STYLOSANTHES CAPITATA VOG., SOME AGRONOMIC ATTRIBUTES, AND RESISTANCE TO ANTHRACNOSE (*COLLETOTRICHUM GLOEOSPORIOIDES* PENZ.)

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ABSTRACT

Stylosanthes capitata *Vog., a perennial, self-regenerating legume pasture species was collected in eastern Brazil and Venezuela and evaluated in field and pot studies at CIAT in Colombia, South America. Several accessions of the species proved highly resistant to both Colombian and Australian races of the fungal disease anthracnose* (Colletotrichum gloeosporioides *Penz.) which has severely affected other species of* Stylosanthes. *This resistance of* S. capitata *was maintained over two growing seasons under grazed sward conditions. Accessions of the species also showed ability to grow under low pH conditions and at low levels of soil phosphorus. One accession reached near maximum yield at 8 ppm external level of phosphorus.* S. capitata *shows considerable potential as a pasture species for the savanna regions of tropical America and commercial cultivars are likely to be released in the future.*

INTRODUCTION

The vast tropical savannas constitute the largest area of potentially productive soils in the world. In South America these grasslands developed on oxisols and ultisols are within the 1200 to 2000 mm isohyetes. Soil pH values are generally less than 5 and available phosphorus is less than 5 ppm. The predominant exchangeable cation is aluminium, and growth of cultivated plants and most forage species is severely restricted due to toxic effects of this element. It is to this grassland region that CIAT's (Centro Internacional de Agricultura Tropical) beef production program in Colombia is directing its primary efforts to increase cattle productivity. The emphasis is on the search for legumes, both as a means of increased forage quality and as a source of nitrogen for associated grasses.

Species of *Stylosanthes* are generally considered tolerant of acid, infertile soils. However, the commercial Australian cultivars of stylo (*S. guianensis*) which are the source of nearly all seed traded internationally, and the Brazilian cultivar IRI 1022 were all shown to be susceptible to anthracnose disease in tests in Colombia (Anon. 1973). Most collections of *S. guianensis, S. hamata* and *S. humilis* were also susceptible to the disease.

Anthracnose disease, caused by *Colletotrichum gloeosporioides* Penz. is responsible for loss of vigour, defoliation and often death of susceptible species of *Stylosanthes* over a wide latitudinal range in tropical America. The disease was first recorded in 1937 at the Federal Experiment Station, Deodoro, Brazil, on plants of *S. guianensis* and *S. humilis* (Anon. 1937). Stylo anthracnose was identified as a major problem in Colombia in 1972 and systematic screening of *Stylosanthes* spp. for anthracnose resistance was initiated (Anon. 1972).

The widespread occurrence of stylo anthracnose in tropical and subtropical America and recent reports of the presence of this devastating fungal disease on *Stylosanthes* spp. in Africa (Clatworthy 1975), Australia (Pont and Irwin 1976, O'Brien and Pont 1977), Thailand (K. Chutikul personal communication) and Florida (Sonoda *et al.* 1974) emphasise the need for disease-resistant varieties.

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The *Stylosanthes* evaluation project of CIAT seeks to identify anthracnose resistant genotypes which are also adapted to low base status oxisols such as occur on the *llanos* of Colombia and the *campo cerrado* in Brazil. Preliminary trials suggested that the species *S. capitata* could meet these requirements.

S. capitata, a native of eastern Brazil and Venezuela, has a restricted distribution in comparison to the widespread species *S. guianensis* and *S. humilis* (Mohlenbrock 1957). Collection localities for accessions in the CIAT gene bank range from lat. 21°S in Brazil to 10°N in Venezuela (Figure 1). *S. capitata* occurs in treeless and open woodland savanna habitats on acid (pH < 5), infertile, sandy soils, and often in association with *S. bracteata, S. scabra* and "fine stemmed" forms of *S. guianensis.* The species is absent from the savannas on the western side of the South American continent.

