

THE CONTRIBUTION OF PLANT INTRODUCTION TO PASTURE DEVELOPMENT IN THE WET TROPICS OF QUEENSLAND

W. A. T. HARDING*

ABSTRACT

The emergence of a viable cattle fattening industry in the high rainfall tropics of north Queensland is a direct consequence of the introduction and development of suitable pasture species. Before 1940, introduced grasses were used to raise productivity but legumes were needed for sustained production.

*Testing revealed a promising group of tropical legumes—*Centrosema pubescens*, *Stylosanthes guyanensis* and *Pueraria phaseoloides*. Pastures based on these legumes with either *Panicum maximum* or *Brachiaria mutica* were commercially successful, but these species still had a number of deficiencies. During the past decade new species or cultivars were sought, specifically to improve seasonal distribution of growth, to exploit fully the favourable growing conditions and to improve resistance to grazing pressure.*

*Replacement cultivars of *C. pubescens* and *S. guyanensis* and another legume *Desmodium heterophyllum* were released in 1971, and an introduction of *P. maximum* is in an advanced stage of testing.*

Mixed pastures have been developed for most ecological situations.

INTRODUCTION

The high rainfall zone of north eastern Queensland is a narrow strip of country lying between the coastal ranges and the sea. It receives more than 1500 mm mean annual rainfall and includes the area from Cape Tribulation ($15\frac{1}{2}^{\circ}\text{S}$) in the north to Bambaroo (19°S) south of Ingham. Results obtained are also applicable to the areas of Cape York Peninsula and the Mackay/Proserpine area which receive annual rainfall of more than 1500 mm.

Precipitation is mainly of summer incidence, South Johnstone for example receiving 50% of its 3204 mm annual rainfall in January, February and March. Rainfall is lowest and least reliable in spring. Temperatures are usually favourable for pasture growth throughout the year. The mean maximum and minimum temperatures at South Johnstone are 23.6°C and 13.7°C in July and 30.8°C and 21.8°C in December. Light frosts are experienced in more southern areas.

Native pastures, where these occur, are in open forest and tea tree country as well as on small areas of treeless plain. They consist principally of species of *Imperata*, *Heteropogon*, *Themeda*, *Aristida*, *Eragrostis*, *Ischaemum* and *Panicum*. These pastures have very low carrying capacity and usually only fatten over the four wettest months of the year.

Pasture development for dairying commenced on a small scale towards the end of the 19th century. Further pastures were developed in the Daintree area and around Tully following increasing interest in cattle fattening, especially for the export trade in chilled beef in the 1930's. In all these developments only grasses were planted, the main species being para (*Brachiaria mutica*), guinea (*Panicum maximum*), and molasses (*Melinis minutiflora*). The initial fertility of, and production from, the cleared scrubs was high but deterioration of these grass-based pastures occurred with loss of nitrogen. It became necessary to develop legume

*Department of Primary Industries Research Station, South Johnstone.

based pastures since they offered the cheapest method of raising the nitrogen nutrition of the pasture and the dietary protein of the grazing animal. In order to exploit fully the high rainfall and frost free conditions, it has been necessary to introduce new plants which are suited to intensive grazing and to the many ecological conditions which exist in the region. It is necessary also to maintain a wide range of material which may be used in the event of failure of an important species due to pests or diseases. Suitable grass-legume mixtures are now available for most situations in the wet tropics.

SOUTH JOHNSTONE PLANT INTRODUCTION

The Queensland Department of Agriculture and Stock* commenced investigations into pasture problems at the South Johnstone Research Station in the late 1930's. Over 1100 pasture introductions have since been made and of these 44% occurred in the past six years, reflecting the increased awareness of the need for improved pastures.

Introduction in the pre-war period

The first introductions included temperate, sub-tropical and tropical legumes. The temperate legumes (*Medicago*, *Trifolium* and *Lespedeza* spp.) were unsuccessful but the tropical legumes thrived (Schofield 1941). Of these the most successful were centro (*Centrosema pubescens*), stylo (*Stylosanthes guyanensis*), puero (*Pueraria phaseoloides*), and calopo (*Calopogonium mucunoides*).

