Agronomy in the Isohyperthermic Savannas (Carimagua)

Germplasm evaluation and selection

The aim of this work is to provide forage species adapted to the soils of low nutrient status, and select species which are resistant to pests and diseases and can withstand heavy grazing. A number of grasses and legumes have been identified which meet these criteria.

A current and more specific objective is to identify species and ecotypes of grasses and legumes which are more compatible under sward conditions, form stable associations, and persist longer under grazing.

Over one thousand accessions representing nine legume genera and seven grass genera are under evaluation in nursery plots or in grazed swards. Their inventory is presented in Table 1.

Preliminary evaluation of grass germplasm

The range of promising grass species with good adaptation to savanna conditions was further expanded. Main emphasis is on Brachiaria spp. and Andropogon gayanus.

Experience over the last four years indicates that Desmodium ovalifolium can withstand competition from aggressive mat-forming grasses. Consequently, Brachiaria species and ecotypes assumed greater importance in the testing program. Several accessions are currently being evaluated in association with Desmodium ovalifolium ecotypes.

Brachiaria dictyoneura CIAT 6133 continued to show good performance. It combined well with Desmodium canum and Desmodium ovalifolium. It was grazed in preference to Brachiaria humidicola when animals had free access to both species.

Brachiaria dictyoneura is a strongly rhizomatous grass with a rather tufted growth habit. Morphologically it resembles Brachiaria humidicola. One of the important attributes of Brachiaria dictyoneura is a high caryopsis content of the florets coupled with high seed yield. At Carimagua this species produced 405 kg/ha of cleaned seed in the year of establishment with an average caryopsis content of 44%. Both yield and caryposis content were significantly (P=0.01) higher than those of Brachiaria humidicola (Table 2). Apparently, freshly harvested seed of Brachiaria dictyoneura has a strong dormancy. Sulfuric acid treatment for 25 and 20 minutes gave 6% and 3% germination one month after harvesting. Shorter periods of acid treatment as well as heat treatments were ineffective in increasing germination. When the lemma and palea were removed, 15% of the naked caryopses germinated within one week and without acid treatments. This phenomenon would suggest the presence of germination inhibiting substances within the glumes and/or caryopses (Table 3).

Table 1. Forage species introductions under evaluation at Carimagua, 1980-81.

Legumes				Grasses		
Genus	No. of species	No. of accessions		Genus	No. of species	No. of accessions
Aeschynomene	18	193		Andropogon	1	46
Arachis	2	2		Brachiaria	8	18
Cassia	2	21		Echinocloa	1	1
Calopogonium	1	1		Hemarthria	1	1
Centrosema	18	172		Melinis	1	1
Desmodium	12	196		Panicum	2	2
Stylosanthes	11	242		Setaria	1	1
Tephrosia	1	1				
Zornia	8	281				
Total legumes	9	73	1109	Total grasses	7	15	70
Total No. of accessions						1181

Table 2. Seed production potential of two species of Brachiaria, Carimagua, Llanos Orientales.

Species	Yield (kg/ha)	Caryopsis content (%)	No. of seeds per kg
B. dictyoneura CIAT 6133	405.20**	44**	200,000
B. humidicola CIAT 619	286.40	18	250,000

** P = 0.01

Table 3. Effect of treatment on the germination of Brachiaria dictyoneura CIAT 6133 seed.

Treatment	Means of four replications (%)
H_2SO_4 25' + Tiourea	6
H_2SO_4 20' + Tiourea	3
H_2SO_4 15' + Tiourea	0
Control	0
Naked caryopsis	15

Brachiaria brizantha CIAT 664. This ecotype of signal grass was introduced from Puerto Rico where it was rated as one of the top yielders. An important attribute of this Brachiaria species is its rapid spread by stolons. Currently, its productivity is being tested in association with eight ecotypes of Desmodium ovalifolium. Another accession, CIAT 6298, has a similar prostrate, creeping habit, but it is somewhat less vigorous.

