PASTURE ESTABLISHMENT AND MANAGEMENT IN THE LLANOS ORIENTALES OF COLOMBIA

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ABSTRACT

The establishment of pastures in the Llanos Orientales of Colombia is relatively easy during several months of the year, but the cost is high, mainly because of the fertilizers and the tillage required to control the native vegetation and prepare the soil. At the Centro Nacional de Investigaciones Agropecuarias in Carimagua, species and ecotypes are being sought that are tolerant to acidity and efficient in the utilization of the available nutrients in the soil, thus trying to reduce the cost of fertilizers and soil amendments. On the other hand, different tillage and sowing systems are being studied in order to reduce the costs of controlling the vegetation and the risk of erosion during pasture establishment. *Brachiaria decumbens* is probably the most widespread grass in tropical America and the one that is most frequently planted at present. As for grass/legume associations in Carimagua, good results have been obtained with *Pueraria phaseoloides* and *B. decumbens;* great domination of the legume over *Hyparrhenia rufa* and *Melinis minutiflora* has been observed. A challenge for the present and the future, for those who work in pasture establishment and maintenance, is to design systems that allow stable and persistent associations among legumes and grasses such as *B. decumbens,* starting many times not with the native savanna but with established pastures.

Pasture establishment in the Llanos Orientales of Colombia is relatively easy due to the favorable environmental conditions that prevail during several months of the year. The Centro Nacional de Investigaciones Agropecuarias (CNIA) at Carimagua, where almost all the work and observations on which the report is based were carried out, is located at 4°37'N; at an altitude of 175 meters. The mean temperature is 26°C, with an annual mean rainfall of 2200 mm (ranging from 1450 to 2500 mm) over a six-year period, and with a mean evapotranspiration potential of 2200 mm. The rainy season normally begins in April and terminates towards the end of November. As can be observed in Figure 1, the monthly rainfall from May to October averages more than 200 mm. Moreover, the frequency of dry periods of more than a week during said season is low, except for August, when it is slightly longer.

The soils are Oxisols (Tropeptic Haplustox isohyperthermic), fine-clayey mixed, with very flat to softly sloping lands (2 to 3% maximum) and excellent physical conditions. The most important characteristics are given in Table 1. It is evident that the

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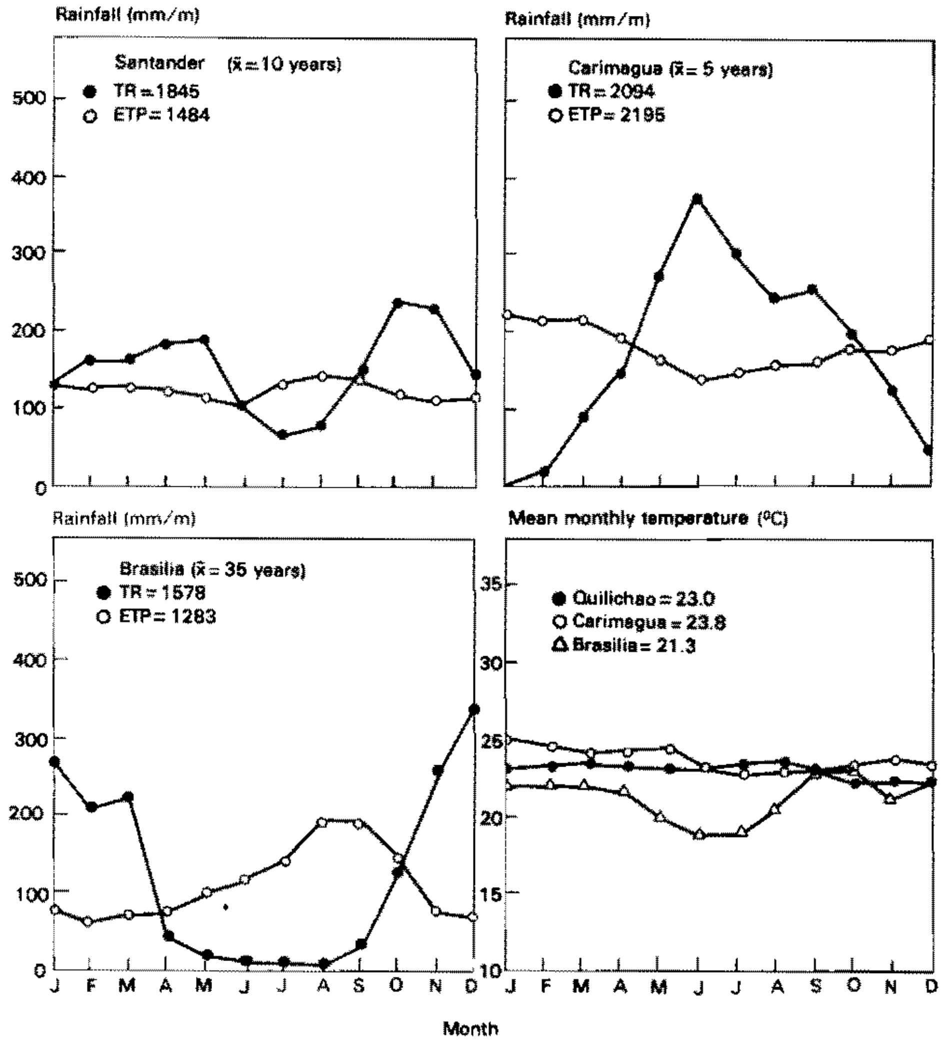

