Multilocational testing of grasses and legumes in the humid tropics of South America

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ABSTRACT

Adaptability of 5 grass and 13 legume accessions tested in 34 regional agronomic trials throughout the South American humid tropics was assessed by conducting multilocational analysis on seasonal dry matter yield at 12 weeks regrowth. Among legumes, *Stylosanthes guianensis* CIAT 184 and 136, *Desmodium ovalifolium* CIAT 350, *Zornia latifolia* CIAT 728 and *Centrosema macrocarpum* CIAT 5065 were high yielding in both rainfall periods and showed high capacity to respond to better environmental conditions. *Centrosema brasilianum* CIAT 5234, *C. pubescens* CIAT 438 and *Desmodium heterophyllum* CIAT 349 had low productivity and low response to environmental quality. For grasses, *Andropogon gayanus* CIAT 621 outyielded *Brachiaria brizantha* CIAT 6780, *B. decumbens* CIAT 606, *B. dictyoneura* CIAT 6133 and *B. humidicola* CIAT 679 during the high rainfall period but had dry matter yields similar to the other accessions during the low rainfall period, except for CIAT 679. During minimum rainfall *B. brizantha* CIAT 6780 showed the highest ability to respond to quality changes of the environment, followed by *A. gayanus* CIAT 621 and *B. dictyoneura* CIAT 6133, whilst a lower response was recorded for *B. decumbens* CIAT 606 and *B. humidicola* CIAT 679. During maximum rainfall all accessions showed an intermediate response to better environmental conditions. This study demonstrated that a range of adapted forage legume and grass options are now available for the South American humid tropics.

Keywords: Adaptation, grasses, humid tropics, legumes, multilocational evaluation, South America

INTRODUCTION

Large areas of rainforests in tropical South America have been cleared and converted to pastures. Of the approximately 10 million ha of cattle pastures established in Amazonia, about 50 % are currently in advanced stages of degradation. This is mainly because of inappropriate management practices and the use of forage germplasm poorly adapted to the prevailing environmental conditions such as acidic, low-fertility soils and high pest and disease pressures (Serrão and Toledo 1990). National pasture research institutions and CIAT's Tropical Pastures Program recognised this problem. They are therefore collaborating within the International Tropical Pastures Evaluation Network (RIEPT) in the evaluation of adaptability of new grass and legume germplasm to climatic, edaphic and biotic conditions in the region's different ecosystems.

This paper reports on the results of a multilocational analysis on the adaptability of 5 grasses and 13 legumes evaluated in 34 RIEPT regional trials throughout the South American humid tropics.

METHODS

Source of information

This study used data from 34 RIEPT agronomic (type B) regional trials conducted between 1979 and 1991 in humid tropical ecosystems of Bolivia, Brazil, Colombia, Ecuador and Peru. Table 1 presents the range of geographic and environmental conditions covered by the sites, and Table 2 shows the grasses and legumes included in the study. RIEPT type B trials correspond to multilocational agronomic evaluation experiments for distinct grass and legume accessions sown in monospecific plots (2.5 x 5.0 m) in rows 0.5 m apart, with three replications. Toledo and Schultze-Kraft (1982) described the methodology for management and evaluation of the trials.

Analysis of information

Multilocational analysis of adaptability was performed on seasonal dry matter (DM) yield at 12 weeks regrowth. For this purpose the methodology described by Eberhart and Russell (1966), modified by Toledo et al. (1983), was applied. Environmental indices representing site mean DM yield minus overall mean yield of all accessions, except the one under consideration, were calculated for each accession. Based on these environmental indices and the yields of each accession at each site, linear regressions were calculated where the intercept (a) represents the mean DM yield of an accession across locations and the slope (b) is the ability of an accession to respond to environmental changes.

RESULTS AND DISCUSSION

For legumes, *S. guianensis* CIAT 184 proved to be the outstanding accession, with excellent DM yields and response to quality changes in the environment in both precipitation periods (Table 2, Figure 1). *S. guianensis* CIAT 136 performed similar to *S. guianensis* CIAT 184 during maximum rainfall; however, during minimum precipitation, its productivity and particularly its capacity to respond to environmental quality were reduced in comparison with CIAT 184. *D. ovalifolium* CIAT 350, *Z. latifolia* CIAT 728 and *C. macrocarpum* CIAT 5065 were highly productive accessions during both periods of precipitation and showed a high response ($b \geq 1$) to quality changes in the environment, although CIAT 5065 had a somewhat lower capacity to respond to environmental quality during maximum rainfall. This fact may be associated with its lack of tolerance to high freatic levels. Of this group of superior accessions, *S. guianensis* CIAT 184 has been released as cv. Pucallpa in Peru and *D. ovalifolium* as cv. Itabela in Brazil.

Centrosema acutifolium CIAT 5112 maintained its productivity around average during both periods of precipitation and showed intermediate response to environmental changes. The other *C. acutifolium* accession (CIAT 5568), in comparison, was less productive, possibly due to its observed higher susceptibility to fungal disease. Its ability to respond to environmental quality, being similar to that of CIAT 5112 during maximum rainfall, increased remarkably during minimum precipitation.

