75 years of scientific and technological advances in pastoral agriculture – what will it take to continue to deliver?

J.R. CARADUS
Grasslanz Technology Ltd, PB 11008, Palmerston North
john.caradus@grasslanz.com

Abstract

Scientific and technological advances are important for any industry to ensure continued improvement in productivity – achieving more output of value per unit of input. Since the majority of New Zealand's pastoral produce is traded internationally we need to ensure that we are the most efficient at growing and producing this produce, whether it is traded as a commodity or as a value added product. The requirement for continued R & D investment in our agricultural knowledge economy is a prerequisite for continued improvements in pastoral agricultural productivity. In reflection, the major scientific and technological advances that have improved on-farm productivity over the last 75 years are described and the challenge is given to determine how this might continue into the future.

Keywords: pastoral agriculture, research and development, technologies

Introduction

Pastoral agriculture continues to be the major driver of new wealth creation for New Zealand. This is despite the enthusiasm from decision makers and politicians of the 1990s who suggested we should 'surf the knowledge wave' to prosperity. The point they missed was that pastoral agriculture has always been New Zealand's knowledge industry. Our success in international markets has been due to the rapid and effective use of new technologies and innovations by farmers. Over the past 75 years the synergistic interaction between researchers, extension specialists, rural professionals, and innovative farmers has ensured that New Zealand pastoral agriculture production is world leading. Some of this innovation has been lead by farmers but often researchers provided the insight to ensure the most effective use of new technologies.

A recent working paper published by New Zealand Treasury underscores not only the importance of the agricultural sector to overall growth and productivity in New Zealand, but also demonstrates that investment in domestic agricultural R & D has generated an annual rate of return of 17% over the past 75 years (Hall & Scobie 2006). They conclude that "our findings typically support the argument that the stocks of domestic knowledge are positively associated with productivity growth. The very existence of foreign knowledge may be a necessary condition for achieving productivity growth in a small open economy. However, in no way could it be argued that it is sufficient. Having a domestic capability that can receive and process the spill-ins from foreign knowledge is vital to capturing the benefits."

While there is no single, widely-accepted measure of innovation, growth of Multi-Factor Productivity (MFP) provides a broad indication.[1] Table 1 shows that the agricultural sector has outperformed the rest of the New Zealand in terms of productivity growth over the past quarter century (1978 – 2001).

Table 1 Compound growth rates in Multi-Factor Productivity.

	New Zealand (%)	Agriculture (%)
Value added basis		
1978 to 1992	1.1	3.7
1992 to 2001	1.3	2.1
Output basis		
1992 to 2001	–	0.7

Source – Statistics NZ, NZ Treasury

Agriculture – New Zealand's Knowledge Industry

New Zealand's international competitive advantage in producing agricultural products will be maintained through the ongoing application of innovative technologies and smart business practices leading to increased on-farm efficiencies, productivity, and added value. Much of this accumulated knowledge and technological advance has occurred over the last 75 years.

Proceedings of the New Zealand Grassland Association provide a valuable resource that captures advances both great and small in acquired and applied knowledge and technologies that have ensured that New Zealand agriculture is world leading. The Proceedings also show that the industry has continually sought to improve its productivity. These are detailed in Appendix 1.

[1] MFP measures the increase in output not accounted for by increases in measured inputs such as labour and capital. For national economies, MFP is usually measured on a value-add basis (defined as the net returns to labour and capital after deducting the cost of other inputs), whereas industry-level comparisons across time are often based on output produced. The economics literature notes that MFP measures not only the rate of technological change but also the associated "free lunches" arising from scale economies and externalities between firms, industries and countries.

The following are some of the more significant advances (details of advances since 1930 are given in Appendix 1):

- Understanding of pasture grazing management
- Animal improvement – high fertility sheep, improved feed conversion efficiency in dairy, development of the first full "New Zealand" breed of dairy cattle based on elite animal genetics
- Plant improvement – use of non-toxic grass endophytes, effective rhizobium strains, improved cultivars
- Subdivision – including the use of electric fencing
- Product harvesting technologies – herringbone and rotary dairies, and electric sheep shears
- Understanding of plant nutrition and the use of fertilisers – aided by aerial topdressing
- Identification of nutrient deficiencies affecting animal health
- Use and adoption of H1 short rotation ryegrass by farmers
- Use of mineral nitrogen
- Nitrification inhibitors
- Animal vaccines
- DNA testing to simplify calf identification
- Electronic identification (ID) ear tags on cows to automate audio alerts, automatically draft cows
- Software for predicting soil response to a range of fertiliser applications so as to minimise nitrate runoff
- Indirect pasture measurement techniques – plate meters, satellite images

