NOVEL GRASSES AND LEGUMES GERMPLAM: ADVANCES AND PERSPECTIVES FOR TROPICAL ZONES

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Abstract

It has been the aim, in the present article, to bring together as much as possible scientific evidence and experience in new available germplasm for tropical zones.

The economic importance of the *Brachiaria*, *Paspalum* and *Pennisetum* grasses is well established. New germplasm has become available since 1980. This paper reviews evaluations of *Brachiaria* accessions in humid lowlands and savannas of tropical America. The selection criteria need to be revised. Also, it is necessary to expose the new material as early as possible to farmers in order to select new germplasm with high chances of adoption.

Within the genus *Paspalum*, *P. dilatatum* is possibly the most widespread. It has made a considerable contribution in the past, providing some of the best early season feed. In this paper, new data on *P. atratum* will be presented.

Since 1985 a great effort had been made on *Pennisetum*. New cultivars are available.

The main legumes genera to be discussed are *Arachis* spp., *Calopogonium mucunoides*, *Centrosema* spp., *Desmodium* spp., *Glycine* spp., *Macroptilium* spp., *Neonotonia wightii* and *Stylosanthes* spp.

On *Arachis*, a historical perspective of the collection and evaluation in South America as well as a summary of the regional experience on Central America, Australia and United States would be presented. Some preliminary data on the drought tolerance and animal performance is discussed. For more than one hundred accessions evaluated through 1992 until 1997, twenty accessions of *A. pintoi* are outstanding and deserve further regional evaluation.

Calopogonium mucunoides, although not widely used (like any other pasture legume today in tropical America), is the most popular forage legume amongst farmers in Brazil. A collection of 215 accessions was evaluated in the Cerrado ecosystem. A negative relationship between the degree of pilosity and *in vitro* dry matter digestibility was found. Within the seventeen accessions selected, two of them, CIAT 822 and 20709 were outstanding for their leaf retention during the dry season.

Also, *Macroptilium*, *Neonotonia* and *Stylosanthes*, deserve special mention because attempts to develop cultivars from them have been determined and sustained.

Finally, there is also an opportunity to search for new alternatives within the new available collection of *N. wightii*. Three new accessions are promising.

Keywords: Topical forage grasses and legumes, new germplasm, agronomic evaluation

Introduction

The reason for the greater attention paid to grassland is not far to seek. Agricultural science in the nineteenth and nearly the end on the twentieth centuries had tended, in all countries to neglect tropical grasses and legumes as a subject for experimental and research study. The technicians and teachers of that period concentrated their energies on the more normal crops of an arable agriculture. The arable concept seemed to fit in well with the rapid expansions on arable farming in Europe and the Americas.

In tropical America, grasslands studies, seem at the moment, to be as on the crest of a wave: the intensified treatment, which they now receive, is widespread.

Grass-legume agronomy studies must fundamentally have an ecological approach. We must take into account the environment under which their leys are growing, and that environment embraces soil, animal and climate.

The grass-legume sward is obviously of great economic significance to the world over.

It has been the aim, in the present article, to bring together as much as possible of the available new accessions of grasses and legumes in the tropical world.

1 - Brachiaria **species**

Agronomic performance across ecosystems

Tropical America savannas – Cerrado ecosystem

The savanna ecosystem is varied and extensive, covering about 250 million hectares in South America. The most relevant sub ecosystems are the Cerrados and the Llanos. It is characterized by a well-defined dry season and acid-low fertility soils. A few *Brachiaria* species have shown wide adaptation and are extensively used. These were introduced from Africa in the 1950s and 1960s, and spread, at first, vegetatively and then by seed, covering today an estimated 100 million hectares.

New germplasm has become available since 1980, when colleting trips were undertaken in East Africa, and intensive evaluation programs were developed throughout the region.

Grasses of the *Brachiaria* genus are extremely important forages for cattle production. In Brazil, carrying capacity was increased from 0.4 head ha^{-1} on native savanna pasture in 1950, to 0.7 head ha^{-1} in 1990, a 73% increase due mainly to the use of improved pastures, especially *Brachiaria*.

The choice of cultivars for improved pastures has been extremely limited but the few commercial cultivars of *Brachiaria* have shown good adaptation and production. These reproduce by apomixes resulting in extensive areas planted to a single genotype. Consequently, problems such as the massive attack of spittlebugs (Homoptera:Cercopidae) have arisen.

Despite important constraints, *Brachiaria* cultivars make an impressive contribution to animal production and certainly continue to do so, especially with the release of new cultivars.

Development of new cultivars depend on germplasm diversity, which was virtually nonexistent in America until a large collecting effort was undertaken by CIAT and ILRI under the auspicious of the International Board for plant genetic Resources - IPGRI and collaborations of national institutions in six East African countries (Keller-Grein *et al*., 1996).

In 1987, EMBRAPA introduced a large *Brachiaria* germplasm collection from CIAT, and agronomic evaluation began in both the Cerrados Agricultural Research Center (EMBRAPA-CERRADOS) and the Beef Cattle Agricultural Research Center (EMBRAPA-CNPGC), respectively.

More than 340 accessions of 12 *Brachiaria* species were evaluated in small plots from 1987 to 1992 at EMBRAPA-Cerrados.

Of the collection, 52% comprises accessions of *B. brizantha,* by far the most variable and promising species represented. Dry matter yields (DMY) for the best-adapted accessions, 85% of which were *B. brizantha*, ranged from 16-to 21 t ha^{-1} in the rainy season. Dry season DMY were lower, although several accessions performed better than the commercial cultivars. Seed yields showed a wide range of variability among accessions (4 to 155 kg ha^{-1}).

Twenty-four accessions were selected from the previous study (Grof, 1989a). Several accessions out yielded cv. Marandu, representing distinct growth forms with specific agronomic characteristics. The selected ones were: CIAT 26110, 16315, 16306 and 16488 (BRA-004308,

-003441, -003361 and -004391, respectively).

At EMBRAPA-CNPGC, 320 accessions were evaluated. From these, eleven superior accessions of *B. brizantha,* one of *B. jubata*, and two of *B. humidicola* were selected. *B. brizantha* presented the widest diversity and the highest production. The selected accessions have a high leaf-to-stem ratio, fast regrowth, and a good seasonal distribution of total yield.

From a new group of 200 accessions introduced from CIAT in 1994 and the results obtained in the Cerrados Center, a common group was selected for regional agronomic and grazing trials (BRA-002801, -002844, -003000, -003204, -003247, -003361, -003387, -003395, -003441, -003450, -003484, -003719, -003824, 003891, -003948, 004308, -004391, -005011, -005118).

Tropical America savannas – Savanna ecosystem

The list of materials evaluated includes 376 accessions of twelve *Brachiaria* species, of which *B. brizantha* comprised 52% and *B. decumbens*, *B. humidicola* and *B. ruziziensis* together another 35%.

