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TROPICAL FORAGES PROGRAM

TROPICAL FORAGE GERMPLASM

GERMPLASM EVALUATION: COLOMBIA

AGRONOMY: MEXICO, CENTRAL AMERICA AND THE CARIBBEAN

AGRONOMY CERRADO

SOUTHEAST ASIAN REGIONAL FORAGE SEEDS PROJECT

GENETICS

ENTOMOLOGY

PLANT PATHOLOGY

PLANT NUTRITION

FORAGE QUALITY RUMINANT NUTRITION

SEED BIOLOGY

ECONOMICS

TROPICAL FORAGE GERMPLASM

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Highlights

In 1992, major acquisitions to CIAT's collection of tropical forage germplasm were a donation of *Panicum maximum* germplasm, originating from the French ORSTOM collection and new legume germplasm from a collection trip to Vietnam and Thailand. A survey of seed health status of *Stylosanthes* spp. stored under short-term conditions over varios years, with special emphasis on anthracnose, revealed the need for further studies. Monitoring of seed germination of those accessions stored in the base collection for five and more years was initiated, indicating that high quality seed may be stored over a long period of time. In two collaborative projects, taxonomy and genetic variability of *Brachiaria* are being studied, utilizing morphological characters and isozymes.

Germplasm Management

Status of the Collection

CIAT's collection of tropical forage germplasm is managed by the Genetic Resources Unit (GRU), since 1990. The collection consists of about 150 genera with more than 700 wild and undomesticated species of possible forage potential. These species belong predominantly to the legume family, about 10% are grasses. At present, 23,266 accessions are registered, of which 20,194 accessions are conserved in the collection (Table 1). Of the conserved accessions 70% (14,136 accessions) have enough seed for distribution.

The number of introduced accessions per species ranges from one to over 1500, reflecting the relative importance of each species as defined by the Tropical Forages Program (TFP). Hence, 5017 accessions (25% of the conserved collection) belong to 18 "key" species in nine genera, for which, within the CGIAR system, CIAT has the international mandate to create a base collection.

Acquisition and Introduction

New introductions. The TFP's general research strategy is to exploit the natural genetic variability of undomesticated species, especially of legumes. In recent years, acquisition of new germplasm was strategically focused on filling in geographic and genetic gaps, and in response to international requests to specific needs. In 1992, the collection increased by a total of 222*[1] accessions (Table 1). Among these, a major donation of *Panicum maximum* germplasm, originating from the French ORSTOM collection, was received from the Centro Nacional de Recursos Genéticos (CENARGEN), Brazil.

In 1992, new legume germplasm was acquired, particularly from a collection trip to Vietnam and Thailand under the leadership of Dr. R. Schultze-Kraft, which was jointly funded by CIAT and the International Board for Plant Genetic Resources (IBPGR). The collection route in Vietnam followed a north-south transect of the country from Hanoi to Ho Chi Minh City. In Thailand, germplasm was collected from the central and northeastern regions, emphasizing various *Desmodium* spp. and related genera, and *Pueraria phaseoloides*. This collection is at present being cleared of postquarantine; it will then undergo initial seed increase. This is the first forage legume germplasm from Vietnam to be incorporated into CIAT's collection.

Postquarantine. The tropical forage germplasm received by CIAT from continents other than the Americas has to undergo a postquarantine check by the Instituto Colombiano Agropecuario (ICA), in collaboration with the TFP's Phytopathology Section, before initial seed

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1 All data with * need to be confirmed.

multiplication can be undertaken. In 1992, about 450 legume and grass accessions entered postquarantine and 217 materials were released.

Conservation

Initial multiplication and rejuvenation. After acquisition and release from postquarantine, germplasm has to be multiplied. So far, 70% of CIAT's tropical forage germplasm collection has been increased; only a backlog of 6056 accessions remains. In 1992, the Section completed increasing those accessions with very small quantities, i.e., 1-10 seeds, of original seed. Unfortunately, because of the poor quality of the stored seed, 30% (70 of 233) of these accessions did not germinate. Increase and rejuvenation averaged about 2200 accessions in 1992. Besides key genera, such as *Centrosema, Desmodium, Pueraria*, and *Stylosanthes*, large collections of *Chamaecrista, Erythrina, Galactia, Glycine, Macroptilium, Vigna*, and *Paspalµm* received the most attention for seed increase.

Seed health. A major objective of CIAT's GRU is to store in the germplasm bank high quality and seed highly viable that is free of seedborne diseases. In the past, little was known about the general health of seeds of those accessions conserved in the germplasm bank which were increased at Quilichao where anthracnose, caused by *Colletotrichum gloeosporioides*, is the major disease in *Stylosanthes* germplasm. In collaboration with the Phytopathology Section of the former Tropical Pastures Program, a survey of seed health status of *Stylosanthes* spp. was carried out, with special emphasis on anthracnose. Seed of accessions were chosen, which were multiplied at Quilichao and stored under short-term conditions seven to more than ten years. 80 seeds per accession were put on an agar-oats medium in petri dishes and incubated at 28°C during 10-12 days. Of 125 accessions in three *Stylosanthes* species, 21 (17%) were infested by anthracnose. Within the infested accessions, the anthracnose incidence varied from 1-6% in *S. capitata*, 1-10% in *S. guianensis*, and 1-3% in *S. scabra*. These preliminary results indicate that further study of the seed health status of the germplasm to be stored and internationally distributed has to be emphasized in the future.

Long term storage. CIAT needs to have a base collection stored under long term conditions and to have the collection conserved in at least one other institution as a safeguard against the risk of loss. In 1992, a total of 418 samples, especially of *Stylosanthes capitata* and *Vigna* spp., were put under long term storage. So far, 4289 samples (24% of the legume collection) form part of CIAT's tropical forage germplasm base collection (Table 1). The ten leguminous key species are represented in higher proportions (40%). No grasses have yet been stored under long-term conditions.

Monitoring seed germination. In 1992, monitoring of seed germination of those accessions stored in the base collection for five and more years was initiated. The germination of a random sample of 178 accessions was monitored for the first time in 1992. The relative high germination rate of 92% in long-term storage indicates that legume seed of high quality may be stored over a long period of time without major loss of germinability.

Characterization

Shrubby species. Morphological characterization was carried out with emphasis on new shrubby germplasm, such as pigeonpea (*Cajanus cajan*), *Calliandra* and *Dendrolobium* spp., *Desmodium velutinum*, *Erythrina, Flemingia, Phyllodium*, and *Sesbania* spp. This work aimed to develop morphological descriptors for multipurpose forage trees and shrubs (MFTS) and to describe the existing intraspecific variability to classify germplasm in morphological plant types. Some agronomic characters were also recorded, such as vigor, seed production, and regrowth after cut.

Little variation was found in CIAT's small collection of *Cajanus cajan* originated mainly from Brazil. Among 81 accessions of *D.*

velutinum, ample variation was found and seven morphological plant types were identified according to leaf shape, variegation, and pubescence, growth habit, and plant height. The *Flemingia* collection comprised 53 accessions of *F. macrophylla* and other species, some of which are not yet identified. The morphological variation found, led to the definition of 11 morphological plant types, which may even reflect different species. Most of the *Phyllodium* germplasm lacks identification at species level. The five morphological types identified are probably different species.

Distribution 1980-1992

The data of germplasm distribution during 1980-1992 were completely standardized, computerized, and incorporated into CIAT's database. This gives easy access to detailed information about, for example, users and their preferences for species and genera. The genera most frequently distributed over this period were *Centrosema*, *Stylosanthes*, *Desmodium*, and *Leucaena* among the legumes; and *Brachiaria* and *Panicum* among the grasses. However, the germplasm requested usually covers far more than the key genera as defined by the TFP. During the period recorded, samples of 25* to over 60* genera were distributed per year.

In 1992, the GRU received a total of 183 requests, and 3208 samples were distributed to 20* countries all over the world (Table 1). Mainly advanced materials, recommended by the TFP, were distributed. However, there was a heavy increase in requests for shrubby germplasm, and particularly for materials for soil cover and erosion control, such as the grass *Vetiveria zizanioides*.

Documentation and Data Management

Reliable documentation and efficient data management are basic for germplasm management. CIAT's Data Services Unit (DSU) implemented the new data management system, ORACLE, for the GRU.

Nomenclature and taxonomy. In the last years, germplasm which still lacks identification at species level was reduced to 2508 accessions (12% of the collection conserved), particularly in the genera *Crotalaria, Desmodium, Indigofera, Tephrosia*, and *Zornia* (214, 120, 134, 114, and 857 unidentified accessions, respectively). *Crotalaria* and *Desmodium* specimens were shipped in 1990 and 1989 to the respective taxonomists in Colombia and Japan. Collaboration with the Botanical Garden and Botanical Museum (BGBM) of Berlin, Germany, to study the taxonomy of *Zornia* was initiated in 1992. L. P. de Queiroz from University of Feira de Santana, Brazil, determined ten species among 116 unidentified accessions of *Canavalia*. Over 130 previously unidentified accessions of *Cassia* sp., established for initial seed increase, were determined according to the revision of Irwin and Barneby[2]. Most of them belonged to the genus *Chamaecrista*.

Passport data. The revision of passport data continued with emphasis on germplasm which originated from Colombia and Brazil. Important institutions with which CIAT has jointly collected or exchanged a large proportion of its germplasm, such as ILCA, CENARGEN, CSIRO, and the University of Florida, have been contacted, and data are being exchanged. The data of the *Centrosema* World Catalog[3] were completely integrated into the general database.

Herbarium. The reference herbarium grew, particularly in its representation of genera and species. At present, 104 of the 163 registered genera and 491* of the 789* species of the tropical forage germplasm collection are held in the herbarium. In 1992, the represented accessions increased by more than 900 specimens to 10,655, that is, almost 46% of the registered accessions.

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2 Irwin, H. S. & Barneby, R. C. 1982. The American Cassiinae: A synoptical revision of Leguminosae tribe Cassieae, subtribe Cassiinae, in the New World. Memoirs of the New York Botanical Garden, vol. 35, parts 1 and 2. 918 pp.

3 Schultze-Kraft, R.; Williams, R. J.; Coradin, L.; Lazier, J. R. and Kretschmer, A. E., Jr. 1990. World catalog of *Centrosema* germplasm. CIAT, Cali, Colombia. 321 pp.

variability is being performed at present.

Reproductive biology

Pollination mechanisms determine the basic considerations for seed collection and multiplication methods applied in genetic resources management. Because little is known about reproductive biology of most of the species held in CIAT's tropical forage germplasm collection, this becomes a high priority research agendum, at least for key genera and species.

The reproductive biology of *Centrosema brasilianum* has already been studied at CIAT's headquarters at Palmira. A negative (recessive) marker was provided by two white-flowered accessions (CIAT 5305 and 15918). In 1991, high outcrossing rates of 31 and 54%, respectively, were obtained in open pollination. [1] To further measure the environmental influence on outcrossing, a comparative study is being carried out at Palmira, Quilichao, and Popayán.

New studies of reproductive biology included *Centrosema rotundifolium* Martius *ex* Bentham, a *Centrosema* species with a prostrate growth habit. This amphicarpic species drew attention because of its ability to bury seed. It originates from sandy soil areas in northeastern Brazil, with very low to medium rainfall and a long dry season.

Based on a literature search, a checklist for morphological markers in legumes was developed. This checklist will be applied to all germplasm in initial seed increase so to use them in further research in reproductive biology.

1993 Activities

Besides routine germplasm management in the coming year, the following activities will be emphasized:

(1) Integration of computerized distribution and short-term storage data;

(2) Completion of the revision of passport data and publication of regional catalogs;

(3) Implementation of a computerized control over quarantine and field multiplication;

(4) Conservation of original seed under long-term conditions;

(5) Computerization of plantlet characterization data;

(6) Characterization of *Chamaecrista*, *Paspalum*, and *Brachiaria* germplasm in Quilichao, in collaboration with the TFP's Germplasm Section;

(7) Characterization of new *Arachis pintoi* germplasm by morphology and isozymes; and

(8) Development of computerized labels for the Herbarium.

Table 1. Acquisition of tropical forage germplasm, inventory of conserved accessions, and distribution in 1992. (no. of accessions)

Genus	Short-term storage		Long-term storage	Distri-bution
	New in 1992	Inventory 30.09.92	Inventory 30.09.92	1992
Legumes				
Aeschynomene	9	987	244	
Calopogonium	4	530	102	
Centrosema	22	2394	904	
Desmodium	21	2794	464	
Galactia	8	557	273	
Macroptilium	6	603	389	
Pueraria	0	238	42	
Rhynchosia	4	445	0	
Stylosanthes	19	3584	756	
Vigna	5	733	324	
Zornia	4	1028	0	
Other	49	4237	791	
Total legumes	169	18130	4289	
Grasses				
Andropogon	0	100	0	
Brachiaria	0	687	0	
Hyparrhenia	0	61	0	
Panicum	58	597	0	
Other	5	612	0	
Total grasses	63	2057	0	
Other families	0	2	0	0
Grand total	223	20192	4289	3208

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	New in 1992	Inventory 30.09.92	Inventory 30.09.92	
Legumes				
Aeschynomene	9	987	244	95
Arachis	0	24	9	103
Cajanus	0	89	50	121
Calopogonium	4	530	102	223
Centrosema	22	2394	904	333
Chamaecrista	9	300	0	74
Codariocalyx	0	35	0	80
Cratylia	0	14	0	57
Desmodium	21	2796	464	418
Flemingia	0	93	0	127
Galactia	8	557	273	31
Leucaena	2	196	84	55
Macroptilium	6	603	389	96
Pueraria	0	238	42	28
Rhynchosia	4	445	0	20
Stylosanthes	19	3584	756	294
Teramnus	4	374	65	105
Vigna	5	733	324	76
Zornia	4	1028	0	63
Other	43	3112	583	339
Total legumes	160	18132	4289	2738
Grasses				
Andropogon	0	100	0	1
Brachiaria	0	687	0	286
Hyparrhenia	0	61	0	58
Panicum	58	597	0	106
Pennisetum	0	53	0	47
Other	5	612	0	3
Total grasses	63	2057	0	501
Other families	0	2	0	0
Grand total	223	20194	4289	3239

Valle, C. B. do; **Maass, B. L.**; Almeida, C. B.; Costa, J. C. G. Morphological characterisation of Brachiaria germplasm. XVII International Grassland Congress. 8-21 February 1993, New Zealand and Queensland, Australia. (Submitted for publication)

3. Workshop papers

Lascano, C. E.; **Maass, B. L.**; Thomas, R. J. 1992. Multipurpose trees and shrubs at CIAT. Paper presented at the Consultative meeting on ICRAF's proposal for the development of Multipurpose Tree Germplasm Resource Centre, 2-5 June 1992, Nairobi, Kenya.

GERMPLASM EVALUATION: COLOMBIA

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During 1992 agronomic evaluation of natural forage germplasm collections has been conducted by the TFP in Colombia at the ICA Carimagua Research Center for the Llanos ecosystem (isohyperthermic savanna), at the ICA La Libertad Research Center near Villavicencio for the Llanos piedmont ecosystem, and at La Rueda ranch of the Fondo Ganadero del Valle located near Florencia, Caquetá representing the tropical rainforest ecosystem.

Summary of the years work

A total number of 1264 accessions of herbaceous and shrubby forage legume species and 470 grass accessions (Table 1) have been screened in monospecific small-plot clipping trials (Category II) to select lines adapted to the climatic, edaphic and biotic conditions of the respective ecosystems. At Carimagua most of the work is conducted at two fertilizer levels, one which is recommended for upland rice in the Colombian Llanos (kg/ha: 50P, 100K, 20S, 5Zn, 80N, 300 dolomitic lime) and another which considers the recommendation for pasture establishment in Carimagua (kg/ha: 20P, 20K, 12S, 12Mg and 40N [grasses]) to assess germplasm response to higher soil fertility. A new Category II screening methodology recently initiated at Carimagua, consists of testing legumes in association with a grass to assess already in this early stage of evaluation grass-legume compatibility.

Table 1. Germplasm evaluation at three screening sites of CIAT's Tropical Forages Program in Colombia during 1992.

Species	Carimagua	V/cencio	Florencia
Leguminous shrubs and subshrubs			
Codariocalyx gyroides	27		27
Cratylia argentea	10	11	11
Dendrolobium lanceolatum	25		
Desmodium velutinum	107		86
Flemingia macrophylla	65		57
Tadehagi spp.	40		
Herbaceous legumes			
Arachis glabrata			15
Arachis pintoi		8	8
Cajanus scarabaeoides	28		34
Calopogonium mucunoides	30	30	
Canavalia spp.	120		
Centrosema rotundifolium	5	6	6
Centrosema spp.	19	27	49
Desmodium gangeticum	47		
Desmodium heterocarpon			
D. heterocarpon subsp.*ovalifolium*		28	11
Desmodium heterophyllum			11
Desmodium strigillosum	10		11
Dioclea guianensis	19		
Periandra sp. nov.	3	4	
Pseudarthria viscida	33		
Pueraria phaseoloides		163	8
Pueraria spp.		11	
Uraria spp.	38		
Total legumes	626	297	341
Grasses			
Brachiaria humidicola	59		
Brachiaria spp.	204	34	77
Hyparrhenia spp.			35
Panicum maximum		30	31
Total grasses	263	64	143

Screening activities at Villavicencio have been concluded during this year. At Carimagua evaluation of large collections of shrubby and herbaeous legume species which were established in 1989 and 1990 also concluded during the year. The results obtained allow for updating of the germplasm list for the Llanos ecosystem. Evaluation of two collections of *Brachiaria* spp. and *B. humidicola* and of four legumes in association with a grass are still in progress.

New major germplasm screening activities were initiated during the reporting year at La Rueda ranch near Florencia in close collaboration with the Fondo Ganadero del Valle. Emphasis is being given to the evaluation of shrubby legumes. However, a considerable number of preselected accessions of a broad range of herbaceous legumes and three important grass genera have also been established.

A series of regional type B trials conducted within the RIEPT at different sites in the Llanos and piedmont have been concluded, and results are available in the CIAT data base.

Major research findings

Shrubby legumes

Since 1989 considerable emphasis has been given to testing shrub legume species. Evaluation of collections of *Cratylia argentea, Desmodium velutinum, Flemingia macrophylla* and *Tadehagi* spp. among others was concluded this year.

The *C. argentea* collection proved to be well adapted to the environmental conditions both at Carimagua and Villavicencio. Dry-matter forage yields showed differences among accessions at both sites being the yields considerably higher at

Table 2. Performance of a collection of *Cratylia argentea* at Carimagua and Villavicencio (Category II evaluation).

CIAT accession no.	DM yield during max.rainf.[1] (g/plant)		Leaf proportion[1] (% of total DM)		IVDMD (% leaf DM)[2]		
	Villavicencio	Carimagua	Villavicencio	Carimagua	V/cencio. Min.rainf.	Carimagua Min.rainf.	Carimagua Mx.rainf.
18673	112.9 a[3]	31.8 bc	58	71 a	32.0	44.8	50.8
18957	100.4 ab	29.2 bc	67	70 ab	51.9	46.1	51.1
18674	98.9 ab	--	78	--	34.3	--	--
18675	95.3 ab	36.6 abc	70	67 cd	49.6	47.3	52.2
18676	92.2 ab	47.5 ab	71	69 abc	47.1	44.9	50.9
18668	86.6 abc	51.8 a	74	64 e	46.7	51.1	54.4
18672	84.1 abc	39.6 abc	63	68 bcd	49.0	43.2	50.5
18671	79.3 bc	32.2 bc	66	68 bcd	43.7	48.9	54.5
18666	77.2 bc	34.3 abc	70	70 ab	47.3	49.3	54.9
18516	72.1 bc	25.1 c	75	70 ab	43.9	51.1	53.5
18667	57.7 c	41.1 abc	72	67 cd	46.4	48.2	54.4
Mean	86.9	36.9	69	68	44.7	47.5	52.7

1. Means of two cuts with 12 weeks of regrowth each.
2. Means of one cut.
3. Means in each column followed by the same letter are not significantly different ($P < 0.05$).

Villavicencio than at Carimagua (Table 2). Leaf proportion of total DM was relatively high as well as the values recorded for IVDMD.Agronomic evaluation of two experiments of 59 and 48 accessions of *D. velutinum* established at Carimagua in 1989 and 1990, respectively, was concluded during this year. Regarding the 1990 trial the variation found among accessions with regard to some important agronomic traits and nutritive value is summarized in Table 3. Dry matter yields, leaf proportion and the number of basal shoots varied considerably between rainfall periods. The collection showed a response to the higher soil fertility for the above mentioned agronomic traits except for leaf proportion during maximum rainfall. Leaf proportion of total DM was in general low in comparison with other shrubby species such as *C. argentea* or *E. macrophylla*. Nutritive value, however, proved to be considerably higher than in the case of *F. macrophylla* or *Tadehagi* spp.

With regard to the experiments of *F. macrophylla* and *Tadehagi* spp. considerable morphological variation was detected among accessions of both germplasm collections. A number of accessions were well adapted to the environmental conditions and had high DM yields. However, the relatively low nutrient value of both species may limit their use as fodder plants.

During the coming dry season the whole collection of shrubby legumes will be submitted to grazing animals to assess their acceptability. The results will be taken into account for the final selection of accessions.

<u>Herbaceous legumes</u>

Arachis pintoi

Of the 8 accessions evaluated at Villavicencio, CIAT 18747 and 18748 produced more dry matter during the wet season than the check CIAT 17434 while CIAT

Table 3. Performance of a collection of *Desmodium velutinum* (48 accessions) at Carimagua.

Characteristic	Fertilization	Maximum rainfall		Minimum rainfall		Most promising accessions CIAT Nos.
		Mean	Range	Mean	Range	
DM yield (g/plant)	Rice	21.8 a*	9.6 - 43.5	7.8 a	2.6 - 19.6	13218,23973,23974,23977,23985,23990
	Pasture	16.2 b	4.4 - 32.7	4.3 b	1.1 - 11.1	23920,23973,23977,23985,23996,33242
Leaf proportion (%DM)	Rice	34.7 a	23.3 - 49.5	25.9 a	17.9 - 35.1	13218,23915,23925,23985,23990
	Pasture	35.6 a	25.3 - 52.6	22.9 b	11.4 - 39.0	23925,23979,23985,23990
Basal shoots (No./plant)	Rice	22 a	7 - 45	13 a	4 - 24	13218,23915,23973,23974,23977,23990
	Pasture	17 b	6 - 34	9 b	3 - 17	13218,23915,23973,23977,23985
Crude protein (% leaf DM)	Pasture	14.0	9.8 - 18.0			23159,23247,23915,23925,23928,23985
IVDMD (% leaf DM)	Pasture	55.4	47.3 - 64.3			23272,23915,23920,23925,23973,23979 23985

* Means in each column for each characteristic followed by the same letter are not significantly different ($P < 0.05$).

Table 4. Performance of 8 accessions of *Arachis pintoi* at Villavicencio.

CIAT	DM yield (kg/ha)[1]		Soil cover (%)[1]		Seed yield[2]	Crude protein[3]
accession no.	Max.rainfall	Min.rainfall	Max.rainfall	Min.rainfall	(kg/ha)	(% total DM)
18748	750 a[4]	203 ab	51.6 a	33.7 a	1898 a	19.6
18747	633 ab	129 bc	44.5 a	27.8 a	1385 a	20.2
18744	472 bc	155 abc	49.5 a	28.3 a	1570 a	17.1
18752	459 bc	213 a	61.2 a	40.0 a	1892 a	21.9
18745	382 c	86 c	32.5 a	18.7 a	1538 a	20.5
17434	328 c	131 bc	44.4 a	34.0 a	2123 a	19.6
18751	326 c	125 bc	36.6 a	35.0 a	1878 a	24.1
18746	322 c	135 abc	50.0 a	30.7 a	1815 a	19.6

1. Means of 2 cuts in each season with 12 weeks of regrowth.
2. Means of 2 harvests.
3. One harvest during minimum rainfall
4. Numbers in the same column followed by the same letter do not differ significantly ($P < 0.05$).

18752 was more productive than the control accession during the dry season (Table 4). With regard to soil cover and seed yield none of the accessions proved to be better than CIAT 17434.

Centrosema rotundifolium

A stoloniferous growth habit, amphicarpy and adaptation to poor soils are valuable characteristics for a potential use of this species as a pasture plant. Five accessions have been evaluated at Carimagua and 6 accessions at Villavicencio. Dry matter yields were rlatively low and varied considerably between rainfall periods. At Carimagua accession CIAT 25120 was the most promising with regard to DM yield and soil seed reserve (Table 5). At Villavicencio this accession as well as CIAT 5260 showed the best performance. At both sites all accessions were susceptible to leaf-sucking insects, *Rhizoctonia* foliar blight and *Phoma* leaf spot. It seems to be important to broaden the genetic base by gathering more germplasm to better assess the agronomic potential of this species.

Table 5. Agronomic performance of 5 *Centrosema rotundifolium* accessions at Carimagua.

CIAT accession number	Dry matter yield (kg/ha)[1]				Soil seed reserve ($No.seeds/m^2$)[2]	
	Maximum rainfall		Minimum rainfall		Rice fert.	Pasture fert.
	Rice fert.	Pasture fert.	Rice fert.	Pasture fert.		
25120	827 a [3]	943 a	65 a	97 a	704	700
5721	294 ab	476 b	45 b	45 b	116	62
25148	412 ab	292 bc	34 b	38 b	64	28
5283	305 ab	235 bc	75 a	61 b	34	36
5521	112 b	124 c	78 a	48 b	8	26
Mean	429	414	59	58	184	170

1. Means of 2 harvests with 12 weeks of regrowth each.
2. Evaluated 2 years after establishment.
3. Means in the same column followed by the same letter do not differ significantly ($P < 0.05$).

Calopogonium mucunoides

Thirty accessions have been evaluated both at Carimagua and Villavicencio. Establishment was good and most accessions produced high DM yields during the first cut. At Carimagua, regrowth was poor resulting in very low DM production during the first year after establishment. All accessions were completely defoliated during the dry season in the second year after establishment and did not regrow in the following rainy season. The whole collection showed poor soil seed reserve and there occurred no seedling regeneration. At Villavicencio the collection also exhibited a poor performance during the dry season but there was a good regrowth and seedling regeneration after the first rains. Considerable variation has been detected with regard to DM production, stolon root development, soil cover and seed production which ranged between 8 and 110 g/m^2. However, the high incidence of an isometric virus in all accessions may limit the usefulness of this species in the area of Villavicencio.

Grasses

Panicum maximum

Twenty-seven accessions of *Panicum maximum* selected originally from a collection of 463 accessions at Carimagua were evaluated near Villavicencio together with common Guinea and cvs. Petrie and Tobiatá as controls. Considerable variation was observed for morphological characteristics (including plant height and leafiness), dry matter yields and nutritive value (Table 6).

Most of the accessions showed symptoms of nutrient deficiency and incidence of smut was quite common. However, accessions CIAT 6799 and 6944 proved to be well adapted to the environmental conditions and were selected for further testing. These two accessions are already being tested in a category III trial at Carimagua.

Table 6. Performance of 30 selected accessions of *Panicum maximum* at Villavicencio.

Characteristic	Mean	Range	Outstanding CIAT accession numbers		
DM production (g/plant)					
Maximum rainfall	55.2	16.3 - 163.1	6799	6944	6299
Minimum rainfall	14.2	3.0 - 41.2	6944	6799	16024
Plant height (cm)					
Maximum rainfall	48.9	32.6 - 77.2	6799	6837	6299
Minimum rainfall	39.1	21.6 - 62.0	6944	6799	16065
Crude protein (% Leaf DM)	7.4	3.5 - 11.9	6177	6971	16032
IVDMD (% Leaf DM)	36.5	30.9 - 50.2	16019	6799	6973

Brachiaria spp.

A collection of 30 accessions selected in a preliminary evaluation trial at Carimagua mainly on the basis of spittlebug resistance were tested together with four checks in small plot cutting trials at Carimagua and Villavicencio. Plots were established in a *B. decumbens* pasture to assure high pressure of spittlebug.

Considerable infestation by spittlebug occurred at Carimagua only at the end of the trial while at Villavicencio no high infestation occurred during the duration of the experiment.

