A STRATEGY FOR THE GRADUAL REPLACEMENT OF NATIVE SAVANNA ON AN OXISOL IN EASTERN COLOMBIA

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ABSTRACT

A strategy for gradually replacing native savanna with introduced species has been tested on an oxisol in the Llanos Orientales (Eastern Plains) of Colombia. Immediately after burning, four associations (*Pueraria phaseoloides* and *Desmodium ovalifolium* each with *Brachiaria humidicola* and *Andropogon gayanus*) were planted in 0.50, 2.5 and 5.0 m tilled and fertilized strips, with intervening strips of undisturbed savanna of 2.0, 10.0 and 20.0 m, respectively. Vegetative material was used for *B. humidicola*; others were sown. Grazing with 1 steer ha^{-1} began when introduced species were well established (about 10 months) with no further burning. Esophageal fistulated animals were also used periodically to estimate the botanical and chemical composition of the diet. Stocking rate has been increased as area colonized by introduced species increased. Each year, an additional 20% of the area was fertilized in strips adjacent to the planted area without further tillage nor planting. The legumes have served as "pioneers", aggressively invading the undisturbed savanna and have covered 20% of the area $year^{-1}$ in all but the widest strips. *B. humidicola* has invaded the area colonized by the legume in both associations while *A. gayanus* has not produced seed in either association and under the grazing management imposed, has failed.

Animals have readily consumed legumes and most native species including "weeds", resulting in at least 7% protein in the diet, even in the dry season, and in liveweight gains in the order of 450 g A^{-1} day^{-1} year round compared to 200 g A^{-1} day^{-1} in native savanna under traditional burning management.

INTRODUCTION

In a continuing search for lower cost and more reliable methods of pasture establishment, a number of options have been tested at Carimagua, a national agricultural research center of the Colombian Institute of Agriculture (ICA) in the Eastern Plains of Colombia located at 4.5° north latitude, 71° west longitude. The Station is 150 m above sea level, with a mean annual temperature of 27°C and annual precipitation of 2100 mm, which falls mainly from April through November, with a sharp dry season from December through March.

Pasture establishment is generally thought to be more costly in remote tropical areas than in traditional agricultural areas because of lack of adequate infrastructure, thus higher on-farm costs of inputs. However, one major cost component is almost always much lower in frontier areas: the opportunity cost of the land during the establishment phase. Thus, considerable attention has been given to establishment methods which require relatively more time to complete but with less risk than traditional planting systems (Spain, 1978, 1981).

Early attempts to establish pasture species by fertilizing and oversowing undisturbed native savanna were unsuccessful in Carimagua (Spain, unpublished). Adequate stands were sometimes achieved but seedlings failed to persist and develop, apparently a common experience in other tropical ecosystems (Cook, 1980). However, subsequent small plot trials indicated that some species, when well established in tilled and fertilized strips, were able to invade and displace native savanna with different degrees of tillage and vegetation control ranging from burn only to disk tillage (CIAT, 1979). The legumes Desmodium ovalifolium and Pueraria phaseoloides were capable of invading and displacing burned native savanna. It was also noted that after the legumes displaced the native savanna, aggressive companion grasses readily invaded the area. These results plus other observations served as a basis for the experiment described.

STRATEGY AND METHODS

It was postulated that native savanna could be supplemented by introduced species planted in cultivated and fertilized strips and by gradually increasing the area fertilized as the introduced species spread from the original strip, the savanna could eventually be completely replaced. Immediately after burning, four associations, P. phaseoloides and D. ovalifolium each with Brachiaria humidicola and Andropogon gayanus, were planted in 0.5, 2.5 and 5.0 m strips with intervening strips of undisturbed savanna of 2.0, 10.0 and 20.0m. P. phaseoloides, D. ovalifolium and A. gayanus were sown in 50 cm rows with 3, 1 and 5 kg seed ha^{-1} respectively. Vegetative material was used for planting B. humidicola spaced at 50 cm in 50 cm rows.

Three paddocks, each 66.66 x 100 m were established for each association, with only internal replication of planting patterns. The 0.5 m strips were prepared with a modified stubble mulch sweep; the

2.5 and 5.0 m strips with one pass, each of a chisel plow and an offset disk.