The results of a series of cutting trials on a range of grasses indicated the species considered suitable for development as pasture types (Schofield 1944). Most exhibited marked seasonability of production. Among those which acquired commercial value at that time or later were *Brachiaria decumbens* (signal grass), generally the highest yielding, *Panicum maximum* var. *typica* (common guinea), *Melinis minutiflora* (molasses) and *Brachiaria mutica* (para).

Other grasses in the trial were rejected because of low productivity, unavailability of seed, or poor competitive ability. These included *Cenchrus ciliaris*, *Digitaria milanjiana*, *Paspalum dilatatum*, *Pennisetum clandestinum*, *Cynodon plectostachyum*, *Urochloa bolbodes*, *Hyparrhenia aucta*, *Chloris gayana* (C.P.I. 6585 and C.P.I. 6586), and *Panicum maximum* Q 1200, Q 1202, vars *trichoglume* and *coloratum* and two unnumbered introductions.

Introduction in the 1940's and 1950's

The number of new introductions during this period was small, and only pangola (*Digitaria decumbens*), elephant grass (*Pennisetum purpureum*), and Hamil (*Panicum maximum*) were added to the recommended list. New legumes considered promising included *Desmodium heterophyllum*, *D. canum*, *D. scorpiurus* and *Vigna hosei*. Palatability of a range of tropical legumes was tested as many were originally plantation cover crops and grazing experience with them was minimal. The rating order for palatability was:—puero, *V. hosei*, centro, *D. heterophyllum* and calopo (Graham 1951).

Several mixtures were selected according to anticipated compatibilities and adequate seed supplies (Graham 1951). After seven years in grazing trials at Utchee Creek (the nearby sub-station of South Johnstone) the mixtures considered most promising were guinea/centro, guinea/puero and para/puero. Mixtures containing molasses grass or stylo were insufficiently vigorous on these highly fertile soils (De Brey pers comm). Highest stocking rate (2.7 head/ha) and liveweight gains (682

*Now Department of Primary Industries.

kg/ha) were obtained on the guinea/centro pasture. The inclusion of centro resulted in higher stocking rates and gains than those obtained from guinea grass alone. These pastures were capable of fattening at least 2.5 head per hectare per annum (De Brey pers comm).

By the end of the 1950's, pastures had been developed for country with soils of moderate to high fertility and confident recommendations could be made. Molasses grass was used as a pioneering species and the permanent grasses included para for wetter areas and guinea for better drained sites. The legumes recommended were centro and puero, with stylo for steeper and poorer lands. An 18 month old steer coming on to the pastures could be turned off in under 12 months as a high quality fat bullock (Walsh 1959).

Introduction in the early 1960's

Better prices for beef brought an upsurge in interest in cattle fattening and more interest was shown in country with infertile soils.

The key to development of the coastal forest country was superphosphate. Economic returns from beef, cheap land clearing by high powered machinery, successful grass-legume mixtures and effective regrowth control also contributed to the economic development of the poorer soils (Teitzel 1969a). Mixtures containing common guinea with centro, stylo and puero were successful in the granite sands carrying open forest (Grof and Harding 1970a). On the less well drained country Hamil was substituted and para was used in wet or poorly drained situations.

By the mid sixties information on the basic grass-legume mixtures was available and deficiencies of existing species recognised. These were mainly associated with seasonal habit of growth. Pastures were stocked to suit periods of slowest growth which occurs over the cool season. The tremendous production over the summer "wet" was under-utilized and largely wasted. In the legumes, better competitive ability with vigorous grasses and persistence coupled with high yield over the whole season were required. Lack of useful variation in the existing and new introductions hampered improvement of commercial cultivars.

