AGRONOMIC EVALUATION OF GRASSES IN THE TROPICAL SAVANNAS OF SOUTH AMERICA. III.

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INTRODUCTION

Grasses form the predominant vegetation type in the tropical savanna regions of South America. Unfortunately, a substantial proportion of the indigenous species are of such poor nutritive value that they are not consumed by cattle at any time. This contrasts markedly with the situation in African savannas where the great majority of grasses are well accepted by cattle during the period of active growth (PALADINES 1975). Not surprisingly most of the economically important pasture grasses of the tropics have originated in Africa. However, when introduced into the American tropics some of these species have spread rapidly and widely (PARSONS 1972). This third review considers the progress that has been made in selecting grasses for the acid, infertile soils in the savannas of tropical America.

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1. Andropogon gayanus KUNTH.

Andropogon is a large and heterogenous pantropical genus of perennial species. One species in particular, Andropogon gayanus CIAT 621, had earlier shown considerable potential for Oxisol-Ultisol savannas of tropical America (CIAT 1976). CIAT 621 originated from the Shika Experiment Station in Nigeria. Surprisingly, the species has not yet evolved into a commercial cultivar in Africa despite being a highly valued component of native pasture.

Subsequent to its introduction a series of agronomic trials were initiated by CIAT (at the Carimagua Research Centre) and various national research institutions in Latin America to evaluate the potential of A. gayanus primarily in the vast Ultisol and Oxisol savanna regions of the continent. The results of these preliminary agronomic investigations in Colombia have been summarized by JONES (1979) and three experiments have been reported in detail by GROF (1981). Some of the preliminary agronomic work conducted with CIAT 621 at the Cerrados Agricultural Research Centre (CPAC) near Brasília, Brazil has been summarized by THOMAS. et al. (1981). These early reports clearly demonstrated the potential of A. gayanus as an alternative forage grass species for the acid-soil savanna regions of tropical America. No serious disease or insect problems were detected during these early evaluations in tropical America. This is in striking contrast to the severe spittlebug problems which have been encountered with Brachiaria decumbens another introduced grass species well adapted and widely used in both savanna ecosystems.

As a result of further evaluation at a number of locations, accession A. gayanus var. bisquamulatus CIAT 621 has now been released in Brazil as cv. Planaltina (THOMAS et al. 1981) and in Colombia as cv. Carimagua 1. Peru, Venezuela and Panama subsequently released the same accession.

A. gayanus var. bisquamulatus is a highly productive species well adapted to savannas or forest ecosystems in tropical America and a wide range of altitudes (up to 2000m), climates and soils. The most favourable environment according to JONES (1979) appears to be at less than a 1000m altitude, more than 750mm annual rainfall and a dry season of three to five months. However, BOGDAN (1977) notes that the species is sufficiently drought resistant to withstand up to nine months without rain. Its drought tolerance may be largely due to its capacity to root deeply, taking advantage of stored subsoil moisture (CIAT 1979).

The cultivar shows excellent tolerance of low soil pH and high aluminium saturation. SPAIN (1979) studied the effect of application of lime (0-6 t/ha) on 38 species of grasses and legumes in an Oxisol in the Colombian Llanos. Maximum production of A. gayanus occurred at zero lime application (90 per cent aluminium saturation) in contrast to Hyparrhenia rufa which responded up to a level of 2 t/ha of lime. In Brazil, Andropogon grew vigorously on an Oxisol at pH 4.6 and 80 per cent aluminium saturation while Panicum maximum var. trichoglume cv. Petrie only produced acceptable levels of dry matter when aluminium saturation was reduced to 20 per cent (CIAT 1981).

Critical external levels of P, K, Ca, Mg and S required in the soil solution to obtain 80 per cent of maximum yield at 8 weeks of plant growth were determined for the main grass species used in the savanna ecosystem. For A. gayanus and B. decumbens critical values were 20, 20, 100 and 12 kg/ha of P, K, Ca and Mg respectively. The critical levels were lower for B. humidicola e.g.: 10, 10, 50, 6 (P, K, Ca and Mg) and higher for Panicum maximum e.g.: 40, 25, 250, 15 (P, K, Ca and Mg) kg/ha. Again, the lowest S requirements were shown by A. gayanus and B. humidicola CIAT 679, 10 kg/ha and 5 kg/ha respectively. In the case of B. decumbens cv. Basilisk the critical level was 20 kg S/ha, and it was the same level as required by the legume Stylosanthes capitata to produce 80 per cent of its maximum dry matter yield. (CIAT 1982; J.SALINAS, pers. comm.).

