez	B
Pinar del Río	MINAG./J. Paretas	B
Dominican Republic		
Santo Domingo	CENIP/G. Español	B
Ecuador		
El Napo	INIAP/K. Muñoz	B
Nicaragua		
El Recreo	MIDINRA/C. Avalos	B
Nueva Guinea	MIDINRA/A. Cruz	B
Panamá		
Calabacito	IDIAP/M.A. Avila	B
Chiriqui	U. Panama/J. Quintero	B
Peru		
Alto Mayo	INIAP/E. Palacios	B
Yurimaguas	INIPA-NCSU/R. Schaus	B
Tarapoto	INIPA/G. Silva	B
Coperholta	INIPA/W. López	B
Pucallpa	IVITA/H. Ordoñez	B
Venezuela		
Guachi	U. Zulia/I. Urdaneta	B
Mantecal	FONAIAP/R. Torres	B
Calabozo	MAC/C. Sánchez	B
Atapirire	FONAIAP/D. Sanabria	B
El Tigre	FONAIAP/D. Sanabria	A
Jusepin	UDO/M. Corado	B

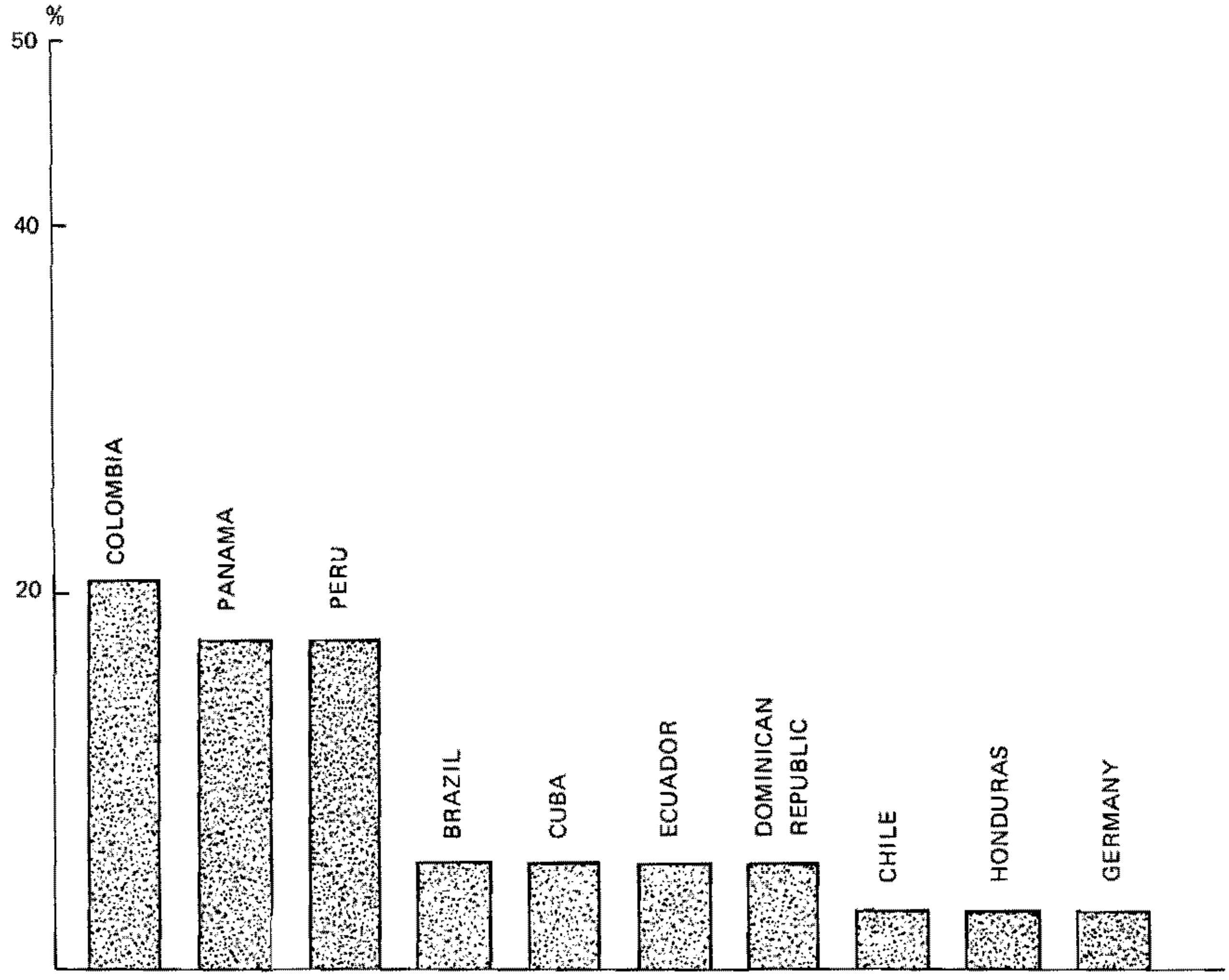


Figure 1. Percentage by country of total participants in the Tropical Pastures Training Program during 1983.

