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Introduction of Legumes in *Brachiaria humidicola* Pasture Using Macro-Pellet

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Introduction

The animal productivity in the grass-legume association is generally recognized to be much higher than in the grass-based pasture in the tropics[1,4]. However, vast pastures of *Brachiaria* spp. such as *B. humidicola*, *B. decumbens* and *B. dictyoneura*, which are certainly the most valuable grasses in the tropics of South America, are left low nutritive due to the lack of adapted cultivars of legumes to be accompanied.

Several promising legumes capable of producing high yields under the infertile acid soil conditions in tropical South America have recently been released by Centro Internacional de Agricultura Tropical (CIAT). These legumes have persistence abilities under grazing, associated with adequate competitiveness with grasses, and provide grazing cattle with a high nutritive value[4,7]. In practice, however, in introducing these new legumes by the conventional fertilization method, an extremely high cost incurred is of a major problem, which is caused by mainly the high application rate of chemical fertilizers required. Therefore, in introducing legumes, it is prerequisite to develop a low-cost technology[9].

Use of macro-pellets of fertilizers to which crop seeds adhere would be one of the effective technologies in introducing legumes at a low cost[5].

The macro-pellet is a large-sized chunk composed of chemical fertilizers, weighing about 10 g each, with the legume seeds stuck on the surface by gum arabic. It is applied in the pasture with a low density (1,000–3,000 pellets/ha), following the seed-bed preparation. The legume seeds are released from the pellets' surface by rainwater immediately after the application, and germinate around or/and under the pellets. From a viewpoint of the fertilizer placement technique, the legume plants established around the pellets receive a high rate of nutrients from localized chemical fertilizers, while the total amount of fertilizer on a per hectare basis is very low due to the low density application of macro-pellets. This application system of fertilizers using macro-pellets was recognized to be very effective for increasing

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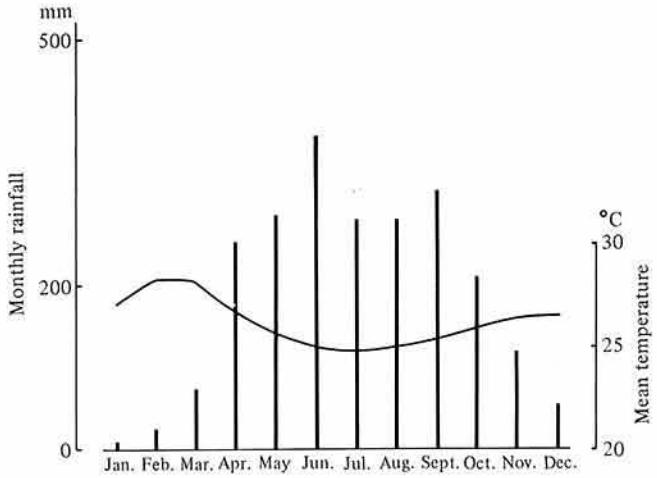

Fig. 1. Rainfall and mean temperature at Carimagua

the efficiency of fertilizer use in infertile acid soils of the tropics[6]. A field trial on the macro-pellets was undertaken at Carimagua in the Eatsern Plain of Colombia, in collaboration with the tropical pasture program of CIAT. This paper presents the results of the trial for the improvement of grass-based pasture of *B. humidicola* with the introduction of legumes using a macro-pellet system.

Materials and method

1) Experimental site and climate

This experiment was carried out at the national agricultural research station of Instituto Colombiano Agropecuario (ICA) located at Carimagua of Llanos Orientales, 4.5° north latitude and 71° west longitude. The station is 175 m above sea level, with a mean yearly temperature of 26°C and annual precipitation of 2,280 mm. Fig. 1 shows monthly rainfall and mean monthly temperature at the station. The rainy season normally begins in April and terminates at the end of November, and the temperature fluctuation is small throughout the year.

2) Experimental pasture and soils

The experimental field was primarily a degraded grass-based pasture of *Brachiaria humidicola* established in 1980. The size of the trial field was 1.8 ha.

