Australian Government
Australian Centre for International Agricultural Research

High-yielding anthracnose-resistant *Stylosanthes* for agricultural systems






Editor: S. Chakraborty

High-yielding anthracnose-resistant *Stylosanthes* for agricultural systems

Edited by Sukumar Chakraborty

Australian Centre for International Agricultural Research
Canberra 2004

The Australian Centre for International Agricultural Research (ACIAR) was established in June 1982 by an Act of the Australian Parliament. Its mandate is to help identify agricultural problems in developing countries and to commission collaborative research between Australian and developing country researchers in fields where Australia has a special competence.

Chakraborty, S. (ed.) High-yielding anthracnose resistant *Stylosanthes* for agricultural systems. ACIAR Monograph No. 111, 268 p.

ISBN: 1 86320 442 3

1 86320 443 1

Technical editing: Joanne Mason, Mason Edit, Adelaide

Design and layout: Fivefold Creative

Printing: Union Offset

Contents

High-yielding anthracnose-resistant *Stylosanthes* for agricultural systems

Section A *Stylosanthes*: a versatile tropical legume

Section B Anthracnose resistant *Stylosanthes*

B1. Germplasm evaluation & cultivar development

Section B

Anthracnose resistant *Stylosanthes*

B1: Germplasm evaluation & cultivar development

Chapter 10

Regional evaluation of *Stylosanthes* germplasm in Brazil

Celso Dornelas Fernandes[1], Sukumar Chakraborty[2], Bela Grof[3], Hortência Maria Abranches Purcino[4], Maria do Socorro Bona Nascimento[5], Maria José D' Ávila Charchar[6], Jaqueline Ros emeire Verzignassi[7] and José Marcelino Sobrinho[8]

Summary

Accessions and cultivars of *Stylosanthes capitata, S. macrocephala, S. guianensis, S. scabra* and *S. seabrana* were evaluated for agronomic performance and anthracnose resistance at five field sites in Brazil spanning the states of Chapadão do Sul-MS, Goiânia-GO, Planaltina-DF, Sete Lagoas-MG and Teresina-PI. The field trials were laid out as a complete randomised block design replicated four times and planted at the beginning of the rainy season. Each replicate 5x2 m plot consisted of four rows of each accession/cultivar. Data on dry matter, seed yield and anthracnose severity were collected during two years of this study and analysed separately for each site. Results showed considerable genetic variability among the germplasm of *Stylosanthes* studied for each character. The most promising accessions yielded 11–16 t dry matter/ha annually and seed yields reached up to 600 kg/ha. Anthracnose was a serious problem on susceptible accessions at some sites with high rainfall. The study forms a basis for the targeting of specific accessions to suit regional climatic conditions.

[1] Embrapa Gado de Corte/Uniderp, C.P. 154, 79002-970, Campo Grande-MS, Brazil
[2] CSIRO Plant Industry, Queensland Bioscience Precinct, 306 Carmody Road, St Lucia, Queensland 4067, Australia
[3] Amiga Court, Palmwoods, Queensland 4555, Australia
[4] EPAMIG/CTCO, Rod. MG 424 Km 64, 35715- 000, Sete Lagoas-MG, Brazil
[5] Embrapa Meio Norte, Av. Duque de Caxias, 5660, Teresina-PI, Brazil
[6] Embrapa Cerrados, Rod. BR 020, Km 18, 73-301-970, Planaltina-DF, Brazil
[7] Universidade Estadual de Maringá, Maringá-PR
[8] Universidade Católica de Goiás, Goiânia-GO
Correspondence should be addressed to: Celso Dornelas Fernandes
celsof@cnpgc.embrapa.br

Introduction

Species of the genus *Stylosanthes* are widely distributed in tropical and subtropical regions of the Americas, Africa and Asia. The main centre of origin and diversity is Brazil, the native habitat of 25 of the 45 described species (Stace & Edye 1984). The genus is adapted to a variety of edaphic and climatic conditions and has good potential as cultivated forage in Brazil. Anthracnose, caused by *Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc., the anamorphic form of *Glomerella cingulata* (Stonem.) Spauld & Scherenk, has been the main limitation to the commercial utilisation of *Stylosanthes*. This fungus has an extensive genetic diversity in Brazil (Weeds et al 2003) and resistant cultivars of the legume can potentially become susceptible to the disease only a few years after their commercial release.

