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are therefore higher for the latter than for *B. decumbens*. **Harvest costs** depend basically on the method used for harvesting, and are highest in the case of manual harvesting of *A. gayanus* seed which is more labor demanding. Mechanical harvesting is cheaper in both grass species, but 1.7 times higher seed yields are obtained with manual harvesting. Thus, the final comparison between harvesting methods has to be done in terms of the price at which seed can be produced in each instance, and not just on the basis of production costs.

Table 90 shows the minimum price which could be charged for the seed to maintain the target 10% IRR. Prices can be substantially lowered through the use of manual harvesting, but this method can only be used in small areas due to high labor requirements. For a given harvesting method, economies of scale are minimal. The largest reduction in seed price can be achieved by obtaining sustained high seed yields. Using the *B. decumbens* crop for seed production during five instead of three years would have almost no effect on seed price, as shown in Table 91. Moreover, it is likely that seed yields will decrease over time and/or more fertilizer will be required; thus the impact of longer crop duration might be to increase rather than decrease production costs.

Table 91. Effect duration of crop productivity of Brachiaria decumbens on the price of seed[1] (1979 US$/kg pure seed).

Pasture duration (years)	Area planted (ha)				
	25	50	100	200	300
3	21	20	18	18	17
5	22	19	17	17	16

1 Prices shown are estimated by fixing the internal rate of return at 10% assuming an average yield of 30 kg/ha of pure seed of Brachiaria decumbens, and using mechanical harvesting.

If average yields are achieved, the price of pure seed of *B. decumbens* should be between US$15/kg - US$15/kg-20/kg, and US$8/kg-19 kg for *A. gayanus* seed. Assuming a 90% purity of commercial classified seed, price of *B. decumbens* seed should be half the price which currently prevails in the region. It can be concluded that the high prevailing price is due to low seed yields, high risk, high profit margin or a combination of these factors.

TRANSFERENCE OF TECHNOLOGY

This section was reorganized during 1979 with the following objectives: (a) to coordinate the technical aspects of training activities; (b) to propose the strategy and mechanisms for validation of technology on tropical pasture production and utilization; and (c) to coordinate activities related to international collaboration.

Training

A total of 42 professionals received training during 1979 in the various sections of the Program to continue the efforts on developing and strengthening a network of scientists and technicians working on tropical pastures on acid, infertile soil conditions in Latin America (Table 92).

Among these, eight visiting research associates participated in collaborative projects with universities in Canada, Colombia, England, France, United States and West Germany, to fulfill requirements for MS, PhD, or equivalent degrees. In addition, five visiting research associates and nine postgraduate interns for research participated in projects related to specific activities within the Program. The main purpose of these types of training activities is the strengthening of national programs to conduct independent and cooperative research with CIAT at the regional level.

Twenty four professionals from nine countries in the target area of the Program in Latin America, representing research and development institutions participated in the Second Course on Research on Tropical Pasture Production and Utilization conducted during the first semester 1979. A third course with similar objectives has been planned for the first semester in 1980.

Table 92. Countries of origin of professionals trained in Tropical Pastures at CIAT in 1979.

Country	No. of professionals	Country	No. of professionals	Country	No. of professionals
Antigua	1	Colombia	11	Perú	5
Argentina	1	Cuba	4	Venezuela	7
Belize	3	Dominican Republic	1	Australia	1
Bolivia	3	Ecuador	3	Holland	2
Brazil	6	Guatemala	1	United States	5
Chile	1	Nicaragua	3	West Germany	2
				Total	60

1 The disciplines in which training participants specialized include Agronomy, Animal Health, Economics, Enthomology, Germplasm, Production, Seed Production, Soil Microbiology, Soils, Pasture Establishment, and Pasture Utilization.

Experiments for training purposes

Several experiments have been established at CIAT-Quilichao to serve as a basis for training on research methodology on pasture evaluation, and on methodology related to regional trials on adaptation of tropical pasture species to acid infertile soil conditions. In addition to training purposes, experiments on weed control were also conducted.