Although well adapted to low fertility soils A. gayanus is capable of responding to applications of fertilizer. A comparison of the response of A. gayanus, P. maximum and Brachiaria decumbens to application of nitrogen showed that at zero level A. gayanus produced almost twice the dry matter of the other two species (CIAT 1979). A. gayanus responded positively up to 200 and 400 kg N/ha respectively. Good responses have also been observed in savanna regions to the application of phosphorus (CIAT 1978; CIAT 1982) and other nutrients (THOMAS et al. 1981).

A. gayanus is very tolerant of fire as one would anticipate in a grass originating from African savannas where vegetation is regarded as sub-climax, created by fire from a climax vegetation of arboreal types. Burning in the early dry season encourages rapid development of new tillers. The production of dry matter in A. gayanus four weeks after burning was 50 per cent higher than that of B. decumbens and twice that of H. rufa (CIAT 1979).

The grass is easily established from seed or from crown splits. SPAIN (1979), in Colombia, established 1000 plants/ha (3.16m between plants) of the species from crown splits in September 1977. The cultivar produced seed at the end of November. The seed that had fallen and settled in furrows left by a field-cultivator germinated after the first rains in March 1978. In April, plants numbered 150/m² compared to 15/m² for P. maximum. A. gayanus can be sown with annual companion crops such as maize and soyabeans (HAGGAR 1969).

In the Cerrados of Brazil, under relatively low fertility conditions, A. gayanus has shown a remarkable constancy of dry matter production in the three seasons (1979-1982) following the establishment year (THOMAS and ANDRADE 1984b). This is illustrated in Fig. 1. Three other species growing under the same conditions showed a significant decline in productivity after the second season. A major advantage of A. gayanus is its good compatibility with many pasture legumes, making it possible to establish legume-based pastures. GROF (1981), in Colombia, found that the species performed well under cutting with Stylosanthes guianensis, S. capitata and Centrosema species. In Brazil, the species has shown good compatibility with Stylosanthes capitata, S. macrocephala and S. guianensis in small plots under a close grazing regime (THOMAS and ANDRADE 1984a).

The cultivar is a short-day plant, with a critical day-length for flowering of between 12 and 14 hours (TOMPSETT 1976). At 3° - 4°N in Colombia the plant flowers throughout the year. Flowering is variable and prolonged within plants and mature spikelets shed progressively. In Brazil at 16°S, flowering is well synchronized with the first flowers appearing in late April and seed harvested in the dry season from late May to early June. Pure seed yields as high as 300 kg/ha have been obtained near Brasília at latitude 16°S (ANDRADE et al. 1983b). Seed yields in other areas of Latin America are reported by FERGUSON et al. (1983). Under relatively high fertility conditions lodging of seed crops has taken place in Brazil when plants were allowed to reach their full height potential. Cutting the crop in mid-January or grazing up to mid-February prevented lodging and gave the highest seed yields (ANDRADE and THOMAS, unpublished data).

No major fungal diseases have been recorded and no serious insect pests have so far been found in Bolivia, Brazil, Colombia, Ecuador, Panama, Peru or Venezuela. False army worm (*Mocis latipes*) attacks on *A. gayanus* are sporadic and of seasonal occurrence in Colombia. *Bacillus thurigiensis* acts as an agent of biological control of the larvae of this pest. Leaf damage by yellow aphid (*Sipha flava*) on *A. gayanus* coincides with the period of highest rainfall (May-July) CIAT (1981). *Rhynchosporium* leaf spot has been recorded on *A. gayanus* for the first time in a high rainfall (>3500mm) region of Colombia. The pathogen caused only slight damage and the disease is considered of minor consequence (CIAT 1980). The major problem for grasses in the savanna regions is the incidence of spittlebugs, principally of the genera *Aeneolamia*, *Deois* and *Zulia*. In field studies at CPAC, near Brasília, COSENZA (1982) found that *A. gayanus* was one of the most resistant grasses to spittlebugs, and probably displays antixenosis and antibiosis to nymphs of the insect.

Although *A. gayanus* is regarded as a grass of medium to low nutritive value (JONES 1979) it is well accepted by cattle throughout the year. This relatively low feeding value of the species is offset by its compatibility with many legumes, which would be expected to improve quality in legume-based pastures. In addition, new genotypes evaluated at CIAT exhibit variation in leafiness and intake (CIAT 1983). In selected leafy types intake in crated wethers was 71.8g/kg$^{-0.75}$/day which compared favourably with some legumes and was markedly higher than that of the more stemmy genotypes. No animal disorders have so far been caused by the species while Bovine Photosensitization remains a problem in the widely grown *B. decumbens* (NOBRE and ANDRADE 1976; CIAT 1980).

