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Surface-Sowing of Legume Seed in Savanna of South America

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Abstract

Seven legume species were subjected to evaluation of their adaptability to surface-sowing such as broadcasting and pellet-sowing in the burnt savanna in Colombia. Suitable legume species and sowing methods were identified in each of the three experimental sites, which varied in soil types. The findings obtained are as follows: (1) Stylosanthes guianensis was suited for both broadcasting and pellet-sowing: (2) Under the infertile condition of soil such as sandy clay loam, broadcasting was not suited, pellet-sowing of S. guianensis might be recommendable; (3) Under such fertile soil condition as light clay or silty clay soils, broadcasting of *S. guianensis* well fitted; (4) *Stylosanthes capitata and Desmodium ovalifolium* would have possible suitability for broadcasting in fertile soil, although some problems caused by microelement deficiency for S. capitata and insect damages for *D. ovalifolium* should be overcome; (5) *Centrosema acutifolium* could be properly sown with pellets, although some microelements had to be added to pellets; (6) *Flemingia macrophylla, Purearia phaseoloides* and *Stylosanthes macrocephala* were not suited for surface-sowing; and (7) Broadcasting produced more legume plants in number than the pellet-sowing did, while the size of individual plants with the former was smaller than that with the latter, showing efficiency of fertilizing by pellet.

Discipline: Grassland
Additional key words: broadcasting, burning, pellet, soil fertility

Introduction

In the savanna area of Brazil and Colombia, underutilized grazing lands extend over 300 million ha. For the purpose of attaining a low cost improvement of productivity of these savanna lands, an introduction of legumes to the existing vegetations is required.

Since 1970, Centro Internacional de Agricultura Tropical (CIAT) has undertaken a series of experiments to select suitable legumes and grasses for the poor soils characterized by low pH, low fertility and high aluminum saturation in savanna of South America. But a low cost method of introducing legumes to savanna has to be established yet.

In the present studies, the surface-sowing of legumes in burnt savanna was tried using seven species selected by CIAT. Among the tropical legumes surface-sown, Townsville stylo proves to be successful[8,15] in the native grassland of speargrass (*Heteropogon contortus*) in Australia. *Stylosanthes guianensis*[9,16] in the native grassland in Solomon Islands, *Siratro*[3] and six species of *Stylosanthes*[11]

The present paper is prepared on the basis of the results obtained in the cooperative study of Tropical Agriculture Research Center, Japan and Centro Internacional de Agricultura Tropical, which was implemented during the period 1989 to 1991.
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in the speargrass in Australia are identified to be successful. Most tropical grasses were not successful[3,7,17], however, except *Urochloa mosambicensis* in the Townsville stylo dominated pasture[7] or in the native grassland of speargrass[17] in Australia.

For the success of surface-sowing of temperate grasses, necessity of herbicide is stressed[1,5,6], while temperate legumes can successfully be introduced without herbicide[1,10]. Ability to survive and grow under uncultivated conditions and under the dominance of native grasses might be different among the species. Importance of selecting species suited for the surface-sowing is stressed in temperate grasses and legumes[4,13]. Considering the difficulties in introducing tropical grasses through surface-sowing, the effort in this experiment was mainly concentrated to selection of tropical legume species suitable for the South American savanna.

Although one of the important factors restricting surface-sowing is the competition for soil moisture[2,10], South American savannas have enough monthly rainfall 200 mm in Brasilian Cerrados and 300 mm in Colombian Llanos during the rainy season, which allows introduced legume to survive.

Another important factor is the competition for soil nutrient. Under the fertility of South American savanna soils, the competition for nutrients between the legumes sown and the native grasses is severe. To enhance growth of the introduced legume seedling, a macro-pellet method was developed, in which seeds and fertilizers were put in the same spot, making minimum use of seeds and fertilizers[12,14].