At Carimagua, three accessions of *B. brizantha* CIAT No.6297 (cv. Marandu), 16827 and 16829, and *B. subilifolia* accession CIAT 16961 were not infested while *B. brizantha* CIAT 26646 cv. La Libertad was susceptible to the insect. The highest number of nymphs (314/6 m^2) (data provided by the Entomology section) was observed in the susceptible *B. decumbens* control accession CIAT 606 (cv.

Basilisk). Of the resistant accessions CIAT 16827 which resembles cv. Marandu showed good agronomic performance.

Other evaluations under cutting

A new Category II evaluation methodology is presently tested at Carimagua to assess already in this early phase of screening the compatability of legumes with a grass. Four stoloniferous legumes were established in 1991 in small plots together with *Brachiaria dictyoneura* cv. Llanero on two soils and at two fertility levels. Some preliminary results are presented in Table 7.

Arachis pintoi CIAT 17434 seems to perform better on the heavy soil at Alcancía

Table 7. Dry matter production[1] and soil cover of 4 stoloniferous legumes in association with *Brachiaria dictyoneura* cv. Llanero at two sites and with two levels of fertilization at Carimagua.

Species and CIAT accession no.	Fertilization	Yopare (32.6% sand)			Alcancía (7.4% sand)		
		Min.rainf.	Max. rainfall		Min.rainf.	Maximum rainfall	
		DM yield (kg/ha)	DM yield (kg/ha)	Cover (%)	DM yield (kg/ha)	DM yield (kg/ha)	Cover (%)
Arachis pintoi CIAT 17434	R[2]	32	259	38	114	271	20
	P	2	37	24	20	40	10
Centrosema rotundifolium CIAT 25120	R	6	528	26	0	256	23
	P	11	608	28	11	102	23
Desmodium heterocarpon subsp. *ovalifolium* CIAT 13305	R	632	1437	61	302 –	847	41
	P	935	1670	60	525	423	34
Desmodium heterophyllum CIAT 349 cv. Johnstone	R	330	229	19	170	99	21
	P	80	19	9	120	59	19

1. 12 weeks of regrowth in each season.

2. Fertilization for rice (R) and pastures (P), respectively.

Centrosema rotundifolium CIAT 25120 had a poor growth during the dry season at both sites and fertility levels. During the rainy season it performed better on the sandy soil.

Desmodium ovalifolium CIAT 13305 was the most productive and competitive species. It obtained highest yields at Yopare and similar to *C. rotundifolium* did not respond to higher fertility.

Desmodium heterophyllum cv. Johnstone grew best on the Yopare soil at the high fertility level. Since this trial is still in progress, no final conclusions can be drawn yet.

Multilocational agronomic evaluation

Nine RIEPT regional type B trials were conducted in the Colombian Llanos and piedmont during the past five years. A combined analysis was performed with the data obtained during the second year of evaluation of a number of legume accessions common over 6 trials which were located at Carimagua, El Capricho, Malibú, Maracaibo, Maracay and Pizano. Superior performance was registered for *D. ovalifolium* accessions CIAT 13089 and 13092 and *S. guianensis* var. *pauciflora* CIAT 11844 (bred line) both during the rainy and the dry season. Performance of *Arachis pintoi* CIAT 17434, *Centrosema brasilianum* CIAT 5234 and several accessions of *Pueraria phaseoloides* was rather poor (Table 8).

Table 8. Dry matter yields and ground cover of forage legumes evaluated in RIEPT regional type B trials in the Colombian Llanos (Combined analysis over 6 evaluation sites[1]).

Species	CIAT accession (No.)	DM yield (kg/ha/12 wks)	Ground cover (%)
1. Maximum precipitation			
D. ovalifolium	13089	1628 a[2]	78 a
S. guianensis	11844	1541 a	52 b
D. ovalifolium	13092	1388 ab	68 a
S. guianensis	10136	1226 b	42 bcd
Z. glabra	8279	1179 b	44 bc
S. guianensis	2031	1125 b	34 cde
S. capitata	10280	1099 b	52 b
C. acutifolium	5277	820 c	54 b
P. phaseoloides	17290	458 d	43 bcd
P. phaseoloides	9900	360 d	27 e
P. phaseoloides	17325	354 d	23 ef
Z. glabra	9279	313 d	31 de
C. brasilianum	5234	260 d	23 ef
A. pintoi	17434	163 d	14 f
2. Minimum precipitation			
S. guianensis	11844	438 a	19 abc
D. ovalifolium	13089	314 b	25 a
D. ovalifolium	13092	230 bc	19 abc
D. ovalifolium	350	221 bc	15 bcd
C. acutifolium	5277	177 cd	21 ab
Z. glabra	8279	148 cd	13 cd
P. phaseoloides	17290	148 cd	15 bcd
C. brasilianum	5234	113 d	10 d

[1]Location of trials: Carimagua, El Capricho, Malibú, Maracaibo, Maracay and Pizano.
[2]Means followed by the same letter for each precipitation period do not differ significantly ($P<0.01$).

AGRONOMY: MEXICO, CENTRAL AMERICA AND THE CARIBBEAN

AGRONOMY: MEXICO, CENTRAL AMERICA AND THE CARIBBEAN

The forage evaluation project for Mexico, Central America and the Caribbean, is a joint effort between the Ministry of Agriculture of Costa Rica (MAG), IICA (Instituto Interamericano de Cooperación para la Agricultura), CATIE (Centro Agronónico Tropical de Investigación y Enseñanza) and coordinated by the Tropical Forage Program (PFT) of CIAT throughout the RIEPT-CAC (Red Internacional de Evaluación de Pastos Tropicales for México, Central America and the Caribbean). Main sites of pasture germplasm screening in Costa Rica are located in Guápiles (very humid tropics), Atenas (subhumid tropics) and San Isidro (seasonal evergreen tropical forest).

I. Pasture work during 1992 (Highlights)

During 1992 concluded the agronomic evaluation of 290 accessions of Brachiaria spp and 90 accessions of Leucaena spp respectively in Guápiles and Atenas.

Seed multiplication and distribution of promising germplasm to member countries of the RIEPT-CAC continued during 1992. Seed production studies were carried out on A. pintoi (pattern of flowering and harvesting time) and in B. brizantha cv Diamantes 1 (CIAT 6780), CIAT 664 and B. dictyoneura CIAT 6133 (burning and N effects on seed yield and quality).

The evaluation under grazing (Type D trial) of B. brizantha cv Diamantes 1 (CIAT 6780) in monoculture and in association with A. pintoi CIAT 17434 continued for the third year in Guápiles (project MAG/CIAT). Germplasm and assessment was given to MAG (San Isidro) and ITCR (San Carlos) in Costa Rica for the establishment during 1992 of two Type C grazing trials with the species B. brizantha cv Diamantes 1, CIAT 664 and B. dictyoneura CIAT 6133 in association with A. pintoi CIAT 17434.

New pasture studies initiated during 1992 included the response of A. pintoi CIAT 17434 to levels of Ca, P, Zn, Mo and Cu in Guápiles, and the effect of lime, P and S on seed yield in San Isidro. The adaptation of 20 new accessions of Brachiaria to the acid soils of San Isidro was initiated.

An experiment to observe competence and persistence of 5 Brachiaria (B. brizantha cv Diamantes 1, CIAT 6387 and CIAT 664, B. dictyoneura CIAT 6133 and B. humidicola CIAT 16886) with ratana (Ischaemum indicum) was established in Guápiles.

II. Main research findings during 1992

2.1 Germplasm evaluation (Category II)

2.1.2 Leucaena

The evaluation of 90 accessions of *Leucaena* spp was terminated in Atenas during 1992. Eatable dry matter production (leaves and thin stems) and plant height was measured every 8 weeks during the wet season (5-6 months) and every 12 weeks during the dry period. Plant cuttings were made at 45 cm height on each evaluation date.

A cluster analysis of the data permitted to form seven contrasting groups based on the parameters studied (Table 1). Plant yields and regrowth were high for cluster 7 which was formed only by *L. leucocephala* CIAT 17263. This plant produced nearly twice more eatable dry matter that other outstanding accessions both during the dry and wet season. This particular accession was collected in Mexico and donated to the TFP by CSIRO of Australia.

Cluster 4 grouped 16 accessions of *L. leucocephala* and one of *L. diversifolia* (CIAT 17503). This group followed in dry matter yield and plant regrowth to cluster 7, but had similar percentage of dry matter production during the dry season ($P < 0.05$). During this period, cluster 1 was nil in production and had the lowest regrowth capacity as illustrated in Table 1. This cluster was formed totally by 22 accessions of the species *L. leucocephala*.

Table 1. Dry matter production and plant regrowth of 90 accessions of *Leucaena* spp established in Atenas and ranked in 7 distinct clusters. Costa Rica, 1992.

Cluster (No.)	g DM/plant*	% DM during dry season	Height ** (cm)
1	44 f***	0 d	66 f
2	890 cd	21 cb	102 d
3	1088 c	25 ab	118 c
4	1779 b	18 c	131 b
5	345 ef	17 c	78 e
6	573 de	29 a	83 e
7	3635 a	20 c	170 a

* Cuts every 8 weeks during wet season and every 12 weeks during dry. Cutting height, 45 cm
** Mean regrowth height during the wet season
*** $P < 0.05$, Duncan's Multiple Range Test

The hybrids of _L._ _leucocephala_ CIAT 17434, CIAT 17475, CIAT 17476 and CIAT 17478 were represented in different cluster, indicating contrasting plant characteristics. On the other hand, _L._ _leucocephala_ CIAT 17502 (cv Cunningham) was within cluster 5, a group of low regrowth and low dry matter yield, meanwhile CIAT 18477 (cv Perú) was situated in cluster 2, a group of intermediate values. _L._ _diversifolia_ CIAT 17503, was the best accession within this species.

For the whole _Leucaena_ collection DM yields were highly correlated with plant height ($P < 0.0001$), and had a high coefficient of determination ($r^2 = 0.90$), indicating a very close relationship between these two parameters.

The complete composition of the different clusters is given below:

Cluster 1: _Leucaena_ _leucocephala_ CIAT N°: 9415, 17482, 9101, 18480, 937, 17498, 7987, 7453, 18482, 9411, 17494, 9443, 17493, 9377, 9437, 17489, 17473, 17483, 9421, 18479, 7415, 8815

Cluster 2: _Leucaena_ _leucocephala_ CIAT N°: 17486, 17501, 7452, 7984, 17224, 17492, 17223, 17477, 9904, 17479, 932, 9464, 18478, 18477, 751, 7929, 17480, 17495, 9441

Leucaena _diversifolia_ CIAT N° 17461

Cluster 3: _Leucaena_ _leucocephala_ CIAT N°: 7985, 17488, 8069, 17219, 17218

Leucaena _shannonii_ CIAT N° 17487

Cluster 4: _Leucaena_ _leucocephala_ CIAT N°: 9119, 17474, 785, 17491, 9993, 18481, 871, 7986, 7384, 17467, 18483, 734, 7930, 17217, 17500, 9442

Leucaena _diversifolia_ CIAT N° 17503

Cluster 5: _Leucaena_ _leucocephala_ CIAT N°: 7965, 9379, 17475, 17502, 9132, 9438, 7872, 17222, 9133, 17499, 17484

Cluster 6: _Leucaena_ _leucocephala_ CIAT N°: 7988, 17476, 766, 7385, 9383, 7356, 17496, 17481, 17389, 17478

Leucaena _pulverulenta_ CIAT N° 17490

Leucaena _diversifolia_ CIAT N°: 17588, 17485

Cluster 7: _Leucaena_ _leucocephala_ CIAT N° 17263

2.1.3 Arachis pintoi

This legume continues as highly promising for the seasonal and humid tropic ecosystems of the RIEPT-CAC region. Persistence under grazing and compatibility with stoloniferous grasses are among the desirable qualities of this plant, but also the legume is showing high potential as cover crop in banana plantations, palm trees, coffee and pepper orchards. Presently this legume is in high demand as experimental germplasm from all the RIEPT-CAC countries.

2.1.3.1 Seed production

A seed production study was carried out at two contrasting sites, namely Guápiles and San Isidro. The accessions CIAT 18748, 18744 and 17434 (cv Amarillo) of *A. pintoi* were planted in both sites by vegetative material. Seed yield was measured at 8, 12, 16 and 20 months postplanting in Guápiles, and at 8, 16 and 20 months in San Isidro.

Seed yield of *A. pintoi* was affected by site ($P < 0.05$). Overall, San Isidro produced 18% more seed than Guápiles (Table 2; 765 vs 535 kg/ha respectively). Date of harvest did not affect seed yield in Guápiles, although yield tended to decrease with plant age, particularly for the accession CIAT 18748. At San Isidro however, there were significant differences among harvest dates; low yields were observed at 8 months postplanting, these increased to a peak at the 16th month harvest and declined again at 20 months. This may be related to the number of flowers and pattern of flowering observed for the two sites (not reported here).

Flowering pattern in Guápiles was not influence by dry spells because the continual availability of moisture at this site. At San Isidro with 3-4 months dry season, an abundant flush of flowering occurred in May at the beginning of the rainy season, and in mid July, following a short dry spell. This probable accounted for the high seed yield recorded in the month of October (16th month harvest) in that site.

At Guápiles site, significant differences ($P < 0.05$) in seed yield were observed among the *Arachis* accessions; CIAT 17434 was the more prolific with nearly 1 ton/ha of seed, whilst CIAT 18744 had the lowest seed yield (Table 2), although the seeds were larger (10.5 and 14.6 g/100 unit weight of pod respectively). This particular accession produced more stolons per unit area, leading to higher dry matter yields in Guápiles (14 ton/ha of cumulative top growth). Contrary to Guápiles, in San Isidro there were no significant differences ($P < 0.05$) in seed yield among accessions (Table 2), and seed yields were greater, possibly influenced by seasonal changes in soil moisture as mentioned before. A high proportion of the pods were concentrated within the first 10 cm of the soil profile.

Table 2. Yields of seeds in pods of *A. pintoi* accessions harvested at different dates in San Isidro and Guápiles, Costa Rica (More than 90% purity).

SITE	GUAPILES					SAN ISIDRO			
Harvest date (months)	8	12	16	20	Mean	8	16	20	Mean
CIAT No.									
17434	893	1040	963	927	956[a]	480	1378	547	802[a]
18744	169	102	194	170	159[c]	483	973	866	774[a]
18748	706	467	332	464	492[b]	225	1336	596	719[a]
Mean	589[a]	536[a]	496[a]	520[a]		396[c]	1229[a]	670[b]	

* Mean values within sites with different letters are statistically different, $P < 0.05$ (Duncan)

3. Grazing trials

3.1 Category III, Type C trial

Persistence under grazing of the grasses B. brizantha cv Diamantes I (CIAT 6780) and B. humidicola CIAT 6369 in association with the legumes A. pintoi CIAT 17434, C. macrocarpum CIAT 5713 and S. guianensis CIAT 184 has been under evaluation for three years in Guápiles. The experiment (a rotational of 5/30 days occupation/rest) is conducted by U. Wageningen/CATIE within the context of the CATIE/MAG/CIAT collaborating pasture project. Table 3 shows that the legumes C. macrocarpum and S. guianensis have disappeared in the B. brizantha pastures and drive in very low proportions in B. humidicola. Meanwhile, A. pintoi have persisted and even increased with time, particularly under the high stocking rate of 3.0 AU/ha for both grasses. The balance of the grass/legume association presently is better in B. brizantha than in B. humidicola pastures; under high stocking rate the latter grass has been dominated by A. pintoi and weeds like Mimosa pudica and Paspalum fasciculatum.

Table 3. Mean percentage dry weight of the last five grazing cycles of the legumes A. pintoi, S. guianensis and C. macrocarpum and volunteer spp., in association with the grasses B. brizantha and B. humidicola at two stocking rates in Guápiles, Costa Rica. (M. Ibrahim, unpublished).

Stocking rate (AU/ha)	B. brizantha (cv Diamantes 1) 1.75	3.0	B. humidicola (CIAT 6369) 1.75	3.0
Legumes				
A. pintoi CIAT 17434	8.4	22.4	18.6	30.6
volunteer spp.*	2.1	6.7	17	35.0
S. guianensis CIAT 184	0	0	4.5	2.4
volunteer spp.	2.8	9.0	44	59.0
C. macrocarpum CIAT 5713	0	0	0.8	4.5
volunteer spp.	9.0	4.8	88.8	59.4

* Mainly Mimosa pudica and Paspalum fasciculatum

It has been observed in this experiment that the half-life of A. pintoi populations is not affected by treatments and exceeds two years (M. Ibrahim, unpublished). Meanwhile C. macrocarpum and S. guianensis had lower survival rates particularly in association with B. brizantha. Notable too is the quality improvement of the associated grass where A. pintoi is the companion legume (Table 4). Considerable increases in CP and IVDMD can be observed, indicating an efficient grass utilization of the N fixed to the soil by this legume.

3.2 Category IV, Type D trial

The evaluation under grazing of B. brizantha cv Diamantes 1 (CIAT 6780) in monoculture and associated with A. pintoi CIAT 17434 entered the third year of evaluation in Guápiles. The experiment (a rotational 7/21 days, occupation/rest) is conducted by MAG within the context of the MAG/CIAT collaborating pasture project. Table 5 shows that the high stocking rate (3.0 UA/ha) has significantly reduced ($P < 0.05$) forage availability for both the

Table 4. Crude Protein (CP) and In vitro dry matter digestibility (IVDMD) of hand plucked samples taken from the grasses B. brizantha and B. humidicola associated with A. pintoi in Guápiles, Costa Rica (M. Ibrahim, unpublished).

Legumes	Grasses: B. brizantha (%) (cv Diamantes 1)		B. humidicola (%) (CIAT 6369)	
	CP	IVDMD	CP	IVDMD
A. pintoi CIAT 17434	13.0	63.0	12.0	64.0
C. macrocarpum CIAT 5713	10.0	60.2	11.0	54.5
S. guianensis CIAT 184	10.5	59.6	9.0	60.3

Table 5. Forage in offer, legume proportion and animal liveweight in pastures of B. brizantha (CIAT 6780) cv Diamantes 1 in monoculture and associated with A. pintoi CIAT 17434 after 14 grazing cycles in Guápiles, Costa Rica, 1992.

Pastures	Stocking rate (UA/ha)	Forage in offer (ton DM/ha)	Legume (%)	Animal Liveweight (g/an/day)
Bb/Ap	1.5	6.2 a*	6.0 b*	611.0 a**
Bb/Ap	3.0	4.1 b	32.0 a	623.7 a
Bb	1.5	6.0 a		568.0 a
Bb	3.0	3.6 c		333.0 b

* $P < 0.05$
** $P < 0.1$

grass in monoculture and in association with the legume; the reduction has been more severe for the grass alone. In the associated pastures, A. pintoi has increased in proportion in response to high stocking, and this corresponds with observations made in the Type C trial reported above. Animal liveweight has been significantly low ($P < 0.1$) for the grass alone under high stocking, but similar for the low stocking and the low and high stocking rate of the grass in monoculture and associated with the legume respectively, although there is a clear tendency for higher liveweight gains for the associated grass, and this is expected to increase with time as a response to the improved quality of the B. brizantha in association, as reported above in the Type C trial for the same type of grass/legume association.

III. Projected activities during 1993

- Initiate agronomic evaluation of selected P. maximum accessions in the acid soils of San Isidro.

- Initiate agronomic evaluation of the shrubs C. argentea (11 accessions), Uraria spp (26 accessions) and D. velutinum (21 accessions) in Atenas and San Isidro.

- Evaluate the effect of P and lime on seed yield of 3 accessions of A. pintoi.

- Evaluate the regrowth capacity of 3 accessions of A. pintoi after burning and herbicide treatments.

- Initiate the study of persistence and regrowth under mob grazing of selected Brachiaria spp in Guápiles.

- To initiated a field study of selected Brachiaria accessions to differences in soil moisture content (to be discussed).

- To initiated evaluation under grazing of selected P. maximum accessions associated with legumes in Guápiles.

- To initiate studies of adaptation to differences in altitude of selected germplasm of A. pintoi, S. guianensis, Centrosema, Brachiaria and Panicum in Costa Rica.

List of Publications during 1992

1. Scientific Journals

1.1 Argel, P.J. y A. Valerio. 1992. Selectividad de herbicida y control de malezas en *Arachis pintoi*. *Pasturas Tropicales* (CIAT). In press.

2. Conference papers

2.1 Argel, P.J. and A. Valerio. 1992. Effect of crop age on seed yield of *Arachis pintoi* at two sites in Costa Rica. (Submitted for the XVII IGC, New Zealand and Australia 1993).

3. Workshop papers

3.1 Liberación de nuevos cultivares forrajeros en Centroamérica, México y El Caribe, and

3.2 Perspectivas regionales en pasturas y semillas de especies forrajeras para Centroamérica, México y El Caribe.

(Both topics presented in pasture seed workshop held in Comayagua (Honduras), March 2-7, 1992).

3.3 Experiencia Regional con *Brachiaria dictyoneura* CIAT 6133 (Topic presented in Panamá, the 27th August 1992, during official release of this grass as cv Gualaca).

3.4 Consideraciones forrajeras sobre el pasto ratana (*Ischaemum ciliare*) y alternativas para mejorar su productividad (Topic presented in San Carlos (Costa Rica) in workshop organized by Dos Pinos on pasto ratana: ¿Alternativa o problemática en nuestra ganadería?; San Carlos April 3, 1992.

AGRONOMY CERRADO

AGRONOMY CERRADO

1. Highlights of the year

Germplasm collection

- During 1992 was made an effort in order to increase the size of the *Arachis spp* collection. The size of the initial collection was increased in 655%.

- Another trip was also made to search for *S.capitata* germplasm with emphasis in the late flowering type. Twelve new accession were found.

Germplasm evaluation

- The agronomic evaluation of the 215 accessions of *Calopogonium mucunoides* was completed. Pre-selected germplasm is under seed multiplication.

- The first trial with 33 *Arachis* spp accessions established in 1990 on a seasonally flooded land was completed. The selected accession BRA 15253 b is under seed multiplication and grazing (2 years from initial agronomic evaluation to seed multiplication and grazing).

- The believed low seed-top yield on *S.guianensis* var. vulgaris BRA 017817/CPAC 1230/CIAT 2950 was broken. With small but estrategic irrigations during the dry period (June-August) the pure seed yield was drastically increased from 82 to 333 kg.pure seed.ha.

Seed multiplication

- The recorded five kg of available seed in 1990 for the pre-selected germplasm was increased during 1992 up to 963 kg.

2. Summary of research findings

Grasses

Paspalum spp

During 1992 the agronomic evaluation of 42 accessions on a red-yellow-latosol was closed. The average accumulated DMY during the rainy season of 1991 and 1992 ranged from 0.5 to 21 $t.ha^{-1}$. Detailed information on DMY distribution, regrowth, leaf: stem ration and quality was presented in Annual Review 1991, Section 9.

Seed yields showed a wide range of variability among accessions, and ranged from 0 to 1500 kg/pure seed/ha^{-1}.

A new trial was established in order to evaluate all the available germplasm at CENARGEN. The controls are the pre-selected *Paspalum* spp, *Brachiaria* spp accessions plus the commercial grasses used in the area (Table 1).

Legumes

Arachis spp

The agronomic evaluation of 33 accessions established on a seasonally flooded land with a high water table was fully carried out. Trends were similars to the ones presented in the Annual Report 1991, Section 9.

The IVDMD in all plant-components was estimated in the nine pre-selected accessions. The IVDMD of the whole-plant parts, leaf, stem and "litter" is presented on Table 2. Figures reported are high and similar to the ones recorded before in previous Annual Reviews 1988-1991. An important point is the high values obtained in the litter fraction and in the root fraction (Table 3).

The estimated pure seed yield on the pre-selected accessions ranged from 22 up to 1515 kg/pure seed yield/ha $^{-1}$ (Table 4).

The pattern of flowering was recorded. Although some variations in the total number of flowers/m^2 is presented within the accessions under evaluation, the highest value for all of them was registered in December and reached the lowest value in April (Table 5).

S.guianensis

An agronomic trial was carried out in order to measure the effect of supplementary irrigation during the dry period on seed yield.

Plots were watered between June and August. Seed yield was increased from 82 to 333 kg/pure seed/ha^{-1}. This simple agronomic trial reconfirm the high agronomic potential of *S.guianensis* var. vulgaris BRA 017817/CPAC 1230/CIAT 2950.

Germplasm collection

During 1992 three trips for collecting legume germplasm were made, and special emphasis in the genera *Arachis* was given. They were conducted in collaboration with CENARGEN under the leadership of Dr. J. F.M. Valls.

The first trip covered a major portion NW of Minas Gerais State, and south of Bahia mainly the east part of San Francisco Valley area where any collecting trip was made until now (Figure 1). The collected material was transported to CPAC for initial multiplication (Table 6). In the second trip, some areas of Goias, Minas Gerais and Tocantins were covered (Figure 2). The collected material (Table 6) is under initial multiplication.

A third collecting trip was made late August in order to concentrate in the identification of late flowering material of *S.capitata* (Figure 3). The collected germplasm (Table 6) is ready for the initial seed multiplication.

Seed production

The seed multiplication and production was a very important part of the work during 1990-1992.

The results are recorded on Table 7. The initial 5 kg of available seed in 1990 was increased during 1992 up to 963 kg, a 193 fold increase.

3. Summary of projected activities

The effort on collecting new germoplasm in *A.pintoi* will continue.

New areas and partners would be search in order to accelerate and increase the amount of seed from the new germplasm.

