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THE ANIMAL PRODUCTION POTENTIAL OF FOUR ASSOCIATIONS BETWEEN *Andropogon gayanus* KUNTH AND LEGUMES IN THE EASTERN PLAINS IN COLOMBIA

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Animal production from *Andropogon gayanus* CIAT 621 in associations with *Zornia* sp. CIAT 728, a mixture of *Stylosanthes capitata* CIAT 1019 and 1315, *S. capitata* CIAT 1405 and *Pueraria phaseoloides* (kudzu) CIAT 9900 was studied over four years at Carimagua. Continuous grazing was used and the stocking rates were adjusted to 1.2 animals/ha in all associations during the dry season, while in the rainy season, rates of 1.3, 1.8, 1.4 and 1.9 head/ha were used in the four mixtures, respectively. Animal production for each mixture averaged 172, 193, 192 and 182 kg/head, respectively, with no differences ($P > 0.05$) between treatments, although during the dry season, mean liveweight gains on the *Zornia* sp. mixture, 167 g/head, was significantly lower ($P < 0.05$) than the mean on the other mixtures (303, 291 and 397 g/head/day, respectively) due to defoliation caused by the fungus *Sphaceloma* sp. Year effects were highly significant ($P < 0.001$), with the weight gains obtained in the first year, 633 g/head, being significantly higher ($P < 0.05$) than gains in the second (482 g/head) and third (495 g/head) years, with the gains obtained in the fourth year (413 g/head) being inferior ($P < 0.05$) to all the rest, due to a reduction in the dry matter on offer and the percentage of legume in the swards. These mixtures were capable of increasing the productivity of *A. gayanus* by 55-65 % but more information is required as to their management and maintenance fertilisation after the second year of continuous grazing so that good persistency and balance between sward components may be achieved and animal production maintained.

Key words: Oxisol, *A. gayanus*, *Zornia* sp., *S. capitata*, *P. phaseoloides*.

Andropogon gayanus Kunth is a grass species of west African origin. It is a perennial, tussock-forming, tall-growing grass which produces abundant forage of moderate nutritive value and good palatability compared with the majority of tropical grasses (González and Gerardo, 1982). It is highly tolerant of acid, high aluminium saturated soils of low natural fertility which are characteristic of the Oxisols and Ultisols (Jones, 1979). If small amounts of fertiliser, particularly phosphorous (P), are applied to the soil, *A. gayanus* has proved superior in terms of dry matter production when compared with other grass species adapted to an Oxisol (Salinas and Delgadillo, 1980) and an Ultisol (Tergas and Urrea, 1980).

Legumes of the genus *Zornia* J.F. Gmel are relatively new forage species, of American origin, which are very well adapted to poor, acid soils. *Zornia latifolia* is regarded as particularly promising, specially for savannah ecosystems (Schultze-Kraft and Giacometti, 1979). *Stylosanthes capitata* Vog. is another comparatively new forage legume, native to the savannahs of tropical America which has a high potential due to its adaptability to acid soils of poor natural fertility and its other

advantages, including the production of dry matter during the dry season, its resistance to pests and diseases and its persistence under cutting as well as grazing (Schultze-Kraft and Giacometti, 1979; Grof et al 1979; Edye and Grof, 1979). On the other hand, *Pueraria phaseoloides* Benth is a legume of tropical Asian origin which is widely known as a forage species in various parts of the world (Bogdan, 1977; Skerman, 1977) and which has shown a good potential for animal production in the eastern plains of Colombia (Tergas et al 1983a, 1983b).

A. gayanus has proved compatible in associations both with erect as well as with creeping legume species (Jones, 1979). Good agronomical results have been produced with *Clitoria ternatea* in Australia (White et al 1959), as well as with *Centrosema pubescens* and *Desmodium* spp in Ghana (Tetteh, 1976) and Colombia (Grof, 1981, 1982), with *Stylosanthes* spp, *Zornia* spp and *Galactia striata* in Brazil (Thomas et al 1981). Up to the present time, only preliminary results from Colombia have been reported concerning weight gains of cattle grazing these associations (Tergas et a., 1982a, 1982b). The main objective of this study was to evaluate the potential for animal production of four legumes adapted to poor, acid soils in mixtures with *A. gayanus* in the eastern plains of Colombia.