As part of the training program, two experiments were established in late 1977 to determine the relative adaptation of selected grass and legume ecotypes under grazing and forage species under cutting, to different levels of soil fertility at CIAT-Quilichao. Although little change occurred due to fertilizer treatments, except for a significant increase in available P and exchangeable Ca, selected grass and legume ecotypes responded differently and some showed good dry matter yields indicating remarkable adaptation to these conditions (Figures 77 and 78).

On the basis of first year yields, *Cynodon dactylon* cv Coast-cross 1 could be considered the best adapted improved short-creeping grass according to criteria on plant survival, tolerance, and adaptation to acidity and low soil fertility developed by the Soil Plant Nutrition section, compared to the native grass *Paspalum notatum,* producing a similar dry matter yield at the highest fertility level with 85 and 67% relative yield at the medium and low fertility levels, respectively. *Digiratia decumbens* and *Cynodon nlemfuensis* performed well only at the highest soil fertility level. *Brachiaria humidicola, B. decumbens* and *Melinis minutiflora* performed very well; *B. decumbens* outyielded all other grasses in this group. *Andropogon gayanus* 621, *Panicum maximum* and *Paspalum plicatulum* were the best adapted, tall-fufted grasses; *P. maximum* produced the highest dry matter yields during the first year.

The best adapted and more productive legume ecotypes which also were relatively disease-free were *Desmodium ovalifolium* 350, *Centrosema* sp. 438 and *Pueraria phaseoloides* for the trailing types, and *Stylosanthes hamata* 118 and *S. capitata* 1019 for the bush types. Within this last group, *Macroptilium* sp. 535, *S. guianensis* 136 and 184 performed relatively well at the beginning but showed very little persistence towards the end of the first year due to fungal diseases.

Figure 79 shows the results with the forage species. *Pennisetum purpureum* cv. H-534 was the only species producing high dry matter yield at the higher soil fertility level; however, the relative yield at the medium and low levels were below the limits for good