Andropogon gayanus. In populations of Andropogon gayanus, the percentage of early flowering, stemmy types is showing an increase with advancing generations. The aim of the Andropogon gayanus improvement project is to produce a vigorous and fairly uniform, late-flowering cultivar.

Andropogon gayanus is a strongly out-crossing, practically self-incompatible grass. The polycross technique was considered most appropriate with this grass. It is based on the vegetative propagation of clones with the desired characters and selection of those with progenies exhibiting the highest percentage of these characters. The principle is to arrange the provisionally selected plants in such a way that they pollinate each other uniformly. A time table and schematic plan of the project is shown in Table 4.

Table 4. Time table and schematic plan of the Andropogon gayanus improvement project.

1979	Selection of late flowering, vigorous segregates of A. gayanus, establishment of clonal propagates in space-planted field plots, 16 clones x 5 plants x 3 replications, seed harvested from "seed islands" containing the best late flowering plants.
1980	To ensure maximum intercrossing, 12 clonal selections were intercrossed in the plant house to form synthetic I.
1981	Twelve clones and their polycrossed seeds were established in replicated field plots. Parent offspring relationship was determined on the basis of yield and flowering/maturity date. Final selection of genotypes with high combining ability for vigor and late flowering habit, seed production of synthetic II.

Preliminary evaluation of legume germplasm

Arachis pintoi. Most wild species of Arachis examined to date suffer from a range of fungal and virus diseases, which normally affect the cultivated species as well. This new accession, originally from Bahía, has shown good tolerance to pests and diseases over the past two years. Arachis pintoi spreads by stolons; an important attribute of this legume is its compatibility with the stoloniferous Brachiaria humidicola. In general, perennial species of peanut provide high quality fodder.

Seed production is feasible and it may be tried on sandy soils; like other peanuts, it sets pods underground. They are rather small, and it is hard to recover the seeds.

Aeschynomene. Preliminary agronomic evaluation of 193 accessions representing 18 species was started 12 months ago. A very small number of accessions exhibited tolerance to disease and insects. Included in this group were eight accessions of Aeschynomene americana out of a total of 64 accessions of this species. By the end of August several of

these showed symptoms of one or more fungal diseases, anthracnose being of very common occurrence. Aeschynomene villosa CIAT 7008 was one of the accessions that was still disease-free after one year; this prostrate, fine-leaved species appears to have the morpho-agronomic attributes to withstand intense grazing.

Cassia. A few disease-resistant accessions of Cassia rotundifolia show useful forage traits, e.g. early vigor, disease tolerance, late flowering and good seed production. The seed pods do not shatter very easily, and at this stage CIAT Nos. 8389, 8390 show some promise.

Centrosema. All species under observation including C. macrocarpum and C. brasilianum were severly attacked by leaf diseases. Less damage occurred in the plots under grazing. Nevertheless, it will be necessary to examine other species and ecotypes of Centrosema for disease resistance. Annual yields of dry matter of six Centrosema accessions are shown in Table 5.

Desmodium ovalifolium. Of the 12 species under observation, ecotypes of Desmodium ovalifolium and Desmodium canum continued to show good promise. An "in depth" study of D. ovalifolium ecotypes was commenced. Marked variation was observed among the nine ecotypes included. Dry matter "on offer" was recorded during the first semester in grazed pastures of these nine ecotypes, each established in association with Brachiaria humidicola.

The top yielder was CIAT accession 3652. The standard CIAT 350 and the other ecotypes gave presentation yields ranging from 8 to 10.6 t/ha. Legume percentages of five mixtures containing high yielding ecotypes ranged from 62 to 77%. The remaining four ecotypes produced 6.2 to 7.9 t/ha DM, and legume percentages in these associations ranged from 50 to 59% (Table 6).

Seed yield, variation in flowering/maturity dates

Variation was observed among the accessions of D. ovalifolium in flowering/maturity dates. CIAT 3784 was the earliest. It began flowering shortly after the end of the wet season. By the last week of December it had reached the "full seedhead" stage. Hand harvesting of mature seed in 2 x 1 m^2 quadrats in each of the four replications was carried out on 27 December.