Figure 1. **Rainfall and mean temperature at Carimagua, State of Meta, Colombia (Lat. 4°37'N, long. 71°36'W; alt. 200 m); Quilichao, State of Cauca, Colombia (Lat. 3°06'N; long. 76°31'W; alt. 990m); and Brasilia, FD, Brazil (Lat. 15°36'S; long. 47°42'W; alt. 1010 m).**

principal problems for pasture establishment in Carimagua lie in the low fertility of the soils and their high level of acidity.

Although pasture establishment is relatively easy, it is too expensive and there is a great danger of erosion when traditional systems are used. Therefore, research at Carimagua has been focused on the reduction of costs and the risk of erosion.

SELECTION FOR EDAPHIC CONDITIONS

The low fertility and high acidity of the soil can be modified by applying fertilizers and lime. An alternative consists in selecting species that are more tolerant to low fertility and acidity of the soil.

Fertilization with phosphorus

Tropical crops, especially forages, vary greatly in their P requirements (5). In 1977 a

Table 1. **Characteristics of an Oxisol (Tropeptic Haplustox, fine-clayey, mixed, isohyperthermic).**

Horizon	Clay	Sand	pH (H_2O)	OM	Exchangeable cations Al	Ca	Mg	K	CEC	Al saturation	Available P Bray II	Available H_2O
cm	%	%		%	meq/100 g					%	ppm	%, vol
0-20	37	6	4.9	3.1	2.8	0.2	0.2	0.1	3.4	82	0.9	9
20-51	39	5	5.0	1.5	2.0	0.1	0.1	0.1	2.3	85	0.4	7
51-82	40	5	4.8	0.8	1.9	0.1	0.1	0.1	2.2	84	0.9	5
82-117	40	5	5.4	0.6	1.1	0.1	0.1	0.1	1.6	69	0.4	5
117-132	48	5	5.8	0.4	-	0.2	0.2	0.3	0.8	-	0.4	6
132-152	52	4	5.9	0.3	-	0.2	0.2	0.3	0.7	-	0.4	7

glasshouse trial was conducted using an Oxisol from Carimagua, to which 0 to 240 kg P/ha were applied (3). Plant-available P was determined by utilizing the Bray II extractant solution and Cate and Nelson's method (1) for determining critical levels; these varied from less than 3 to more than 10 ppm (see Fenster's and León's paper, Fig. 1). Among the six introductions whose P requirement was less than 4 ppm, four belong to the species *Stylosanthes capitata* Vog., one of the most promising for Carimagua conditions. Other promising species for Carimagua are *Andropogon gayanus* Kunth and *Desmodium ovalifolium* Vahl., both with critical levels somewhat higher than the ecotypes of *S. capitata, Zornia* sp. and one *Stylosanthes guianensis* (Aubl.) Sw. One ecotype of *Macroptilium* and two of the genera *Desmodium* had much higher requirements, around 10 ppm, but still lower than the critical levels of the majority of annual crops.

Liming trials

During 1977, 38 grass and legume species were tested in the field; 0, 0.5, 2 and 6 t/ha of lime were applied to give an Al saturation level of approximately 90, 85, 60 and 15%, respectively. The effect of lime on DM of 11 grasses is given in Figure 2. Several species including *Brachiaria decumbens* Stapf., *Brachiaria humidicola* (Rendle.) Schweikt., *Brachiaria mutica* (Forsk) Stapf., *A. gayanus, Panicum maximum* Jacq. and *Digitaria decumbens* Stent. showed excellent tolerance to Al and all reached near maximum yield with application rates of 0 to 0.5 t. On the other hand, *Hyparrhenia rufa* (Nees) Stapf., a grass that is quite common in the tropics, responded very satisfactorily up to a level of 2 t/ha.