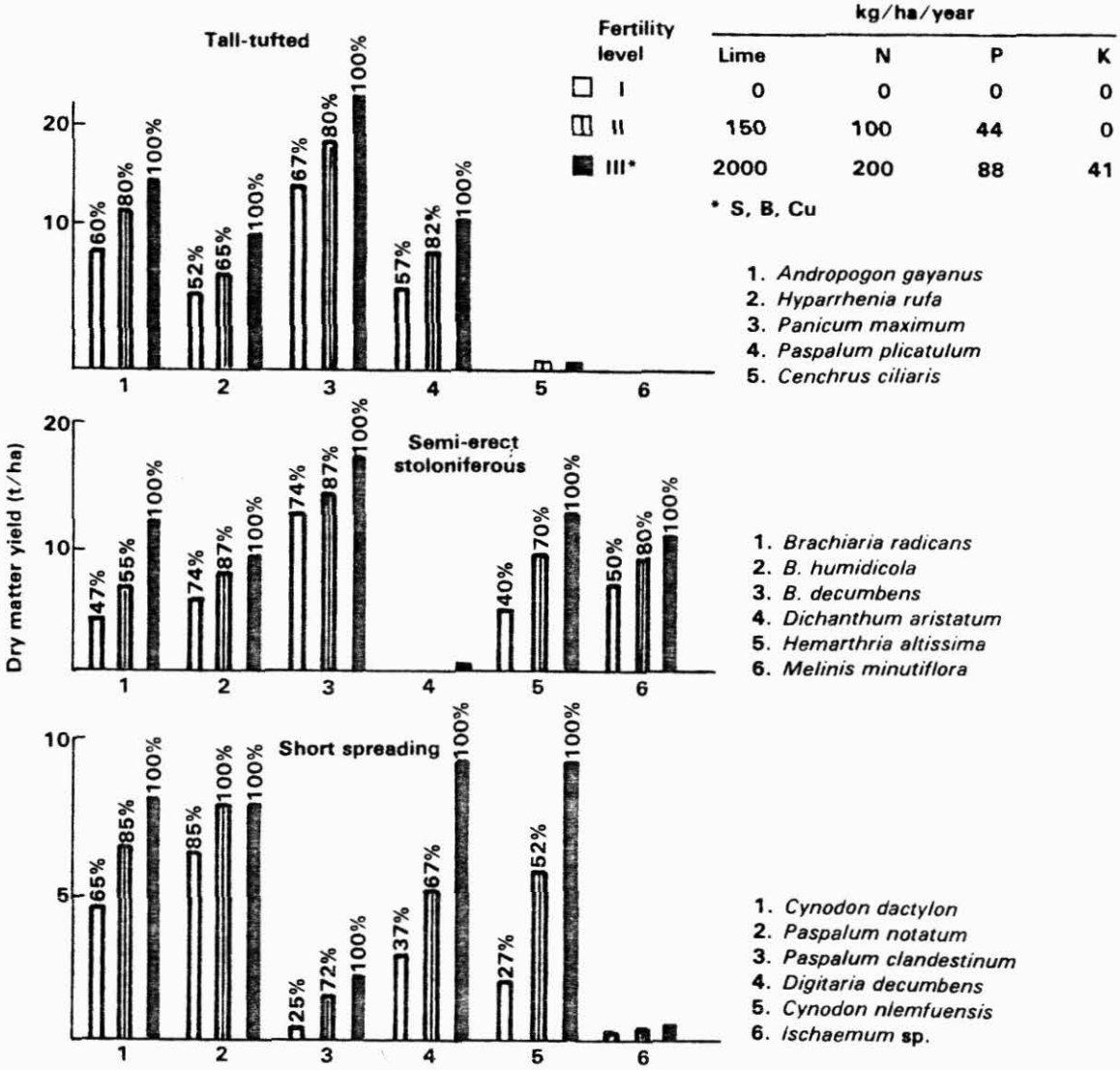

Figure 77. First year dry matter yields and differential responses of three tropical grass groups to three soil fertility levels at CIAT-Quilichao, 1979.

adaptation. *Axonopus scoparius* was better adapted but its productivity during the dry season was only 10% of the annual yield, indicating poor adaptation to drought. All of the other species, including good materials such as *Saccharum officinarum, Manihot sativa,* and *Leucaena leucocephala* performed poorly, showing the limitations in the use of forages for feed supplementation during the dry season under acid, infertile soil conditions.

Table 93 shows the results of the evaluation of selected grass and legume ecotypes for adaptation at CIAT-Quilichao. This experiment was part of the network of regional trials which was established in 24 sites in eight countries in the target area of the Program. After 16 months, the three grasses were performing very well without any significant difference in dry matter yield and growth rates, and *S. capitata* 1019 and 1405 were outyielding all of the other legumes and were observed relatively free of diseases and insect-pests.

Validation of Technology

Results of experimental work and of evaluation of improved pasture species in the regional trials network are very encouraging.