Two other accessions, CIAT 3666 and 3793, were the next to ripen the seed and were harvested on 27 January. Although these ecotypes showed prolific flowering, seed yields were much reduced due to severe moisture stress. Both December and January were rainless in Carimagua.

A second flowering was observed immediately after the early opening rains in February, and seed was harvested in all plots on 24 April. On this occasion seed yields were low in all accessions.

Table 5. Dry matter "on offer" in grazed pastures of six accessions of *Centrosema* spp. in association with *Andropogon gayanus*.

Mixture	Dry matter "on offer"					
	Dry season		Wet season			
	Grass	Legume	Grass	Legume	Total (kg/ha/year)	Legume (%)
	(kg/ha/season)					
A. gayanus + *C. brasilianum* 5234	4219	5482	9733	7706	27140	48.6
A. gayanus + *C. brasilianum* 5184	3634	5281	9553	3752	22220	40.7
A. gayanus + *C. brasilianum* 5181	6945	5240	11312	3172	26669	31.5
A. gayanus + *C. macrocarpum* 5062	4450	4973	10290	3935	23648	37.7
A. gayanus + *C. macrocarpum* 5276	4188	4670	11077	3423	23358	34.7
A. gayanus + *Centrosema* sp. 5278	4561	4451	13686	6418	29116	37.3

Table 6. Dry matter "on offer" in grazed pastures of nine ecotypes of D. ovalifolium in association with B. humidicola for the period 30 Jan. 1981 to 14 July 1981.

Ecotypes	Grass	Legume	Total	Legume
		(t/ha)		(%)
3652	4.0	13.4	17.4	77
350	4.4	10.6	15.0	71
3794	5.5	9.2	14.7	63
3793	5.1	8.2	13.3	62
3666	4.8	9.0	13.8	65
3776	6.4	7.9	14.3	56
3780	5.0	7.2	12.2	59
3784	5.4	7.8	13.2	59
3788	6.3	6.2	12.5	50

There was an inverse relationship between seed yield and dry matter (DM) yield. To date, the late flowering CIAT 3652 produced the highest DM yields and the lowest seed yields. The early flowering 3784 produced the highest seed yield but it had lower DM yields than five other accessions. CIAT 3784 and four other accessions also yielded more seed than the control variety CIAT 350.

Seedling counts carried out in July also showed variation among the ecotypes in self-propagation. The highest number of volunteer seedlings was found in CIAT 3784. It is recommended to test 3784 in regions with shorter growing season. Yields of clean seed obtained during the first semester and results of seedling counts are summarized in Table 7.

In a normal season much higher seed yields are expected from the late flowering ecotypes including CIAT 350. However, the very late flowering accession CIAT 3652 may be a poor seed producer in most circumstances.

Observations on the palatability of Desmodium ovalifolium ecotypes carried out during the wet season showed the following trends:

- In some ecotypes presentation yields under grazing declined more rapidly than in others; in one case this was associated with a higher CP content in the herbage.

- Tannin levels in the leaves were high in all cases and showed an increase from 5.9% in May to 39% in July. In comparison, Desmodium canum (range 7-12.8%) and D. gyroides (range 2.2-6.5%) showed considerably lower levels of tannin content. The latter two legumes had a higher palatability rating than any D. ovalifolium.

Figure 1. Desmodium ovalifolium CIAT 3784, a free-seeding ecotype, regenerates by auto-propagation.

Table 7. Yields of clean seed* and number of volunteer seedlings in grazed pastures of nine accessions of Desmodium ovalifolium, Carimagua, Llanos Orientales.

CIAT Accession No.	Seed (kg/ha)	Mean number of seedlings per m^2
3784	152.57	53.31
3666	109.10	9.81
3793	48.94	40.06
3780	15.15	18.50
3788	4.50	21.25
3794	2.75	2.75
3776	1.75	2.56
3652	0.82	0.19
350 (control)	0.75	2.88
L.S.D. P = 0.05	54.84	15.82
P = 0.01	74.32	21.43

Correlation coefficient for all comparisons: 0.54 (P = 0.01)

*Mechanically scarified seed.