Introductions in the post 1965 period

The first plant collecting mission specially aimed at finding pasture plants for the wet coastal areas was undertaken by Dr Bela Grof. Following collections made in 1965 in Central and South America, Ghana, Kenya, Nigeria, Malaysia and the West Indies, over 500 introductions were received at South Johnstone. The characterization and testing of these accessions has been the main work since 1965. Subsequently, in co-operation with C.S.I.R.O., some 150 accessions of *Stylosanthes* spp. (including 53 of *S. guyanensis*) were grown at South Johnstone, Lansdown and Samford (Burt et al, 1971).

As a result of this work, one new centro cultivar (Belalto) and two stylos (Cook and Endeavour) have been released as replacement cultivars for centro and Schofield stylo respectively. Another legume, *D. heterophyllum*, has also been released.

Centrosema

About 60 introductions have been made, mainly of *C. pubescens*. Common centro, originally described by Schofield (1941), is highly persistent in grazed swards and is adapted to soils of medium to high fertility with fair to good drainage in high rainfall frost free environments (Walsh 1958). In addition to raising nitrogen in the associated grass and protein in the diet of the grazing animal (Walsh 1959), the inclusion of centro has maintained organic matter and nitrogen fertility (Bruce 1965). An undesirable feature is its sensitivity to low temperatures. During the cool season, growth rate and nitrogen fixation decline greatly or cease altogether (Bowen

1959), and the plants are susceptible to plant pathogens and insect attack. A cultivar with better cool season growth and strong stoloniferous development was required (Grof pers comm).

One introduction of *C. pubescens*, Q 8333 from Costa Rica, exhibited consistently better cool season growth and higher annual yields than common centro. It was less susceptible to damage by red spider mite and *Cercospora* leaf spot over the cool season. It was also more resistant to weed invasion (Grof and Harding 1970b).

Under grazing with guinea grass, it survived better than common centro and *C. brasilianum* Q 8216 (Harding and Cameron 1972). This was attributed to its greater overall vigour and its twining and trailing growth with well developed stolons. It has been successfully introduced by sod seeding into a legume deficient guinea pasture (unpublished records—Queensland Dept. of Primary Industries). It was released as Belalto centro, and seed should be available in commercial quantities by the 1972/73 season.

Other species included *C. plumieri* which establishes readily and has good early vigour but does not tolerate cutting; *C. brasilianum* which gave high annual yields but lower winter yields than Belalto centro; *C. virginianum* which produced only moderate bulk but had a sprawling growth habit with a strong tendency to root at the nodes. The latter two species have been successfully hybridized. The growth of the hybrids was superior to that of the parents and heterotic effects were evident in greater stolon development and in better disease and insect resistance (Grof 1970).

Stylosanthes

S. guyanensis cv. Schofield is the most successful legume for the infertile soils supporting coastal eucalypt and tea tree forest, and it has the capacity to associate effectively with guinea grass cultivars or with creeping grasses provided the pasture is kept short (Gilchrist 1967). It does not tolerate frequent close grazing especially in conjunction with vigorous stoloniferous grasses like pangola or *Brachiaria decumbens*. Vegetative growth is slow during its flowering and seeding period which extends from June to October (Grof pers comm).

A total of 170 introductions were grown and tested. In order to permit intensive use, high yielding types were sought which would produce a large number of leafy branches close to ground level. Superiority of the decumbent over the erect stylos in yield and persistence under cutting was the direct result of better survival of the decumbent form. This was attributed to a greater concentration of leaves in the basal region of the decumbent growth form (Grof, Harding and Woolcock 1970). However, the decumbent types which have been tested (Q 8442 and C.P.I. 41218) still have a pronounced warm season growth pattern.

One accession, Q 8558, introduced in 1965 from south west Guatemala, showed superior growth over the early summer period, gave higher annual yields than Schofield stylo and was more competitive with associated grasses. It has been released as Endeavour stylo (Harding and Cameron 1972).