Much information on the performance of *A. gayanus* has accumulated since its introduction and early commercial acceptance in several tropical American countries. Until recently, one of the major deficiencies in our knowledge of this grass has been the lack of data on its productivity and performance under actual grazing conditions.

In Colombia a good grass-legume balance (60:40) was maintained in an *A. gayanus* - *D. ovalifolium* association, considering the high palatability of the grass relative to the legume. The mixture was grazed on a 1-week-in and 1-week-out system, using five Criollo x Zebu weaner heifers with an initial live-weight equal to two animal units (1 A.U. = 420 kg) per ha over a period of 555 days. The annual presentation yields for three associations i.e. Brachiaria humidicola, A. gayanus and B. decumbens each with D. ovalifolium in one grass-one legume mixtures were 21.72, 19.59 and 17.30 t/ha per year. Brachiaria humidicola was the highest yielding grass and both B. humidicola and A. gayanus produced significantly better presentation yields than B. decumbens. The legume contents of the three mixtures were uniformly high and ranged from 42 per cent for the B. humidicola - D. ovalifolium and A. gayanus - D. ovalifolium associations, to 46 per cent for B. decumbens - D. ovalifolium (GROF 1984).

The first grazing productivity experiments of A. gayanus were sown in the Colombian Llanos in 1976. Well-established pastures of the species have a higher carrying capacity and, therefore, higher levels of animal production per unit area than that of B. decumbens. In Colombia continuously grazed pastures of A. gayanus produced 248 to 451 kg/ha live-weight per annum compared to 176 to 266 kg/ha/annum for B. decumbens (CIAT 1981)(Table 1).Liveweight gains per head were of a similar order for both pasture types. The productivity of the grass can be increased by 40-60 per cent when grazed in association with an appropriate legume species. Liveweight gains from A. gayanus-legume pastures have ranged from 126 to 349 kg/ha/annum and 126 to 200 kg/animal/annum (CIAT 1981; CIAT 1982), (Fig. 2).

New introductions and clonal families from CIAT 621 are currently under evaluation in Colombia. Preliminary observations indicate variation in such characteristics as dry matter yield, tillering, leafiness and heading date.

2. Brachiaria decumbens STAPF.

Species of Brachiaria, introduced in the 1950's and 1960's, are widespread in both savanna and cleared forest regions of the humid lowlands of South America. They have largely displaced Pangola grass (Digitaria decumbens) in these countries, because of its susceptibility to the yellow sugarcane aphid and diseases. Of the perennial species of Brachiaria, B. decumbens and B. humidicola have attained major economic importance in these areas.

B. decumbens inhabits a variety of climax and derived plant communities, open grasslands and savanna woodlands on the Great Lakes Plateau in Uganda and adjoining countries of east and central Africa (LOCH 1977). B. decumbens is an erect or decumbent leafy perennial rooting at the lower nodes. A recent taxonomic treatment of 51 species, cultivated in Brazil, was published by SENDULSKY (1978) and includes the description of this species. According to this author, there are two widespread forms of B. decumbens in Brazil. The first was introduced in 1952 by the Instituto Agronômico do Norte (IPEAN), Belém, and a second form was introduced into the state of São Paulo from Australia. The Australian form is a more robust, suberect plant with fertile seeds while the IPEAN form is decumbent, rooting at the nodes and exhibited poor seed production. LOCH (1977) published a comprehensive review of the world literature on B. decumbens.

Commercial scale seed production of B. decumbens was initiated in North Queensland, Australia, where results of early investigations proved B. decumbens to be functionally a fertile grass, germination of otherwise sound caryopses being impeded by dormancy factors (GROF 1968). Australian seed of B. decumbens cv. Basilisk was imported into Brazil from 1972 onward and, until about the mid-1970's, some 2 million kg of this seed reached the South American market (Australian Seed Producers, pers. comm.). By this time local production fulfilled requirements.

The major limitation to B. decumbens is its poor resistance to spittlebugs. In both Brazil and Colombia, B. decumbens was found to be highly susceptible to spittlebugs (CIAT 1982; COSENZA 1982).

B. decumbens is a highly productive grass and, where it is not affected by spittlebug attacks, it normally outyields other tropical grass species. The comprehensive review published by LOCH (1977) gives production data on a world-wide basis. In the Colombian Llanos, the resistant species, B. humidicola produced a higher growth rate and presentation yield than B. decumbens (GROF 1984). Liveweight gains obtained on pure grass stand of B. decumbens in the Llanos are summarized in Table 3. Exceptionally high dry matter production and animal liveweight gains have been recorded on intensively managed, nitrogen fertilized B. decumbens pastures. Two outstanding cases were reported by LOCH (1977) in his review paper. On the wet tropical coast of North Queensland with the application of 196 kg N/ha/year and a constant stocking rate of 4.5 animal units/ha, over one thousand kg/ha per year beef liveweight gain was obtained.

