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TGS news & views

about pasture development in the tropics and subtropics

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Special issue – Farrer Oration 2005

This issue of the newsletter carries a version of the Farrer Oration given by Dr Bob Clements. Many years ago, Bob was a Principal Research Officer in what was then CSIRO Division of Tropical Pastures, specialising in breeding lucerne and the species *Centrosema*. Bob has been a strong supporter of the Tropical Grassland Society, and was awarded a Fellowship in 1995 He went on to become Chief of the Division of Tropical Crops and Pastures before becoming Director of ACIAR (Australian Centre for International Agricultural Research) from 1995 until 2002. He is now Executive Director of the ATSE Crawford Fund.

Bob was invited to give the prestigious Farrer Oration last year, with the event partly sponsored by this Society. By definition, the Oration is just that—a talk, supplemented in this case with a PowerPoint presentation.

What we present here is not a direct transcription but text that was subsequently prepared for us by Bob, and now supplemented with some of the screens from his PowerPoint presentation.

The theme of the oration revolves around the uptake of technology—how some technologies are almost universal within a decade while others take many decades. Bob looks at some of the drivers of adoption of information technology, genetically modified crops and tropical legumes.

"Shaking windows, rattling walls"

Bob Clements

In the 1960s, the American folk-singer Bob Dylan wrote a song called "The times they are a-changing". I expect that many people in the room know the tune, and some would remember the words. The song captured the mood of the times. It not only became the anthem of the civil rights movement in the United States, but it also heralded a period of sustained social and technological change probably unequalled in the history of the world.

It is trite to say that time are changing. We live in a time of such pervasive and dramatic change that we are hardened to it. When I was a boy, I lived for a few years with my grandfather, who was then in his eighties, and I remember thinking that he had lived through an amazing period of change. As a teenager, he had ridden his horse from Sydney to Cobar to visit his sister. There were no motor cars, and most people still travelled by horse-drawn vehicle or steam train. By the time he died, all his children owned motor cars, the aeroplane had made rapid international travel possible for the rich, transistor radios were just becoming available to the masses and TV had been invented. We were beginning to write with ball-point pens.

Continued on page 6 ...

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Society News

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Apologies to all those who have tried to contact us on the tgs@csiro address. Your emails were going to the CSIRO server in Brisbane but were not being redirected to the Secretary working in Toowoomba; Cristine had been wondering why none were coming through to her. Problem solved now with a big backlog of hundreds of spam emails to be sorted and deleted.

Your subscription renewal is due now

The Journal archive

Past issues of Tropical Grasslands have been archived on our Web site to allow Internet searching. These archives are in a variety of forms. More recent issues are totally searchable pdf files but earlier issues have searchable titles and abstracts as pdfs but the main papers have to be as images. Basically the key words are usually in the title or abstract while the text images can be read on the screen or printed.

Issues 1 to 13 (1967–1969) are available as titles only so that the titles are searchable. If the paper content is wanted, it will have to be ordered from a library service.

Issues for the previous year are available only to journal subscribers.

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Date claimer for field day at Mutdapilly
on 27th June 2006 at
DPI&F Mutdapilly Research Station

This is going to be a big day. So be there to find out what might be happening to subtropical dairying and dairy pastures

The provisional program starts at 10 a.m. with the opening by the Minister for Primary Industries, who will also launch the Dairy Plus booklet.

Industry talks

The future of research in the subtropics
Future of the dairy industry in the subtropics
How TGS and ASAP fit into the future.

Science talks

The relevance of the Qld Dairyfarm Accounting Scheme to industry development
M5 learnings—The performance of five dairy farming systems
Protein Plu$ and milk quality

12.30 -1.15 p.m. Lunch and trade displays

Afternoon

Three concurrent field tours looking at:
Water Use Efficiency and sustainability
Temperate species pasture trials
The Animal House – the quality of milk produced under 2 temperature regimes.

Wine and cheese testing and close at 3 pm

No more details are available at present so keep checking the TGS web site.

Letter to the Editor

Too cold for leucaena on the Downs?

Tarramba leucaena has been widely planted in Central Queensland in recent years. It was released within a year or so of when I left CSIRO (and direct involvement in pastures). I seem to remember its main advantage was one of seedling vigour and, as a result, had been lead to believe that it was much easier to establish. I have also been told that it was more cold tolerant than the older varieties.