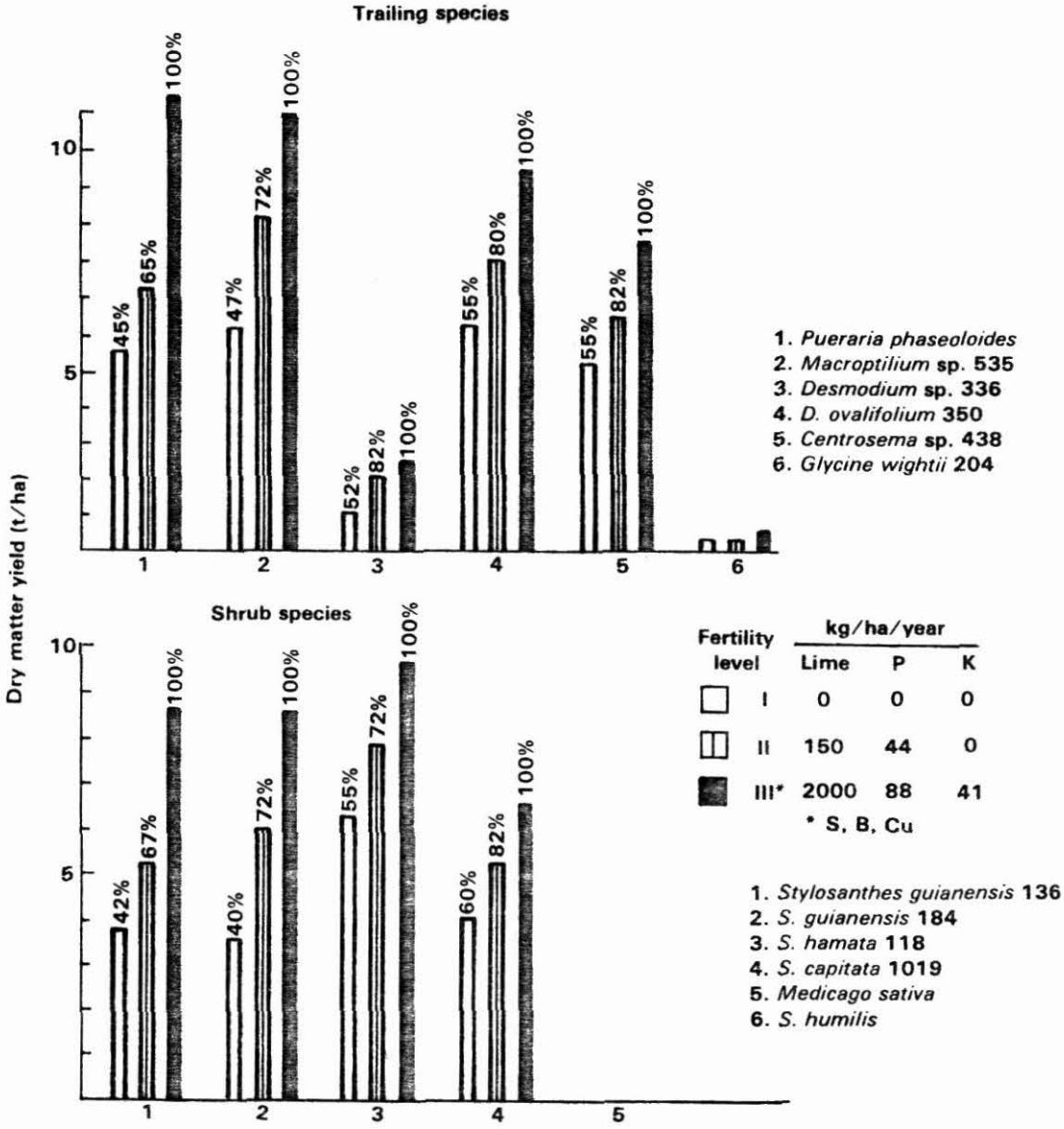

Figure 78. First year dry matter yields and differential responses of two tropical legume groups, to three soil fertility levels at CIAT-Quilichao, 1979.

The strategy that has been considered for the validation of technology in the near future includes: (a) the identification of active development institutions in the target area of the Program; (b) the training of professionals in the validation and transfer of technology; and (c) the participation in all activities related to regional trials to identify germplasm that could be used in validation trials at the farm level.

Regional trials

During 1979, the Tropical Pastures Program focused attention on the organization and execution of the Regional Trials Network. A Regional Trials Committe was formed in order to integrate other sections of the Program in the handling of the Network.

The range of ecosystems included and the technical and economic constraints most common to the participant institutions in the Network were taken into account by the committee in the elaboration of an Organization and Methodology proposal for the evaluation of the Regional Trials Network.

