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Status of *Stylosanthes* development in other countries. I. *Stylosanthes* development and utilisation in South America

J.W. MILES AND C.E. LASCANO
Centro Internacional de Agricultura Tropical, Cali, Colombia

Abstract

Research aimed at developing various *Stylosanthes* species as forage crops in South America began with the collection of Brazilian germplasm in the 1960s. These efforts have intensified greatly in the past 25 years with the participation of a number of local, national and international institutions. Eight cultivars have been released through the evaluation and selection of the resulting collections. However, the commercial success of these cultivars has ranged from limited to non-existent. Absence of commercial adoption is attributed to lack of interest in forage legume technology and to deficiencies in released cultivars. Poor persistence, commonly attributed to susceptibility to anthracnose, and problems with commercial seed production are perceived as major limitations of existing cultivars. Recent cultivar development projects in Brazil are based upon lessons learned from previous experience and may lead to expanded use of this valuable tropical legume genus.

Introduction

Concerted efforts at development of pasture technology for the vast natural savanna regions and humid forest margins of South America began in the 1960s. The physical and socio-economic environment is described by Spain and Ayarza (1992). Sánchez and Isbell (1979) directly compare and contrast the soils of tropical America with those in tropical Australia. In general, the soils of the neo-tropical savannas have excellent physical structure, but they are highly weathered and of low fertility. Acidity and aluminum toxicity are common constraints. Moisture stress in the neo-tropical savannas is not severe, with adequate to excessive rainfall for 6–8 months of the year. Biotic stresses, on the other hand, are critical.

Traditionally, livestock production has been based on extensive exploitation of native range with increasing use of introduced grasses (*e.g. Panicum maximum, Brachiaria* spp.) over the past quarter century.

Several *Stylosanthes* species have attributes which attracted attention in the early days of the search for tropical forage legumes. Perhaps the foremost consideration of forage researchers in tropical America was the ease of establishment and productivity of *Stylosanthes* spp. even under difficult edaphic conditions of extreme acidity, aluminum toxicity, and low fertility (Sánchez and Isbell 1979; Spain and Ayarza 1992). Success with *Stylosanthes* in Australia perhaps further biased pasture legume development work in tropical America towards the genus.

All of the *Stylosanthes* spp. used as forage are of tropical American origin. The fact that these *Stylosanthes* spp. are native has had a profound effect on their development as forage plants in tropical America as researchers have had to address a wide range of biotic constraints to productivity and persistence.

A voluminous literature documents attempts to develop *Stylosanthes* spp. into successful forage crops in tropical America. Reviews were published in 1984 (Thomas) and 1986 (Thomas and Grof). The anthracnose disease is a persistent subject of the literature on *Stylosanthes*.

We did not find a similar review published in the 10 years since Thomas and Grof's (1986) paper, perhaps in large part because of greater interest in other tropical forage legume genera. The impact of *Stylosanthes* spp. on tropical American livestock production is not proportional to the research literature generated over the past 30 years or so.

Correspondence: J.W. Miles, CIAT, Centro Internacional de Agricultura Tropical, Apartado Aéreo 6713, Cali, Colombia. e-mail: J.MILES@CGNET.COM

History

The first commercial use of *Stylosanthes* spp. in tropical America, in the early 1970s, was based upon the importation of seed of Australian cultivars, mostly to Brazil. While the cultivars introduced were all of native American species, the lines developed commercially in Australia were selected in the absence of anthracnose. These cultivars of *S. guianensis*, *S. humilis* and *S. scabra* are very susceptible to anthracnose and quickly succumbed upon re-introduction to tropical America, where the disease is endemic and the pathogen is highly diverse.

The quick demise of the highly susceptible Australian cultivars impressed upon forage researchers the overriding importance of the anthracnose disease to the success of *Stylosanthes* in tropical America. Yield losses can range up to 100% (Lenné 1986). Indeed, Trutmann (1994) states that "Anthracnose is the most serious biotic factor limiting the establishment and persistence of the legume [*Stylosanthes* spp.] in tropical American pastures." However, in spite of the unquestioned importance of anthracnose, early concepts were perhaps too simplistic in assuming that all that was needed in a successful *Stylosanthes* cultivar was resistance to anthracnose.