The release of Tarramba also coincided with a reduction in QDPI pasture involvement and an upsurge in Landcare officers (often with little pasture experience) providing pasture information. They had people like Peter Larsen speak at field days about leucaena and its establishment. Peter promoted Tarramba very strongly, to the extent that little seed of the older varieties was planted for a number of years, despite the fact that the cost of Tarramba seed was almost double that of Cunningham. I think that this is one of the reasons why there has been so much Tarramba planted in recent years.

About 4 to 5 months ago, Keith McLachlan from the Leucaena Network contacted me about a Training School that they were running in this area. I asked him a lot of questions about Tarramba, and specifically asked him for any information that he might have on added cold tolerance of Tarramba over Cunningham (after all one of the functions of the Network was to promote Leucaena and distribute technical information on it). He said that he had never seen any information to support this claim. A couple of years ago I also bumped into a guy who came from around Banana, where leucaena has been grown for quite a few years. I asked him about leucaena and the merits of the 'new' variety Tarramba over Cunningham. He told me that some people in the area had planted both and could not see any difference, apart from growth habit. I have a similar story from two Landmark clients who planted leucaena in the Wandoan area last year.

Is there any technical information on the cold tolerance of different leucaena cultivars or lines?

Sid Cook, Landmark , Dalby
Formerly Principal Research Officer,
CSIRO Tropical Agriculture

Cassia – wynner or loser?

Wynn cassia, round-leaf cassia (*Chamaecrista rotundifolia*) is a tropical legume used mainly for improving the nutritive value of native pastures.

It has many useful attributes for this role; it establishes quickly, does not need a specific Rhizobum, naturalises and spreads well from heavy seed set, will grow in typically infertile grazing soils, the leaf has moderately good protein levels and it is not so palatable that it is grazed out.

BUT its palatability is sometimes too low. If stock do not eat the Wynn cassia it can become almost dominant after a couple of years. This dominance may not be permanent as the balance between grass and legume will swing with the level of available nitrogen in the soil. After a couple of years of strong legume growth, soil nitrogen levels will increase and the grass component should rebound.

But any dominance of a pasture by a plant that the stock do not seem to be eating will create anxiety in the paddock manager's mind.

Articles in News & Views

TGS News & Views has carried articles about Wynn cassia over the recent years. 'Wynn cassia in south-east Qld' (Vol. 20. No 1&2) by Lyle Winks, our TG journal editor and Beaudesert grazier, extolled the virtue of the plant and how he wished he had planted more earlier.

Dense cassia in blue couch paddock—rejected by horses

The other 'Wynn cassia – eaten or rejected?' (Vol 21. No. 3) described some of the problems being experienced in the Douglas Daly flood plain in the NT where the cry was "I wish I had never planted it at all."

Horses don't like cassia –

More recently I have been contacted by the owner of a small life-style property near Canungra in the Gold Coast hinterland. The owners run horses (and deer) and have found that cassia is spreading fast but, as it is not eaten over summer by the horses, there are dense patches up to 50 cm high. It is difficult to just point out that horses are notoriously fussy about what they eat and are the quickest wreckers of good pastures (I been told that they often refuse to graze fodder oats), and maybe introducing some cattle might improve the grass-legume balance.

– neither do the owners

The owners don't want the cassia, call it a noxious weed and have taken to spraying herbicide (without exceptional success). They contacted a local newspaper and demanded Wynn's reclassification as a noxious weed. The attributed comment that they fear that 'people who have unproductive land with poorer stock will use this invasive legume to improve productivity instead of feeding grain' suggests a difference between the economics of producing beef and keeping recreational horses.

The point here is that the property owners have raised the issue, and this increases pressure on pasture agronomists, seed merchants and commercial beef producers.

Other experiences?

I have contacted some colleagues about Wynn cassia and am using this newsletter to ask readers to provide their experiences of the legume in different environments (semi-arid versus high rainfall, free-draining soils versus heavier loams or clays).

My own experiences have been in South Burnett speargrass country. When we fisrt planted the seed in a speargrass paddock near GinGin with around 900 mm rainfall, it was obvious that it grew well but that mixed breed weaners did not like it and they not grow well, but they didn't grow well on plain speargrass either. Over the next few years, yearling steers grew better with cassia than on unimproved speargrass but still tended to leave the legume until the grass matured in autumn. In one year, they suddenly started to hit the cassia around mid-April. Applying superphosphate greatly increased the growth of the legume but didn't appear to make the cattle eat more. Taller undefoliated cassia is not very drought resistant. The twin leaves fold together and can turn red, the old leaves then drop leaving a woody stem. We saw this also in a densely-planted seed production block on sandy soil. And hay made from this sort of material can resemble match sticks.