The center one third of the 2 wider strips was planted to grass and the balance to legume, whereas with the 0.5 m strips, every third strip was planted to grass. Each year, an additional 20% of the area was fertilized in strips adjacent to the planted area, without further tillage nor planting. The savanna has not been burned since the initial planting as it was not considered necessary for management of the supplemented savanna nor compatible with the planted legumes.

Fertilizer rates applied to the planted area for establishment were 26 kg P and 105 kg Ca ha^{-1} from basic slag, 36 kg K, 40 kg S and 20 kg Mg ha^{-1} from potassium - magnesium sulphate.

Light grazing began six months from planting and the paddocks were stocked with 1 steer ha^{-1} after 10 months, using four groups of two animals, one for each association, moving rotationally through the three paddocks (three strip width treatments). The paddocks were stocked at the beginning of each dry season with recently weaned yearlings weighing approximately 180 kg. When replaced after one year weights range from 275-325 kg. A salt mineral mix was supplied *ad libitum*. Stocking rates were increased to 1.5 steers ha^{-1} in 1982 as area colonized by the introduced species and forage availability increased. Subsequent adjustments are shown in Table III. Esophageal fistulated animals were used in the *B. humidicola* with *D. ovalifolium* and *P. phaseoloides* strips to estimate the botanical and chemical composition of the diet over a period of one year during the second and third year after establishment.

RESULTS

The advance of planted species with time is shown in Table I, and in Figure 1 for the B. humidicola + P. phaseoloides treatments. The goal of 20% additional coverage per year has been achieved in all but the widest strip system with P. phaseoloides which in association with B. humidicola had covered the entire area in one year when planted in the 0.5 m strips and in 2 years in the 2.5 m strips. In associations including D. ovalifolium, more than 60% of the area was covered in the 0.5 m strip by the end of the first year. By the end of the second year the 2.5 and 5.0 m strips had covered more than 40% of the area. However, due to a severe attack of a stem nematode (Lenné, 1983) during the second year, this legume failed to advance in the third year and coverage was reduced in the 2.5 and 5.0 m treatments.

Andropogon gayanus failed in this experiment, in part due to establishment problems and because of selective grazing from the outset. This has prevented flowering and seeding, and resulted in a rapid decline of the original population due to severe overgrazing. Thus, the associations with A. gayanus were essentially legume with native savanna after the first year, as can be observed in Figure 2.

In spite of heavy grazing, B. humidicola has effectively colonized much of the area. It has spread much more rapidly in association with P. phaseoloides than with D. ovalifolium, in part due to the rambling open growth of the former. It rapidly dominated the entire planted strip and has gradually followed the legume into the area originally occupied by the undisturbed savanna.

An estimate of the diet composition of fistulated steers averaged across strip width treatments is shown in Table II. The legume proportion in the diet, although extremely variable, was not affected by initial strip width and adequate protein levels (7%) were recorded in the forage consumed, even during the dry season. The high legume selection in the rainy season contrasts with observations made in improved grass-legume associations (CIAT, 1982). This is probably the result of the lower quality of the unburnt-native grasses. It is postulated that, as a result of legume consumption, animals were able to utilize the low quality unburnt-savanna as has been reported by Minson and Milford, 1967, and Siebert and Kennedy, 1972.

Animal performance in this experiment has been equal to or superior to performance observed in savanna under traditional burning management (Paladines and Leal, 1978), with the possible exception of the A. gayanus + D. ovalifolium - treatment. Differences in performance between this association and the other 3 have been consistently very large (Table III). Over a period of three years, gains during the rainy season on the A. gayanus + D. ovalifolium treatment averaged 216 g day^{-1} versus 456 g day^{-1} on the association of A. gayanus + P. phaseoloides. This marked contrast in animal performance is probably due to the differences in quality of the two legumes (Abaunza, 1982). The positive effect of a grass with D. ovalifolium is reflected in the high gains (456 g day^{-1}) obtained in the association with B. humidicola.

In addition to consuming what are normally considered desirable savanna species, including Trachypogon vestitus, Paspalum pectinatum and Axonopus spp., animals have aggressively grazed such "weed" species as Andropogon bicornis, Panicum rugii and Leptocoryphium *lanatum*. No serious weed problems have appeared in any of the pastures.

The savanna has been subjected to increasing competition from invading legume and grass, and from increased grazing pressure as the proportion of legume increased and savanna decreased, especially in the *A. gayanus* treatments, in which the only grasses were savanna species after the first year.