The first field evaluation emphasized the identification of spittlebug-resistant *Brachiaria* accessions. Five *B. brizantha* accessions CIAT 6690, 16126, 16388, 16827 and 16829 and the control cv. Marandu (CIAT 6297), were selected for a grazing experiment, using *Centrosema acutifolium* as the associated legume. Later (1991–1994), a second set of 186 accessions from ten different species of *Brachiaria* was evaluated at Carimagua, Colombia.

In another trial, including more than fifty *B. humidicola* accessions were evaluated to identify environmentally adapted accessions with better nutritive value and seed production than the commercial cv. Humidicola – CIAT 679. The variation among accessions was very great.

After fourteen years of evaluation in the Tropical Pasture Program of CIAT a list of twenty accessions were selected for regional evaluation through Colombia (CIAT 606, 6133, 6387,16113, 16121, 16212, 16315, 16322, 16327, 16467, 16488, 16497, 26110, 26124, 26180, 26318, 26556, 26562, 36060 and 36061).

Small-plot evaluation in mixtures under grazing

A series of small-plot grazing trials, including various *Brachiaria* species and accessions, has been conducted at the Carimagua Research Station, to study the compatibility of adapted grasses and legumes and their persistence in mixtures.

Brachiaria and Desmodium associations.

An acceptable percentage of legumes were maintained in a grazing trial of two *B. brizantha* accessions (CIAT 664 and 665, recently reclassified as *B. decumbens*), each associated with *Desmodium incanum*. In an association with *B. dictyoneura* CIAT 6133, however the same legume was the weaker competitor in the sward.

Satisfactory legume contents were recorded in rotational grazing trial for *D. incanum* CIAT 13032 in association with *B. brizantha* CIAT 664 and 6370, *and B. humidicola* CIAT 6369 (Grof 1985a).

B. decumbens cv. Basilisk and *A. gayanus* CIAT 621 (now as cv. Carimagua 1) were each evaluated in association with *D. ovalifolium* CIAT 350 (now cv Itabela). *B. decumbens* formed a more stable association with this aggressive legume than did *A. gayanus*, which was dominated by the legume. In another trial, total annual DM yields were highest for the association of *D. ovalifolium* CIAT 350 with *B. humidicola* CIAT 679, followed by the association with *B. decumbens* cv. Basilisk, and lowest for the association containing *A. gayanus*. Growth rates and annual yields of the legume did not differ significantly in association with *B. decumbens* cv Basilisk and *B. humidicola* (Grof 1982 and 1984).

Cultivar Humidicola was the highest and cv. Llanero the lowest yielding grass of five accessions of *Brachiaria (B. brizantha* CIAT 664, 665, and 6298, *B. dictyoneura* cv. Llanero, and *B. humidicola* cv. Humidicola) that were evaluated in association with eight accessions of *D. ovalifolium*. These results were related to selective grazing of cv. Llanero, which is the more palatable grass, but the less tolerant of spittlebug attack.

Brachiaria and Arachis pintoi associations.

Comparing different species and accessions of *Brachiaria*, the highest growth rate and total annual DM yield of *A. pintoi* CIAT 17434 (cv. Maní Forrajero Perenne) were recorded in association with cv Llanero (Grof 1985b).

Legume content in associations with *B. brizantha* CIAT 664, *B. dictyoneura* cv. Llanero, *B. humidicola* cv. Humidicola, and *B. ruziziensis* CIAT 6291 increased with time, to as much as 36% and 44% in cv. Llanero and cv. Humidicola pastures, respectively. The highest legume contents occurred in the associations with *B. brizantha* (72%) and *B. ruziziensis* (70%) because spittlebug attack permitted the legume to colonize the areas left by the grass.

In a subsequent trial, with other *B. humidicola* accessions (CIAT 679, 6369, 6705, and 6709) and *B. brizantha* cv. Marandu, the proportion of *A. pintoi* increased overtime, leading to legume dominance in the associations with CIAT 6369 and 6709 at the end of the experiment. The other associations were more balanced. Grazing pressure had no effect on the performance of these associations.

Brachiaria and Centrosema acutifolium associations.

Five selected accessions of *B. brizantha* (CIAT 6690, 16126, 16338,16827, and 16829) and *B. brizantha* cv. Marandu were tested in association with *C. acutifolium* as common legume. During two years of grazing CIAT 16827 and 16829 was the most productive and persistent, performing similarly to cv. Marandu, whereas grass productivity and content markedly decreased in the other associations, leading to suspension of grazing.

Regional experience with *Brachiaria* in the tropical America humid lowlands

In the American humid lowlands, *Brachiaria* is almost exclusively planted as a monocrop. As a monocrop *B. decumbens* has two drawbacks. One is the increase in photosensitetization and the other one, is the higher susceptibility to spittlebugs when compared with grass-legume mixtures.

B. decumbens compatibility with legumes is reported with *Desmodium ovalifolium* cv. Itabela; *Centrosema macrocarpum* CIAT 5713; *Pueraria phaseoloides* and *A. pintoi* cv. Amarillo (Argel and Keller-Grein, 1996).

B. humidicola cv. Humidicola is a stoloniferous grass that tolerates waterlogged soils although it can withstand dry periods. Due to its stoloniferous growth habit, is reputedly difficult to associate with tropical forage legumes. However, productivity and stable associations have been reported with *D. ovalifolium* cv. Itabela in Brazil, Colombia and Perú and with *A. pintoi* cv. Amarillo. Other less persistent associations have been reported with *C. macrocarpum* CIAT 5062, *C. brasilianum* CIAT 5234, *C. mucunoides* and *P. phaseoloides* (Argel and Keller-Grein, 1996).

B. dictyoneura cv. Llanero is regarded as a medium-quality grass that tolerates heavy grazing. It is not highly competitive during establishment, which favor forage legumes. Successful and very productive associations have been reported with *C. acutifolium*, *C. macrocarpum*, *Stylosanthes guianenssis*, *A. pintoi*, *P. phaseoloides* and *D. ovalifolium*. However showed poor ability to compete for light when intercropped with either *Vigna unguiculata* or *Glycine max* (Argel and Keller-Grein, 1996).

The final commercial cultivar used in the region, *B. brizantha* cvs. La Libertad and Marandu have been available to farmers for the past fifteen years. Cultivar La Libertad adapts to less fertile soils than cv. Marandu. On the other hand, cv. Marandu associates well with *D. ovalifolium*, *C. brasilianun*, *C. macrocarpum*, *C. mucunoides*, *P. phaseoloides* and *A. pintoi*. This grass apparently competes efficiently with companion crops. Pérez *et al*. (1993) reported that intercropped with soybean, it yielded 66% of the yield in monoculture, suggesting shade tolerance and efficient use of light and soil nutrients.