In the Mount Perry hills, cassia was defoliated by frost but regrew from the stem butt – or from seed.

I saw dense Wynn cassia planted near Kabra, Rockhampton (rainfall closer to 800 mm). It looked affected by dry conditions but was certainly not being grazed avidly. I was told about cassia near Gympie (rainfall closer to 1100 mm) that grew thickly over 50 cm tall and was not being eaten by cattle.

My next experience was at Gayndah (with rainfall closer to 750 mm). Here cassia planted into speargrass country never had a chance to grow tall. Steers grazed it avidly so that the plants formed small rosettes about 15 cm across; it appeared moderately drought-tolerant in this form and still flowered and set seed.

As a result of these observations, we recommended that cassia be sown at low seed rates and not in high rainfall regions.

Email me your experiences

But I haven't seen any of my old pasture areas for over a decade. What has happened and what are your experiences? and send any photos.

Other legume dominance

Legume dominance has also been noted in Queensland with some other tropical legumes. Some of the shrubby stylos are not very palatable, or relatively less palatable than green grass) during the wet season, but then provide good protein feed when the cattle need it as the native grasses hay off.

In some cases, stylo becomes dominant because the legume allows higher stocking rates than the native grass can stand. Here, fire and spelling can help to bring back the grass. In other cases, dominance results from the stylo being more effective at extracting phosphorus from low-P soils than the grass. Applying superphosphate redressed the grass-legume balance by feeding the grass.

In other cases again, there may be a case for sowing a more aggressive grass. On the horse property, the local grass was only blue couch (*Digitaria didactyla)* which is not very aggressive. Grasses such as Rhodes grass or Blue Dawn Brunswick grass (*Paspalum nicorae*) growing with cassia could provide a productive and stable pasture.

Rosette form of Wynn cassia under grazing in more arid regions (Gayndah).

What are your experiences—good or bad—with grazing Wynn cassia?

Please send me a note.

'Shaking windows, rattling walls' *continued from page 1*

The process of change has been just as dramatic in the fields of agriculture as it has in other aspects of our daily lives.

Change in farming in my time

When I left school, just before Bob Dylan wrote about changing times, I planted wheat using a kerosene-powered tractor, and I harvested it using a ground-drive header. My crop grew higher than my head, about half of it fell over, and I harvested six bags of grain to the acre (about 1.2 tonnes per hectare). It was carted in bags to the nearest silo. My crop wasn't quite equal to the district average, but it wasn't bad for the times—and I made enough money to go to university.

Today, Australia's average wheat yield is approaching 2 tonnes per hectare (still low by world standards) and increasing by about 1% per year. Farmers work their land with large air-conditioned diesel-powered tractors using remote sensing (global positioning systems) technology, sow low-growing wheat varieties, use heavy applications of agricultural fertilisers and other chemicals, harvest the crop with motor harvesters, store the grain on-farm, transport it in bulk, sell it to quality-conscious markets around the world, and trade in grain futures and options in Sydney and Chicago.

Green revolution

On the global scene, the 1960s and 1970s also witnessed the so-called green revolution, particularly in Asia, where new varieties of wheat and rice were grown by countless millions of small farmers, thus averting a potential world food shortage. It was perhaps the greatest example of widespread adoption of new agricultural technologies in the history of agriculture.

What brings about such dramatic changes in agriculture? What can we learn from studying patterns of technology adoption? In the remainder of this oration I would like to look at several examples of technology adoption and see what conclusions can be drawn.

Information and Communication Technology: the internet

The current revolution in information technology has significant implications for everyone, including farmers. One element of this is mobile telephone technology. I expect that just about everyone in this room owns or uses a mobile telephone. In 1998, 44% of Australian households had access to a mobile telephone (Australian Bureau of Statistics 2005). That figure grew to 72% in 2002 – just 4 years - and has almost certainly grown since then. Worldwide, in 2002 the number of mobile telephone subscribers exceeded for the first time the number of fixed-line subscribers, and there are now claimed to be more than 1.7 billion mobile telephone users – more than one person in every four people on the planet (Silver Kris 2005). It is hard to think of a more rapid adoption of a scientific technology than this, even though Australian farmers suffer significant access disadvantages.