Table 1. *Paspalum* spp accessions under evaluation

Genera/Species	No. BRA
P. arundinellum	012602
P. guenoarum	003824,006572,014851,012483
P. plicatulum	004120,008567,008648,008672, 008869,008877,008893,008923, 008940,008958,008974,008982, 009016,009032,009083,009105, 009229,009717,009784,011479, 012645,
P. sp. gr. plicatula	005819,006602,006611,006700, 006718,008613,008630,008681, 009202,010391,010511,011207, 011517,012424,012521,012556, 012645,012700,012866,012874, 013297,013692,013978,014010, 014354,014630,014729,014826, 014885,V11802/1 **
P. compressifolium	005080,008508,008524,008532, 011282,011355,013102,014907
P. sp.	V11843*,MS-040****,
P. notatum	Q-3667*, BE-1 hib. sex., BE-1 hib. apo.
P.intermedium	V11801 **, 012599
P.conspersum	012793 ,012661,V11855 **,
P.sp. gr. virgata	0012921,V11884 **,3136***,
P. virgatum	V11830 **
Control	
B. brizantha	CIAT 16315, cv. Marandú,
B. decumbens	CIAT 16488
A. gayanus	cv. Planaltina
Paspalum spp.	009415,009610,009652,009687, 010154,010537,011053,012912, 012939,013311,cv. Pantaneiro
P. maximum	cv. Vencedor

* No. Quarin,** No. Valls,*** No. CPAC,**** No. Mario Sóter

Table 2. *Arachis* spp. IVDMD of plant components

Accession BRA No.	IVDMD, % whole plant	leaf	stem	litter
17531	59 a*	65 a	41 a	–
13251	57 a	61 ab	47 a	33 ab
15253 b	56 a	58 bc	49 a	32 ab
43	56 a	51 de	43 a	–
33	55 a	58 bc	44 a	21 b
45	55 a	54 cd	48 a	23 b
15121	54 a	56 c	45 a	38 a
12106	52 a	46 e	52 a	23 b
15598	50 a	48 e	43 a	26 b

* $P < 0.05$

Table 3. *Arachis* spp: IVDMD of the roots

Genera/specie BRA No.	Roots, IVDMD % Lab 1*	Lab 2
A. pintoi 33	65.4	65.5
A. pintoi 15253 b	65.4	57.4
A. pintoi 15598	65.3	67.5
A. repens 12106	65.3	57.3
A. pintoi 13251	62.9	59.7
A. pintoi 45	62.6	61.9
A. pintoi 15121	62.2	62.2
A. pintoi 43	59.5	57.2
A. glabrata 17531	54.5	52.7

*Lab 1 = EV - UFMG; Lab 2 = TFP - CIAT

Table 4. Pure seed yield at 26 months from sowing

Accession BRA No.	Seed yield kg/ha^{-1}
15253a	1515 a*
15121	1355 ab
13251	892 abc
0045	653 abc
15253b	580 bc
15598	406 c
0033	306 c
17531	29 c
0043	22 c

* $P < 0.05$

Table 5. Flowering pattern in *Arachis* spp accessions

Accession BRA No.	Month N*	D	J	F	M	A
	No. flowers/m^2					
-0033	528	3568	1948	468	288	104
-0043	736	1512	28	0	0	0
-0045	1004	4332	1912	412	392	96
12106	0	0	0	0	0	0
13251	1852	2900	624	44	120	36
15121	816	1988	1052	156	28	36
15253a	276	1236	384	264	140	8
15253b	108	2004	4	40	4	0
15598	20	1724	592	200	36	12
17531	12	500	36	0	0	0

* 1991/1992

Table 6. Collected germplasm during 1992

Genera/Specie	First trip*	Second trip**	Thrid trip***
	------------- No. accessions	---------------	
A. pusilla	3		
A. sylvestris	1		
Arachis sp.	1		
A. pintoi	16	7	
A. repens	2		1
A. postrata	8		
S. capitata			12

* States: Minas Gerais - Bahia - Goias
** Goias - Minas Gerais - Tocantins
*** Goias - Mato Grosso

Table 7. Available seed from the selected germplasm

Genera/Specie	Accessions No.	Pure seed Kg.
Brachiaria spp	13	163
P. atratum	1	225
Paspalum spp	6	237
P. maximum	8	65
A. pintoi	1	17
Centrosema spp	5	31
S. guianensis	2	165
P. phaseoloides	4	60
TOTAL		963

Agronomy Cerrado

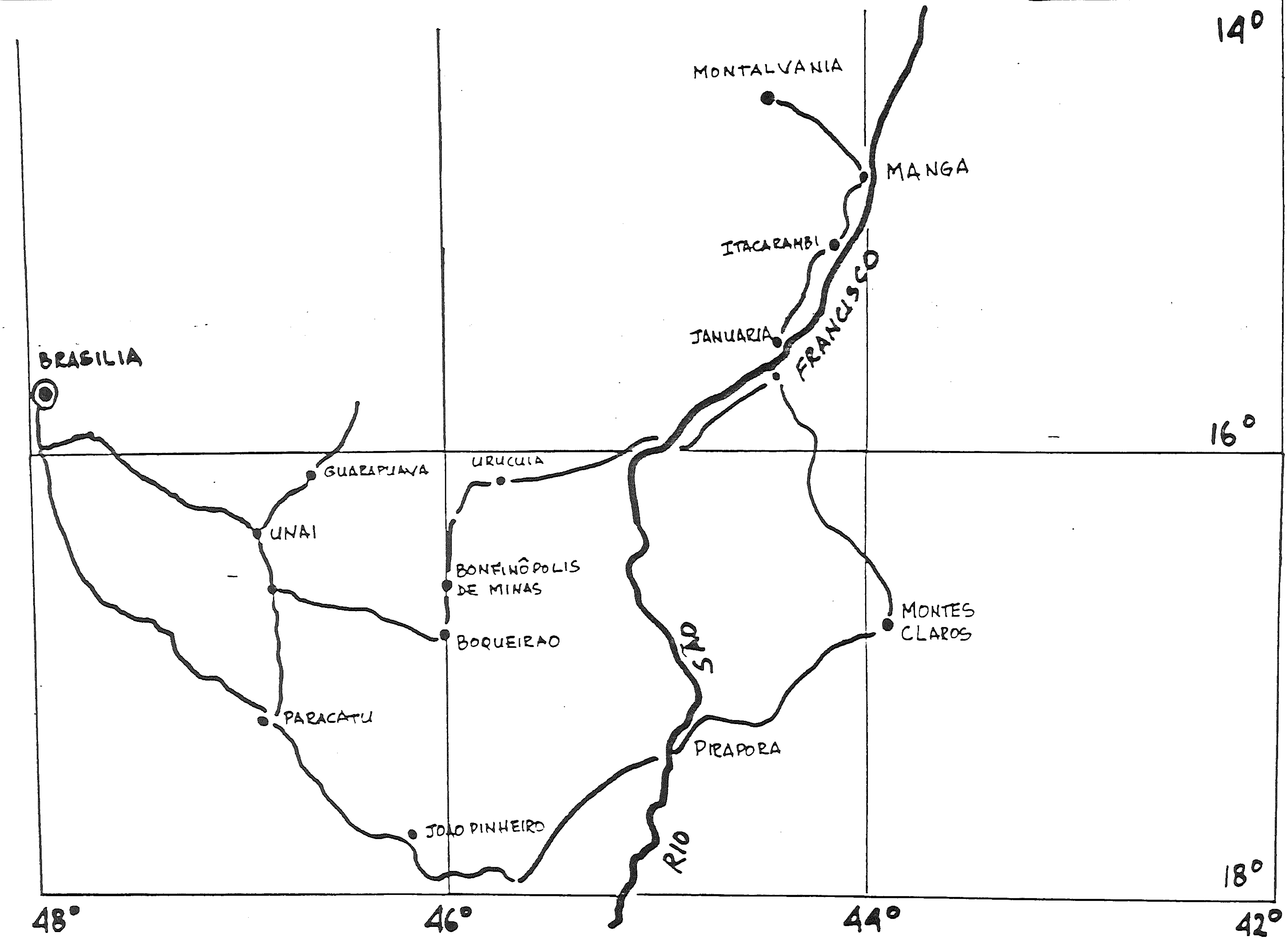
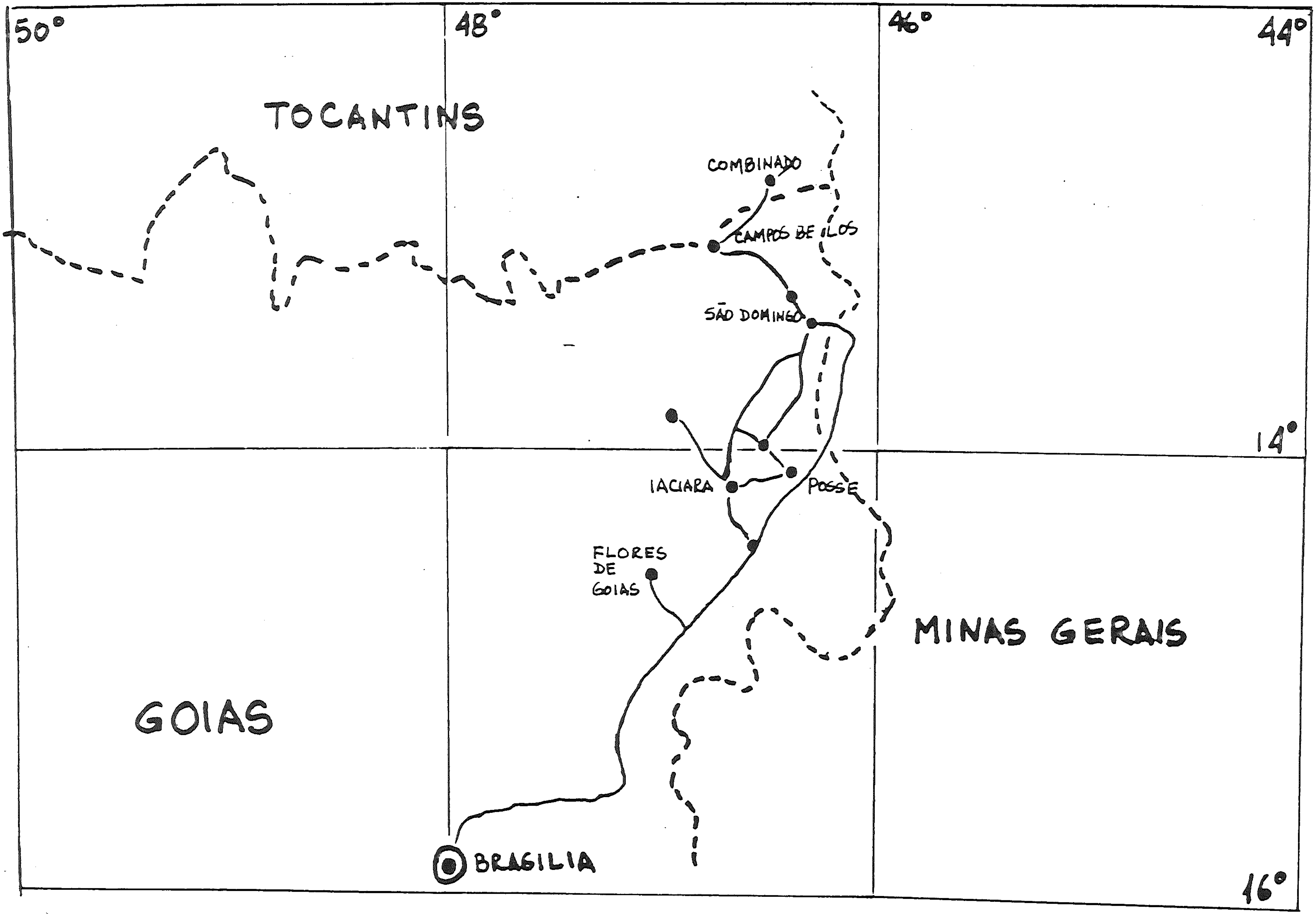


FIGURE 1. AREA COLLECTED FOR ARACHIS SPP.

FIGURE 2. AREA COLLECTED FOR ARACHIS SPP.



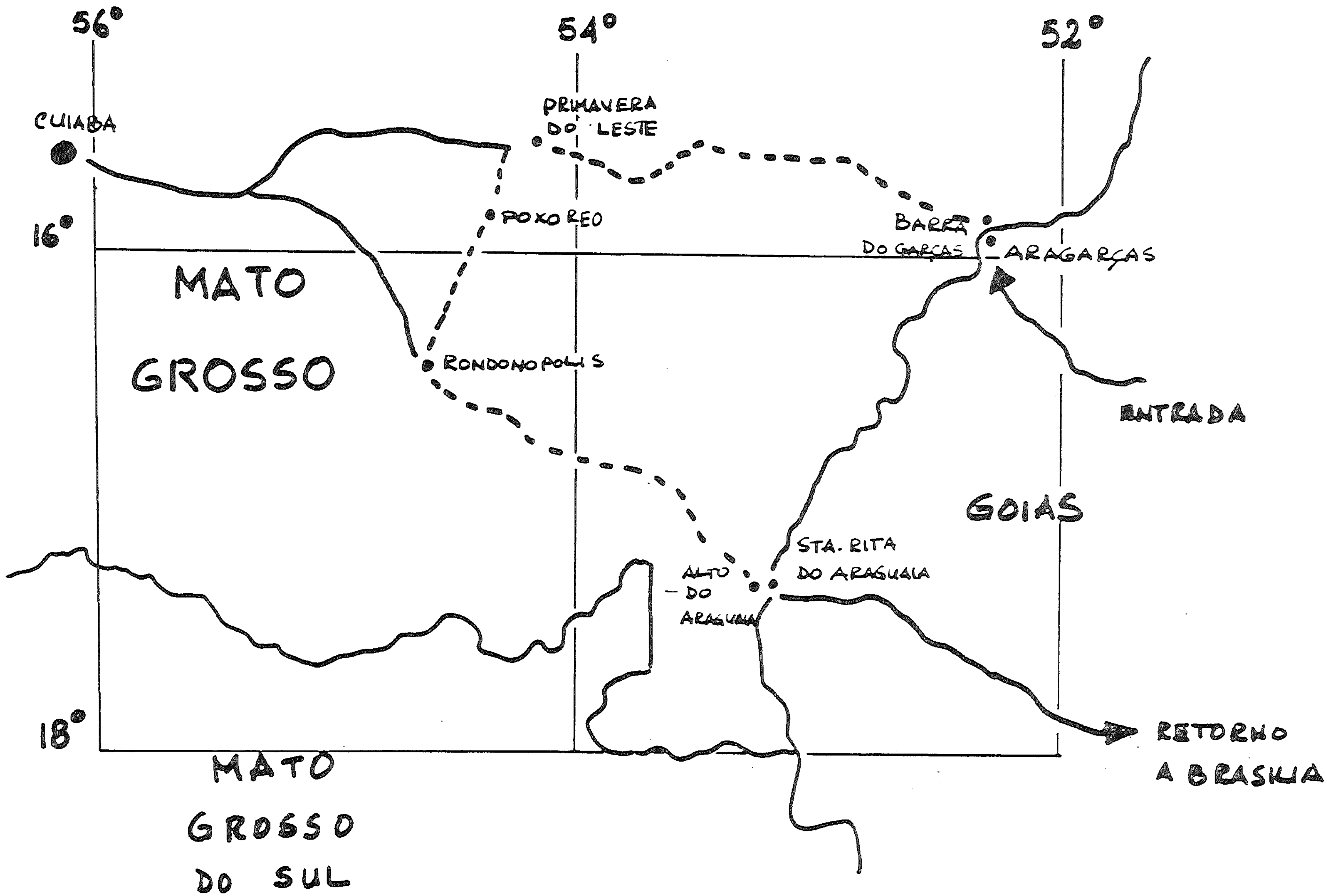


FIGURE 3. AREA COLLECTED FOR S. CAPITATA

LIST OF PUBLICATIONS

(I) Scientific Journal

Pizarro, E.A.; Amaral, R. y Vera, R.R. 1992. *Panicum maximum*: Efecto de la época de diferimiento en producción y calidad. Pasturas Tropicales (en prensa).

Pizarro, E.A.; Ayarza, M.A.; Spain, J.M.; Carvalho, M.A. y de Sousa, M.A. 1993. *Stylosanthes guianensis*: Efecto de la irrigación estratégica en la producción de semillas. Pasturas Tropicales (en revisión).

Valerio, A.; Pizarro, E.A. y Argel, P. 1992. Introducción y evaluación de gramíneas forrajeras tropicales en Centroamérica: Trópico subhúmedo. Pasturas Tropicales (en prensa).

(II) Workshop papers

Avila, P.; Pizarro, E.A. y Franco L.H. 1992. Establecimiento y producción de gramíneas y leguminosa forrajeras en La Alegría, Puerto Gaitán, Meta, Colombia. In: Pizarro, E.A. (comp). 1992. Red Internacional de Evaluación de Pastos Tropicales (RIEPT): Resúmenes de trabajos. 1a. Reunión de la RIEPT-Sabanas (en prensa).

Carvalho, M.A.; Maciel, D. y Pizarro, E.A. 1992. Introdución y evaluación agronómica de ecotipos de *Calopogonium mucunoides* en el Cerrado. In: Pizarro, E.A. (comp). 1992. Red Internacional de Evaluación de Pastos Tropicales (RIEPT): Resúmenes de trabajos. 1a. Reunión de la RIEPT-Sabanas (en prensa).

Carvalho, M.A.; Pizarro, E.A.; Valls, J.F.M. y Maciel D. 1992. Introdución y evaluación agronómica en el Cerrado de *Paspalum* spp. In: Pizarro, E.A. (comp). 1992. Red Internacional de Evaluación de Pastos Tropicales (RIEPT): Resúmenes de trabajos. 1a. Reunión de la RIEPT-Sabanas (en prensa).

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Franco, L.H.; Molina D.L. y Pizarro, E.A. 1992. Establecimiento y producción de gramíneas y leguminosas forrajeras en Las Leonas, Puerto Lopez, Meta, Colombia. In: Pizarro, E.A. (comp). 1992. Red Internacional de Evaluación de Pastos Tropicales (RIEPT): Resúmenes de trabajos. 1a. Reunión de la RIEPT-Sabanas (en prensa).

Oliveira, M.A.S.; Teixeira, R.; Souza, M.A. e Pizarro, E.A. 1992. Efeito da cigarrinha das pastagens *Deois flavopicta* (Stal, 1854) no comportamento dos diferentes ecotipos de *Brachiaria* spp no D.F. - Brasília. In: Pizarro, E.A. (comp). 1992. Red Internacional de Evaluación de Pastos Tropicales (RIEPT): Resúmenes de trabajos. 1a. Reunión de la RIEPT-Sabanas (en prensa).

Pizarro, E.A.; Amaral, R y Vera, R. 1992. *Panicum maximum*: Efecto de la época de diferimiento en producción y calidad. In: Pizarro, E.A. (comp). 1992. Red Internacional de Evaluación de Pastos Tropicales (RIEPT): Resúmenes de trabajos. 1a. Reunión de la RIEPT-Sabanas (en prensa).

Pizarro, E.A.; Avila, P. y Franco, L.H. 1992. Establecimiento y producción de gramínea y leguminosas forrajeras en La Reserva, Puerto Gaitán, Meta, Colombia. In: Pizarro, E.A. (comp). 1992. Red Internacional de Evaluación de Pastos Tropicales (RIEPT): Resúmenes de trabajos. 1a. Reunión de la RIEPT-Sabanas (en prensa).

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Pizarro, E.A.; Carvalho, M.A.; Valls, J.F.M. y Maciel D. 1992. Comportamiento agronómico en áreas de bajos en el Cerrado de *Arachis* spp. In: Pizarro, E.A. (comp). 1992. Red Internacional de Evaluación de Pastos Tropicales (RIEPT): Resúmenes de trabajos. 1a. Reunión de la RIEPT-Sabanas (en prensa).

Pizarro, E.A.; Franco, L.H. y Molina, D.L. 1992. Establecimiento y adaptación de 20 accesiones de *Pueraria phaseoloides* en las Leones, Puerto Lopez, Meta, Colombia. In: Pizarro, E.A. (comp). 1992. Red Internacional de Evaluación de Pastos Tropicales (RIEPT): Resúmenes de trabajos. 1a. Reunión de la RIEPT-Sabanas (en prensa).

Sobrinho, J.M.; Pizarro, E.A., Viana H.A. e Oliveira, M.A.S. 1992. Avaliação de ecotipos de *Brachiaria* spp quanto a resistência a cigarrinha das pastagens na região de Goiania, GO. In: Pizarro, E.A. (comp). 1992. Red Internacional de Evaluación de Pastos Tropicales (RIEPT): Resúmenes de trabajos. 1a. Reunión de la RIEPT-Sabanas (en prensa).

Souza, M.A.; Pizarro, E.A., Carvalho M.A., Grof, B y Shultz, A.L. 1992. Avaliação agronômica de gramíneas e leguminosas forrageiras en Planaltina, DF. Brasília. In: Pizarro, E.A. (comp). 1992. Red Internacional de Evaluación de Pastos Tropicales (RIEPT): Resúmenes de trabajos. 1a. Reunión de la RIEPT-Sabanas (en prensa).

(III) International Grassland Congress

Pizarro, E.A.; Valls, J.F.M.; Carvalho, M.A. and Charchar D'Avila, M.J. 1993. *Arachis* spp: Introduction and evaluation of new accessions in seasonally flooded land in the brazilian Cerrado. In: XVII International Grassland Congress, Palmerston North, New Zealand (aceptado para publicación con el No. 1019*1).

Valls, J.F.M.; Pizarro, E.A. and Carvalho, M.A. 1993. Evaluation of a collection of *Paspalum* sp. *aff.P.plicatulum* for the Cerrado ecosystem, Brazil. In: XVII International Grassland Congress, Palmerston North, New Zealand. (aceptado para publicación con el No. 912*2).

(IV) Book

Argel, P.J. and Pizarro, E.A. 1992. Germplasm case study: *Arachis pintoi*. In CIAT. Pastures for the Tropical Lowlands: CIAT's contribution. Cali, Colombia. 238 p. Chapter 5, pp. 57-73.

SOUTHEAST ASIAN REGIONAL FORAGE SEEDS PROJECT

GENETICS

GENETICS

OBJECTIVES

The Section's objective is two-fold. It seeks, by directed genetic recombination, to develop and improve gene pools with combinations of desirable attributes not found in natural germplasm. Parallel to the development of enhanced gene pools, the Section seeks to generate information on genetics and plant breeding methodologies for undomesticated, largely unknown species.

The Section seeks to establish and maintain collaborative research links with scientists in national programs in Latin America, as well as with advanced research laboratories in developed countries. A very productive, mutually beneficial collaboration exists with Dr. C. do Valle (EMBRAPA/CNPGC, Campo Grande - MS, Brazil). We have participated actively in the international apomixis network, APONET, coordinated by Dr. Y. Savidan of ORSTOM, France. Collaborative projects with specialized units within CIAT, particularly the Biotechnology Research Unit, have grown substantially during the past year.

Stylosanthes

S. guianensis. Only three minor activities are ongoing in the *S. guianensis* breeding project which began in 1980. We continue to maintain the natural selection paddocks originally established at Carimagua in 1984. Substantial *S.*

guianensis still remains in these plots, with an apparently marked effect of stocking rate on presence of *S. guianensis*. Eventually these plots must be sampled and a rigorous assessment of the results of this exercise conducted.

Six bulk advance populations are also being maintained at Carimagua. These are three early-flowering populations, essentially *S. guianensis* var. *vulgaris*, and three late-flowering populations, essentially pure *S. guianensis* var. *pauciflora*. We hope to compare these populations with appropriate germplasm accessions in terms of their forage and seed yield and disease resistance, next year at Carimagua.

We are currently multiplying seed of two pedigree-derived *S. guianensis* lines, previously designated line 41 and line 44 (CIAT 11833 and CIAT 11844, respectively). Two thousand square meters of each line were planted at Carimagua. Seed harvest is anticipated for next December or January.

S. capitata. We continue to develop a series of highly inbred *S. capitata* lines by single seed descent. Seventy-five lines are being maintained and these are now in the third or fourth generation of inbreeding.

Brachiaria spp.

Development of gene pools. The objective of the *Brachiaria* improvement project remains that of creating combinations of attributes that have not been found in natural germplasm. Particularly we are seeking spittlebug-resistant lines adapted to acid, low fertility soils. The project is based upon a sexual tetraploid *B. ruziziensis*, which we received in 1988 from Dr. do Valle. This sexual tetraploid serves as a bridge allowing recombination of genes between accessions of the naturally apomictic species *B. brizantha* and *B. decumbens*.

Fundamental to the genetic improvement project is quick and reliable identification of reproductive mode (apomixis vs. sexuality) in segregating, hybrid populations. We had anticipated relying upon progeny tests to determine reproductive mode. However, it has been possible to introduce a major advance in the handling of the *Brachiaria* breeding population owing to our strengthened capacity to determine reproductive mode by cytological techniques. Instead of recombining every two years (with a progeny test in alternate years), we can now select and recombine every year.

Thus, in 1992, we planted a large recombination block, which included 1700 unique genotypes as maternals and vegetative replicates of 42 known apomicts as pollinators. The maternals represent the open-pollinated progeny of sexual individuals in the 1991 crossing block or first cycle hybrids selected from last year's evaluation trial. These 1700 maternals are either known sexuals or of unknown reproductive mode. They are planted in alternate points in a square grid. Remaining points are planted with the known apomictic pollinators, which are first cycle hybrids selected and vegetatively propagated from our 1991 evaluation trial. The sexual (or unknown) maternal plants are being evaluated visually for growth habit, vigor, leaf:stem ratio, rooting of stolons, and flowering time and abundance. Inferior segregates are culled. The remaining, selected individuals are being sampled for determination of reproductive mode by embryo sac analysis, which ought to be essentially complete by year's end. Open-pollinated seed is being harvested from the maternals. Before planting time in 1993, reproductive mode will be known for all selected maternals, so that another crossing block can be planted with known apomicts as pollinators, and open-pollinated progenies of known sexuals as maternals.

A second, and separate, *Brachiaria* gene pool is being developed from selected, sexual, first-cycle hybrids. If the hypothesized model for genetic control of apomixis is correct (i.e. apomixis conditioned by a single, dominant gene), then sexual hybrids exposed to pollination only by other sexual genotypes ought to give uniformly sexual progeny. Thirty-one sexual hybrids, involving a total of 10 apomictic parents (Table 1), were propagated vegetatively and planted in isolation at Carimagua. Open-pollinated seed is now (September, 1992) being harvested on individual plants. Examination of reproductive mode of the open-pollinated progeny of this crossing block will shed valuable light on the genetic control of apomixis. However, the major purpose of forming a population which breeds true for sexuality is to permit the application of simple methods of mass or half-sib recurrent selection to its genetic improvement without the need for assessment of reproductive mode.

Table 1. Pollen parents of first cycle, sexual hybrids included in 'elite sexual pool'.

Male parent (CIAT)	No. hybrids
00606	11
06297	1
06387	2
06780	2
16107	1
16126	1
16152	1
16296	1
16827	6
16829	5
[26646	1*]
Total	31

* culled, susceptible to virus

Spittlebug. In August we experienced a heavy and apparently uniform natural spittlebug infestation on last year's trial of first cycle hybrids. This allowed us opportunistically to identify, at least tentatively, a number of hybrids which appear to have useful levels of spittlebug resistance. Some of these had been advanced to this year's crossing block on the basis of other selection criteria. Many others had not been selected. It is also abundantly clear now that the selections made in the absence of spittlebug attack include many very susceptible genotypes.

During the remainder of 1992 and in 1993, we shall confirm spittlebug reaction of these hybrids by the glasshouse bioassay developed by the Entomology Section. For those apparently spittlebug-resistant hybrids whose reproductive mode is unknown embryo sac analysis will be done. It is very encouraging that already we have identified 11 sexual hybrids with relatively good spittlebug resistance. These will be used increasingly as maternals in the crossing program, as they represent much more desirable sources of sexuality than the original tetraploidized sexual *B. ruziziensis*, which is extremely susceptible to spittlebug.

Artificial infestation by release of spittlebug adults was attempted this year in the crossing block. Adults were released two to three times per week during late July and August.

The population of spittlebug nymphs was increasing in this year's crossing block during the latter part of August, whether from natural or artificial infestation. Infestation was not uniform, however, even though we attempted to enhance the natural population by releasing adults captured in adjacent fields and even on spreader rows of a single, very susceptible clone of the tetraploid *B. ruziziensis*. Nymph counts were taken on 308 plants uniformly distributed over the

70 x 157 m space planting. Nearly 30% of the genetically uniform, susceptible host plants had no nymphs at all, while a few plants were heavily infested (Figure 1). Following two weeks of unusually dry weather in early September, the population of both adults and nymphs dropped drastically, and it may now be impossible to get an assessment of reaction to spittlebug in this year's crossing block before selections must be made for next year's crossing block.

We obtained tentative evidence this year suggesting that artificial field infestation with by release of spittlebug adults may be effective in increasing subsequent nymph populations. In a field adjacent to the crossing block nymphal counts were negatively correlated with distance from the crossing block where adults were released. However, the association was not strong [$r^2 = 0.0625$, 119 df ($p<0.01$)], and in any case it could be caused by any other environmental gradient across the test field.

A major limitation in the *Brachiaria* project is our continuing inability to induce at will heavy, uniform spittlebug infestation in the field at Carimagua. We anticipate decentralizing field testing next year, with a large planting near Florencia, Caquetá, and perhaps at one or more additional sites in the Colombian north coast or Venezuela.