The results in the field were very similar to a glasshouse trial carried out in 1976, in which several tropical grasses were planted in nutrient solutions with Al concentrations ranging from 0 to 4 ppm. The effect of Al on four species is shown in Figure 3. *Cenchrus ciliaris* L. was the most affected, followed by *H. rufa. P. maximum* responded to the first increase in Al and was affected adversely only at the highest level. *B. decumbens* was not affected by any of these concentrations. Yields of *P. maximum* decreased at the 0 level of lime (highest level of Al) in the field as well as in the glasshouse.

Table 2 shows the yields of eight legumes in the first cutting. It should be noted that originally the 0 level of lime did not include Mg; the other levels received Mg applications in order to maintain the Ca/Mg relation constant at 10:1. Therefore, part of the response at the level of 0.5 t of lime may be an effect of the Mg and not of the lime itself, especially in the case of *D. ovalifolium* and *Pueraria phaseoloides* (Roxb) Benth. var. *javanica* (Benth.) Bak. and possibly the

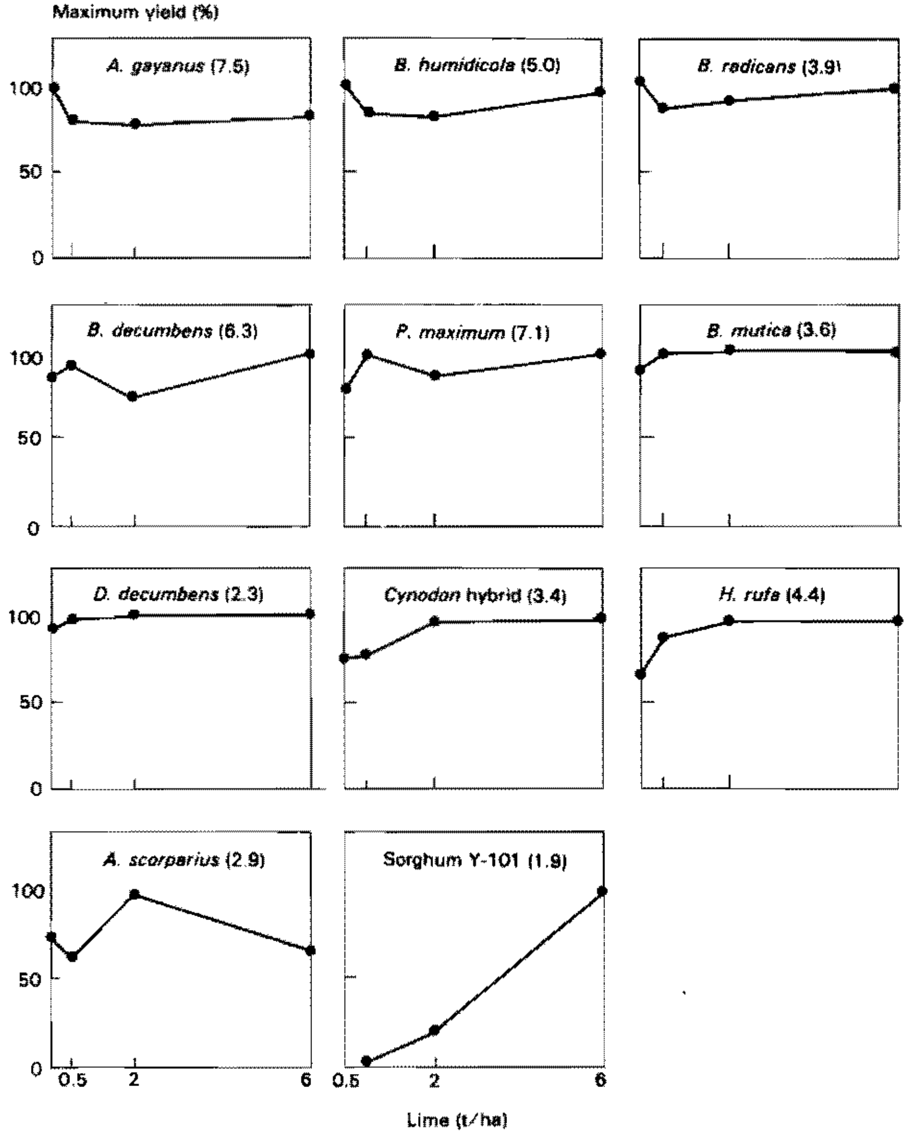

Figure 2. **Response of 11 grasses to liming on an Oxisol at Carimagua. DM production is giving in parentheses. The amounts are averages of four to five cuttings during 1977.**

hybrid *Centrosema* sp. 1733 and *C. pubescens*.