The savanna soils are often low in available nitrogen, and low forage availability and quality of native or cultivated grass pastures in the dry season is a major constraint to livestock production. Forage legume species adapted to these soils and weather conditions can have an important impact on pasture-based animal production and soil fertility when used as a pasture crop with grasses or as a cover crop to improve fertility through biological nitrogen fixation (Andrade et al, this volume; Cameron & Chakraborty, this volume).
The introduction of legumes in grass-based pastures improves the quality of forage due to increased protein availability, and animal performance improves as a consequence (Hall & Glatzle, this volume). The genus *Stylosanthes* contains many multi-purpose species that have been used to integrate animal and crop production, and aid in the revegetation of fragile environments in Asia (Phaikaew et al, this volume), Africa (Pengelly et al, this volume) and Australia (Hall & Glatzle, this volume).

There is a long history of research and development on *Stylosanthes* germplasm in Brazil but the commercial success with released cultivars has been short lived in most countries in South America including Brazil (Andrade et al, this volume). No fewer than ten cultivars have been released in Brazil; early cultivars were imported from Australia but many have been developed through evaluation and selection by EMBRAPA and its international collaborators such as the Centro Internacional Agriculture Tropical (CIAT) (Andrade et al, this volume). The main reasons for failure include poor seed yield, susceptibility to anthracnose, poor persistence under grazing, a lack of consideration of alternative usage of a pasture species, and a reliance of farmers on N fertilised grass pastures (Andrade et al, this volume; Miles & Lascano 1997). Extensive evaluations of germplasm through a network of regional sites had been carried out for a number of years. However, this activity has been greatly reduced in recent years and, as a consequence, identification of promising *Stylosanthes* germplasm through national and international programs has almost come to a standstill. To increase the range of materials available to Brazil, and to select well-adapted, productive and anthracnose-resistant *Stylosanthes*, new germplasm and bred lines from EMBRAPA, Australia and CIAT were evaluated in a collaborative project funded by the Australian Centre for International Agricultural Research (ACIAR) during 1996–2003. This paper reports on the productivity and anthracnose resistance of these new materials from a regional evaluation across selected edaphic and climatic conditions in Brazil.

Materials and Methods

A total of 26 accessions and cultivars of *S. guianensis, S. scabra, S. capitata, S. macrocephala* and *S. seabrana* from EMBRAPA, CSIRO (Australia) and CIAT were evaluated during a two-year period at five separate field sites in Brazil, representing different agroclimatic zones. Sites were selected to represent areas where *Stylosanthes* species have either shown promise or have the potential to be used as a pasture and forage legume. Replicated plots were established at Chapadão do Sul in Mato Grosso do Sul, Teresina in Piauí, Sete Lagoas in Minas Gerais, Goiânia in Goiás and Planaltina in the Federal District (DF). The number of accessions of the various species and the geographical location of these sites are given in Table 10.1.

At each site a field trial was laid out in a complete randomised block design with four replicate plots established at the beginning of the rainy season. Annual dry matter (DMY) and seed yield (SY) were recorded from replicate plots of each accession from an area of at least 2x3 m in each established plot. Anthracnose severity was assessed during the growing season on a randomly selected branch on each plant within each plot at approximately 15-day intervals. Plants were visually assessed for disease severity using a 10-point rating scale, where: 0 = disease free; 1 = 1–3% leaf area diseased and defoliated; 2 = 4–6%; 3 = 7–12%; 4 = 13–25%; 5 = 26–50%; 6 = 51–75%; 7 = 76–87%; 8 = 88–94%; 9 = 95–100% (Chakraborty 1990).

Data on DMY, SY and anthracnose severity were separately analysed for each site. Results were compared by analysis of variance and clustering and means were separated at the 5% probability level (Scott & Knott 1974). Data on anthracnose severity (sev.) were √(sev. +0.01) transformed before analysis to stabilise variance.