Table 1. Soil texture of the experimental field at Carimagua

Soil depth (cm)	Soil particles (%)			Texture
	Sand	Silt	Clay	
0— 5	57	24	19	S L
5—10	56	24	20	S L
10—15	56	21	23	S L
15—20	56	21	23	S L

Tables 1 and 2 show physico-chemical properties of the soils of the experimental pasture situated on an oxisol. The soils were of sandy loam and acidic, and recognized to be very infertile due mainly to deficiencies of P, K, Mg, S and Ca. The soils were also characterized by a low cation exchange capacity with a high Al saturation.

3) Experimental design

The experimental design was split-plot with combinations of three kinds of seed-bed preparation as main plots and three legume species as sub-plots. The plots were randomly arranged with three replications; each plot was 14 × 14 m in size.

4) Seed-bed preparation

Prior to the field trial, the whole area of

Table 2. Chemical characteristics of soils of the experimental field at Carimagua

Soil depth (cm)	O. M. (%)	pH	Exchangeable cations (meq/100 g soil) Al	Ca	Mg	K	CEC	Al Saturation (%)	Ava. P Bray II (ppm)
0— 5	1.4	5.0	0.8	0.2	0.1	0.1	1.1	73	2.4
5—10	1.1	5.3	0.8	0.1	0.0	0.0	1.0	80	1.9
10—15	1.2	5.2	0.8	0.1	0.0	0.0	1.0	80	1.3
15—20	0.8	5.0	0.7	0.1	0.0	0.0	0.9	78	1.8

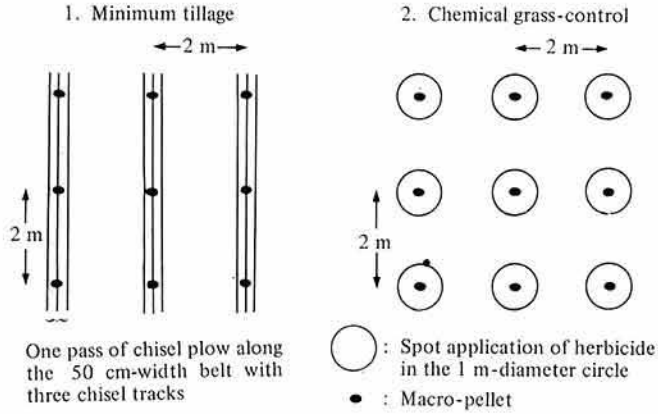

Fig. 2. Seed-bed preparations with minimum tillage or grass-control with herbicide

the pasture was burned at the end of July in 1986, two weeks before the seed-bed preparation. Three types of seed-bed preparation were tested in this experiment; comprising the minimum tillage with and without chemical grass-control, and the nontillage with chemical grass-control. The procedures of seed-bed preparation are shown in Fig. 2. The minimum tillage was accomplished by one pass of the chisel plow, as shown in Fig. 2. The chemical grass-control was provided by spot-application of Glyphosate as shown in Fig. 2. In the plot under minimum tillage with chemical grass-control, the herbicide was applied in the circle set up on the chisel tracks.

5) *Application of macro-pellets with legume seeds*

The structure of the macro-pellet subjected to test in this experiment is shown in Fig. 3. Thirty seeds of *Desmodium ovalifolium* (CIAT 3788), 12 seeds of *Centrosema brasilianum* (CIAT 5234) and 6 seeds of *Arachis pintoi* (CIAT 17434) were separately stuck with gum arabic on the surface of large sized pellets. The pellets, weighing 13.8 g each, were composed of complete fertilizers and the binding materials as shown in Table 3.

The macro-pellets with each legume were planted on 2 August 1986, one week after seed-bed preparation. Each pellet was placed in the center of the 2×2 m grid in the plot so that it took the position at the middle of the belt of chisel tracks and at the center of the circle treated with the herbicide (Fig. 2). The planting density was 2,500 pellets/ha. Two weeks after planting, rhizobium was inoculated by spraying its solution on legume seedlings and soil.