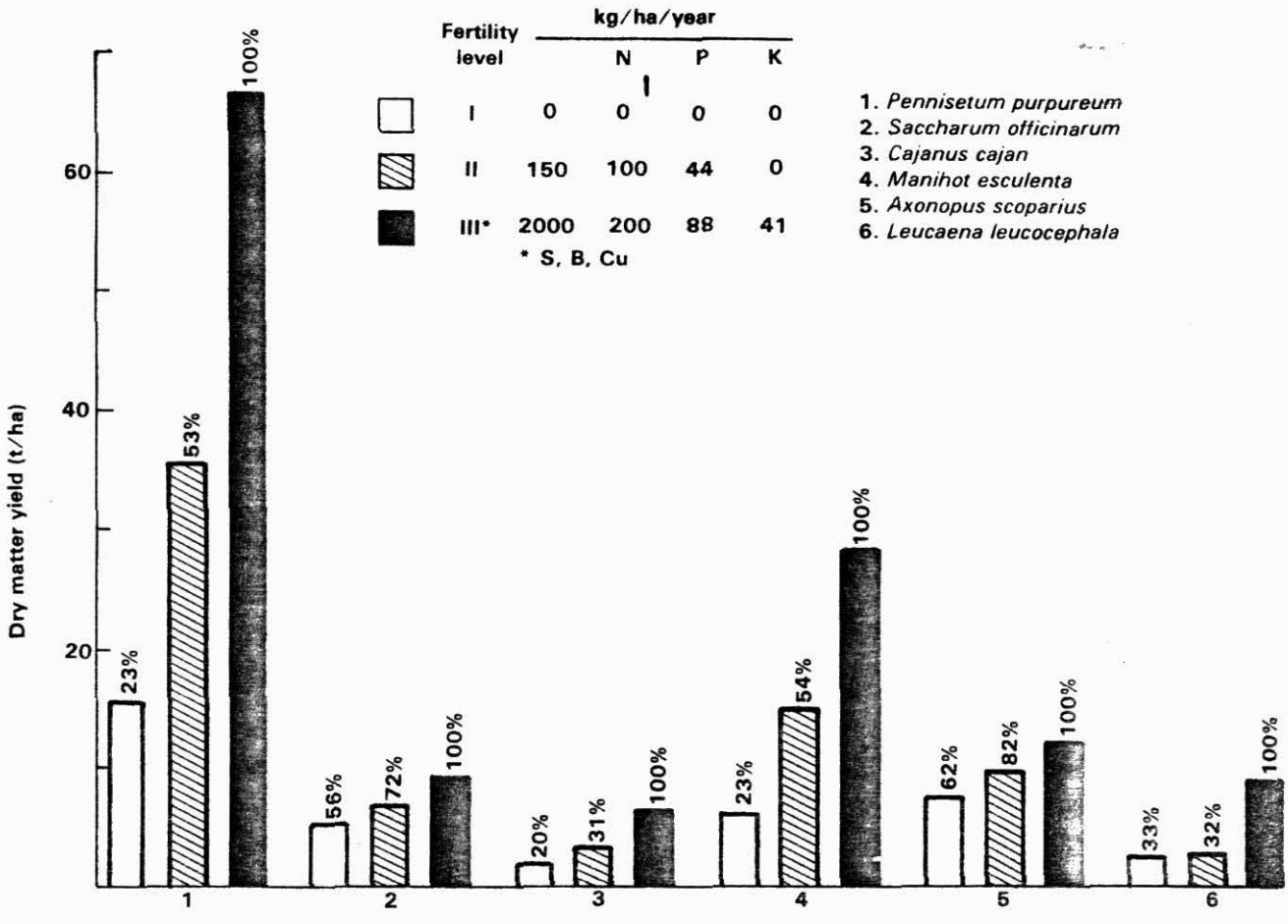

Figure 79. First year dry matter yields and differential responses of forage species to three soil fertility levels at CIAT-Quilichao, 1979.

