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The role of genetic resources in developing improved pastures in the humid zone of northern Australia

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Abstract

The value of introduced tropical forages to the grazing industries of the Australian tropical and subtropical humid zones is discussed. Pasture legumes which were released in the early years of improved pasture development often failed to persist, mostly due to overstocking which, in turn, was influenced by factors such as low beef prices, adverse seasons and inadequate maintenance fertiliser. There is a continuing need for cultivar development to meet changes in requirement and to overcome deficiencies identified in existing cultivars.

The historical development of perennial *Arachis* as a forage in Queensland is briefly reviewed to illustrate research pathways, and suggestions made for the further development of this genus. It is concluded that there is a continuing need for a tropical forage genetic resource to service the needs of Australian industries in the humid zone, and that reliance on genetic resource centres overseas is not a viable option.

Introduction

The humid zone in northern Australia extends along much of the east coast and also takes in the north-western portion of the Northern Territory around Darwin. Generally, it could be considered as those areas receiving an average annual rainfall in excess of about 900 mm south of the tropic and about 1200 mm north of the tropic. Soils in the zone are predominantly podzols, podzolics, soloths and solodics, interspersed with areas of red and yellow earths, krasnozems and prairie soils. All but the krasnozems and prairie soils have low phosphorus status, and many have multiple deficiencies, especially of potassium, sulphur and molybdenum. Native vegetation ranged from heath and heath woodland on the podzols and podzolics of the coastal lowlands, through eucalypt woodland and forest on the lower fertility soils to rainforest on the krasnozems. Much of the original rainforest and large tracts of the sclerophyll forest have been cleared for agricultural production.

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Land use

Major rural industries in the zone are sugar, beef, dairy, forestry, fruit and vegetables. The livestock industries are relegated largely to those areas where soils and/or topography preclude some form of cropping.

Unimproved pastures

Beef is produced largely from native pastures based predominantly on rangelands, generally dominated by *Heteropogon contortus* and, to a lesser extent, *Themeda triandra*, and from areas of naturalised species such as *Bothriochloa pertusa*, *Digitaria didactyla* and *Axonopus affinis* (these species were introduced in the 1930s, early 1900s and late 1800s, respectively). Beef production from native pastures is limited by carrying capacity of the pastures and the length of season over which quality forage is produced. At stocking rates of 3–8 ha/adult equivalent, growth rates ranging from 70–220 kg/hd/yr have been achieved, depending on soil fertility and condition of pasture.

Native and naturalised pastures in the humid zone are generally incapable of producing the desired levels of liveweight gain in dairy heifers or economic levels of milk production. It has been shown that total milk production over the first 3 lactations is increased by over 20 kg for each additional kilogram liveweight at first calving. Few farmers attempt to produce milk from cows grazing native pasture, but dairy herds quite commonly graze areas of unimproved naturalised pasture. Production from these pastures varies markedly depending on species present and soil fertility, but may be as low as 2000 L/cow. Milk production is extremely sensitive to quantity and quality of feed on offer.

Improved pastures

It has been recognised for a long time that introduced species can have the same beneficial effect on animal production in the tropics that temperate introductions had in the southern states. Of the perennial warm-season species, grasses were the earliest introduced. Paspalum (*Paspalum dilatatum*), which is now naturalised over large areas of the humid subtropics, was introduced in the early 1870s by Baron von Mueller (Barnard 1969), reaching Queensland in 1896. Another grass now widely naturalised in this zone is molasses grass (*Melinis minutiflora*) introduced in the 1900s (Barnard 1969). The earliest warm-season legume introductions, all introduced in the 1930s, were the twining species, calopo (*Calopogonium mucunoides*), centro (*Centrosema pubescens*) and puero (*Pueraria phaseoloides*). Some species were accidentally introduced; for example, Townsville stylo (*Stylosanthes humilis*) arrived in north Queensland prior to 1913 (Humphreys 1967). This early low level of introduction accelerated during the 1940s and has continued with varying intensity to the present (Eyles *et al.* 1985; B.C. Pengelly, personal communication). Evaluation of this introduced material led to the release of about 20 warm-season cultivars suited to the humid zone in the 1960s and a similar number in the 1970s. Approximately 25 have been released in the 1980s and 1990s (Hacker 1997).

Impact

The release of these varieties has produced a dual benefit to farmers — increased production from improved pastures and an alternative source of income from pasture seed production. Introduction of a legume into native pastures can increase annual liveweight gain/head by 10–50 kg, but does not improve carrying capacity significantly. Carrying capacity can be increased using introduced grasses, particularly with the addition of nitrogen fertiliser or a vigorous nitrogen-fixing legume.