Results and Discussion

The number of accessions/cultivars evaluated at each site varied from 21 to 26 (Table 10.1). Accessions of the five *Stylosanthes* species were initially selected for the regional sites according to their expected performance at these sites, and not all species or accessions were grown at every site. Therefore, results for each site are given separately. However, many accessions were common to all sites and their relative performance at each of the five sites was also compared; findings are given for a small subset of accessions. This work forms the basis for the evaluation, selection and release of a new *S. macrocephala – S. capitata* composite cultivar for use in central Brazil (Verzignassi et al 2002). This has come seven years after the release of Mineirão in 1993 and has the potential to start a renewed interest in *Stylosanthes* in Brazil, following

Table 10.1 *Stylosanthes* species accessions and cultivars evaluated at field sites in Brazil.

Site and state	Latitude and Longitude	*S. capitata*	*S. macrocephala*	*S. guianensis*	*S. scabra*	*S. seabrana*	Total
Chapadão do Sul, MS	20º 26' S, 54º 42' W	5	6	5	7	0	23
Goiânia, GO	16º 36' S, 49º 16' 50" W	5	6	5	5	0	21
Planaltina, DF	15º 36' S, 47º 12' W	5	5	2	12	2	26
Sete Lagoas, MG	19º 28' S, 45º 15' W	5	5	2	8	2	22
Teresina, PI	5º 14' 35" S, 42º 11' 38" W	5	6	5	5	0	21

disappointments with many of the earlier released cultivars. Unrelated to this work, a second new *S. capitata* cultivar is at a pre-release stage (Andrade et al, this volume). In the final section of this study we record and review the performance of cultivar Campo Grande.

Performance of accessions at each site

Chapadão do Sul Overall, accessions of *S. capitata* performed the best at this site, with all accessions reaching over 11 t/ha. This species was followed by *S. guianensis* and *S. macrocephala*, and *S. scabra* was the least productive (Table 10.2). However, the *S. guianensis* cv. Mineirão (accession GC 984) produced the highest DMY yield at 13.8 t/ha, with the *S. capitata* – *S. macrocephala* cultivar Campo Grande (GC 2260) a close second at a DMY reaching up to 13.4 t/ha.

Stylosanthes macrocephala produced the highest quantity of seeds, generally close to 300 kg/ha, and *S. capitata* produced over 200 kg/ha. Both *S. guianensis* and *S. scabra* were poor seed producers, although some *S. guianensis* produced nearly 100 kg/ha of seeds. The poor herbage and seed yield of all *S. scabra* accessions indicate that this species was not suited to the local agroclimatic conditions. The *S. guianensis* cv. Mineirão had the lowest seed yield of only 5.6 kg/ha despite its high forage availability and DMY. Poor seed yield of Mineirão in the first few years of its establishment has been the most significant impediment to its large-scale commercial utilisation in Brazil (Andrade et al, this volume).

The data on anthracnose severity indicate considerable variation in resistance among the various accessions tested. Overall, *S. macrocephala* and *S. guianensis* showed higher resistance than *S. capitata* or *S. scabra*. Among the accessions, GC 1496 (*S. scabra* cv. Fitzroy) was the most susceptible and GC 1507, GC 1508 (both *S. macrocephala*) and GC 1585 (*S. guianensis*) were the most resistant.

Based on their overall performance, accessions GC 1466, GC 1585 and GC 2260 were selected for further studies.

Goiânia The overall DMY of *S. guianensis* was the best at Goiânia, although accessions did not produce the same level of DMY at this site as in Chapadão do Sul (Table 10.2). No other species produced over

Table 10.2 Dry matter, seed yield and anthracnose severity rating of accessions of *Stylosanthes* species evaluated at Chapadão do Sul in Mato Grosso do Sul and Goiânia in Goias over a two-year period.