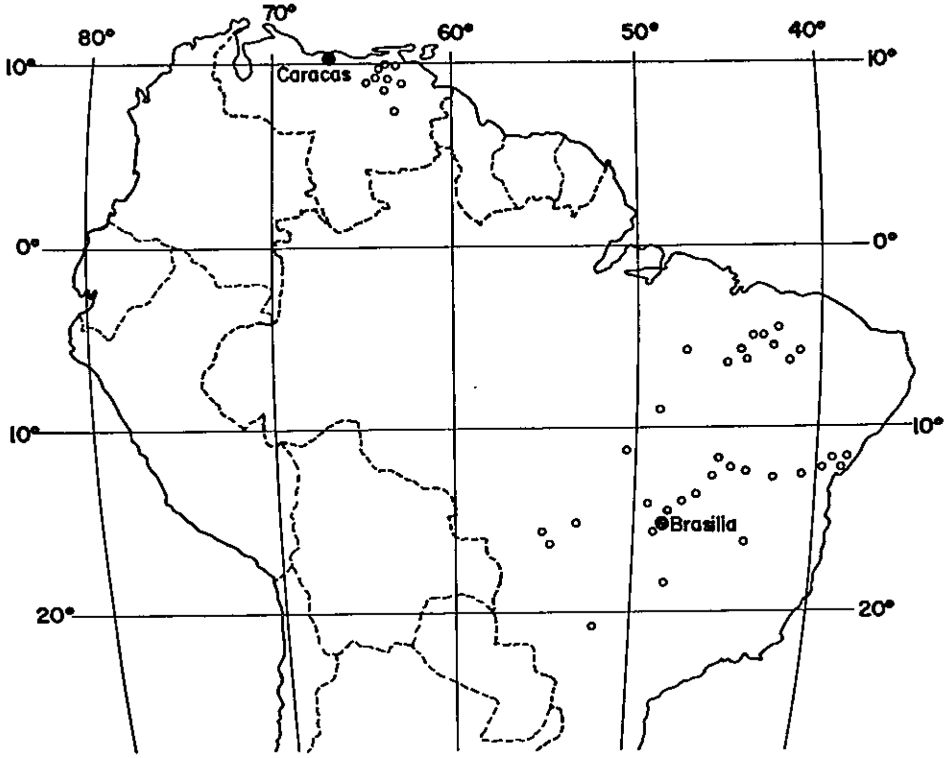

FIGURE 1

Collection sites of *S. capitata* in Brazil and Venezuela.

Ecotypes differ in many morphological characters including size and shape of inflorescence, habit of growth, hairiness of stem and leaf and color of stem. There is considerable variation between accessions in flowering date. Those from the southern limit of distribution of the species commence flowering in the Colombian *llanos* (lat. 4°30′ N) in August, at least one month ahead of the accessions from the north-eastern states of Brazil. *S. capitata* is a hardy perennial but it also regenerates from self-sown seed, which germinates readily in the season following establishment.

This paper reports some agronomic attributes of *Stylosanthes capitata*, response to P and Ca, critical values of P and reaction to anthracnose.

EXPERIMENTAL

DM yield in 15 S. capitata *accessions*

A randomized complete block field design with four replications was used to evaluate 15 accessions of *S. capitata* and two of *S. bracteata*. Thirteen of the *S. capitata* accessions were mid-season, one was early and one was late flowering. The experiment was sited 40 km south of Cali at Santander in the Cauca Valley of Colombia lat. 3°06′ N, long. 76°31′ W, altitude 990 m, rainfall 1845 mm, on a well drained ultisol. Soil chemical attributes are listed in Table 1. Eight weeks old seedlings were square planted on a 50 cm spacing, with 20 plants per plot. A basic fertilizer dressing of 40 kg ha^{-1} P as triple superphosphate was applied at planting. Four yield cuts were taken during the year at approximately eight week intervals and in each plot the four centre plants were harvested at a height of 15 cm. After each harvest an equalizing cut was made at the same height.

Under the infrequent cutting regime superimposed on this experiment all *S. capitata* accessions seeded and a dense sward was obtained in the season following establishment. The late and early flowering accessions were the highest and lowest yielding ($P < 0.05$) accessions respectively.

