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The Use of Seeds Fixed onto Fertilizer Pellets for Pasture Establishment in the Llanos Orientales of Colombia

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Introduction

The Llanos Orientales of Colombia is savanna land extending between the river Meta and the river Orinoco, separating Colombia and Venezuela. This land is mostly used for extensive grazing but cattle productivity is very low under present management. Pasture establishment in the Llanos Orientales is technically easy if machinery and chemical fertilizers are available[14]. However, the conventional method of forage planting using disks and broadcasting of chemical fertilizers is too expensive and there is danger of soil erosion, during the establishment phase. Furthermore, this frontier land is located far from urban areas and lacking access roads, hence the transportation of materials for pasture establishment is very costly. Surface sowing without tillage would reduce the cost of land preparation and minimize the danger of erosion, but it has not been successful in these native savannas[1,14].

On the other hand, surface sowing of seeds coated with fertilizer showed some advantages in pasture establishment[4,9,10,13,18], but the effectiveness of the fertilizer used for coating was negligible[1]. For the purpose of giving a favorable nutritional condition to seedlings for a long growth period, a large amount of fertilizers must be used. This results in a thick coating layer of concentrated fertilizer. However, such coated seeds definitely cause physical hindrance to germination and chemical injury to seedlings. In practice, therefore, the coating layer should be thin and soft, and the amount of fertilizer is quite limited[3,5,6,11,13,19].

The new type of seed preparation, i.e. seeds fixed onto fertilizer pellets (hereafter abbreviated to "seed-pellets"), is quite different from the seeds coated with fertilizer, mentioned above. This type of seed-pellets was already developed and used by one of the present authors in Japan[8]. The result of the first trial on the use of the seed-pellets in pasture establishment on the native savanna of the Llanos Orientales of Colombia is presented in this paper.

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Materials and methods

1) *Experimental sites*

The two experimental sites were located at 4.5° north latitude, 71° west longitude and 160 m above sea level on the ICA-CIAT station of Carimagua in eastern Colombia. The soils at both sites are oxisols, one is a sandy loam and the other clay loam. Both soils represent an average productive level of the native savanna.

Some physico-chemical properties of the soils are shown in Table 1. Both are acidic, showing high aluminium saturation and a low level of available phosphorus. The sandy loam soil is characterized by a low water holding capacity due to small pore-volume and large pore-size.

2) *Seedbed preparation*

After burning the natural grassland at the end of August, 1985, the following three treatments were given to prepare seedbed.

(1) Control: No further treatment.

(2) Herbicide treatment: Glyphosate solution was sprayed to each planting spot (50 cm ϕ) and seeds were sown after 30 days.

(3) Tillage treatment: The field was tilled with a chisel plow to about 10 cm in depth and 15 cm in width, early in September.

3) *Sowing forage legumes and grass*

(1) Seed-pellets: The seed-pellets (Fig. 1) were placed on the soil surface at 1 m distance between rows on October 1–3.

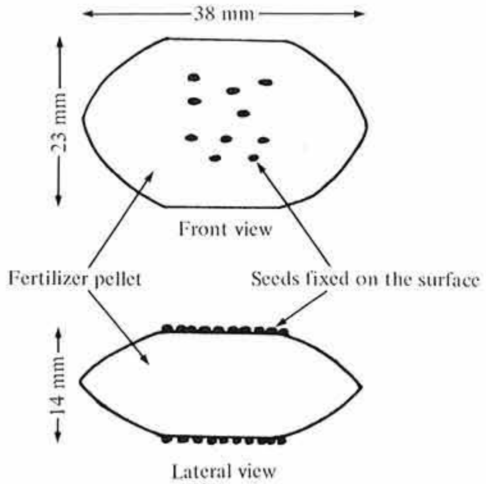

Fig. 1. Schematic presentation of the seed-pellet

(2) Spot-sowing: Granular fertilizer was applied to each spot (10 cm ϕ) and seeds were sown at the fringe of the applied fertilizer on October 1–3, at the same spacing as in (1). The amount of fertilizer elements in the granular fertilizer was the same as that of the seed-pellets, and the number of seeds sown was the same for both cases.