The dairy sector

In the dairy industry, labour productivity measured as cows managed per labour unit has increased by 45% over the last decade and, when measured as milksolids harvested per labour unit by 65% (Table 2). Over the last decade the dairy industry has substantially increased milksolids produced per ha and per cow (Table 2).

In the 1940s, the leading dairy farmers were achieving 250-300 lb milkfat/acre. This is equivalent to about 500 kg milksolids/ha. The average was approximately 140 lb milkfat/acre (Hunger 1951), compared with the average now of 860 kg milksolids/ha. This is approximately a two-fold increase over 60 years. Today some leading farmers are achieving close to 2000 kg milksolids/ha. The Lincoln University dairy farm which uses little supplementary feed achieves approximately 1700 kg milksolids/ha; this is a three- to four-fold increase on what was possible 60 years ago.

The meat and wool sectors

In the sheep industry there has been increased production occurring at a time when labour numbers have decreased (Bray 2004). Sheep farming performance, based on lamb and mutton carcass weights, lambing percentages and wool weights, has improved 35-55% per labour unit/1000 stock units. This indicates improvements in efficiency of labour through increased use of technology.

The substantial growth in financial returns from sheep in recent years has occurred in spite of the large drop in sheep numbers. It is due not only to increased market demand but to impressive increases in sheep performances that have offset the impact of declining sheep numbers. Remarkable gains that have been made include:

- A 25% increase in lambing percentage and carcass weight since the 1980s.
- Increased lamb meat production with carcasses which are more suited to high value markets, despite sheep numbers decreasing. Furthermore, this has happened without changes in stocking rate, lambing date, or use of new pastures and only a small change in seasonal slaughter pattern.
- An increase in lamb growth rates by 50 g/d since the 1980s – a major change that has not been identified before.
- An outstanding achievement of a 3.5 kg increase in carcass weight without an increase in fatness.

Grassland Improvement and Management – Our Legacy

Before 1930, there were no certified cultivars of ryegrass or white clover; fertiliser topdressing was ineffective because of the absence of a good pasture legume; expansion of grassland into difficult areas and soils was impeded by lack of knowledge and know how (Saxby 1954).

A meeting was called by A.H. Cockayne (Assistant DG of Agriculture) on the 19/20 January 1931 with the

Table 2 Changes in on-farm productivity (using both partial and total measures) over the last decade (Caradus 2005).

Criteria	1994/95	2003/04	Change (%)
Cows per ha	2.48	2.75	+10.9
Milksolids per hectare (kg/ha)	671	889	+32.4
Milksolids per cow (kg/cow)	271	322	+18.8
Cows per labour unit	96	140	+45.8
Milksolids per labour unit	26 016	42 981	+65.2

aim of "the betterment of research, investigation, demonstration or instruction in grassland management generally". Twenty one people attended from the Department of Agriculture, Canterbury Agricultural College (now Lincoln University), Massey University, Cawthron Institute and the fertiliser industry (Saxby 1954). In his address, Cockayne called for "a grassland caucus which will dominate grassland research and improvement". This lead to the establishment of the New Zealand Grassland Association and the first meeting was held in Palmerston North on 5 August 1931. It was attended by 28 people.

The Association had a faltering beginning. The depression meant that meetings were planned and then cancelled, and finances were strained; the second meeting did not occur until April 1933. This was a conference in which the President made his address by radio broadcast from his hospital bed, and where there was acrimonious debate over seed certification and the formation of the seed industry. At this conference the first farmer paper was presented and, other than during the war years (1940 to 1946), we have held successful conferences annually ever since. By 1954 we had 784 full members and 127 conference members, a total of 911 which is not very different from today. Interestingly, farmers made up about half the membership (Saxby 1954) then as they do today.

Over the past 75 years the New Zealand Grassland Association has been a focal point for introducing new knowledge and technologies, providing an opportunity for debate and refinement of knowledge, and then uptake by consultants and farmers to improve the productivity of our grassland farming operations. Many of these are summarised in Appendix 1.