However, the truly remarkable IT revolution is in internet communication. The internet originated in the USA, and grew slowly between 1969 and 1989, when there were about 100,000 users. The World Wide Web emerged during the early 1990s. By 1995, it was the main carrier of traffic, and a variety of services including search engines and internet access providers were emerging. There were then about 25 million internet users. From that point onwards, growth was spectacular. In 2005, just ten years later, 957 million people - 15% of the world's population - one person in every seven people on the planet - had access to the internet. Australians are particularly avid users; only a small handful of countries (Sweden, the USA and perhaps the Netherlands) may be heavier users per head of population. The pace of adoption is so great that figures are quickly out of date. In 2003, more than half of Australian households had internet access (Australian Bureau of Statistics, 2005; Caslon Analytics 2005), and three quarters of the adult population were "active internet users". This included 54% of Australian farmers – more than four times as many as in 1998 (Australian Bureau of Statistics 2005). There was a strong relationship between farm size and internet usage: 79% of farms with an estimated value of agricultural operations of $1 million or more used the internet in 2003, compared with 30% of those with an EVAO of less than $50,000.

The Internet revolution

Internet access in Australia in 2003:

- 3 out of 4 of all adults
- 54% of all Australian farmers
- 79% of 'big' farmers

The better farmers increasingly use the internet to access weather information, follow commodity prices and futures markets, access agricultural information and decision support services and communicate with other farmers. A USA study in 2002 showed that use of the internet significantly improved the productivity of grain farmers, and the same seems likely to apply in Australia.

Genetically modified (GM) crops

The history of adoption of GM crops is well documented, particularly by ISAAA (International Service for the Acquisition of Agr-Biotech Applications) who distribute a weekly summary of world developments. A good deal of the information in this section has been derived from this source. Commercial adoption commenced in 1996, when 1.7 million hectares were grown.

Since then, the rate of adoption has been extraordinary. In 2004, there were 81 million hectares of GM crops sown – up by 20% from 2003 (67.7 million hectares). If the total world area of arable land and land under permanent

Genetically modified crops

Area sown (M ha)

1996: 1.7	1999: 39.9	2002: 58.7
1997: 11.0	2000: 44.2	2003: 67.7
1998: 27.8	2001: 52.6	2004: 81.0

5% of the world's cropped area is now sown to GM crops

The growth rate has been at double-digit levels for 9 years

Despite concerns:

– GM cotton area will grow in Brazil, China and India
– GM soybean area will grow in Brazil
– China is likely to approve GM rice soon
– Growth may be greatest in developing countries
– Total area to reach 150M ha by 2010

crops is taken to be around 1.5 billion hectares , at least one hectare in every 19 hectares of sown crops is now sown to GM varieties. GM crops were grown by more than 8 million farmers in 17 countries in 2004—up from 7 million farmers in 2003.

The principal GM crops in 2004 were soybeans, cotton, canola and maize. In 2004, 56% of the world's soybean crop, 28% of the world's cotton crop, 19% of the canola crop and 14% of the maize crop was sown to GM varieties with the main countries being USA, Argentina, Canada, Brazil, China and Paraguay.

GM crops are profitable

World: $US 27 billion contribution to farm incomes by 2004

– environmental benefits - 15% less pesticide use
– social benefit from GM cotton in China - $US 334 million in 1999 (2nd year of adoption)

A key driver of the adoption of GM crops is farmer profit. A recent analysis of the benefits of GM crops to date, at the level of farm incomes, indicates that a cumulative benefit of USD 27 billion had been accrued by farmers to 2004. Brookes and Barfoot 2005 authors show that 95% of the farm income benefits have been received by growers of soybeans, cotton and maize in the USA; of soybeans and maize in Argentina and Brazil; and of cotton in China.. Most of these benefits had resulted from savings in the costs of production. Environmental benefits were also substantial. Adoption of GM crops had resulted in a 15% reduction in pesticide use in cotton crops (77 million kg less insecticide applied since the introduction of GM cotton) and a total reduction of 172 million kg of insecticides applied to all GM crops. And greenhouse gas emissions had been reduced by 10 billion kg.

This is not the only economic analysis of the benefits of GM crops. In China, the benefits from GM rice have been estimated at $US 4 billion per year.