PUBLICATIONS

ANDRADE, R.P. de; THOMAS, D. and FERGUSON, J.E. 1983. Seed production of pasture species in a tropical savanna region of Brazil. I. Legumes. Tropical Grasslands 17: 54-59.

ANDRADE, R.P. de; THOMAS, D. and FERGUSON, J.E. 1983. Seed production of pasture species in a tropical savanna region of Brazil. II. Grasses. Tropical Grasslands 17: 59-64.

AYARZA, M.A. y SALINAS, J.G. 1982. Estudio comparativo de la tolerancia al aluminio en tres leguminosas forrajeras. Suelos Ecuatoriales. 12 (1): 110-126, 1983.

BRADLEY, R. 1983. Fijación de nitrógeno por leguminosas: aspectos agronómicos relacionados a su inoculación con Rhizobium. Suelos Ecuatoriales 13 (2): 28-35.

BRADLEY, R. 1983. Perspectivas en la investigación en fijación de nitrógeno en suelos tropicales. Suelos Ecuatoriales 13 (2): 45-50.

BRADLEY, R., AYARZA, M.A.; MENDEZ, J.E.; and MORIONES, R. 1983. Use of undisturbed soil cores for evaluation of Rhizobium strains and methods for inoculation of tropical forage legumes in a Colombian Oxisol. Pl. Soil 74 (2): 237-247.

BRADLEY, R.; DE OLIVEIRA, L.A.; and BANDEIRA, A.G. 1983. Nitrogen fixation in Nasutitermes in Central Amazonia. In: Social insects in the tropics, Vol. 2, 235-244. P. Jaisson (ed.). Univ. of Paris Press. ISBN 2-86707-001-5.

…INGTON, N.R.; GONZALEZ, C.A.; VEIL, J.A.; VERA, R.R.; TEIXEIRA, …V.M.; and ASSIS, A.G. DE. 1983. A bio-economic modeling project …or small-scale milk production systems in South-East Brazil. …ricultural Systems 12 (1): 37-60.

… M. 1983. "Salivita" o "mion" de los pastos, plaga …tante de las gramíneas en la América tropical. Revista … Ed. No. 6: 38-39, Cali, Colombia.

… R. 1983. Economic aspects of small scale ranching on …pastures in the Colombian Llanos. CIAT, Palmira…

…, B. 1983. …

…ma. Sol…

PUBLICATIONS

ANDRADE, R.P. de; THOMAS, D. and FERGUSON, J.E. 1983. Seed production of pasture species in a tropical savanna region of Brazil. I. Legumes. Tropical Grasslands 17: 54-59.

ANDRADE, R.P. de; THOMAS, D. and FERGUSON, J.E. 1983. Seed production of pasture species in a tropical savanna region of Brazil. II. Grasses. Tropical Grasslands 17: 59-64.

AYARZA, M.A. y SALINAS, J.G. 1982. Estudio comparativo de la tolerancia al aluminio en tres leguminosas forrajeras. Suelos Ecuatoriales. 12 (1): 110-126, 1983.

BRADLEY, R. 1983. Fijación de nitrógeno por leguminosas: aspectos agronómicos relacionados a su inoculación con Rhizobium. Suelos Ecuatoriales 13 (2): 28-35.

BRADLEY, R. 1983. Perspectivas en la investigación en fijación de nitrógeno en suelos tropicales. Suelos Ecuatoriales 13 (2): 45-50.

BRADLEY, R., AYARZA, M.A.; MENDEZ, J.E.; and MORIONES, R. 1983. Use of undisturbed soil cores for evaluation of Rhizobium strains and methods for inoculation of tropical forage legumes in a Colombian Oxisol. Pl. Soil 74 (2): 237-247.