The amount of chemical fertilizers and legume seeds required for the experiment was

Table 3. Weight and chemical composition of the macro-pellet tested at Carimagua

Weight (g/pellet)	Chemical composition (g/pellet)					Binding material Gypsum % (g/pellet)
	P	K	Mg	S	Ca	
13.8	0.79	1.27	0.56	0.30	1.01	11.4 (1.57)

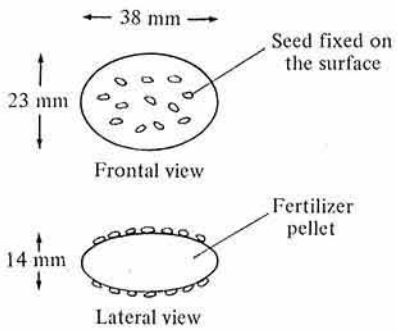

Fig. 3. Schematic presentation of the macro-pellet tested at Carimagua in 1986-1988

Table 4. Amounts of legume seeds and chemical fertilizers on a per hectare basis used for the macro-pellet system in the field experiment

Seeds		Fertilizers	
Legumes	kg/ha	Component	kg/ha
Desmodium ovalifolium	0.1	P	2.0
Centrosema brasilianum	1.2	K	3.1
Arachis pintoi	3.1	Mg	1.4
		S	0.8
		Ca	2.5

shown in Table 4. The application rates of P, K, Mg, S and Ca were 2.0, 3.1, 1.4, 0.8 and 2.5 kg/ha, respectively. The amounts of seed requirements of *D. ovalifolium*, *C. brasilianum* and *A. pintoi* were 0.1, 1.2 and 2.3 kg/ha, respectively.

6) *Grazing management after planting*

In order to reduce the competition between *B. humidicola* and the legumes sown, an intermittent grazing, comprising monthly grazing/resting period of 5/25 or 7/23 days, was repeated every month with 20 cattle in the pasture during the period September 1986 to May 1987.

Since June 1987, the grazing system was changed so that an alternate grazing could take place between the two paddocks prepared in the separated pasture, for the purpose of evaluating the animal productivity in the pasture. The rotation period between the two paddocks was basically 14/14 days. However, this period was occasionally modified in order to keep the balance of vegetational composition between the grass and legumes, according to the conception of the flexible grazing management in grass-legume association[8]. The stocking rate in this system was 3.3 heifers/ha during the wet and the early dry seasons and 2.2 heifers/ha during the rest dry season.

Results and discussion

1) *Early establishment of legumes*

Early establishment of legume seedlings is vital in the effective use of grass-legume association under infertile acid soil conditions in Eastern Plain of Colombia. In this regard, Table 5 shows effects of the tillage and grass-control with herbicide on the establishment of legumes planted under the macro-pellet system in the grass-based pasture of *B. humidicola*. The legume seeds were easily separated from surface of the macro-pellets with the rain water immediately after the placement, and attached themselves to the soil around or/and under the pellets. The seeds were not washed away by run-off water even under the heavy rainfall. They were also protected from the heat of strong sunshine. Consequently, high rates of early establishment of legume seedlings were ensured by the use of macro-pellet system. No significant difference could be seen among the

Table 5. Effect of tillage accompanied by chemical grass-control on the establishment of legumes planted with the macro-pellet in the grass-based pasture of *Brachiaria humidicola*, one month after planting (Planting date: 2 Aug. 1986)

Legumes	Percentage of establishment[2)]		
	I [1)]	II	III
Desmodium ovalifolium	90.5	95.2	86.9
Centrosema brasilianum	92.9	92.9	78.3
Arachis pintoi	90.5	95.3	51.2

1): Tillage and grass-control with herbicide
I ; Minimum tillage with chemical control,
II ; Minimum tillage without chemical control,
III ; Nontillage with chemical control.
2): Percentage of macro-pellets with viable legume seedlings against the total number of the macro-pellets planted.

methods of seed-bed preparation, except for *A. pintoi*.