		Chapadão do Sul			Goiânia		
Accession No. (GC)	Species	Dry matter yield (t/ha)	Seed yield (kg/ha)	Anthracnose severity	Dry matter yield (t/ha)	Seed yield (kg/ha)	Anthracnose severity
348	*S. guianensis*	9.1 b[1]	47.5 d	1.2 e	5.6 c	29.8 d	2.4 a
984	*S. guianensis*	13.8 a	5.6 d	1.4 d	11.5 a	8.5 e	1.7 c
1082	*S. capitata*	12.8 a	287.8 a	2.2 b	8.0 c	625.0 a	2.0 a
1173	*S. capitata*	12.8 a	273.5 a	2.2 b	7.1 c	500.3 b	1.9 b
1466	*S. capitata*	11.4 a	277.5 a	2.0 c	6.2 c	335.8 b	1.6 c
1468	*S. guianensis*	9.3 b	100.4 c	1.5 d	12.9 a	157.5 c	1.2 d
1469	*S. capitata*	12.3 a	223.3 b	2.3 b	7.0 c	287.3 c	1.6 c
1490	*S. scabra*	5.8 c	40.8 d	2.3 b	5.4 c	110.3 d	2.1 a
1493	*S. scabra*	5.1 c	84.0 c	2.0 c	4.8 c	200.9 c	1.2 d
1496	*S. scabra*	–	–	2.8 a	–	–	–
1498	*S. scabra*	6.3 c	79.6 c	2.2 b	6.1 c	483.3 b	1.4 d
1500	*S. scabra*	–	–	1.6 d	–	–	–
1507	*S. macrocephala*	7.2 c	316.2 a	1.1 e	5.1 c	124.5 d	2.2 a
1508	*S. macrocephala*	8.5 b	309.0 a	1.1 e	5.1 c	76.3 d	2.2 a
1511	*S. macrocephala*	9.2 b	214.6 b	1.3 d	6.0 c	157.0 c	2.2 a
1536	*S. scabra*	6.3 c	47.7 d	2.1 b	4.8 c	259.5 c	1.9 b
1538	*S. scabra*	4.6 c	99.0 c	2.2 b	6.2 c	222.3 c	1.9 b
1557	*S. guianensis*	8.7 b	40.1 d	1.7 c	8.8 b	78.8 d	0.8 e
1582	*S. macrocephala*	9.1 b	328.2 a	1.3 d	6.0 c	206.3 c	2.2 a
1585	*S. guianensis*	10.9 b	106.5 c	1.1 e	12.5 a	138.3 d	1.4 d
1586	*S. guianensis*	9.7 b	161.0 c	1.4 d	10.1 b	164.5 c	1.9 b
1587	*S. macrocephala*	9.1 b	298.5 a	1.4 d	6.7 c	105.5 d	2.2 a
2260	*S. capitata* – *S. macrocephala*	13.4 a	314.6 a	1.8 c	7.0 c	432.8 b	1.6 c

[1] Means followed by a different letter are not significantly different according to the Scott-Knott test (P≥0.05)

10 t/ha and there was very little difference in DMY between *S. capitata, S. macrocephala* and *S. scabra,* or between accessions among these species. Seed yield of all species and accessions was generally higher than in Chapadão do Sul and *S. capitata* GC 1082 produced over 600 kg/ha of seeds. In contrast to Chapadão do Sul, some *S. scabra* accessions produced >400 kg/ha seed; however, the relative ranking of most accessions remained the same as at the Chapadão do Sul site and, despite improvements in seed yield for nearly all accessions, Mineirão produced only 8.5 kg/ha seed. Anthracnose severity ratings of species and accessions had a narrower range than at Chapadão do Sul and both the least and most resistant accessions were from *S. guianensis.* GC 1468 and GC 1585 were selected for further study.

Germplasm evaluation and co-workers at the Goiânia site.

Planaltina and Sete Lagoas Overall, DMY of most accessions was lower at Planaltina than at Sete Lagoas. Only one accession at Planaltina produced over 10 t/ha, whereas ten accessions produced over 10 t/ha at Sete Lagoas (Table 10.3). The DMY of *S. guianensis* GC 348 at Goiânia and Planaltina was <7 t/ha (Table 10.2), but over 15 t/ha, as high as the cultivar Mineirão, at Sete Lagoas.

Although *S. guianensis* accessions generally had the highest DMY at both sites, the same accession did not produce the highest seed yield at both sites. Seed production at the two sites largely followed trends in DMY; however, at Sete Lagoas the cultivar Mineirão did not produce any seed and data on seed yield were unavailable for a large number of other accessions. The most prolific seed producers were GC 1517 (*S. macrocephala*), GC 1579 (*S. guianensis*), GC 1588 (*S. seabrana*) and GC 2256 (*S. scabra*) at Planaltina; and GC 1093, GC 1463, GC 1511, GC 1582 and GC 2260 at Sete Lagoas.

