FURTHER EVALUATION OF FORAGE GERMPLASM AT THE CENTRO DE PESQUISA AGROPECUARIA DOS CERRADOS IN CENTRAL BRAZIL

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The Centro de Pesquisa Agropecuária dos Cerrados (CPAC) of EMBRAPA is situated 35 km from Brasilia at latitude 15°36' south, longitude 47°42' west and altitude 1000 m. Average rainfall is 1578 mm per annum, of which 90 per cent is distributed between October and March inclusive. Average year round temperature is 21°C. In 1978 a pasture agronomy programme was initiated to develop new adapted forages for the 'cerrados'. The principal aim was to evaluate new germplasm collected by CIAT and national institutions and to select productive forage species resistant to pests and diseases that would persist under grazing on acid, low fertility soils with minimal inputs of fertilizer. Selected accessions would then be tested at other sites in the 'cerrados' through the regional trial network. Initially, evaluation of germplasm was conducted on the dark-red latosol and red-yellow latosol, both Oxisols. More recently studies have commenced on the humic gleys, which occur in low-lying sites subject to periodic flooding or waterlogging known as 'varzeas'. Preliminary results for the first four years of the project were reported by Thomas and Andrade (1983). This paper summarizes the main developments in forage evaluation at CPAC.

METHODOLOGY

Germplasm is tested through a systematic multi-category evaluation programme. In the preliminary stages accessions are evaluated as spaced plants against control accessions. The main interest here is general adaptation to climatic, edaphic and biotic factors. Seed of promising germplasm is multiplied and these accessions are further evaluated in small individually-grazed plots. Each legume is sown separately with a grass, whilst selected grasses are sown with a legume. When seed supplies allowed, evaluation was conducted at two stocking rates, obtained by adjustment of paddock size. The major interests at this level of evaluation are species persistence and compatibility. Where large numbers of accessions of a species were selected and seed supplies were limiting, evaluation was conducted in smaller plots under a 'mob' grazing regime. Finally, the best combinations are evaluated under continuous grazing in large-scale trials at three stocking rates obtained by varying paddock size. Measurements of animal gain, pasture yield and botanical composition are being made. Throughout all categories of the evaluation programme the same minimal inputs of fertilizer are applied. Virgin soil areas are selected and no attempt is made to change soil pH or neutralize exchangeable aluminium.

RESULTS AND DISCUSSION

Legumes

Since 1978, 1533 legume accessions have been evaluated, of which

57 per cent are species of Stylosanthes. Thomas and Andrade (1983) identified seven 'key' species for the 'cerrados' environment. These were Stylosanthes guianensis var. pauciflora (the "tardío" group), S. capitata, S. viscosa, S. macrocephala, Centrosema macrocarpum, C. brasilianum and Zornia brasiliensis. The latter is no longer regarded as a key species because of extreme problems of animal acceptability.

1. S. guianensis var. pauciflora

Pasture development in Latin America has placed much reliance on commercial cultivars of S. guianensis from Australia and Brazil. These are often referred to as the 'common' types of the species and are all highly susceptible to anthracnose. Newer accessions of 'common' types collected in South America and evaluated at CPAC were also badly attacked by the disease. In the last ten years a new morphologically distinct group has been recognized. These accessions, commonly referred to as the 'tardío' group, and identified as S. guianensis var. pauciflora are viscid and pilose; predominantly late-flowering with generally good anthracnose resistance. Plants of this type are only found in the savannas of Brazil and Venezuela.

At CPAC, 127 accessions of the 'tardio' group have been evaluated. All were well adapted to the climate and soil conditions. Almost all were late-flowering, initiating flowers in April or May. In a comparison of a number of Brazilian and Venezuelan lines there was marked variation in plant yield (Table 1). Brazilian accessions generally produced more dry-matter than Venezuelan accessions. Anthracnose resistance and digestible dry-matter (DDM) contents were also markedly higher in the Brazilian introductions. No significant

Table 1. Means and ranges for dry-matter yield, chemical composition and reaction to anthracnose of two groups of accessions of 'tardío' stylo from Brazil and Venezuela evaluated at CPAC, Brazil.