BRADLEY, R.; DE OLIVEIRA, L.A.; and BANDEIRA, A.G. 1983. Nitrogen fixation in Nasutitermes in Central Amazonia. In: Social insects in the tropics, Vol. 2, 235-244. P. Jaisson (ed.). Univ. of Paris Press. ISBN 2-86707-001-5.

BROCKINGTON, N.R.; GONZALEZ, C.A.; VEIL, J.A.; VERA, R.R.; TEIXEIRA, N.M.; and ASSIS, A.G. DE. 1983. A bio-economic modeling project for small-scale milk production systems in South-East Brazil. Agricultural Systems 12 (1): 37-60.

CALDERON, M. 1983. "Salivita" o "mion" de los pastos, plaga importante de las gramíneas en la América tropical. Revista ASIAVA. Ed. No. 6: 38-39, Cali, Colombia.

DAVIDSON, B. R. 1983. Economic aspects of small scale ranching on improved pastures in the Colombian Llanos. CIAT, Palmira, Colombia.

EDYE, L.A. and GROF, B. 1983. Selecting cultivars from naturally occurring genotypes: Evaluating Stylosanthes species. In: Genetic Resources of Forage Plants, eds. McIvor J.G., and Bray, R.A. CSIRO, Melbourne, Australia. pp. 337.

FERGUSON, J.E. 1983. An overview of the release process for new cultivars of tropical forages. 20th Congress International Seed Testing Association. Ottawa. 17-25 June.

FERGUSON J.E. 1983. El proceso de liberación de nuevos cultivares de forrajeras. X Seminario Panamericano de Semillas, Quito 7-11 Noviembre.

FERGUSON, J.E. and SANCHEZ, M. 1983. Estrategias para mejorar la disponibilidad de semillas forrajeras. XXIX Reunión Anual de PCCMCA, Panamá 5-8 Abril.

FERGUSON, J.E.; THOMAS, D.; DE ANDRADE, R.P.; SOUSA COSTA, N.M., and JUTZI. 1983. Seed production potentials of eight tropical pasture species in regions of Latin America. Proc. 14th International Grasslands Congress. Lexington, Kentucky, 1981.

GOMEZ, C.G.; LENNE, J.M., and TORRES, C. 1983. Etiology of dieback of Centrosema spp. and the effect of the pathogen on yield and quality during the period of establishment of the legume. Phytopath. 73: 122 (Abstr.).

GROF, B. 1983. Preliminary studies on the performance of accessions of tropical fine stem stylo (Stylosanthes guianensis Sw. var. guianensis) in the eastern plains of Colombia. Tropical Grasslands, 17, 164-170.

GROF, B. 1983. Selección de cultivares forrajeras partiendo de muchas entradas sometidas a pastoreo. En: Germoplasma forrajero bajo pastoreo en pequeñas parcelas. Metodologías de Evaluación. Eds. O. Paladines y C. Lascano. CIAT, Cali, Colombia, pp.186.

GUALDRON, R. y SALINAS, J.G. 1982. El azufre en suelos de los Llanos Orientales de Colombia. Suelos Ecuatoriales. 12 (2): 221-230, 1983.

IRWIN, J.A.G., CAMERON, D.F. and LENNE, J.M. 1983. Response of Stylosanthes to anthracnose. In: Biology and Agronomy of Stylosanthes, ed. Stace and Edye, CSIRO, Townsville, Australia.

LASCANO, C. 1983. Factores edáficos y climáticos que intervienen en el consumo y selección de plantas forrajeras bajo pastoreo. En: Paladines, O. y Lascano C. (eds.). Germoplasma forrajero bajo pastoreo en pequeñas parcelas. CIAT, Cali, Colombia. p.49-64.

LASCANO, C., HUAMAN, H. y VILLELA, C. 1981. Efecto de frecuencia e intensidad de pastoreo en selectividad animal en una asociación gramínea + leguminosa. Agronomía Tropical 31: 171-188, 1983.

LENNE, J.M. 1983. Anthracnose (Colletotrichum gloeosporioides) of Stylosanthes capitata: Implications for future disease evaluation of indigenous tropical pasture legumes. Phytopath. 73: 123 (Abstr.).

LENNE, J.M. 1983. Antracnosis (Colletotrichum gloeosporioides) de Stylosanthes spp.: Distribución y severidad en diferentes ecosistemas en Suramérica tropical. IX Reunión de ALPA, Chile, July, 1983.

LENNE, J.M. 1983. Approaches to disease management in tropical pastures in South America. Symposium Paper, ICPP, August, Melbourne, Australia.