Materials and Methods

The research was carried out at the Centro Nacional de Investigaciones Agropecuarias (CNIA) at Carimagua. Details of the location, climate and soils have been given by Tergas *et al.* (1983a). The four associations of *Andropogon gayanus* var. Carimagua 1 (CIAT 621) with the legumes 1) *Zornia* sp. CIAT 728, 2) a mixture of *Stylosanthes capitata* CIAT 1019 and 1315, 3) *S. capitata* CIAT 1405 and 4) *Pueraria phaseoloides* (kudzú) CIAT 9900 were established from seed in paddocks of 2 ha each, during the rainy season of 1978. The following year, reseeding was carried out to increase the populations of the grass *A. gayanus* and the legume *Zornia* sp. CIAT 728. Fertiliser application at establishment consisted of 50 kg P_2O_5 per hectare in the form of Thomas slag (15% P_2O_5) and 22 kg K_2O, 18 kg MgO and 22 kg S per hectare, respectively, in the form of potassium sulphate and magnesium for the first three associations and 100 kg P_2O_5, 50 kg K_2O, 18 kg MgO and 22 kg S per hectare from the same sources for the mixture with *P. phaseoloides*. All mixtures received a maintenance dressing of 11 kg P_2O_5, 13 kg K_2O, 11 kg MgO and 13 kg S per hectare from the same sources during the rainy season of 1980.

Management and sampling:

Grazing was started at the beginning of the dry season in December, 1978, with a stocking rate of 2 animals/ha in all mixtures, but it was later necessary to adjust the stocking rates to maintain a balance between the species. Thus, the weighted mean stocking rate was 1.7 animals/ha for the dry season and between 1.5 and 2.0 animals/ha for the rainy season of 1979. From 1980 onwards, the stocking rate in the dry

season remained at 1.0 animals/ha in all the mixtures and adjusted to between 1.0 and 2.0 animals/ha during the rainy season, according to the state of growth of the pasture and the amount of legume present.

Two crossbred Criollo-Zebu steers of approximately one year old and with an initial liveweight of 150-180 kg were used, with another two animals of 180-200 kg liveweight for the seasonal adjustments in stocking rates. At the end of each calendar year, the animals were replaced by another similar group. All cattle received mineral supplements and water *ad libitum*. During the first two years, the animals were weighed after 16 hours without food, but later they were weighed directly from the field.

The dry matter on offer was determined in both seasons of the year at first by randomly cut samples and later by the method of Haydock and Shaw (1975). All the combined samples were separated into green leaves, stems and dead material and dried at approximately 60°C for 48 hours to determine dry matter content. At the same time that the samples were taken, the botanic composition of the various associations was determined.

Statistical analysis:

The experimental design consisted of randomised blocks with four treatments corresponding to each of the four legumes used in the mixtures. For reasons of management, it was only possible to analyse the results of one repetition using analysis of variance in which the animals were considered as the experimental unit. Daily liveweight gains of the animals during the dry season, rainy season and over the whole year were used as dependent variables and the grass-legume mixtures and years as sources of variation.

The model used was $Y_{ijk} = \mu + A_i + L_j + (A \times L)_{ij} + e_{ijk}$, where Y_{ijk} = daily liveweight gain of steer k in association j during year i, A_i = effect of year i, L_j = effect of the mixture including legume j, $(A \times L)_{ij}$ = effect of the combination of year i with association j and e_{ijk} = experimental error, made up of the variation between animals in each combination of years and legumes. Means were compared using Duncan's Multiple Range Test in cases where the significance of the difference was $P < 0.05$.

Results and Discusion

Table 1 shows the mean liveweight gains of the steers over the whole year as well as for the dry and rainy season separately for the legume associations combined. The effect of year was highly significant ($P < 0.01$) for both seasons and for years as a whole, while the interaction year x treatment was only significant ($P < 0.05$) during the dry season (Table 4). The gains appeared to be more uniform from year to year on the *P. phaseoloides* treatment (Figure 1). Mean productivity was always superior in the rainy season compared with the dry season (595 versus 389 g/head/day). Mean output in the first year, 633 g/head/day, fell significantly ($P < 0.05$) during the second year to 482 g/head/day,

Figure 1:
Interaction year-treatment in associations of A. gayanus with legumes during the dry season at Carimagua, 1979-1982