The plants of *A. pintoi* (CIAT 17434) were poorly established in the plot of nontillage with chemical grass-control. A number of seedlings of *A. pintoi* were killed after germination. This damage was caused by their thick radicles which had failed to penetrate into the solid soils under the nontillage condition. In ensuring the stands of *A. pintoi* seedlings, it was recognized essential to break the hardpan of the soil surface with tillage by one pass of chisel plowing.

2) Changes in legume coverage under grazing during one year after planting

Changes in legume coverage pattern under the grazing condition was subjected to comparison among the different treatments in this field trial, the result of which is shown in

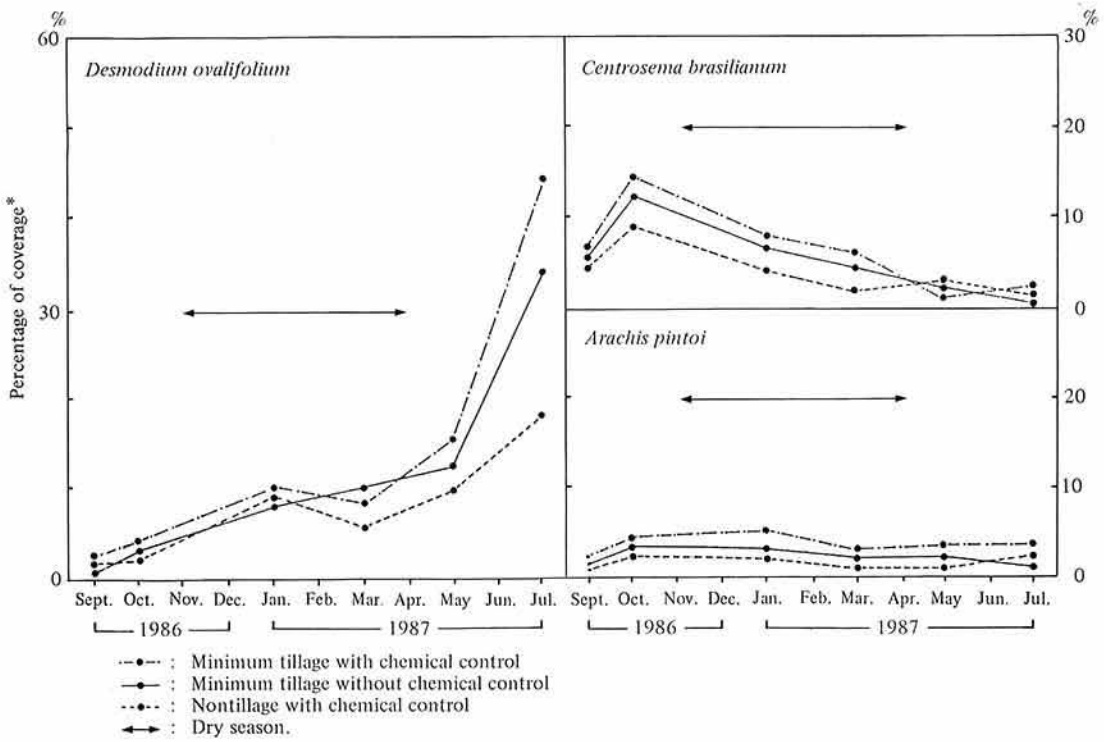

Fig. 4. Effect of tillage and vegetation control with herbicide on changes of the coverage of legumes under grazing in the grass-based pasture of *Brachiaria humidicola*
* Estimated in a 1×1 m quadrate centered around the macro-pellet.
Planting date: 2 Aug. 1986.

Fig. 4. The coverages were measured in a 1 × 1 m quadrate which was located around the macro-pellet in each plot. The plants of *D. ovalifolium* grew slowly during the first nine-month period after planting until the end of dry season. However, faster growth took place since the beginning of the succeeding wet season, resulting in the coverage of over 30% in July of 1987, one year after planting in the plots of minimum tillage both with and without chemical grass-control. However, the coverage in the plot of nontillage with chemical grass-control was much lower (18%). The reason for such a low coverage might have been caused by the weak competition of *D. ovalifolium* with *B. humidicola* regenerated from the underground órgans in the area treated with the herbicide. From these results, it was concluded that the minimum tillage with one pass of chisel plow was very effective for the plant growth of *D. ovalifolium* grown under the macro-pellet system.