LENNE, J.M. 1983. A stem gall nematode on Desmodium ovalifolium in Colombia. Pl. Dis. 67: 557.

LENNE, J.M. 1983. Diseases of tropical forage plants in Colombia. Phytopath. 73: 123 (Abstr.).

LENNE, J.M. 1983. Enfermedades importantes de plantas forrajeras tropicales en Suramérica. IX Reunión de ALPA, Chile, July.

LENNE, J.M., CALDERON, M. and GROF, B. 1983. Disease and pest problems of Stylosanthes. In: Biology and Agronomy of Stylosanthes. Ed. Stace and Edye, CSIRO, Townsville, Australia.

LENNE, J.M., VARGAS, A., and TORRES, C. 1983. Pathogenic variation among isolates of Colletotrichum gloeosporioides affecting Stylosanthes spp. Phytopath. 73: 123 (Abstr.).

LEON, L.A., and TOLEDO, J.M. 1983. El fósforo, elemento clave para las pasturas en la Amazonía. Suelos Ecuatoriales 12 (2): 246-269.

MILES, J.W. 1983. Natural outcrossing in Stylosanthes capitata. Tropical Grasslands 17: 114-117.

PALADINES, O. y LASCANO, C. 1983. Recomendaciones para evaluar germoplasma forrajero bajo pastoreo en pequeños potreros. En: Paladines, O. y Lascano, C. (eds.). Germoplasma forrajero bajo pastoreo en pequeñas parcelas. CIAT, Cali, Colombia, p. 165-183.

PIZARRO, E., ed. 1983. Resumen general de los trabajos presentados y conclusiones de los grupos de trabajo. En: II. Reunión de la Red Internacional de Evaluación de Pastos Tropicales. Cali, Colombia, CIAT, 1982. Resultados 1979-1982. pp. 449-453.

PIZARRO, E., ed. 1983. II Reunión de la Red Internacional de Evaluación de Pastos Tropicales. Cali, Colombia, CIAT, 1982. Resultados 1979-1982. 460 p.

PIZARRO, E.A.; TOLEDO, J.M.: RAMIREZ, A.; GOMEZ-CARABALY, A.; FRANCO, L.H.; SALINAS, J.G. 1983. Introducción y Evaluación de Forrajeras Tropicales: Llanos de Colombia (Resumen). Trabajo presentado en la IX Reunión de la Asociación Latinoamericana de Producción Animal, Santiago, Chile.

PIZARRO, E.; VERA, R.R.; DAS GRACAS MORAIS, M.; CARNEIRO, J.A. 1983. Producción y valor nutritivo de leguminosas tropicales durante el período seco: Neonotonia wightii (Resumen). Trabajo presentado en la IX Reunión de la Asociación Latinoamericana de Producción Animal, Santiago, Chile.

RIVAS, L. y CORDEU, J.L. 1983. Potencial de producción de carne vacuna en América Latina: estudio de casos. CIAT, Septiembre.

SAIF, S.R. 1983. Bibliography on vesicular-arbuscular mycorrhizae (1970-1982). CIAT, Cali, Colombia, 143 p.

SAIF, S.R. 1983. Respuesta de las plantas forrajeras tropicales a las aplicaciones de roca fosfórica y micorriza en un Oxisol no esterilizado. En: Memorias de la I Conferencia Latinoamericana de Roca Fosfórica, Octubre 10-15. Cochabamba, Bolivia (In press).

SALINAS, J.G. 1983. Mejoramiento de los procedimientos de evaluación del fósforo en suelos ácidos de América tropical. Trabajo presentado en la I Conferencia Latinoamericana sobre Roca Fosfórica, Cochabamba, Bolivia, Octubre 10-15, 28 p.

SALINAS, J.G. 1983. Soil adaptation and nutrient requirements of various Stylosanthes. 30 p. In: D.L. Plucknett and H. Sprague (eds.). Detecting mineral nutrient deficiencies that affect production of crop plants in temperate and tropical regions (In press).

SALINAS, J.G. 1983. Tolerancia diferencial de las plantas a la acidez y a la baja disponibilidad de fósforo en suelos del trópico americano. Trabajo presentado en el VIII Congreso Latinoamericano de la Ciencia del Suelo. Mar del Plata, Argentina, Octubre 24-28. 30 p.

SALINAS, J.G. y LASCANO, C. 1983. La fertilización con azufre mejora la calidad de Desmodium ovalifolium. Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia. Boletín Informativo de Pastos Tropicales 5 (1): 1-6.

