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PRELIMINARY OBSERVATIONS ON THE EFFECT OF COMPETITIVE INTERFERENCE ON STAND MAINTENANCE OF STYLOSANTHES CAPITATA ASSOCIATED WITH ANDROPOGON GAYANUS IN THE EASTERN PLAINS OF COLOMBIA

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INTRODUCTION

The Tropical Pastures Program of CIAT (Centro Internacional de Agricultura Tropical) has worked cooperatively with ICA (Instituto Colombiano Agropecuario) since 1970 at Carimagua a national agricultural research center in the Eastern Plains of Colombia Carimagua is located at 4°37 N Lat 71°36 W Long at an altitude of 175 m Average annual rainfall is 2 100 mm distributed from April to December Mean annual temperature is 26°C mean minimum is 20°C mean maximum is 33°C The predominant soils are fine textured Oxisols (Tropeptic Haplustox isohyperthermic) The chemical characteristics of a well drained profile from Carimagua are shown in Table 1

The objectives of research conducted at Carimagua include the development of low cost low input technology to increase livestock production on the acid infertile savannas of Tropical America Since forage quality is recognized as the principal limiting factor in these ecosystems the program has focused on the collection and testing of legumes and grasses most of which have evolved in similar ecosystems

Several promising species have been identified since the program was initiated in 1970 Among them are *Andropogon gayanus* Kunth var *bisquamulatus* (CIAT ecotype 621) and *Stylosanthes capitata* Vog (Centro Internacional de Agricultura Tropical 1977)

A gayanus (Gamba grass) is a large tufted perennial grass of West African origin It is widely distributed across a belt of savannas with average annual rainfall ranging from ± 600 to 1 400 mm It forms dense tussocks up to 1 m in diameter and 2 m in height Bowden (1964) Introduced into the Colombian Llanos from Northern Nigeria in 1974 (Grof 1981) *A gayanus* proved to be very well adapted to

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TABLE 1 Some characten tic f Car magu Ox sol

Depth	Clay	Sa d	O M	pH	P (B ay I I)	E hangeabl t ons Al	Ca	Mg	K	N	ECEC	Al Sat.
cm		%			ppm	m q/100 g						%
0-12	38	12	4 0	4 5	1	3 8	0 2	0 2	0 1	0 1	4 4	86
12 32	41	11	2 0	4 6	1	2 8	0 1	0 1	0 1	0 1	3 1	89
32 58	43	11	1 7	4 8	T	2 1	<0 1	<0 1	0 1	<0 1	2.3	91
58-88	45	12	0 9	5 2	T	0 7	<0 1	<0 1	<0 1	<0 1	0 9	78
88-148	45	12	0 6	5 1	T	0 6	<0 1	<0 1	<0 1	<0 1	0 8	75

F m G R 1971

the soil and climate of the ecosystem yielding over 17 T D M /ha/year (Centro Internacional de Agricultura Tropical 1978 and Jones 1979)

S capitata is a perennial self regenerating legume native to Brazil and Venezuela (Grof et al 1979) Introduced to Colombia in 1974 it is considered one of the most promising legumes for the Llanos ecosystem It combines tolerance to anthracnose and stemborer attack and is very productive on extremely acid highly Al saturated soils (Centro Internacional de Agricultura Tropical 1977)

TABLE 2 Recommended Fertilizer Rates for *A gayanus* x *S capita a* associations (kg/ha)

Objec ive	P	K	Mg	S	Ca
Establishment	22	20	12	12	100
Maintenance	5	10	8	8	25

From Spain J M (ed) 1982

PERFORMANCE AND MANAGEMENT OF THE ASSOCIATION

These two species were planted in association at Carimagua for the first time in 1976 and initial results were very favorable The high seed production potential of *S capitata* was considered a key self propagation mechanism which would contribute to a stable mixture with *A gayanus* under grazing (Centro Internacional de Agricultura Tropical 1978) A note of caution was sounded by the report that *S capitata* seedlings were often dwarfed and exhibited severe potassium and magnesium deficiency symptoms in the presence of mature *A gayanus* plants These observations underscored the importance of competitive interference in grass legume associations (Centro Internacional de Agricultura Tropical 1978)

By 1981 the association had proven to be highly productive resulting in live weight gains of up to 200 kg/animal/year and 320 kg/ha/yr However low vigor of second generation *S capitata* seedlings under grazing was identified as a problem and objective of future research (Centro Internacional de Agricultura Tropical 1981) This problem is now thought to be one of the main causes of limited persistence of the legume in the association under present management conditions