In the very equitable climate of the Cauca Valley in Colombia, approximately 1700 kg/ha per year liveweight gain was recorded on N fertilized B. decumbens pasture grazed by 6 animal units/ha, and fertilized with 50 kg N/ha after each grazing at 6 weeks intervals.

Very few results are published on dry matter production and liveweight gains obtained on B. decumbens-legume mixtures. Indeed, there are few legume species compatible with this aggressive grass species. To date, for the higher rainfall savannas, the stoloniferous subshrub Desmodium ovalifolium offers the best promise. In the Colombian Llanos a perennial species of groundnut, Arachis pintoi, Krap. et Greg. nom. nud. (CIAT 17434) is showing early promise in association with several species of Brachiaria (B. GROF, unpublished data).

Also in the Colombian Llanos, Pueraria phaseoloides was used in blocks or in strips to supplement B. decumbens. In each case, the legume covered 30 per cent of the total area. Under controlled grazing conditions stocking rates of 1.25 and 2.00 animals/ha were employed during the dry and wet season, respectively. Over four years, average liveweight gains ranged from 183 kg/animal/ha to 157 kg/animal/ha per year for strips and blocks respectively. Unsupplemented B. decumbens pastures produced average liveweight gains of 145kg animal/ha per year (CIAT 1983).

Bovine Photosensitization was recorded on B. decumbens pastures in four Brazilian states in 1975-1976 (NOBRE and ANDRADE 1976). The problem was diagnosed in Colombia in 1978 (CIAT 1979). In Brazil, photosensitization was associated with the presence of the saprophytic fungus Pithomyces chartarum which produces spores containing the hepatotoxin sporidesmin. In an experiment in the Llanos of Colombia, 961 animals were allowed to graze on pure stands of B. decumbens. Over a period of four years 4.7 per cent of the cattle under 2 years of age were affected by photosensitization and 2.7 per cent fatal cases were recorded (GARCIA et al. 1982).

3. Brachiaria humidicola (RENDLE) SCHWEICKT.

Brachiaria humidicola is indigenous to eastern and south-eastern tropical Africa where it occurs in relatively moist areas. It has been used as a forage species in Kenya, Zimbabwe, Fiji, Australia and the Amazonian regions of Brazil.

B. humidicola is very well adapted to the iso-hyperthermic savannas but is not productive in the iso-thermic savannas in areas where rainfall is $<$1600mm and length of dry season six months or more. In an experiment at CPAC, near Brasília, B. humidicola was the lowest yielding grass in the three seasons (1979-1982) following the establishment year (Fig. 1).

The species is well adapted to the Oxisol-Ultisol soil associations and is tolerant of high aluminium and phosphorus stress (CIAT 1981). In the Llanos of Colombia 14 grasses were treated with levels of lime varying from 0 to 6 t/ha. Aluminium saturation ranged from 10 to 90 per cent.

B. humidicola produced the highest dry matter yield in the absence of lime (CIAT 1978). The grass has a lower external calcium requirement than B. decumbens (CIAT 1982). Only 50 kg Ca/ha (= 125 kg/ha calcitic limestone) were required to obtain 80 per cent of maximum yield on an Oxisol in the Colombian Llanos. Internal calcium requirements ranged from 0.25 per cent in the wet season to 0.22 per cent in the dry season. External phosphorus and potassium requirements were also low requiring only 10 kg/ha of each nutrient for 80 per cent of maximum yield. Intraspecific variation exists in tolerance to toxic levels of manganese (CIAT 1982). Accession CIAT 675 produced similar amounts of dry matter when exposed to 10 or 86 ppm manganese in the soil. On the other hand, the yield of CIAT 679 was reduced by more than 50 per cent at the higher level.

B. humidicola responds well to nitrogen, shows good regrowth following burning and is more flood tolerant than B. decumbens .

COSENZA (1982) found no spittlebug damage in B. humidicola in experimental plots despite a high population of nymphs. B. humidicola was found in experiments to be more resistant to the insect than B. decumbens (CIAT 1982). However, in the humid tropics of Brazil stands of B. humidicola are badly attacked by spittlebug.

At 16°S latitude in Brazil, B. humidicola flowers in late December following the establishment year, and may flower twice in the wet season. Although dry matter production is relatively poor in drier areas of the Cerrados of Brazil, high seed yields are possible with inputs of fertilizer. ANDRADE *et al*. (1983b) obtained pure seed yields of 501 kg/ha in the second season of an experiment.