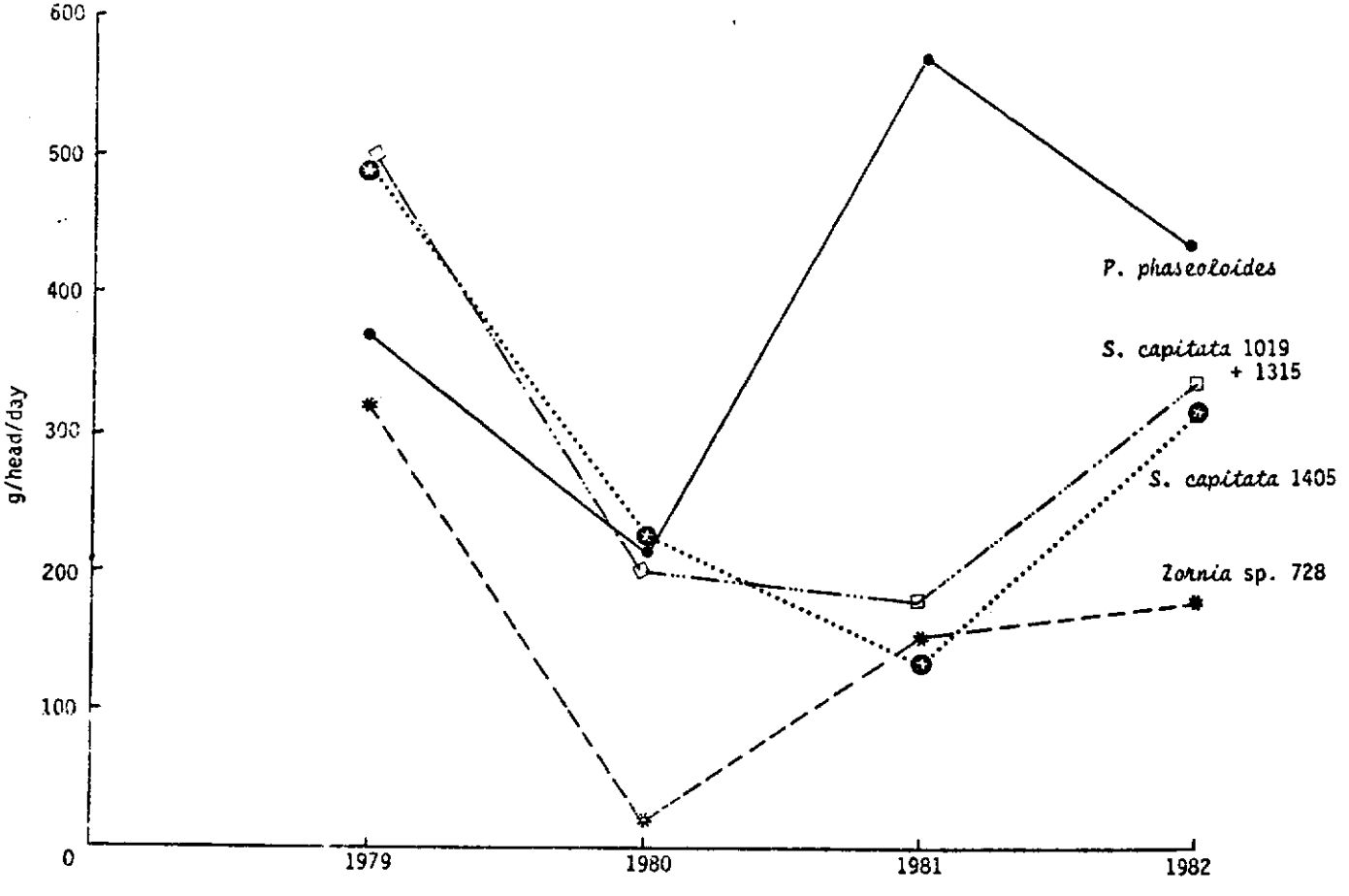

Table 1:

Mean annual liveweight gains of steers on the four mixtures of A. gayanus with Zornia sp. 728, Stylosanthes capitata 1019 + 1315, S. capitata 1405 and Pueraria phaseoloides (kudzu) at Carimagua, 1979-1982.

Year	Stocking rate	Season		Annual Total
	(head/ha)	Dry	Rainy	
		g/head/day		
1979	1.7/1.8	420a[2]	708a	633a
1980	1.0/1.7	164c	631b	482b
1981	1.0/1.6	258b	580b	495b
1982	1.0/1.5	315b	462c	413c
Mean	1.2/1.7	389	595	506

[1] Dry/rainy seasons, respectively.

[2] Values in each column corresponding to each year accompanied by different letters are significantly different ($P < 0.05$).

remained stable in 1981 and decreased again to 413 g/head/day ($P < 0.05$) during the last year of the experiment.

Mean liveweight gains in the association between A. *gayanus* and P. *phaseoloides* were significantly higher ($P < 0.05$) during the dry season than those obtained with S. *capitata* which, in turn, was superior to the *Zornia* sp. mixtures ($P < 0.05$), as shown in Table 2. However, no significant differences ($P > 0.05$) were found between mixtures during the rainy season or over years as a whole.