In another field trial carried out at Carimagua during 1977, a very definite response to Mg was recorded in the case of *D. ovalifolium* and *P. phaseoloides*. The results of the first cutting are given in Table 3. *S. capitata* and *Zornia* sp. CIAT 728, which did not show any response to lime, are exceptionally vigorous. *Centrosema plumieri* (Pers.) Benth. is definitely the most sensitive to acidity in this group of legumes.

It is obvious that among the different species and sometimes among ecotypes of the same species, there are very important substantial differences with regard to acidity

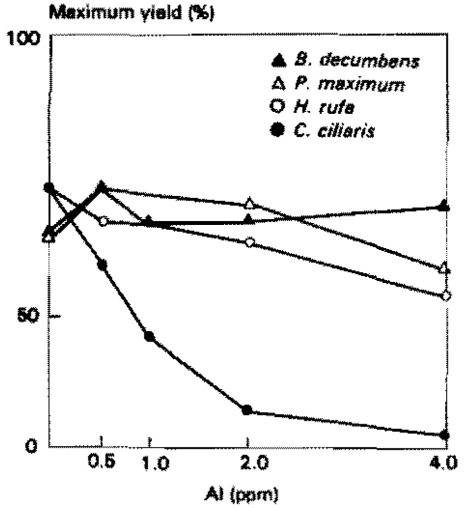

Figure 3. **Effect of Al concentration on DM production of grasses in nutrient solutions.**

and P requirements. The first step in taking advantage of these differences consists simply in testing and selecting from among the most productive species the ecotypes that require less modification of the soil. Another important step is to include in forage improvement programs the selection of grasses that adapt best to the savanna soils, which as a rule are extremely acid and very low in fertility.

LAND PREPARATION AND CONTROL OF VEGETATION

After modifying the chemical conditions of the soil, the most costly operation in pasture establishment is the preparation of the land and control of native vegetation and weeds that compete with the grass.

The traditional method of preparing the land for pasture establishment in the Llanos Orientales consists in passing heavy offset disks two or three times or once with a plow followed by the offset disks. These systems give adequate, often excessive, preparation of the land for pasture establishment. The problem lies in the high cost of tillage and in the danger of erosion and loss of great quantities of soil when the terrain is sloping.

For the last three years, several minimum and nontillage systems with chemical control of the native savanna have been tried. The system that has given best results to date is the use of stubble mulch sweeps to undercut the savanna vegetation at a very shallow depth to separate the aerial part from the root system, this method leaves all the stubble on the surface of the ground (2). The power required for the job is less than in the case of the disks and plow that are commonly used in this area. The main difficulty with the stubble mulch sweep

Table 2. **Effect of lime on DM production of eight legumes at first cutting at Carimagua, 1977.**

	Lime (t/ha)			
	0	0.5	2	6
	kg DM/ha			
C. plumieri CIAT 414	0	0	582	1698
Centrosema sp. CIAT 442	445	912	2014	2769
Centrosema sp. CIAT 438	356	1330	1568	1317
C. pubescens CIAT 413	680	1729	1996	2035
D. ovalifolium CIAT 350	1118	2302	2018	2480
P. phaseoloides CIAT 9900	1286	1688	1422	1434
Zornia sp. CIAT 728	3000	3108	2686	2628
S. capitata CIAT 1019	2365	2361	3011	2478

Table 3. **Effect of Mg on DM production of three legumes, at first cutting in Carimagua, 1977.**

	Mg (kg/ha)	
	0	20
	— kg DM/ha —	
Zornia sp. CIAT 728	2436	3151
D. ovalifolium CIAT 350	675	1552
P. phaseoloides CIAT 9900	229	739

method is that a certain level of soil moisture is required for it to work well; but in order to obtain optimal control of the vegetation, some dry days are required after tillage. Therefore, the most appropriate moment for using the sweeps would be at the beginning and towards the end of the rainy season, when the rains are less and still permit adequate control of vegetation. The ideal would be to be able to control the savanna to sow and fertilize the introduced species simultaneously, but conditions favorable for sowing are precisely the least appropriate for controlling the native savanna.