This proposal was submitted for discussion and approval to the attendants of a workshop on the Regional Trials Network held at CIAT, October 1-4, 1979. Ninety-one scientists and officers of institutions of 14 countries participated (Table 94).

The approved proposal clearly establishes the orientation of the Regional Trials Network towards studying pasture germplasm adaptability to the different major ecosystems rather than considering the network as a medium for technology validation.

An experimental sequence for germplasm evaluation through the network was approved (Figure 80). In Regional Trials A (RTA), the survival to main factors of the ecosystem (climate, soil, diseases and insects) will be studied. This first step included a large number of entries (more than 100) to be tested in few sites representing the major ecosystems.

The Regional Trials B (RTB) should evaluate a reduced number of entries (approximately 25) selected for each major ecosystem from the RTA. This RTB will be carried out in subecosystems within a major ecosystem. At this stage of the evaluation, dry matter yield of individual ecotypes is measured during the periods of maximum and minimum rainfall.

The discussions during the workshop were restricted to the evaluation methodologies of RTA and RTB. It was agreed that a uniform evaluation system should be used to obtain reliable and comparable data throughout the network.

Table 93. Dry matter yields and average growth rates of selected grass and legume ecotypes under grazing 16 months after establishment at CIAT-Quilichao, 1978-79.

Ecotypes	Dry matter[1] yield (kg/ha)	Production (kg/ha/day)
Grasses		
Andropogon gayanus 621	27,132a[2]	56.7a
Brachiaria decumbens 606	25,964a	56.8a
Panicum maximum	33,089a	67.1a
Average	28,728	60.2
Legumes		
Pueraria phaseoloides 9900	9,697c	19.0c
Desmodium heterophyllum 349	6,005d	12.3d
D. ovalifolium 350	9,187c	19.9c
Stylosanthes capitata 1405	17,514a	36.7a
S. capitata 1019	18,170a	37.1a
S. hamata 147	13,055b	26.9b
Centrosema pubescens	7,975c	17.3cd
Centrosema sp. 438	8,869c	17.8c
Macroptilium 535	8,155c	15.8cd
Average	8,033	27.0

1 80°C for 36 h.
2 Numbers within colums followed by the same letters are not significantly different at the 0.05 level.