Centrosema pubescens CIAT 5189 and *Pueraria phaseoloides* CIAT 9900 had DM productions below average and showed intermediate response to quality changes in the environment. This was not expected in the case of CIAT 9900 since tropical kudzu is known to be a well-adapted productive legume throughout the humid tropics. It seems that the performance of this accession reflects its susceptibility to cutting and requirements of higher levels of soil fertility than those prevailing at the experimental sites. The latter also applies for CIAT 5189.

Zornia glabra CIAT 7847 yielded around or above average; its response to better environmental conditions, being intermediate during the high rainfall period, decreased somewhat during the low rainfall season.

C. brasilianum CIAT 5234, *C. pubescens* CIAT 438 and *D. heterophyllum* CIAT 349 had relatively low DM yields during maximum and minimum rainfall periods and showed little response to better environmental conditions. In the case of CIAT 5234 this was due to considerable defoliation caused by rhizoctonia foliar blight, especially during the maximum precipitation period, while the performance of CIAT 349 and 438 seems to reflect higher nutrient requirements, in addition to attacks by leaf-eating insects and susceptibility to cercospora leaf spot of the latter accession.

For grasses (Table 2), average DM yields were, as could be expected, in general higher than those of legumes. *A. gayanus* CIAT 621 outyielded the other species during the high precipitation period, but all of them had a similar intermediate response to improvement in the environment. During the low rainfall period, all accessions, with the exception of *B. humidicola* CIAT 679, obtained similar good DM yields. Response to environmental quality during minimum rainfall was high for CIAT 6780, followed by CIAT 621 and 6133, and intermediate for CIAT 606 and 679. In both periods B. humidicola CIAT 679 had the lowest DM yield.

CONCLUSIONS

Results of multilocational agronomic evaluation of forage plants in the humid tropics of South America indicate that *S. guianensis* CIAT 184 and 136, *D. ovalifolium* CIAT 350, *Z. latifolia* CIAT 728 and *C. macrocarpum* CIAT 5065 are legumes of high productivity and adaptability. For grasses, *A. gayanus* CIAT 621 and *B. brizantha* CIAT 6780 showed high DM production and intermediate to high adaptability. In addition, *B. dictyoneura* 6133 showed a good response to better environments during minimum rainfall conditions. There are now germplasm options available to pasture researchers in humid tropical ecosystems for advanced testing and development of adapted grass and legume cultivars. These adapted cultivars should permit productive and stable pastures to replace degraded areas.

ACKNOWLEDGEMENTS

We are grateful to the pasture scientists of national research institutions in tropical South America who participate in the RIEPT for providing the data used in this study.

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Table 1. Range of environmental conditions at the 34 regional trial sites.

Parameter	Minimum	Maximum
Location and climate		
Latitude	17°12'S	9°10'N
Longitude (West)	39°10'	76°59'
Altitude (m.a.s.l.)	4	990
Rainfall (mm/year)	1200	4660
Mean annual temperature (°C)	20.3	28.3
Soil		
Sand (%)	1	80
Clay (%)	10	68
pH	3.7	6.4
Organic matter (%)	0.6	8.8
P (ppm)	<1	22.0
Al saturation (%)	0	91.7

Table 2. Mean DM yield (a) and adaptability index (b) for grasses and legumes.

Species	CIAT accession no.	Maximum precipitation a (kg/DM/ha)[2]	b	S_b[1]	R^2	Mininum precipitation a (kg/DM/ha)	b	S_b	R^2
GRASSES									
A. gayanus	621	6592a[3]	0.87	0.21	0.40**[4]	4300a	1.02	0.09	0.82**
B. brizantha	6780	5275b	0.86	0.37	0.44*	4338a	1.42	0.15	0.93**
B. dictyoneura	6133	4942b	0.55	0.13	0.56**	3498ab	1.02	0.09	0.88**
B. decumbens	606	4880b	0.78	0.12	0.60**	4287a	0.79	0.13	0.54**
B. humidicola	679	4215b	0.94	0.17	0.73**	3225b	0.68	0.07	0.90**
LEGUMES									
S. guianensis	184	3654a	1.42	0.20	0.71**	2845a	1.48	0.18	0.77**
S. guianensis	136	3470a	1.49	0.20	0.64**	2315abc	0.92	0.13	0.63**
D. ovalifolium	350	3065ab	1.20	0.15	0.69**	2397ab	1.34	0.10	0.86**
Z. latifolia	728	2752bc	1.17	0.10	0.83**	2351ab	1.15	0.15	0.69**
C. macrocarpum	5065	2564bcd	0.86	0.18	0.51**	2485ab	1.43	0.17	0.74**
Z. glabra	7847	2417bcde	0.88	0.12	0.80**	2244abcd	0.66	0.22	0.40**
C. acutifolium	5112	2267cdef	0.82	0.12	0.81**	2126bcde	0.92	0.14	0.82**
P. phaseoloides	9900	2034defg	0.64	0.09	0.66**	1842bcdef	0.89	0.11	0.69**
C. pubescens	5189	1773efgh	0.95	0.08	0.89**	1667def	0.73	0.11	0.71**
C. pubescens	438	1688fgh	0.64	0.07	0.72**	1402fg	0.53	0.09	0.52**
C. acutifolium	5568	1511gh	0.89	0.12	0.87**	1704cdef	1.33	0.22	0.80**
D. heterophyllum	349	1435gh	0.48	0.14	0.44**	950g	0.57	0.05	0.88**
C. brasilianum	5234	1172h	0.35	0.10	0.44**	1548ef	0.69	0.08	0.84**