4) *Fertilizer*

(1) Seed-pellet: Chemical composition of the fertilizer used is shown in Table 2. It was almost identical with the recommended composition of nutrients for pasture establishment in Carimagua[15]. However, the amount of nutrients applied as seed-pellets per unit

Table 1. Physico-chemical properties of the soils in the experimental fields

	Horizon (cm)	Clay (%)	Sand (%)	pH (H_2O)	OM (%)	Exchangeable cations(meq/100g) Al	Cu	Mg	K	CEC	Al saturation (%)	Available P Bray II (ppm)	Three phase distribtion of soil* Solid	Liquid	Air(%)
Clay loam	0– 5	33	12	5.3	3.7	2.2	0.3	0.1	0.1	2.7	83	3.0	43.6	32.1	24.3
	5–10	34	11	5.1	2.1	2.2	0.2	0.1	0.1	2.5	89	2.1	44.5	33.3	22.2
	10–15	36	11	5.1	2.5	2.0	0.1	0.0	0.0	2.2	90	1.3	45.9	33.8	20.4
	15–20	37	10	5.2	2.1	1.8	0.2	0.1	0.0	2.0	88	0.9	43.4	29.9	25.8
Sandy loam	0– 5	19	57	5.0	1.4	0.8	0.2	0.1	0.1	1.1	73	2.4	53.5	19.2	27.3
	5–10	20	56	5.3	1.1	0.8	0.1	0.0	0.0	1.0	80	1.9	54.2	19.0	26.8
	10–15	23	56	5.2	1.2	0.8	0.1	0.0	0.0	1.0	80	1.3	53.7	19.5	26.7
	15–20	23	56	5.0	0.8	0.7	0.1	0.0	0.0	0.9	78	1.6	53.9	19.3	26.7

Table 2. Chemical composition of fertilizers used for the seed-pellet

Common name	Chemical formula	Mineral composition(%)					
		N	P	K	Ca	Mg	S
IBDU	$\begin{matrix}NH_2CONH \\ NH_2CONH\end{matrix}\rangle CH \cdot CH\langle\begin{matrix}CH_3 \\ CH_3\end{matrix}$	31.0	0.0	0.0	0.0	0.0	0.0
Multiphosphate	$\begin{bmatrix}Ca(H_2PO_4)_2H_2O \\ CaHPO_4 \cdot 2H_2O \\ MgHPO_4 \cdot 3H_2O\end{bmatrix}$	0.0	13.0	0.0	10.7	4.8	0.0
Potassium silicate	$K_2MgSi_3O_8$	0.0	0.0	8.6	5.7	2.4	0.0
Potassium sulfate	K_2SO_4	0.0	0.0	44.8	0.0	0.0	18.3
Gypsum	$CaSO_4 \cdot 2H_2O$	0.0	0.0	0.0	20.3	0.0	16.3
Pellet for legumes*		0.0	5.2	5.0	9.2	3.0	2.2
Pellet for mixed sowing of legumes and grass**		2.4	4.3	4.2	8.3	2.8	1.6

* It contains 40.0% multiphosphate, 46.3% potassium silicate, 2.3% potassium sulfate, and 11.4% gypsum.

** It contains 8.0% IBDU, 33.3% multiphosphate, 48.7% potassium silicate, and 10.0% gypsum.

area was 1/3 of that recommended one. The fertilizer was highly compressed to form an almond shape with a small amount of water glass. The pellet weighs 13.5 g with apparent density of 1.9 g/cm³. Seeds are fixed on the surface of fertilizer pellets by a water soluble adhesive.

Forage species used and the number of seeds per pellet are as follows:

	Seeds/pellet
Stylosanthes macrocephala	20
Centrosema acutifolium	5
Pueraria phaseoloides	10
Brachiaria dictyoneura	10

(2) Granular fertilizer: Two kinds of fertilizers were used for spot-sowing,

a) the "granular" type was identical with the fertilizer pellet,

b) much finer one and it contained the same amount of nutrients (N, P, K, Mg, S) as the seed-pellet but urea, superphosphate, potassium chloride, magnesium chloride and sulphur were used as sources.