Table 1. Physical and chemical properties of Oxisol soils at the experimental sites

Property	Sandy clay loam (SCL)	Light clay (LiC)	Silty clay (SiC)
Clay (%)	17	26	35
Sand (%)	65	44	14
Silt (%)	18	30	51
pH (H_2O)	5.1	4.9	4.8
Organic matter (%)	0.89	1.64	2.8
Al (meq/100 g)	0.7	1.6	2.8
Ca (meq/100 g)	0.13	0.17	0.42
Mg (meq/100 g)	0.08	0.03	0.13
K (meq/100 g)	0.03	0.03	0.05
P (ppm)	2.0	1.6	2.0
Al saturation (%)	77	88	82
C.E.C. (meq/100 g)	0.94	1.83	3.40

In order to ensure keeping seeds and macro-pellet in the same spot, they were both put in paper bags before sowing[14]. Under sandy soil conditions with poor fertility, fertilization is essential in introducing legumes, while under comparatively fertile soils, broadcasting of legume seeds without fertilizers may succeed.

The present paper accounts for the results obtained from a series of the experiments that were carried out to identify sowing methods and legume species suitable for different soil fertility.

Surface-sowing of *D. ovalifolium* with macro-pellet into burnt savanna (Experiments 1, 2 and 3)

1) Experimental methods

(1) Species sown: *Desmodium ovalifolium* CIAT 13089.

(2) Sowing method: Seeds were sown on the soil surface, being attached to pellets, which were placed at a rate of one each in a quadrate of 2 × 2 m in burnt savanna.

(3) Sites: The Carimagua Experimental Station in Llanos in Colombia. It is located at latitude 4°37′ N, altitude 175 m, and soil type is Oxisol. Experiments 1 and 2 were conducted on sandy clay loam soil (SCL 65% sand) and Experiment 3 was on light clay soil (LiC 44% sand). Soil characteristics are shown in Table 1. Monthly rainfall and air temperature are shown in Fig. 1.

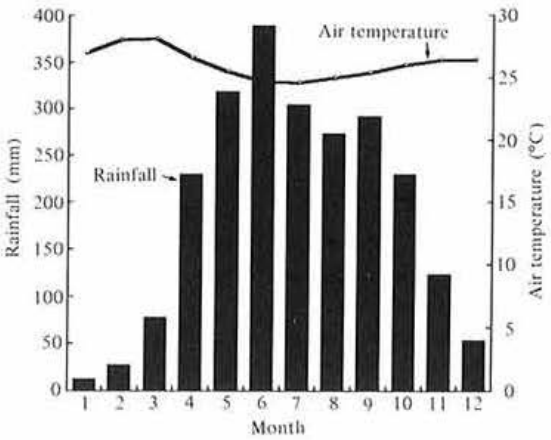

Fig. 1. Monthly rainfall and mean air temperature (average of 18 years) at Carimagua Experimental Station

(4) Sowing dates: Experiment 1, 13 May 1989; Experiment 2, 29 August 1989; and Experiment 3, 30 August 1989.
(5) Composition of pellet and preparation for sowing: Table 2 shows size and fertilizer composition of macro-pellet. About 30 seeds and one pellet were put together in a small paper bag (10 × 5 cm). Sowing rate was about 0.2 kg/ha.
(6) Management after sowing: Cattle had free access to the experimental sites.
(7) Land preparation and plot size: The seeds were sown immediately after the savanna field was burnt. In Experiment 1, additional three soil preparation methods were tested: i.e. (a) sowing one month after burning, (b) sowing after cutting, and (c) sowing after minimum tillage. Minimum tillage was undertaken with a chisel plow, producing bands of 50 cm width with an interval of 2 m. Pellets were placed on these bands. Plot size was 12.5 a in Experiment 1 for each treatment, and 1 ha in Experiments 2 and 3. There was no replication.
(8) Observation methods: Frequency counts and size measurements of the plants intercepting the three lines of 50 m length each were made for Experiment 1, and 100 m line for Experiments 2 and 3. Regarding dry weight measurement, four plots for Experiment 1 and six plots for Experiment 2 of 1 m^2 were cut in each treatment. In regard to coverage, 10 plots for Experiment 1 and 20 plots for Experiment 2 were examined in each treatment.

2) Results

Experiment 1: Although the growth of *D. ovalifolium* was slow in the first year, it was rapid in the second year (Fig. 2). There were no differences among the sowing methods in terms of plant size. Percentage of surviving plants was highest in the plot sown immediately after burning. Coverage and dry weight percentage of legume in savanna were 30 and 10%, respectively, in the third year (Table 3).