B. humidicola is very acceptable to cattle when it is kept short and leafy. In the early wet season the dry matter digestibility of *B. humidicola* was higher than that of *B. decumbens*, but declined faster over time. This was accompanied by reduced digestibility and voluntary intake in crated sheep. Levels of animal production on pure pastures of *B. decumbens* over two years at different stocking rates have ranged from 176 to 266 kg liveweight/ha and 116 to 130 kg liveweight/animal (CIAT 1981). Comparable values for *B. humidicola*-legume associations were 156 to 493 kg/ha and 45 to 152 kg/animal (CIAT 1983).

B. humidicola is highly compatible with the legume *Desmodium ovalifolium*. Associations produced annual dry matter yields of 17.4 t/ha in Colombia (CIAT 1983). *B. decumbens*-*D. ovalifolium* associations in the same period produced 13.9 t/ha dry matter.

Confusion exists in the literature between this species and *B. dictyoneura*. In his book, BOGDAN (1977) considers reports on *B. dictyoneura* from Fiji and other countries as referring to *B. humidicola*. Morphologically, *B. humidicola* resembles *B. dictyoneura* but is strongly stoloniferous whereas the latter is rhizomatous and stoloniferous with a rather tufted growth habit. There are also differences in chromosome numbers. According to BOGDAN (1977) in *B. humidicola* 2n=72 whereas in *B. dictyoneura* 2n=42.

In Colombia accessions of *B. dictyoneura* have shown good adaptation to the Llanos ecosystem. Some differences have been noted between the two species. Seed yields and caryopsis content of the flowers in *B. dictyoneura* CIAT 6133 were significantly higher than in *B. humidicola* (B. GROF, unpublished data). Clean seed yields of 405 kg/ha were obtained in the establishment year and a caryopsis content of 44 per cent. Comparable values reported by CIAT (1982) for *B. humidicola* were 286 kg/ha and 18 per cent (Table 2). Freshly harvested seed of *B. dictyoneura* shows strong dormancy. Sulphuric acid treatment for 25 and 20 minutes gave 6 per cent and 3 per cent germination one month after harvesting. Shorter periods of acid treatment as well as heat treatments were ineffective in increasing the germination of this seed. When the lemma and palea were removed, 15 per cent of the naked caryopses germinated within one week and without acid treatment (CIAT 1982).

B. dictyoneura CIAT 6133 exhibited a higher protein content, digestibility and intake than *B. humidicola*. This was attributed to the higher leaf: stem ratio of *B. dictyoneura* relative to *B. humidicola* (CIAT 1983; C. LASCANO, pers. comm.).

In Brazil, the only accession of *B. dictyoneura* hitherto tested appears to be more susceptible to spittlebugs than *B. humidicola* (COSENZA 1982).

4. *Brachiaria brizantha* (HOCHST, EX A. RICH.).

Brachiaria brizantha is a tufted perennial that occurs throughout tropical Africa under an annual rainfall of

800mm mainly in grasslands with scattered bush (BOGDAN 1977). The species has been tested in Africa, various Pacific Islands, India, Sri Lanka, Malaysia, Puerto Rico and Surinam. The distinction between various *Brachiaria* species is unclear and confusion is common. In the older literature other species of the genus have frequently been grown under the name of *B. brizantha*. As LOCH (1977) points out *B. brizantha* and *B. decumbens* intergrade completely on all morphological features and the descriptions of the two species represent nothing more than the two extremities of the range of variation. However, since the two extremes are so very different, LOCH believes it is worthwhile to maintain them as separate species and provides a key by which they can be recognized.

B. brizantha shows good adaptation to the savanna regions and is tolerant of acid soils and relatively low nutrient status. Under a high aluminium and phosphorus stress (95 per cent Al; $<$ 2 ppm P), in a field experiment in the Colombian Llanos, *B. brizantha* produced more dry matter than *B. ruziziensis*, *B. arrecta* (syn. *B. radicans*) or *B. mutica* (CIAT 1981). Tolerance to manganese toxicity varies with ecotype. At a level of 86 ppm soil manganese the yield of ecotype CIAT 665 was higher than at 10 ppm manganese. On the other hand, the yield of ecotypes CIAT 667 and CIAT 6016 was reduced at the higher level (CIAT 1982). *B. brizantha* has a low external calcium requirement and required only 100 kg Ca/ha to obtain 80 per cent of maximum yield. This application was equivalent to 250 kg/ha calcitic lime which had no effect on soil pH or aluminium saturation CIAT (1982). Internal calcium requirements varied with season and ranged from 0.32 to 0.37 per cent. Phosphorus and potassium requirements were also found to be low and only 20 kg/ha of each nutrient was necessary to attain 80 per cent of maximum yield. B. brizantha responds well to nitrogen and dry matter yields of 2.5 t/ha were obtained in an 18 week period (CIAT 1979).