The failure of *A. gayanus* to function well, and its replacement by savanna resulted in the loss of two of the originally planned associations but provided some valuable information on legume + savanna associations that otherwise would not have been gained. The heavy attack of nematode on *D. ovalifolium* has somewhat limited the value of this legume. Only one association has functioned as planned; that of *B. humidicola* and *P. phaseoloides*. As shown in Figure 2, savanna continues to play a prominent role in this pasture in the wide strip planting in spite of the current stocking rate of 2 A ha^{-1}. In the medium strip width, the role of savanna in the pasture is rapidly waning and it has declined even more drastically in the narrow strip system. Thus the goal of savanna replacement with a productive association of introduced species has been achieved. The *D. ovalifolium* + *B. humidicola* association will probably persist, but productivity may be somewhat limited by the nematode problem.

IMPLICATIONS

The system of gradual replacement of savanna with strip planted, aggressive, introduced species is viable for the ecosystem in which it is being tested. The time required for replacement depends on strip width and spacing, and species in association. It will also undoubtedly be affected by grazing management and fertilizer strategy.

The high liveweight gains of animals on the *P. phaseoloides* + savanna association indicate clearly that with adequate supplementation, it is possible to manage native savanna without burning while obtaining excellent animal performance. Much higher stocking rates are possible than with traditional burning management where as much as 80% of the biomass produced is burned. This has lead to the establishment of a new savanna "supplementation" trial in which only legumes are planted, in narrow strips, occupying from 2.5 to 30% of the total area with a range of stocking rates from 0.33 to 1.33 animals ha^{-1} (CIAT, 1983). This trial will provide information on the long-term effects of managing supplemented savanna without burning and at relatively high stocking rates on the dynamics of introduced and native species and animal performance.

CONCLUSIONS

Gradual replacement of savanna with fertilized, introduced forage species can be achieved on the well drained oxisols of the Llanos Orientales of Colombia. Pastures in formation can be grazed with increasing stocking rates as percent of the total area occupied by the introduced species increases. Management of legume supplemented savanna without burning is feasible and animal performance is superior to that observed with animals on traditionally managed native savanna.

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Table I. The effect of planting pattern, association and time on the advance of planted strips.

Association	Initial strip width 1980		Average strip width and % total area covered					
	planted	savanna	m	%	m	%	m	%
B. humidicola	0.5	2	1.7	67	2.5	100	2.5	100
+	2.5	10	6.0	48	7.2	58	7.2	58
D. ovalifolium	5.0	20	8.4	34	10.4	42	9.1	36
B. humidicola	0.5	2	2.5	100	2.5	100	2.5	100
+	2.5	10	7.7	62	12.5	100	12.5	100
P. phaseoloides	5.0	20	8.3	33	15.2	61	14.0	56
A. gayanus	0.5	2	1.7	67	2.5	100	2.5	100
+	2.5	10	6.0	48	6.3	50	7.2	58
D. ovalifolium	5.0	20	7.8	31	12.4	50	9.3	37
A. gayanus	0.5	2	2.5	100	2.5	100	2.5	100
+	2.5	10	8.1	64	13.5	100	13.5	100
P. phaseoloides	5.0	20	10.7	43	16.3	65	18.3	73

Table II. Legume proportion and crude protein content of forage selected by esophageal fistulated steers grazing native savanna plus strips of *B. humidicola* associated with *D. ovalifolium* and *P. phaseoloides*.

Season	Native savanna + Strips			
	B.humidicola+D.ovalifolium		B.humidicola+P.phaseoloides	
	Legume in diet (%)	Protein in diet (%)	Legume in diet (%)	Protein in diet (%)
Dry[a]	57.2 ± 39.6[d]	8.8 ± 2.0	53.1 ± 35.3	7.3 ± 2.5
Rainy				
First half[b]	41.9 ± 14.3	9.4 ± 1.6	38.1 ± 10.5	12.1 ± 1.1
Second half[c]	66.1 ± 15.8	9.8 ± 1.0	49.9 ± 1.0	11.7 ± 0.6

a/ January-March (1982)
b/ April-August (1981)
c/ September-December (1981)
d/ Mean and standard deviation

Table III. The effect of association and years on mean liveweight gains in a savanna replacement trial.