Table 2. Size and chemical composition of macro-pellets

Length (cm)	Width (cm)	DM weight (g)	Fertilizer composition (%)					
			N	P_2O_5	K_2O	Mg	Ca	S
3	1.5	8.8	0.2	7.8	4.1	2.1	13.9	4.0

Experiment 2: *D. ovalifolium* also grew well, though its growth in the first year (1989) was very slow (Fig. 3). Coverage and dry weight percentage of the legume crop in savanna were 30 and 7%, respectively, in the third year (Table 4).

Experiment 3: The growth of *D. ovalifolium* was slow in this experiment because of constant heavy grazing on this site. However, *D. ovalifolium* survived and grew steadily under this condition (Table 5).

From these results, it is concluded that the surface-sowing of *D. ovalifolium* with pellets is acceptable

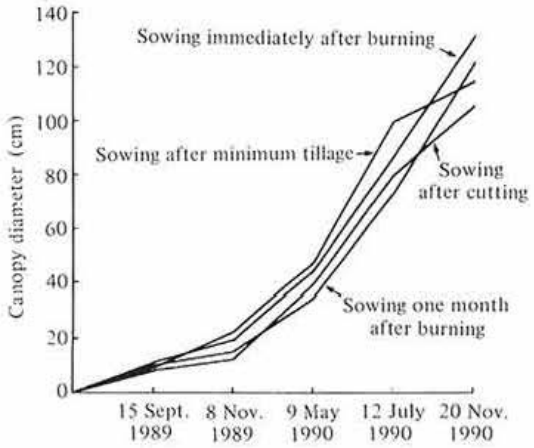

Fig. 2. Growth in canopy diameter of *D. ovalifolium* sown with pellets under different land preparation on sandy clay loam soil in May 1989 (Experiment 1)

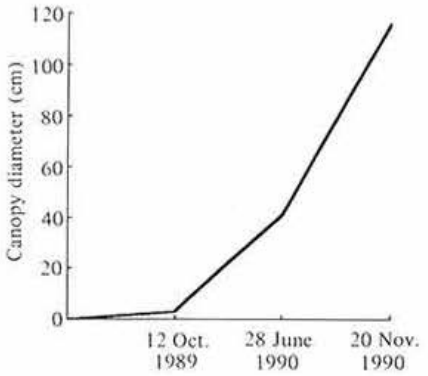

Fig. 3. Growth in canopy diameter of *D. ovalifolium* sown with pellets on sandy clay loam soil in August 1989 (Experiment 2)

Table 3. Growth of *D. ovalifolium* sown with pellets under different land preparation on sandy clay loam soil in May 1989 (Experiment 1)

Methods of sowing	Date of observation					
	15 Sept. 1989	20 Nov. 1990	28 May 1991			
	Growing spot* (%)	Growing spot (%)	Legume coverage (%)	Legume dry weight (g/m^2)	Savanna grass dry weight (g/m^2)	Legume dry weight (%)
Sowing immediately after burning	83	77	37	18.3	120.5	13.2
Sowing one month after burning	82	69	24	6.7	111.8	5.7
Sowing after cutting	63	36	30	5.1	144.9	3.7
Sowing after minimum tillage	63	41	18	7.7	97.5	7.3
LSD 5%	17	29		n.s.		

* Surviving legume % out of total sown spots.

Tale 4. Growth of *D. ovalifolium* sown with pellets on sandy clay loam soil in August 1989 (Experiment 2)

Date of observation					
12 Oct. 1989	20 Nov. 1990	28 May 1991			
Growing spot* (%)	Growing spot (%)	Legume coverage (%)	Legume dry weight (g/m^2)	Savanna grass dry weight (g/m^2)	Legume dry weight (%)
55	41	30	11.4	145.8	7.3

* Surviving legume % out of total sown spots.