From the co-operative trials with C.S.I.R.O. in 1967 and 1968 and subsequent sward trials under cutting and/or grazing, *S. guyanensis* C.P.I. 38754 cv. Cook (introduced from Colombia) was selected as a potential replacement for Schofield stylo. It is a mid-season type, flowering in May. In a cutting trial, it did not enter a fully reproductive phase as did the early and late flowering types. During the reproductive phase of these stylos the plants are dormant with little vegetative growth. In a cutting and grazing trial with associated grasses, it outyielded Schofield, Endeavour and 3 other stylos (C.P.I. 33437, C.P.I. 41218 and Q 8442) over the whole season. Additionally, it was more competitive than the other stylos (Harding and Cameron 1972). Seed of Cook stylo is in the process of certification as a new cultivar. Commercial quantities of seed should be available by 1972/73.

Pueraria

P. phaseoloides (puero) is suited to almost the whole range of soil fertility and drainage situations on the wet coast. Its twining, trailing and strongly stoloniferous growth habit enable it to combine with either tufted or decumbent grasses (Grof pers comm).

It is highly palatable and under continuous heavy stocking is easily grazed out (Graham 1946 and Walsh 1958). Once it is fully established over a whole paddock, persistence is not a problem (Teitzel 1969b) and it may become a major component of the pasture when rotationally grazed (De Brey pers comm). Because of its susceptibility to overgrazing, it is probably best not to use it as the sole legume in a pasture.

There has been little variation in apparent seasonal growth rates among the ten introductions at South Johnstone. Two, Q 6993 and C.P.I. 29497, were selected for seed increase as they are marginally more vigorous than the commercial line (Harding—unpublished data).

Glycine

G. wightii cv. Tinaroo grows reasonably well in the cooler months on the fertile well drained soils. When planted with other legumes, such as centro, more legume is available over the whole season. However, in common with other *G. wightii* introductions it is susceptible to leaf fungal diseases during the wet season.

About 20 introductions have been tested. At Utchee Creek, two introductions (C.P.I. 18103 and C.P.I. 28279) grew very well and completely suppressed green panic under grazing (Gilchrist pers comm). One of these, C.P.I. 28279, is showing promise in the Atherton Tableland where it apparently has wider adaptability than Tinaroo (Walker pers comm.). It may find a place in well drained or drier situations in East Palmerston and Ingham pastures in combination with other legumes.

Desmodium

Within this genus, there is a very wide range of growth forms. The 130 introductions grown (Grof pers comm) have included tall shrubby, semi-decumbent and prostrate types. The shrub or browse desmodiums like *D. distortum* and *D. asperum*, although having potentially high yields, are short lived and do not fit into existing pasture systems. The medium growth forms, such as the semi-decumbent *D. intortum*, usually grow well in the first season but rapidly deteriorate due to leaf fungal diseases and "legume little leaf" virus. Low growing types such as *D. scorpiurus* and *D. canum*, while having desirable stoloniferous growth habit, thrive only in lighter, well drained soils (Grof pers comm).

One interesting plant rediscovered in recent years has been *D. heterophyllum*. It originated in S.E. Asia but is indigenous or naturalized in areas such as Taiwan, Ceylon and Fiji. Introduced in 1945 from New Guinea it was included in early legume trials and recognised as potentially useful with the stoloniferous grass *Brachiaria miliiformis* (Graham 1948). Although dry matter yields do not appear to be high, it is an efficient fixer of nitrogen and is able to colonise and associate effectively with closely grazed or low growing grasses. *D. heterophyllum* has shown great promise in combination with pangola grass in grazing trials at South Johnstone (Harding and Cameron 1972). The major problem is to obtain sufficient seed for large scale sowing but planting by vegetative means is practicable.

Calopogonium

C. mucunoides (calopo) was one of the earliest introductions tested (Schofield 1941). It is short lived and unpalatable to stock (Walsh 1958). In all, 13 accessions of the genus have been studied. Of these *C. coeruleum* C.P.I. 28107 showed some promise with higher cool season yields than centro and high annual yields (Harding

—unpublished data). It also has a desirable twining and trailing growth habit with strong stolon development. It is only suited to areas of high fertility and good drainage where *Belalto centro* grows equally well.