Resistance in Europe

Adoption is occurring in the face of strong resistance from consumers in some developed countries, notably in Europe, and from some Non-Government Organisations. Confronted with this resistance, many countries are proceeding extremely cautiously. But European resistance appears to be weakening. In May 2004, the European Union lifted its six-year de facto moratorium on GM crop and food approvals. In September 2004, a maize cultivar (grown since 1998 in Spain for livestock feeds) was approved for planting throughout the EU. Italy approved the planting of GM crops in January 2005. In May 2005, the Portuguese Council of Ministers approved the planting of GM maize in that country. And in August 2005, the European Commission granted Monsanto approval to export a GM maize cultivar called MON 863 for animal feed.

European pressure has been influential in conditioning African attitudes to GM crops. Despite recent signs that a number of African countries will move to adopt GM crops, at present such crops are grown commercially only in South Africa.

GM and Asia – China leads

Many people believe that Asia will be a key battleground for adoption of GM food crops, and that adoption of GM rice will open a floodgate of approvals. China has the largest plant biotechnology capability outside North America, and has invested heavily in GM rice. Numerous potential GM cultivars have been field-tested (some since 1998), and it seems likely that several cultivars resistant to rice pests and/or diseases, drought and salinity may be released during the next year. Release has been delayed by concerns about global anti-GM crops sentiment, but in the end the potential benefits to farmers and consumers may be irresistible. Huang et al (2003) have estimated that the adoption of GM rice would be worth approximately USD 4 billion a year to China by 2010, even if other countries ban imports of rice from China. Farmers would benefit from increased yields and lower production costs, and other consumers would benefit from lower rice prices.

Other Asian countries are proceeding cautiously in commercialising food crops. GM maize is already grown in the Philippines.

Wake up and catch up, Oz?

A recent Australian study (ABARE) indicates that as much as $3 billion could be lost by 2015 if Australia fails to commercialise GM crops. A 2005 RIRDC study suggested that Australia could gain $15.3 million per year if biotech crops were adopted. There are signs that after almost a decade of cautious analysis, Australia's farmers are becoming weary of disinformation produced by environmental activists and other well-meaning groups and are ready to move on, especially in view of the analysis that shows markets will be found for GM produce.

The annual increase in the extent of adoption of GM crops seems certain to continue at levels of 10-20% with a 2005 prediction that the area will reach 150 million hectares by 2010. Continued expansion of the area sown to GM cotton seems assured. In China, the share of the cotton crop sown to GM cultivars is projected to increase from 45% of area in 2001 to 92% of the area by 2010. India is projected to plant 1M ha of GM cotton in 2005 (up from 550,000 ha in 2004). Brazil approved GM cotton in 2005, and only non-availability of Monsanto seed held back the growth rate.

Tropical forage legumes

Like some other scientists in the room, I spent a good deal of my career working on tropical forage legumes. The idea was that these plants would fill the same kind of role in tropical pastures as their counterparts in temperate and Mediterranean pastures – contributing nitrogen that would improve forage quality, lift the productivity of associated grasses for livestock production and provide nitrogen for crops in rotation with pastures. For about 50 years from 1950-2000, there was a very significant investment in tropical forage legume technology in Australia, and the work spilled over to the international arena, particularly in CIAT, ILRI and other international agricultural research centres, in Brazil and in several developing countries.

The adoption of tropical forage legumes in Australia has been summarised by numerous authors. Unlike the dramatic adoption of internet technology and GM crops, adoption of tropical forage legumes in Australia has been relatively slow.

Tropical forage legumes

Australia

- 50-year R&D investment in northern Australia
- About 1.5M ha sown in N. Australia by 1995
- Benefit:cost ratio of stylo R&D $263
- Graziers' rate of return 7-30%
- Probably 2.0 M ha sown by 2005

World

- 5 million ha sown
- Two-thirds in developing countries
- at least 500,000 farmers

By 1995, about 1.0 million hectares had been sown to stylo (*Stylosanthes* spp), and another 0.5 million hectares had been sown to other legumes. However, a benefit/cost analysis of the investment in Stylosanthes technology alone (Chudleigh and Bramwell 1996) showed that the Net Present Value of the technology to be $263 million (benefits projected to 2020). The costs of establishing legume-based pastures and investing in additional cattle are significant, but the analysis showed that the returns to farmers were of the order of 7-30%, depending on the level and value of the increased productivity – a reasonably profitable investment.