C. brasilianum and *A. pintoi* showed an extremely low coverage (less than 5%) in all the plots after one year of planting. *C. brasilianum* vigorously grew during the first three months and achieved relatively higher covergaes (9.1–14.7%), as compared with the other legumes in October 1986. However, it was selectively grazed by cattle during the succeeding dry season, so that the coverage was drastically reduced. Although *A. pintoi* was relieved of the damage of selective grazing, it could not expand the coverage due to its poor ability of competition with *B. humidicola* during the dry season.

Table 6. Coverages of *Desmodium ovalifolium* and *Centrosema brasilianum* planted in the grass-based pasture of *Brachiaria humidicola* during the dry season under the periodical grazing

Season	Legumes	Percentage of coverage	
		Beginning of grazing	End of grazing
Beginning of dry season (Nov. 1986)	*C. brasilianum*	14.2	7.6
	D. ovalifolium	3.7	3.7
Middle of dry season (Jan. 1987)	*C. brasilianum*	7.8	4.3
	D. ovalifolium	10.3	9.7

1): Percentage of the coverage was estimated in a 1×1 m quadrate centered around the mocro-pellet at the beginning and end of each time of periodical grazing.

The trial of this study showed that *D. ovalifolium* was the most suitable legume species to be associated with the *B. humidicola* pasture under the macro-pellet system. As shown in Table 6, the relative selectivity of *D. ovalifolium* by grazing cattle was obviously lower than the case in *C. brasilianum* during the dry season. This result indicates that the lower palatability would be one of the important characteristics of legumes to be competitively grown in the grass-based pasture with the macro-pellet system.

3) Expansion of D. ovalifolium under grazing with minimum tillage without chemical grass-control

Although the greatest coverage of *D. ovalifolium* was seen in the plot of minimum tillage with chemical grass-control (Fig. 4), the practical use of herbicide would be very difficult in the marginal areas due to its high costs. Therefore, it is preferable not to include the use of costly herbicides if a sufficient coverage of *D. ovalifolium* could be assured with only minimum tillage.

Fig. 5 shows changes of the coverage pattern of *D. ovalifolium* under the grazing condition in the plot of minimum tillage without chemical grass-control. The measurements were taken for each of the 1 × 1 m grid in the quadrate area of 6 × 7 m set up in the plot. *D. ovalifolium* has expanded vigorously along the belt of chisel tracks since one year after planting. The coverage of the legume plants reached approximately 40% of the total plot area in September 1987, 14 months after planting. In addition, *D. ovalifolium* plants expanded its coverage to the space between the belts of chisel tracks. They covered over 60% of the total area in November 1987, 16 months after planting, when the top dry weight of *D. ovalifolium* exceeded *B. humidicola* by 25% (Table 7). At this stage,

Table 7. Top weight of *Brachiaria humidicola*+*Desmodium ovalifolium* association in the plot of minimum tillage without chemical grass-control, 16 months after planting (Planting date: 2 August 1986)

Top weight[1] (DM g/m²)				Percentage of legume (%)[2]
B. humidicola	*D. ovalifolium*	Standing dead material	Total	
76	95	38	209	45.5

1): Estimated on the basis of plants harvested at the 3 cm height above ground in a 2×2 m quadrate of each plot.
2): Percentage of top weight of *D. ovalifolium* against the total weight.