At least during the wet season, there were no marked differences in palatability between the ecotypes of D. ovalifolium currently under trial at Carimagua.

Desmodium canum. The original selection from old pastures, established over four years ago, CIAT 3005A, a rather robust growth form, is continuing to show the best promise. So far, no major insect or disease problems occurred in this species. The ecotype 3005A was included in various mixtures with molasses grass, several Brachiaria species and Andropogon gayanus. These companion grasses were selected to include a range of species from the least competitive molasses grass to the most aggressive species such as Brachiaria spp. and Andropogon gayanus.

Stylosanthes guianensis, "fine-stemmed" stylo. Some 42 accessions were established of this species form in legume-only sward plots in late 1980. Five accessions showed satisfactory performance, yield and disease tolerance in the second season under a seasonal cutting regime (Table 8).

Table 8. Dry matter yields of five ecotypes of S. guianensis "tardío" type.

CIAT No.	Seasonal yield (t/DM/ha)		Total year
	Wet	Dry	
10136	6.6	1.6	8.2
1062	5.9	1.4	7.3
1317	4.8	1.0	5.8
1808	4.0	0.9	4.9
2034	5.8	1.2	7.0

Accession CIAT 10136 was the top yielder in this experiment, and at this point in time CIAT 1808 is highly resistant to anthracnose. However, none of these accessions produce adequate amounts of seed for self-regeneration, and certainly none of them produce sufficient seed to make commercial seed production an economically feasible proposition. A few ecotypes of S. guianensis, however, are showing promise, being resistant to anthracnose and stemborer; they are free-seeding types as well.

Zornia. The two species, Z. brasiliensis and Z. myriadena are the best species and their resistance to fungal diseases is still holding. Nutrient contents of both are exceptionally high. Both species were included in sward plot studies. Again, grass species of greatly different growth habit and vigor were used in order to test their compatibility with these distint growth forms of Zornia.