A number of grazing experiments have been recorded. Ibrahim (1994) found high DMY, particularly at the low stoking rates of 1.75 animal units ha^{-1}, when associated with *A. pintoi*, *C. macrocarpum* CIAT 5713, or *S. guianensis* CIAT 184. *Arachis pintoi* cv. Amarillo persited over

3 years under grazing, especially at the high stoking rate (3 head ha^{-1}). After four years of grazing, the association yielded an annual 990 kg ha^{-1} of beef; 300 kg^{-1} more than did the grass alone.

Regional experience with *Brachiaria* in Australia and the South Pacific

In pastures where N is deficient, *B. decumbens* and *B. humidicola* can coexist with adapted legumes. In Australia, *C. mucunoides* combines well with *B. decumbens* and *D. heterophyllum* as has *Vigna parkei* cv. Shaws.

The most promising legume, however, is *A. pintoi* cv. Amarillo.

In the South Pacific, small holders combine *B. decumbens* or *B. humidicola* with *D. heterophyllum*, *Vigna hosei*, *C. pubescens*, *Aeschynomene americana* cv. Glenn, *A. pintoi* and *A. repens*. In Fiji, *A. pintoi* formed stable mixtures with both grasses. Similarly *B. decumbens* combined successfully with *A. glabrata* in Indonesia (Stür *et al*.,1996)

Regional evaluation: RIEPT survey

In addition to the multilocational testing of *Brachiaria* species in the South America savanna ecosystem, a survey on *Brachiaria* spp. was carried out within the International Tropical Pastures Evaluation Network (RIEPT, its Spanish acronym). The objective was to get from local agronomists the experience of local farmers and researchers in the principal genera/species of grasses used in the region as well as to know about problems related to establishment, aggressiveness and to know their comments and recommendations for future research.

In relation to failures at establishment the data collected appointed *Andropogon gayanus* as the "outstanding" grass in that sense. *A. gayanus* failure is 50% of the cases reported while *Brachiaria* spp. only fails in 12% of the cases. The main factor for this behavior is the quality of seed that comprises for more than 70% of the problems at establishment.

Within the grasses evaluated *B. humidicola*, *B. dictyoneura* and *B. decumbens* presented the highest degree of aggressiveness. They are on top of the ranking followed by *B. brizantha* with the lower index among the genus.

Another important data collected was the different capacity for seed production among localities. In nearly all the cases *A. gayanus* produced good seed. The genus *Brachiaria* has a variable degree from 30% for *B. ruziziensis* up to 80% of success for *B. decumbens*.

The ranking of the selected grasses among the *Brachiaria* genus, *B. decumbens* was the leader.

The selection criteria currently used need to be revised. The fact that farmers continue to show preference for *B. decumbens* cv. Basilisk despite its high susceptibility to spittlebugs indicates that they value its forage agronomic attributes.

Exposing new materials as early as possible to farmers will contribute to the selection of new *Brachiaria* germplasm with high chances of adoption. In the long term, grass monocultures, without associated legumes, constrain productivity (Armstrong *et al*., 1999a and b).

2 – *Paspalum*

Agronomic characteristics and potential use in tropical America

Paspalum is the predominant American genus. It contains approximately 400 species, most of which are good for grazing. Several accessions are adapted to wet sites with very low incidence of spittlebug. This last characteristic being the major limiting factor of exotic species such as *B. decumbens* and *B. humidicola.*

In the Cerrado, a set of 42 native accessions was evaluated (Valls *et al*., 1993). The DMY in the first ten months after establishment ranged from 350 to 4500 kg ha^{-1}. The first regrowth (47 days from the start of the rainy season) ranged from 400 to 4000 kg ha^{-1}. The mean DMY accumulated during two rainy seasons ranged from 0.5 to 21 t ha^{-1}. In a seasonally flooded land in the Cerrado ecosystem total annual DMY ranged from 2.0 to 29 t ha^{-1} (Grof *et al*., 1989b). Mean DMY accumulated during the dry season (May-October) for the 29 surviving accessions ranged from 20 to 1500 kg ha^{-1}. Only two accessions BRA -012874 and BRA -009610 reached more than 1 t DM ha^{-1} with 30 and 34% of green leaf-stem material retention, respectively. The green leaf content at the end of the second dry season (282mm accumulated rainfall) ranged from 0 up to 63%. The highest leaf retention during the dry season was 63% for *Paspalum* spp. BRA -010154.

Seed yields were variable (0 - 1.500 kg ha^{-1} of pure seed) and related to the flowering cycle. The early flowering type reached a pure seed yield of 113 $\pm$ 115 kg ha^{-1}, the intermediate group 420 $\pm$ 568 kg ha^{-1} and the late flowering type 844 $\pm$ 588 kg ha^{-1}. Although pure seed yield were variable in the evaluated collection they were higher than the ones reported by Grof *et al*., (1989c) for *Brachiaria* spp. (4 to 155 kg ha^{-1}) at the same experimental site and for Cameron and Humphreys (1976) for the *P. plicatulum* cv. Rodd's Bay (61 to 360 pure seed yield with 0 to 400 kg N ha^{-1}, respectively).

The work conducted supports the evidence that the *Paspalum* accessions under evaluation presents a high and relatively constant seed yield and better synchronization of flowering than many tropical pastures grasses evaluated in the area. Similar consideration has been quoted by Stür and Humphreys (1987) for *P. plicatulum* cv. Rodds Bay vs. *B.decumbens* cv. Basilisk.

After these preliminary and encouraging results a new set of 84 native *Paspalum* accessions, plus the most important commercial cultivars of other genera and species were evaluated. A cluster analysis procedure was applied. Three main groups were obtained. The cluster with the highest yield included the commercial cultivars of *A.gayanus* cv. Planaltina, *B. brizantha* cv. Marandu and *P. maximum* cv. Vencedor and four of the 84 *Paspalum* accessions under test. The mean CP was 9.4 $\pm$ 1.49% and the mean IVDMD 46 $\pm$ 7.24% with thirty-four units of difference between accessions (30% for BRA -012921 to 64% for BRA -003824, -014851, -018996). Exotic African grasses in the genus *Brachiaria* had similar values.

Another important characteristic under evaluation in the new *Paspalum* accessions is the yield response in some of them to the increase in fertility. The data collected showed a mean average increase of 250% in DMY, when the fertilizer applied was increased from the pasture establishment level to the crop establishment doses.

Some of the outstanding attributes mentioned before such as good seed yield, similar nutritive value to the exotic commercial grasses, the facility for eradication, the highly resistance to the spittlebug and the high DMY obtained in seasonally flooded situations call for more attention and evaluation of this American genus in the Cerrado and in the Humid Tropics of Tropical America. Recent publications analyze and report agronomic data and appoint other potential use (Batista and Godoy, 2000)

Fortunately, in other parts of the world, some species, specially *P. atratum* is receiving attention. Brazilian germplasm has been released in Argentina, Australia, Asia and United States.