The genus *Stylosanthes* began to receive serious attention from tropical forage researchers in South America in the late 1960s and early 1970s. The initial focus was on assembling germplasm collections for evaluation and selection of superior lines (Edye and Grof 1983). A number of institutions participated in this effort. *Stylosanthes* breeding programs have been conducted on a much more limited scale (Miles and Grof 1997).

Stylosanthes germplasm collection was begun in Brazil by the IBEC Research Institute (IRI) in São Paulo State (Hymowitz 1971; Schultze-Kraft and Giacometti 1979; Schultze-Kraft *et al.* 1984). By the mid-1970s, the Centro Internacional de Agricultura Tropical (CIAT) and Genetic Resources Center (CENARGEN) of the Brazilian Corporation for Agricultural Research (EMBRAPA) assumed major roles in *Stylosanthes* germplasm acquisition. Brazilian state institutions, particularly EPAMIG in Minas Gerais (*e.g.* Costa and Ferreira 1984), the Instituto de Zootecnia in São Paulo (Rocha 1979), and EMGOPA in Goias have made significant contributions to *Stylosanthes* germplasm acquisition. The major existing *Stylosanthes* collections held in South America are at EMBRAPA/CENARGEN and at CIAT (Schultze-Kraft *et al.* 1984).

Since the early 1970s, evaluation of these germplasm collections and the selection of agronomically superior types have been actively pursued at EMBRAPA's Cerrados Agricultural Research Center (CPAC) and National Center for Beef Cattle Research (CNPGC) as well as by CIAT's Beef Production System Program (later Tropical Pastures Program, currently Tropical Forages Program).

National programs in other Latin American countries have participated actively in the evaluation of *Stylosanthes* germplasm, largely as members of a forage regional agronomic evaluation network (RIEPT, from its Spanish name) originally coordinated by CIAT (Pizarro 1988).

Screening of large sets of the newly collected germplasm confirmed the critical need for anthracnose resistance (Baldion *et al.* 1975). Perhaps more significantly, field evaluation identified several factors in addition to anthracnose which constrain the survival and persistence of *Stylosanthes* in the tropical American lowlands (Lenné and Calderón 1984; Lenné 1994). The effect of a stem-boring insect (*Caloptilia* sp.) on the survival of *Stylosanthes* stands was often difficult to separate from that of anthracnose (CIAT 1979). Symptoms of a widespread wilting/die-back disease, whose causal organism has been tentatively identified as *Neocosmospora vasinfecta* (Lenné 1990), were often attributed to *Colletotrichum*, the causal agent of anthracnose. The wilt disease may be a common cause of stand loss, both in pure stands such as seed-multiplication plots, and in associated pastures (Lenné 1994; Trutmann 1994; CIAT 1995). Seed-yield reductions of around 85% owing to a bud worm (*Stegasta bosquella*) have been documented (CIAT 1989). Beyond its effect on seed production, this insect certainly must have an impact on the buildup of soil seed reserves and consequently on persistence through seedling recruitment.

In spite of these limitations, productive, disease- and insect-resistant lines within known species like *S. guianensis* were identified. Useful *Stylosanthes* species essentially new to agriculture, such as *S. capitata* (Grof *et al.* 1979) and *S. macrocephala* (Schultze-Kraft *et al.* 1984), were identified. At least under experimental conditions, these promising materials were reasonably persistent and had a demonstrable, positive effect on animal productivity (Thomas and Grof 1986; Thomas *et al.* 1987; Ferguson 1992).

Cultivar releases

Eight cultivars have been released in South America. All were developed directly from natural germplasm accessions. Bogdan (1977) mentions Brazilian cultivars, Deodoro and Deodoro 2. Commercial seed of these cultivars was never produced (Thomas and Grof 1986).

S. guianensis IRI-1022 is mentioned in several publications as a "cultivar" (*e.g.* Thomas and Grof 1986). However, a formal release notice could not be found. It appears that this line was widely available in Brazil from the early 1970s or earlier, at least to forage researchers. IRI-1022 is a vigorous line of var. *vulgaris* (Thomas and Grof 1986). However, it is susceptible to anthracnose and never found significant use in commercial pasture development.