At the time of the 19th International Grassland Congress in Brazil (2001), a consensus was emerging that there had been very little adoption of tropical forage legumes except in Australia. A survey of adoption around the world was therefore undertaken, and nineteen poster papers were commissioned to present information from particular countries or regions. The results (Shelton et al. 2005) are summarised in Table 1. (See Tropical Grasslands December 2005)

The data show that about 5 million hectares had been sown to tropical forage legumes by 2005; that about two thirds of this area was in developing countries; and that at least 500,000 farmers were benefiting from the use of the technology. The most significant legumes were *Stylosanthes* species (approximately 2.4 million hectares), *Vigna unguiculata* [dual-purpose cowpeas] (1.4 million hectares), *Pueraria phaseoloides* [kudzu] (about 480,000 hectares) and *Leucaena leucocephala* (about 170,000 hectares – almost certainly under-estimated).

Authors of the commissioned papers also provided their views on reasons for successful adoption (Shelton et al. 2005). In order of declining perceived importance, these included:

- The technology met farmers' needs and provided profits
- The technology matched farmers' socio-economic circumstances and skills
- Critical partnerships were in place (eg governments, private sector, farmers)
- Key stakeholders provided long-term commitment
- Farmer-centred R,D&E programs were implemented.

The availability of reliable supplies of good-quality seed was crucial to the successful adoption of these legumes. In some cases, the private sector provided the seed supply; in other cases, the seed was supplied by or organised by governments, or by NGOs.

Another feature of the results was the very wide range of farming systems in which the legumes were employed. An extreme example was the use of stylo leaf meal as a component of rations for monogastric animals in China. A less extreme example was the 'Amarasi' system in Indonesia, in which leucaena was cut and fed to tethered cattle. In Australia and Brazil, extensive grazing by cattle was the norm; in numerous cases, the legumes fitted farming systems that had not originally been contemplated by the researchers who developed the legumes.

The beef cattle industry in Australia

We have considered three particular examples of agricultural technology and its adoption. More generally, it is helpful to look at the development of an entire industry sector. In this case I have chosen to examine the history of development of the beef cattle industry in Australia, and I am indebted to the historical research conducted by Ted Henzell (Henzell, in press).

Table 1. *Summary of areas sown to tropical forage legumes in 2005*

Country or region	Principal species	Area sown ('000 ha)	Number of farmers
Australia	*Stylosanthes* spp	1,500	n.a.
	Leucaena leucacephala	100	400
	Clitoria ternatea	100	500
	Centrosema pascuorum	5	100?
Brazil	*Stylosanthes* spp	150	n.a.
	Pueraria phaseoloides	480	5,400
	Arachis pintoi	65	1,000
USA (Florida)	*Arachis glabrata*	8	n.a.
	Aeschynomene americana,	65	750
	Desmodium heterocarpon	14	200
West Africa	*Vigna unguicalata*	1,400	350,000
	Stylosanthes, *Centrosema* and *Aeschynomene* spp	19	27,000
East Africa	Tree legume hedges	4 million m	40,000
China	*Stylosanthes* spp	200	30,000
Thailand	*Stylosanthes* spp	300	12,000
India	*Stylosanthes* spp	250	5,000
Indonesia (NTT)	*Leucaena leucocephala*	70-93	n.a.
Indonesia (Lombok)	*Sesbania grandiflora*	n.a.	65,000
Nepal	*Arachis pintoi*	n.a.	20,000
TOTAL		4,726	557,350

Long history of resistance to change

The Australian beef cattle industry in its earliest days used technology derived mainly from Britain. This included cattle farming practices, breeds and meat processing technologies. There were some clear differences associated with an early differentiation of beef cattle from dairy cattle in Australia, and a greater reliance on natural pastures as the source of cattle feed. Mechanical refrigeration technology was available from the 1870s, and the first shipment of frozen beef from Australia occurred in 1879/80, but exports developed quite slowly until the 1950s – a period of well over 50 years – partly because other countries had captured Britain's markets.