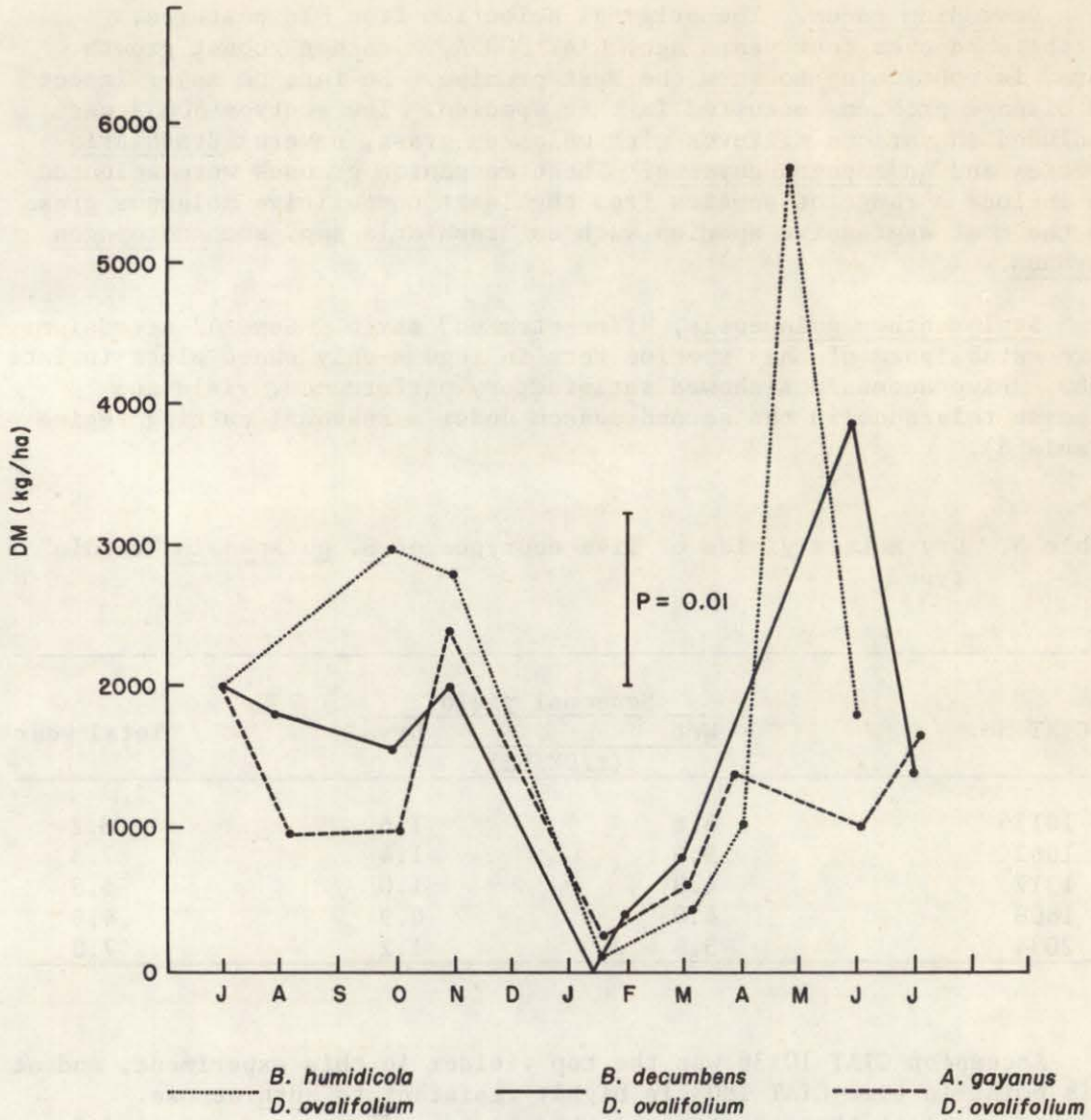

Figure 2. Growth rates of Brachiaria humidicola - Desmodium ovalifolium, B. decumbens - D. ovalifolium and Andropogon gayanus - D. ovalifolium pastures harvested by cutting at six-week intervals.

Grass-Legume Associations Under Grazing

B. decumbens - D. ovalifolium vs. B. humidicola - D. ovalifolium. These mixtures were grazed by 2.5 animals/ha all year-round.

B. humidicola showed significantly higher growth rate in grazed pastures than B. decumbens, and this resulted in a significantly ($P = 0.01$) higher total yield of the B. humidicola - D. ovalifolium mixture (Figure 2). No significant difference occurred in these two associations between legume yields. Also the Brachiaria humidicola - Desmodium ovalifolium association produced the highest presentation yields. The legume percentage in this pasture showed a marked build-up during the wet season (Table 9), (Fig. 3).

Andropogon gayanus - D. ovalifolium. Growth rates and presentation yields of the component of this mixture were remarkably uniform throughout the year indicating grass-legume compatibility under a suitable grazing pressure. In general, this mixture was less productive than D. ovalifolium with the two Brachiaria spp.

Stylosanthes capitata. Two experiments are in progress with 10 and 16 accessions of S. capitata, respectively, each in mixture with A. gayanus. The former pasture is two years old and the latter one was established in 1980. This second experiment also includes seven S. macrocephala ecotypes. A marked reduction in the yields of these legumes occurred in the second year following establishment. Again, the S. macrocephala accessions were in the low-yielding group, an obvious competition effect from the tall A. gayanus (Tables 10 and 11).

Table 9. Dry matter "on-offer" in a Brachiaria humidicola - Desmodium ovalifolium pasture - Carimagua, Llanos Orientales.