In 1983, 3 *Stylosanthes* species cultivars were formally named and released, 2 by EMBRAPA/CPAC for Brazil, and 1 by the former Instituto Colombiano Agropecuario (ICA) in Colombia. *S. macrocephala* cv. Pioneiro and *S. guianensis* var. *pauciflora* cv. Bandeirante, released by EMBRAPA/CPAC, were products of a collaborative research effort between EMBRAPA/CPAC and CIAT's Tropical Pastures Program (Sousa *et al.* 1983a; 1983b). Each was a single germplasm accession which had survived a rigorous evaluation process beginning with small-plot agronomic clipping trials through large-scale animal productivity experiments carried out over several years. In spite of extensive testing, neither cultivar ever achieved significant adoption. The failure of cv. Bandeirante was apparently largely owing to difficulties in seed production (Andrade and Thomas 1987) and consequent lack of seedling recruitment under grazing. *S. macrocephala* cv. Pioneiro, although anthracnose-resistant and a good seed producer, was low yielding. While it was well adapted to west-central Brazil, it did not perform well in regions of higher rainfall owing to foliar disease problems (B. Grof, personal communication).

Colombia's national agricultural research institute, ICA, released *S. capitata* cv. Capica in 1983 (Instituto Colombiano Agropecuario 1983). Capica was released as a blend of 5 *S. capitata* accessions which had been tested separately and found to be productive and resistant to anthracnose in pure-stand agronomic trials in the Colombian llanos. Release of a mixture rather than a single accession was supposed to insure stability of disease resistance. Capica achieved some adoption and small quantities of commercial seed were produced and commercialised during the late 1980s (Ferguson *et al.* 1989). However, most of the pastures planted to Capica were part of official promotion programs. Subsequent spontaneous adoption has been essentially nil. Eleven years after the release of Capica, Bernal (1994) stated that "its use has still not become generalised". Persistence of cv. Capica has been disappointing, but it is not clear whether this is owing to disease (anthracnose or *Rhizoctonia* foliar blight) or to other causes. With the demise of adult plants within 2 years of pasture establishment, productivity of seedlings of subsequent generations is very low, apparently because of their inability to compete with the established grass (Valencia 1983; Rojas and Lascano 1991).

In 1985, an accession of *S. guianensis* var. *vulgaris*, CIAT 184, was released as cv. Pucallpa by IVITA (Instituto Veterinario de Investigaciones Tropicales y de Altura) and INIPA (Instituto Nacional de Investigaciones y Promoción Agropecuaria) (Amézquita *et al.* 1991) for use in the humid tropics of eastern Peru. Although CIAT 184 is known to be susceptible to anthracnose, it performs well in the humid tropics where disease severity is less than in savanna ecosystems, purportedly owing to the presence on *Stylosanthes* leaf surfaces of bacteria antagonistic to the anthracnose pathogen (Lenné and Brown 1991). However, persistence in grazed pastures, even in the humid tropics where anthracnose is not a concern, has been poor. Pucallpa is still planted to some extent both in Peru and in Colombia, but this is almost exclusively by research and/or development organisations. This same accession is grown on 35 000 ha in southern China, mainly for leaf meal production for poultry and swine feed concentrate (Liu *et al.* 1995).

A *S. guianensis* var. *vulgaris* accession (BRA-017817 = CIAT 2950) was released as cv. Mineirão by EMBRAPA/CPAC and EMBRAPA/CNPGC in 1993. This accession was collected in

1979, and has been under testing since 1980. It is a vigorous, productive line and is reported to be persistent and free from disease or insect pests in grass-legume associated pastures. However, in spite of relatively limited testing, deficiencies are already becoming apparent. The cultivar is late flowering and seed yield is only moderate (F.D. de Sousa, personal communication). A wilt disease has caused stand losses in small-plot experiments and is a cause for concern.

Commercial seed crops in 1994 and 1995 were disappointing due to unfavourable weather. Interest among ranchers has been keen with the very limited quantities of seed available in 1995 being marketed in 200 gm packets at US$55 (equivalent to $275 per kg!). It is expected that approximately 20 t of commercial seed will be produced in 1996 (F.D. de Sousa, personal communication).

Economic importance

In the absence of reliable and comprehensive data on commercial seed sales, it is difficult to determine the economic importance of *Stylosanthes* cultivars in South America. It appears, however, that the impact of *Stylosanthes* on commercial livestock production has not been great. While many hectares of *Stylosanthes*-grass pastures have been planted, most of these have been part of official promotion campaigns. Almost without exception, the legume component of these pastures has not maintained productivity beyond 2 years. Spontaneous adoption of *Stylosanthes* cultivars to date has been very limited.