For many years, Australia relied on British breeds to upgrade the founding herds, which were derived from mixed sources – India, the Cape of Good Hope and England. Within 40 years, pure-bred representatives of most of the British breeds had been introduced and used as sires, but it took many more years for the upgrading process to be completed. By 1848, Shorthorns were the predominant breed in Victoria and the preferred breed nearly everywhere, and by 1889 (100 years from first settlement) they were the predominant breed throughout Australia. During the 20th century, other British breeds became prominent in southern Australia, but Shorthorns were still the main breed in northern Australia until after the Second World War. Brahman cattle were re-introduced to Queensland in 1933, but it was not until the second half of the 20th century that Brahmans and Brahman crosses began to displace British breeds in the north, and the real change did not occur until the 1970s and 1980s. Such adoption of technology can hardly be described as rapid. Indeed, Henzell notes that northern cattlemen strongly opposed CSIRO's research on tropical breeds of cattle, which showed that such breeds had greater resistance to heat, ticks and worms and did better on low-quality feeds than British breeds. Henzell suggests that, in the end, the change was probably triggered by the need to control cattle ticks, which had built up resistance to the various chemical controls that were then available.

Turning to cattle production practices, it is hard to find an example of a rapidly-adopted technology, especially in the north, until the last quarter of the 20th century. The task of fencing in Australia's cattle herd occurred fairly quickly in the south, but took much longer in northern Australia. Thus, improvements in mating, weaning, fattening and other aspects of herd management developed slowly in northern Australia, over time periods measured in decades. Better feeding practices including those based on improved pastures were adopted slowly, as we have seen. The limited profitability of the northern beef industry provided few incentives for technology adoption until the second half of the 20th century.

In contrast to this history of slow change in northern Australia, dramatic changes occurred late in the 20th century that are still in progress. The opening of new export markets from 1957 onwards, including a profitable live cattle trade, provided new financial incentives for cattle producers. Between 1950 and 1980, Australian beef exports increased more than tenfold, until about two-thirds of the total beef produced was exported. Premium prices for high-quality products drove investment in feedlots, commencing in the 1970s. By 1999, 20% of the beef cattle slaughtered in Australia had been through a feedlot.

A similar dramatic change occurred as a result of government regulation. Concern to protect export markets in the 1970s led to a scheme to eradicate bovine tuberculosis and brucellosis, and this in turn required northern cattle producers to fence their properties and muster cattle cleanly using helicopters. By the early 1990s, Australia was effectively free of these two diseases, and the scheme had led to significant improvements in herd control and station management.

In summary, after a very long history of resistance to change, in the last quarter of the 20th century a mixture of financial incentives and government regulation led to rapid adoption of technology in the Australian beef cattle industry. It has indeed been a period of shaking windows and rattling walls.

Lessons learnt, and conclusions

Looking back at these examples of technology adoption, it is hard to escape the conclusion that two key drivers of adoption are personal utility (particularly profit) and government regulation.

In the case of personal utility, profit is probably the key motivator. There is an enormous literature on the adoption of technology by farmers with quite a lot having a sociological flavour. However, some of the most convincing analyses describe a typical sigmoid adoption curve, where the slope indicates the rate of acceptance and the ceiling measures the level of usage when adoption stabilises and where profitability can often explain differences in both the slope and ceiling of the sigmoid curve. Of course, other things may also influence the slope and ceiling, including the regulatory environment.

Other aspects of personal satisfaction might include food security, savings in personal exertion (labour-saving technologies), and intellectual satisfaction (eg an interest in new machinery or electronic gadgets). It is not clear from these examples whether profit remains such a key motivator after a certain minimum personal or farm income is reached, or for adoption of technologies that affect long-term sustainability or off-farm impacts.

In many cases the role of the private sector is crucial, and the stimulus for private sector investment is again profit. Interestingly, the international agricultural research community increasingly recognises the need for greater investment by the private sector to deliver technologies to small farmers in developing countries, and is investigating a range of public/private partnerships.

Affordability of the technology is also critical. In the case of tropical forage legume technology, the significant investment required for pasture establishment and maintenance and additional livestock may have been a much greater barrier to adoption than was realised at the time.

The role of government regulation is probably greatest when market failure occurs. For example, when profitability for the individual farmer is low (eg where benefits cannot be appropriated by the individual farmer, or where benefits occur off-farm), regulation may be needed to raise the slope or ceiling of the adoption curve.

Lesson learned

Two key drivers of dramatic change in agriculture:

- – personal utility (especially profit)
- – government regulation

Other factors

Other aspects of personal utility
– food security
– greater personal convenience
– intellectual satisfaction
Access to information
– complexity, etc
Affordability of adoption
Risk
Ongoing supply of technological inputs

Times they are a'changing – full circle

Bob Clements' introduction reminds me of the story about four generations.