TABLE 1

Chemical properties of the soils in the experiments.

Soil	pH (H_2O)	P ppm	Org. C%	Exchangeable cations meq/100g^{-1}				Al Saturation %	CEC
				Al	Ca	Mg	K		
Santander Ultisol	4.1	1.8	4.1	2.7	.65	.49	.36	64	4.2
Carimagua Oxisol	4.3	0.9	3.1	2.8	.20	.20	.10	82	3.4

Response to phosphorus

The response of an early, mid-season and late flowering ecotype of *S. capitata* to nine incremental rates of P (i.e.: 0, 5, 10, 15, 20, 30, 60, 120, 240 kg ha^{-1}) applied at $CaH_4(PO_4)_2$ was examined in a pot culture experiment. Plants were grown in 15 cm diameter plastic pots filled with 1800 g of Carimagua oxisol. Dry matter yield and phosphorus concentration in plant tops were measured and uptake of phosphorus was calculated.

Incremental rates of phosphorus increased dry matter yields of all three *S. capitata* ecotypes. In general, the three accessions grew vigorously with only moderate applications of phosphorus. Dry matter yields showed a straight line increase up to 20 kg ha^{-1} rate of applied P. Only the high yielding mid-season accession showed a yield increase beyond this rate of P application. Progressive additions of P increased the concentration of P in the tops as well as the uptake of P. Again, above 20 kg ha^{-1} application rate of P, both uptake and concentration of P remained static for early and late flowering *S. capitata* while in the case of the mid-season accession these values increased up to the highest rate of application (Figure 2).

Phosphorus response of six Stylosanthes *species*

Relative dry matter yields of plant tops and external P critical values were determined for six *Stylosanthes* species, including *S. capitata*, in a pot experiment. The