Production systems

The use of *Stylosanthes* in South America under experimental conditions in diverse production systems has been recently reviewed (Miles *et al.* 1994). These systems include supplementation of native savanna range, either in protein banks or oversown into native pasture, and as an associate in improved grass pastures. Use of *Stylosanthes* in South America as a cover crop or green manure is limited to small areas in the Amazonian basin of Peru. Under experimental conditions, and at least to a limited extent on farms, *Stylosanthes* spp. find use in systems where pasture species are sown simultaneously with a crop — generally rice (Thomas *et al.* 1992; Zeigler *et al.* 1992). The adaptation of *Stylosanthes* spp. to these systems is likely related to ease of establishment from seed at relatively low seeding rates compared with other well adapted legumes such as *Arachis pintoi* or *Centrosema* spp.

Current constraints to production

Stylosanthes spp. have many attributes which make them logical forage legume choices for infertile soils in lowland tropical environments. Their impact on animal performance has been amply documented both under experimental station conditions and on farm. Adoption in South America, however, has not met expectations.

While anthracnose certainly posed an absolute constraint on the use of the Australian *S. guianensis* cultivars and early germplasm selections such as IRI-1022, CIAT 136, and CIAT 184 in the tropical American savannas, more recent selections and bred lines have good resistance to anthracnose. Their lack of persistence appears to be related to other biotic pressures or to agronomic deficiencies such as poor seed production or inappropriate plant type to tolerate grazing. As *Stylosanthes* spp. form persistent and productive associations in Australia (where they are exotics), it seems most likely that failure to persist in tropical America is owing to biotic constraints whose importance and even identity have yet to be determined clearly. Differences in target environment — more humid tropics in South America as compared with subhumid to semi-arid regions of Australia — with the consequent differences in the species of *Stylosanthes* used, may further explain differences in persistence of *Stylosanthes* in pastures between the 2 continents.

A major constraint seems to be a lack of appreciation among South American graziers of the benefits of forage legumes. This has been reinforced by the spectacular failure of early introductions of Australian commercial *Stylosanthes* cultivars and several real deficiencies in the later cultivars.

Future prospects for the industry

While the history of commercial use of *Stylosanthes* in South America is more one of failures than of successes, new developments in *Stylosanthes* germplasm selection and breeding may alter this assessment radically. A continuing search for new *Stylosanthes* genotypes appears warranted in light of the many very positive attributes of the different species for the difficult edaphic conditions of low fertility and low pH which are so prevalent in tropical America. Initial interest in cv. Mineirâo has been remarkably strong. The future of *Stylosanthes* will depend upon the development of persistent, productive cultivars, or on finding niches, such as fallow improvement and short-term crop-pasture rotations, where the positive attributes of *Stylosanthes* fill a real need of producers. Given the dearth of forage legume options for tropical America, *Stylosanthes* should continue to have some role to play.

Conclusions and future research priorities

Considerable effort has been dedicated to *Stylosanthes* development to overcome perceived deficiencies in existing germplasm. A large portion of this effort has gone to overcoming the limitation of anthracnose. However, in spite of this work which has lead to the release of 8 cultivars in South America, adoption remains meagre to date.

Organised research effort on the genus has been largely dormant over the past decade or so as other promising legume genera such as *Centrosema* and, more recently, *Arachis* have attracted attention of forage workers and research institutions. It is difficult to recommend a renewal of major research on germplasm development in *Stylosanthes* in South America, except perhaps in Brazil, particularly if this would imply decreasing investment in genera such as *Arachis*, which show much greater potential. In addition to germplasm, other areas of *Stylosanthes* research may prove productive, at least in the short term.

We need greater attention to identifying the real constraints to adoption. These studies ought to lead to clearer definition of objectives for future germplasm development efforts, including plant breeding.

Another possibly profitable area of research is in the identification of production niches where *Stylosanthes* can fill a real need of producers. There is good evidence from experience of researchers and plantation producers in Peru that *S. guianensis* has a role in fallow improvement and as a cover crop.

Stylosanthes spp. have many positive attributes. Of particular relevance for tropical America is adaptation to difficult edaphic conditions. However, use of *Stylosanthes* in grazed pastures has met with only limited success in tropical America, where all commercial species are native and subject to a wide range of endemic pests and pathogens. The value of *Stylosanthes* in tropical American agriculture will depend on either advances in *Stylosanthes* germplasm development, or on identifying production niches such as cover crop or short-term pasture-crop rotations, where existing *Stylosanthes* selections perform adequately.

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