Table 2:

Mean liveweight gains of steers grazing associations of Andropogon gayanus with legumes at Carimagua, 1979-1982.

Treatment	Stocking rate	Season		Annual total
	(Head/ha)	Dry	Rainy	
		g/head/day		
Zornia	1.2/1.3	167c[2]	596a	470a
S. capitata 1019+1315	1.2/1.8	303b	622a	529a
S. capitata 1405	1.2/1.4	291b	623a	526a
P. phaseoloides	1.2/1.9	397a	540a	498a

[1] Dry/rainy seasons, respectively.

[2] Values in each column corresponding to each year accompanied by different letters are significantly different ($P < 0.05$).

Table 3:
Mean animal production in associations of Andropogon gayanus at Carimagua, 1979-1982.

Treatment	Stocking rate (head/ha[1])	Production per Head (kg)	Production per ha (kg)
Zornia sp. 728	1.2/1.3	172a[2]	242
S. capitata 1019 + 1315	1.2/1.8	193a	321
S. capitata 1405	1.2/1.4	192a	305
P. phaseoloides	1.2/1.9	182a	313

1 Dry/rainy seasons, respectively.

2 Values in each column corresponding to each year accompanied by different letters are significantly different ($P < 0.05$).

Animal production was directly related to mean annual liveweight gains and no significant difference was observed between associations (Table 3). Animal output per hectare was related to changes in the stocking rate and was notably lower in the *Zornia* sp. mixture as a result of the reduction in stocking rate during the rainy season from the second year onwards. Otherwise, there were no important differences between the mixtures. These levels of liveweight gain in mixtures of *A. gayanus* with legumes represent an increase of 55-65 % compared with those obtained with *A. gayanus* alone at Carimagua (Tergas et al 1982b; Velásquez *et al.*, 1982) and are similar to those reported for mixtures of *A. gayanus* with *Centrosema* sp. CIAT 438 and with *P. phaseoloides* CIAT >900 in an Ultisol in Colombia with a better rainfall regime (Tergas et al 1982a). This increase is mainly due to the effect of the legume in improving animal production during the dry season, since weight losses are observed when the grass alone is used in a pure stand. Output per hectare has usually been found to be slightly higher when the grass is used in a single stand than in mixtures at Carimagua because stocking rates as high as 3.3 head/ha may be used during the rainy season without noticeably affecting production per animal or the persistence of the sward (Tergas et al 1982b).

Very little information exists in the literature concerning animal production from *A. gayanus* in other parts of the tropics (Jones, 1979; González and Gerardo, 1982) and practically no data have been reported on results from mixtures with legumes comparable to those obtained at Carimagua. Nevertheless, similar weight gains per animal have been reported from different tropical grass-legume mixtures by various authors (Nuthall and Whiteman, 1972; Whiteman, 1976; Stobbs, 1974; Whiteman, 1980), while the superior weight gains per hectare reported by these

workers are due to the use of higher stocking rates. It is important to point out that, in most other studies, soil fertility has been higher than that of Oxisols and Ultisols. Also higher fertiliser treatments were used at establishment and for maintenance in some cases, compared with the present study.

The results in terms of weight gains are closely related to the quantity of dry matter and the proportion of legume on offer between years during the experimental period and between the dry and rainy seasons (Table 4). In the *Zornia* sp. mixture, an important reduction in dry matter and the proportion of legume on offer was caused by defoliation due to the fungus *Sphaceloma* sp. from the first rainy season onwards, and this was acompanied by a decrease in the production of *A. gayanus* due to attacks by ants (*Acromyrmex* spp.)(Calderón, personal communication). In the *S. capitata* mixture, a reduction in dry matter and the amount of legume available also occured between the first and second years, possibly due to the effect of the initial stocking rates, and there was also a reduction in the availability of the *A. gayanus*, due to ant damage (*Acromyrmex* spp.). In the case of *P. phaseoloides*, the situation was different since, from the first rainy season onwards, the legume tended to dominate the sward due to selection of the grass by the animals under continuous grazing. Finally, in 1982, there was a reduction in the total amount of forage available from all the mixtures as well as in the botanical composition of the legumes, which significantly affected animal output during the last year of the experiment.