Table 10.3 Dry matter, seed yield and anthracnose severity rating of accessions of *Stylosanthes* species evaluated at Planaltina in Brasilia-DF and Sete Lagoas in Minas Gerais over a two-year period.

		Planaltina			Sete Lagoas		
Accession No. (GC)	Species	Dry matter yield (t/ha)	Seed yield (kg/ha)	Anthracnose severity	Dry matter yield (t/ha)	Seed yield (kg/ha)	Anthracnose severity
348	*S. guianensis*	6.4 b1	161.1 f	1.8 b	15.2 a	19.5 c	0.3 a
984	*S. guianensis*	8.2 a	3.0 f	0.7 d	15.2 a	0.0 c	0.3 a
1059	*S. capitata*	5.0 c	101.3 f	1.6 b	7.3 d	562.3 b	0.3 a
1084	*S. capitata*	4.5 c	20.2 f	2.2 a	9.6 c	413.0 b	0.1 a
1093	*S. capitata*	2.1 d	48.6 f	1.8 b	5.8 d	759.0 a	0.3 a
1179	*S. capitata*	5.3 c	45.6 f	1.3 c	11.0 b	408.8 b	0.1 a
1463	*S. guianensis*	9.4 a	617.0 b	2.2 a	14.3 a	500.8 a	0.3 a
1496	*S. scabra*	4.7 c	579.2 b	0.8 d	–	–	–
1498	*S. scabra*	6.6 b	116.4 f	1.3 c	–	–	–
1500	*S. scabra*	5.1 c	36.0 f	1.0 d	7.3 d	–	0.1 a
1511	*S. macrocephala*	7.5 b	467.2 c	1.7 b	12.1 b	1066.3 a	0.4 a
1517	*S. guianensis*	10.5 a	776.4 a	2.1 a	12.7 b	401.8 b	0.1 a
1540	*S. scabra*	6.8 b	116.3 f	1.1 d	7.9 c	–	0.3 a
1579	*S. guianensis*	8.8 a	797.6 a	2.1 a	11.5 b	180.0 b	0.1 a
1582	*S. macrocephala*	7.4 b	630.0 b	1.0 d	14.2 a	948.0 a	0.1 a
1588	*S. seabrana*	4.5 c	810.7 a	1.4 c	9.0 c	–	0.3 a
1589	*S. seabrana*	4.9 c	573.2 b	1.3 c	6.9 d	–	0.1 a
2252	*S. scabra*	5.9 b	121.6 f	1.0 d	–	–	–
2253	*S. scabra*	4.9 c	198.5 e	1.2 c	7.2 d	–	0.3 a
2254	*S. scabra*	4.9 c	92.3 f	2.2 a	10.6 b	–	0.9 a
2255	*S. scabra*	6.1 b	321.0 d	2.2 a	4.2 d	–	0.1 a
2256	*S. scabra*	3.7 c	686.5 a	1.6 b	4.5 d	–	0.3 a
2257	*S. scabra*	6.0 b	361.9 d	1.4 c	9.5 c	-	0.6 a
2258	*S. scabra*	6.4 b	92.6 f	1.8 b	6.8 d	–	0.1 a
2259	*S. scabra*	7.0 b	337.7 d	1.1 d	–	–	–
2260	*S. capitata* – *S. macrocephala*	4.3 c	187.4 e	1.9 b	12.8 b	1675.0 a	0.1 a

[1] Means followed by a different letter are not significantly different according to the Scott-Knott test (P≥0.05)

There was a range of anthracnose resistance among accessions of *S. guianensis, S. capitata* and *S. scabra* at Planaltina, but anthracnose was not a problem at Sete Lagoas and most accessions developed very low anthracnose severity. GC 1463 and GC 1517 were selected for further study at Planaltina and GC 1463, GC 1582 and GC 2260 at Sete Lagoas.