SANCHEZ, P.A. y SALINAS, J.G. 1983. Suelos acidos - Estrategias para su manejo con bajos insumos en América tropical. Sociedad Colombiana de la Ciencia del Suelo, Bogotá, Colombia.

SCHULTZE-KRAFT, R., ALVAREZ, G.; BELALCAZAR, J.; HENAO, M. DEL R.; NUÑEZ, R. y ORTIZ, J. 1983. Catálogo de germoplasma de especies forrajeras tropicales. Cali, Colombia, CIAT. 719 pp.

SCHULTZE-KRAFT, R., BELALCAZAR, J. y BENAVIDES, G. 1983. Recolección y evaluación agronómica preliminar de nuevas especies de leguminosas forrajeras tropicales. Memorias de la XXIX Reunión del PCCMCA, Panamá, 5-8 Abril. (In press).

SCHULTZE-KRAFT, R.; REID, R.; WILLIAMS, R.J. and CORADIN, L. 1983. The existing Stylosanthes collections. In: Stace, H.M. and Edye, L.A., The Biology and Agronomy of Stylosanthes. Academic Press, Melbourne, Australia, 580 pp.

SERE, C. (editor). 1983. Trends in CIAT Commodities. Internal Document - Economics 1-8 March.

SERE, C. and VERA, R. 1983. Cow-calf systems in the savannas of tropical Latin America - A systems diagnosis. Paper presented in the 5th World Conference on Animal Production, Tokyo, Japan, August 14-19.

SPAIN, J.M. 1983. Guía y formato para la preparación de ayudas visuales. Preparado como base de un seminario presentado en CEPLAC, Octubre.

SPAIN, J.M. 1983. Suelos marginales y pastos tropicales: Hacia un uso más eficiente de recursos. Trabajo presentado con el VI Foro Internacional de Taxonomía y Manejo de Suelos. Turrialba, Costa Rica. Octubre 24-Noviembre 4.

SPAIN, J.M., FRANCO, L.H.; NAVAS, G.E.; LASCANO, C., and HAYASHI, H. 1983. The gradual replacement of native savanna on an Oxisol in Eastern Colombia. Paper to be presented at the International Savanna Symposium, Brisbane, Australia, May 28-June 1, 1984. (In press).

TERGAS, L.E. 1983. Efecto del manejo del pastoreo en la utilización de la pradera tropical. En: O. Paladines y C. Lascano, ed. Germoplasma forrajero bajo pastoreo en parcelas pequeñas: Metodologías de Evaluación. Memorias de una Reunión de Trabajo, Red Internacional de Evaluación de Pastos Tropicales, CIAT, Cali, Colombia. p. 65-80.

TERGAS, L.E.; PALADINES, O.; KLEINHEISTERKAMP, I. y VELASQUEZ, J. 1983. Productividad animal de praderas naturales con pastoreo complementario en Pueraria phaseoloides en los Llanos Orientales de Colombia. Producción Animal Tropical 8: 203-211.

TOLEDO, J.M. 1983. Ensamblaje de germoplasma en pasturas: problemática de experimentación. En: Paladines, O. y Lascano, C. (eds.). Germoplasma forrajero bajo pastoreo en pequeñas parcelas. Memorias de una Reunión de Trabajo, Cali, Colombia, CIAT, 1982. pp. 1-10.

TOLEDO, J.M.; AMEZQUITA, M.C.; y PIZARRO, E. 1983. Análisis del comportamiento del germoplasma evaluado por la RIEPT en los ecosistemas dsabana y bosque tropical. En: Pizarro, E. (ed.). II Reunión de la Red Internacional de Evaluación de Pastos Tropicales. Cali, Colombia, CIAT, 1982. Resultados 1979-1982. pp. 429-447.

TORRES, C. and LENNE, J.M. 1983. Effect of various seed treatments on the survival of Corynebacterium flaccumfaciens in seeds of Zornia sp. CIAT 7847. Phytoph. 73: 125 (Abstr.).

VARGAS, A. and LENNE, J.M. 1983. Foliar blight (Rhizoctonia solani) in Centrosema brasilianum and preliminary studies of the antagonistic organisms. Phytopath. 73: 125 (Abstr.).

VERA, R.R. et al. 1983. Eficiencia de conservación de la materia seca, energía y nitrógeno en la hemificación de Neonotonia wightii. ALPA, Chile. (In press). Abstract.