Table 5. Number and size of *D. ovalifolium* sown with pellets on light clay soil in August 1989 (Experiment 3)

Characteristic	Date of observation	
	11 Oct. 1989	19 Nov. 1990
Growing spot (%)*	89	65
Legume canopy diameter (cm)	6	61

* Surviving legume % out of total sown spots.

under the burnt savanna condition.

Selection of legume species for pellet-sowing (Experiment 4)

Although the surface-sowing of pelleted *D. ovalifolium* was found to be feasible in Experiments 1, 2 and 3, there was a need to identify better legume species for surface-sowing with pellets.

1) Experimental methods

(1) Species tested: *S. capitata* "Capica", *C. acutifolium* "Vichada", *F. macrophylla* CIAT 17403, *D. ovalifolium* CIAT 13089, *S. macrocephala* CIAT 1643, *P. phaseoloides* CIAT 9900, and *S. guianensis* "Pauciflora".

(2) Sowing method: Seeds were sown on the soil surface with pellets, which were placed at a rate of one each in a quadrate of 1 × 1 m in burnt savanna. Sowing rate for each species was about 0.5 kg/ha.

(3) Sites: Sandy clay loam soil (SCL 65% sand), light clay soil (LiC 44% sand) and silty clay soil (SiC 14% sand) in Carimagua Experimental Station (Table 1).

(4) Sowing dates: 21 May to 8 June 1990.

(5) Plot size: 20 × 40 m for each species. No replication.
(6) Management after sowing: Cattle had free access to the experimental sites.
(7) Observation methods: Frequency counts and size measurements were made on the plants intercepting the two lines of 40 m length in each legume species. For dry weight measurement, three plots of 1 m^2 were cut in each legume species.

2) Results

As is shown in Table 6, *S. guianensis* grew well at the three sites. *D. ovalifolium* grew well in 1990, but decreased its number in 1991 because of the damages caused by ants and grasshoppers. *S. capitata* grew well on SiC soil but its growth was not sufficient, showing microelement deficiency, on SCL and LiC soils. *C. acutifolium* grew well on SCL and SiC soils, while not on LiC soil. This legume also showed symptoms of deficiency of microelement, possibly zinc. *P. phaseoloides* demonstrated good growth on SiC soil in 1990, but it disappeared in 1991.

From these results, it is concluded that *S. guianensis* is a suitable legume for pellets sowing, and that *D. ovalifolium* is strong in competition with its stoloniferous growth habit. However, this experiment

Table 6. Number and size of legumes in the experiment for selection under pellet-sowing (Experiment 4)

	Date of observation				
	9 July 1990	23 Oct. 1990		18 May 1991	
	Growing spot* (%)	Growing spot (%)	Legume canopy diameter (cm)	Growing spot (%)	Legume canopy diameter (cm)
Soil texture: Sandy clay loam					
S. capitata	42	28	3.8	9	21.7
C. acutifolium	56	56	27.3	28	31.6
F. macrophylla	24	0	–	0	–
P. phaseoloides	53	35	16.3	0	–
S. macrocephala	11	0	–	0	–
D. ovalifolium	80	79	16.5	0	–
S. guianensis	36	29	13.9	36	39.0
LSD 5%	32	46		n.s.	
Soil texture: Light clay					
S. capitata	60	33	11.8	29	16.3
C. acutifolium	53	19	18.3	0	–
F. macrophylla	10	0	–	0	–
P. phaseoloides	28	0	–	0	–
S. macrocephala	27	10	8.6	15	14.6
D. ovalifolium	87	44	21.6	25	28.2
S. guianensis	45	36	26.4	35	25.6
LSD 5%	15	13		n.s.	
Soil texture: Silty clay					
S. capitata	67	21	31.9	36	34.9
C. acutifolium	30	39	52.1	30	52.4
F. macrophylla	6	0	–	0	–
P. phaseoloides	34	25	45.0	0	–
S. macrocephala	23	0	–	0	–
D. ovalifolium	58	21	44.8	11	43.3
S. guianensis	28	36	40.5	43	58.8
LSD 5%	24	n.s.		8	

Sowing date: 21 May to 8 June 1990.
* Surviving legume % out of total sown spots.