The species is drought tolerant but not flood tolerant and responds to burning better than B. decumbens or B. arrecta (CIAT 1979). No diseases have been observed in the savanna regions but insects, principally spittlebugs, are a serious problem in other Brachiaria species. COSENZA (1982), in field investigations in the Cerrados of Brazil, found B. brizantha to be the most resistant of the Brachiaria species. Spittlebugs were found on B. brizantha but no damage recorded.

B. brizantha appears to have a higher nutritive value than many other species. In Uganda, BREDON and HORRELL (1962) found that the species together with Cynodon dactylon had the highest nutritive value of nine grasses samples. In Colombia, the nitrogen content and digestibility of leaf tissue under cutting in the wet season was 2.3 per cent and 62.6 per cent respectively. Corresponding values for Andropogon gayanus were 1.7 per cent and 52.6 per cent and for Hyparrhenia rufa 1.6 per cent and 48.1 per cent respectively.

GROF (1982) found good compatibility between B. brizantha and Desmodium ovalifolium under cutting in Colombia. Annual dry matter yields of the association were 10547 kg/ha and a good grass-legume balance (69:31 per cent) maintained. Four accessions are currently showing promise in the respective savanna ecosystems. In Brazil, the early flowering (January-February at latitude 16°S) accessions CIAT 6016 and CIAT 6021, introduced from Ecuador, have outyielded B. decumbens cv. Basilisk (CIAT 1982). In Colombia the best accessions are CIAT 664 and 6387. The latter showed a high level of resistance to spittlebug. In August 1983, B. brizantha cv. Marandú was jointly released by the National Beef Cattle Research Centre (CNPGC) and the CPAC of EMBRAPA for use in the Brazilian Cerrados. This cultivar was introduced into Brazil in 1967 from the Marandellas Research Station in Zimbabwe (formerly Rhodesia). Early testing of the accession was conducted in the state of São Paulo. The cultivar is very productive and highly resistant to spittlebug attack. In preliminary grazing experiments with set stocking, mean daily liveweight gains have been in the order of 200 and 600g/animal in the dry and wet seasons respectively. New experiments are in progress to measure animal production from cv. Marandú in association with legumes such as S. macrocephala.

5. Panicum maximum JACQ.

The genus Panicum contains up to 500 annual and perennial species of various habit which occur in warm countries in the tropics. The most important species of the genus is Panicum maximum, which has been reviewed by MOTTA (1953), McCOSKER and TEITZEL (1975) and BOGDAN (1977). P. maximum is native to tropical Africa and is concentrated in areas between the 20° latitude lines that receive more than 1300mm annual rainfall and below 2000m altitude. The species shows considerable natural variation with many distinct types occurring especially in East Africa. A number of commercial cultivars has been used widely in tropical America, particularly in Brazil, giving high levels of animal production (ROCHA et al. 1983). However, these cultivars tend to have relatively high nutrient requirements and are not as drought tolerant as many other grasses. In recent years new ecotypes of the species have been introduced by CIAT into the acid, infertile savanna areas from collections existing in Australia, Cuba, Ecuador, Puerto Rico, Kenya and Ivory Coast. Some of these ecotypes show promise for the savanna regions.

P. maximum has shown some tolerance to both aluminium and manganese toxicities (CIAT 1978; CIAT 1982). When subjected to lime levels ranging from 0 to 6 t/ha P. maximum produced its highest yield at 0.5 t/ha. In solution culture the species was found to be more tolerant of aluminium than either Hyparrhenia rufa or Cenchrus ciliaris. The species is also very resistant to burning, and four weeks after burning the amount of regrowth was appreciably more than that of five Brachiaria species, H. rufa or Paspalum plicatulum (CIAT 1979).

P. maximum shows good compatibility with a wide range of legume species. In associations with species of Centrosema under cutting in Colombia, legume contents ranged from 21 to 31 per cent (CIAT 1979). When grown with Desmodium ovalifolium five accessions of the grass produced annual dry matter yields ranging from 10220 to 12322 kg/ha under cutting (GROF 1982). Legume contents varied from 39 to 56 per cent.

Ecotypes of P. maximum show variation in disease and insect tolerance. Two fungal diseases have been observed attacking the species in tropical America. Smut caused by Ustilago species and Cercospora leaf spot (CIAT 1980). In Brazil COSENZA (1982) found that a number of lines of P. maximum were only slightly damaged by spittlebugs and cultivar Makueni was amongst the most resistant of the grasses evaluated.