Hybridization with B. jubata. What may turn out to be a major breakthrough was made this year with the successful interspecific hybridization of sexual, tetraploid *B. ruziziensis* and apomictic tetraploid *B. jubata*. Two hybrids have been confirmed by electrophoretic analysis (Figure 2). The parental species are apparently only distantly related, as the two hybrid plants obtained to date are the result of several hundred pollinations. This success offers the prospect of

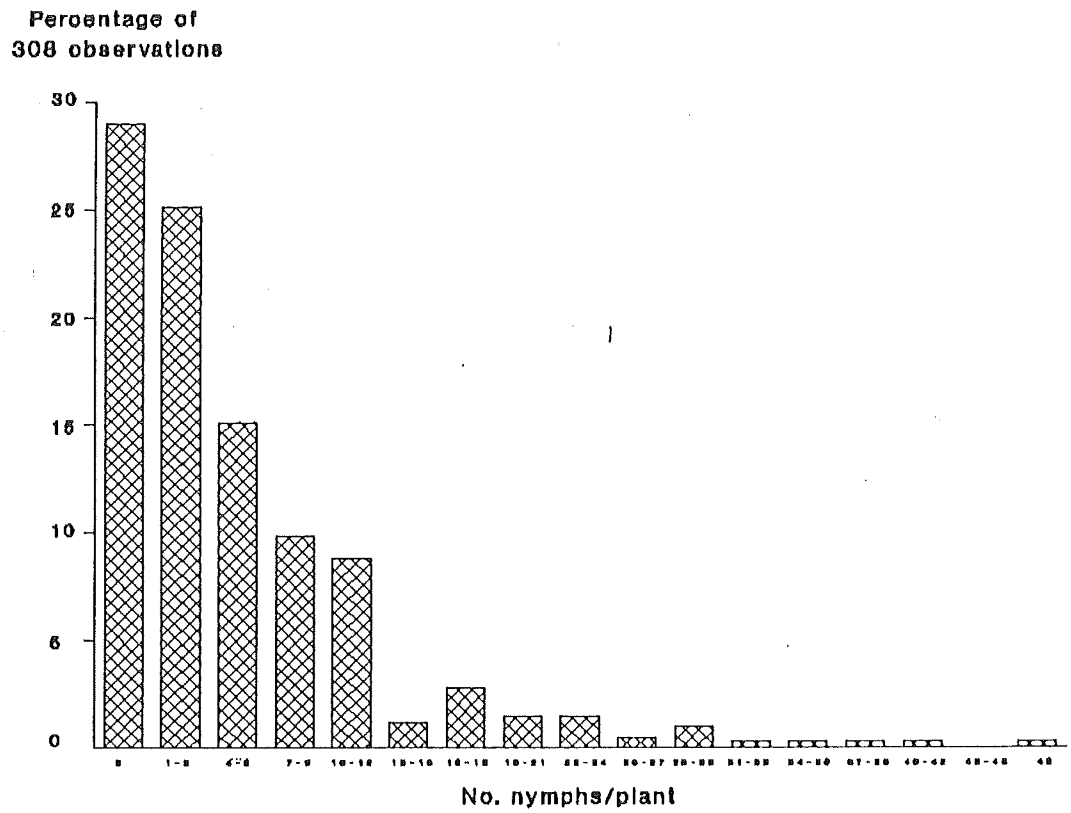

Figure 1. Number of spittlebug (*Aneolamia* spp.) nymphs per plant on 308 space-planted individuals of a single, susceptible tetraploid *Brachiaria ruziziensis* clone uniformly distributed in the *Brachiaria* crossing block.

incorporating spittlebug resistance from *B. jubata*, which seems to be hormonal in nature, into the *B. ruziziensis/B. decumbens/B. brizantha* breeding pools. It remains to be determined whether the hybrid plants are fertile, or whether they can be used in backcrosses to transfer *B. jubata* genes to the breeding pools.

<u>Molecular markers</u>. In collaboration with CIAT's Biotechnology Research Unit (BRU), a project is now underway whose objectives are, firstly to find a marker

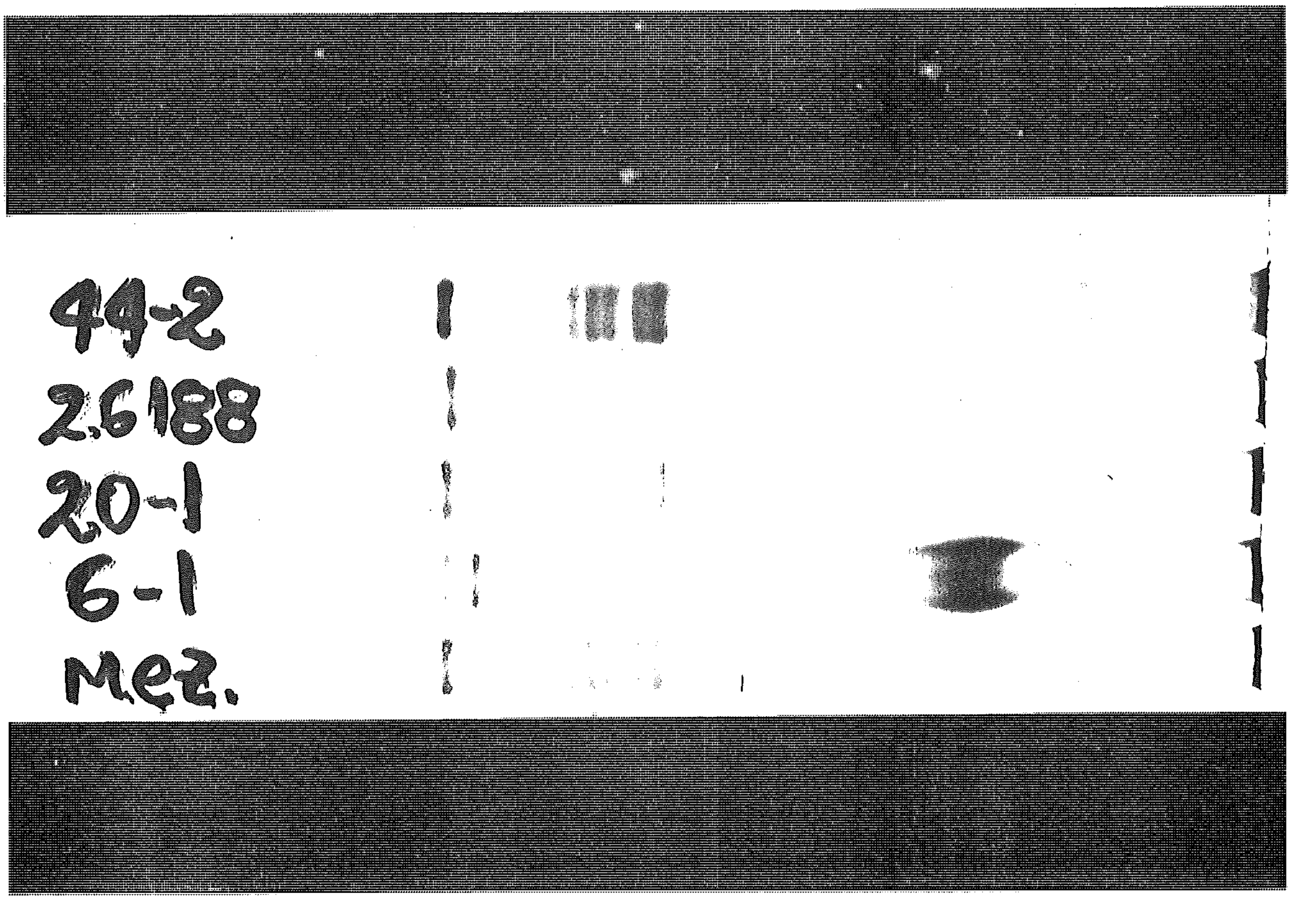

Figure 2. Alpha-Beta esterase bands of sexual tetraploid *B. ruziziensis* (44-2), apomictic tetraploid *B. jubata* (26188), and two putative hybrids (20-1 and 6-1). (Mez is a mixture of tissue from the two parentals.)

closely linked to the gene controlling reproductive mode, and secondly, eventually to develop something like a complete genetic map of the *B. ruziziensis/B. decumbens/B. brizantha* complex. As a first step, a number of RAPD probes are being run on bulk samples from sexual or apomictic hybrids and parental accessions. A more complete description of methods and results will be found in the report of the BRU.

<u>Anther culture</u>. A visiting researcher from the Agronomic Institute of Paraná (Brazil) initiated work which we expect will eventually lead to the successful application of anther culture to Brachiaria. The ability to generate haploids (2n

= 2x = 18) from natural apomictic tetraploids (2n = 4x = 36) would be extremely useful in several ways. Firstly, it ought to be possible to produce sexual haploids from selected apomictic tetraploids. Upon chromosome doubling of these sexual haploids, sexual tetraploids could be produced. These would contain genes from the original apomictic tetraploid, but in a sexual tetraploid genotype, thus potentially greatly enriching the available pool of sexual tetraploids. Further, a random array of haploids derived from a tetraploid would provide material of direct utility in the development of genetic maps.

ENTOMOLOGY

ENTOMOLOGY

INTRODUCTION

The goal of the Entomology Section of the Tropical Forages Program is to develop environmentally and economically sound control methods for the principal insect pests of forages in tropical Latin America. The section is guided by the philosophy of Intergrated Pest Management (IPM) that requires an interdisciplinary approach to research, technology development and implementation. IPM utilizes all suitable methods to reduce loss due to insect damage below economic injury levels while minimizing the use of chemical pesticides and contributing to sustainable production systems. Indeed, the IPM movement, through its focus on alternatives to chemical control in the most effective and least toxic combinations, is recognized to be basic foundation for sustainable agriculture (National Research Council 1991). In the neotropics, use of chemical control of insect pests in extensive pasture systems is minimal, particularly in unimproved pastures. Therefore, the goal of the section is to avoid the adoption of chemical control as intensification of pastures proceeds and the unit value of pasture land increases as the result of adoption of improved grasses and legumes. The section focuses on development of compatible control components (host plant resistance, cultural control, biological control, chemical control) that can be implemented by producers or NARDS personnel. This is done in collaboration with the Genetics, Regional Agronomy and Plant Pathology sections of the TFP, CIAT's BRU, and outside collaborators (Brazil, Costa Rica, and USA).

The section concentrates its research efforts on two priority areas thereby concentrating on permanent solutions to major universal insect pests of key herbaceous germplasm species within CIAT's priority ecosystems. Cercopid (spittlebug) pests of Brachiaria and polyphagous leaf-cutter ants are the predominant pests of forage grasses throughout Latin America. While other arthropod pests may occur locally or sporadically on forage species, none have been demonstrated to cause significant loss over wide geographical areas. The section monitors newly emerging pests on promising grass and legume germplasm in collaboration with the program's regional agronomists and NARDS personnel, but other constraining pests of universal nature have not been identified.

We include in this report information on a newly reported pest of *Brachiaria*, the burrowing bug, *Scaptocoris castanea* (Cydnidae), that is a potential problem in sandy soils of the piedmont area. Basic studies of biology and life history of this insect are needed but cannot be given priority until its importance as a major pest has been demonstrated. Work on insect pests of legumes has not been emphasized due to lack of adoption of these materials or failure to identify pests as a key limitation to utilization. An example is *Cyrtocapsus* spp. on *Centrosema* spp. Although capable of causing severe damage in pure stands, the importance of this insect in associations is dubious and the failure of *Centrosema* to persist under grazing is the more serious limitation to its adoption. Therefore, work on this pest has been suspended until the value of *Centrosema* can be proven. In the case of *Arachis pintoi*, no important pest has yet been identified. This legume is undergoing rapid adoption in some areas and problems may be expected to appear that were not obvious during the evaluation and selection process as the area planted to *A. pintoi* increases.

Development of control for cercopid pests (spittlebugs); of *Brachiaria* concentrates on host plant resistance with a minor effort on microbial control and cultural control. Components under development for leaf-cutter ant control include, host plant resistance, cultural control and action thresholds for chemical control. The emphasis on host plant resistance is conditioned by the tremendous potential for impact of varietal improvement, the ease of adoption in low to medium-input systems, and the availability of a large amount of genetic variability including spittlebug resistance in CIAT's germplasm collection. However, it can be expected that susceptible cultivars such as *B. decumbens* cv. Basilisk and *B. dictyoneura* cv. Llanero will continue to be grown in many areas and options for control of cercopids in these pastures should be explored (see 1.3 below).

Recent reduction in staff allocation from one to 0.5 senior staff for Tropcial Forages Entomolgy has required an analysis of priorities and responsibilities assumed by the section. Some reduction in acitivity is anticipated ant this will be addressed in the work plan presented during the TFP Internal Review. Regional evaluation for reaction to pests of advanced materials and monitoring for new pests is expected to be carried out by the regional agronomists and NARDS personnel with backup support from the TFP Entomologist. Similarly, routine evaluation of breeding lines and progeny will be done in close collaboration with the Genetics section. The emphasis of the Entomology Section will be on development of methods (e.g., bioassays) and elucidation of resistance mechanisms in the case of host plant resistance and in development of alternative methods of control such as entomopathogens.

gravity and deployed in field plots of *Brachiaria* in Carimagua. High levels of predation by a complex of species of generalist predatory ants were observed. Attempts to identify the ant species involved produced a list of over x species in x subfamilies. It was demonstrated that predatory ants can be effectively controlled through the use of toxic baits. Future efforts to infest with eggs will include the use of baits to exclude egg predators from plots prior to infestation.

Mechanism studies.

Studies to determine the biochemical basis of resistance to cercopids in *Brachiaria* have been carried out in collaboration with Dr. John Steffens at Cornell University. Results of a masters thesis by Alfora Gonzales, an ICA employee, largely disprove the hypothesis that resistance in certain highly antibiotic accessions of *B. jubata* is due to the presence of phytoecdysteroids. This conclusion is based on a search for the presence of

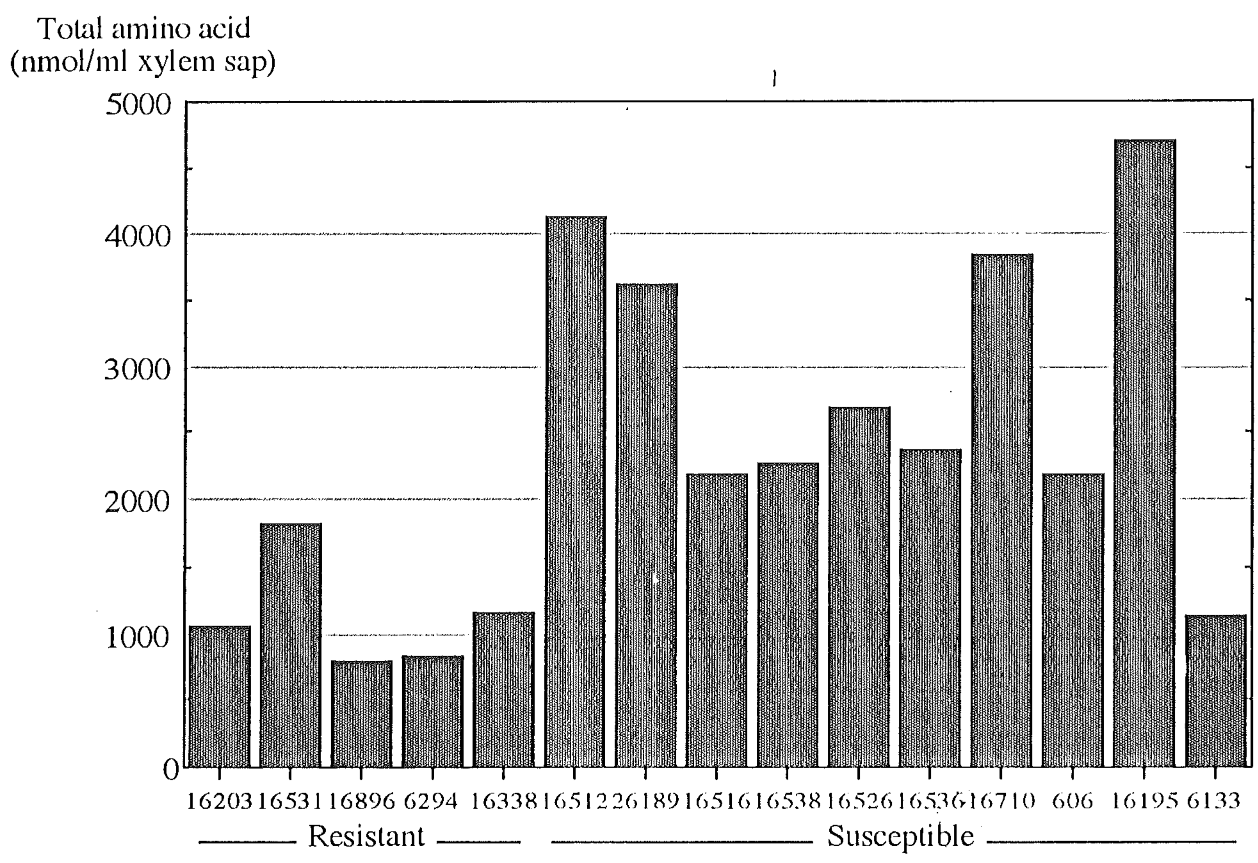

Figure 1. Total amino acid concentration in xylem sap of 15 accessions of *Brachiaria*. (Data courtesy of Alfora Gonzalez)

phytoecdysteroids by Thin Layer Chromatography (TLC) and High Performance Liquid Chromatography (HPLC). Since the alternative to the presence of unique secondary compounds that condition antibiosis is the absence of required nutrients or an imbalance in the nutrient status of the xylem, A. Gonzalez proceeded to analyze amino acid, mineral, ion, and cation concentrations in freeze-dried samples of xylem sap. Xylem sap was collected from potted plants grown in sterilized soil from Quilichao. The concentration of 20 amino acids was determined for 15 accessions for which spittlebug performance has been characterized (figure 1). No correlation was found when μmol of total amino acid per ml of xylem sap was regressed on adult emergence. A significant correlation (R^2=0.64) was found when total amino acids or the concentration of Asp+Gln (the principal a.a. components) was regressed on adult emergence for 11 accessions of *B. jubata* (figure 2). Measurements of mineral, ion and catin concentrations did not yield any obvious relation to resistance. Plans for characterization of enzymatic N transport, organic acids and the C:N ratio may yield additional insight into resistance mechanisms.

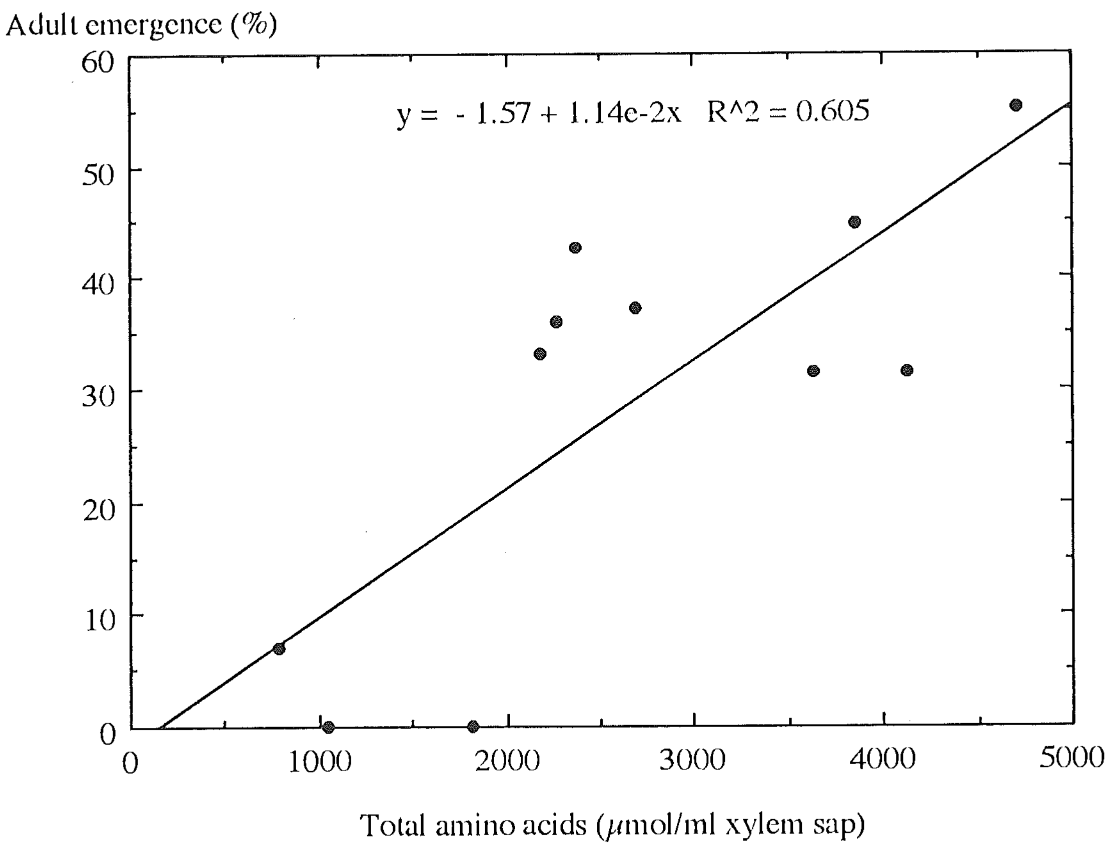

Figure 2. Regression of total amino acid concentration in 11 accessions of *B. jubata* on adult emergence of *Aenolamia varia* in the glasshouse.

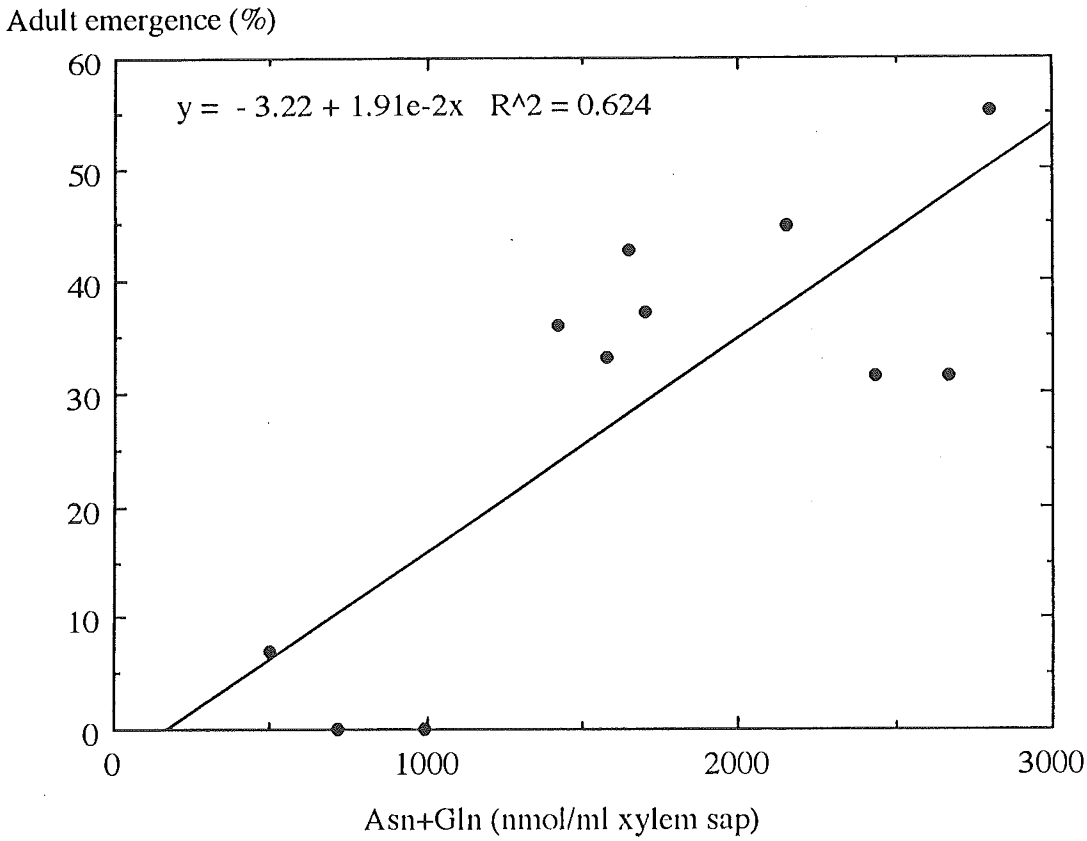

Figure 3. Regression of concentration of asparagine and glutamine in xylem sap of 11 accessions of *B. jubata* on

<u>1.2 Influence of grazing on spittlebug density</u>

Counts of spittlebug nymphs in the Core Experiment at Carimagua confirmed assumptions on the impact of grazing on spittlebug populations, namely, that spittlebug is favored by low stocking rates and greater grass biomass (Koller & Valerio 1988). Nymph density was generally higher in plots with low stocking rate compared to medium and high stocking rates while the presence of a legume or the fertility level had no effect on nymph density (figure 4). This effect of grass height and biomass accumulation of spittlebug density makes seed production of susceptible grasses such as *B. dictyoneura* cv. Llanero particularly difficult. Significant losses in seed yield this year at Carimagua were attributed to high spittlebug populations in cv. Llanero (Alvaro Rincón, personal communication).

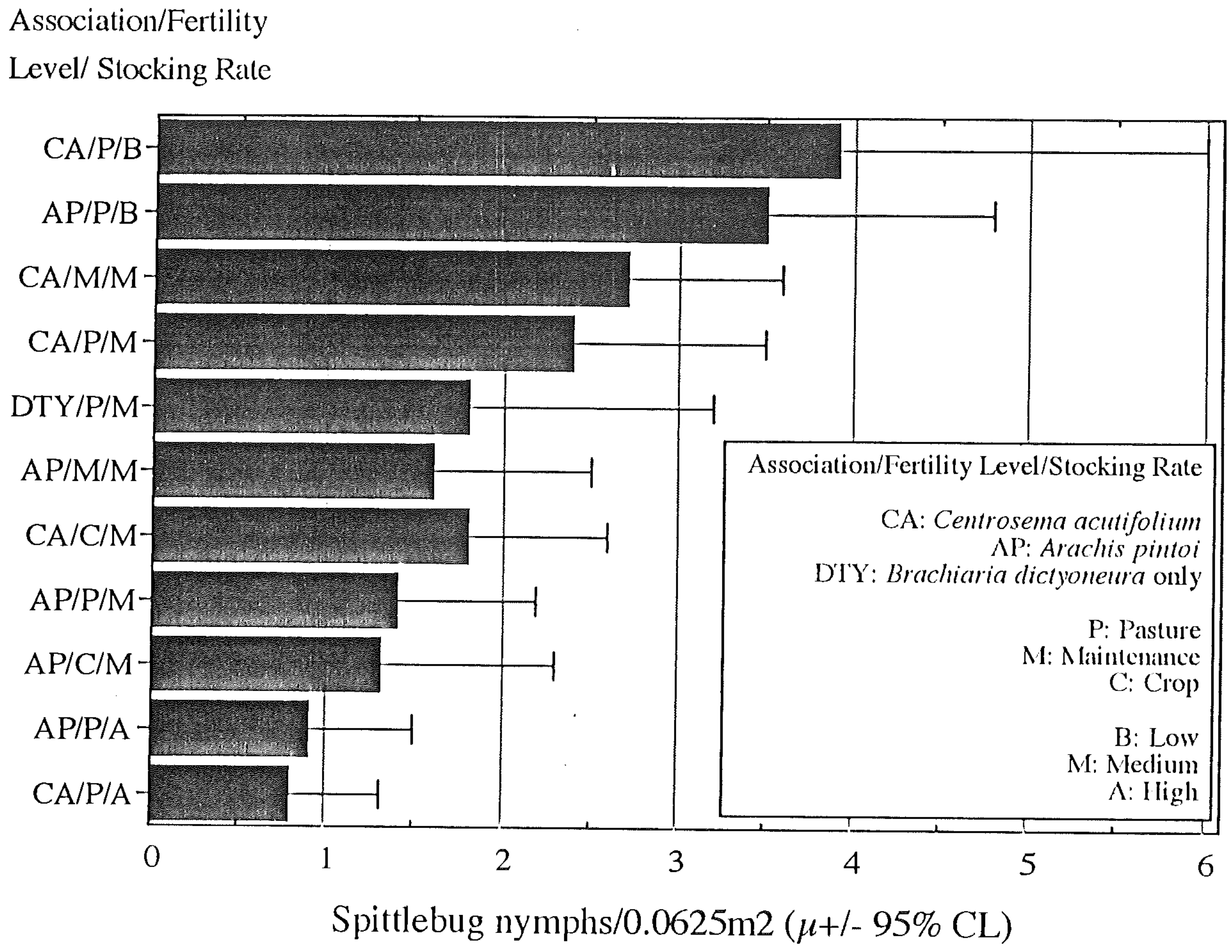

Figure 4. Density of spittlebug nymphs (*Aeneolamia* spp.) on *B. dictyoneura* cv. Llanero in pure stand and associated with either *C. acutifolium* cv. Vichada or *Arachis pintoi* at three fertility levels and three stocking rates. "Core" experiment, Introducciones, Carimagua, August, 1992.

1.3 Microbial control

Since susceptible cultivars of *Brachiaria* will not be completely replaced by new spittlebug-resistant cultivars in the near future, control is desirable in established pastures in intensive systems and in seed production plots particularly susceptible to attack. The use of fungal entomopathogens such as *Metrhizium anisopliae* has been studied for a number of years without significant adoption. One contraint to progress in selection of aggressive strains and basic studies of the infection process in spittlebugs has been the lack of rearing techniques for spittlebugs and bioassay systems. The development of a large colony of spittlebug at CIAT has led to its adaptation to these tasks. During 1992, a technician from DIECA (Dirección de Investigación y Extensión de la Caña de Azucar), Costa RIca, was trained by the Entomology Section in mass rearing and bioassay techniques. DIECA plans to use these methods to select strains of *Metarhizium* and other pathogens for control of cercopids in pasture/sugarcane systems.