VERA, R.R.; PIZARRO, E.A.; MARTINS, M.; and VIANA, J.A.C. 1983. Yield and quality of tropical legumes during the dry season: Galactia striata (Jacq.) Urb. In: Smith, J.A.; Hays, V.W., eds. Lexington, Kentucky, 1981. Proceedings. Boulder, Col, Westview Press. pp. 786-788.

VERA, R.R.; SERE, C. y KLEINHEISTERKAMP, I. 1983. Análisis comparativo de sistemas extensivos de cría en Brasil, Colombia y Venezuela. Presentado en la IX Reunión de la Asociación Latinoamericana de Producción Animal, Santiago, Chile, Julio 25-29.

WILLIAMS, R.J.; REID, R.; SCHULTZE-KRAFT, R. and COSTA, N.S. 1983. Natural distribution of Stylosanthes. In: Stace, H.M. and Edye, L.A., The Biology and Agronomy of Stylosanthes. Academic Press, Melbourne, Australia, 580 pp.

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Table 4 shows the principal parameters of biological efficiency during the first year of monitoring. The reproductive performance is better than usually found in extensive cow-calf systems. This is due to the preferential use of the best pastures for milking cows and the more intensive management.

The average duration of the lactation is remarkable. The differences between the farms result rather from the possibilities of milking during the dry season owing to the feed availability, than from the natural drying of the cows. The average figure of 304 days is double the 150 days' lactation for dual purpose cattle frequently mentioned in the literature.

The production levels per cow in the herd are relatively low because of the low average production level per milked cow (3.15 kg/cow in milk/day) and in some cases the low percentage of the total lactating cows being milked.

On an average, 276 kg of milk per year are produced per hectare. This low level reflects the importance of other categories such as dry cows, replacements and male stock within the structure of the herd. This is also reflected in the importance of meat in terms of physical production with 46 kg/AU/year and 62 kg/ha/year.

The combined analysis of these parameters permits to state that:

a) Farm 01 operates on better land resources which allow a higher stocking rate, cattle with a high proportion of European inheritance, higher production of milk and beef, despite clearly emphasizing milk production as reflected in the light weight of male calves.

b) Farm 04 shows another extreme situation. The soil is of lower fertility and, additionally, pastures are overgrazed (2 AU/ha). Calving rate is low, mortality of calves high, weight at weaning low and the milk production per cow in the herd is the lowest in the sample. The same accounts for the beef production per hectare.

c) Other farms with resources of lesser quality than Farm 01, but run with lower stocking rates like Farm 06, reach better results per animal and in some cases even per hectare.

The differences in production reflect to some extent qualitative differences of the land resources, but unlike the extensive beef operations in tropical savannas, the management, particularly the stocking rate, have a strong influence on the productivity of the system.

The economic performance of the farms is shown in Table 5. The average gross income amounts to US$8,544 with beef and milk contributing approximately to equal parts. Nevertheless, not all this income is in cash because of changes in livestock inventory and other improvements like fencing, etc., carried out by the farm personnel.

Within the cost structure, hired labour is the most important element considered under the heading of cattle management, and to some extent

Table 4 ETES-PANAMA: main technical coefficients (June 81-May 82).

Coefficients	Farm						Average
	01	02	03	04	05	06	
Calving rate[1]	70.0	73.2	79.1	63.3	57.7	98.9	73.1
Mortality rate adult cattl.	0.0	0.0	6.9	5.2	0.0	0.0	3.3
Mortality rate calves	11.8	0.0	25.3	58.8	3.3	2.7	19.5
Age first calving	30.1	34.7	42.4	41.4	38.8	30.6	37.5
Weight (kg)							
Cow	392	341	310	343	327	372	337
Weaner	98	145	133	89	165	163	132
Milk production							
Mean lactation length (days)	354	407	288	240	293	240	304
Litres per:							
. lactating cow	1247	890	1484	783	584	662	1156
. cow in the herd	751	560	578	344	418	425	509
. hectare/year	608	259	260	326	208	220	276
Beef production							
kg/AU/year	63	55	45	25	55	50	46
kg/ha/year	100	67	57	53	61	65	62
Equivalent beef production[2]							
kg/AU/year	102	77	67	40	74	66	67
kg/ha/year	161	92	83	85	81	87	89
Stocking rate (AU/ha)[3]	1.8	1.2	1.2	2.1	1.1	1.3	1.3

1/ June 1981-May 1982: heifers not included.

2/ 10 litres milk - 1 kg beef.

3/ Only cattle.