Observations with commercial cultivars and new ecotypes indicate that good seed yields are possible in the Cerrados region. Over a three year period at latitude 16°S in Brazil, P. maximum var. trichoglume produced pure seed yields of 99 to 162 kg/ha/annum (ANDRADE et al. 1983b). P. maximum is day-neutral in its photoperiodic response and multiple annual flowering peaks are observed. The time between onset of flowering and harvest is short (26 to 34 days) and three harvests per season are possible.

BOGDAN (1955) classified 47 ecotypes of P. maximum in Kenya into four broad groups. The three perennial groups were (1) a medium-sized type with predominantly basal leaves; those are characterized by the cultivars Makueni and "common", (2) var. trichoglume type with numerous leaves and fine stems; characterized by the cultivar Petrie green panic and (3) tall-vigorous type with large leaves and rather thick stems; characterized by the cultivars Hamil and Colonião. Three accessions have been selected as being promising for the Cerrados region. Two accessions CIAT 6116 and 6124 belong to the var. trichoglume group and CIAT 6141 belongs to the medium-sized group.

The discovery of sexuality in natural populations in eastern Africa has recently added a new dimension to the search for new variation in the species (SAVIDAN 1983). Many genes hitherto unavailable to the plant breeder because of apomixis could potentially be released and promising new types created by hybridization. These lines are currently under evaluation in Brazil and Colombia.

CONCLUSIONS

In the search for new forage plants for the acid, infertile savannas of tropical America emphasis to date has been placed on the selection of adapted legumes. The need to also find suitable grasses is necessitated by the low nutritive value of a substantial proportion of indigenous grasses, the relatively high nutrient requirements of many commercial cultivars and the susceptibility of the widely-grown Brachiaria decumbens to insect pests. A number of species originating on the African continent have shown considerable promise for the Oxisol-Ultisol savannas and have demonstrated a high tolerance of low soil pH and toxic levels of aluminium and manganese. Since large areas of acid, infertile soils exist in tropical Africa there is considerable scope for further collection of plant material of value to tropical America. It is highly likely that most collections to date have been made on the more fertile African soils. It is also the opinion of the authors that more attention should ge given to the genus Paspalum. Few species of this predominantly American genus have been evaluated as potential forage plants though the genus contains up to 250 species most of which, as BOGDAN (1977) points out, are good grazing grasses. Preliminary evaluation has begun in Brazil, with P. conspersum and P. guenoarum showing promise for the Cerrados region.

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Figure 1. PERFORMANCE OF TROPICAL GRASSES UNDER GRAZING AT CPAC, NEAR BRASILIA, BRAZIL.(Source: Thomas and de Andrade 1984[b])