Group	DM Yield (g/plant)	DDM "In vitro" (%)	N Content (%)	Ca Content (%)	P Content (%)	Anthracnose Reaction[b] (1.0-5.0)
Brazil						
Range	7.2-34.0	37.25-48.78	1.58-2.04	0.60-0.96	0.08-0.18	1.0-3.0
Mean	12.5	42.75 (40.80)[a]	1.83 (7.71)	0.77 (5.03)	0.13 (2.07)	2.0
Venezuela						
Range	1.0-11.3	22.76-46.50	1.58-2.37	0.50-0.92	0.13-0.22	3.5-5.0
Mean	6.5	37.17 (37.52)	1.96 (7.92)	0.74 (4.93)	0.18 (2.43)	4.5
LSD[c]	3.4 ***	(2.07) ***	NS	NS	(0.14) ***	0.4 ***

a/ Arcsin transformation in parenthesis.
b/ 1.0 = no disease; 2.0 = few lesions, no defoliation; 3.0 = moderate leaf and stem lesions, little defoliation; 4.0 = severe leaf and stem lesions, severe defoliation; 5.0 = plant death.
c/ LSD = least significant difference; NS = not statistically significant; *** = very highly significant; P = 0.001.

differences in nitrogen (N) or calcium (Ca) contents were observed although Venezuelan accessions tended to have higher phosphorus (P) levels. The greater vigour and better anthracnose resistance of Brazilian accessions suggests that further germplasm collection should be concentrated in Brazil. Eighteen accessions have been selected and 7 are already under grazing (Table 2). One, CIAT 2243, has been named as the cultivar Bandeirante. Animals grazing an association of Andropogon gayanus cv. Planaltina and cv. Bandeirante have given maximum liveweight gains of 0.764 kg per head per day in the wet season and 0.202 kg per head per hay in the dry season in the first two years of a grazing trial.

2. S. capitata

Two-hundred and seventeen accessions from Brazil and Venezuela have been evaluated at CPAC. All accessions showed good climatic and edaphic adaptation and there was marked variation in dry-matter production. In a comparison of 107 introductions under cutting, 8 per cent were scored as high yielding, 28 per cent as moderate and 64 per cent as low yielding. In general, Venezuelan accessions were less vigorous than Brazilian introductions. Accessions also showed wide variation in flowering time. Sixty-one per cent initiated flowering in April, 32 per cent in February or March and only 7 per cent in January. Nevertheless, all introductions were excellent seed producers with CIAT 1405 yielding as much as 1000 kg per ha pure seed.

The primary limitation is anthracnose but substantial intraspecific variation and resistance occur. In general, Venezuelan accessions showed good resistance to the disease. One-hundred and twenty-one accessions were screened in the field by Lenné et al.

Table 2. Presentation dry-matter yields in the second wet season of some accessions of S. guianensis "tardío" associated with A. gayanus or B. brizantha under grazing at CPAC, Brazil.

Accession No.	Legume Presentation Dry-Matter Yields (t/ha)			
	A. gayanus		B. brizantha	
S. guianensis var. pauciflora	5.11.84	19.5.85	5.11.84	19.5.85
CIAT 2243 (control	0.87	2.21	0.68	3.45
CIAT 2078	0.13	1.07	0.27	1.08
CIAT 2191	0.70	2.87	0.53	2.13
CIAT 2203	0.65	2.34	0.53	2.51
CIAT 2244	1.01	1.58	0.54	1.88
CIAT 2245	0.66	1.67	0.47	1.09
CIAT 2315	0.26	1.08	0.33	1.39
CIAT 2328	0.29	1.43	0.36	2.18
S.E.[1]	0.16	0.46	0.08	0.25

1/ S.E. = Standard error of a treatment mean.

(1984) at CPAC and at two sites in Colombia over a three year period. In Brazil, 85 per cent of accessions were susceptible whereas 94 per cent were resistant in Colombia. In comparative seedling pathogenicity tests with isolates from both countries, those pathogenic to a wide range of accessions were found only in Brazil. This strongly suggested that specialized isolates of the fungus exist in Brazil (the native habitat and probable centre of diversity of the legume) and not in Colombia. This study emphasized the need to screen indigenous tropical pasture legumes for disease resistance in native habitats.

Four Brazilian accessions have been selected and two, CIAT 1019 and CIAT 1097, are in advanced stages of testing. In small-plot grazing trials, Thomas and Andrade (1984a) found that these accessions persisted well over 4 years with both A. gayanus cv. Planaltina and Brachiaria decumbens cv. Basilisk (Table 3). In larger grazing trials associations of these legumes with A. gayanus cv. Planaltina have given maximum liveweight gains of 0.780 kg per head per day in the wet season and 0.152 kg per head per day in the dry season over a two year period.