Perusal of NZGA conference proceedings indicates that many of the challenges and opportunities facing us today are not new. For example:

- Effective technology transfer and adoption of new knowledge and technologies has always been a challenge. In 1933, Connell commented that there was a need for the social science research to be used to assist with increasing the uptake and adoption of new knowledge and technologies. Callaghan (1935) and Hamblyn (1947) also expressed concerns about extension methodology. Robertson (1980) suggested that the language used by scientist in communicating their results was not conducive to rapid understanding. The effectiveness of discussion groups in raising on-farm production was described by McKenzie (1980). The recurring theme of improving uptake of technologies by farmers was reiterated by Webby & Sheath (1991), McRae (1992), Garland (1993), MacClean *et al.* (1997), Manson (1999), Webby (2002), van der Geest (2002), Prewer & van Bysterveldt (2004), and Savage & Lewis (2005).
- National production targets are not new. In 1947 there was an espoused target to "double our production in the immediate future" (Levy 1948). And again in the early 1960s a target to increase dairy production by 40 to 50% was articulated (Smith 1964).
- The need to manage a farm as both a cash flow and capital asset business was identified by Candy in 1934
- The use of fertiliser nitrogen as a means of getting better growth from ryegrass pastures was first proposed by Holford (1934) and mentioned as a passing trend by Harris (1968), Ball (1969), O'Connor & Gregg (1971), Sherlock & O'Connor (1973), Ball *et al.* (1975), Luscombe (1979), Luscombe & Fletcher (1981), and Thomson & Roberts (1981). Buxton (1981) noted that use of more than 80 kg N/ha would be uneconomic on dairy farms and suggested its best use was in late autumn to allow more on-farm wintering of cows. Again it was reported that N use on dairy farms in the Waikato (Bryant *et al.* 1981) and Taranaki (Thomson *et al.* 1991) would not be economic; Morris & McRae (1990) also suggested that N use in beef production would not be economic. Further reporting indicated that winter N applications did not give economic returns for early lambing systems (Sheath *et al.* 1991). However, since the mid-1990s many papers have demonstrated the benefits of N use. This change has been due more to the increase in returns for dairy (1990 onwards) and for sheep/beef (2000 onwards) than a reduction in the cost of N and its application. Management decisions to lift annual feed demand (and hence production) above what can traditionally be supplied even from a well fertilised (P, K, S) grass/clover pasture heavily favours the use of N as the most cost effective feed source.
- The importance of pasture quality over simply the quantity of dry matter was first mentioned by Riddet (1938)
- Rates of pasture re-sowing have been low for decades. Connell (1938) estimated that at the pasture renewal rates then, it would take 35 to 40 years to re-sow the farmland being used. Today it is little better with a 30 year timeframe required for re-sowing all farmland. Lancashire (1985) also challenged the industry to enlarge and diversify the demand for New Zealand bred cultivars.
- Quality feed supply was identified as being of equal importance with cow pedigree (Hunger 1951).
- That labour supply limits pastoral agricultural production was indicated by Moore (1953).
- Illegible slide presentations were identified as a

challenge from the start. Saxby (1954) commented that "a scheme had been devised whereby the bane of all audiences, the illegible slide can be banished forever".