Table 7. Dry weight of legumes and savanna grass in the experiment for selection under pellet-sowing (Experiment 4)

	Legume dry weight (g/plant)	Legume dry weight (g/m^2)	Savanna grass dry weight[a)] (g/m^2)	Legume (%)
Soil texture: Sandy clay loam				
S. capitata	0	0	–	–
C. acutifolium	1.9	0.5	196.9	0.3
F. macrophylla	0	0	–	–
P. phaseoloides	0	0	–	–
S. macrocephala	0	0	–	–
D. ovalifolium	0	0	–	–
S. guianensis	11.8	4.3	(196.9)	2.2
Soil texture: Light clay				
S. capitata	8.4	2.4	80.8	3.0
C. acutifolium	0	0	–	–
F. macrophylla	0	0	–	–
P. phaseoloides	0	0	–	–
S. macrocephala	5.7	0.9	(80.8)	1.1
D. ovalifolium	4.9	1.2	(80.8)	1.5
S. guianensis	3.8	1.3	(80.8)	1.6
Soil texture: Silty clay				
S. capitata	10.9	4.0	209.9	1.9
C. acutifolium	8.8	2.6	(209.9)	1.2
F. macrophylla	0	0	–	–
P. phaseoloides	0	0	–	–
S. macrocephala	0	0	–	–
D. ovalifolium	10.0	1.1	(209.9)	0.5
S. guianensis	11.1	4.7	(209.9)	2.2

Sowing date: 21 May to 8 June 1990. Cutting date: May 1991.
a): Dry weight of the total savanna grass, consisting of some components indicated with and without parentheses.

showed that it was susceptible to insect damages.

For the success of pellet-sowing for *S. capitata* and *C. acutifolium*, some microelements have to be added to pellets. *F. macrophylla, P. phaseoloides* and *S. macrocephala* were not suitable for this sowing method.

Selection of legume species for broadcasting (Experiment 5)

1) Experimental methods

(1) Species, sites, plot size, and management after sowing: The same as those of Experiment 4.

(2) Sowing method: Two kg/ha seeds of each species were broadcasted in burnt savanna.

(3) Sowing date: 6 July 1990.

(4) Observation methods: Referring to legume number and size measurements, five plots of 1 m^2 were examined for each legume species. For dry weight determination, three plots of 1 m^2 were cut for each species.

2) Results

Table 8 indicates that in every site, *S. guianensis* grew well, although the number of legumes on SCL soil was 1/3–1/5 compared with other sites. On SCL soil, most legumes disappeared except *S. guianensis.*

S. capitata showed deficiency in microelement, probably zinc. One year after sowing, however, they grew vigorously on LiC and SiC soils. *D. ovalifolium* grew well on LiC soil, but the number of legumes decreased on SiC soil because of insect damages. *S. macrocephala* grew on LiC and SiC soils, but the number and size of plants were insufficient. *C. acutifolium, F. macrophylla* and *P. phaseoloides* proved to be unsuitable for broadcasting.

Table 8. Number and size of legumes in broadcast experiment (Experiment 5)

	Date of observation			
	Oct. 1990		May 1991	
	No. of legumes (/m²)	Legume canopy diameter (cm)	No. of legumes (/m²)	Legume canopy diameter (cm)
Soil texture: Sandy clay loam				
S. capitata	0	–	0	–
C. acutifolium	0	–	0	–
F. macrophylla	0	–	0	–
P. phaseoloides	0	–	0	–
S. macrocephala	0	–	0	–
D. ovalifolium	0	–	0	–
S. guianensis	0.8	1.7	2.4	10.0
Soil texture: Light clay				
S. capitata	9.6	5.2	13.8	14.0
C. acutifolium	0.8	15.0	0	–
F. macrophylla	0	–	0	–
P. phaseoloides	0	–	0	–
S. macrocephala	1.8	5.0	3.0	11.0
D. ovalifolium	8.4	6.3	10.6	10.0
S. guianensis	6.6	9.6	6.8	17.0
LSD 5%	5.7		4.8	
Soil texture: Silty clay				
S. capitata	2.8	1.7	3.6	8.3
C. acutifolium	0.6	30.0	0.4	22.5
F. macrophylla	0	–	0	–
P. phaseoloides	0	–	0	–
S. macrocephala	1.0	2.3	1.2	4.0
D. ovalifolium	3.6	1.7	1.2	15.0
S. guianensis	5.4	17.5	11.4	14.0
LSD 5%	n.s.			