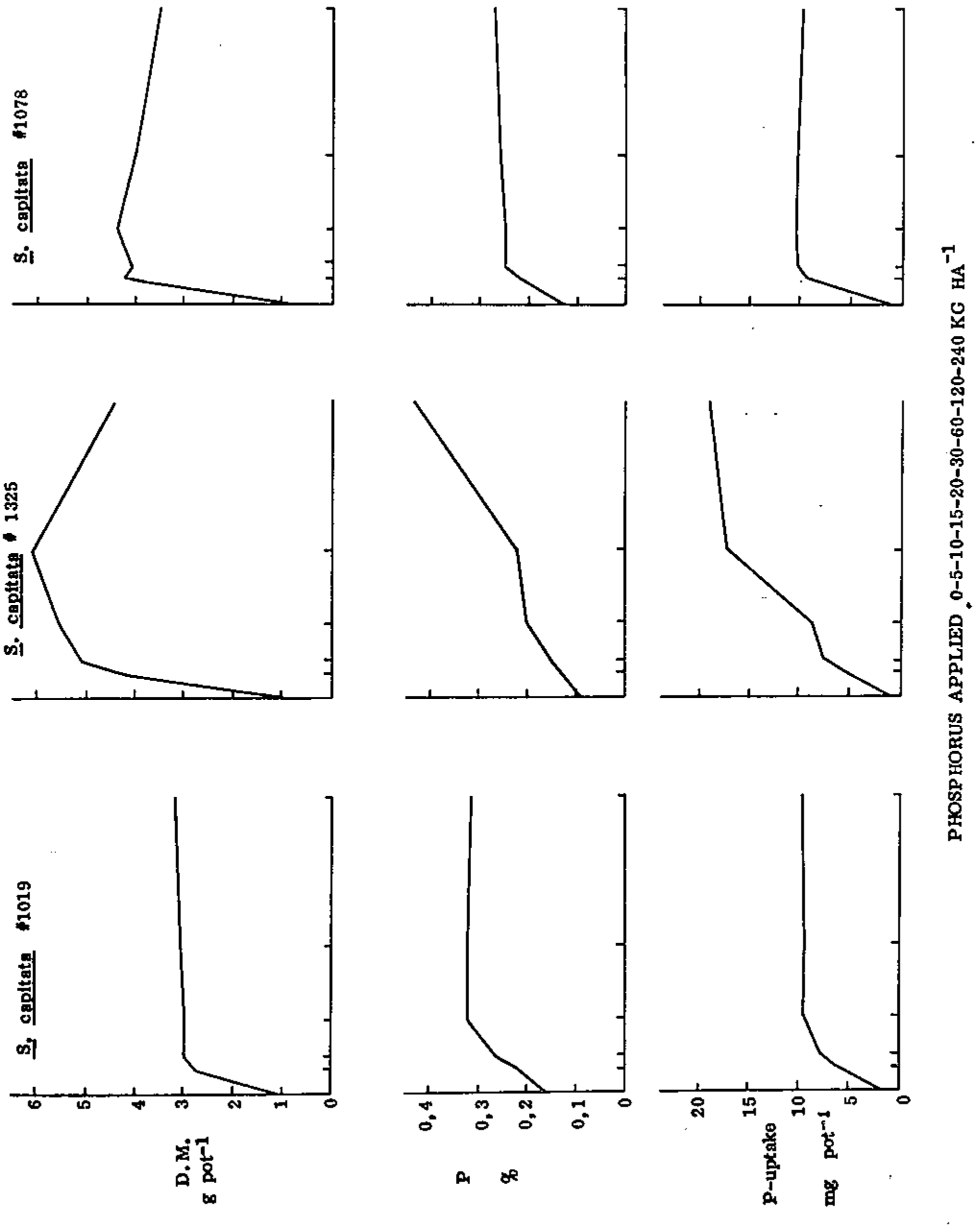

FIGURE 2
Dry matter yield, P concentration (in plant tops) and P uptake of three *S. capitata* accessions.

weight of soil and soil type, and the same rates of P were used as in the former experiment. The six legumes chosen were from widely different soil, pH and environmental situations, ranging from an alkaline littoral soil in Ecuador (*S. sympodialis*) to soils with pH values below 5. These very acid soils are representative of regions where *S. capitata, S. viscosa* and *S. scabra* are found. The *S. hamata* accession used was from soil of pH 5.

Figure 3 shows critical value curves for *S. capitata* CIAT 1019 and five other *Stylosanthes* spp. Relative yields of dry matter, expressed as percentages of maximum yield for each species, have been plotted against P levels of the fertilized soil determined by the Bray II method. The arrows indicate the critical values, that is the