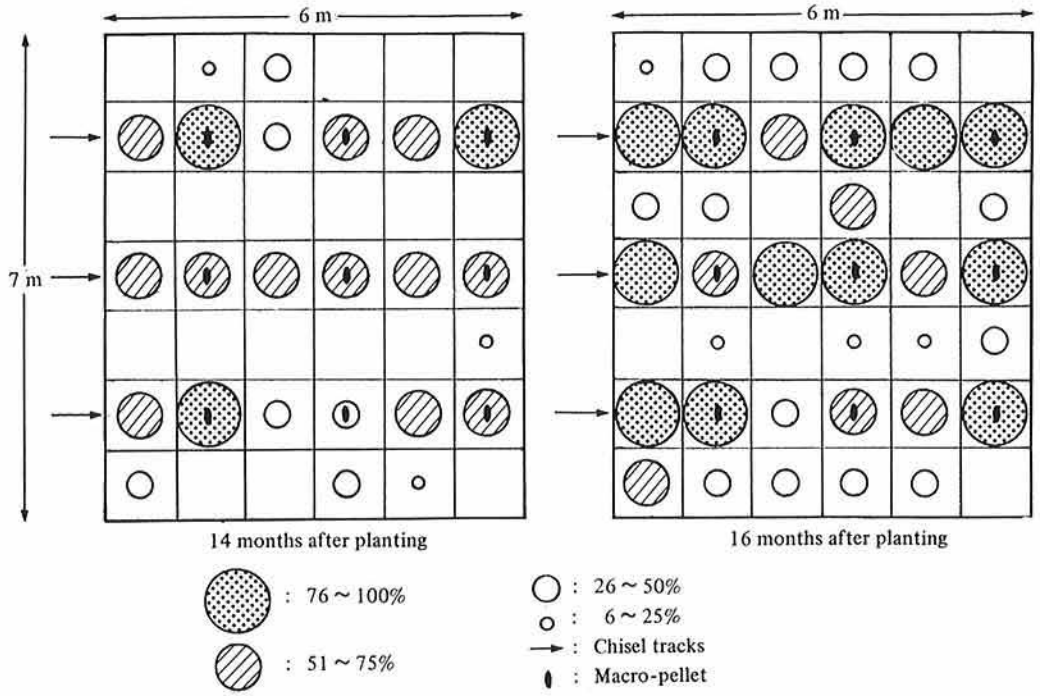

Fig. 5. Changes of the coverage pattern of *Desmodium ovalifolium* under grazing, planted with the macro-pellet system following minimum tillage without chemical grass-control

no difference in the coverage could be seen between the two plots of minimum tillage with and without chemical grass-control. However, in the plot of nontillage with chemical grass-control, the coverage was very low (approximately 10% of the total area). It is therefore concluded that the combination of *D. ovalifolium* accompanied by minimum tillage without chemical grass-control would be the most effective and economical introduction of legumes using macro-pellet in the grass-based pasture of *B. humidicola*.

The chemical fertilizers used for macro-pellets are of the form of solid and large-sized chunk, consisting of slowly-soluble nutrient sources. It was indicated (unpublished) that the macro-pellet type of fertilizers could continue to be effective for a period of over one year after application. This might have also been the case in this experiment, where the chemical fertilizers of the macro-pellets could have been effective for the growth and expansion of *D. ovalifolium* during at least one year period. It is, however, unlikely

that the expanded growth of the legume plants during the period of 14 to 16 months after planting (Fig. 5) was also attributed to the effectiveness of the remaining fertilizers. It is estimated that *D. ovalifolium* plants have an ability of intaking some nutrients, even though rare in the soils, for its plant growth under their developed root system.

4) Animal productivity in the B. humidicola and D. ovalifolium association

Under the alternate grazing system using two paddocks, the plants of *D. ovalifolium* started encroaching on the other plots along the chisel tracks from September of 1987, 14 months after planting. At the same time, a great coverage by *D. ovalifolium* plants was also observed in the border areas of the experimental plots, where the macro-pellet legume was planted following the minimum tillage at the beginning of this experiment. In November 1987, the whole area of the pasture was covered by an association of *B. humidicola* and *D. ovalifolium*.

An availability of *D. ovalifolium* and botanical composition in the pasture during the three grazing periods from November 1987 to July 1988 is presented in Table 8. The legume percentage in the total top weight increased with the lapse of the grazing period, and reached the level of over 34% in the third period. The maximum top weight of *D. ovalifolium* was obtained in the middle of dry season (695 kg/ha dry matter); 85% of which was composed of the stem weight, while the highest percentage of the leaf weight was seen in the early wet season (54.7%).

