LEGUME ESTABLISHMENT ON NATIVE PASTURES OF CERRADOS[1]

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ABSTRACT - Several methods for introducing legumes into a native pasture were tested in an open grass savanna with some shrubs and small trees, which is known as "campo sujo", in the Cerrados region of Brazil. Three legumes (*Calopogonium mucunoides* (Desv.), *Stylosanthes capitata* (Vog.) and *Galactia striata* (Jacq.)) were tested with all planting methods. Planting methods consisted of oversowing, oversowing after disc-harrowing, and sodseeding. Each method was tested with and without previous burning. Results showed that all planting methods which provided some soil surface disturbance were more effective than oversowing in terms of number of plants established. *Stylosanthes capitata* was slow to establish but contributed more to total dry matter production during the second year than the other species. The highest dry matter production and crude protein content were obtained in the native pasture + *Stylosanthes capitata* treatment. Dry matter yield as high as 2,266 kg/ha^{-1} and 6.4% crude protein content were recorded. In the unimproved native pasture (control) the dry matter and crude protein levels obtained were 738 kg/ha^{-1} and 2.4%, respectively.

Index terms: *Stylosanthes, Calopogonium mucunoides, Galactia striata,* pasture improvement.

ESTABELECIMENTO DE LEGUMINOSAS EM PASTAGENS NATIVAS DOS CERRADOS

RESUMO - Vários métodos de estabelecimento de leguminosas em pastagem nativa foram testados. As leguminosas estudadas foram *Calopogonium mucunoides* (Desv.), *Stylosanthes capitata* (Vog.) e *Galactia striata* (Jacq.). Os métodos de estabelecimento comparados foram: semeadura a lanço sem preparo do solo, semeadura a lanço após uma gradagem leve e semeadura em linhas. Cada um destes tratamentos foi comparado com e sem queima prévia da área. Os resultados mostraram que o número de plantas leguminosas estabelecidas foi superior nos tratamentos em que alguma movimentação do solo foi efetuada. O *Stylosanthes capitata* mostrou um estabelecimento lento e pouco crescimento no primeiro ano, mas no segundo ano foi a leguminosa mais produtiva. A maior produção de matéria seca e o teor mais elevado de proteína bruta foram observados em tratamentos com pastagem nativa + *Stylosanthes capitata,* onde foram registradas produções de 2.266 kg/ha^{-1} de matéria seca e 6,4% de proteína bruta. No tratamento pastagem nativa sem leguminosas, a produção de matéria seca e o teor de proteína bruta foram, respectivamente, 738 kg/ha^{-1} e 2,4%.

Termos para indexação: *Stylosanthes, Calopogonium mucunoides, Galactia striata,* estabelecimento de pastagens, melhoramento de pastagens, pastagens nativas.

INTRODUCTION

The performance of beef cattle in the tropical savanna region of Brazil is low as a result of the poor quality and productivity of the native vegetation (Kornelius et al. 1979). Although cultivated grass-legume pastures offer an alternative for improved year-round animal nutrition and higher productivity, large areas of the region are expected to remain as native pasture for many years. This is due to high establishment costs of cultivated pastures, the substancial resources needed for complete development of such a large region and the unsuitability of some areas for cultivation.

An alternative approach for low-cost pasture improvement would be the introduction of legumes into the native pasture (Smith 1966, Stocker & Sturtz 1966, Keya et al. 1971, Keya & Eijnatten 1975, Warboys 1966, Lowe et al. 1977). The success of this method depends on many factors including the degree of competition from the native grasses. Although some grass cover is desirable and may improve legume establishment as a consequence of better soil moisture conservation (Miller & Perry 1968), several authors (Lowe et al. 1977, Warboys & Johnson 1966) have demostra-

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ted that some mechanical soil disturbance is necessary to reduce competition.

With the purpose of testing the potential of several methods of legume establishment in native savanna, an experiment was initiated in 1977 in an area of open grass savanna with small trees and shrubs ("campo sujo") in the Cerrados of Brazil. The results presented were collected during a two-year evaluation period based on plant establishment counts and clippings.