At present several systems are being evaluated, including the sweeps, chemical control of the savanna, burning of the savanna and the traditional systems, with the purpose of studying more thoroughly the possibilities of reducing the costs of preparing the land for pastures.

SOWING SYSTEM

In 1977 a study was started in which several aspects of establishment were combined in a single trial, looking for a way to reduce costs. Inputs such as capital, labor and fertilizers do not generally abound in the savanna zones. In the paricular case of pastures, the seed or vegetative planting material is rarely available in sufficient quantities and is often costly in the initial stages of cattle development programs.

The Oxisols of the Llanos Orientales are kept weed free several months after tillage if fertilizers are not applied. Taking advantage of this fact, ten species were sown at a density of 1000 plants/ha (3.16 m between plants), expecting self-seeding of the intermediate area as the result of either seed production or coverage by stolons. Initially only one plant was fertilized in an area of approximately 0.1 m^2. Sixteen combinations of fertilizers, mainly P and K, were studied. The rates of application in the treated area varied from 50 to 900 kg P_2O_5 and 0 to 150 kg K_2O, since at the beginning only one hundredth of the area was treated. The second stage of fertilization (the area between plants) was delayed until a good population was obtained, by means of seed production or coverage by stolons, in order to prevent weed competition.

In Figure 4 the results obtained with four stoloniferous grasses during the first stage are presented, in terms of length of the four longest stolons of each plant and the number of stolons per plant longer than 1 m (in the case of *Brachiaria radicans* Napper, longer than 2 m). At levels of 0.5 to 1.0 g/plant, P affected the length of the four longest stolons of *B. decumbens, B. humidicola* and *B. radicans*. The *Cynodon* hybrid responded up to 3 g/plant. On the other hand, the effect of P on the number of stolons longer than 1 m was especially noticeable for *B. decumbens* and *B. radicans*, especially with rates up to 9 g/plant.

The response to K was especially noticeable in terms of number of stolons longer than 1 or 2 m. In less than three months, *B. radicans* had covered almost all the area between the plants. *B. humidicola* was slower but continued to grow during the dry season, giving almost complete coverage in the best treatments. *B. decumbens,* whose initial development was very fast and almost totally vertical, also extended over more than half the area during the dry season.

A. gayanus and *P. maximum* (planted in August) produced seed as of December; and when the first rains began in April, *A.*

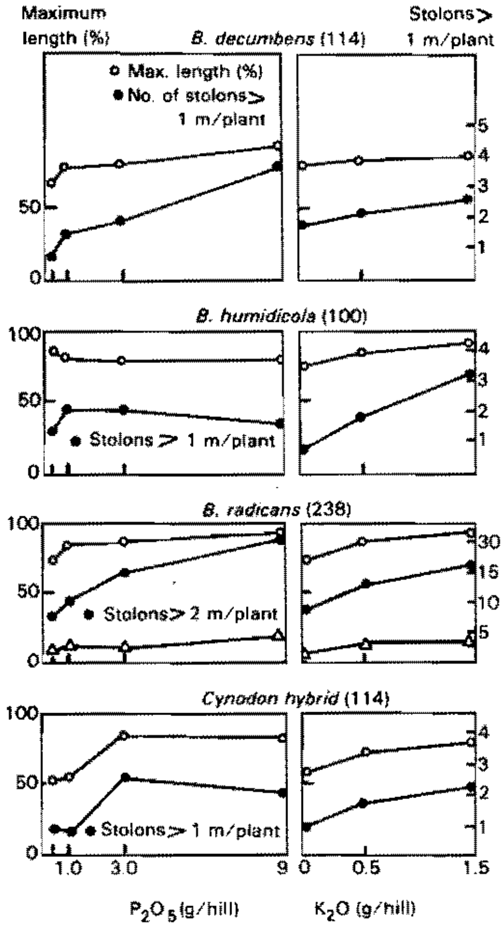

Figure 4. **Effect of P and K on the number of stolons and percentage of maximum length of the four longest stolons per plant of four grasses, 12 weeks after planting with vegetative material. The average length in cm of the four stolons per plant in the best treatment is given in parentheses.**

gayanus had covered the whole area with a population that was too dense. *P. maximum* is developing an adequate population in the majority of the treatments.