Paspalum atratum

Agronomic performance in South America

In Corrientes-Argentina, *P. atratum* cv. Cambá-FCA exhibits conditions of adaptability for poor and well-drained soils (Quarín and Urbani 1993).

In Rondonia State-Brazil, Costa *et al*. (1999a) evaluated the agronomic performance of *P. atratum* BRA-009610. DMY ranged from 1.4 to 6.4 t DM ha^{-1}, with 6 to 12% CP.

The same authors evaluated the behavior and agronomic potential from different tropical grasses as a ground cover in well-established rubber plantations. The grasses *B. brizantha* cv. Marandu, *B. humidicola* and *P. atratum* BRA-009610 were outstanding for yield, stability and ground cover (Costa *et al*., 1999b).

In relation to agronomic trials there is only one experiment related with date of establishment and seeding rate, emphasizing the need of over four kg ha^{-1} when weeds were present (Carvalho *et al*., 1997). The same authors suggested that establishment in the Cerrado need to be done between October and December. Later, poor establishment was obtained.

The effect of the animal on the pasture and their reverse consequence was evaluated in *P. atratum* BRA-009610 (EMBRAPA-Cerrados named recently as cv. Pojuca) associated with *A. pintoi* BRA-031143 during four years (Table 1; Barcellos *et al*., 1997). Rates of daily weight gain obtained were compatible to those found in *A. pintoi* cv. Amarillo in association with *Brachiaria* spp. High annual yield per hectare in tropical ecosystems is reached only when forage species have high yield potential and when nitrogen is applied. The available data on beef cattle production with *Paspalum* species is presented in Table 2.

(Table 1. Animal live-weight and milk production in *A.pintoi*-grass based pastures)

(Table 2. *Paspalum*: Beef cattle production from grazing trials)

Agronomic performance in the United States

The grass *P. atratum* cv. IRFL 658 was evaluated under grazing in Florida State University-USA. The IVDMD ranged from 50 to 68%, mean CP 11% and a mean seed yield of 200 kg ha^{-1}.

In Florida, Kretshmer *et al*. (1994) reported a live weight gain of 0.710 kg a^{-1} d^{-1} and 240 kg ha^{-1} in 100 grazing days. The same authors results its competitively against *P. notatum* and *Cynodon dactylon.*

In a recent publication Kalmbacher *et al*. (1997) quoted that Suerte Atra *Paspalum* is a cultivar owned by the University of Florida, emphasizing that this grass has a unique combination of rapid establishment from seed and adaptation to wet, acid and infertile soils. Also, said that is excellent for growing cattle and pest and disease resistant. Data is reported on Table 2.

Agronomic performance in Australia

This grass is yet to prove in Queensland. Bruce Cook (personal communication) said that it has many useful qualities including good palatability, late flowering and reasonable seed set, although it isn't very drought hardy nor frost tolerant.

It is really competing for a place with *Setaria* spp. since both are adapted to moist, occasionally waterlogged conditions. *P. atratum* has the advantage over *Setaria* in remaining apparently less fibrous due largely to the restricted flowering season.

In Australia *P. atratum* was released as cv. Hi-Gane, which is the same variety as cv. Suerte in the USA. At this moment probably no more than 50 ha^{-1} are planted.

Agronomic performance in Indonesia, Philippines and Thailand

Although recently introduced to this part of the world, the agronomic evaluation, multiplication and adoption are very dynamic.

During 1999, two tones of pure seed were produced for regional evaluation (Werner Stür, personal communication). On the other hand, the exposure of the new germplam on farmers field have resulted in new alternative uses. *P. atratatum* BRA-009610 cv. Ubon, is at this moment in more than 500 farms. Recent reports mentioned that Ubon *Paspalum* is selling like hot cakes and it is quoted to be the best grass for former rice paddy fields. Local farmers call *P. atratum* cv. Ubon the grass for wealth (Bela Grof and Michael Hare, personal communication).

3 - *Pennisetum purpureum*

Main agronomic features and potential use

Elephant grass, *P. purpureum* (L.) Schumach., also known as Napier grass, is native to Africa. It has been introduced into nearly all tropical and subtropical regions from sea level to altitudes of 2000 masl where rainfall exceeds 1000 mm per year. Elephant grass grows best when temperatures are hot, yet it tolerates cool temperatures down to 10ºC before growth ceases. Frost will kill top growth but leave roots unharmed. Periods of drought restrict growth; however, with the onset of rains, plants resume rapid growth. The grass will not tolerate water logging or flooded conditions, and it is not adapted to wet soils where *P. atratum* cv. Pojuca thrives. Is a robust perennial bunch-grass consisting of many cane like stems up to 3-4 cm thickness that grow to heights of 2-6 m.

Elephant grass is very responsive to fertilizer and is one of the fastest-growing, highest-yielding grasses. However few national and international centers are interested in the agronomic or in a breeding project. Fortunately, since 1985 a great effort had been taking into account by EMBRAPA-CNPGL (National Milk Research Center) and Florida University. Since them, several cultivars and fifty accessions have been tested in at network approach in twelve Brazilian States. From the above-mentioned work *P. purpureum* cv. Pioneiro was released. The DMY of cv. Pioneiro ranged from 35-to45 t DM ha^{-1} $year^{-1}$ with good adaptation to the SE and central West areas. In a very short period of time new cultivars of this important grass would be available for tropical America (Antonio Vander Pereira, personal communication).

Arachis species

Agronomic performance of forage *Arachis* through ecosystems

Agronomic evaluation on wild communities

Three wild communities have been monitored regularly in nature. The first one, located in the State of Goias-Brazil (15º 26' S; 47º 21' W and 700 masl) is a natural sward association of *A. pintoi* BRA/CIAT -015121/18748 and *H. rufa*. The data collected confirm the high yield (11 t DMY ha^{-1} year), the stability of the legume through time as the botanical composition confirm (13%), a high soil seed-bank reserve of 330 kg ha^{-1}, a very high nutritive value (70% IVDMD and 22% CP for the legume) and an average value of 54% IVDMD and 8% CP for the grass.

The second monitored association is located in Minas Gerais State, Brazil (17º 09' S; 44º 39' W and 500 masl). The natural sward is composed with *A. repens* BRA -014788 and a mixture of *Brachiaria arrecta* and *Paspalum* spp. The animal live weight gain recorded after one year of grazing reached 200 g day^{-1} and 200 kg ha^{-1}.

The third wild community is composed for a single population of *A. sylvestris* BRA -013423 located in the State of Goias, Brazil (15º 13' 21" S and 47º 09' 52" W at 570 masl). This dense and healthy community has on average 140 plants m^{-2} and a natural soil seed-bank reserve of 2.5 t ha^{-1}. These three examples from nature demonstrate the astronomic potential of the genus in yield, nutritive value and persistence through their natural soil seed reserves.