In regard to the productivity of animals, liveweight gains obtained in the pasture during the three grazing periods is presented in Table 9. In the first and second grazing periods under the dry season, the cattle had low weight gains (174 and 131 g/AU/day) under the stocking rate of 1.4 and 1.1 AU/ha. However, this result does not imply that the cattle productivity was low, because it is generally recognized that animals stocked in the grass-based pasture of *Brachiaria* spp. do not gain or occasionally lose their weight during the dry season at Carimagua[2,3]. Significant gains of the liveweight (938 g/AU/day) were obtained during the third period of the early wet season under the

Table 8. Availability of *Desmodium ovalifolium* and botanical composition in the pasture under the alternate grazing system

Grazing period	Available *D. ovalifolium*[1]		Percentage of legume (%)[3]
	Weight (DM kg/ha)	Leaf (%)[2]	
I Nov. 1987~Jan. 1988	295	28.6	16.2
II Jan.~April 1988	695	15.1	30.3
III April~July 1988	470	54.7	34.2

1): Sampling date: I ; 23 Nov. 1987, II ; 25 Feb. 1988, III ; 23 June 1988.
2): Percentage of leaf weight of *D. ovalifolium* against the total weight of leaf and stem.
3): Percentage of *D. ovalifolium* weight against the total top weight.

Table 9. Liveweight gains in the pasture of *Brachiaria humidicola*+*Desmodium ovalifolium* association under the alternate grazing system

Grazing period	Grazing days	Stocking rate (AU[1]/ha)	Liveweight gain (g/AU/day)
I Nov. 1987~Jan. 1988	59	1.4	174
II Jan.~April 1988	119	1.1	131
III April~July 1988	76	1.8	938

1): AU (Animal unit)=400 kg Liveweight.

higher stocking rate of 1.8 AU/ha. From these results, it is concluded that *D. ovalifolium* introduced with the macro-pellet would make an important contribution to the improvement of cattle productivity in the grass-based pasture of *B. humidicola*.

Summary

With the purpose of improving nutrition of the grass-based pasture of *Brachiaria humidicola*, an experiment to introduce legumes using seed-fixed macro-pellets was carried out in Llanos Orientales, Colombia. In August 1986, three kinds of promising legumes released by CIAT (*Desmodium ovalifolium*, *Centrosema brasilianum* and *Arachis pintoi*) were planted under the macro-pellet system in the grass-based pasture, following three types of land preparation, comprising minimum tillage with and without chemical grass-control, and nontillage with chemical grass-control. The planting density was 2,500 pellets/ha.

The use of seed-fixed macro-pellets resulted in a satisfactory early-establishment of legumes regardless the differences of the method of seed-bed preparation, with an exception of *A. pintoi* introduced in the plot of nontillage with chemical grass-control. *C. brasilianum* vigorously grew after early-establishment, but was damaged by selective grazing. *A. pintoi* could not expand coverage due to its poor ability of competition with *B. humidicola*. The coverage of *D. ovalifolium* gradually expanded under grazing, and 16 months after planting, it reached over 60% of the whole area of both plots under the minimum tillage with and without chemical grass-control, while much lower coverage took place in the plot of nontillage with chemical grass-control. This result indicates that the combination of *D. ovalifolium* with minimum tillage would be the most adequate practice for introducing legumes in the pasture using macro-pellets.

It was observed that the liveweight gains of cattle stocked in the *B. humidicola* and *D. ovalifolium* association were higher compared than those in the grass-based pasture. Remarkable liveweight gains (938 g/AU/day) were seen during the early wet season under the stocking rate of 1.8 AU/ha.

Under the macro-pellet system adopted in this experiment, a very low application rate of chemical fertilizers (P: 2.0 kg/ha) was effective enough to secure the plant growth of legumes. In addition, the seed requirement of *D. ovalifolium* was 0.1 kg/ha. These requirements were only 5 to 10% of the conventional method. Such a low level of the input requirements has significant implications for reducing the costs in practice. It is therefore concluded that the macro-pellet method would play a key role in improving the productivity of grass-based pasture through the introduction of *D. ovalifolium* in the Llanos Orientales.

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