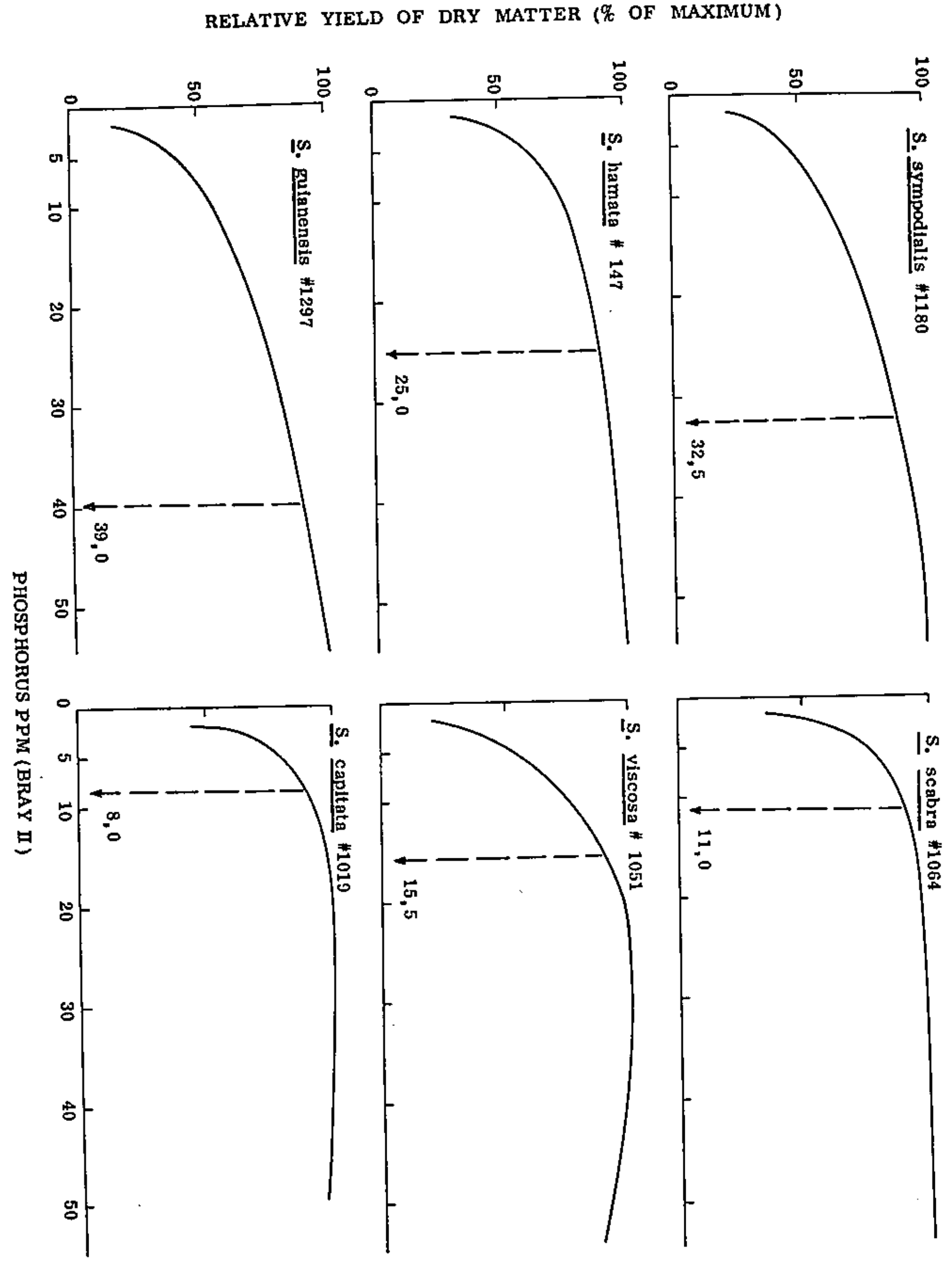

FIGURE 3
Relative yield of dry matter and critical P values for six *Stylosanthes* spp.

phosphorus concentrations at 90% of maximum dry matter yield. Near-maximum yield was reached by *S. capitata* at 8 ppm external P level. The same yield plateau was attained by *S. guianensis* at a substrate phosphorus level of 39 ppm. With respect to critical P values the species tested were in this order: *S. guianensis* > *S. hamata* > *S. viscosa* > *S. scabra* > *S. capitata.*

Response of S. capitata *and four other legumes to liming*

The effect of the addition of $CaCO_3$ on the growth of five legumes on an acid oxisol (pH 4.3) was studied using a 5 × 2 randomized block design with 8 replications. The soil was an acid clay loam from Carimagua, Llanos Orientales, Colombia (Table 1) on which *Centrosema* and *S. hamata* growth in the field had been poor. Plants were grown in 250 g of soil in undrained stereofoam cups. Treatments were: (a) nil and 4000 kg ha^{-1} $CaCO_3$ applied as precipitated $CaCO_3$ and mixed through the soil. Addition of $CaCO_3$ increased soil pH to 6 at 8 weeks from sowing. (b) five legumes—*S. hamata* CIAT 174, *S. guianensis* CIAT 181 and CIAT 64A, *S. capitata* CIAT 1019, *Centrosema* sp. CIAT 1733. All basal fertilizer equivalents were calculated on the surface area basis and applied in solution.