1/ Standard error of b.
2/ Regrowth of twelve weeks.
3/ Means followed by the same letter are not significantly different ($P < 0.05$).
4/ *, ** regression significant at $P < 0.05$, $P < 0.01$, respectively.

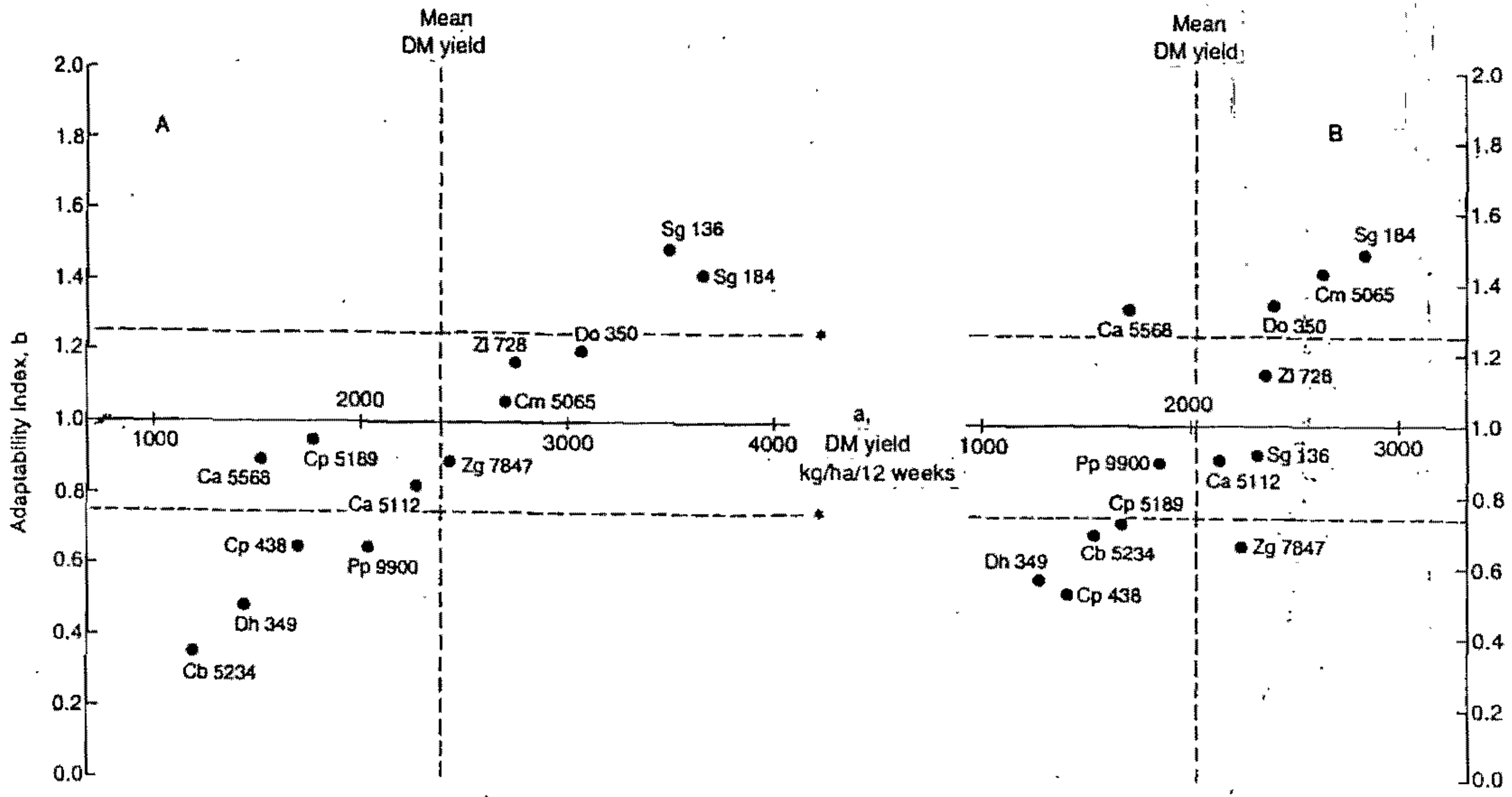

Figure 1. Classification of legumes by productivity level (a) an adaptability index (b) during maximum (A) and minimum (B) rainfall. (* = confidence interval for b around 1.)