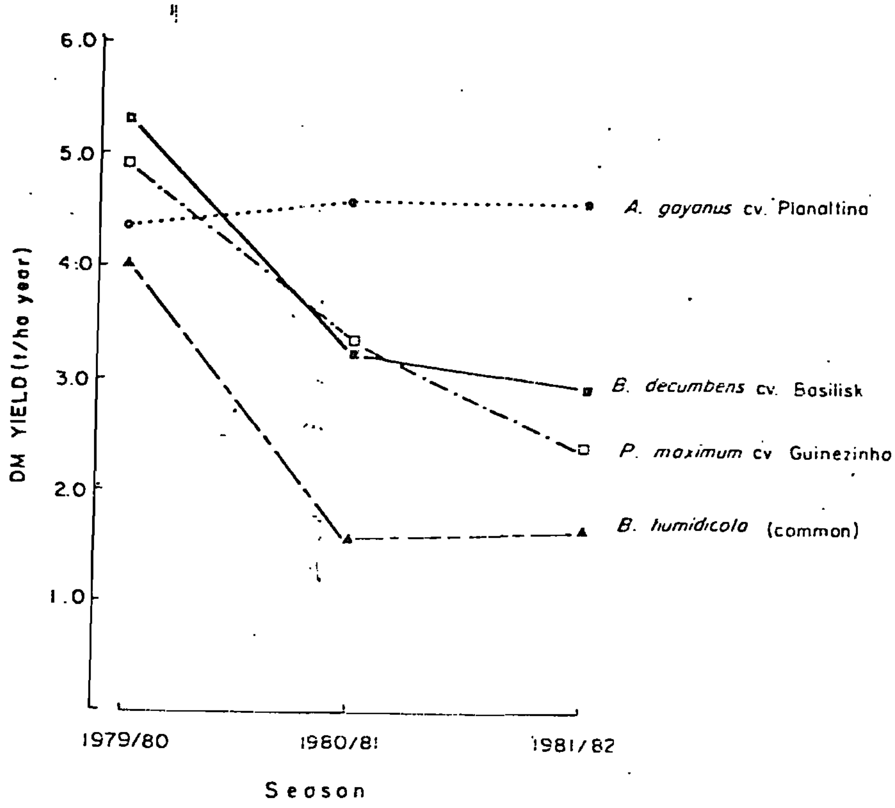

Figure 2. Animal liveweight gains on *Andropogon gayanus* alone and in association with ecotypes of *Stylosanthes capitata* or *Pueraria phaseoloides*. Stocking rates used in the experiment were one animal/ha during the dry season and two animals/ha during the rainy season. (Source: CIAT 1983).

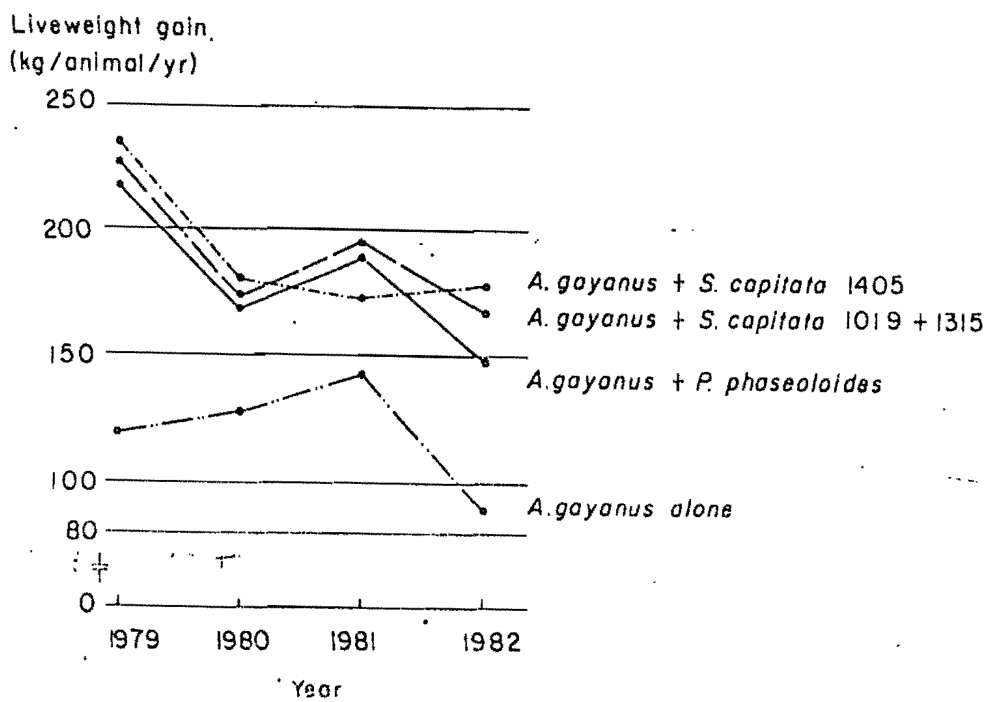

Table 1. Liveweight gains on *Andropogon gayanus* under continuous grazing in Carimagua, Llanos Orientales.

Treatment	1979 Season			1980 Season		
	Stocking rate (animal/ha)	Liveweight gains (368 days)		Stocking rate (animal/ha)	Liveweight gains (362 days)	
		per animal (kg)	per ha (kg)		per animal (kg)	per ha (kg)
High	4.4	90	396	1.0	77	248
Medium	3.4	115	391	1.5	126	451
Low	2.4	119	285	2.0	153	359

(Source: CIAT 1981)

Table 2. Seed production potential of two species of *Brachiaria*, Carimagua, Llanos Orientales.

Species	yield kg/ha.	Caryopsis content %	No. of seeds per kg
B. dictyoneura CIAT 6133	405.20**	44**	200.000
B. humidicola CIAT 679	286.40	18	250.000

** P = 0.01

(Source: CIAT 1982).

Table 3. Average liveweight gains (1976-1979) on Brachiaria decumbens under continuous grazing in Carimagua.

Treatment	Average: Stocking rate (A.U./ha)	Gain per animal (kg/A.U./year)	Gain per hectare (kg/ha/year)
Fixed stocking rate	1.7	116	176
Variable stocking rate (rainy season)	0.73/3.0[1]	127	235
Variable stocking rate (dry season)	1.0/2.0	146	266
Average		130	

(1) Dry season/rainy season, respectively

(Source: CIAT 1981)