Harvest date	B. humidicola	D. ovalifolium	Grass + legume	Legume (%)
	t/ha			
15- II-80	6.11	0.95	7.06	13.46
1- IV-80	5.43	0.73	6.16	11.85
13- V-80	4.51	0.70	5.21	13.44
23- VI-80	5.25	0.85	6.10	13.93
5-VIII-80	3.49	0.98	4.47	21.92
16- IX-80	2.96	0.94	3.90	24.10
29- X-80	2.82	1.73	4.55	21.98
10- XII-80	2.65	2.73	5.38	18.59
23- I-81	2.02	1.36	3.38	40.23
Total	35.24	10.97	46.21 $\bar{X}$:	23.74
S.E.	0.64	0.37	0.79	

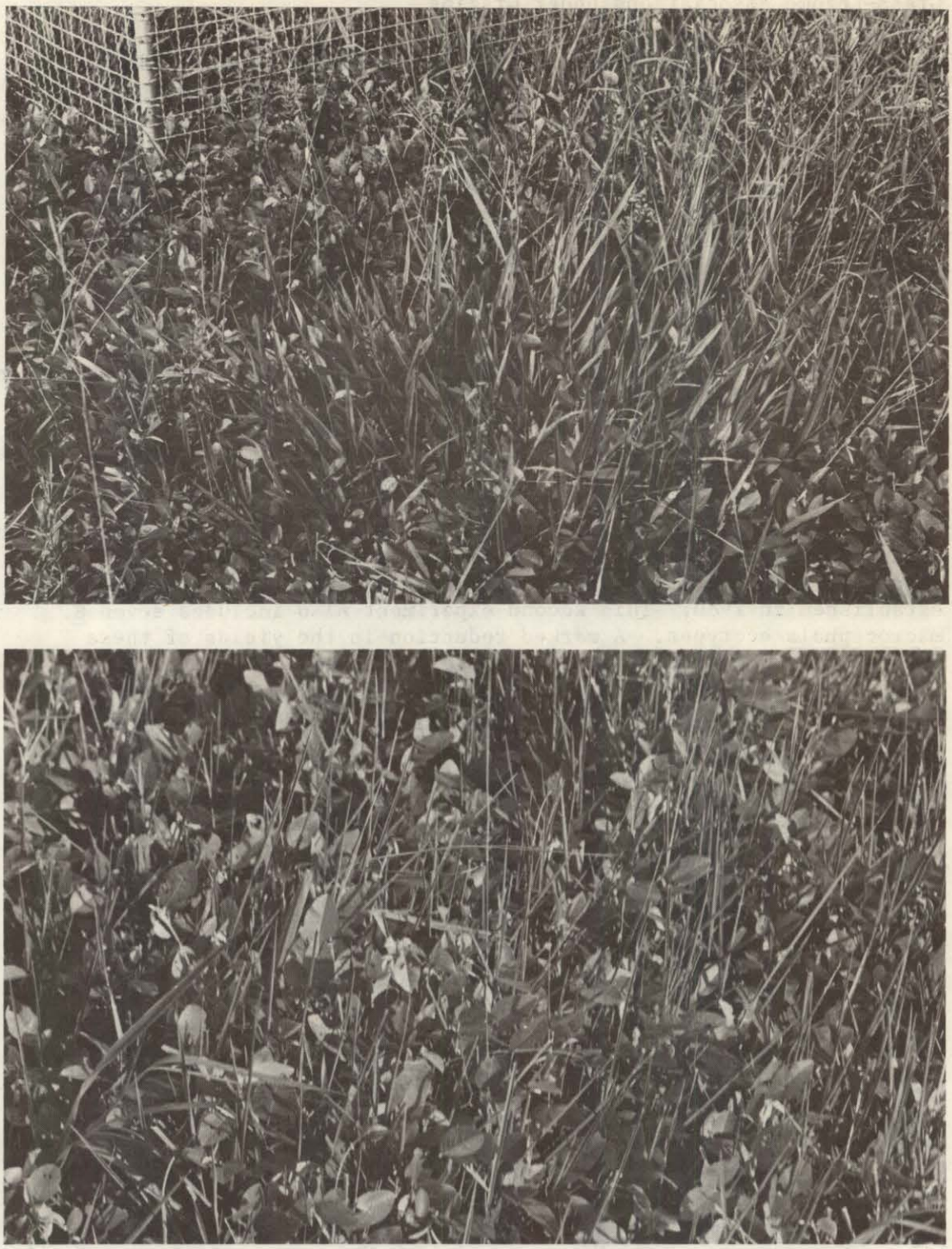

Figure 3. Desmodium ovalifolium formed productive and stable associations with Brachiaria decumbens (photo above) and B. humidicola (below) at Carimagua in the Llanos Orientales.