Three strains of *M. anisopliae* from a collection of approximately 50 strains maintained at CIAT were compared for pathogenicity to eclosing nymphs while another compared the effects of application dates.

Comparison of strains by bioassay

No difference was found in the number of adults emerging from pots sprayed with one of the three strains of *M. anisopliae* tested (Table 1). Mean mortality in treated pots was approximately 45% compared with 21% in untreated pots. However, more nymphs were infected by the pathogen when the conidial suspension was sprayed onto the soil surface of the pots 8 days before egg eclosion compared with the spray simultaneous with eclosion and 8 days after eclosion (Table 2). We suspect that production of conidia during a saprophytic stage caused greater infection pressure in pots sprayed 8 days before eclosion. These data imply that field application of *M. anisopliae* should be carried out prior to the eclosion of spittlebug nymphs rather than waiting for damage symptoms to appear. Application strategy should focus on establishing and maintaining adequate inoculum pressure during the rainy season. Such an approach might be particularly appropriate for seed production plots of susceptible cultivars.

Table 1. Mortality of nymphs of *A. varia* exposed to three strains of *Metarhizium anisopliae* under glasshouse conditions. Palmira, 1992

Strain (Source)	Mortality (%)[1]
Control	20.9 a
V1 (Venez)	44.4 b
1822 (Col)	46.4 b
1760 (Bra)	47.6 b

[1] DMRT (α=0.05)

Table 2. Mortality of nymphs of *A. varia* exposed to *Metarhizium anisopliae* at three dates of application under glasshouse conditions. Palmira, 1992.

Tmt	Mortality (%)[1]
Control	20.9 a
8 DAI	34.1 b
0 DAI	45.7 bc
8 DBI	58.5 c

[1] DMRT (α=0.05)

2. Leaf-cutter ants

2.1 Host plant resistance

Five commercial varieties of *Brachiaria* were tested for resistance to cutting by the leaf-cutter *Acromyrmex landolti* during establishment and resistance of these grasses to colonization by *A. landolti* in years subsequent to establishment. Those cultivars resistant to cutting (cvs. Marandú, Basilisk, *B. humidicola* cv. Común) were also colonized less by the leaf-cutter over 2 years after planting. Whole leaf homogenates of these cultivars were incorporated into agar and tested for their effect on the growth of the attine symbiont Attamyces bromatificus. Results indicate that resistance in the field to *A. landolti* is conditioned by the ability of the grass substrate to inhibit the growth of the ant fungus (figure 5). A simple bioassay has been developed to confirm these results and begin to look for the active components in resistant accessions.

2.1 Cultural control

Effect of date of soil preparation

Data collected during 1991 showed that the vertical position of colonies of *A. landolti* varies greatly over the calendar year. Colonies achieve a depth of more than 2 meters during the dry season while during the rainy season colony activity is concentrated in the first few centimeters of soil. A trial was initiated at Carimagua in November, 1991 to test the hypothesis that the depth of colonies affects their susceptibility to disruption by cultural practices, specifically, the timing of land preparation by chisel plow. Plots were prepared on ten dates from 15 November, 1991 through 15 June, 1992. Colony density of *A. landolti* was determined by complete counts monthly throughout the period. No effect of date of preparation was found on effectiveness of cultural control. All treatments had similar colony densities by July (figure 6). These data support the conclusion of Lapointe et al. (1990) that timing of land preparation does not significantly affect the level of mortality of colonies of *A. landolti*. In this study, land preparation resulted in excellent control independent of the date of preparation.

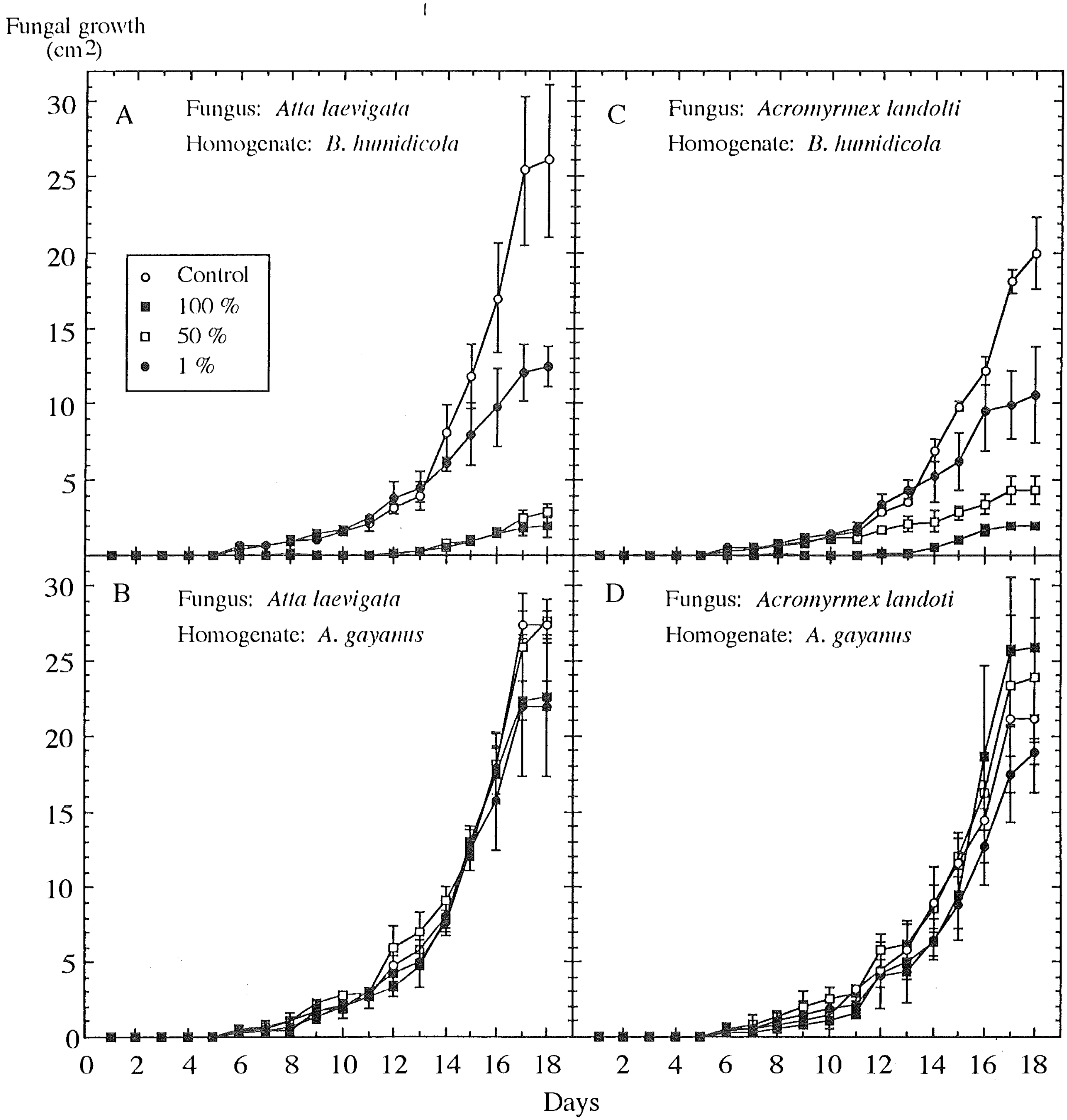

Figure 5. Growth of the attine fungus isolated from two leaf-cutter species on plain agar medium (control) on agar with whole leaf homogenate at three concentrations of a susceptible (*A. gayanus*) and a resistant (*B. humidicola*) forage grass.

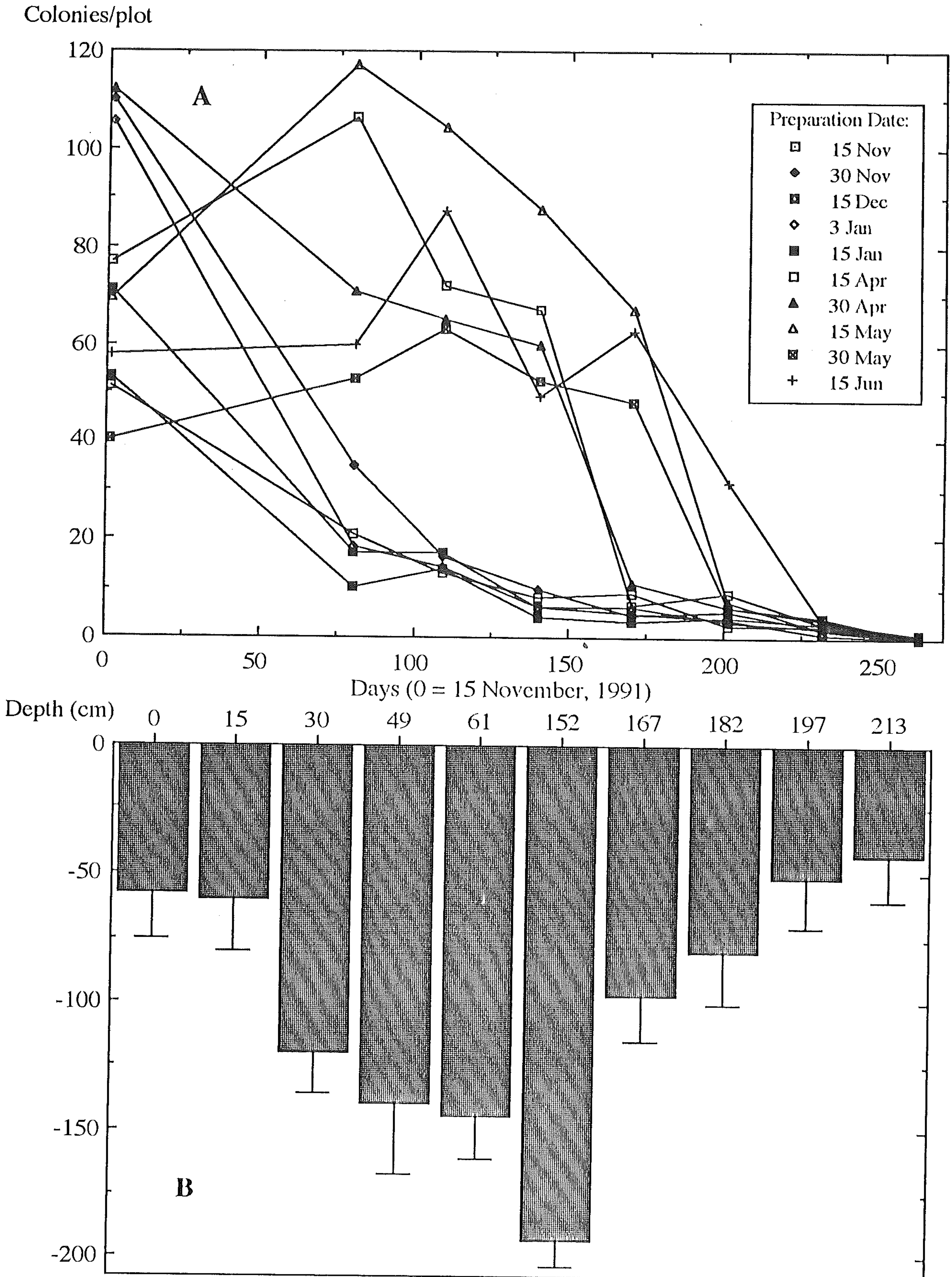

Figure 6. A: Effect of varying date of initial soil preparation (chisel) on survival of colonies of *Acromyrmex landolti*. B: Depth on deepest active chamber of nests of *A. landolti* in control plots adjacent to treatment plots. El Tomo, Carimagua, November 1991 - June, 1992.

3. New, potential pests

3.1 The burrowing bug, *Scaptocoris castanea*, (Cydnidae)

Scaptocoris castanea is a burrowing Hemipteran that has been reported causing damage to *Brachiaria humidicola* pastures in very sandy soils in the piedmont region of Colombia and in the state of Mato Grosso, Brazil. It appears to occur only in very light soils and so far has not been reported from other soil types.

PROJECTED ACTIVITIES

It is proposed that all field work on leaf-cutter ants related to pastures be eliminated with emphasis placed on determining the mechanism of resistance to leaf-cutters in *Brachiaria* through laboratory bioassays and biochemical analysis. This will require work to further characterize the fungus and determine its growth requirements. Through collaboration with the BRU, we hope to begin a search for activity in chemically defined plant fractions. The emphasis for spittlebug will be on glasshouse bioassay of sexual progeny and the elucidation of resistance mechanisms through collaboration with Cornell University and the BRU. Field evaluation of germplasm collections and of *Brachiaria* hybrids will have to be assumed by the regional agronomy sections and the genetics sections, respectively.

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PLANT PATHOLOGY

PLANT PATHOLOGY

(August - October 1992)

Introduction

The major objectives of the Plant Pathology Section of the Tropical Forages Program during the past several years have been diagnosis and documentation of diseases in tropical forages. Considerable progress has been achieved in effectively documenting diseases of forage crops caused by fungi, although bacterial diseases have been largely neglected. The Section is entering a new phase where the major objectives are focusing on efforts to develop new techniques for disease evaluations, to conduct in-depth research on important pathogens, and to design strategies for effective disease control measures. With the advent of recombinant DNA technology and the availability of techniques, it is time for the Section to begin a new phase and design novel methods and strategies of disease management.

Highlights

The Section has been without a plant pathologist for quite a while and as a result it is in a state of disarray. It requires a lot of time and effort to revitalize and restructure the research program with set priorities. The Section is deficient in laboratory equipment and trained support staff. The staff number has been liberally and drastically cut by 50% during the time the Section was without a plant pathologist. Many of the existing laboratory equipment such as refrigerators, incubators, water baths, growth chambers, etc. have been out of order for many years. Many of these are currently repaired and in perfect working conditions, and some new spare parts are needed for others.

In the meantime experiments were conducted which produced very promising results. Bacteria isolated from the surfaces of *Stylosanthes guianensis* cultivar "Pucallpa" in Pucallpa, Peru were reported to inhibit mycelial growth of isolates of *Colletotrichum gloeosporioides* on agar medium (Lenne and Brown, 1991). Some of these bacteria were retrieved from storage and cultured on fresh nutrient agar. It was not possible to recover all the original collections due to poor storage methods used. Two isolates of *Bacillus subtilis* produced antibiotics with a broad spectrum of antifungal activity (Kelemu, unpublished). Crude antibiotic preparations inhibited mycelial growth of a number of fungi including *Colletotrichum lindemuthianum*, *Rhizoctonia* spp., *Colletotrichum gloeosporioides*, *Thanatephorus cucumeris*, *Pyricularia oryzae*, *Rhizoctonia* spp., which are pathogenic on beans, *Arachis* spp., *Stylosanthes* spp., beans, rice, *Brachiaria* spp., respectively. These unconcentrated preparations were as effective (or more effective in the case of *Rhizoctonia* spp.) as the fungicide benomyl in restricting fungal mycelial growth on agar. *C. gloeosporioides* cultures exposed to *B. subtilis* produced significantly fewer numbers of spores than the controls. These are important preliminary findings with a wide range of potential applications. Pathogens or non-pathogens can be sources of useful genes for increasing plant disease or insect damage resistance. For example, the gene for a chitinase enzyme cloned from the bacterium *Serratia marescens* has enhanced resistance to *Rhizoctonia solani* in tobacco plants (Boglie *et al.*, 1991). The enzyme degrades the chitin in the cell walls of the fungus.

The second finding was the discovery of a "new" bacterial disease on *Brachiaria brizantha* cv. Marandú in Carimagua, Colombia. Heavily blighted leaf samples were collected from field plots on September 23, 1992. Isolations from these samples revealed *Xanthomonas*-like colonies on nutrient agar. *Xanthomonas* has been reported to infect *Brachiaria* spp. in French Guyana (Bereau, 1984). More research is needed to verify the identity of the organism and its transmission.

There are 6611 isolates of fungi (6045 isolates of these are *Colletotrichum* spp.) and 150 isolates of bacteria stored in the Section. Unfortunately, the storage conditions are so poor that it may not be possible to recover all of them. Work has begun to revive the isolates on agar media, to evaluate their pathogenic ability on their respective hosts and to restore them using freeze-dry methods. However, the work has been slower than expected due to labor problem and lack of equipment.

Summary of Research Findings

I. Antibiotic production by *Bacillus subtilis* and its antifungal activity.

Bacteria have been reported to produce toxic metabolites effective against fungi (Weller and Cook, 1982; Gutterson *et al.*, 1986). In recent years, scientists have devised novel approaches towards disease and insect management. These approaches involve the use of microbial genes as sources of disease resistance. At the time when there is a growing concern over the use of agricultural chemicals, these approaches may prove to be environmentally sound and provide new sources of resistance especially to those diseases and insects to which there is no known plant genetic resistance. Two isolates of *Bacillus subtilis* , I_2, I_5, among the culture collection of the Section, inhibited mycelial growth of *C.*

gloeosporioides on agar medium. Lenne and Brown (1991) implicated antibiotic production by the bacterium as the cause of inhibition.

Studies on these isolates of the bacterium since August, 1992, have revealed a number of interesting preliminary results.

1. Mycelial growth of isolates of *C. gloeosporioides* 136 (Colombia) and 184 (Peru) is inhibited by both isolates I_2 and I_5 on nutrient agar (Table 1, Figure 1).
2. Antibiotic production by I_2, I_5 resulted in the antagonistic activity (Table 1, Figure 2).
3. Exposure of isolates of 136, 184 to *Bacillus subtilis* isolates I_2 or I_5 resulted in drastic reduction in fungal spore production as compared to the controls (Table 2).

Table 1. Mycelial growth of isolates of *C. gloeosporioides* 136 (Colombia) & 184 (Peru) on nutrient agar*.

(Kelemu, unpublished).

Treatment	136	184
Bacillus I_2	1.7	1.2
Bacillus I_5	1.7	1.0
Control	3.5	2.3

* Radius measurement in cm.
10 days old cultures at 28°C.

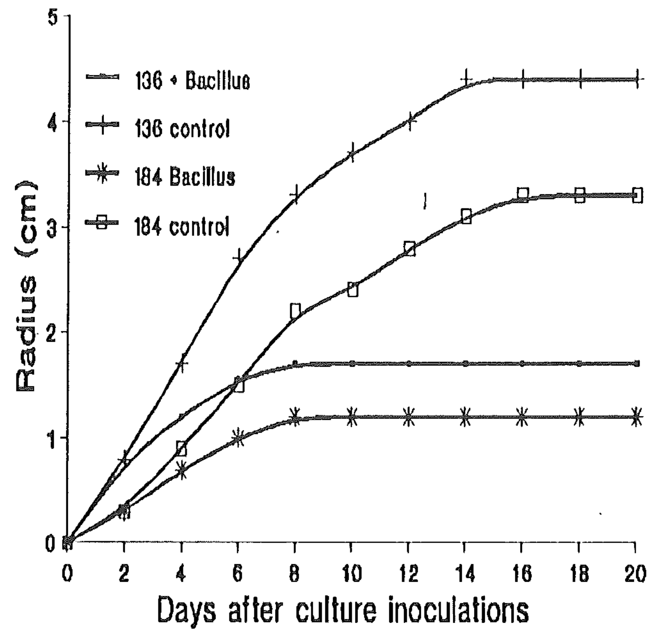

Figure 1. Mycelial growth of isolates of *C. gloeosporioides* on nutrient agar expressed in distance of radial growth (Kelemu, unpublished).

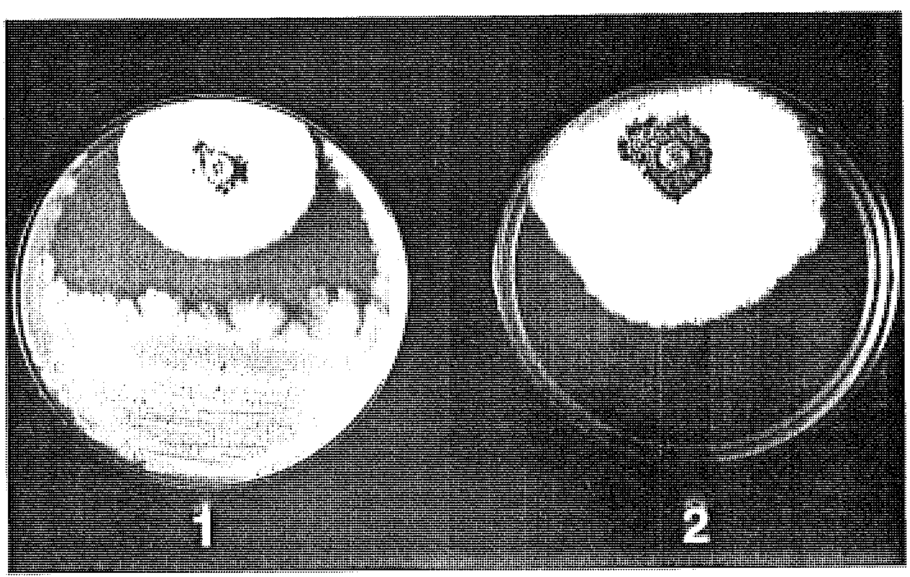

Figure 2. Mycelial growth inhibition of *C. gloeosporioides* 136 by *Bacillus subtilis* (1), and (2) control (Kelemu, unpublished).

Table 2. Spore production by *C. gloeosporioides* isolates 136Q (Colomhia) and 184 (Peru) in the presence and absence of *B. subtilis* on nutrient agar*.

(Kelemu, unpublished).

Plates	136 + *Bacillus*	136 control	184 + *Bacillus*	184 control
1	2.4×10^4	1.7×10^8	2.3×10^4	8.5×10^6
2	2.0×10^4	8.3×10^8	1.3×10^4	8.7×10^6
3	2.5×10^4	5.6×10^8	2.9×10^4	8.0×10^6
4	1.2×10^4	7.5×10^8	2.2×10^4	7.9×10^6
5	1.6×10^4	1.2×10^8	2.5×10^4	8.2×10^6
$\bar{x}$	1.9×10^4	4.8×10^8	2.3×10^4	8.2×10^6

* Spores/ml

4. Several fungi (both foliar and soil-borne) which are pathogenic on different host plants showed sensitivity to the antibiotic(s) of *Bacillus subtilis* I_2, I_5 (Table 3).
5. Crude antibiotic preparations devoid of bacterial cells were as effective (*C. gloeosporioides* isolates 136, 184), or more effective (*Rhizoctonia* spp.), as the fungicide Benomyl ($C_{14}H_{18}N_4O_3$) in inhibiting mycelial growth on nutrient agar medium (Figures 3, 4).

The above findings are very encouraging since the antibiotic(s) are not only highly effective in restricting fungal growth but also they have a broad spectrum of activity against fungi of different host-origin and biology. Experiments will be conducted to address the following:

1. Possible use of crude antibiotic preparations in seed-treatment.

Table 3. Fungi inhibited by antibiotic(s) of *Bacillus subtilis* on agar medium*.

(Kelemu, unpublished).

Pathogen	Host
Colletotrichum lindemuthianum	Beans
Rhizoctonia	*Arachis* sp.
Rhizoctonia	*Brachiaria* sp.
Colletotrichum gloeosporioides	*Stylosanthes* sp.
Thanatephorus cucumeris (= *Rhizoctonia solani*)	Beans
Pyricularia oryzae	Rice

* Cultures were grown on nutrient agar at 28°C.

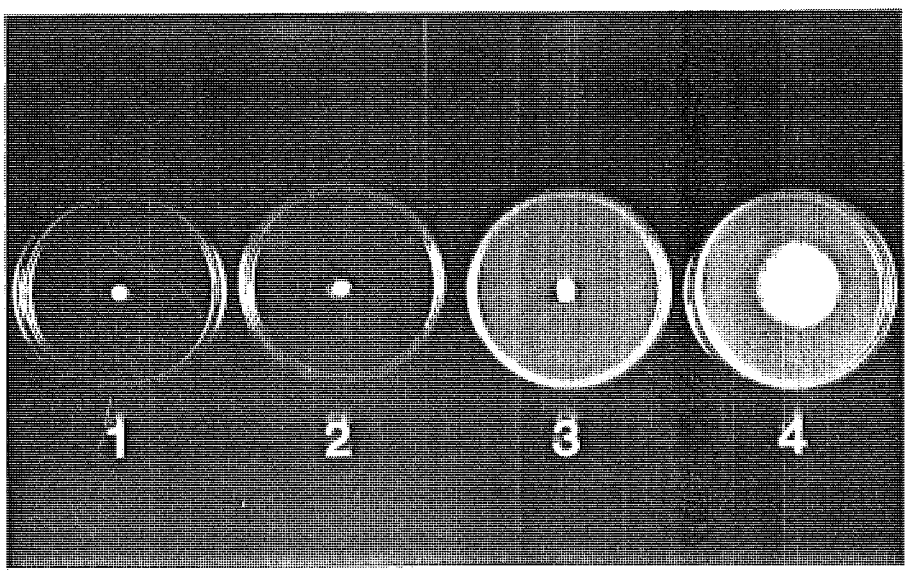

Figure 3. *C. gloeosporioides* growth inhibition by antibiotic(s) of *B. subtilis* I_2 (1), *B. subtilis* I_5 (2), benomyl (3), and control (4) (Kelemu, unpublished).

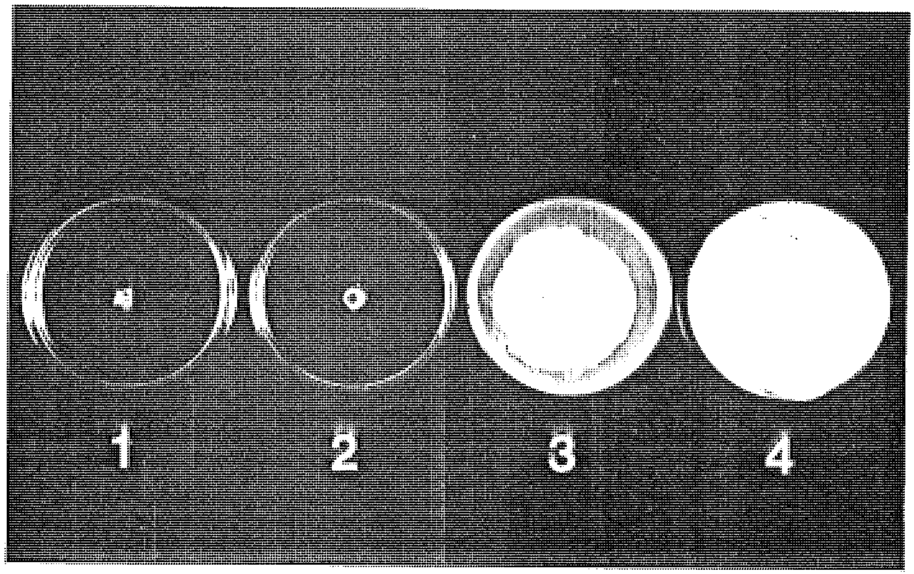

Figure 4. *Rhizoctonia* spp. (host *Arachis* spp.) growth inhibition by antibiotics from *B. subtilis* I_2 (1), *B. subtilis* I_5 (2), benomyl (3), and control (4) (Kelemu, unpublished).

2. Direct use of bacterial cells in seed-treatment and disease control in plants.
3. Selection of genetic markers for the bacterial isolates (this is simply marking the isolates for certain antibiotic resistance in order to trace the bacterium in the field, greenhouse, laboratory, and to avoid contaminations).
4. Characterize and purify the antifungal antibiotics (in collaboration with Dr. J. Mayer).
5. Cloning of genetic determinants for inhibition of fungal growth.

6. Genetic engineering of *Stylosanthes, Brachiaria*, etc. using the cloned genetic determinants from *Bacillus* to enhance resistance to *Colletotrichum, Rhizoctonia*, etc.

While outlining this seemingly ambitious but highly feasible approach to disease control, it may be important to answer the following questions:

A. Are the antibiotics produced by *B. subtilis* toxic to humans and/or animals?
B. Do fungi mutate easily to combat the antibiotics?
C. Can the gene(s) be expressed in plants to an effective level?

II. Culture Collections

The Section possesses a large number of culture collections which have been collected from a number of locations since 1979. Most of the isolates in the collection are *Colletotrichum* spp. (Table 4). There is an urgent need for reviving the cultures from storage and restoring them using freeze-dry methods which are less bulky and more reliable than the current methods.