5) Experimental procedures

The experimental design was split-plot with seedbeds and seed treatments as main plots and forage species as sub-plots with three replications. The individual sub-plot area was 5 × 4 m. The experimental areas were treated with aldrin after germination to eliminate leaf-cutter ants. Growing seedlings were counted at 2 months after planting.

Results and discussion

Weather data from October to early December, 1985 at Carimagua headquarters are shown in Fig. 2. Heavy rain occurred twice during the first week after planting. There was almost no rainfall after the end of November, when the dry season normally begins.

As shown in Table 3 and Table 4, it was clearly observed that the use of seed-pellets was very effective in promoting seed-germination and seedling establishment of three legume species and one grass species under three different seedbed conditions (untreated control seedbed, treated seedbeds with herbicide, and tillage). Table 3 gives the percentage of sowing spots showing seedlings growing to the total number of the sowing spots, while Table 4 gives the percentage of the number of growing seedlings to the total number of seeds sown.

The beneficial effect of seed-pellets on germination and seedling establishment is ascribed to the following three factors. First, favorable microenvironmental conditions are present at the interface between the bottom of the seed-pellet and the soil surface. Seeds are protected from strong sunshine and also

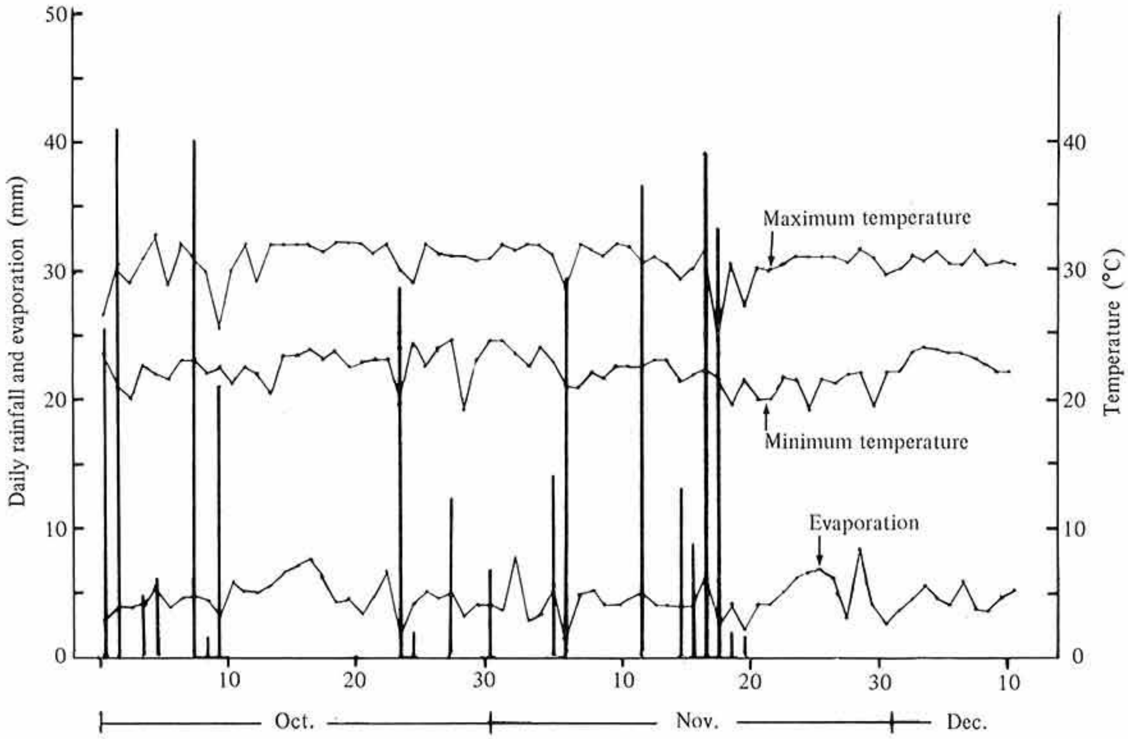

Fig. 2. Daily rainfall (columns), evaporation, and temperature in Carimagua during the experimental period