Table 10. Mean monthly presentation yields of 10 ecotypes of *Stylosanthes capitata* in association with *A. gayanus* in the first and second year.

CIAT Accession No.	Year 1	Year 2
1315	978	236
1318	951	144
1323	786	180
1342	681	108
1405	741	418
1325	668	134
1693	760	335
1728	1222	351
1943	413	144
1019	787	298

Table 11. Mean monthly presentation yields of 16 ecotypes of *Stylosanthes capitata* and 7 *S. macrocephala* in association with *Andropogon gayanus* under grazing (2 Dec. 1980-7 Sept. 1981).

CIAT Accession No.	DM (kg/ha)
S. capitata	
1686	2744
1441	2139
2013	1792
1414	1710
1019	1475
2044	1274
1318	952
1315	946
2041	912
2055	826
1943	651
2201	570
2092	482
1642	466
1781	411
55840 (CSIRO)	
S. macrocephala	
1643	739
2039	668
1582	552
2061	471
2066	421
2093	301
2082	290

Desmodium gyroides (= Codariocalyx g.) - D. ovalifolium - Andropogon gayanus. The mixture containing both legumes produced the highest total yield. D. gyroides was preferentially grazed in the two-legume mixture, and the role of D. ovalifolium as a ground cover legume seems to function well (Table 12).

Table 12. Dry matter "on offer" in Andropogon gayanus, Desmodium ovalifolium and Codariocalyx gyroides associations.

Mixture	Grass[1] (kg/ha)	Legume[1] A (kg/ha)	Legume[1] B (kg/ha)	Legume (%)
A. gayanus - D. ovalifolium	15310	13041**		46
A. gayanus - C. gyroides	19033**		12569**	40
A. gayanus - D. ovalifolium - C. gyroides	13202	7841	9235	56
* P = 0.05	3606	2174	2420	
L.D.S.** P = 0.01	5463	3189	4443	
c.v.	13.15%	9.25%	9.87%	

[1] $\bar{X}$ of ten cuts.

Plans for the Future

Grasses

1. Evaluation of a wider range of accessions of Brachiaria spp., e.g., B. humidicola, B. dictyoneura, B. brizantha is of particular importance, with the aim to find productive companion grasses for various types of D. ovalifolium, and resistance to spittlebug.

2. Andropogon gayanus: seed multiplication and testing of the synthetic variety in mixtures under grazing.

Legumes

1. S. guianensis, "fine-stemmed" stylo. It is proposed to continue the search for seeding types and accessions resistant to anthracnose and stemborer in cooperation with the Plant Pathology and Entomology sections, followed by agronomic evaluation of free-seeding ecotypes in grass-legume associations.

2. S. capitata. Multilocational testing of 5 to 10 promising ecotypes in the Regional Trials Network in the Llanos of Colombia, Venezuela and in Roraima, Brazil. Preference to be given to accessions resistant to anthracnose and stemborer at all three sites. This should be an opportunity to test bred-lines of S. capitata produced by the Legume Breeding section.

3. Desmodium ovalifolium. Continue evaluation of existing collection and new accessions to be obtained. Include selected material in the Regional Trials Network and test different flowering/maturity types and adaptation of early flowering accessions to lower rainfall conditions.

4. D. canum. Evaluate promising lines under grazing. CIAT 3005A to be included in regional trials and grazing productivity experiments.

5. Centrosema spp. In collaboration with the Plant Pathology section, study performance of new accessions with the objective of selecting disease resistant material of C. macrocarpum, C. brasilianum, C. pubescens. Test accessions of other species (C. arenarium, C. rotundifolium) in grass-legume mixtures under grazing.

6. Zornia spp. Test new accessions of Z. brasiliensis and study seed production potential of existing and new ecotypes of Z. myriadena.