Great grandfather's only mode of transport was his horse—on which he went everywhere. He trusted his horse but was not going to ride on one of those smoke-belching Puffing Billys. No trains, thank you.

Grandfather was happy to go on a train for a long journey but no way was he going to get into one of those clattering horseless carriages. No cars, thank you.

Father went everywhere in his car—his pride and joy, but didn't want to hurtle through the air in one of those wire and cloth flying machines. No planes, thank you.

Son is quite happy to fly around the world at 30,000 ft in a jumbo jet at 600 mph, but no way is he going to get on one of those unpredictable horeses.

Another letter to the Editor

Don't forget the twiners!

The special issue of Tropical Grasslands (2005) Volume 39 No 4 is entirely devoted to papers commissioned to survey the successful adoption of tropical legume technology around the world.

I have some concerns with certain historical aspects of the 'overview paper', but my main concern is that in the entire suite of papers, there is not a mention of successful adoption of vine legume/semi-erect grass pasture systems in large-scale projects in the humid tropics of Australia, Southeast Asia and the Pacific Islands. Most were established during the 1960s and '70s and there remain examples which have sustained profitable levels of animal production for more than thirty years.

The pasture system generally consists of mixtures of Centro (Centrosema pubescens), Puero (Pueriaria phaseoloides) and Calopo (Calopogonium mucunoides) grown in association with various cultivars of Panicum and Setaria and less frequently with cultivars of Brachiaria and Paspalum. In cooler upland areas such as the Atherton Tableland of Australia, Tinaroo Glycine and Greenleaf Desmodium were more popular legume components.

Planners of the survey determined that for adoption to be considered successful, at least 50,000 ha of the pasture system had been planted in farmers' fields. I have personally had professional contact with plantings of Centro/Puero/Calopo/Grass pastures in Australia,

Papua New Guinea and the Philippines which readily satisfy this criterion. I have also sighted successful adoption of the technology in large projects managed by GRM and others in the Philippines and Malaysia. Additionally, Centro/Puero/Calopo mixtures have been widely used in a number of countries for grazing under coconuts and to a lesser extent for grazing under oil palm and rubber.

Most of the commercial examples that I have been associated with were planted in the 1960s and 70s. I still maintain contact with some projects in Australia and PNG and can confirm that there are commercial examples in both countries which have sustained commercial beef production for 20 to 30 plus years. I have lost contact with projects in the Philippines and Malaysia and there could also be examples of sustainability there.

There have been few plantings of vine legume/semi-erect grass pasture systems in Australia and PNG since the early 1980s when the following three systems became more popular.

1. Leucaena pastures became conceptually popular following reports of superior growth rates from cattle grazing them. However, leucaena has not been a success in the wet tropics of Queensland where acid soils and vigorous weed populations are endemic.
2. Robust pasture systems based on Brachiaria decumbens and Brachiaria humidicola became particularly popular on farms which participated in the expansion of the sugar and banana industries. Robust systems which required less attention to fertilizer and grazing management were attractive to farmers who gave highest priority to cash crops. However, with the steady depletion of soil N levels with time, these pastures became progressively less productive and less competitive against weeds. Additionally, until the increased sugar price this year (2006), farmers were becoming aware that cattle fattening on some of the higher input pasture systems was more profitable per hectare than growing sugar cane.
3. Grass–N fertilizer systems have become a preferred option following commercial demonstrations of sustained high production and bio-economic analyses of individual farming enterprises. At prices of beef and N fertilizer which have been encountered since the early 1980s, analyses indicate that Grass–N pastures grown on suitable land classes are capable of significantly higher profits per hectare than other pasture options. Assessments of land capability and the objectives of individual enterprises are important components of the bio-economic analysis.

Despite a lower priority rating over recent years, the fact remains that vine legume–semi-erect grass pasture systems were successfully adopted over sizeable areas in the Australasian wet tropics and provided profitable levels of sustainable production for many years. This pasture system could again become a favoured option in the region if there were changes in the relative prices of beef and N fertilizer. Apparently this situation already exists in Brazil where, as reported in the survey paper by Valentim and Andrade, some 480,000 ha of Puero–grass pastures have been established in the Amazon region.

A review survey, claiming to be a worldwide analysis of the successful adoption of tropical legume pastures, should surely have provided a reliable assessment of the past and potential contribution of vine legume–semi-erect grass pasture systems in the high rainfall tropics.

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