MATERIAL AND METHODS

The experiment was conducted at the Centro de Pesquisa Agropecuária dos Cerrados (CPAC), Planaltina, DF, Brazil, where a cooperative pasture research program exists between Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), and Centro Internacional de Agricultura Tropical (CIAT). CPAC is situated at latitude 15°S and altitude 1000 to 1100 m. Rainfall is 1578 mm per annum with 90 per cent falling from October through March.

The experiment was carried out on a native pasture in which grasses were dominant, with some small trees and shrubs. This type of vegetation is known in Brazil as "Campo Sujo" and occurs in areas of very low soil fertility (Lopes & Cox 1977). Predominant grasses belong to the genera *Andropogon, Paspalum, Aristida, Panicum* and *Echinolaena* whilst the most common legumes belong to the genera *Cassia, Calliandra* and *Zornia.* The presence of some *Cyperacea* was also observed. The soil at the site classifies as a red-yellow latosol according to the Brazilian Soil Classification System and is characterized by low pH, high aluminium saturation, low cation exchange capacity and almost no weatherable minerals. It would classify as ACRUSTOX, according to U.S. Soil toxonomy (Soil Survey Staff 1975). Some chemical properties of surface soil samples are presented in Table 1.

The experiment consisted of eight treatments: 1) Oversowing native savanna; 2) oversowing after light disc-harrowing; 3) sodseeding; 4) oversowing after burning; 5) oversowing after burning and disc-harrowing; 6) sodseeding after burning; 7) oversowing after broadcasting of 1 ton ha^{-1} of lime following light disc-harrowing; and 8) a control consisting of native savanna without seed or fertilizer application.

Burning was performed at the beginning of the rainy season when vegetation was already growing. Disc-harrowing was performed with a four-section tandem disc, fully closed, to cause minimum soil disturbance. In the sodseeding treatment, 2.5 cm wide bands at 50 cm spacing were tilled to a depth of 5 cm with a rotary-tiller direct planting machine. Seeds and fertilizers were placed by hand, directly on top of the furrows with very light covering. All plots except the control received fused calcium magnesium phosphate (CMP) at a rate equivalent to 40 kg/ha of Phosphorus (P). Potassium (K), Sulphur (S) and Zinc (Zn) were also applied at rates of 65, 47 and 4 kg/ha, as potassium chloride, gypsum and zinc sulphate, respectively. Sodium molybdate was applied at a rate of 0.5 kg/ha.

TABLE 1. Chemical characteristics of surface soil samples (0-20 cm) from the experimental area. (Means of four samples).

pH (H_2O, 1:1)	4.6
$Ca^{++} + Mg^{++}$	0.26 me/100 g
K^{+}	0.06*me/100 g
Al^{+++}	0.18 me/100 g
Available P	Traces*

* Double acid extraction, by the method of North Carolina State University. Ca^{++}, Mg^{++} and Al^{+++} extracted in 1N KCl.

Three legumes were tested with all planting methods: Local cultivars of galactia (*Galactia striata*), calopo (*Calopogonium mucunoides*), and stylo (*Stylosanthes capitata*) CPAC 846 (CIAT 1405). All species were sown at 6 kg/ha of commercial seed, without scarification.

All treatments were arranged in a split-plot design with main plots in completely randomized blocks replicated four times. Planting methods were allocated to 12 m x 12 m main plots and legume species to 4 m x 12 m subplots. Plant counts were made 60 and 120 days after seeding using a 0.25 m^2 quadrat located at random five times within each subplot. In the sodseeding plots, five plant counts were made using the same 0.25 m^2 quadrat in such a way that 50 cm length of row were sampled each time.

Dry matter production and botanical composition of forage were estimated by cutting the pasture at a height of 10 cm, at the beginning of the dry season. In each subplot a single 6 m^2 sampling area was cut and two 4 m^2 sampling areas in the second cut. Total forage harvested was separated into native grasses, sown legumes and other plants which were mainly broad leafed-plants native to the Cerrados, most of which are considered of limited or no value as forages. Dry matter percentage was determined for each component by drying at 70°C for 72 hours. Crude protein content of native grasses and sown legumes was also determined.