Grazing

A gayanus/S capitata pastures at Carimagua have been grazed continuously with seasonal adjustment of stocking rates 2 animals/ha during the 8 months rainy season 1 animal/ha during the dry Grazing usually starts toward the end of the year of establishment

Fertilizer

In the CIAT general recommendations for pasture establishment edited by Spain (1982) fertilizer application rates are separated in two categories establishment and maintenance Establishment are selected to provide for the rapid establishment of vigorous stands Rates are based on results of several years of monoculture small plot experiments under cutting management Phosphorus and calcium from basic slag or rock phosphate are usually banded with the seed and other nutrients are broadcast to prevent seedling damage from excessive salt concentration Maintenance rates a e estimated from extraction data derived from the same plots adjusted to allow for recycling by the grazing animals The recommended fertilizer rates for *A gayanus/S capitata* associations are shown in Table 2

Developmental stages of the *A gayanus* x *S capitata* association

A gayanus is a rather weak seedling but once established it is a strongly competitive perennial in the Colombian Llanos In contrast *S capitata* is a strong seedling and rapidly develops into a robust plant However it does not behave as a true perennial in the Carimagua ecosystem but more as a biennial depending on seed for self regeneration This gives rise to three developmental stages in the life of the association establishment post-establishment and legume stand maintenance (self regene ation)

Establishment

Since the two species are established by seed this stage includes germination and seedling development of both components It is recommended that the two species be planted simultaneously in separate rows 0 50 to 1 000 m apart At this stage *S capitata* is often the dominant species due to greater seed reserves and more vigorous early growth The legume also rapidly develops a strong tap root system which effectively protects the seedling during periods of water stress which often occur early in the rainy season

Post-establishment

By the end of the first year and through the second a good balance between the legume and grass components is usually achieved and maintained There are however striking morphological differences between the two species which undoubtedly condition their nutrient needs and uptake and affect their competitive abilities

The root system of *A gayanus* has been studied in detail by Bowden (1963) who identified three morphologically distinct types fibrous roots extending laterally over 1 m from the plant cord roots extending at a 30 to 40° angle to the soil surface for approximately 50 cm and vertical roots which penetrate to depths greater than 80 cm These fractions represented 50 40 and 10% of the total root weight One of the authors has repeatedly observed a strong depressing effect of *A gayanus* plants on the growth of seedlings of the same and other species which coincides with the approximately 1 m length of the fibrous root system reported by Bowden (op cit) The root system of *S capitata* has not been studied in such detail but it appears to have a typical tap root penetrating to 1 50 m or more depth judging from soil moisture extraction studies at Carimagua which show that late flowering *S capitata* ecotypes can extract all of the available water from the profile to a depth of 1 50 m by the end of the dry season (Centro Internacional de Agricultura Tropical 1979)

Several studies have shown that cation exchange capacity of legume roots is about twice that of grass roots This may be an explanation for the advantage of grasses in the uptake of K and other monovalent cations in competition with legumes (Asher & Ozanne 1961 and Haynes 1980)

A gayanus appears to be particularly responsive to K fertilization In a field trial Carimagua it did not respond to P application in the absence of K while significant responses up to 44 kg/ha of P were obtained when 30 and 80 kg/ha K were applied This trial revealed a higher efficiency of K utilization for *A gayanus* than for *Brachiaria decumbens* and *B humidicola* (Centro Internacional de Agricultura Tropical 1980)

Legume stand maintenance (self regeneration)

The two species have very different patterns of persistence With appropriate management stand maintenance of *A. gayanus* is no problem original planting pat

terns can still be observed 5 years after planting In contrast *S capitata* "mother plants start degenerating toward the end of the second year or early in the third and the legume fraction of the pasture declines sharply thus regeneration from seed is a key mechanism for stand maintenance The legume is a prolific seeder more than 1000 seedlings per m^2 have been observed in *A gayanus* associations in Carimagua (M Sanchez personal communication) but the number of seedlings decreases rapidly under grazing The major ... main stunted at about 3 to 4 cm height with minute chlorotic leaves failing to effectively replace the rapidly declining original stand Tissue analyses of these plants confirm severe K deficiency status (I Valencia unpublished data) Many plants of this type can be found in the older pastures in Carimagua and it is rather obvious that they do not contribute significantly to forage quality nor volume

EXPERIMENTAL WORK

It is clear that the stage of legume self regeneration is of great importance to the survival of the association and although there must be other factors involved competitive interference between mature *A gayanus* plants and *S capitata* seedlings appears to be a major limitation