Savannas and humid tropics of tropical America

A. pintoi

Although agronomic evaluation of *A.pintoi* in South America started only in 1976 by Bela Grof at CIAT-Quilichao, more than 50 agronomic trials have been carried out. A brief summary of the outstanding data will be reported for the main ecosystems of tropical America.

Savannas: Llanos of Colombia

Since 1976 until 1992 most evaluation has focused on *A. pintoi* CIAT 17434, today cv. Amarillo. Performance in these regional evaluations (through the RIEPT) was considered poor to regular in relation to other legumes. On the other hand, the performance in association with grasses under grazing was so superior to that of other legumes, encouraged research workers to release the mentioned accession as cultivar "maní forrajero perenne" despite the poor to regular agronomic background. This contradictory experience through the Llanos of Colombia between standard cutting trials in small plots vs. grazing experiments in association with a grass, suggests that traditional evaluation procedures for legumes and specially a stoloniferous one such as *A. pintoi* need to be questioned and urgently modified. Results from clipping experiments can be misleading, because of the artificial nature of defoliation, unless the experiments are designed specifically to investigate problems that have arisen under grazing.

Brazilian savannas: Cerrado

Well-drained plains dominate, but these are intersected with poorly drained lowlands that comprise 30% of the total area. In 1987 *Arachis* germplasm were evaluated in the lowlands and since 1991 in the well-drained plains (Pizarro and Rincón, 1994).

1- Seasonally flooded land

Thirty-three accessions of *Arachis* species, provided by CENARGEN, started being evaluated in 1990. All plant components (above-ground and underground) were estimated. The accumulated total DMY within the eleven pre-selected accessions ranged from 9-to 24 t ha^{-1} within the two years of evaluation. Edible green dry matter during the wet season ranged from 2 to 9 t ha^{-1} and from 2 to 4 t ha^{-1} during the dry period (Pizarro and Rincón, 1994). The ratio DMY efficiency/precipitation ranged from 2 to 7 kg DM ha^{-1} mm in the rainy season and from 12 to 23 kg DM ha^{-1} mm during the dry season in a seasonally flooded land.

One of the important features of the *Arachis* genus, section Caulorhizae (for erosion control and sustainability) is the different capacity for ground cover between accessions and species. Within the evaluated germplasm, the colonized area over time ranged from 128 to 198% over the first 480 days from sowing.

A second set of forty-eight accessions of *A. pintoi* and *A. repens* associated with *P. atratum* BRA

-009610 was evaluated in the two principal landscapes (savanna and the seasonally flooded land). The range of ground cover at nine weeks of growth varied from 65% to 100% for different accessions. The most outstanding accessions after one year from establishment were: (*A. repens* BRA -031861 and *A. pintoi* BRA/CIAT -031143/22160, -030449, -031836, -031828, -031844,

-031135, -015121/18748, -013251/17434, -030546 and -015598/18750).

A third set of eighty accessions, associated with the selected *B. decumbens* CIAT 16488 was conducted. During establishment, detailed data such as growing capacity of primary, secondary, tertiary, etc. stems was recorded. There were large differences in the maximum diameter reached and in the number of primary and secondary stems at 39 and 148 days from planting. The mean daily growth of the primary stems within accessions was 5, 3, and 2 mm d^{-1} at 39 days of growth and 6, 5, and 3 mm d^{-1} at 148 from sowing in three mentioned of the outstanding accessions (BRA/CIAT -031143/22160; -013251/17434 and -015121/18748, respectively).

Another set of *A. pintoi* accessions (BRA –013251, -015121, -030368, -031135, -031143, -031542, -031828) was associated with a very aggressive grass component like *P. maritimum* BRA –000078. The *A. pintoi* accessions BRA –030368 and –031542 diminished (5% of the botanical composition) after two years of cuttings and consecutive grazing. The *A. pintoi* accession BRA-031828 was the only one to comprise 60% of the sward, showing good vigor and excellent health. The accession *P. maritimum* BRA-00078 showed high branching ability and stem growth, reaching an average length of 702 ± 308 cm^{-1} per plant and a daily growth rate of 6.8 ± 3.0 cm^{-1} d^{-1}, between the first 100 days from planting. These results highlight the potential of this association for use in degraded areas to control erosion and weeds.

2 - Well-drained savannas

A special emphasis was put in this area for two important reasons. First, the lack of enough available legume-germplasm for this ecosystem and second to select within the new collected *Arachis* germplasm suitable accessions with faster establishment and especially, drought tolerance.

Several experiments were conducted between 1991 and 1997 in order to know if *A pintoi* will survive the normal long dry spell (4-6 months, with high temperature and very low relative humidity).

In a pilot trial, it was observed that *A. pintoi* BRA/CIAT -031143/22160 survived four long dry spell seasons, with considerable green leaf retention and DM production. Green leaf percentage drop from 38% from the middle of the dry season up to 15% at the end of the dry spell. On the other hand, the total DMY increases up to 1.2 t ha^{-1} at the end of the dry season. Although yields are not as high as other forage grasses, the green DMY ranged from 3.6 t ha^{-1} from the middle of the dry season up to 1 t ha^{-1} at the very end. The pure soil seed-reserve reached 720 kg ha^{-1} at 18 months from planting.

In another trial, eight accessions were established and evaluated in pure stands. Ground cover at 12 weeks from planting ranged from 4% for *A. glabrata* BRA -017531 up to 46% for *A. pintoi* BRA/CIAT -031143/22160. Total DMY ranged from 1-to 4.4 t ha^{-1} in the first year. A positive feature is that the survival of the genus and species was confirmed (*A. pintoi* and *A.*

glabrata) as well as the heterogeneous colonizing capacity in the new available germplasm. The colonized area over one year after sowing ranged from 100% for three accessions (*A. glabrata* BRA -017531; *A. pintoi* BRA –030082, -030261) up to 218% for *A. pintoi* BRA/CIAT -031143/22160.

Between 1992 and 1997 were introduced and evaluated in the Cerrado ecosystem new 117 *Arachis* accessions (ninety-eight *A. pintoi* and nineteen *A. repens*).

The main agronomic evaluated parameters were: vigor, ground cover, DMY, green leaf retention during the dry period, pest and disease resistance and seed yield. With all the parameters an agronomic adaptation index was calculated for each accession. The data presented in Table 3 is a summary of six years evaluation.

The pre-selected 22% of the *Arachis* germplasm deserve regional agronomic evaluation. The green leaf retention during the six-month dry spell in the Cerrado confirms the potential contribution of the *Arachis* genus.

(Table 3. Outstanding *A. pintoi* and *A. repens* accessions evaluated between 1992 to 1997 in the Brazilian Cerrado.)