Table 3. Effect of seed-pellet sowing on the number of sowing spots which showed growing seedlings (expressed in % of the total number of sowing spots), observed 2 months after sowing

Soil	Species	No. of sowing spots (in %) with growing seedlings in 3 field plots differently treated as indicated below							LSD (P< 0.05)
		No treatment	Herbicide application			Tillage			
		Seed-pellet	Seed-pellet	Spot sowing[a)]	Spot sowing[b)]	Seed-pellet	Spot sowing[a)]	Spot sowing[b)]	
Clay loam	*S. macrocephala*	98.3(85.7)**	93.3(78.1)	81.7(63.7)	88.3(73.9)	100.0(90.0)	100.0(90.0)	91.7(76.8)	20.5
	C. acutifolium	100.0(90.0)	94.2(79.6)	60.0(51.1)	66.7(56.0)	100.0(90.0)	100.0(90.0)	96.7(83.9)	
	P. phaseoloides	91.7(76.8)	90.0(71.6)	43.3(40.8)	41.7(40.2)	98.3(85.7)	96.7(83.9)	88.3(73.5)	
	*P. phaseoloides**	83.0(66.1)	73.3(60.3)	48.3(44.0)	33.3(34.9)	100.0(90.0)	95.0(79.6)	96.7(81.4)	
	*B. dictyoneura**	88.0(74.8)	88.3(70.5)	30.0(32.9)	38.3(37.8)	93.3(75.3)	88.3(70.5)	80.0(65.0)	
Sandy loam	*S. macrocephala*	95.0(79.0)	96.7(81.4)	68.3(61.0)	56.7(49.0)	93.3(75.3)	98.3(85.7)	85.0(68.0)	25.3
	C. acutifolium	91.7(80.0)	83.3(70.1)	5.0(10.4)	8.3(16.2)	100.0(90.0)	86.7(76.9)	100.0(90.0)	
	P. phaseoloides	68.3(56.8)	71.7(58.2)	11.7(12.1)	20.0(25.3)	100.0(90.0)	98.3(85.7)	100.0(90.0)	
	*P. phaseoloides**	71.1(58.9)	48.3(43.9)	6.7(11.9)	3.3(8.6)	93.3(81.3)	95.0(79.0)	95.0(79.6)	
	*B. dictyoneura**	76.7(66.1)	63.3(52.9)	1.7(4.3)	8.3(13.2)	91.7(76.2)	95.0(79.0)	98.3(85.7)	

a), b) : Corresponding to the granular fertilizer in the text.
* Legume-grass mixed sowing: Seeds of 2 species were fixed together on each pellet.
** Arcsine transformation.

Table 4. Effect of seed-pellet sowing on the number of growing seedlings (expressed in % of the total number of seeds sown) observed 2 months after sowing