Eight bred *S. scabra* lines and two *S. seabrana* selections from Australia were also evaluated at these two sites. At Planaltina their DMY were in the range 3.7–6.4 t/ha, which was lower than many other accessions, but the seed yield of one *S. seabrana* line (810 kg/ha) was comparable to the best seed producers at this site. There was a similar trend in DMY of the Australian selections at Sete Lagoas, but seed production data were not available for this site.

Germplasm evaluation at the Planaltina site.

Teresina Overall, many accessions of *S. guianensis, S. capitata, S scabra* and *S. macrocephala* produced their highest DMY at Teresina, and seed yield was moderate to high (Table 10.4). *Stylosanthes capitata* GC 1082, *S. scabra* GC 1498, *S. macrocephala* GC 1511 and *S. guianensis* GC 1557 were among the best, with DMY in the range 15–17 t/ha. The seed production of some ten accessions reached above 300 kg/ha, although Mineirão produced only 0.4 kg/ha. The semi-arid conditions at this site meant that weather was not conducive to severe anthracnose development. Most accessions developed only a few minor lesions to allow any discrimination between accessions or species. The most promising accessions according to DMY and seed yield were GC 1082, GC 1173, GC 1469, GC 1498 and GC 2260.

Table 10.4 Dry matter, seed yield and anthracnose severity rating of accessions of *Stylosanthes* species evaluated at Teresina in Piau over a two-year period.

Accession No. (GC)	Species	Dry matter yield (t/ha)	Seed yield (kg/ha)	Anthracnose severity
348	*S. guianensis*	11.2 b[1]	17.5 c	0.1 a
984	*S. guianensis*	13.8 b	0.4 c	0.1 a
1082	*S. capitata*	16.1 a	613.2 a	0.1 a
1173	*S. capitata*	16.0 a	605.8 a	0.1 a
1466	*S. capitata*	16.2 a	613.7 a	0.1 a
1468	*S. guianensis*	13.5 b	121.8 c	0.1 a
1469	*S. capitata*	15.9 a	617.3 a	0.1 a
1490	*S. scabra*	13.7 b	336.8 b	0.1 a
1493	*S. scabra*	12.6 b	339.5 b	0.1 a
1498	*S. scabra*	17.0 a	—	0.1 a
1507	*S. macrocephala*	8.8 c	486.3 b	0.1 a
1508	*S. macrocephala*	10.8 c	400.0 b	0.1 a
1511	*S. macrocephala*	14.0 a	491.2 b	0.1 a
1536	*S. scabra*	8.6 c	119.5 c	0.1 a
1538	*S. scabra*	14.8 a	—	0.1 a
1557	*S. guianensis*	15.0 a	155.9 c	0.1 a
1582	*S. macrocephala*	13.5 b	648.5 a	0.1 a
1585	*S. guianensis*	13.3 b	144.8 c	0.1 a
1586	*S. guianensis*	13.2 b	20.8 c	0.1 a
1587	*S. macrocephala*	11.6 b	342.2 b	0.1 a
2260	*S. capitata- S. macrocephala*	12.8 b	608.9 a	0.1 a

[1]Means followed by a different letter are not significantly different according to the Scott-Knott test (P≥0.05)

Relative performance at the five sites

Although the performance of the five accessions varied across the five sites, *S. guianensis* cv. Mineirão produced the highest DMY at all sites and, except at Goiânia and Planaltina, *S. capitata – S. macrocephala* cv. Campo Grande also performed well (Figure 10.1). Overall, Sete Lagoas and Teresina had the highest DMY of most accessions. In contrast, seed production was very patchy across all sites and accessions and no single accession consistently produced high seed yield at all five sites (Figure 10.1). *Stylosanthes guianensis* accession 348 and Mineirão consistently produced very poor seed yield at all five sites. Based on these results, Sete Lagoas appears to be the best site for seed production of *S. macrocephala* and needs to be considered as a site for commercial seed production of the newly released cv. Campo Grande. The five accessions were very well separated according to their anthracnose resistance at Planaltina, which has long been recognised as a site for severe anthracnose development due to conducive weather and inoculum availability (Chakraborty et al 1997). Mineirão had the lowest severity of all five accessions at this site, indicating its superior anthracnose resistance.