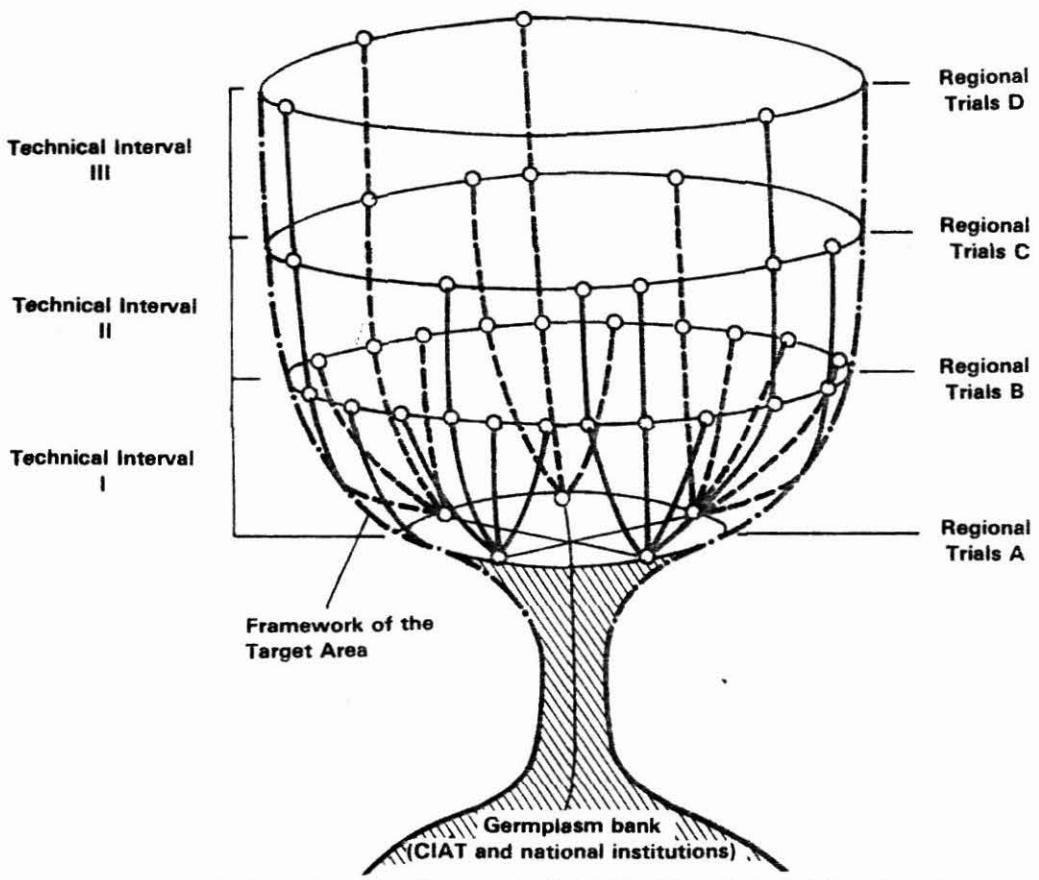

Figure 80. Germplasm flow through the Tropical Pastures Regional Trials Network.

Table 94. Participants in the workshop on the Network of Regional Trials for Adaptation of Tropical Forage Species held at CIAT, October 1-4, 1979.

Country	Institution	Number of participants by Institutions	Countries
Australia	Davis Laboratory	1	1
Bolivia	Centro de Investigación Agrícola Tropical, Santa Cruz	2	2
Brazil	CEPLAC, Bahía	1	
	CIAT-CPAC, Brasilia	3	
	EMAPA, Maranhao	1	
	EMBRAPA, Brasilia	1	
	EMBRAPA/CENARGEN, Brasilia	2	
	EMBRAPA/CNPGC, Mato Grosso	1	
	EMBRAPA/CNPGL, Minas Gerais	3	
	EMBRAPA/CPAC, Brasilia	3	
	EMBRAPA/CPATU, Pará	2	
	EMGOPA, Boiás	1	
	EPAMIG, Minas Gerais	3	
	FAO/UEPAE, Teresina, Piauí	1	
	IAPAR, Paraná	1	23
Colombia	CENICAFE	1	
	CIAT	20	
	Fondo Gandero del Putumayo	1	
	ICA	4	26
Cuba	Instituto de Ciencia Animal	1	
	Ministerio de Agricultura	4	5
Ecuador	Escuela Superior Politécnica de Chimborazo	2	
	INIAP	4	6
Guyana	Livestock Development Co. Ltd.	1	
	Ministry of Agriculture	1	2
Jamaica	Ministry of Agriculture	1	1
Mexico	INIA	1	1
Nicaragua	INTA	1	1
Peru	COPERHOLTA, Tarapoto	1	
	INIA/CIA, Tarapoto	1	
	INIA-NCSU, Yurimaguas	2	
	IVITA, Pucallpa	2	
	Universidad Agraria "La Molina", Tarapoto	1	7
Suriname	Ministry of Agriculture	1	1
Trinidad	Ministry of Agriculture	1	1
Venezuela	Centro Nacional de Investigación Agropecuaria	1	
	FONAIAP	3	
	FUSAGRI	1	
	Universidad Central de Venezuela	5	
	Universidad de Oriente	2	
	Universidad de Zulia	2	14
	Total of participants		91

Table 95. Tropical Pastures publications issued in the established CIAT series during 1979.