Vigna

Of the 38 introductions tested two are available as pasture legumes. These are *V. hosei* (Sarawak bean) and *V. luteola* (Dalrymple vinya). *V. hosei* associates effectively with short growing grasses but is easily grazed out and gives variable performance due to disease and insect attack. Dalrymple vinya establishes quickly and gives good early growth (Davidson 1966). It is susceptible to overgrazing and dry conditions but associates well with para in some situations. All the vinyas tried were susceptible to insect and disease attack.

Other Legume Genera

Leucaena leucocephala grows well at South Johnstone and Utchee Creek. Efforts to establish and maintain pure stands or stands in association with different grasses have failed due to weed and management problems. As with the *Vigna* species, plants of the genera *Phaseolus* (40 introductions), *Dolichos* (15) and *Teramnus* (20) establish quickly but usually fail due to fungus or virus diseases. Of these, *Rhizoctonia solani* affects *Macropodium atropurpureum* (formerly *Phaseolus atropurpureus*) and "legume little leaf" affects *Macrotyloma axillare* (formerly *Dolichos axillaris*) and *Lotononis bainesii*.

Panicum

Most of the 55 panics grown have been *P. maximum*. Their compatibility and long term persistence with legumes in grazed swards, ease of establishment from seed and good response to fertilizers are distinct advantages. On the other hand their rapid growth rate in summer and subsequent deterioration result in management problems. This applies especially to the "giant" guineas like *coloniao* or *Hamil*.

The fine stemmed guineas like *Gatton*, *Petrie* and *Sabi* panics and creeping guinea are insufficiently vigorous in wet coastal pastures, as also are the varieties of *P. coloratum* (Teitzel pers comm).

One introduction of guinea, C.P.I. 37910, shows superior growth over the cool season with only moderate growth during the "wet" (Grof and Harding 1970a). Of medium height (1.5-2m), it produces a large volume of leaf with few inedible stems. These advantages should allow more latitude in its management and result in better use of wet season growth. Obtained from Kitale Research Station, Kenya as cv. *Makueni*, it is morphologically distinct from other commercial varieties used on the wet coast in that practically the whole surface, including the exposed stem, is covered in short dense hairs. The spikelets are also covered with short dense hairs and have a purplish tinge. (Harding—unpublished data.)

Brachiaria

B. decumbens (signal grass) was introduced to South Johnstone in 1936 and was included in early cutting trials where it exhibited ability to produce high yields (Schofield 1944). It grows on most soils but does not tolerate flooding. The more important wet coastal grasses, pangola, para, *Hamil* and common guineas, and *B. ruziziensis* were outyielded by signal grass (Grof and Harding 1970a). It withstands high grazing pressures and is an ideal grass for smothering weeds (Walsh 1959). It responds well to fertilizer nitrogen, giving good dry season responses, and both dry matter yields and nitrogen percentages are increased (Grof pers comm). Initially its adoption was hampered by lack of understanding of germination requirements of its seed. Only recently has it been shown to produce viable seed (Grof 1968). In general, seed stored for at least 10 months has a reasonable germination.

B. mutica (para) remains the best grass for wet situations. Centro, stylo and pueru grow well with it. It also responds to fertilizer nitrogen. Although cuttings are usually used for planting, high quality seed can be obtained with correct cultural treatment (Grof 1969a).

B. ruziziensis (Kennedy ruzi) is highly palatable, high yielding in both dry matter and seed, and resists heavy grazing pressure (Davidson 1966). However, it does not appear compatible with commercially available legumes, its winter growth is comparatively slow and it is only suited to well drained fertile soils (unpublished records—Queensland Dept. of Primary Industries). Now that seed of signal grass is readily available it should no longer be considered.