Improved liveweight gains from introduced pasture species are also important in dairying, remembering the impact of liveweight at first calving on subsequent milk production. However, the overall effect of improved pastures on milk production is more dramatic, with 3500 kg milk/cow/yr being achievable on grass-legume pasture alone, usually with a stocking rate of 1 cow/ha. Higher production per hectare can be achieved using nitrogen fertiliser and increased stocking rates, although it is recommended that stocking rate on nitrogen-fertilised grass pasture should not exceed 2.5 cows/ha to minimise the animal's weight loss. It should be noted that production responses to introduced species are partly attributable to the effect of the fertiliser that is often necessary for successful performance of these plants.

Pasture seed production is an obvious prerequisite to obtaining these benefits. Seed production of warm-season species is largely carried out on the Atherton Tableland and coastal southern Queensland, although substantial amounts are also produced in central Queensland. Table 1 presents estimates of annual seed production of the major species and species groups as reported by Loch (1995).

Table 1. Estimates of annual seed production of warm-season forages in Australia (Loch 1995).

Species	Seed production (t)
Grasses	
Cenchrus spp.	500+
Chloris gayana	400
Sorghum hybrid cv. Silk	400
Panicum coloratum	200
Panicum maximum	150
Axonopus affinis	150
Brachiaria decumbens	100
Setaria sphacelata	75
Setaria incrassata	60
Pennisetum clandestinum	50
Bothriochloa/Dichanthium spp.	35
Other tropical grasses	100
Legumes	
Lablab purpureus	600+
Vigna unguiculata	300+
Stylosanthes spp.	250
Aeschynomene spp.	50
Neonotonia wightii	30
Chamaecrista rotundifolia	30
Other tropical legumes	60

The continuing need

Although many cultivars were evaluated in grazing experiments prior to release, results from experiments did not always translate to commercial benefits. Research demonstrated the benefits to be had from pasture improvement, indicated appropriate levels of stocking and demonstrated responses to fertiliser application. However, a number of factors have influenced the success of the tropical grass-legume technology as initially proposed. Early work showed that raingrown pastures in coastal areas based on twining legumes could carry 1–2 beasts per hectare year-round, but grazing patterns by herds in large paddocks proved to be different from those in small experimental paddocks. Cattle, particularly *Bos indicus*, tend to graze in groups, putting greater pressure on some areas of the paddock than others. They also tend to return to areas where regrowth is short and succulent. This placed great strain on the twining legume that could not tolerate the regular defoliation. As the legume succumbed to grazing pressure, nitrogen injection into the forage system was reduced and pasture productivity declined, with the result that pressure increased further, causing a downward spiral. Many of the large pasture developments along the east coast proved unsustainable even in good seasons, using recommended stocking levels and grazing and fertiliser management. Without back-up areas available, legume-based pastures lasted in a productive state no more than 5–7 years. Pasture longevity was also influenced by climate and markets. At times over the last 30 years, rainfall in much of the designated region has been well below average. Successive years of markedly below-average rainfall caused reduction in plant growth with a consequent increase in grazing pressure, and accelerating pasture decline.

Another factor which, over recent years, has influenced persistence of legume-based pastures has been beef prices. These fluctuate markedly depending on world demand. When prices are low, there is a tendency for farmers to retain cattle in the hope markets will improve. Once again, this increases the pressure on the pasture with the same inevitable result. Also, when beef prices are low, farmers tend to reduce spending on pasture maintenance fertiliser. This has been a contributing factor to pasture decline.

It has become obvious that there was much more to pasture success than good science and an effective extension program. The technology had to be appropriate to the needs of industry, and the basic component of the technology was the species. These not only had to be adapted to soil and climatic variables of the region but also had to have sufficient elasticity to tolerate the pressures imposed as a result of changing market values — they also had to be productive. This becomes even more complex when one considers that each of the grazing industries has different requirements. Beef cattle, while needing reasonable quality forage, do not have the same high demands as dairy cattle. Dairy farming produces a more predictable and profitable (on a per hectare basis) income than beef farming. Consequently, dairy farmers are more likely to spend the money necessary to produce and maintain productive pasture. Regular movement of dairy stock enables farmers to adjust grazing pressures more readily through the use of a greater number of smaller paddocks than can beef producers who traditionally have less subdivision. The other minor industries also have specific needs. Horses are subject to big head disease (*Osteodystrophia fibrosa*) if grazing forage which is high in oxalate. Goats prefer browse. Deer have requirements more similar to those of dairy cattle.

However, in all cases, the productivity of the pasture is dependent on the nitrogen source, be it legume or fertiliser. While fertiliser nitrogen is an easily managed option, it is not widely accepted, mostly due to cost and farmer perceptions of profitability, and in recent years, concerns over its effect on the environment. Legume-based pastures are largely the more attractive option to farmers, but for legumes to function effectively, they must be persistent, and as described above, many cultivars released in the past have been unreliable in this regard.