Code	Title	Language	Pages	Press run
02E1G-78	Annual Report 1978	English	182	940
02S1G-78	Separata Informe Anual 1978	Spanish	193	1500
05EG-1	Handbook for the Collection, Preservation and Characterization of Tropical Forage Germplasm Resources	English	102	500
05SG-1	Manual para la Colección, Preservación y Caracterización de Recursos Forrageros Tropicales	Spanish	106	500
03EG-5	Pasture Production in Acid Soils of the Tropics	English	488	2917
03SG-5	Producción de Pastos en Suelos Acidos de los Trópicos	Spanish	524	3020
08SG-1	Resúmenes Analíticos sobre Pastos Tropicales, Vol. I	Spanish		1500
01SG-1	Boletín Informativo de Pastos Tropicales No. 1	Spanish		1200

Figure 81. Location of the first Regional Trials for adaptation of tropical forage species in Latin America by ecosystems.

It was also approved that the network should include Regional Trials C and D in which selected germplasm from RTB (5 to 10 entries) should be evaluated in grass/legume mixtures under grazing. The methodologies for these two levels will be discussed in a future workshop planned for 1981.

Reports of the first Regional Trials already established were presented. Figure 81 shows the location of the existing trials in the target area.

Eventually the Regional Trials Network will provide information to the national institutions and to CIAT about the range of adaptability of pasture germplasm to specific ecological conditons. This information should be a solid basis for extrapolating tropical pastures research findings throughout the target area of the Program.

Printed Media

New titles in the area of tropical pastures published by CIAT in 1979 are shown in Table 95. At CIAT's Documentation Center a newsletter on tropical pastures (in Spanish) was initiated to provide relevant network information to researchers, basically in Latin America.

CIAT/IFDC PHOSPHORUS PROJECT

The objective of the CIAT based IFDC Phosphorus Project is to develop a phosphorus management strategy for the various crops and cropping systems now employed on the acid infertile soils of subtropical and tropical Latin America. Since the soils under consideration are low in both available and total P and generally have a high P fixation capacity, the P needs of the soil as well as the plant must be considered. It is not likely that these P needs will be accommodated through the use of triple- or simple-superphosphate (TSP and SSP, respectively) because of their high cost per unit of phosphate. Also, since these forms of P are quite soluble, a large percentage of the P is fixed by the soil and thus, in part, is not available to the plant.

It seems reasonable, therefore, that less available forms of P such as phosphate rock (PR), partially acidulated PR, cogranulated mixtures of S with PR, and cogranulated mixtures of TSP or SSP with PR may be reasonable alternatives to either TSP or SSP. Not only are these forms of P less likely to be fixed by the soil but their residual value should prove to be superior to that of the more available forms of P. It is also logical to take advantage of the soil acidity by using PR or other similar P carriers that will respond favorably under an acid environment.

In addition, the cost per unit of P as PR is about one-third that for TSP or SSP. In this regard, South America is fortunate in that there are some 17 known major PR deposits (CIAT Annual Report, 1978).

A series of greenhouse and field experiments have been established in Colombia, Ecuador, and Peru in which many of these South American PRs and their altered products are being tested for agronomic effectiveness using several different test crops. To date, many of these PR carriers appear to be promising and in some instances have shown to be superior to TSP.

Phosphate Rocks

A greenhouse experiment was conducted on an Oxisol from Las Gaviotas in the Colombian Llanos Orientales, to compare the agronomic effectiveness of 18 different phosphate rocks (PR) with TSP, and *Panicum maximum* as the test crop. Yield results are given in Table 96.

The PRs which are known to be highly reactive such as North Carolina, Fosbayovar, and Gafsa performed nearly as well as TSP. Other PRs such as South Africa, Florida, Huila, Maranhao, Arad, and Pesca also appear promising for direct application. In general, the effectiveness of all the rocks increased with higher rates when compared to simiar rates of TSP.

In a field experiment conducted on a Carimagua Oxisol with *Brachiaria decumbens,* six PRs were compared to TSP. This long-term experiment which was established in 1976 included application rates ranging from 0 to 400 kg P_2O_5/ha, all broadcast and incorporated into the topsoil. To date, the grass has