This system could result highly advantageous for establishing pastures in the less fertile savanna areas. In addition, it is probable that some farmers are willing to wait longer if there is a reduction in the initial investment of capital and other inputs such as labor, seed and fertilizers, which are scarce in these areas. This study is being expanded in 1978 in an attempt to find less costly tillage systems within the reach of the medium-size farmer.

SPATIAL DISTRIBUTION OF FORAGE SPECIES

The most appreciated pasture in tropical America at present, is, undoubtedly, *B. decumbens*. It has a very high stocking capacity and is highly resistant to trampling. It does not have high nutrient requirements and is tolerant to soil acidity. Nevertheless, some of its advantages such as aggressiveness and the formation of a very strong grass, become disadvantages when it is planted in association with a legume. There are only a few cases of successful, stable association with *B. decumbens*. At Carimagua a grazing trial was begun in 1976 using *P. phaseoloides* in association with *B. decumbens, Melinis minutiflora* Beauv. and *H. rufa*. The legume was planted in 2.5-meter strips, intercalated with equally wide strips of the grasses. The trial includes three resting periods (28, 42 and 56 days) between intensive grazing periods and fertility maintenance treatments by applying 15 to 45 kg/ha/yr of P_2O_5. Thus far the association between *P. phaseoloides* and *B. decumbens* has been good, with a very strong domination of the legume over *H. rufa* and *M. minutiflora*. *B. decumbens* is invading the strips of *P. phaseoloides* but the latter is also invading those of *B. decumbens*. Up to the present, it seems probable to obtain a good association that could last several years utilizing the strip system.

In any pasture formed exclusively by grasses, N becomes a limiting factor sooner or later. One of the greatest challenges for those who work with pastures and forages in the tropics is to develop and perfect systems for introducing legumes into pastures established with *B. decumbens*, which with time become less productive because of the lack of N, especially in areas where it is not economically feasible to use nitrogenous fertilizers.

It is possible that some legumes such as *D. ovalifolium* or *Desmodium heterophyllum* DC. can compete and persist in compatible associations with *B. decumbens* if optimal pasture management systems are found, but the great majority of the legumes do not seem to be able to compete in traditional mixtures.

THE FACTOR OF FERTILITY IN THE MANAGEMENT OF ASSOCIATIONS

In temperate zones it is believed necessary to fertilize the legume of the association and to manage the grass through grazing. Normally, legume requirements are higher than those of the grasses. However, the opposite is true of several tropical species: the grasses are sometimes less demanding than the legumes. This creates the possibility of utilizing the fertility factor as a tool in the management of the associations by using grasses that are more demanding than the legume. It has been noted, in general, that *S. capitata* and *Zornia* sp. are less demanding legumes with regard to P, as compared with grasses such as *P. maximum* and even *A. gayanus*. Trials are being started to prove the hypothesis that fertility (in this case the level of P) can be utilized to stimulate or depress the grass development with relation to the legume in the management of forages under grazing.

When experiments were begun in the Llanos, the most common grasses in the region were *M. minutiflora* and *H. rufa*. It was believed, therefore, that the two of them were rustic with low fertility requirements. Experience has shown that *M. minutiflora* is really an exceptionally rustic species for the savanna soils; but *H. rufa* has very high P and K requirements and is less tolerant to acidity under grazing. After having good populations of *H. rufa* in several pastures, they disappeared completely as a result of the fertility factor and possibly soil acidity, in spite of having been planted in the lowlands where the stress caused by the dry season was much less and where the soils were more fertile and less acid. The dry season tends to intensify both limiting factors. *H. rufa* presently has little priority in the research being done in the savanna at Carimagua.

Based on the experience acquired to date, the grass species can be classified in the following order of requirements: *M. minutiflora*<*B. decumbens*<*A. gayanus*<*P. maximum*<*H. rufa*. The legumes follow this order: *S. capitata*<*Zornia* sp.<*D. ovalifolium* <*P. phaseoloides*<*C. pubescens*.

In relation to the maintenance of fertility in pastures under grazing in the Llanos, there is little information available. On the one hand, there is almost no experience in legume/grass associations; on the other hand, it seems that N is the most limiting factor (except for *H. rufa* and *Paspalum plicatulum* Michx.); and therefore there has been no great response to P and K after the establishing stage, when N is not applied. Some experience has been obtained in the utilization of small fenced lots within the pastures in which small parcels are studied for their response to the application of nutrients after a certain number of years of grazing. As soon as some stable legume/grass associations are obtained, it is probable that the rate of fertilizers required for the good maintenance for grass will go up notably as the stocking capacity increases, especially during the dry season.

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