III. Identification of a "new" bacterial disease of *Brachiaria*

Field plots of *Brachiaria* spp. particularly *B. brizantha* cv. Marandú showed leaf blight symptoms in Carimagua. Samples were collected on September 23, 1992 for further examinations in the laboratory. The samples were cut into small pieces around young advanced lesions, surface sterilized and ground in sterile distilled water using sterile mortar and pestle. The suspensions were then plated on fresh nutrient agar media. *Xanthomonas*-like colonies were consistently

Table 4. Collections of microorganisms in Plant Pathology Section, Tropical Forages Program.

Number of isolates	Fungi	Bacteria
6045	*Colletotrichum* spp.	
566	*Aspergillus, Fusarium, Macrophomina, Rhizoctonia, Rhynchosporium*, other Miscellaneous	
135		Miscellaneous non-plant pathogenic
15		Miscellaneous plant pathogenic (mostly *Corynebacterium* spp.)

isolated from all the samples. These colonies were used to inoculate *B. brizantha* cv. Marandú in the greenhouse. Symptoms identical to those observed in Carimagua were not reproduced. However, isolations from inoculated leaves produced the "same" *Xanthomonas*-like colonies, whereas control leaves failed to do so. More research will be carried out to verify the causal organism and to study its biology. Attention has to be given to this disease as *Brachiaria* is an important forage monocot, and as bacterial diseases can become controversial especially if they can be seed-borne.

IV. Disease diagnosis - Location Carimagua

Leaf samples were collected from heavily diseased plants in the germplasm evaluation plots. Isolations were made from each sample in the laboratory and results are listed in Table 5.

Table 5. Isolations of organisms from diseased forage crops in Carimagua (22-24 September, 1992).

Host	Disease symptom	Organisms isolated	Remarks
Arachis	Leaf spot	*Colletotrichum* spp.	
Brachiaria	Leaf blight and leaf scald	*Rhizoctonia* spp.	
Centrisoma	Black mold, Leaf spot	*Phoma* spp.	May not be the real cause
	Leaf scald	*Rhizoctonia* spp.	

SUMMARY OF PROJECTED ACTIVITIES FOR 1993

1. Reviving and restoring the 6761 isolates of organisms stored in the Section since 1979.
2. Developing reliable and reproducible inoculation methods for *Rhizoctonia* spp. and *Colletotrichum gloeosporoides*.
3. The use of *Bacillus subtilis* in effective disease management
   - antibiotics produced by *B. subtilis*
   - gene(s) encoding antibiotic(s)
   - gene(s) transfer into *Stylosanthes* and others
4. Literature search on diseases of *Arachis* coupled with disease surveys.
5. Some collaboration with CSIRO/Australia on anthracnose disease of *Stylosanthes*. There is a basic need for developing a well-defined set of differential host cultivars for differentiating isolates of *C. gloeosporoides*. DNA fingerprinting of isolates of the fungus may not be of much value unless it is somehow connected with the phenotypes of host-pathogen interactions. Dr. John Miles will be requested to join this effort.

Potential Projects

1. Documentation of bacterial diseases of forages.
2. Collection and preservation of micro-organisms of the Amazon for possible use of their desirable genes in plant genetic engineering. This may potentially attract outside funding.
3. Studies on endophytes of grasses
   - toxicity to animals
   - potential as biocontrol agents
   - potential to enhance drought resistance

Many grasses are reported to harbor systemic endophytes in their leaves, seeds, and stems. Experiments have shown that infected grasses are toxic to cattle, but resistant to diseases and insects (Clay, 1989). Endophyte-infected plants were shown to be more drought tolerant than uninfected ones (Arachevaleta, *et. al.* 1989). This potential project, if backed with promising preliminary data, can be of interest to funding agencies.

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PLANT NUTRITION

PLANT NUTRITION
ANNUAL REPORT 1992

Highlights

* *Arachis pintoi*, a tropical forage legume, was shown to be more efficient in acquiring aluminum-bound phosphorus (Al-P) and organic phosphorus from acid soil than a tropical forage grass, *Brachiaria dictyoneura*. This finding suggests that association of *A. pintoi* with *B. dictyoneura* increases total phosphorus acquisition from infertile acid soils.

* Described and photographed the foliar symptoms of nutrient disorders in *Brachiaria decumbens, Arachis pintoi, Stylosanthes capitata* and *Centrosema acutifolium*.

Research activities

The goal of the Plant Nutrition Section is to define the adaptation attributes of tropical forage species. The Section's main objectives are: (1) to identify the mechanisms by which tropical forage species adapt to nutrient-poor acid soils in order develop suitable screening criteria and evaluate potential trade-offs; and (2) to evaluate the role of forage legumes in soil enhancement. The Section's two main objectives are related to the following strategic objective of the Tropical Forages Program (TFP): defining factors contributing to adaptation and productivity.

During 1992, the Section focused its research work on two main areas: (1) adaptation of forage plants to acid soils; and (2) nutrient cycling in savanna systems. The latter work has been carried out as a multidisciplinary team effort between the TFP and Savannas Program.

Adaptation of forage plants to acid soils

Results obtained from the glasshouse experiments conducted during the past two years indicate that in forage species adapted to nutrient-poor acid soils, fixed carbon is preferentially partitioned towards root growth at the expense of leaf expansion and shoot growth. The response to an increase in phosphorus (P) supply in acid soil was greater in a grass (*Brachiaria dictyoneura*) than in three legume species (*Arachis pintoi, Stylosanthes capitata*, and *Centrosema acutifolium*) in terms of both shoot and root growth. This increased response to P supply in a grass was associated with higher P use efficiency (g of forage produced for g of P in the shoots). But the P uptake efficiency (measured as mg of P uptake per unit root weight or length) of the three legumes was several times higher than that of the grass. Phosphorus uptake per plant, at a given soil P supply, might be improved by: (1) a root system that provides greater contact with P; (2) a greater uptake per unit of root, due to enhanced uptake mechanisms; and/or (3) an ability to utilize insoluble organic or inorganic P forms that are relatively unavailable or poorly available to plants. Association of VA mycorrhizae significantly affects each of these attributes. We need information on these mechanisms to explain the differential responses of grass/legume species.

(i) Uptake of phosphorus from different P sources

A glasshouse study was conducted to test whether the higher P uptake efficiency of acid-soil-adapted legume species is due to the increased ability of legumes to mobilize P from less soluble forms of phosphate (Al-P) and also from organic P sources. A grass (*Brachiaria dictyoneura* CIAT 6133) and a legume (*Arachis pintoi* CIAT 17434) were selected to grow either as a monoculture or as a grass + legume association. Two contrasting acid-soil types (Oxisol) from Carimagua were used: sandy loam (Alegria, 65% sand) and clay loam (Pista, 18% sand). Both soils are characterized by low pH (< 5.1) and high Al saturation (> 77%), but the sandy loam had lower levels of soil organic matter and total nitrogen than the clay loam. The available P in the soil was about 2 ppm in both types before fertilizer application. Soil was placed in containers (40 kg of soil) and fertilized at the rates (kg ha^{-1}) of : 40 N, 66 Ca, 28 Mg, 100 K, 20 S, 2 Zn, 2 Cu, 0.1 B, and 0.1 Mo. P sources used were: calcium phosphate ($CaHPO_4$), aluminum phosphate ($AlPO_4$), phytic acid (organic P), and cattle manure (dung P). A control with no added P was included in the experiment. The rate of 20 kg ha^{-1} was chosen for each source. The dung P represents a combination of inorganic and organic P forms. Twenty plants were grown in each container. Deionized water was added as needed. Containers were arranged in a randomized complete block design with three replications. All containers received mycorrhizal inoculation (*Glomus occultum*), while the legume received inoculation with an effective *Rhizobium* strain (CIAT 3101). Plants were harvested after 74 days of growth.

Because the differences in P acquisition contrast more between the grass and the legume than between the two types of acid soil, the results obtained from clay loam soil are presented below. Shoot biomass production per unit soil surface area of both species was higher with a Ca-P source than with the other three sources, Al-P, organic P, and dung P (Fig. 1A). The grass produced twice as much shoot biomass as the legume with a Ca-P source. The grass plants increased shoot biomass production 6.6-fold with a Ca-P source compared with the control (no P added). The increase in shoot biomass of the legume was 2.2-fold with a Ca-P source. When no P was added, the legume and the grass + legume association produced more shoot biomass than the grass alone. The response of the grass in both root and shoot biomass production with different P sources was similar (Fig. 1B). But in the case of the legume, differences in root biomass production with different P sources were not significant. The highest root biomass production was observed for both species with the Ca-P source.

Both species acquired more P from the soil when it was supplied as Ca-P rather than as the three other sources (Fig. 2). When there was no P added to the soil, total P uptake (shoot + root) per unit soil surface area by the legume or the association was at least 3.8-fold higher than that of the grass grown as a monoculture. The legume's ability to acquire more P per unit soil surface area was maintained with different P sources added to the soil. It is interesting to note that the legume plants grown either as a monoculture or an association can absorb more than twice the amount of P from Al-P when compared with the grass plants.

The relationship between total P uptake and root biomass indicates that the legume roots acquired more P per unit root weight than the grass roots (Fig. 3). The superior ability of legume roots to acquire P from different P sources was associated with higher levels of inorganic P in roots and the activity of the enzyme acid phosphatase in roots (Table 1). The higher P use efficiency observed with the grass was associated with higher levels of the activity of the enzyme acid phosphatase in leaves.

(ii) Foliar symptoms of nutrient disorders in tropical forage species

The symptoms of nitrogen, phosphorus, potassium, magnesium, calcium, sulfur, and zinc deficiencies, manganese toxicity in leaves, and aluminum toxicity in roots have been developed, described, and photographed for *Brachiaria decumbens* CIAT 606, *Arachis pintoi* CIAT 17434, *Stylosanthes capitata* CIAT 10280, and *Centrosema acutifolium* CIAT 5277.

Plant nutritional disorders are most often manifested as growth irregularities, so that distinguishing among two or more deficiencies may be difficult. Because many deficiency symptoms are similar, identifying where the deficiency occurs can be very important. We have developed a key to symptoms of nutrient deficiency in tropical forage species to summarize which factors can help to identify a particular deficiency symptom.

Figure legends

Fig. 1. Shoot (A) and root (B) biomass production of *B. dictyoneura* (Bd), *A. pintoi* (Ap), and an association of Bd + Ap grown with different P sources in a clay loam soil.

Fig. 2 Total phosphorus uptake per square meter of soil surface area for *B. dictyoneura* (Bd), *A. pintoi* (Ap), and an association of Bd + Ap grown with different P sources in a clay loam soil.

Fig. 3 Relationship between root biomass and total phosphorus uptake for *B. dictyoneura* and *A. pintoi* grown with different P sources in a clay loam soil.

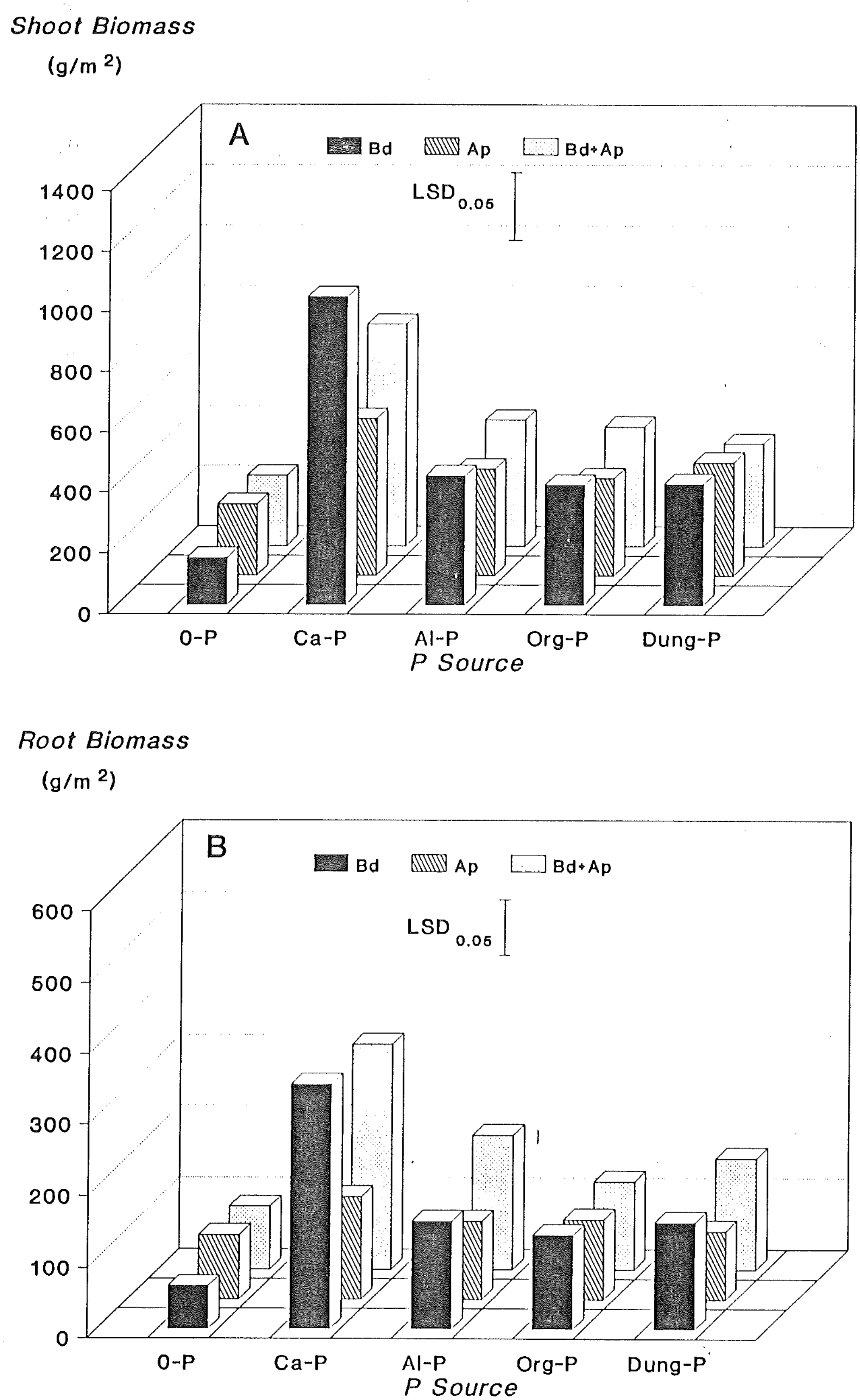
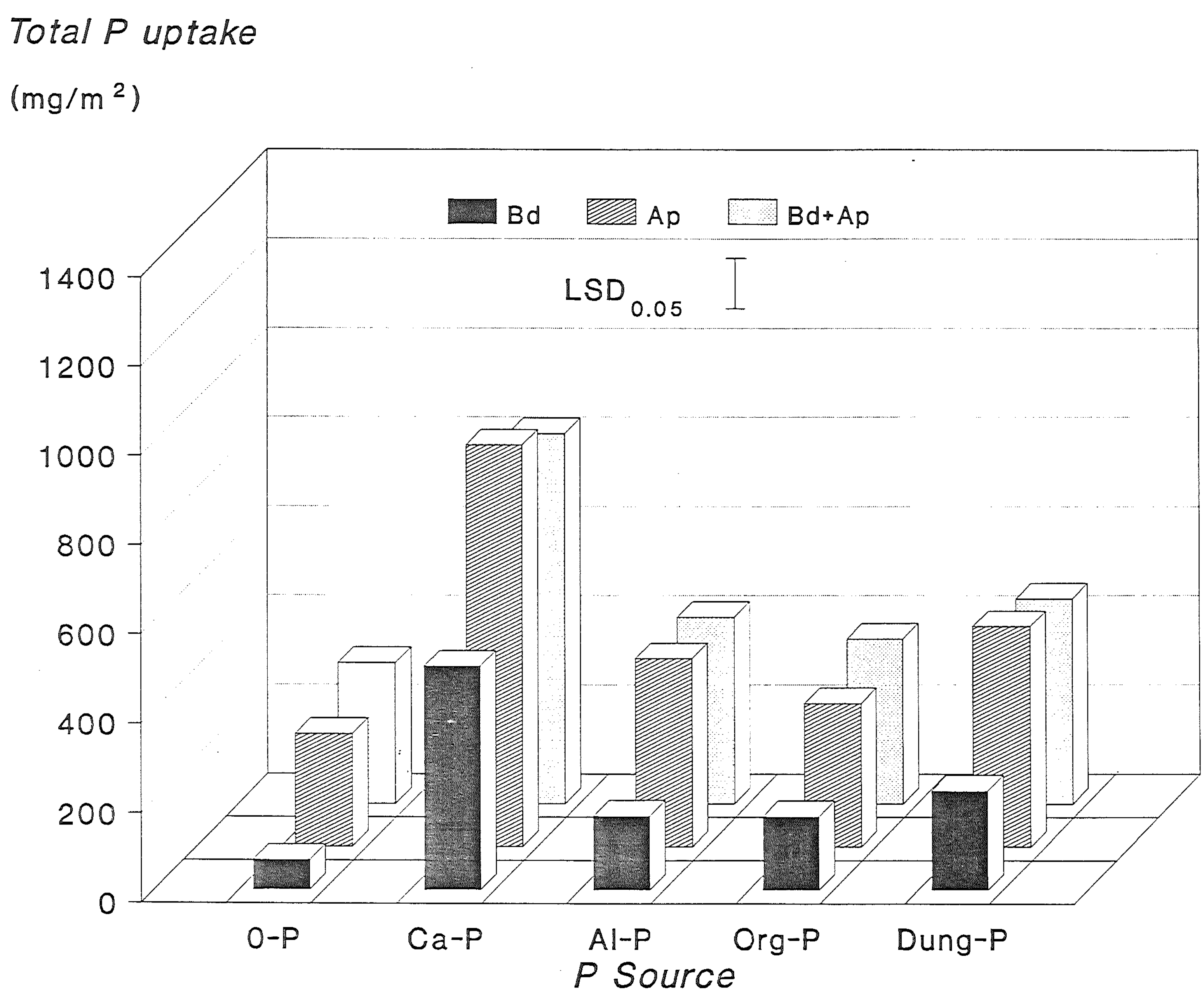
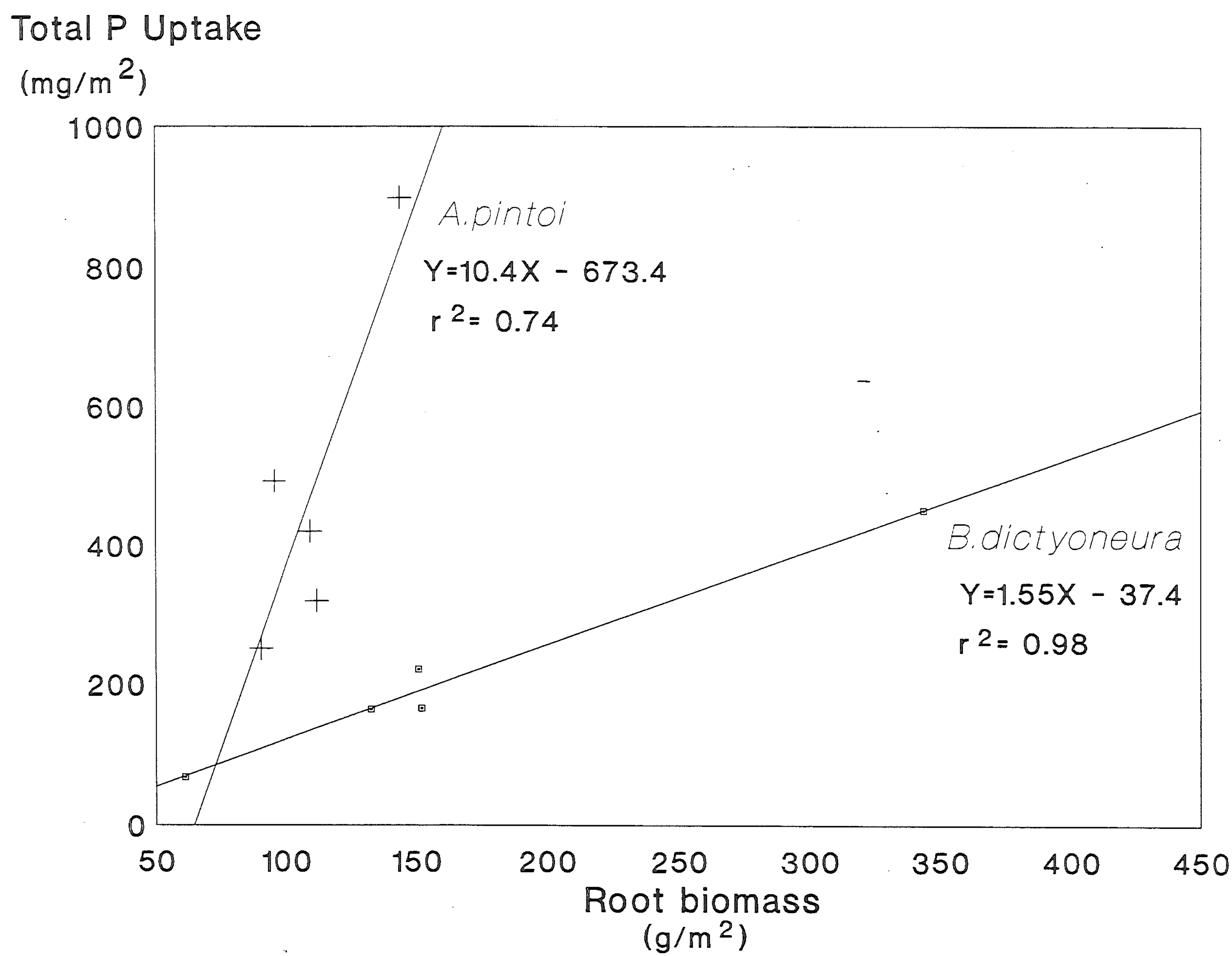

Shoot Biomass
(g/m 2)
A
Bd
Ap
Bd+Ap
LSD 0.05
1400
1200
1000
800
600
400
200
0
0-P
Ca-P
Al-P
Org-P
Dung-P
P Source
Root Biomass
(g/m 2)
B
Bd
Ap
Bd+Ap
LSD 0.05
600
500
400
300
200
100
0
0-P
Ca-P
Al-P
Org-P
Dung-P
P Source

Figure 1



Total P uptake
(mg/m 2)
Bd
Ap
Bd+Ap
LSD 0.05
1400
1200
1000
800
600
400
200
0
0-P
Ca-P
Al-P
Org-P
Dung-P
P Source

Figure 2



Total P Uptake
(mg/m2)
1000
800
600
400
200
0
50
100
150
200
250
300
350
400
450
Root biomass
(g/m2)
A.pintoi
Y=10.4X - 673.4
r2= 0.74
B.dictyoneura
Y=1.55X - 37.4
r2= 0.98

Figure 3

Table 1. Leaf and root physiological characteristics of *B. dictyoneura* and *A. pintoi* grown with different P sources in a clay loam soil.

Characteristics	P source								
	O-P		Ca-P		Al-P		Org-P		
	Bd	Ap	Bd	Ap	Bd	Ap	Bd	Ap	LSD (P = 0.05)
Leaf P (%)	0.04	0.09	0.06	0.15	0.03	0.11	0.05	0.09	0.01
Leaf acid phosphatase ($\mu mol/m^2/s$)	20.6	3.18	10.1	1.71	11.7	3.17	17.8	1.54	3.77
P use efficiency (g/g)	2370	973	2058	622	2640	863	2448	1115	349
Root P (%)	0.02	0.08	0.02	0.16	0.02	0.10	0.02	0.08	0.016
Root Pi ($\mu g/g$ fresh wt.)	14	46	7.5	261	15	104	15	58	22
Root acid phosphatase ($\mu mol/g$ fresh wt./min)	2.3	2.7	0.51	2.23	1.08	1.74	1.09	1.59	0.84

Projected activities for 1993

1) A rapid, nondestructive and repeatable seedling-based bioassay is required to select acid-soil-adapted genotypes from *Brachiaria* hybrids generated by the Genetics Section. The suitability of a seedling bioassay technique will be tested using parental materials of the *Brachiaria* hybrids.

2) Preliminary research work done at CIAT/CPAC, Planaltina, Brazil, indicates that deterioration of *Brachiaria brizantha* cv. Marandu pastures may be due to the autoallelopathic property of this cultivar. This possibility will be tested by a pot culture study using residues and extracts of leaves and roots from *Brachiaria brizantha* cv. Marandu in comparison with *B. decumbens* and *B. humidicola.*

3) Intraspecific variation in plant adaptation to acid-soil conditions was observed in *Brachiaria humidicola*, *Panicum maximum*, *B. ruziziensis*, and *Centrosema pubescens* from the TFP's germplasm evaluation work. But the soil-plant factors that influence this intraspecific variation are not clear. Therefore, a glasshouse study will be conducted using these materials and growing them in two contrasting soil types (Oxisol) at low and high soil fertility. The information obtained from this trial will be useful to develop screening procedures to evaluate the adaptation of forage germplasm to acid-soil conditions.

List of Publications

(i) Scientific Journals

I.M. Rao, W.M. Roca, M.A. Ayarza, E. Tabares and R. García 1992. Somaclonal variation in plant adaptation to acid soil in the tropical forage legume *Stylosanthes guianensis*. Plant and Soil (in press).

I.M. Rao, R.S. Zeigler, R. Vera and S. Sarkarung 1993. Selection and breeding for acid-soil tolerance in crops: Upland rice and tropical forages as case studies. BioScience (accepted with revisions).

(ii) Conference papers

I.M. Rao, M.A. Ayarza, R.J. Thomas, M. Fisher, J.I. Sanz, J. Spain and C. Lascano 1992. Soil-plant factors and processes affecting sustainable production in acid soils of lowland tropics. Poster presented at the International Crop Science Congress, 14-22 July 1992, Ames, Iowa, USA.

R.J. Thomas, I.M. Rao, M.A. Ayarza, J.I. Sanz, M. Fisher and C. Lascano 1992. How much pasture legume is needed to avoid depletion of soil reserves? Poster presented at the International Crop Science Congress, 14-22 July 1992, Ames, Iowa, USA.

I.M. Rao, M.A. Ayarza, R.J. Thomas, M.J. Fisher, C. Lascano and V. Borrero 1993. Adaptation responses of tropical grass-legume associations to acid soils. Proc. XVII International Grassland Congress, New Zealand

& Queensland, Australia (in press).

Fisher, M.J., C.E. Lascano, R.J. Thomas, M.A. Ayarza, I.M. Rao, G. Rippstein and J.H.M. Thornley 1993. An integrated approach to understand soil-plant-animal interactions on grazed legume-based pastures on tropical acid soils. Proc. XVII International Grassland Congress, New Zealand & Queensland, Australia (in press).

Thomas, R.J., M. Fisher, C. Lascano, I.M. Rao, M. Ayarza and N. Asakawa 1993. Nutrient cycling via forage litter in tropical grass/legume pastures. Proc. XVII International Grassland Congress, New Zealand & Queensland, Australia (in press).

Ayarza, M.A., I.M. Rao, R.J. Thomas, M.J. Fisher, C.E. Lascano and P. Herrera 1993. Standing root biomass and root distribution in *Brachiaria decumbens/Arachis pintoi* pastures. Proc. XVII International Grassland Congress, New Zealand & Queensland, Australia (in press).

(iii) CIAT Publications

I.M. Rao, M.A. Ayarza, R.J. Thomas, M.J. Fisher, J.I. Sanz, J.M. Spain and C.E. Lascano 1992. Soil-plant factors and processes affecting productivity in ley farming. In: Pastures for the tropical lowlands: CIAT's contribution. pp. 145-175. CIAT, Cali, Colombia.

I.M. Rao 1993. Adaptation of plants to acid soils. Proc. of the workshop on "Managing Legume-based Pastures in the Tropics." CIAT, Cali, Colombia.

I.M. Rao, M.A. Ayarza, V. Borrero and R. García 1993. Plant nutritional disorders of tropical forage species. RIEPT manual on agronomic evaluation (in press).