3. S. viscosa

One-hundred and sixty-nine accessions have been introduced into CPAC. Accessions have shown excellent climatic and edaphic adaptation and four introductions were selected on vigour and disease resistance for further evaluation. These are CIAT 1094, CIAT 2368, CIAT 2903 and CIAT 2923. All accessions were classified as mid- or late-season flowering types and begin producing flowers from February onwards.

Table 3. The performance of S. capitata CIAT 1019 and CIAT 1097 under grazing in association with A. gayanus cv. Planaltina and B. decumbens cv. Basilisk.

	Andropogon only	Andropogon+S. capitata 1019	Andropogon+S. capitata 1097	SE	Brachiaria only	Brachiaria+S. capitata 1019	Brachiaria+S. capitata 1097	SE
			TOTAL DRY-MATTER YIELD (t/ha/year)					
1978-79	1.73	1.04(71)[1]	1.60(62)	0.26	2.09	1.04(26)	2.59(25)	0.25
1979-80	4.58	2.64(38)	4.05(31)	0.58	4.54	4.34(14)	5.22(31)	0.35
1980-81	3.27	4.97(26)	4.97(26)	0.27	1.98	4.20(34)	4.10(38)	0.21
1981-82	3.56	4.87(24)	4.87(24)	0.27	2.58	3.86(21)	3.80(23)	0.27

1/ Values in parenthesis are legume contents (% dry-matter).

The major limitation to the use of the species is anthracnose. In 132 accessions evaluated for the disease, 22 per cent were moderately to highly susceptible whilst 78 per cent showed low susceptibility or no disease symptoms. CIAT 1094 is outstanding in this respect showing no disease problems for seven years. There is now a need to acquire information on compatibility with grasses, persistence under grazing and acceptability to animals.

4. S. macrocephala

One-hundred and seventeen accessions have been evaluated at CPAC. All accessions show excellent adaptation to edaphic and climatic conditions. Considerable intraspecific variation exists in dry-matter production and chemical composition. In a comparison under cutting of 38 accessions, 11 per cent were scored as high yielding, 37 per cent as moderate and 52 per cent as low yielding. At the end of the wet season digestible dry-matter contents ranged from 31.55 to 57.15 per cent, nitrogen contents from 1.33 to 2.09 per cent, calcium contents from 0.79 to 1.32 per cent and phosphorus contents from 0.12 to 0.28 per cent.

Accessions have proved the most resistant to anthracnose of all Stylosanthes species tested at CPAC. Only 20 per cent were highly susceptible compared to 79 per cent for S. scabra and 100 per cent for S. humilis. Most accessions begin to flower in February or early March, and only one CIAT 2133 flowered later in April. S. macrocephala is a prolific seed producer with pure seed yields of 350 kg per ha recorded in CIAT 1281 (formerly erroneously called S. bracteata CIAT 1582).

Six accessions CIAT 1281, CIAT 2039, CIAT 2053, CIAT 2133, CIAT 10007 and CIAT 10009 have been selected. CIAT 1281 persisted well in small-plot grazing trials with both A. gayanus cv. Planaltina and B. decumbens cv. Basilisk over a four-year period (Thomas and Andrade, 1984a), and was subsequently named the cultivar Pioneiro. More recent grazing studies have shown accessions CIAT 2039 and CIAT 2053 to be more vigorous than cv. Pioneiro (Table 4).

5. C. brasilianum

One=hundred and fifty-eight accessions have been introduced into CPAC, and have shown excellent adaptation to climatic and edaphic factors. Introductions were very vigorous and covered a given area rapidly. Most accessions flowered from early April onwards; only 5 per cent of the introductions flowered earlier than this time. Seed production was very good and tolerance to the dry season was moderate with some leaf loss.