3 - Humid tropics

The adaptation of *A.pintoi* (mainly CIAT 17434) in the humid tropics of South America, using the same methodology than in the savannas was better than in the Llanos of Colombia, with an agronomic performance ranging from poor to excellent and with higher DMY and ground cover.

In Central America and the Caribbean, agronomic performance is outstanding up to the present. Dry matter yield ranged from 1 to 4 t ha^{-1} in a twelve week growth period (Argel, 1994).

Also promising results are obtained in those accessions taken into account. For example in Ecuador accessions CIAT 18751 and CIAT 18748, gave better yield than *A. pintoi* cv Amarillo (Pizarro and Rincón, 1994). Also in the Central America region accession CIAT 18744 is outstanding (Argel, 1994).

In summary, *A. pintoi* grows well on a wide range of soils with textures varying from heavy clay to sand, but seems to grow better in sandy loam's if moisture is not limiting. In general, DMY of *A. pintoi* in different ecosystems is a response to differences in soil and climatic conditions.

Agronomic features

1 - Establishment

The slow establishment of *A. pintoi* CIAT 17434 is relatively well documented (Pizarro and Carvalho, 1994). In general, experimental data collected shows that better soils; higher rainfall and fertilizer placement to the seed increase the rate of establishment.

Experiments in order to study the effect of the level of fertility on the rate of establishment and yield were conducted. Three accessions (BRA/CIAT –015598/18750; -031143/22160 and BRA -031852) were planted in a red-yellow latosol in order to measure the response to phosphorus. When the level of P_2O_5 increase from 50 to 200 kg ha^{-1} the response in dry matter yield ranged from 72% to 116% (Góis *et al*., 1997).

Fortunately, there are big differences in the rate and speed of ground cover in the new available germplasm, now with more than 120 accessions available in the *A. pintoi* group.

Two trials, one with forty-eight accessions associated with a grass (*P. atratum* BRA - 009610) and another one with eighty A. *pintoi* accessions associated with *B. decumbens* CIAT 16488 were done. Large variation was found during the establishment period within the new collected germplasm.

A series of experiments have been done in order to select germplasm that establishes more rapidly plus the use of some agronomic practices that could encourage better establishment. An experiment was conducted in order to measure the ground cover in four of the first pre-selected *A. pintoi* accessions. The four accessions (BRA/CIAT -013252/17434,-015598/18750,

-031143/22160 and -031852) were planted in a red-yellow latosol by seed and vegetative material. Results clearly show that at twelve weeks from planting the ground cover in the seed planted material ranged from 30% to 63% and from 14% to 46% in the vegetative-planted material. At twelve weeks from planting the mean ground cover was 53 % and 28% for seed and vegetative propagation, respectively, a 50 % difference.

Other scope that can be used for improvement is perhaps the association of *A. pintoi* with other species within the genus like *A. hypogaea* and *A. sylvestris* both with recognized annual cycle and fast to very-fast establishment.

Annual species are used successfully for pastures in regions with pronounced regular summer or dry winter or cold seasons. In these "drought-evaders" their persistence rest on adaptations that enable reproduction to occur under grazing. Such is the case with the *Arachis* genus in nature. Another important agronomic characteristic that is taking place in this ecosystem is the coincidence of flowering with peak pasture growth, which reduces the risk of reproductive failure, as happen in *Trifolium repens*.

Persistence of the annual legumes is achieved through prolific seeding coupled with varying degrees of hard seeded ness.

In order to select germplasm of *A. hypogaea* as a partner for *A. pintoi* it was necessary in the first place, to screen the available material. Seventy accessions of *A. hypogaea* were evaluated. Based on the results obtained *A. hypogaea* IAC 5554, 5054, 5480, 5069, 2233, 5015 and ICRISAT 11326, 11341, 11317, 11328, 11312, 11342, 11331 deserve further evaluation (Pizarro *et al*. 1996)

Therefore with one of this alternatives, the soil will be covered fast with the annual species meanwhile the perennial one such as *A. pintoi* with a ground cover ranging from 164% to 305% one year after planting and a DMY accumulated varying from 2.6 to 4.3 t ha^{-1} will be available latter as the annuals dry or died.

The agronomic practice with a mixture of annuals and perennial components it not knew, and it is really what nature offers to us.

2 - Drought tolerance

Some basic principles of drought tolerance have been presented and discussed by Pizarro and Rincón (1994).

The doubt about the drought tolerance capacity *of A. pintoi* in association with grasses on the higher parts of the landscape in the Cerrado ecosystem is today questionable. However, six years research results from *A. pintoi* accessions and *A. glabrata* were conclusive. In *A. pintoi* BRA/CIAT -031143/22160 the green dry matter percentage ranged from 38% to 15% at the end of the second dry period. The high proportion of the root component in this accession was 58% with a total root DMY of 17 t ha^{-1}, with 60% of the root-system in the top 30 cm, penetrating up to 1.95m in depth.

This agronomic attribute might have helped in the efficient absorption and utilization of water and nutrients under stress conditions. The deep-root system also detected in the drought tolerant rice cultures under upland conditions, support for the present findings.

In the literature some studies demonstrated that, under water stress, peanut roots (*A. hypogaea*) reached greater depth compared to non-stressed peanut roots (Pizarro *et al*. 1996).

Other favorable point for the survival of *A. pintoi* in these severe conditions is the fast and high soil seed-bank built by this legume. For example, the recovered pure seed yield at 15 months post planting in a red-yellow latosol with 65 % clay content ranged from 50 to 600 kg ha^{-1} for the *A. pintoi* group. In the same trial, annual DMY ranged from 0.5 up to 4.4 t ha^{-1}.

3 - Seed production

Data collected to date (mainly in one accession) confirm that *A. pintoi* cv. Amarillo is a prolific seeder (Pizarro and Rincón, 1994).

The new collected germplasm under evaluation confirm the above mentioned but also show a huge difference in seed production between accessions within the *A. pintoi* group and also within the *A. repens* group always vegetatively propagated due to the reported lack of producing seed (Pizarro *et al.*, 1993).

With this outstanding agronomic attribute, the main constraint is only seed harvesting. The over-claimed mechanical problem is not a real one. In first place, the Australian seed-harvesting machine is a reality as is real, the different type of seed harvested machines designed by men in order to collect difficult agricultural products such as: cassava, carrots, peanuts, potatoes, sugar beet, etc.

Future agronomic selection criteria should also incorporate measurements on peg length and resistance as the native people of South America made on *A. hypogaea* decades ago.

Information on crop management is needed, especially on the effect of cutting and /or grazing on seed yield. It is well known the effect of the removal of herbaceous portions on seed production. The intensity of this effect depends upon the amount and frequency of removal, and the period in the growing season when removal takes place (Pizarro *et al*., 1998). Preliminary data on the subject suggest that drastic defoliation between three and six months after planting greatly reduce seed production comparing when the cutting was made after peak flowering took place (700 vs. 180 kg ha^{-1}).