RESULTS AND DISCUSSION

Legume establishment

Calopo and galactia showed the highest number of plants per unit area in all methods (Table 2). However, due to differences in seed size, percent germination and hardseed content of the legumes

TABLE 2. The effect of establishment methods on stands of three legumes 60 and 120 days after planting. (Plants m^{-2}, means of 20 observations).

Establishment method	Stylo		Calopo		Galactia	
	Days after planting					
	60	120	60	120	60	120
1. Oversowing	1	1	11	1	3	1
2. Burning	2	1	8	3	2	1
3. Harrowing	2	2	31	12	13	4
4. Burning + Harrowing	4	2	29	16	10	5
5. Sodseeding	2	1	32	17	12	4
6. Burning + Sodseeding	3	1	40	16	8	4
7. Harrowing + Lime	4	2	32	14	11	7

L.S.D. ($P < 0.05$) = 2

used, comparisons will be made only among establishment methods within species.

Results showed that establishment methods that included some soil surface disturbance improved sharply the number of legume plants established, confirming previous observations by Kornelius et al. (1979). Burning did not improve establishment compared to oversowing alone, nor did it improve establishment when combined with harrowing or sodseeding. The results from oversowing were extremely poor in terms of number of plants established, especially when plants were counted 120 days after sowing. Disc-harrowing and sodseeding were the most efficient methods of establishment, especially when calopo and galactia were used.

The low number of stylo plants counted was probably the result of the high proportion of hard seed in this species, a characteristic that does not favour rapid establishment but assures germination over a long period of time, thus providing several opportunities for establishment under variable weather conditions. However, as will be seen, stylo contribution to total dry matter yield improved in the second year.

Miller & Perry (1968) obtained successfull establishment with Townsville lucerne (*Stylosanthes humilis* (H.B.K.)) in native pastures at Katherine, Australia, on untreated surfaces contrasting with results observed in the present experiment. This could be the result of better adaptability of this annual legume to establishment in untreated surfaces as well as to differences in soil and climatic conditions. Soil moisture was favourable at sowing time but no rainfall was recorded for a period of eleven days thereafter. Average daily evaporation from class A evaporation pan was 9.1 mm for the same period. From there on, rainfall followed the normal pattern of the region, in which periods of more than five days without rain are considered abnormal.

Effect of establishment methods on the native vegetation

The effect of establishment method on native vegetation in terms of number of plants per m^2 can be seen in Table 3. *Adropogon, Paspalum* and *Echinolaena* were the most frequent genera and can be used as an index of the effects of establishment methods on the native vegetation. Burning alone reduced the number of plants of *Andropogon* sp by half compared with oversowing, but did not affect other grasses. Disc-harrowing significantly reduced the number of plants of both *Andropogon* and *Paspalum* but did not affect *Echinolaena inflexa*. When disc-harrowing was performed after burning the effect on native savanna was more drastic and the number of grasses was reduced to one third or less. Even so, *Echinolaena inflexa* was less affected than other grasses. Sodseeding, when performed without burning, was the establishment method that least affected the native savanna. Although little is known about the feeding value of most grasses in the Cerrados, it appears that

TABLE 3. Number of native plants per m^2 120 days after sowing legumes by seven methods of establishment.

Establishment methods	Broad leaf plants	*Andropogon* sp.	*Paspalum* sp.	*Echinolaena inflexa*	Total grasses[1]
Oversowing	23	21	12	9	54
Burning	29	11	13	10	42
Harrowing	30	9	6	9	28
Burning + Harrowing	25	4	4	5	17
Sodseeding	23	14	12	11	47
Burning + Sodseeding	32	10	12	5	34
Harrowing + Lime	25	8	6	8	25
L.S.D. ($P \leq 0.05$):	(N.S.)	3	3	3	6

[1] Three reported grasses plus *Panicum cervicatum* (Chase), *Aristida* sp., *Setaria geniculata* (Lam.) Beauv. and some unidentified grasses.