To study the effect of root competition on legumes self regeneration an experiment was conducted during the rainy season of 1981 In a 3 year old stand of *A gayanus* CIAT 621 *S capitata* CIAT 1019 was seeded in PVC cylinders 15 cm diameter x 30 cm length which were driven into the soil between *A gayanus* rows to exclude *A gayanus* roots from the rhizosphere of *S capitata* seedlings In another treatment 3 cm rings of the same pipe were placed on the surface to define the treatment area while continuing to allow root competition Population density of *S capitata* was set at 100 seedlings per m^2 A missing nutrient element series was superimposed as split plots on the main treatments root competition and no-root competition The complete fertilizer treatment consisted of the following rates (kg/ha) 50N 20P 40K 100Ca 20Mg 20S 4Zn 2Cu 1B 0 1Mo and 0 5Mn The effect of competition was much greater than that of nutrients there were tenfold differences in dry matter production between root competition and non root competition treatments A most interesting result was that the ranking order of critical nutrients changed between the root competition and non competition treatments Although K an important critical factor in both situations nitrogen appeared to improve the competitive ability of *A gayanus* to the detriment of *S capitata* seedlings in the root competition treatments as shown in Table 3

The overriding effect of root competition in this experiment underscores the importance of competitive interference The results also suggest that the role of N is one of non competitive interference Harper (1964) defined non competitive

TABLE 3 The effect of nutrients and root competition from the companion grass on dry matter production of *S. capitata* seedlings.

Treatment	gDM/10 plants	Maximum yield (%)
NC[1] complete	6 88 a[2]	100
NC minus Ca	6 80 a	99
NC minus micronutrients	6 64 a	96
NC minus Mg	6 42 a	93
NC minus S	6 38 a	92
NC minus P	6 12 a	88
NC minus N	5 94 a	86
NC minus K	4 76 b	69
NC nil	2 06 c	30
C minus N	1 16 cd	17
C minus Ca	0 80 d	12
C minus P	0 76 d	11
C Complete	0 70 d	10
C minus S	0 66 d	10
C minus micronutrients	0 66 d	10
C minus Mg	0 52 d	8
C nil	0 36 d	5
C minus K	0 28 d	4

1 C = root competition NC = no root competition

2 Number followed by the same letter are not significantly different ($P \leq 0.05$)

interference as the direct stimulation of one species by another in an association The positive response of *S capitata* to the minus N treatment under root competition suggests that nitrogen is stimulating the competitive ability of *A gayanus* Nitrogen fixed by *S capitata* in the association should have the same effect thus explaining the cyclic nature of grass and legume vigor observed in the older Carimagua pastures

DISCUSSION

The present concepts of maintenance fertilization although useful for many tropical forage associations need to be reviewed for cases such as the *A gayanus/S capitata* association where species differ greatly in growth habit and life cycle A similar problem may arise with any association of strongly perennial grasses with biennial or weakly perennial legumes Studies of the ecological interrelations among species differing in their life cycles have shown that nutrient competition is always as important factor influencing botanical composition and pasture balance (Torsell 1973 and Smith & Crespo 1979) Potassium may be the critical nutrient due to its

extreme mobility and to the ability and strong tendency of grasses to absorb this nutrient far in excess of their needs

Fertilizer rates needed to insure vigorous development of seedlings in grazed pastures may well be much higher than those required for initial establishment In this case it may be useful to think in termos of banding maintenance fertilizer to selectively favor a few seedlings instead of broadcasting over the entire area Since there are many more seedlings in second and third year swards than needed for stand maintenance it would suffice to provide favorable growth conditions for a small percentage of the total population

For this to be effective planting pattern concepts also need to be reviewed It seems logical to try to avoid the zone of maximum competition of a vigorous species like *A gayanus* by increasing row spacing thus creating a more favorable environment for seedling development It may be possible to maintain the initial planting pattern over time by selective fertilization These and other alternatives are presently under study at Carimagua

Improved pastures are by definition non equilibrium systems (Tothill 1978) There are two types of nutrient effects which may determine the failure of a species in an association One is a direct negative effect resulting in deficiencies toxicities or the alteration of the relationship between nutrient uptake and/or translocation The other is an indirect negative effect resulting from a positive effect on the associated species through modification of its morphology or chemistry thus improving its competitive ability A very delicate balance between these dynamic effects which are in turn affected by a diverse set of biotic and abiotic factors and by management determines the life span of an improved pasture association

The problem of second generation seedling establishment in grazed pastures is of special importance in highly weathered soils of the humid tropics which are characterized by low cation exchange capacity almost complete lack of primary minerals as nutrients replacement sources and marginal to submarginal fertility status for most of the essential elements In such soils a well adapted strongly perennial species could accumulate most of the essential nutrients available in the soil in its biomass thus greatly inhibiting the establishment of seedlings which have very low competitive ability during a period of high nutrient requirements