4 - Potential contribution of A.pintoi as a ground cover

Results indicate that *A. pintoi* is a multiple-use ground cover crop with a high potential to contribute to sustainable agricultural systems (Ayarza *et al*, 1998).

Compared with traditional cover species such as *C. pubescens* and *P. phaseoloides*, *A. pintoi* has the advantage of a no twining habit, with a substantial reduction in maintenance costs.

Although no more than approximately 6500 ha^{-1} are planted, mainly in USA, Australia, Colombia and Costa Rica the potential as a ground cover over the tropical world exist. The main agronomic features for that purpose are: wide adaptation range, persistence, easy vegetative establishment, good spread, shade tolerance and the choice of seeding or no seeding accessions.

5 - Animal production

Annual live weight gains of steers grazing pastures with *A. pintoi* have ranged from 130 to 200 kg $head^{-1}$ and from 250 to 630 kg ha^{-1}. The effect on milk production has been measured in Costa Rica. In association with *Cynodon nlemfuensis*, milk production increased 17% over that of the grass alone fertilized with nitrogen (van Heurck, 1990).

The high potential animal production per unit area in pastures based on *A. pintoi* is a reality in tropical areas with no dry season stress and even in areas with 3-4 months dry season (i.e., Llanos of Colombia, Lascano, 1994) and in the seasonally flooded lands of the Brazilian Cerrado, Barcellos *et al*. (1997), Table 1.

(Table 4. Animal live weight and milk yield in *A. pintoi*-grass based pasture)

A. glabrata

A. glabrata is a long-lived rhizome peanut. Was introduced into Florida, USA in 1936 by F. H. Hull from Brazil. Although with ample distribution in the states of Mato Grosso and Mato Grosso do Sul in Brazil and more than 300 accessions available only few accessions of the section rizomatosae have developed into a potential forage crop in the United States.

A recent review published by French *et al*. (1994) resume the current status both as forage and as a ground cover crop. Only a brief summary of the more relevant data on cv. Florigraze will be presented. The superior persistence and longevity of this cultivar is mainly due to the superior insect resistance and low susceptibility to diseases.

Agronomic characteristics

The DMY of this outstanding cultivar ranged from 3-16 t ha^{-1}. The effect of fertilization on DMY is limited and contradictory (French *et al*., 1994).

The other two agronomic treatments that affect DMY are clipping height and frequency of cutting (French *et al*., 1994)

Establishment

A general statement is that *A. pintoi*, *A. repens* and *A. glabrata* are from very slow to slow to establish (Argel, 1994).

Results showed that the rate of increase in ground cover seems to be related to availability of moisture and soil fertility (Pizarro and Rincón, 1994).

As was shown earlier, there are big differences in the rate of ground cover in the new available germplasm of *A. pinto* and *A. repens*. Recent exploratory collecting trips (looking for variability within *A. glabrata*) have shown that we can still expect to find in nature, accessions with high differences in ground cover, seed production and leaf-stem ratio.

Animal performance

Individual animal live weight gains in pastures based on *A. glabrata* cv. Florigraze have been high. French *et al*. (1994) reported that in two grazing seasons steers in a Florigraze pasture reached on the average nearly 1kg head day^{-1}. In Brooksville, Florida, animal live weight gains during the grazing season ranged from 700 to 900 g head day^{-1} in a mixture of *Cynodon* and *Paspalum* spp. with rhizome peanut cv. Florigraze (French *et al*., 1994).

Results in the United States reported by French *et al*. (1994) showed the potential use of the rhizome peanut as grass, hay and silage for dairy cattle, gestating sows, meat goats, horses and poultry.

Centrosema species

Agronomic performance of new available germplasm

From thirty nine accessions of *C. acutifolim*, seventeen of *C. brasilianum* and twelve of *C. tetragonolobum* only *C. brasilianum* was the specie of the germplasm evaluated that merits further assessment within the Cerrado ecosystem.

The other species (*C. acutifolium* and *C. tetragonolobum*) presented limitations such as reduced flowering; low seed yield potential, and high susceptibility to pests and diseases.

C. brasilianum accessions CIAT 5234, 5178, 5667, 5671, 15387, 15521, 15522 and 15524 are promising and should be evaluated at regional level in association with grasses and under grazing.

Calopogonium mucunoides

Agronomic performance of new available germplasm

Although not widely used (like any other tropical legume today in America), is the most popular legume amongst Brazilian farmers and is the legume seed produced in greatest volume in Brazil. *C. mucunoides* has some limitations. This limitation came into conclusion from only one accession within the *C. mucunoides* group. The agronomic evaluation of 215 accessions showed new light. There were significantly differences in production (1 - 4 t ha^{-1}), seed yields (0 - 450 kg seed ha^{-1}) and nutritive value (38 - 60% IVDMD).

The number of rooted nodes ranged from 8 - 150 m^{-2}. Sixty percent of the collection had a mean number of rooted nodes ranging from 50 - 100 m^{-2}. The range and number of rooted nodes is higher than the reported figures for *C. acutifolium* and *P. phaseoloides* (Pizarro and Carvalho 1997). *In vitro* DMD was correlated with the number of epidermal hairs per unit area. Also, it was found that plant parts are responsible for forage quality. Within accessions, IVDMD was similar for the various plant components, with the exception of green pods that were more digestible (Table 4).

Another factor investigated in an effort to understand the effect of density of epidermal hairs on *C. mucunoides* quality was the chemical composition around hairs. The commercial cultivar and the two less hairy accessions were analyzed for lignin and cutin concentration. Hairs at the base were bicellular and the basal cells were impregnated with lignin and cutin. All these components present diffusial barriers that impede digestibility of intact tissue. The present results may explain in part the low digestibility and acceptability of the commercial cultivar. New alternatives are available for such a valuable, productive and persistent tropical forage legume. Seventeen new accessions were selected (CIAT 729, 822, 884, 887, 7722, 8404, 8405, 8513, 9111, 9450, 17887, 18065, 18107, 18564, 20676, 20709 and 20845). Two accessions, CIAT 822 and 20709, were outstanding for their leaf retention during long dry seasons.

(Table 4. IVDMD in plant components in preselected accessions of *C. mucunoides*)

Desmodium spp

Agronomic performance of new available germplasm

For more than three years 133 accessions of *Desmodium* spp., were evaluated in the Cerrado ecosystem with two levels of fertility. *D. heterocarpum* (fifty accessions), *D. barbatum* (fifteen accessions) and *D. velutinum* (sixty eight accessions) did not persist due to week establishment, low tolerance to drought and high susceptibility to nematodes.