FORAGE QUALITY/RUMINANT NUTRITION

FORAGE QUALITY/RUMINANT NUTRITION

HIGHLIGHTS

During 1992 considerable effort was given to screening CIAT's limited collection of leguminous shrubs for quality and antiquality factors. Our results indicate differences in quality among and within species. Shrub legumes such as *Cratylia argentea*, *Desmodium velutinum* and *Uraria* spp. have low tannin levels and significantly higher digestibility than other species evaluated (Annex Table 1). Among herbaceous and shrub legumes high in tannins, such as *Dioclea guianensis* and *Flemingia macrophylla*, we have found variation in tannin level and digestibility (Annex Table 2), thus allowing the opportunity for selection.

Our work with grasses this year has been limited to follow up a small plot grazing experiment in Carimagua to evaluate selected ecotypes of *Brachiaria brizantha* and *Panicum maximum* in association with *Centrosema acutifolium*. Two high yielding and persistent *P. maximum* ecotypes (CIAT 6799 and 6944) have been identified for acid soils of low fertility.

SUMMARY OF RESEARCH FINDINGS

Tannin Research

It is recognized that some leguminous shrub legumes are characterized by having antiquality factors, such as condensed tannins. Given the emphasis placed by the Tropical Forages Program (TFP) on leguminous multipurpose trees and shrubs, we have given high priority to tannin research.

This year we have compared tannin chemical assays, have studied the effect of tannins on *in vitro* protein and fiber degradation and have evaluated the effect of drying legumes on reactivity of tannins to bind proteins.

Tannin chemical assays. There are several chemical methods available to determine the level of condensed tannins in forage legumes. The Vanillin-HCl assay has been used widely because of its specificity for condensed tannins. However, it it recognized that this method, which uses pure methanol + 1% HCl for tannin extraction and catechins (i.e. monomer) as a standard, can overestimate the level of tannins in plants where these are polymerized. Two other methods, specific for condensed tannins (i.e. proanthocyanidins), are the Butanol-HCl and Butanol-H_2SO_4. With both methods, purified plant extracts of the test plants are used to construct standard curves.

In our laboratory we compared a modified vanillin assay (i.e. extraction of tannins with 70% methanol + 0.5% formic acid + 0.05% of ascorbic acid) and the two Butanol methods, using legumes known to be high in tannins. Our results (Annex Table 3) indicate that the modified Vanillin method resulted in lower estimates of tannins and in different ranking of species, as compared with the two Butanol methods. In contrast, a high correlation (0.98) was found between the Butanol-HCl and Butanol-H_2SO_4 methods when considering only the soluble condensed tannin fraction estimated with the latter.

An advantage of the Butanol-H_2SO_4 method is that it provides estimates of soluble and insoluble condensed tannins (see Annex Table 3). Some researchers have suggested that soluble tannins are responsible for depression of fiber and protein degradation, whereas insoluble tannins have no effect. However, we tend to challenge this view, based on results discussed in the section that follows.

Tannin effect on protein and fiber degradation. Condensed tannins are known to depress protein and fiber degradation in the rumen. This year we investigated how tannins in different legume species affected *in vitro* ammonia production (i.e. protein degradation) and fiber dissapearance (i.e. digestibility). In these studies we used *A. pintoi* as a positive control (i.e. no tannins) and poliethylene glycol (PEG) as a tannin binding agent.

Ammonia levels with *A. pintoi* reached high levels after 48 hr of incubation, regardless of PEG addition (Annex Figure 1). In contrast, low levels of ammonia (< 50 mg/lt) were observed after 48 hr of incubation with *F. macrophylla* and *D. ovalifolium*. By binding tannins in the two legumes with PEG, ammonia production after 48hr of incubation was more than double, as compared to the control.

It is evident that condensed tannins in the forage legumes tested depressed ammonia production. This in turn could adversely affect bacterial protein synthesis, fiber digestion and voluntary intake. A series experiments with cannulated sheep are in progress to test these hypothesis.

Our *in vitro* work with the neutral detergent fiber (NDF) fraction of legumes species of contrasting quality, has clearly shown that tannins greatly depress cell wall digestion (Annex Table 4). Binding tannins with PEG resulted in increases in fiber dissapearance after 48 hr of incubation in *D. ovalifolium* and *Tadehagi* spp., but not in *F. macrophylla*, which consistently has shown higher levels of insoluble condensed tannins as compared to soluble condensed tannins (see Annex Table 3).

In general, our results suggest that both soluble and insoluble tannins affect fiber digestion. We hypothesize that soluble tannins affect fiber digestion by binding to the cell wall and to bacterial enzymes. On the other hand, insoluble tannins are inherently bound to the cell wall making this fraction partially or totally indigestible to rumen microbes, depending on species.

Effect of drying legumes on ability of tannins to bind proteins. We forsee that legume shrubs could be used in fresh or dried form in cut and carry systems in forest margins and hillsides of the tropics. Therefore, we were interested in determining if wilting and sundrying different legume species, changed the reactivity of condensed tannins towards proteins. Tannin extracts from fresh and dried legume samples were used in a protein binding assay (i.e. radial difussion). Results (Annex Table 5) showed that with two *D. ovalifolium* ecotypes (350 and 13089) included in the study tannins were more reactive with proteins when wilted and sun-dried than when fresh. In contrast, sun-drying appeared to have a small or non-significant effect on the protein binding capacity of tannins present in *F. macrophylla*, *Fnyllodium* spp. and *Tadehagi* spp.

The significance of these initial results will be investigated next year by feeding fresh and sun-dried legumes high in tannins to sheep housed in metabolism crates.

Grass germplasm evaluation under grazing

The Agronomy section of the former Tropical Pastures Program selected 5 ecotypes of *Panicum maximum* for acid soils, based on superior forage yield in a well drained savanna site and in a piedmont site in Colombia. These 5 ecotypes (CIAT 6177, 6799, 6944, 6973, and 16042) were included in small plot grazing experiment at Carimagua. Grasses individually sown in association with *Centrosema acutifolium*, have been grazed for 1 year at two grazing pressures. Results indicate that the ecotypes 6799 and 6944 are more productive and vigorous than the other ecotypes, regardless of season of the year or grazing pressure.

We have found small but consistent differences in IVDMD between the selected *P. maximum* ecotypes. Leaves of 6799 have been 1 to 2% units higher in digestibility than those of 6944, regardless of season of the year or grazing management.

In this experiment legume content has been higher with the less vigorous *P. maximum* ecotypes. However, the ecotype 16042, of intermediate vigour, has allowed a high legume content in the forage on offer. This ecotype should be included together with the vigorous ectoypes in future grazing trials designed to measure animal performance (i.e. liveweight gain, milk production).

Assessment of pasture quality with milking cows

At the Quilichao sub-station we have in the past determined short-term effects of grass/legume pastures on milk yield. Our results with *Brachiaria dictyoneura* and *Andropogon gayanus* alone and in association with *Centrosema macrocarpum* and *C. acutifolium* indicate a 10 to 20% increment in milk yield due to legumes. The highest yield increments have been recorded in pastures with 20 to 30% legume content and with cows that had relatively high milking genetic potential.

During 1992 we measured milk production in cows grazing *Brachiaria decumbens* pastures alone and in association with *D. ovalifolium* (CIAT 350) and *Arachis pintoi* (CIAT 17434). Results on milk yield obtained from 4 measurement phases, mostly carried out during dry periods, are presented in Annex Table 6. A clear response to legumes was observed in the first phase, in which milk yields were 25% higher ($P<.10$) in the associations than in the grass alone pasture. In this phase, milk yield was similar in the *A. pintoi* and *D. ovalifolium* associations, which is an unexpected result. In the subsequent phases milk yield was not significantly increased in the two grass/legume pastures.

The lack of response in milk yield of cows grazing *B. decumbens/A. pintoi* maybe related to low legume content in the pasture. The contribution of *A. pintoi* in the forage on offer was extremely low (3 to 5%) in phases 2 through 4 (see footnote on Annex Table 6), which most likely resulted in low legume consumption. This in inferred from milk urea levels, which were similar in the *A. pintoi*-based pastures (7.0 mg%) and the pure grass pasture (8.3 mg %). In other studies, where we have recorded increments in milk yield due to legumes (i.e. *Centrosema* spp.), urea levels in milk have been in the order of 5-10 mg% in the grass alone and 11-26 mg% in the associations.

In *B. decumbens/D. ovalifolium* pastures eventhough legume content in the forage on offer was higher than in the *A. pintoi* pastures, milk urea levels were low (7.5 mg%). This could have also been related to low legume consumption, but also to limited rumen ammonia production due to protection of protein by tannins.

Pasture management and productivity

This year we continued monitoring two grazing experiments at Carimagua, which were initiated in 1988 and 1989.

In the fifth year of grazing, liveweight gains in *B. humidicola/A. pintoi* pastures have been 38% higher on the average than in the straight grass (Annex Table 7). The greatest advantage of the association in liveweight gain was during the wet season, where legume proportion was in the order 14 to 18% as compared to 3-4% in dry season.

Stocking rate effects on liveweight gain have been as expected in the straight *B. humidicola* pastures (i.e. higher individual gains in low stocking rate). However, in the *A. pintoi*-based pastures, individual liveweight gains have been similar in the low (2 A/ha) and middle (3A/ha) stocking rates (see Annex Table 7).

In the fourth year of grazing, pastures of straight *B. dictyoneura* are beginning to show signs of degradation in terms of quality. This year, the highest estimated annual liveweight gain in *B. dictyoneura* was 113 kg/A, which is 55% lower than in *B. dictyoneura/A. pintoi* with the same grazing management (Annex Table 8).

In the *B. dictyoneura* experiment, stocking rate and grazing method have affected liveweight gain and legume content in the pastures. Animal gains in grass and grass/legume pastures were significantly higher with 2 A/ha than with 3 A/ha under alternate grazing (Annex Table 8). In the grass/legume pastures high stocking rate under alternate grazing has negatively affected the proportion of *A. pintoi* in the forage on offer, which has not been the case under rotational grazing. This effect of grazing method on legume content is also reflected in liveweight gain.

In summary, *A. pintoi* based pastures in Carimagua continue to show high animal performance and excellent legume persistence. In the 4th or 5th year of grazing animal productivity is 20 to 60% higher in the associations than in the straight grasses. As expected, legume content in the pastures and animal performance have been significantly affected by grazing management.

SUMMARY OF FUTURE RESEARCH ACTIVITIES

We plan to continue the evaluation of quality and antiquality factors in forage germplasm. Our objectives are: (1) to develop appropriate screening methods for assessment of quality and antiquality factors in key legume species; (2) define feeding value of selected grass and legume species and (3) develop alternative feeding guidelines for selected grass and legume species. To contribute to these objectives we are seeking collaboration with advanced research institutions such as Cornell in the US, and NIR in the UK.

Legume forage germoplasm evaluation

During 1993, we will continue our work with herbaceous and shrub legumes high in tannins to obtain information on: (1) the effect of different levels of tannins on *in vivo* fiber digestion, bacterial protein synthesis and protein flow/absorption in the small intestine of sheep; (2) the effect of feeding fresh, and sun-dryed legumes on tannin reactivity and digestibility/intake and (3) the feeding value of *Cratylia argentea* in terms of milk production.

In collaboration with the rumen microbiology group of Cornell University, we will attempt to identify rumen bacteria capable of degrading tannin complexes.

Grass forage germplasm evaluation

We hope to collaborate with the Genetic and Germplasm sections of the TFP on quality evaluation of grass germplasm. We are specifically interested in screening *Brachiaria* lines coming out of the breeding program for *in vitro* digestibility and the collection of *B. humidicola* for protein content. In addition, we will give high priority to the evaluation of *P. maximum* ecotypes selected for acid soils in terms of animal responses. We plan to evaluate these ecotypes with milking cows in our Quilichao facility.

LIST OF PUBLICATIONS

Scientific Journals

Jones, R.J. and Lascano, C.E. 1992. Oesophageal fistulated cattle can give unreliable estimates of the proportion of legumes in the diets of resident animals grazing tropical pastures. Grass and Forage Science 47:128-132.

Mosquera, P. y Lascano, C.E. 1992. Producción de leche de vacas en pasturas de *Brachiaria decumbens* solo y con acceso controlado a bancos de proteína. Pasturas Tropicales 14:2-10.

Conference Papers

Lascano, C.E. and Carulla, J. 1992. Quality evaluation of tropical leguminous trees and shrubs with tannins for acid soils. *In*: Proceedings XXIX Animal Meeting of the Sociedade Brazileira de Zootecnia, July 19-24, Lavras, MG, Brasil. p. 107-129.

ANNEX - TABLES AND FIGURES

Annex Table 1. Screening legume collections for quality and antiquality factors.

Legume species	No. of accessions	CP (%)	IVDMD (%)	Tannins* (%)
Desmodium velutinum (1989)**	59	16.1 ± 1.9	51.7 ± 3.6	1.5 ± 0.2
Desmodium velutinum (1990)**	46	14.0 ± 1.8	55.4 ± 3.5	1.4 ± 0.3
Cratylia argentea (Carimagua)	10	18.6 ± 1.5	52.7 ± 1.8	0.9 ± 0.1
Cratylia argentea (Quilichao)	11	24.2 ± 2.0	57.9 ± 4.2	1.9 ± 0.6
Uraria spp. (Carimagua)	4	16.9 ± 1.5	56.9 ± 3.6	2.7 ± 0.3

*Total phenols (Folin-Denis).

**Introductions of 1989 and 1990 planted in Carimagua, Yopare.

Annex Table 2. Forage legume ecotypes selected on the basis of quality.

Legume species	Ecotypes (CIAT No.)	IVDMD (%)	Soluble, condensed tannins (%)
<u>Dry season</u>			
Dioclea guianensis	19060	38.6	6.2
Dioclea guianensis	19061	39.5	7.8
Avg. 19 accessions		27.6	14.6
Correlation IVDMD-tannins	-0.86 (P < .001)		
<u>Wet season</u>			
Dioclea guianensis	19060	27.8	17.5
Dioclea guianensis	19061	27.6	19.3
Avg. 19 accessions		20.7	22.7
Correlation IVDMD-tannins	-0.66 (P < .02)		
<u>Int. 1989*</u>			
Flemingia macrophylla	18437	25.1	4.2
Flemingia macrophylla	20626	26.9	4.0
Avg. 41 accessions		17.4	7.0
Correlation IVDMD-tannins	-0.47 (P < .002)		
<u>Int. 1990*</u>			
Flemingia macrophylla	21079	26.4	2.7
Flemingia macrophylla	21090	30.7	0.7
Avg. 22 accessions		19.2	2.2
Correlation IVDMD-tannins	-0.52 (P < .01)		

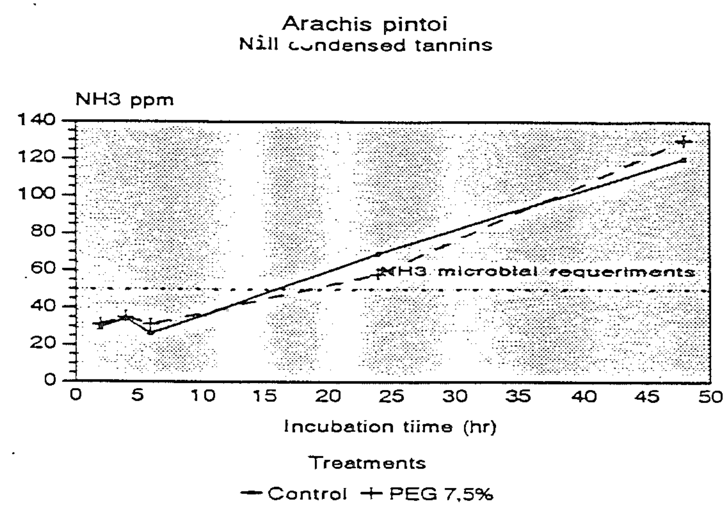
*Wet season (sampling September 1991).

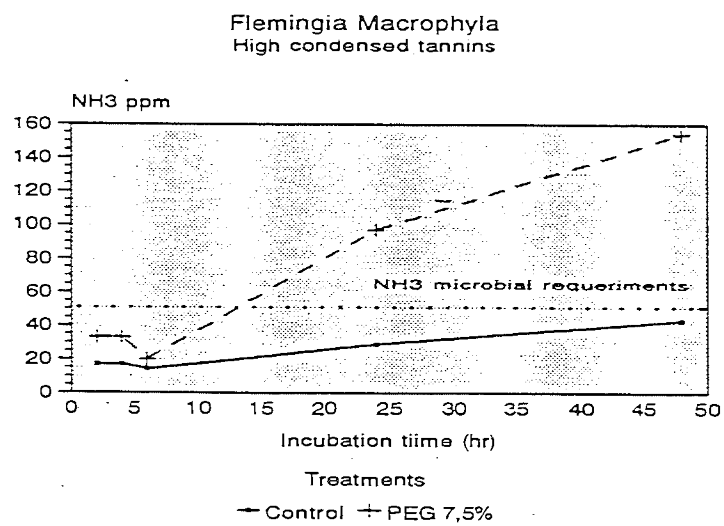
Annex Table 3. Comparison of three methods of determine condensed tannins (CT) in freeze-dried forage legumes.

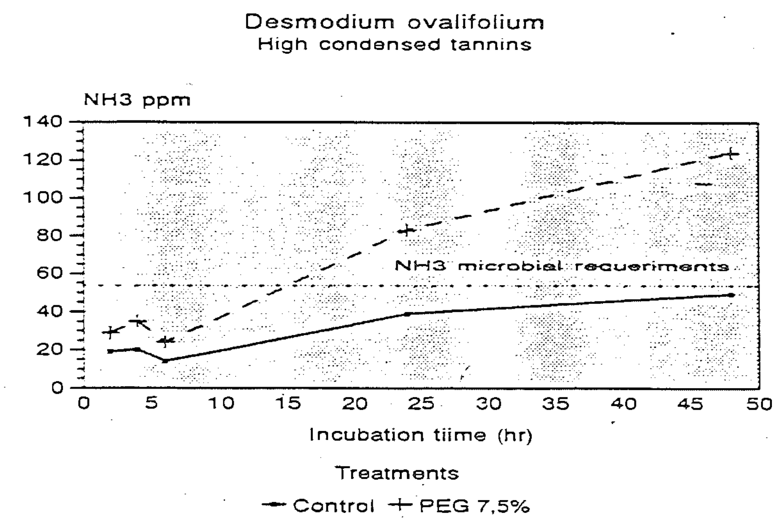
Legume species	Modified Vanillin	Butanol-HCl**	Butanol-H_2SO_4**	
			Soluble	Insoluble
	(% CT)*	(% CT)	(% CT)	
Phyllodium spp.	4.1 ± 0.06	24.4 ± 0.86	14.5 ± 0.45	9.1 ± 0.32
F. macrophylla	– 7.7 ± 0.01	21.0 ± 0.95	9.1 ± 0.08	23.6 ± 0.94
D. ovalifolium	14.9 ± 0.03	19.1 ± 0.94	7.3 ± 0.21	4.9 ± 0.07
Tadehagi spp.	23.3 ± 0.47	33.0 ± 1.07	30.3 ± 2.15	7.4 ± 0.09

* Catechins used as standard; extraction of tannins with solution of 70% methanol + 0.5% formic acid + 0.05% ascorbic acid.

**Plant tannin extract used as standard; extraction of tannins with solution of 70% methanol + 0.5% formic acid + 0.05% ascorbic acid.







Annex Figure 1. <u>In vitro</u> NH3 levels (ppm) at different incubation times of species varying in condensed tannin content with or without PEG.

Annex Table 4. Cell wall dissapearance (%) in different legume species after *in vitro* incubation with and without the addition of a tannin binding agent (PEG).

Legume species	Cell wall dissapearance*	
	- PEG	+ PEG**
A. pintoi (control)	52.4 ± 1.3***	54.5 ± 3.1
Tadehagi spp.	88.7 ± 1.5	78.8 ± 1.2
D. ovalifolium	125.0 ± 3.3	86.3 ± 2.7
F. macrophylla	124.3 ± 1.5	102.9 ± 3.1

*Neutral detergent residues as a percent of original NDF in plant tissue (48 hr *in vitro* incubation).

**7.5% of DM

***Average of 3 determinations and standard deviations

Annex Table 5. Effect of wilting and drying legume species on the ability of tannins to bind protein.

Legume species	Treatment		
	Fresh	Wilted*	Sun-dried
	(g protein bound/100 g DM)		
F. macropylla	4.9	7.8	6.9
D. ovalifolium 350	6.9	18.2	14.2
D. ovalifolium 13089	10.2	17.5	16.7
Phyllodium spp.	12.4	15.5	12.4
Tadehagi spp.	16.7	27.5	16.7

*Samples were wilted for 24 hours and then freeze-dried.

Annex Table 6. Milk yield corrected for fat (4%) of cows grazing *B. decumbens* pastures alone and in association with legumes.

Pastures	Phase 1*	Phase 2**	Phase 3***	Phase 4****
		(kg milk/cow/day)		
Brachiaria decumbens	10.0 b	10.6	8.0 a	6.7
Brachiaria decumbens/A. pintoi	12.4 a	11.1	7.9 a,b	7.1
Brachiaria decumbens/D. ovalifolium	12.7 a	12.1	7.2 b	6.6
Probability	(P<.10)	(P<.15)	(P<.07)	(P<.71)

*Dry period; Holstein cows (1 cow/ha); legume content: 10% A.p. and 10% D.o.

**Wet period; Holstein cows (1 cow/ha); legumen content: 4.5% A.p. and 14% D.o.

***Dry period; Holstein and crossbred cows (2 cows/ha); legume content: 5.0% A.p. and 13% D.o.

****Dry period; Holstein cows (1 cow/ha); legume content: 3.0% A.p. and 13% D.o.

Annex Table 7. Liveweight gain of steers grazing *B. humidicola* alone and associated with *A. pintoi* under alternate grazing (5th year of grazing - Carimagua, 1992).

Treatments	Season		Year**
	Dry*	Wet*	(kg/A)
	(g/A/day)		
B. humidicola alone			
(Stocking rate)			
2 A/ha	261	404	131 b
3 A/ha	273	231	89 d
4 A/ha	189	180	67 e
Mean	241	272	
*B. humidicola/A. pintoi****			
(Stocking rate)			
2 A/ha	346	437	149 a
3 A/ha	325	419	142 a
4 A/ha	214	329	107 c
Mean	295	395	
			($P < .05$)

* 115 days dry, 197 days wet

** Extrapolated to 365 days

***Legume content in pastures
2 A/ha 3% dry; 15% wet
3 A/ha 4% dry; 18% wet
4 A/ha 3% dry; 14% wet

Annex Table 8. Liveweight gain of steers grazing *B. dictyoneura* alone and associated with *A. pintoi* under different managements (4th year of grazing - Carimagua, 1992).

Treatments	Season		Year**
	Dry*	Wet*	(kg/A)
B. dictyoneura alone			
2 A/ha - Alternate	297	315	113 c
3 A/ha - Alternate	113	271	80 d
3 A/ha - Rotational (4P)	144	279	86 d
Mean	183	288	
*B. dictyoneura/A. pintoi****			
2 A/ha - Alternate	515	461	175 a
3 A/ha - Alternate	158	320	98 c
3 A/ha - Rotational (4P)	335	412	141 b
Mean	336	398	
			($P < .05$)

* 118 days dry; 203 days wet

** Extrapolated to 365 days

***Legume content in pastures
2 A/ha - Alternate 17% dry; 23% wet
3 A/ha - Alternate 9% dry; 9% wet
3 A/ha - Rotational 2% dry; 19% wet

SEED SECTION

A. HIGHLIGHTS

1. Documentation.

The priority activity and accomplishment during the year has been an effort to document a large backlog of diverse activities and conduct a synthesis of results and conclusions. A number of manuscripts, including a plenary paper for the International Grasslands Congress, are in development.

2. Promotion of release and seed multiplication of *Arachis pintoi*.

The potential utility and adoption of *Arachis pintoi* prompted the following activities;

a) multiplication of basic seed. This was achieved by a combination of procurement mechanisms, including multiplication by the Section in Colombia at several locations, and contract multiplication in both Colombia and Bolivia by commercial seed enterprises.

b) contributing to the progress of the release process in Colombia. Initiatives and support have been provided to ICA to assist them to plan and advance the release process. As a result, Arachis will be actually released in November 1992. Additionally, basic seed has been offered to ICA and distribution conducted to seed enterprises willing to initiate commercial seed production.

3. Regional Workshop in Honduras, on Pastures and Seeds,.

In April, a Workshop for the Central American region was held at Comayagua, Honduras with joint organization by NRS of Honduras and CIAT. This event was the third of a series but was the first with a genuine regional orientation. The 12 participants came from 7 countries, Mexico, Guatamala, El Salvador Costa Rica, Pamama, Honduras, Belice. The major issues treated were; on-farm evaluation of new pasture associations; the release process of new cultivars; seed multiplication; and future priorities and plans. Participation was by means of a combination of; progress reports, lectures, discussion groups, working groups and reports.

4. Workshop on Seed Systems for the Advisory Committee of RIEPT.

The theme for this Workshop in November is " Developing Seed Systems for Forage Species ". The Workshop will review topics of; initial seed multiplication; the release process and the role of basic seed; mechanisms to promote relevant linkages between research, seed enterprises and other pre-development actors.

B. SIGNIFICANT RESEARCH FINDINGS

1. Seed yield and harvesting methods of *Arachis pintoi*.

The high seed yield potential of *A. pintoi* was further confirmed. In Colombia, recovered seed yields ranged from 1.5 t/ha at 16 mo post establishment (pe), to 3 t/ha at 30 mo pe. In the Yacapani, region of Bolivia, small farmers using artisinal methods recorded from 2-3 t/ha at 18 mo pe.

Partial mechanization of seed harvesting, by means of rotary and flat screen field separators and flat, recovered 80% of seed yield achieved by a totally manual method. Additionally, labour requirements were reduced by 50%, and the relative efficiency of labour (seed /workday) was doubled, while a reduction in seed germination of approx. 15% was indicated.

2. A review of experiences from several on-farm-multiinstitutional projects and Workshops, focussing on issues relevant to the interface of research and development, leads to the following conclusions;

- Such on-farm projects are essential to generate the initial exposure of new materials to a minimum critical mass of pioneer adopters and thereby stimulate adoption.
- Farmers participating in integrated on-farm projects should purchase seeds at full cost, both to initiate market forces and to provide funds for rotation to promote future seed production and marketing.
- The process of release new cultivars is often unrecognized as such by researchers, and over-whelmed by other concurrent processes. As a result, it is given an unbalanced or partial treatment. Frequent deficiencies, include, basic seed, communication with private sector, and release promotion. With new legume species, the complexity of the process increases exponentially with the novelty of the material.
- While research institutions can assign priority and resources, (ie. apply supply push forces) to seed multiplication and thereby generate seeds for

ECONOMIA

Durante 1992 se concluyeron todas las actividades de análisis económico a nivel agregado, que había venido desarrollando en los últimos años la sección de economía del antiguo Programa de Pastos Tropicales. Estas actividades se relacionaban con: 1) Evaluación del impacto Socio-Económico de las nuevas tecnologías de pasturas. 2) Monitoreo de precios de productos e insumos ganaderos en el área de actuación de la Red de Evaluación de Pastos Tropicales (RIEPT) y 3) Cuantificación y Análisis de las tendencias económicas de la ganadería en América Latina Tropical.

1) Evaluación del Impacto Socio-económico de las Nuevas Tecnologías

Este trabajo ya reportado en los informes anuales de 1990 y 1991, se concluyó en 1992, incorporando al Modelo de Evaluación de Excedentes Económicos (MODEXC) nuevas alternativas para el análisis. Se trata de un modelo matemático, implementado para su utilización en microcomputadores dentro de Lotus 123. Se le adicionaron nuevas alternativas para su empleo tales como: mayor flexibilidad para el análisis, al considerar dentro del período total de evaluación distintos subperíodos con

Cuadro 1. Precios relevantes para la siembra de pastos en el área de la RIEPT, 1991 (precios al productor, US$)

Año	Brasilia (Brasil)	Villavo (Colombia)	Apure (Venezuela)	David (Panamá)	Huimanguillo (México)	Asunción (Paraguay)	Corrientes (Argentina)	Coca (Ecuador)	Santa Cruz (Bolivia)
Ganado en pie (kg)	0.80	0.87	1.60	0.90	2.93[a/]	0.68	0.62	1.21	0.86
Urea (kg)	0.44	0.24	0.13	0.27	0.24	0.32	0.37	0.30	0.70
Superfosfato triple (kg)	0.25	0.26	0.17	0.39	0.23	0.40	0.37	0.28	0.70
Gasolina (lt)	0.51	0.15	0.07	0.51	0.23	0.55	0.57	0.11	0.40
Mano de obra (salario 30 días)	93.40	90.80	113.30	150.00	97.60	148.50	160.00	81.80	108.00
Alambre de púas (100 metros)	4.30	8.60	3.70	8.30	8.23	6.31	7.90	5.30	5.40
Maquinaria: tractor 70hp	24712		10833	8000	18536	21605	29133	7227	21778
Leche (litro)	0.23	0.14	0.33	0.21	0.39	0.26	0.10	0.20	0.24
Costo canasta de insumos básicos (US$/hectárea)	97.0	70.3	49.9	109.7	71.6	105.2	112.4	64.9	125.7

a/ Cifra preliminar sujeta a revisión.