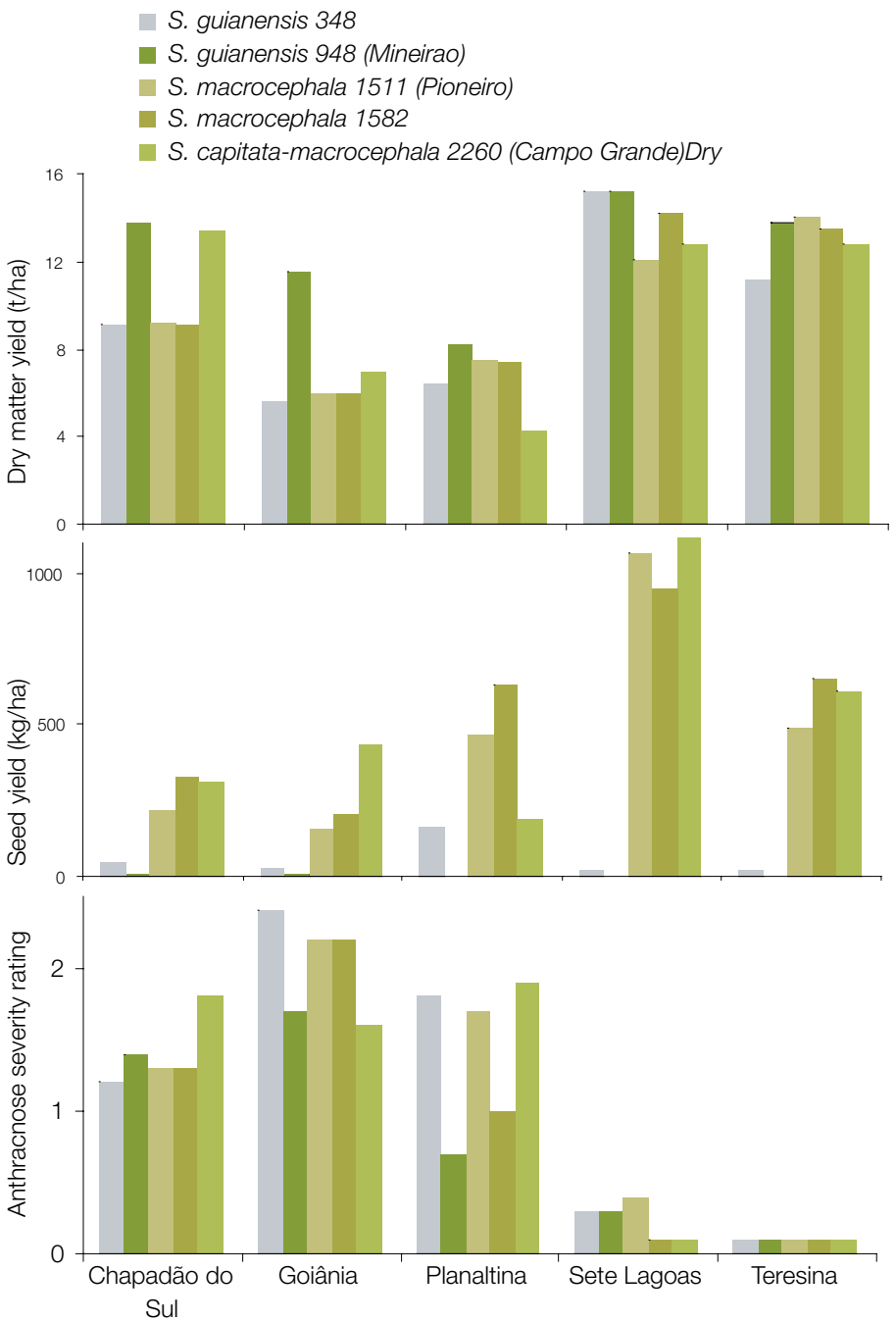

Figure 10.1 Dry matter, seed yield and anthracnose severity of five selected *Stylosanthes* spp. accessions at five different field sites in Brazil.

There was very little anthracnose at either Sete Lagoas or Teresina, and all five accessions had very high DMY at these two sites in the absence of a severe anthracnose challenge.