Macroptilium species

Agronomic performance of new available germplasm

Macroptilium species occur in tropical and subtropical America and the West Indies. They are commonly considered weeds in waste places and along roadsides.

M. atropurpureum known trough cv. Siratro is a twining legume. It is particularly well suited to tropical and subtropical areas receiving 700-1000 mm rainfall. It is not as tolerant to low fertility as *Stylosanthes*, but its nutritive value, good seed commercial yield (100 – 800 kg ha^{-1}), nitrogen fixation (up to 160 kg N ha^{-1}), potential contribution to milk production, and specially its potential role in cropping systems, call the attention for searching new germplasm.

Sixty-three genotypes of *Macroptilium atropurpureum* and twelve *Macroptilium* sp. were evaluated in respect to agronomic adaptation, green leaf retention in dry season, pests and diseases resistance, and seed yield. Attributes evaluated by scores were transformed as indexes, joined with seed yield data and submitted to cluster analysis by complete linkage method. Two principal clusters were obtained, showing high performance genotypes. Outstanding genotypes were *M. atropurpurem* BRA-003808, -003522, -003565, -003310, -003379, -003433, and -003468.

Neonotonia wightii and *Glycine* spp.

Agronomic performance of new available germplasm

During the 1950s the commercial cultivars Cooper, Clarence, Tinaroo and Malawi were promoted and used. Part of their failure trough the tropical world was mainly due to the narrow genetic variability available, low pest and disease persistence and the emphasis in those days in long-term leys. Today, agricultural systems also claim for grass-legume association for easy establishment and more special for easy turnover. The genus *Neonotonia* may play an important role in this new scenario.

For that reason, thirty genotypes of *Neonotonia wightii* and six *Glycine* spp. were evaluated in respect to agronomic adaptation, green leaf retention in the dry season, pests and diseases resistance, and seed yield. Attributes evaluated by scores were transformed as indexes, joined with seed yield data and submitted to cluster analysis by complete linkage method. Clusters were obtained, grouping genotypes with high adaptation and low and/or unstable seed yield. Outstanding genotypes were *N. wightii* BRA-001104, -001261, -001341, and cv. Clarence. Forage attributes and seed production were poorly related.

Stylosanthes spp.

Agronomic performance of new available germplasm

The genus *Stylosanthes* with about forty-four species and sub-species is an important source of pasture legumes for tropical and subtropical environments. Although *S. humilis* and *S. guianensis* have been recognized for at least 60 years, all cultivars with the exception of cv. Schofield have been developed within the last 25 years. Until 1982-83, thirteen cultivars had been released in Australia from five species and eight cultivars from three species in South America.

Despite the effort, most of the available cultivars, were devastated by anthracnose (*Colletotrichum gloesporioides* Penz. et Sacc.). Until now, the two highly successful materials are *S. guianensis* cv. Mineirao and *S. guianensis* CIAT 184 (now cultivar Reynan II). *Stylosanthes guianensis* cv. Mineirao is a late maturity type, poor seed producer and with less agronomic plasticity than other tropical forage legumes.

A new *Stylosanthes guianensis* have recently selected in Brazil (Grof *et al*., 2001a). This intervarietal hybrid stylos (*S. guianensis* var. vulgaris x var. pauciflora) with durable quantitative resistance to anthracnose, mid-season harvest maturity, high DMY and good seed yield was developed at EMBRAPA National Beef Cattle Research Center (EMBRAPA-CNPGC). The authors claim that the distinct advantage of composite hybrids is their considerable genetic diversity in contrast to pure-line cultivars.

During 2000, a new *S. capitata* (based on seventeen genotypes of *S. capitata* and six of *S. macrocephala*) have been released as cultivar Campo Grande using a novel technique to produce resistance to anthracnose in EMBRAPA-CNPGC (Grof *et al*., 2001b). Mean DMY ranged from 5.7 t ha^{-1} to 13.4 t ha^{-1}. Seed-yields in-pod ranged from 245 kg ha^{-1} to 614 kg ha^{-1}.

This multicross with its diverse genetic make-up has a wide application in the acid–soil savannas of tropical America.

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Table 1 - Animal live weight and milk yield in *A. pintoi*-grass based pasture *

Site	Grass	Live weight gains			
		Grass alone		Grass plus *Arachis*	
		kg hd^{-1}	kg ha^{-1}	kg hd^{-1}	kg ha^{-1}
Colombia	**B. dictyoneura**	122	366	152	456
	B. humidicola	96	288	130	390
Costa Rica	**B. brizantha**	126	378	183	549
Brazil	*P. atratum*	-	-	-	630
		Milk yield, kg cow d^{-1}			
		Grass plus 100 kg N h^{-1}		Grass plus *Arachis*	
Costa Rica	*C. nlemfluensis*	7.7		8.8	

* Adapted from: Lascano, 1994; van Heurck, 1990 and Barcellos *et.al*., 1997.

Table 2 - *Paspalum*: Beef cattle production from grazing trials

Specie	kg animal d^{-1}	kg meat ha^{-1}	Source
P. plicatulum cv Rodd´s Bay	0.340	-	Whiteman *et al*. (1985)
P. plicatulum	-	740	Bisset (1975)
P. nicorae	1.2	-	Cook, B. (Personal communication)
P. atratum	0.600	460 – 680	Kalmbacher *et al*. (1997)
P. atratum cv. Suerte	0.710	240	Kretschemer *et al*. (1994)
P. atratum + *A. pintoi*	0.100 – 0.700	550 - 800	Barcellos *et al*. (1997)

Table 3 - Outstanding *A. pintoi* and *A. repens* accessions evaluated between 1992 to 1997 in the Brazilian Cerrado

BRA Number	AAI*	GLRDP**
	%	
-012114	83	87
-013251	82	80
-015121	76	67
-015598	81	80
-020401	75	72
-029190	77	80
-030261	78	90
-030333	79	75
-030449	87	90
-030546	80	85
-030601	75	67
-031127	78	88
-031143	81	65
-031356	70	72
-031496	83	80
-031500	79	76
-031526	87	88
-031534	83	88
-031801	84	76
-031810	83	73
-032280	84	93
-032328	83	80
-032336	90	93
-032395	89	100
-032409	93	100
-032433	83	93

* AAI=Agronomic Adaptation Index; ** GLRDP=Green Leaf Retention in the Dry Period

Table 4 - IVDMD in plant components in preselected accessions of *C. mucunoides*

Plant components	Hairy accessions 34 ± 5 hairs mm^{-2}	Less hairy accessions < 10 hairs mm^{-2}
	IVDMD %	
Whole leaf	41 a*	52 a
Leaf without vein	41 a	49 a
Vein	40 a	50 a
Stem	42 a	52 a
Green pods	48 b	60 b

*Means with accessions followed by the same letter are not significantly different (P<0.05).