Treatment	Year	Stocking rate Dry/Wet (A/ha)	Season Dry 150 days (g/A/day)	Season Wet 210 días (g/A/day)
B. humidicola	1981	- /1.0	-	384
+	1982	1.5/1.5	87	474
D. ovalifolium	1983	1.1/1.0	298	510
B. humidicola	1981	- /1.0	-	481
+	1982	1.5/1.5	274	518
P. phaseoloides	1983	1.1/2.0	443	455
A. gayanus	1981	- /1.0	-	268
+	1982	1.5/1.5	137	218
D. ovalifolium	1983	1.1/1.0	270	163
A. gayanus	1981	/1.0	-	458
+	1982	1.5/1.5	112	437
P. phaseoloides	1983	1.1/1.0	331	474

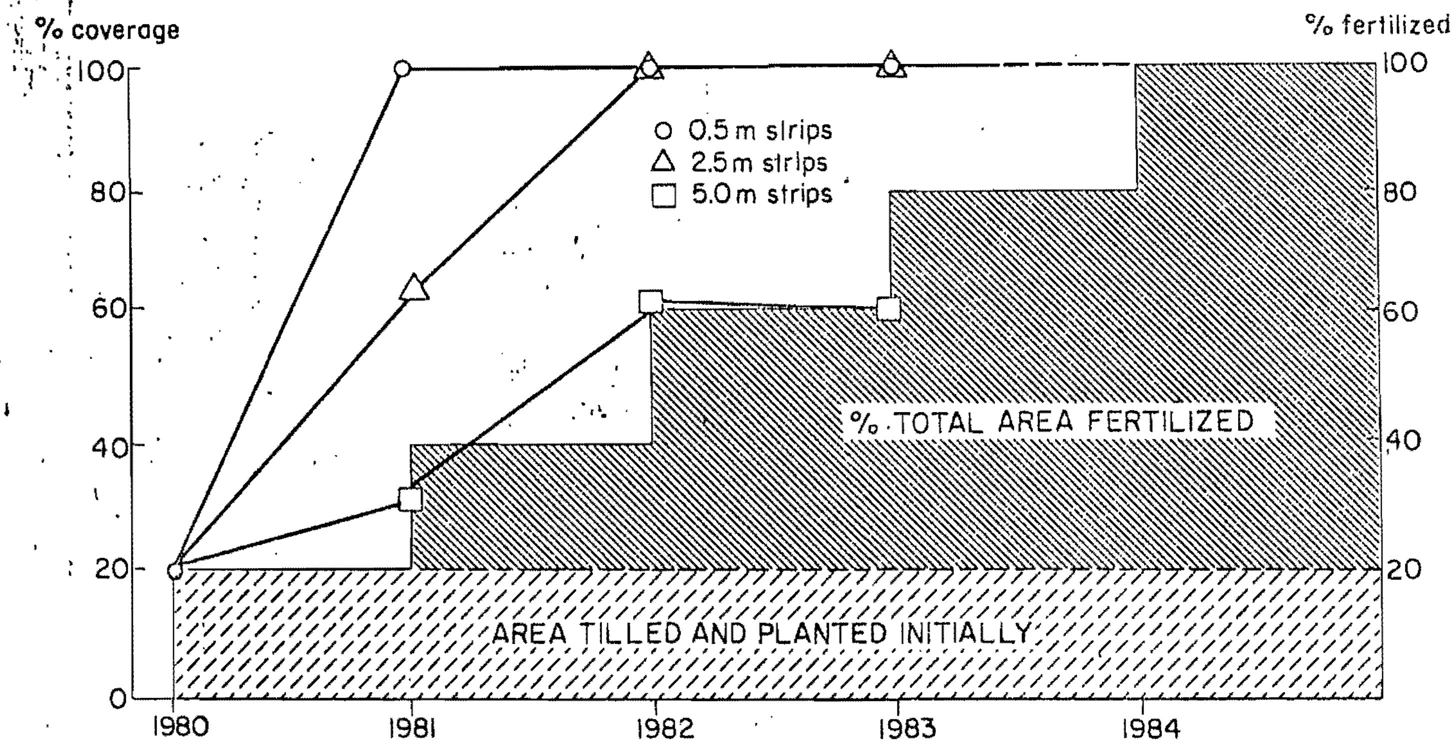

Figure 1. The effect of planting strip width, time and area fertilized on the percent coverage of total area by *P. phaseoloides* and *B. humidicola* in a native savanna replacement trial.