Cuadro 2. Evolución del costo promedio de la canasta de insumos básicos en el área de actuación de la RIEPT, 1983/1991

Insumos	1983	1984	1985	1986	1987	1988	1989	1990	1991	Promedio	Participación porcentual	Tasa anual de crecimiento	Valor de t
Fertilizante	38.9	40.7	35.8	38.9	34.2	37.8	48.9	48.5	44.5	40.9	0.48	2.7	1.96
Mano de obra	17.8	17.5	13.6	14.2	17.2	14.8	17.1	20.0	16.7	16.5	0.19	1.1	0.64
Alambre	12.4	15.6	16.8	13.5	15.1	12.9	13.9	14.0	10.9	13.9	0.16	-2.1	-1.32
Combustible	15.5	16.4	10.5	13.7	12.9	12.7	14.7	18.7	12.7	14.2	0.17	2.5	1.09
Costo total:													
-US$/ha	84.6	90.2	76.6	80.2	79.3	78.2	94.5	101.0	84.8	85.5	1.00	0.8	0.60
-kg carne equivalente	117.4	108.7	116.0	109.8	97.9	130.6	114.1	121.7	97.9	112.7	-	-0.4	-0.32
Precio implícito (US$/kg)	0.72	0.85	0.66	0.73	0.81	0.60	0.83	0.83	0.87	0.77		1.5	0.95
Número de localidades	20	26	32	28	29	26	30	20	21	26			

Cuadro 3. Evolución del costo de la canasta de insumos básicos para la siembra de pastos en localidades seleccionadas de la RIEPT: 1983/1991[a/] (US$/hectárea)

Año	Brasilia (Brasil)	Villavicencio (Colombia)	Apure (Venezuela)	David (Panamá)	Isla (México)	Asunción (Paraguay)	Corrientes (Argentina)	Chipiririí (Bolivia)
1983	85.0	95.2	62.9	122.5	59.7	87.1	118.6	
1984	70.3	92.4	60.1	114.2	55.0	83.4	105.6	
1985	72.0	96.8	34.6	113.9	60.8	56.7	89.7	75.8
1986	77.2	67.6	35.0[b/]	108.4	45.5	94.3	82.8	79.1
1987	79.4	64.3	30.8	107.3	43.1	132.9	76.4	89.1
1988	68.0	67.4	15.9	111.4	63.4	107.2	82.3	
1989	87.0	81.2	39.0	105.0	45.3	115.2	80.2	108.9
1990	94.9	74.2	39.0	108.0[b/]	66.1	101.4	109.9	101.2
1991	75.2	70.3	49.9	109.7	71.6	109.6	181.3	127.1
Promedio	78.9	78.8	40.8	111.2	56.7	98.6	103.0	96.9
Desviación estándar	8.3	12.2	13.9	4.9	9.6	20.5	31.0	17.8
Coeficiente de variación	0.1	0.2	0.3	0.0	0.2	0.2	0.3	0.2
Tasa anual de crecimiento (%)	1.0	-3.7	-4.6	-1.2	1.7	5.1	2.6	nd
Valor de t	0.7	-2.1	0.9	-2.9	0.7	1.8	0.7	nd

nd Información no disponible
Las estadísticas descriptivas excluyen los años donde no se dispone de información

a/ La canasta incluye: 60 kg de P_2O_5, 5 jornales, 10 galones de gasolina y 171 metros de alambre de púas
b/ Valor estimado

PROGRAMA DE FORRAJES TROPICALES

INVESTIGACION EN FINCAS

INFORME ANUAL 1992

HIGHLIGHTS:

A) Se continuaron los proyectos colaborativos interinstitucionales para promover la adopción de los nuevos cultivares de especies forrajeras, adaptadas a las regiones de suelos ácidos de ladera del norte del Departamento del Cauca y del Piedemonte Amazónico del Departamento del Caquetá.

B) Se realizó la evaluación financiera ex-post de un caso en finca, en el que se estableciéron parcelas semi-comerciales de B.decumbens asociada con S.capitata cv CAPICA, a traves del cultivo de arroz y se incluyo la cosecha adicional de semilla sexual de capica.

C) Se concluyeron cuatro tesis de pregrado sobre la evaluación biológica y financiera ex-post de pasturas nativas, en stand puro de gramineas introducidas y de praderas asociadas con leguminosas en distintas regiones de Colombia y sistemas de producción bovina tropical.

D) Se realizó y evaluó una nueva encuesta sobre la adopción de pasturas mejoradas en los municipios de Pto Lopez y de Pto Gaitán en la Altillanura Orientál de Colombia.

ADOPCION DE NUEVOS CULTIVARES DE ESPECIES FORRAJERAS EN LA ZONA NORTE DEL DEPARTAMENTO DEL CAUCA

VARIABLES	INICIAL (1988-1989)	FINAL (1992)
FINCAS ENCUESTADAS (n)	100	90
AREA SEMBRADA (has)	43.9	77.3
DENSIDAD DE SIEMBRA (kg/ha)	2000	1740
PRODUCTORES QUE AMPLIARON AREA (%)	-	53
AREA MEDIA SEMBRADA POR FINCA (ha)	.47	.86
AREA MEDIA EN NUEVOS CULTIVARES (ha)	.47	1.3
AREA MEDIA EN PASTOS (ha)	1.3	2.6
AREA MEDIA EN PASTOS (%)	10	24
LEGUMINOSAS INTRODUCIDAS (%)	0	50

PROYECTOS INTERINSTITUCIONALES

AREAS EN PRADERAS Y SEMILLEROS
CAQUETA
1988-1992

SITIO	Gramineas	Leguminosas	Asociaciones	TOTAL (ha)
Hda La Rueda - FGV	28	12	1753	1791
FINCAS PARTICULARES				
Proyecto Doble Proposito (5)	-	-	20	20
Proyecto Colaborativo (46)	28.5	14.3	181.5	224.3
SEMILLEROS INSTITUCIONES				
ICA - Creced	0.04	0.1		0.14
ICA - CRI Macagual	0.5	1.0	3.5	5.0
NESTLE - Florencia		0.6	3.0	3.6
NESTLE - Doncello		0.5		0.5
SENA - Florencia		0.4		0.4
TOTAL (ha)	55.0	28.8	1961	2045

DOBLE PROPOSITO EN PRADERAS PURAS Y ASOCIADAS
EFICIENCIA PRODUCTIVA Y REPRODUCTIVA

VARIABLES	*Kg leche/vaca/dia*	
B.humidicola	*3.4*	
B.decumbens	*3.5*	
B.decumbens + leg	*3.1*	
B.dictyoneura + leg	*2.9*	
Soca de Sorgo	*5.2*	
Vacas con lactancia completa (#)		*21*
Duracion de la lactancia (dias)		*303*
Leche vendible/lactancia (kg)		*1063*
Interparto (dias)		*431*
Natalidad (%)		*85*
Peso destete (Kg)		*165*
Kg leche/dia IEP		*2.5*
Kg carne/dia IEP		*0.383*
*Equivalente leche Kg/vaca/dia IEP **		*4.0*
*Equivalente carne Kg/vaca/dia IEP **		*1.0*

Hda El Congo - CAUCA, (Garcia,A. y Gomez,J.1992)

* Equivalente 4:1 carne:leche ($/Kg)

DOBLE PROPOSITO EN PRADERAS PURAS Y ASOCIADA

EFICIENCIA PRODUCTIVA Y REPRODUCTIVA

VARIABLES	*Kg leche/vaca/dia*	*vacas/ha*
B.decumbens	*3.4*	*0.9*
B.humidicola	*3.4*	*0.8*
B.hum + leg	*3.5*	*1.1*
Vacas con lactancia completa (#)		*20*
Duracion de lactancia (dias)		*256*
Leche vendible/lactancia (Kg)		*881*
Interparto - IEP (dias)		*411*
Natalidad (%)		*89*
Peso destete (Kg)		*178*
Kg leche/dia IEP		*2.1*
Kg carne/dia IEP		*0.433*
*Equivalente leche Kg/vaca/dia IEP **		*3.8*
*Equivalente carne Kg/vaca/dia IEP **		*0.950*

Hda La Rueda - FONGANAVALLE - CAQUETA, (Gasca,F. 1992)
* Equivalente 4:1 carne:leche ($/Kg)

GANANCIAS DE PESO DE NOVILLAS EN PASTOREO
COMPARACION ENTRE PRADERAS NATIVA,PURA Y ASOCIADA *

VARIABLE	*PRADERA NATIVA (Homolepis aturensis)*	*PRADERA PURA (B.dic+B.hum)*	*PRADERA ASOCIADA (B.dic+B.hum+C.macro)*
Novillas por tratamiento (#)	*20*	*30*	*30*
Edad inicial (dias)	*300*	*300*	*300*
Peso inicial (Kg)	*164*	*159*	*159*
Peso final (Kg)	*278*	*305*	*322*
Carga animal (nov/ha)	*0.4*	*2.0*	*2.0*
Ganancia Peso (Kg/nov/dia)	*.268 a*	*.327 b*	*.368 c*
Produccion de carne (Kg/ha/año)	*37*	*239*	*267*

Hda La Rueda - FONGANAVALLE - CAQUETA (Fonseca,M.W.1992)
* Durante 14 meses de pastoreo
Letras indican diferencia significativa (P>0.01) DUNCAN

PUBLICATIONS 1992

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ESTUDIO DE ADOPCION DE PASTOS Y EXPECTATIVAS SOBRE EL ESTABLECIMIENTO DE PASTOS A TRAVES DE CULTIVOS EN FINCAS DE LA ALTILLANURA ORIENTAL DE COLOMBIA

Con el objeto de estimar el grado de adopción y la evolución de las áreas en cultivares forrajeros que los productores ganaderos han establecido en la Altillanura Oriental de Colombia, se realizo una encuesta en 82 fincas representativas de los sistemas de producción ganadero predominantes en esta región. Esta fincas inicialmente se habian encuestado en 1989.

La información recopilada abarcó además de las siembras anuales de gramíneas y leguminosas, los motivos por los cuales los productores demandas los cultivares forrajeros y los limitantes principales para el establecimiento y mantenimiento de las praderas. Persistencia y causas de desaparición. La encuesta incluye datos sobre prácticas para la labranza del suelo y manejo de los potreros. Igualmente se obtuvieron parámetros sobre los sistemas de producción ganadera (inventario animal, carga animal, actividades ganaderas, prácticas de manejo y sanidad animal).

Se indagó sobre el nivel de difusión del sistema de establecer pastos a traves de cultivos comerciales adaptados a estos suelos, igualmente sobre la experiencia y opiniones de los productores sobre posibles ventajas y desventajas de este sistema integrado. Se inventarió la dotación de recursos productivos disponibles en las fincas.

En el cuadro 1 se presenta el uso actual del suelo de la región estudiada. Aproximadamente el 17% del área está sembrada en pastos y cerca del 3% son asociaciones de gramíneas con leguminosas.

Cuadro No 1. Area de estudio de adopción de pastos. Altillanura Oriental de Colombia, 1992.

	Area estimada (has) 1/	Error de estimación (%)
Area total de estudio	1'076.404	19.52
Sabana nativa	853.145	22.44
Pastos cultivados	172.563	24.96
Asociaciones (gramínea-leguminosa) 2/	30,780	44.03
Bosques	50.303	19.59

1/ Area extrapolada para una población de 728 fincas con base en la muestra aleatoria de 82 fincas que cubren un área de 121.243 has, localizadas en los municipios de Puerto López y Puerto Gaitán (Meta). Estas proyecciones tienen un nivel de confianza del 80%

2/ Incluye 9 fincas que fueron tomadas en reemplazo de fincas encuestadas en 1989: al excluir éstas, se estima en 17,691 has el área en asociaciones (73 fincas).

Los cambios registrados en las áreas sembradas y los productores adoptadores según distintos cultivares en observan en el cuadro 2.

Cuadro No 2. Proporción de siembras y tasa de adoptadores de pastos, 1989-1992.

Especies	Proporción de siembras		Tasa de adoptadores	
	1989 [1]	1992	1989	1992
B.decumbens	51.4	39.2	66.3	62.2
B.humidicola	29.9	33.3	68.6	82.9
A.gavanus	5.0	4.1	15.1	14.6
B.dictyoneura	1.5	3.2	10.5	14.6
B.brizantha	0.2	0.1	4.6	3.7
Otras gramíneas	2.3	1.8	17.4	9.8
Asociaciones [2]	7.8	17.8	20.9	30.5
Total pastos			92.0	98.8

1/ En 1989 y 1992 se reportaron respectivamente 10.461 has y 19.437 has sembradas en pastos en la muestra analizada (86 y 82 fincas, respectivamente para estos dos años).

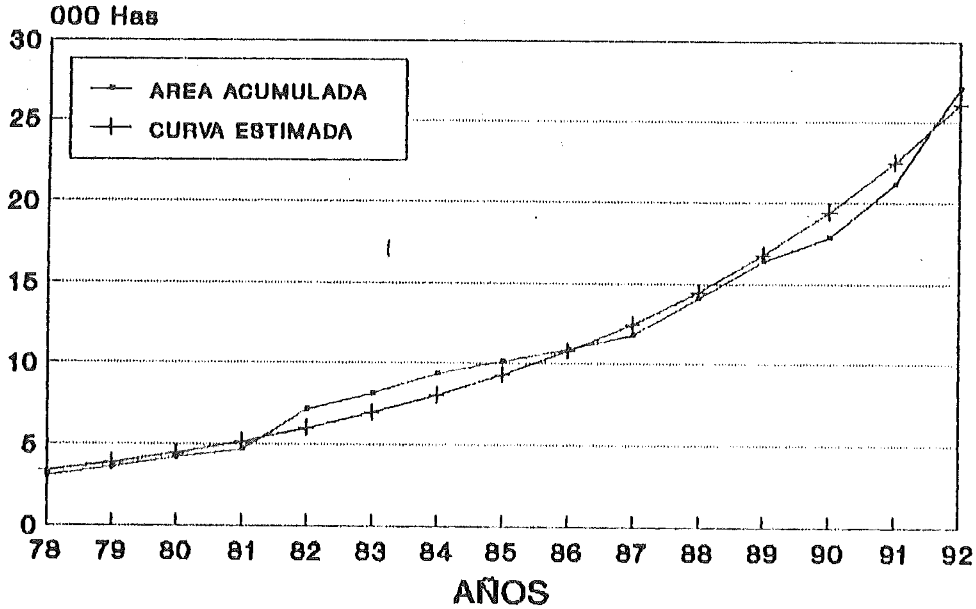
2/ Asociaciones : A. gayanus+S. capitata, B. decumbens+S. capitata, B. dictyoneura+S. capitata, B. brizantha+P. phaseoloides, B. decumbens+P. phaseoloides, A. gayanus+C. acutifolium, otras

En términos generales todos los cultivares señalados han ampliado sus áreas en estos tres últimos años, sobresaliendo las siembras de B. humidicola, B. dictyoneura y de las asociaciones de gramíneas con S. capitata. Pero es necesario resaltar la disminución en términos proporcionales del B. decumbens: la proporción de siembras pasó del 51.4% en 1989 al 39.2% en 1992. (cuadro 2). El B. humidicola pasó del 29.9% al 33.3% y B. dictyoneura, aunque es baja su participación relativa dentro del área en pastos, se incrementó al pasar del 1.5% al 3.2% en estos 3 últimos años. Las Asociaciones aumentaron significativamente su participación al pasar del 7.8% en 1989 al 17.8% en 1992.

Con relación al número de productores nuevos que introdujeron algunos cultivares, sobresalen los adoptadores de B. humidicola y de las asociaciones: la tasa de adoptadores varió del 68.6% al 82.9% entre 1989 y 1992, en el primer caso, y del 20.9% pasó al 30.5% en el caso de las asociaciones. En el caso del B. dictyoneura, esta tasa varió positivamente, pasó del 10.5% al 14.6% entre estos años de referencia (cuadro 2).

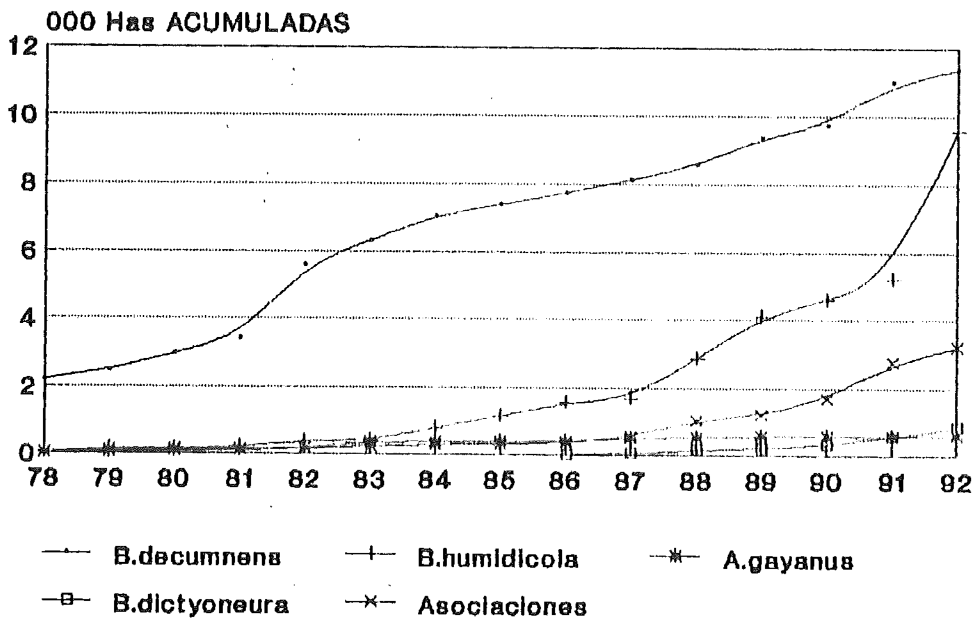
La muy dinámica evolución de siembras de pastos en los últimos 14 años se muestra en la figura 1. Durante este período la tasa media de crecimiento anual del área total de pastos establecidos fué del 14.3%.
La tasa de crecimiento es distinta para cada cultivar, pues se observa cambios importantes en la participación relativa. En la figura 2 se registra las tendencias por cultivar : el B. dityoneura y el B. humidicola son los mas

EVOLUCION ANUAL DE SIEMBRAS DE PASTOS
Altillanura Oriental de Colombia,1978/92
Figura 1



MUESTRA : 82 fincas

EVOLUCION DE SIEMBRAS SEGUN CULTIVARES
Figura 2



dinámicos. Las asociaciones en su conjunto tienen un crecimiento positivo, mayor que otros gramíneas, como es el caso del A. gayanus.

La dinámica de crecimiento del B. decumbens, principal pasto difundido en la región, ha perdido importancia: las proyecciones permiten prever que los productores recuperen las praderas degradadas actualmente en B. decumbens a traves de B. humidicola y B. dictyoneura. Las nuevas siembras con estos dos cultivares en las áreas de sabana, ayudarán a superar el área en B. decumbens.

Los productores demandan los nuevos cultivares por las ventajas productivas que han encontrado en estos pastos. Cerca del 19% de los productores buscan incrementar la ganancia en peso animal y el 15.2% requieren aumentar la carga animal (cuadro 3). La adaptación y persistencia de los cultivares son dos de las características agronómicas consideradas de gran importancia (14.8% y 11.4%, respectivamente) para su adopción.

Cuadro No 3. Motivos por los cuales los productores demandan nuevos pastos y asociaciones. Altillanura Oriental de Colombia, 1992.

Motivos	Participación (%)
1.Buscan incrementar la ganancia en peso	18.89
2.Requieren aumentar la carga animal	15.19
3.Mejor adaptación a los suelos	14.81
4.Persistencia de la pradera	11.44
5.Ensayar los nuevos pastos	10.0
6.Buscan pastos más agresivos	4.44
7.Para establecer lechería (Doble Propósito)	4.07
8.Controlar malezas	3.70
9.Rápida recuperación de las praderas	3.33
10.Valorizar la finca	2.96
11.Otros (resistencia a plagas, etc)	11.17

Muestra : 82 fincas.

Otros motivos tenidos en cuenta por los productores para introduccir pastos en sus fincas son: ensayar los nuevos pastos, buscan pastos mas agresivos, quieren producir leche (Doble Propósito), controlar malezas, recuperación rápida de praderas degradadas y valorizar los predios entre otros motivos. (cuadro 3).

Entre los principales limitantes para una mas rápida expansión de las siembras de pastos, los cuales son reportados por los productores, se cuentan: algunas especies han tenido poca persistencia productiva, existe un gran vacio de extensión, capacitación y divulgación de la tecnología de pasturas, algunos materiales no se adaptan a los suelos, hay escasez y altos precios de semilla comercial, las plagas (Salivazo y las hormigas) restrigen la adopción. Los altos costos de establecimiento y la falta de recursos financieros, también obstaculizan el proceso de adopción. Cuadro 4.

Cuadro No 4. Principales Limitantes para el Establecimiento de Pastos en la Altillanura Oriental de Colombia, 1992.

Limitantes	Participación
1.Poca persistencia de algunas especies	21.69
2.Falta información agronómica (asist.técn)	17.97
3.No se adaptan a los suelos	10.51
4.Hay escasez de semilla comercial	9.49
5.Aparición de plagas	9.49
6.Deficiente calidad nutritiva de algunas especies	8.81
7.Altos costos de establecimiento	5.76
8.Falta terrenos aptos	4.41
9.Alto costos de la semilla	4.07
10.Falta recursos financieros	3.39
11.Inseguridad social, otros	4.41

El nivel de difusión del sistema de establecer pastos a traves de cultivos comerciales es bajo. En el cuadro 5, se presentan las respuestas de los productores.

Cuadro No 5. Nivel de difusión del sistema cultivo-pastos en fincas de la la Altillanura Oriental de Colombia, 1992.
(Porcentajes)

Los productores	Cultivos-pastos[1]		Monocultivos[2]	
	SI	NO	SI	NO
Están informados	67.07	32.93	8.53	91.46
Lo conocen directamente	48.78	51.22	7.31	92.68
Tienen experiencia	7.31	92.69	4.88	95.12

1/ Asociaciones:
Arroz-pastos
Sorgo-pastos
Soya-pastos
Maiz-pastos
Ajonjolí-pastos

2/ Monocultivos:
Arroz, Sorgo
Soya, Maiz
Ajonjolí, Algodón

El 67.1% de los productores ganaderos están informados sobre el sistema integrado cultivo-pastos en áreas de sabana, y el 48.8% conocen directamente algún lote donde se ha ensayado cultivo-pastos (basicamente de arroz-pastos en fincas de la altillanura). Sólo el 7.3% de los productores tienen experiencia en establecer pastos mejorados a traves de cultivos comerciales.

Los monocultivos en están muy poco difundidos en esta región, pues solo 8.5% ha escuchado sobre estos cultivos allí. El 4.9% de los productores han cultivado con fines comerciales en áreas bajas con mejores niveles de fertilidad y disponibilidad de agua para riego (cuadro 5).

Los ensayos en fincas por parte de las instituciones involucradas en estos proyectos (ICA-CIAT-FEDEARROZ), ha sido conjuntamente con la información suministrada por los mismos productores, los dos medios de mayor importancia en la difusión de esta tecnología. Los medios masivos de comunicación (radio, televisión, prensa, boletines técnicos) y los dias de càmpo, han sido de poco impacto a nivel de información y capacitación a los directamente responsables de la adopción de pastos y de cultivos. Ver cuadro 6.

Cuadro No 6. Medios de información difusores de los sistemas cultivos-pastos a los productores, 1992.

Medios de difusión	Participación (%)
Ensayos ICA-CIAT-FEDEARROZ	42.10
Otros productores	28.95
Radio, televisión	11.84
Días de campo	6.58
Extensionistas y asist.técnicos	5.26
Boletines técnicos	5.26

Estos resultados sugieren la necesidad de hacer una mayor transferencia tecnológica por las entidades responsables, empleando para ello los distintos medios de información de mayor acceso a los productores.
Un alto porcentaje de productores (el 63.4%), opinan que el sistema cultivo-pastos es atractivo para su adopción. El 15.8% cree que el establecimiento de monocultivos es viable en sus fincas.

La atractividad del sistema de cultivo-pasto está fundamentada en la necesidad que los productores tienen para ampliar las áreas en pastos mas productivos (34.8%), igualmente un alto porcentaje (32.6%) de la muestra considera que los cultivos comerciales introducidos garantiza la financiación para el establecimiento de las praderas. El 11.2% de los productores estiman que este tipo de asociación o rotación es rentable. La recuperación de praderas degradadas o para efectuar ensayos con el objeto de conocer mejor esta opción tecnológica, son otros de los motivos que incitan a los ganaderos a introduccir este sistema integrado en sus fincas.

El 36% de los productores entrevistados opinan que allí es rentable establecer monocultivos y el 20% de los ganaderos estiman que éstos se pueden adaptar a los suelos mecanizables existentes en sus fincas.

Entre los factores mas limitantes para el establecimiento de cultivo-pastos, se señalan los siguientes (cuadro 7): el 18.3% de los productores no disponen de maquinaria y de equipos necesarios para la realización de las labores básicas; el 16.5% no tienen recursos financieros suficientes para realizar las inversiones requeridas; el 13.9% no cuenta con suelos aptos para establecer cultivo-pastos; el 12.2% tiene criticos problemas de comercialización y el 11.2% opina que la falta de transferencia técnica restringe la adopción de esta tecnologia. Otros limitantes, igualmente aplicables a la adopción de monocultivos, se registran en el cuadro 7.

Cuadro No 7. Limitantes para el establecimiento de cultivos asociados con pastos y monocultivos
Altillanura Oriental de Colombia, 1992
(Porcentajes)

	Limitantes	Cultivos-pastos	Monocultivos
1.	No disponen de maquinaria	18.3	17.3
2.	Faltan recursos financieros	16.5	16.0
3.	Suelos no aptos	13.9	16.1
4.	Problemas de comercialización	12.2	7.4
5.	Falta divulgación técnica	11.2	8.6
6.	Inseguridad social	6.1	6.2
7.	No son rentables	4.3	6.2
8.	Falta infraestructura (vias, bodegas)	3.5	4.9
9.	Insumos no disponibles (semillas)	3.5	3.7
10.	Falta mano de obra calificada	3.5	3.7
11.	Incertidumbre sobre productividad	1.0	3.7
12.	Otros motivos	5.1	6.1

En resumen, el proceso de adopción de cultivares forrajeros en esta región es muy dinámico. Los productores encuentran claras ventajas productivas al mejorar la ganancia en peso y aumentar la carga animal al introducir gramineas y leguminosas asociadas. La falta de persistencia productiva y adaptación de algunos materiales, la degradación causada por el salivazo y las hormigas, son las principales causas que conjuntamente con la falta de transferencia tecnológica y obstaculos en la obtención de semilla comercial, restringen la adopción gramíneas y leguminosas forrajeras.

La ampliación del área en pastos a traves de cultivos adaptados (arroz, soya, sorgo) es una alternativa atractiva para los productores de la región. Pero sus ventajas agronómicas y económicas se ven seriamente afectadas por la falta de experiencia en cultivos, el desconocimiento de este sistema integrado, la poca disponibilidad de maquinaria y equipos, la falta de recursos financieros, el riesgo de uso de suelos no aptos, la falta de infraestructura y los problemas en la comercialización, son los principales factores limitantes para la difusión de esta tecnología en fincas de la Altillanura Oriental de Colombia.