N.S.: No significant differences between methods.

those establishment methods which promoted a good legume establishment with minimum effect on native grasses would be more effective. On the other hand, burning combined with disc-harrowing could be of interest if a grass-legume mixture is to be established, due to the effect of this treatment on reducing native vegetation competition.

Dry matter production

During the first year little increase was observed in dry matter production. Moreover, the effects of establishment methods on the density of the native savanna, were reflected in less total dry matter production following some of the treatments, especially when burning was followed by disc-harrowing.

The contribution of legumes to total dry matter production was also small in the first year, with the exception of galactia in the treatment that included lime. However, during the second year, total dry matter was increased and the contribution of legumes was higher than 30% of total dry matter (Table 4). In spite of the low number of plants observed in the first year, Stylo contributed most to total dry matter in all establishment methods in the second year.

The very low productivity of native savanna of the "campo sujo" type is mainly a result of the extremely infertile soils on which it develops. This is reflected in the extremely low levels of dry matter yield reported. However, it is interesting to note that the dry matter of native grasses increased in all treatments, during the second year, when compared to native savanna. This was due mostly to the effect of fertilizer applied. Highest dry matter production was obtained with disc-harrowing or disc-harrowing plus lime, when not burned (Table 4). The combined effect of legumes introduction plus fertilizer application increased dry matter from 970 in unimproved native pasture to 2,562 kg/ha^{-1}. However, it is more relevant to look at crude protein content figures which increased from 2.4 to 6.4% (Table 5). Although dry matter production levels were still low, the results showed that legume introduction and fertilizer could increase considerably both the quantity and quality of native savanna growing on these very infertile soils. Results suggest that an increase in carrying capacity could be expected with the best treatments under the conditions of the experiment; animal performance should increase more dramatically as a result of improved forage quality.

CONCLUSIONS

Based on plant counts 60 and 120 days after planting the following conclusions can be drawn:

1. Oversowing legumes in native pasture was by far the poorest method studied.

2. Methods involving some surface soil disturbance were more efficient than oversowing alone.

3. Burning the native savanna did not improve legume establishment but reduced the number of plants of some native grasses.

TABELA 4. The effect of establishment methods on dry matter production (kg/ha) of two components of native pasture and three introduced legumes (second year).

Establishment method		Sown legume[1]	Native grasses	Sown legume	Broad leaf plants	Total dry matter
		C	1179	2	253	1434
Oversowing		G	1241	0	267	1508
		S	1231	129	253	1613
	Mean		1217		258	1518
		C	1337	15	195	1547
Burning		G	1266	2	264	1532
		S	1221	53	292	1566
	Mean		1275		250	1548
		C	1551	40	221	1812
Harrowing		G	1760	2	234	1996
		S	1610	656	296	2562
	Mean		1640		250	2123
		C	1262	67	274	1603
Burning + Harrowing		G	1283	53	335	1671
		S	1026	787	297	2110
	Mean		1190		302	1795
		C	1650	25	260	1935
Sodseeding		G	1493	0	266	1759
		S	1290	180	228	1698
	Mean		1478		251	1797
		C	1021	100	246	1367
Burning + Sodseeding		G	1122	23	272	1417
		S	938	34	359	1331
	Mean		1027		292	1372
		C	1298	155	331	1784
Harrowing + Lime		G	1465	134	541	2140
		S	955	839	321	2115
	Mean		1239		398	2013
Native savanna			738	---	232	970
L.S.D. ($P \leq 0.05$):			204[2]	379[3]	107[2]	262[2]

[1] C = Calopo; G = Galactia; S = Stylo.

[2] Between establishment methods means (n = 24)

[3] Between legume dry matter means, within methods (n = 8).

L.S.D. = Least significant difference.

In relation to forage production and botanical composition, the following conclusion were drawn:

1. Applied fertilizers and legume introduction increased dry matter production by more than 100% during the second year but total production was still characteristically low.