During the late 1970s, the research effort began to place more emphasis on persistence under commercial management, rather than using dry matter yield as the prime criterion of merit. Researchers started to take note of those species that had persisted at old evaluation sites but had been rejected on the basis of low dry matter yield. It should be noted that yield evaluations often involved cutting at 10–15 cm at infrequent intervals, a system that tended to favour twining legumes such as siratro (*Macroptilium atropurpureum*) but would almost certainly have rejected many of the useful temperate species such as white clover (*Trifolium repens*). One species that a south-east Queensland research report from the late 1960s dismissed was *Vigna parkeri*, favouring *Desmodium intortum*, which was much higher yielding in the experiment. However, it soon became apparent that the *Vigna* was spreading on the co-operator's farm and the *Desmodium* had died out. Not only this, the same species, and probably the same accession, had colonised the nearby Beerwah Research Station. The Beerwah ecotype was released in 1984 as cv. Shaw, based almost entirely on its ability to persist and spread. This has become a popular variety among dairy farmers in south-east Queensland and northern NSW, the major limitation to wider adoption in the humid zone being seed production.

Arachis — a recent success story for the humid zone

One genus that has risen to prominence as a result of revisiting old evaluation sites is *Arachis* (Cook *et al.* 1994). The first perennial species of *Arachis* were planted by J.F. Miles at Fitzroyvale near Rockhampton in the late 1930s (Miles 1949). These were *A. prostrata* CPI 6930, *A. nambyquarae* CPI 6929 and *A. diogoi* CPI 8987-8. Almost certainly, these epithets were applied to different species from those to which they are currently applied by Krapovickas and Gregory (1994). Despite years of heavy grazing and no fertilisation, there is a population of *Arachis* at the site today covering an area considerably larger than the original plot size, and growing among competitive grasses such as *Paspalum notatum*, *Brachiaria decumbens*, *Bothriochloa inscuplta* and *B. pertusa*. It is uncertain and perhaps irrelevant which of the above accessions this is. The fact remains this variety, now recognised as *A. paraguariensis* CQ 1780, has persisted for about 60 years.

Miles' success with *Arachis* was sufficient to prompt William Hartley to collect wild *Arachis* during his plant collection trip to South America in 1947-48 (Hartley 1949). A rhizomatous accession introduced by Hartley, *A. prostrata* (now *A. glabrata*) CPI 12121, still persists from plantings during the 1960s, at sites extending from Topaz in the north to Samford in the south. Despite the excellent persistence of CQ 1780 and CPI 12121 and other rhizomatous accessions, CPI 19898, 22762, 29986 and 29987, work on *Arachis* did not proceed, probably due to concerns that wild types may carry diseases of the commercial peanut, *A. hypogaea*. As perceptions of merit changed, and as researchers became increasingly aware of the useful characteristics in *Arachis* (tolerance of low fertility and heavy grazing, high quality forage), attention was once again focussed on the genus, commencing in the 1970s. The collection of wild types held by the Australian Tropical Forages Genetic Resource Centre was expanded from 8 accessions in 1962 to over 60 accessions currently. All those available for testing by 1985 were screened at Kingaroy for susceptibility to early leaf spot (*Cercospora arachidicola*), late leaf spot (*Cercosporidium personatum*) and rust (*Puccinia arachidis*), the 3 most damaging fungal diseases of commercial peanut. Resistant lines were further evaluated and susceptible lines rejected.

To date, one cultivar of *A. pintoi* (cv. Amarillo) and one of *A. glabrata* (cv. Prine), have been released as a result of the renewed research activity. An accession of *A. paraguariensis* is showing promise in areas of lower rainfall and a recent introduction of *A. pintoi* appears to have considerable superiority over cv. Amarillo. Due to the diversity within this genus, other cultivars are likely to be released fulfilling roles not only as forages, but possibly also as ground cover or soil conservation species and as ornamentals.

Conclusion

In agriculture, no situation is static — perceptions, needs and wants change; market pressures change. Today's sound forage technology may be inappropriate under an alternative set of conditions — increasing fertiliser prices, declining export beef market, or the development of undesirable nutrient levels in streams due to excessive fertiliser use. Relatively weak, tufted perennials may prove incapable of suppressing invasive weedy introductions such as giant rats tail grass (*Sporobolus pyramidalis*). Alternative species may therefore be required to replace species that require high fertiliser inputs, or to provide stronger competition for the invasive weeds. More competitive legumes may then be required to combine with the more competitive weed-suppressing grass. Alternative varieties may also be necessary to replace commercial varieties ravaged by disease, for example anthracnose in stylos, caused by *Colletotrichum gloeosporioides*, or by insects such as the leucaena psyllid (*Heteropsylla cubana*).

It is important, therefore, to have a resource available from which such material can be selected. It is equally important to stock and maintain this resource. Development and inappropriate land use in many of the forage-rich countries is leading to reduction of biodiversity. Political instability and economic hardship in some countries may also result in the decline or closure of alternative genetic resource centres. Livestock industries of the humid zone of tropical and subtropical Australia have benefitted greatly from material drawn from the ATFGRC, but it would be a mistake to think that its role in providing forage germplasm for the benefit of Australian graziers has come to an end.

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