REFERENCES

ASHER C J & OZANNE P G Cation exchang capacity of roots and its relationship to the uptake of insoluble nutrients Aust J Agric Res 12 755-66 1961

BOWDEN B N Studies on *Andropogon gayanus* Kunth II An autline of morphology and anatomy of *A gayanus* var *bisquamulatus* (Hocht) Hack. J of Linnaean Society 58 509 18 1963

BOWDEN B N Studies on *Andropogon gayanus* Kunth III An outline of its biology J Ecol. 54 255 71 1969

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL Cali Colombia Annual Report 1977 Cali 1977

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL Cali Colombia Annual Report 1978 Cali 1978

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL Cali Colombia Annual Report 1979 Cali 1979

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL Cali Colombia Anual Report 1980 Cali 1980

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL Cali Colombia Annual Report 1981 Cali 1981

GUERRERO R Soils of the Colombian Llanos Orientales composition and classification of selected soil profiles Raleigh North Carolina State University 1971 Tese Doutorado

GROF B The performance of *A gayanus* legume associations in Colombia J Agric Sci 96 233 7 1981

GROF B SCHULTZE KRAFT R & MULLER F *Stylosanthes capitata* vog some agronomic attributes and resistance to anthracnose (*Colletotrichum gloeosporioides* Penz) Tropical grass. 13 28-8 1979

HARPER J L The individual in the population J Ecol. 52 149 58 1964

HAYNES R J Competitive aspects of the grass legume association Adv Agron 3 227-61 1980

JONES A C The potential of *Andropogon gayanus* Kunth in the oxisol and utisol savannas of Tropical America Herb Abst 49 1 8 1979

SMITH R C G & CRESPO M C Effect of competition by white clover on the seed production characteristics os subterranean clover Aust. J Agric Res. 30 597-607 1979

SPAIN J M ed Recomendaciones generales para el establecimiento y mantenimiento de pastos en la zona Carimagua, Llanos Orientales de Colombia Cali CIAT 1982 19p

TORSELL B W R Patterns and processes in the Townsville stylo annual grass ecosystem J Appl Ecol 10 463 78 1973

TOTHILL J C Comparative aspects of the ecology of pastures In WILSON J R ed Plant relations in pastures Canberra CSIRO 1978 p 385-401

PRODUCTIVIDAD ANIMAL Y MANEJO DE *BRACHIARIA HUMIDICOLA* (RENDLE) SCHWEICKT EN LA ALTILLANURA PLANA DE LOS LLANOS ORIENTALES DE COLOMBIA

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INTRODUCCION

Brachiaria humidicola (Rendle) Schweickt es una especie de gramínea promisoria que ha entusiasmado a algunos investigadores y productores sobre todo en las regiones de suelos ácidos e infertiles tanto en las sabanas como en regiones de bosque pero existe muy poca informacion acerca de su productividad animal El objetivo de este trabajo es mostrar las limitaciones de *B humidicola* en cultivo puro en cuanto a ganancias de peso animal en condiciones de sabanas bien drenadas en la altillanura de los Llanos Orientales de Colombia (Salinas y Gualdron 1982)

EVALUACIONES DE GANANCIAS DE PESO

En un experimento que se establecio en Carimagua Llanos Orientales de Colombia en 1978 con *Panicum maximum* *Andropogon gayanus* *Brachiaria decumbens* y *Brachiaria humidicola* con una fertilización similar de 50 kg de P_2O_5 50 kg de K_2O 18 kg de MgO y 22 kg de S por hectarea respectivamente excepto en *P maximum* en el cual se aplicaron 100 kg de P_2O_5 se evaluó durante 2 años el comportamiento de novillos mestizos criollo Cebu de un peso promedio de 150 kg en pastoreo continuo con cargas variables de 1 y 2 novillos por hectarea para las estaciones seca y lluviosa respectivamente Los promedios de ganancias de peso diario (Tabla 1) muestran que el comportamiento animal en *B humidicola* fue inferior al de las demas gramineas sobre todo durante la estacion lluviosa La cantidad de materia seca de hoja y tallo disponible se determino en una muestra de forraje compuesta por 10 submuestras por hectarea de 1 m^2 cada una tomadas al azar cortadas a 10 cm de altura secadas al horno a 60°C por 24 hr y separadas manualmente en sus componentes hoja tallo y material muerto El forraje ofrecido durante la estacion lluviosa de 1979 (Tabla 2) fue mas alto en *B humidicola* que el de las otras gramineas lo cual no explica el comportamiento tan pobre de los novillos en pastoreo durante la mejor epoca de crecimiento del pasto asi mismo la baja producción animal en esta graminea es inconsistente con los valores de digestibilidad encontra