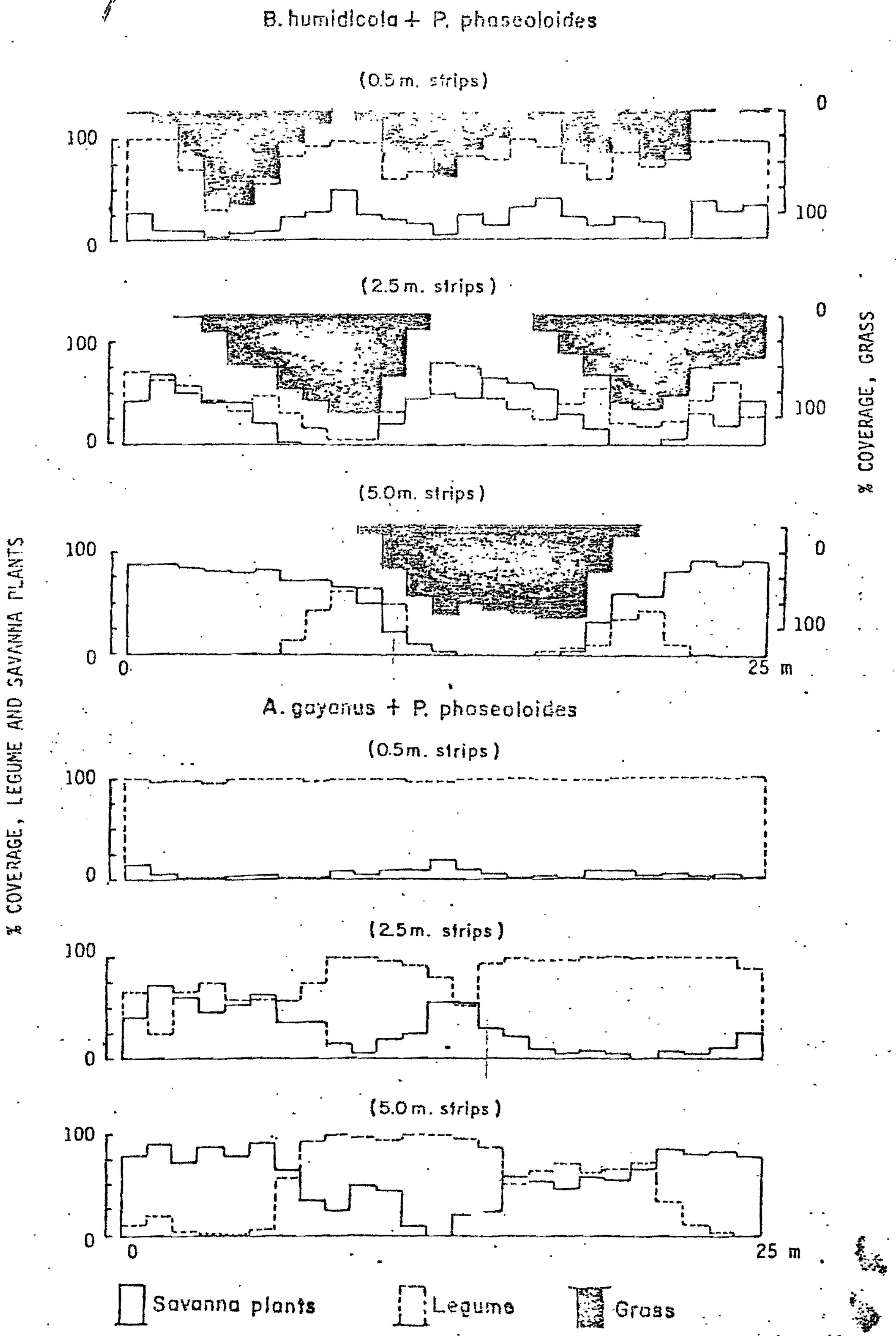

Figure 2. The effect of strip width and association of P. phaseoloides with B. humidicola and A. gayanus on the botanical structure of pastures formed by gradual replacement of savanna by introduced species, in the 4th year after planting.