Digitaria

D. decumbens (pangola) has an aggressive stoloniferous habit, withstands heavy grazing pressures, responds well to fertilizer nitrogen and smothers weeds. It is usually planted in situations too badly drained for the guinea grasses or signal grass and where soils are too poor and quick drying for para (Mortiss 1971). In the past ten years pangola grass has proved a most valuable species in the wet tropics but in recent wet years production has been adversely affected by aphids (*Schizaphis* sp) and rust (*Puccinia oahuensis*) (Teitzel et al. 1972). It has been difficult to keep an adequate proportion of most tropical legumes in association with it except under moderate grazing; and *Desmodium heterophyllum* is the only legume compatible with pangola under heavy stocking pressure. High production has necessitated the use of fertilizer nitrogen. Vegetative planting is necessary but some very successful methods have been evolved (Mortiss 1970). Introductions of *D. decumbens* and *D. pentzii* which set fertile seed were among 45 accessions of the genus tested under cutting. Two lines (Q 10249 and Q 10250) were as high yielding as pangola, but did not produce the aggressive stolons of pangola nor did they grow as well on poorer soils (Harding—unpublished data).

Pennisetum

Most of the 32 introductions have been of *P. purpureum* (elephant grass). These are seasonal in growth, producing high yields in the wet season. They do not stand heavy grazing and their role will be as supplementary grazing or cut forage. The common form, naturalized in many parts of coastal Queensland, is an early flowering fibrous stemmy type. Several introductions which have shown some promise include a seedling selection of the Merker variety released as Capricorn elephant grass from Biloela Research Station (Grof 1969b). This is high yielding, very palatable and in combination with centro gave higher liveweight gains than guinea/centro. In wet conditions it does not persist under grazing. C.P.I. 20464 (R) is another line selected from seedling populations resulting from chance crossing, in this instance of the Cameroon variety. A vigorous type, it outyielded common elephant grass and all other seedling progenies (Grof 1969b).

Paspalum

Some 32 introductions have been made in this genus. *P. plicatulum* cv. Rodd's Bay has been the main cultivar planted in trial and observation areas on the wet coast. On infertile coastal soils at Silkwood it yielded as well as pangola and signal grass although its cool and dry season yield was lower than that of signal grass, and its phosphorous content was low (Harding—unpublished data). Another introduction, *P. coryphaeum*, showed similar growth pattern to Rodd's Bay *plicatulum* but seedling vigour was low. Its phosphorous content was higher. From these tests, the species were found particularly well suited to infertile coastal soils which are flooded in the wet season and then dry out rapidly. (Harding—unpublished data.) They are compatible with stylo, the preferred legume in these situations. High seed yields

are obtained. Accessions with higher cool season yields and better nutritive values would be useful.

Setaria

The *S. anceps* accessions have been inferior to other grasses in use. They have good cool season growth but are not adapted to the hotter months (Teitzel and Mortiss 1971). *S. splendida* (C.P.I. 15899) has been impressive in most situations. It may even be too vigorous for successful combination with available legumes so that a lower quality pasture results. Dry matter yields are high but it does not produce fertile seed and can only be successfully planted by stem cuttings.

Melinis

The introductions in this genus have all been *M. minutiflora* (molasses grass). Little variation of any significance was apparent. Molasses grass has almost disappeared from the scene in sown pastures except in isolated cases where it is used as a pioneer grass to provide fuel for burns in felled scrub.

CONCLUSION

Grasses which give higher yields of digestible nutrients and animal products per acre at high fertilizer efficiency should be sought. Higher dry season yield is probably a better goal than higher total yield. Stocking rates in any case are limited climatically. In the latter part of the wet season pugging of pastures occurs at stocking rates in excess of 5 head per hectare.

In the legumes, ability to produce well under grazing, with good survival and greater competitiveness with grasses is required, rather than total dry matter production. At this stage new cultivars are available which require testing under a wide range of environments to further delineate their areas of usefulness. Additionally, it is important to learn how to manage these cultivars for optimum production.

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