Soil	Species	No. of growing seedlings (in %) in 3 field plots differently treated as indicated below: No treatment	Herbicide application			Tillage			LSD (P< 0.05)
		Seed-pellet	Seed-pellet	Spot sowing[a)]	Spot sowing[b)]	Seed-pellet	Spot sowing[a)]	Spot sowing[b)]	
Clay loam	*S. macrocephala*	25.1(26.8)**	30.3(32.9)	19.5(26.5)	16.8(24.2)	39.0(38.8)	31.8(30.0)	33.7(35.5)	12.2
	C. acutifolium	70.7(57.3)	70.7(57.3)	30.0(32.4)	22.0(26.9)	61.3(51.7)	63.3(53.0)	68.7(56.1)	
	P. phaseolodes	28.3(32.1)	27.3(31.5)	7.3(14.8)	7.3(15.3)	35.3(36.4)	34.7(34.8)	26.7(30.6)	
	*P. phaseolodes**	18.7(25.6)	20.3(26.3)	9.3(17.6)	13.2(13.5)	31.7(34.1)	28.7(32.4)	34.0(35.5)	
	*B. dictyoneura**	30.7(33.6)	40.7(39.4)	8.0(16.2)	8.7(15.1)	33.3(35.2)	32.3(34.7)	37.3(37.5)	
Sandy loam	*S. macrocephara*	32.7(34.4)	28.3(32.3)	7.0(15.3)	7.0(15.3)	25.3(30.1)	23.0(28.6)	16.2(23.7)	18.2
	C. acutifolium	31.3(33.1)	38.0(38.5)	1.3(5.4)	1.3(3.8)	77.3(61.7)	61.3(56.6)	82.0(65.8)	
	P. phaseoloides	17.0(23.7)	17.0(23.7)	2.0(4.7)	2.7(7.6)	34.0(35.6)	39.0(38.5)	33.0(35.0)	
	*P. phaseoloides**	13.3(21.2)	6.7(14.8)	1.2(3.3)	1.3(5.2)	26.6(31.1)	20.7(27.0)	24.7(29.8)	
	*B. dictyoneura**	34.3(34.8)	16.3(23.7)	0.0(0.0)	2.0(6.7)	35.0(36.3)	44.3(41.6)	28.3(31.5)	

a), b), *, ** : See Table 3 for explanation of treatments.

prevented from drying out[12)]. Second, the pellet serves as an "anchor" over the seeds, thus the radicles can more easily penetrate into the soil than in the case of seeds loosely placed on the soil surface. Third, the seeds beneath the pellet are also protected against heavy rain and are not easily washed away.

Tilling increased seedling establishment in both the spot-sowing plots and the seed-pellet plot. However, the effect was greater in the spot-sowing plots (Table 3) because the seeds sown on the tilled soil were fully or partially buried in the soil, resulting in an increase of the seed-soil contact area[16)] which facilitates penetration of the radicles into the soil. The seeds were also protected from washing by heavy rain. On the other hand, in the seed-pellet plot the seed-pellets themselves can exert such favorable effects as shown above to seeds. Therefore, it is natural that tillage effect was not obvious in the seed-pellet plot.

The effect of herbicide treatment on seedling establishment was not clear for either the seed-pellet plot or the spot-sowing plots without tillage treatments, possibly due to low density and limited competition of native grasses in the experimental sites.

The establishment of surface-sown *S. macrocephala* was better than that of other species, presumably because its seeds germinate more rapidly and are small and flat so that they tend to fall into small soil cracks with more moisture than soil surface.

Percentage of growing seedlings of *P. phaseoloides* in the sandy loam was somewhat lower than that in the clay loam, due to the damage by leaf cutter ants although aldrin was applied to both soils.

As already reported[3,5,6,11,13,19)], seeds coated with fertilizer often cause germination failure due to chemical injury. Therefore, high analysis fertilizers can not be used for seed coating. To the contrary, no germination failure occurred with seed-pellets. Thus the effectiveness of the fertilizer used as pellets is expected to last for a longer period because a large amount of high grade analysis fertilizers can be used.

Summary

The effect of the use of "seeds fixed on fertilizer pellets by an adhesive" (abbreviated to seed-pellets) on seed germination and seedling growth of three legumes and one grass species was examined in savanna of Llanos Orientales of Colombia. The seed-pellets were sown to the field which had been treated with

tillage or herbicide in addition to no treatment after burning the natural grassland. Compared to the spot-sowing of seeds combined with granular fertilizer application, the seed-pellets promoted remarkably the seed germination and seedling growth.

Contrary to the use of "seeds coated with fertilizer", which has been attempted in pasture establishment so far, the seed-pellet method developed by the author, Mitamura, was found to be very effective and promising. It has no defects such as physical hindrance of germination or chemical injury of seedlings caused by direct contact with high concentration of fertilizer elements, both of which often occur with seeds coated with fertilizer. Therefore, in preparing seed-pellets, high analysis fertilizers can be used, and, as a result, the fertilizer effect of the seed-pellets is expected to last for a long period to support seedling growth.

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