$CaCO_3$ at 4000 kg ha^{-1} depressed the dry weight of *S. capitata* and *S. guianensis* CIAT 64A (Table 2). Both of these accessions originate from low pH soils. *Centrosema* sp., *S. hamata* and *S. guianensis* CIAT 181 showed positive responses to addition of $CaCO_3$. All three accessions are adapted to soils of higher pH. *S. capitata* did not produce root nodules in the lime treatment but nodulated normally at soil pH 4.3 and at an Al level of 3 meq 100 g^{-1}. In contrast, *Centrosema* sp. was well nodulated in the lime treatment but did not form root nodules in unlimed soil.

TABLE 2

Dry matter yields of four Stylosanthes *accessions and* Centrosema *sp. grown at two pH levels on a Carimagua oxisol.*

Species	CIAT Accession Number	Dry Matter Yelds mg pot^{-1} pH 4.3	pH 6.0	Change due to Liming %
Stylosanthes hamata	174	305.1	453.3	+ 48.6
Centrosema sp.	1733	575.1	779.1	+ 35.5
Stylosanthes guianensis	181	504.9	595.8	+ 18.0
Stylosanthes guianensis	64A	568.4	482.5	— 15.1
Stylosanthes capitata	1019	289.9	201.8	— 30.4

Anthracnose response

Cultures of *C. gloeosporioides* were isolated from diseased stems and leaves of *Stylosanthes* spp. Eight cultures were bulked and used as sources of inoculum for the three experiments reported in this paper. Five isolates were collected from field plots of *S. guianensis* and *S. capitata* in Colombia. Two isolates denoted as 21577 and 21423a were isolated in Australia from diseased *S. humilis* and *S. guianensis* cv. Endeavour respectively. Another isolate was obtained from pods and seeds of *S. scabra* grown in Colombia.

Petri dishes containing potato dextrose agar (Difco) were seeded with conidia and mycelial fragments from stock cultures and incubated at 28°C. After the cultures had grown for two weeks, inoculum was prepared by suspending scrapings of spore masses in distilled water. The concentration of inoculum was adjusted to *ca.* 1×10^6 conidia per ml. Ten plants of each *S. capitata* accession and susceptible checks of *S. guianensis* such as cv. Schofield, also accessions of *S. scabra,* "fine stemmed" forms of *S. guianensis, S. humilis, S. bracteata* with known disease reactions were planted in jiffy pots. All treatments were arranged in three randomized blocks. Plants in the three to four true-leaf stage were sprayed with the inoculum until run-off and kept in a translucent polyethylene mist chamber. A constant saturated atmosphere was maintained with humidifiers for one week. Seven and again fourteen days after inoculation plants were scored for severity of anthracnose infection on a 1–5 scale:

1 = no infection
2 = spots < 1 mm
3 = 25% of leaf area affected
4 = 50% of leaf area affected
5 = dead plant

In experiment 3 treatment differences were tested by Duncan's Multiple Range Test. In Experiments 1 and 2 where there was a wide range in disease response a disease severity index (DSI) was calculated using the following formula:

$$\text{DSI} = \frac{\text{Mean disease score of accession} - \text{mean disease score of experiment}}{\text{standard deviation of mean score of experiment}}$$

(Disease score = weighted means of the five score classes)

In general, *S. capitata* accessions, "fine stemmed" forms of *S. guianensis, S. scabra* and *S. bracteata* showed a higher degree of tolerance to anthracnose than the "common" forms of *S. guianensis* e.g. cv. Schofield (Table 3). Several accessions of *S. capitata* displayed a consistently high level of tolerance to the mixed anthracnose inoculum. However, significant differences were observed among accessions in their tolerance (Table 4).

DISCUSSION

Stylosanthes is a very variable genus which has provided a number of commercial tropical pasture legumes for wet and dry regions of northern Australia and other tropical countries. Experimental data presented in this paper confirm field observations and indicate that *S. capitata* is particularly well adapted to soils of low nutrient status and extreme acidity.

Jones (1974) found considerable differences between *Stylosanthes* spp. in phosphorus utilization and recorded a low uptake of this element by accessions of *S. viscosa* and *S. scabra.* The same author suggested that the inherent characteristics of low uptake of nutrients and low initial growth rate enable these species to survive under conditions of limited nutrient supply. Munns and Fox (1977) reported that in contrast to other tropical legumes, *S. guianensis* and *S. fruticosa* did not respond to lime application on a Hawaiian oxisol and depression of growth occurred at high rates of application. Data reported in this paper on the reaction of *S. capitata* to phosphorus and calcium additions indicate similar trends and corroborate the findings of these authors.