2. Lime increased legume proportion on total dry matter yield, contributing towards a better forage quality.

3. The presence of legume in the pasture, specially stylo, sharply increased total protein of the forage.

TABLE 5. Crude protein (C.P.) content and dry matter yield of native grasses and three legumes sown in native savanna by three selected establishment methods.

Establishment method	Sown species	Native grasses		Legumes		Grass + legume	
		D.M. kg/ha	C.P. %	D.M. kg/ha	C.P. %	D.M. kg/ha	C.P. %
Harrowing	Calopo	1551	2.56 ± 0.19	40	11.74 ± 0.39	1519	2.79
	Galactia	1760	2.72 ± 0.19	2	10.37 ± – –	1762	2.73
	Stylo	1610	2.59 ± 0.11	656	8.96 ± 0.83	2266	4.43
Harrowing + Lime	Calopo	1298	3.09 ± 0.16	155	11.43 ± 0.36	1453	3.98
	Galactia	1465	2.91 ± 0.26	134	9.99 ± 1.26	1599	3.50
	Stylo	955	2.81 ± 0.19	839	10.58 ± 0.48	1794	6.44
Sodseeding	Calopo	1650	2.92 ± 0.14	25	11.03 ± 0.35	1675	3.04
	Galactia	1493	2.56 ± 0.11	0	– – – – –	1493	2.56
	Stylo	1290	2.85 ± 0.16	180	9.64 ± 0.32	1470	3.68
Native savanna	– – –	738	2.44 ± 0.06	– –	– – – – –	738	2.44

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REFERENCES

KEYA, N.C.O. & EIJNATTEN, C.L.M. van. Studies on oversowing of natural grasslands. III. The seeding rates for the establishment of *Desmodium uncinatum* (Jacq.) DC when oversow of sod-seeded in *Hyparrhenia* grassland. East Afr. Agric. For. J., 40(4):359-65, 1975.

KEYA, N.C.O.; OLSEN, F.J. & HOLLIDAY, R. The role of superphosphate in the establishment of oversown tropical legumes in natural grasslands of western Kenya. Trop. Grassl., 5(2):109-16, 1971.

KORNELIUS, E.; SAUERESSIG, M.G. & GOEDERT, W. J. Pasture establishment and management in the Cerrados of Brazil. In: SANCHEZ, P.A. & TERGAS, L.E. ed. Pasture production in acid soils of the tropics; proceedings. Cali, CIAT, 1979. p.147-66.

LOPES, A.S. & COX, F.R. A survey of the fertility status of surface soil under "Cerrado" vegetation in Brazil. Soil Sci. Soc. Am. J., 41:742-7, 1977.

LOWE, K.F.; FILET, G.F.; BURNS, M.A. & BOWLDER, T.M. Effect of sodseeded siratro on beef production and botanical composition of native pasture in south-eastern Queensland. Trop. Grassl., 11(3): 223-30, 1977.

MILLER, H.P. & PERRY, R.A. Preliminary studies on the establishment to Townsville lucerne (*Stylosanthes humilis*) in uncleared native pasture at Katherine, N.T. Aust. J. Exp. Agric. Anim. Husb., 8:26-32, 1968.

SMITH, C.J. Problems in establishing dry-land pastures in Rhodesia. J. Br. Grassl. Soc., 21:238-44, 1966.

SOIL SURVEY STAFF, Washington. Soil taxonomy a basic system of soil classification for making and interpreting soil surveys. Washington, 1975. (USDA. Agriculture handbook, 436).

STOCKER, G.C. & STURTZ, J.D. The use of fire to establish Townsville lucerne in the Northern Territory. Aust. J. Exp. Agric. Anim. Husb., 6:277-81, 1966.

WARBOYS, I.B. Improvement of permanent pasture by overdrilling and oversowing. II. Pasture establishment by oversowing. Exp. Agric., 3:63-72, 1966.

WARBOYS, I.B. & JOHNSON, J. Improvement of permanent pasture by overdrilling and oversowing. I. Pasture establishment by overdrilling. Exp. Agric., 2:309-16, 1966.