Commercial release of cultivars

These regional evaluations form the basis for the release of the *S. capitata* – *S. macrocephala* multiline cultivar 'Estilosantes Campo Grande' (accession GC 2260 in this paper). It was released commercially by the EMBRAPA Beef Cattle centre in 2000 for use in association with *Brachiaria decumbens* mainly on sandy soils of central Brazil (Embrapa Gado de Corte 2000). The variety is recommended for reclamation of mixed grass–legume pastures, where the legume is either sown with fertilisers in rows using zero tillage seeders, following a herbicide application to suppress grass growth; or established after burning the grass-dominated pasture. Seeds were initially multiplied in Chapadão do Sul and then later produced by a large consortium from Mato Grosso do Sul, Minas Gerais and São Paulo states, under EMBRAPA´s supervision. Seeds were commercially available to cattle farmers in 2001. Currently, an area >640 ha is under commercial seed production and the estimated area under grazing in Brazil is up to 100,000 ha. The strong interest in this variety among producers is driven by: a yield of 12–13 t of dry matter/ha/year, leading to an 18–20% increase in liveweight gain in mixed pastures with *Brachiaria decumbens* compared to the grass alone; good seed production (200–700 kg/ha) with further prospects of reducing seed cost from mechanical seed harvesting; over five years' persistence under grazing in well-managed mixed *B. decumbens* pastures due to acceptable levels of anthracnose resistance and high natural reseeding in the pasture; and adding nearly 180 kg N/ha through biological nitrogen fixation in three months compared to 95 kg by *S. guianensis* Mineirão and 88 kg by *S. macrocephala* Pioneiro.

Acknowledgments

The Australian Centre for International Agricultural Research and the Cooperative Research Centre for Tropical Plant Protection, among others, funded much of the research reported in this review. We thank the staff and management of Ribeirão Agropecuária in Chapadão do Sul for their enthusiasm, encouragement and assistance with the field trial at this site. We are grateful to Segenet Kelemu, Ademir Hugo Zimmer, Cesar Heraclides Behling Miranda, José Marques da Silva, José Raul Valério, Josias de Carvalho, Leônidas da Costa Schalcher Valle, Manuel Cláudio Motta Macedo, Roza Maria Schunke and many other individuals who have contributed invaluable ideas and offered technical and other assistance throughout the course of this work.

***Stylosanthes capitata*-*S. macrocephala* cultivar 'Estilosantes Campo Grande' in a commercial farm that is increasingly used for cattle in feedlots (photo: S. Chakraborty).**

References

Chakraborty S. 1990. Expression of quantitative resistance to *Colletotrichum gloeosporioides* in *Stylosanthes scabra* at different inoculum concentrations and day-night temperatures. Australian Journal of Agricultural Research 41, 89–100.

Chakraborty S., Fernandes C.D., Charchar M.J.d'A., Kelemu S. & Cameron D. 1997. Epidemiology of anthracnose at the centre of diversity. Tropical Grasslands 31, 408–416.

Embrapa Gado de Corte 2000. *Estilosantes* Campo Grande: estabelecimento, manejo e produção animal. Campo Grande. Embrapa Gado de Corte. Comunicado Técnico, 618 pp.

Miles, J.W. & Lascano, C.E. 1997. Status of *Stylosanthes* development in other countries. I. *Stylosanthes* development and utilization in South America. Tropical Grasslands 31, 454–459.

Scott, A.J. & Knott, M.A. 1974. Cluster analysis method for grouping means in the analysis of variance. Biometrics 30, 507–512.

Stace, H.M. & Edye, L.A. (eds.). The biology and agronomy of *Stylosanthes*. Academic Press: Sydney, Australia.

Verzignassi, J.R., Fernandes, C.D. & Miranda, C.H.B. 2002. *Estilosantes* Campo Grande**:** current situation and perspectives. *Stylosanthes* international, newsletter issue 7, September 2002

Weeds, P.L., Chakraborty, S., Fernandes, C.D., Charchar, M.J.d'A., Ramesh, C.R., Kexian, Y. & Kelemu, S. 2003. Genetic diversity in *Colletotrichum gloeosporioides* from *Stylosanthes* spp. at centres of origin and utilization. Phytopathology 93, 176–185.