Among the chief factors which limit animal production are the quantity of green forage on offer and the quantity of legume available over time (Mannetje and Eberson, 1980). Mannetje (1972) found that animal production with Siratro was related to the amount of legume present up to 1000 kg/ha, but larger amounts did not increase weight gains. Gillard *et al.* (1980) found no additional response with *S. humilis* and *S. hamata* above 600 kg/ha. Evans (1979) found a positive response in terms of liveweight gain to an increase in legume content up to 30% of the botanical composition of the sward while, in contrast, Watson and Whiteman (1981) found a curvilinear relationship between liveweight gain and the proportion of legume up to 15%, with little change beyond this level in the case of a mixture of *C. pubescens*, *Siratro* and *S. guianensis*. Falvey (1976) obtained a significant positive correlation between legume content and liveweight gains in the dry season ($P < 0.05$), but a negative correlation in the first part of the rainy season ($P < 0.10$), even though the quantity of dry matter was not a limiting factor in either season. Given the objectives of the present study, it was not possible to establish the relationships between the amount of forage offered, its botanical composition and animal production. However, in an additional study carried out with fistulated animals in the same fields, it was shown that they were able to select more legume in the diet and gain weight even when the level of *S. capitata* on offer was less than 15% of the botanical composition, and that during the rainy season the animals selected *A. gayanus* preferentially (CIAT, 1982).

Table 4:

Total dry matter and percentage legume in forage on offer in four associations of A. gayanus with legumes at Carimagua, according to sampling date, 1979-1982.

Dates	*Zornia* sp. 728		*S. capitata*-1019+1315		*S. capitata* 1405		*P. phaseoloides*	
	Dry matter (kg/ha)	Legume (%)	Dry matter (kg/ha)	Legume (%)	Dry matter (kg/ha)	Legume (%)	Dry matter (kg/ha)	Legume (%)
Jan 1979	4375	21.4	4200	92.8	4270	30.4	8310	53.2
Mar 1979	2430	2.6	3150	100.0	SM	SM	5239	33.2
Aug 1979	4250	0.0	3940	59.4	10410	51.5	6830	51.9
Nov 1979	8930	0.0	SM	SM	5950	56.3	5146	56.3
Jan 1980	1449	5.6	6162	48.0	6698	34.9	6022	66.4
Jun 1980	7474	2.0	6254	25.2	6577	22.0	6170	80.7
Oct 1980	4464	1.4	9697	19.2	8537	21.9	12865	85.3
Feb 1981	3659	0.7	11289	28.6	10822	9.0	12019	80.6
Jul 1981	4428	0.0	4696	18.0	6113	24.4	4851	73.0
Jan 1982	41	0.0	2066	0.0	948	10.8	4632	85.2
Feb 1982	1771	0.0	6298	2.5	2711	14.5	3986	79.3
Jul 1982	252	0.0	8665	8.0	6148	13.0	2951	31.5
Nov 1982	729	0.0	2413	0.5	675	36.0	2152	33.1

NM: Not measured.

This study was of considerable importance in the establishment of management guidelines for these mixtures and in the identification of the factors which affect the persistency and stability of the components of the swards. Thus, *Zornia* sp. CIAT 728 proved to be highly susceptible to *Sphaceloma* (CIAT, 1982). The persistency of *S. capitata* depended heavily on the development of new plantlets and, even though it produces a large amount of seed which germinates, there is a strong competition for nutrients, especially potassium, when it is grown in association with *A. gayanus*, and this affects the development of the young plants and the recuperation of the ground cover (Valencia and Spain, 1982). The situation in the case of *P. phaseoloides* was slightly different because of the dominance of this species due the animals' preference for the graminea in the rainy season, which suggests the need for some system of rotational grazing in order to maintain the species balance over time (Lascano, 1983). Problems of persistency of *A. gayanus* were also identified due to attacks from ants (*Acromyrmex* spp.) in the mixtures with *Zornia* sp. and *S. capitata*, and due to lack of vigour in the new shoots in the mixture with *P. phaseoloides*, probably due to selective grazing of the grass. All this information has been useful in the design of new experiments concerning the maintenance fertilisation and management of the pastures to overcome these limitations, in view of the high animal production potential of the mixtures.

Conclusions

This study demonstrates once again the importance of tropical legumes as a means of increasing animal production, especially during the dry season of the year. At the same time, it emphasises the animal production potential of relatively new forage legume species such as *Zornia* sp. and *S. capitata* which are adapted to poor, acid soils.

The contribution of *P. phaseoloides* to animal production in combination with *A. gayanus* is also notable, taking into account the adaptation of this legume to acid soils in conditions where drought stress is not very severe and that it may have an important contribution to make to improving animal production from tropical pastures. The correct management procedures required to achieve persistence and balance between components of the pastures are very important aspects which need more detailed research which is actually in progress, in order to make precise recommendations about the use of the pastures in the eastern plains of Colombia.

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