The major constraint for the species has been the incidence of a complex of fungal diseases 'Rhizoctonia foliar blight' and 'Phomopsis leaf spot'. However, resistance occurred in the majority of lines tested. In an evaluation of 94 introductions, 79 per cent showed little or no disease symptoms and only 10 per cent were highly susceptible. Only 4 lines died from the diseases. On the basis of vigour, seed production and disease resistance 5 accessions (CIAT 5234, CIAT 5518, CIAT 5523, CIAT 5588 and CIAT 5824) have been selected for more advanced testing. Three of these accessions CIAT 5234, CIAT 5523 and CIAT 5824 are already under grazing. Legume contents (on a dry-matter basis) at the end of the first wet season in

Table 4. Presentation dry-matter yields and legume contents of accessions of *Stylosanthes macrocephala* associated with *Andropogon gayanus* under grazing at CPAC, Brazil.

Legume Accessions with *Andropogon*	Presentation Dry-Matter Yields (t/ha) of Andropogon-Legume Associations					
	3.11.82	30.5.83	7.11.83	24.5.84	8.11.84	20.5.85
Stylosanthes macrocephala						
CIAT 1281 (control)	1.20 (21)[1]	3.64 (11)	1.34[2]	2.57 (5)	1.66[2]	3.76 (7)
CIAT 10138	1.29 (18)	2.65 (15)	1.06	2.41 (3)	2.50	4.63 (2)
CIAT 2039	1.54 (71)	2.94 (51)	1.00	1.96 (22)	1.63	5.34 (22)
CIAT 2053	1.18 (68)	3.08 (54)	0.73	2.48 (25)	2.05	5.06 (21)
S.E.[3]	0.09	0.48	0.12	0.33	0.11	0.41

1/ Values in parenthesis are legume contents (% dry-matter).

2/ In samplings on 7.11.83 and 8.11.84 legumes were present but were below sampling height of 10 cm.

3/ S.E. = Standard error of a treatment mean.

the A. gayanus cv. Planaltina plots were estimated to be 67 per cent for CIAT 5824 and 82 per cent for accessions CIAT 5234 and CIAT 5523. The legume contents in plots of Brachiaria brizantha cv. Marandú were approximately 50 per cent of those in the A. gayanus plots.

6. C. macrocarpum

Fifty-eight accessions have been evaluated at CPAC and all showed excellent adaptation to climate and soil conditions. There were no significant pest or disease problems. The presence of anthracnose, 'Cercospora' leaf spot and the 'Rhizoctonia-Phomopsis' complex were recorded, but the incidence of these diseases was low. In general, accessions of C. macrocarpum showed better disease resistance than those of C. brasilianum. However, problems of flowering and seed production at CPAC continue to limit the potential of existing introductions. A breeding programme initiated at CIAT and continued at CPAC has produced hybrids between C. pubescens and C. macrocarpum that are high seed producers. Some 12 to 20 advanced lines, mostly F_6 and F_7 generations are under evaluation (E.M. Hutton, pers. com., 1985). Three of these hybrids are already being tested under grazing in small plots with A. gayanus cv. Planaltina and B. brizantha cv. Marandú.

7. New Germplasm

In recent years new legume germplasm from the genera Desmodium and Pueraria has been collected by CIAT in southeast Asia. In 1984-85, 79 new introductions of D. ovalifolium and 18 new introductions of D. heterophyllum were planted on the dark-red latosol and in the 'varzea' at CPAC. Although it is too early to make any

definitive comments D. ovalifolium accessions CIAT 3673, CIAT 13102 and CIAT 13135 appear more vigorous than CIAT 350 (the control) on the dark-red latosol. Thirty-six lines of P. phaseoloides, 8 lines of an un-named Pueraria species and 3 lines of P. lobata were also planted at CPAC. Introductions of P. phaseoloides appear to be more vigorous than those of P. lobata or Pueraria species. At the end of the establishment year accessions CIAT 744, CIAT 8834 and CIAT 9020 were more productive than the commercial control CIAT 9900.

Grasses

Since 1978 priority has been given to the evaluation of legumes. The number of grasses introduced was relatively low in comparison and totalled 154, of which 51 per cent were species of Panicum.

1. Panicum maximum

Fifty-one accessions evaluated on the dark-red latosol were classified morphologically into three groups:

a) The 'Hamil' group of giant robust types with large leaves and thick stems similar to the commercial cultivar 'Hamil'.

b) The 'Common' group of medium-sized types with predominantly basal leaves usually stemmy and similar to the commercial cultivar 'Common'.

c) The 'Gatton-Green Panic' group of grazing types with numerous leaves and fine stems similar to the commercial cultivars 'Gatton' and 'Petrie Green Panic'.