Sowing date: 6 July 1990.

Weight of the unit plant in pellet-sowing (Table 7) was five times heavier than that in broadcasting (Table 9), showing efficiency of fertilizing with pellets. On the other hand, the number of the legume plants/m² in broadcasting (Table 8) was 30 times than that in pellet-sowing (Table 6), indicating a greater advantage of broadcasting in obtaining a desired plant population.

The above result indicates that *S. guianensis* is a suitable species for broadcasting in burnt savanna. However, under poor soil conditions, broadcasting without fertilizer is not recommendable. *S. capitata* and *D. ovalifolium* can be suited for broadcasting by adding microelements for *S. capitata* and by controlling insect damages for *D. ovalifolium*.

Selection of legume species and sowing method

S. guianensis was proved to be a suitable legume for surface-sowing. Under comparatively fertile soil conditions, broadcasting of this species is also practicable. In poor soil, however, broadcasting is not suited, while pellet-sowing of *S. guianensis* is recommendable.

S. capitata and *D. ovalifolium* can be broadcasted in fertile soil. For other species, pellet-sowing could be recommended, on condition that microelement such as zinc is added.

F. macrophylla, P. phaseoloides and *S. macrocephala* are not suitable for surface-sowing.

Table 9. Dry weight of legumes and savanna grass in broadcast experiment (Experiment 5)

	Legume dry weight (g/plant)	Legume dry weight (g/m^2)	Savanna grass dry weight (g/m^2)	Legume (%)
Soil texture: Sandy clay loam				
S. capitata	0	0	–	
C. acutifolium	0	0	–	–
F. macrophylla	0	0	–	–
P. phaseoloides	0	0	–	–
S. macrocephala	0	0	–	–
D. ovalifolium	0	0	–	–
S. guianensis	2.08	5.0	195.2	2.5
Soil texture: Light clay				
S. capitata	0.69	9.5	99.9	8.7
C. acutifolium	0	0	–	–
F. macrophylla	0	0	–	–
P. phaseoloides	0	0	–	–
S. macrocephala	2.03	6.1	69.3	8.1
D. ovalifolium	0.83	8.8	93.7	8.6
S. guianensis	1.32	9.0	99.8	8.3
Soil texture: Silty clay				
S. capitata	1.06	3.8	229.6	1.6
C. acutifolium	2.20	2.2	147.1	1.5
F. macrophylla	0	0	–	–
P. phaseoloides	0	0	–	–
S. macrocephala	4.08	4.9	191.7	2.5
D. ovalifolium	0	0	–	–
S. guianensis	1.08	12.3	152.3	7.5

Sowing date: 6 July 1990.
Cutting date: May 1991.

Discussion

Factors affecting the survival of surface-sown seedlings may include the ability of absorbing soil nutrient, tolerance to unfavorable environments and insect damages, and others. Further studies are needed to identify these factors more definitely.

CIAT selected two species having high quality, high yielding ability and adaptation to savanna: i.e. *S. capitata* "Capica" and *C. acutifolium* "Vichada". It was found, however, that as far as the ability of survival after surface-sowing was concerned, *S. guianensis* was superior to these species. Higher population density was obtained under broadcasting compared with pellet-sowing. On the other hand, size of individual plants was larger in pellet-sowing than in broadcasting, showing the efficiency of fertilization by pellet.

For stoloniferous legumes such as *D. ovalifolium* and *C. acutifolium,* the initial density is not very important, while for erect type legumes such as *S. guianensis* and *S. capitata,* it seems to be important. One of the factors in selecting a sowing method is the growth habit of plants. Soil type and economy are, among other factors, key factors in selecting an establishment method. An appropriate method for management of pasture after surface-sowing has yet to be investigated sufficiently. The need for maintenance fertilizer after establishment is subjected to further examination. Tolerance of legumes to fire is another important factor for maintaining a mixed pasture of native grasses and introduced legumes.

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