A particularly encouraging feature of the performance of *S. capitata* has been the excellent seedling regeneration in cut and grazed swards. *S. capitata* is a prolific seeder and hard seededness protects the seed against total digestion by ruminants, which in turn aids seed dispersal.

Stylo anthracnose is endemic and widespread in the tropics of South and Central America. Plant resistance is the only practical means of control. Some six hundred accessions of *Stylosanthes* have been tested and *S. capitata* displayed the best tolerance to anthracnose in planthouse and laboratory pathogenicity tests. Several

TABLE 3

Reaction of Stylosanthes *spp. to anthracnose at* 14 *days after inoculation with an aqueous syspension of conidia of* C. Gloeosporioides. *Positive values represent susceptible lines of* Stylosanthes *and negative values indicate various degrees of resistance—Experiments 1 and 2.*

Species	Number of accessions tested	Disease severity index (range)							
		resistant				susceptible			
		–.8 to –.6	–.6 to –.4	–.4 to –.2	–.2 to 0	0 to .4	.4 to 1.2	1.2 to 2.2	2.2 to 3.2
		number of accessions in score classes							
Experiment 1									
S. capitata	8		8						
S. guianensis (fine stemmed)	4		3			1			
S. humilis	1		1						
S. guianensis	7			1			1	4	1
S. scabra	1			1					
S. bracteata	1				1				
Stylosanthes sp.	2		2						
Experiment 2									
S. capitata	10	4	2			1	3		
S. scabra	5	4	1						
S. guianensis (fine stemmed)	4		2			1		1	
Stylosanthes sp.	1	1							
S. bracteata	1					1			
S. humilis	1					1			
S. guianensis	5						1	4	
S. guianensis cv. Schofield (control)	1							1	

TABLE 4

Reaction of 22 *accessions of* Stylosanthes capitata *one* S. bracteata *and two* S. guianensis *controls to anthracnose—Experiment* 3.

Species	CIAT Accession No.	Anthracnose Rating†
S. guianensis	1198	4.82a*
S. guianensis cv. *Schofield*	17	3.18 b
S. capitata	1356	1.69 c
,, ,,	1321	1.44 d
,, ,,	1078	1.27 de
,, ,,	1405	1.25 def
,, ,,	1338	1.24 efg
,, ,,	1019	1.16 efgh
,, ,,	1315	1.15 efgh
S. bracteata	1281	1.11 efgh
S. capitata	1332	1.11 efgh
,, ,,	1339	1.10 efgh
,, ,,	1318	1.08 efgh
,, ,,	1097	1.07 efgh
.. ..	1342	1.05 fgh
,, ,,	1325	1.05 fgh
,, ,,	1328	1.05 fgh
,, ,,	1334	1.05 fgh
,, ,,	1323	1.02 gh
,, ,,	1312	1.02 gh
,, ,,	1343	1.02 h
,, ,,	1191A	1.01 h
,, ,,	1322	1.01 h
,, ,,	1007	1.01 h

†Severity scale based on 1=no infection to 5=dead plant.
*Ratings with different letters are significantly different ($P < 0.05$) by Duncan's multiple range test.

accessions of this species maintained strong field resistance to the disease under actual grazing conditions. Furthermore, ecotypes of *S. capitata* are tolerant to a wider spectrum of pathogenic races of anthracnose than other species of the genus (Grof, unpublished data).

The good potential of *S. capitata*, an agronomically little known legume, as a forage species for oxisol savanna regions in tropical America is indicated. Selected genotypes of *S. capitata* may be used directly as forage cultivars or they can be of value in breeding programs as a source of anthracnose resistance. If anthracnose resistance proves stable under field conditions selected genotypes will be developed as commercial cultivars for different environmental situations.

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