The range of variation in the accessions is shown in Table 5. The range of dry-matter production was wider in the 'Common' group

Table 5. Range of variation in dry-matter production, flowering and chemical composition in accessions of *P. maximum* grown over three years on a dark-red latosol at CPAC, Brazil.

Group	No. Accessions	DM Yield (kg/ha)	Inflorescence No. ($per\ m^2$)	Time of flowering	DDM[1] 'in vitro' (%)	N Content (%)	Ca Content (%)	P Content (%)
Common	29	1530-7476	10-140	Feb.-April	50.01-63.10	1.40-2.06	0.17-0.41	0.12-0.17
Gatton/ Green Panic	16	2207-6073	25-117	Feb.	53.07-67.46	1.34-2.21.	0.23-0.44	0.12-0.18
Hamil	6	2846-6594	21-64	Mar.-April	50.28-55.26	1.55-1.91	0.18-0.36	0.10-0.14

1/ DDM = Digestible dry-matter content.

than in the other two groups. None of the new 'Hamil' type accessions was more productive than the commercial control. All accessions of the "Gatton-Green Panic' group initiated flowering in February, whilst the introductions of the other types began to flower over a much longer period from February to April. Inflorescence production in a number of accessions of the 'Common' and 'Gatton-Green Panic' groups was twice that of the best 'Hamil' types. The chemical composition of some 'Common' and 'Gatton-Green Panic' types was markedly higher than that of the 'Hamil' types. None of the accessions was attacked by pests or diseases.

One accession, CIAT 6116, from the 'Gatton-Green Panic' group is already under grazing in association with two accessions of S. guianensis var. pauciflora CIAT 2243 and CIAT 2245. At the end of the second wet season legume contents in both associations were 72 per cent.

2. Andropogon gayanus

Accession CIAT 621 is now well-established in Brazil as the cultivar Planaltina. Of 21 accessions evaluated at CPAC, none was more productive than CIAT 621. Thirteen of the accessions began flowering in March; 7 (including CIAT 621) in April and only one CIAT 6243 (from Mali) flowered earlier at the end of January. No serious pest or disease problems were noted and CIAT 621 is known to be highly resistant to spittlebugs. The desirable forage characteristics of cultivar Planaltina were described by Thomas et al. (1981). More recent grazing studies reported by Thomas and Andrade (1984b) have demonstrated the remarkable constancy of dry-matter yield over time in

A. gayanus cv. Planaltina whilst that of commercial cultivars of Brachiaria decumbens, B. ruziziensis, B. humidicola and Panicum maximum declined substantially.

3. Brachiaria brizantha

Accession CIAT 6294 was released commercially in 1984 as the cultivar Marandú jointly by CPAC and the National Beef Cattle Research Centre (CNPGC) Campo Grande. The cultivar produces large amounts of seed and shows excellent resistance to spittlebugs unlike the commercial cultivars of B. decumbens or B. ruziziensis. In a small-plot grazing trial, associations between cv. Marandú and S. guianensis var. pauciflora CIAT 2243 and CIAT 2245 contained 59 and 51 per cent legume at the end of the second wet season. In a large grazing trial, an association of cv. Marandú and S. macrocephala CIAT 2039 gave maximum liveweight gains in the dry and wet season of 0.137 and 0.534 kg per animal per day respectively.

4. New Germplasm

Paspalum is a large genus of up to 250 species distributed in the tropics and sub-tropics, mainly in the Americas. On soils such as the red-yellow latosol, problems have been encountered with grasses of African origin. It is conceivable that species of Paspalum might show better adaptation to such soils. Accordingly, preliminary observations have commenced at CPAC with a number of Paspalum species. Already, P. conspersum and P. guenoarum have shown good adaptation to the red-yellow latosol. They are more vigorous than A. gayanus cv. Planaltina, appear to be resistant to spittlebugs, flower and produce

seed. Other species introduced into CPAC include P. maritum, P. mandiocanum, P. plicatulum, P. virgatum and P. densum.

In future at CPAC more emphasis should be given to the evaluation of grasses. In addition to Paspalum, recent collections have been made in Africa by CIAT and the number of accessions of Brachiaria species increased significantly in the germplasm bank. A large number of new introductions of P. maximum from the French research organization ORSTROM is also available in both Colombia and Brazil.

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