- Debate on the appropriate level of phosphatic fertilisation of productive dairy pasture began in the 1950s (Elliott & Karlovsky 1954).
- That having reliable and consistent measures of pasture production is a challenge has been a repeated theme (e.g. Lynch 1959; Wallace 1961; Devantier *et al.* 1998).
- Growing more grass per hectare, that is then efficiently utilised, as a means of continuing to improve animal production was identified by Wallace in 1961.
- In 1968 it was acknowledged that the ability of the New Zealand farmer to remain economically viable in the face of the continuous decline in his terms of trade has been based on technical and management progress (Stewart 1968).
- Adoption of basic management techniques as a requirement for effective pasture establishment was reported by Brougham (1969), Baker (1969), Cullen (1969), and Brock & Kane (2003).
- Difficulty in translating large differences in herbage production levels (caused by grazing management) into differences in animal production was indicated by Brougham (1970).
- Ceiling pasture yields have challenged agronomists, and yet increases in animal production per unit area were reported by Brougham (1976).
- The use of satellites to measure pasture growth appeared in the 1970s (Cochrane 1976; Ellis 1977)
- The knowledge wave was heralded under the guise of information to continue to improve New Zealand's competitiveness by Trim (1980)
- The development of a large range of models for understanding farm systems and to assist with decision making on-farm began to occur in the 1980s (e.g. McCall *et al.* 1986; Baars 1990; Marshall *et al.* 1991; Lewis & Garrity 1993; Barker & Baars 1993; Rollo *et al.* 1996; Metherell *et al.* 1997; Barioni *et al.* 1997; Martins da Silva *et al*. 1997; Wheeler & Thorrold 1997; Davis *et al.* 1998; Barker *et al.* 1998; Ledgard *et al.* 1999; Woodward *et al.* 2000; Ogle *et al.* 2000; Ogle & Tither 2000; Ridler *et al.* 2001; Fiorelli *et al.* 2001; Webby 2002; Wheeler *et al.* 2003; Thorrold *et al.* 2004; Monaghan *et al.* 2004; Zhang *et al.* 2004; Beukes *et al.* 2005).
- The potential impact of plant genomic technologies on pastoral agriculture has been discussed since the 1980s (e.g. White 1988; Woodfield & White 1996; Scott *et al.* 1996; Willocks 1999; Barrett *et al.* 2001; Bryan 2001; Flaville *et al.* 2003; Barrett *et al.* 2004).

An interesting commentary on labour productivity was made in the early 1950s – that "the New Zealand farm worker produces 50% more than his opposite number in Australia, twice that in Argentina, five times as much as in Britain, and 20 times as much as in Japan" (Moore 1953). Does the same still apply?

At a number of conferences we had speakers from overseas updating us on technologies and information from their pastoral systems, e.g. 1956 (South Africa, UK, USA and the Netherlands), and 1970 (UK, USA and South Africa).

Primary Sector Targets 2015

Both the dairy (Anon. 2005a), and meat and wool (Anon. 2005b) sectors have identified goals and targets for their industry to be achieved in the next decade.

For the dairy sector the goal is:

The dairy industry will increase dairy farmer profit and create wealth for the New Zealand economy, through achieving by 2015:

- *50% total productivity[2] gain (4% per year)*
- *35% growth of milksolids (3% per year)*
- *Continued 'freedom to operate' through embracing the following imperatives*
  - *growth and productivity goals must not compromise economic, environmental and animal welfare imperatives*

For the meat and wool sector the goal is:

The sheep, beef, and goat industries to increase progressively until 2015 farmer profit and wealth for the New Zealand economy by:

- *A 35% total productivity[2] gain (3% per year)*
- *Successfully addressing industry imperatives and ensuring that society increases its recognition of the meat and fibre sector as a driver of economic national well-being*

Each has a specific objective for Feed:

For dairy it is –

1. *To profitably increase the metabolisable energy utilised per ha by 50% from grazed forage*
2. *To improve pasture feed quality*
3. *To develop and apply measurements and systems so that supplementary feed is profitably used on dairy farms*

For meat and wool it is –

1. *To cost effectively and sustainably increase by 35%*

[2] Productivity is defined as the level of production (output) per unit of effort (input)

the metabolisable energy available from grazed pasture

2. *To develop and apply measurements and systems to ensure optimal on-farm use of supplementary feed*

The challenge for the research, extension/consultant and farming communities is how to achieve these targets. Can we identify the knowledge and technologies required to achieve either a 50% or 35% increase in metabolisable energy available from grazed forage or pasture?

R & D priorities

Both the dairy and meat and wool sectors have endorsed Strategic Frameworks to provide direction for future on-farm research, development, extension and education. Both sectors have identified similar priorities for increased R & D effort based on these Frameworks – they are:

- Supply of high metabolisable energy forage (includes pasture)
- Environmental integrity and sustainability
- Technology integration to deliver improved farm systems
- Improved adoption of current technologies and knowledge
- Biosecurity – pre-border, post-border and traceability
- Labour supply – quality and capacity

What must be done to ensure our pastoral research community is positioned and resourced to deliver these priorities? This question remains to be answered.

New Zealand's R & D innovation system

Continued advances in on-farm productivity will rely on both Government and industry supported R & D. In conjunction with this, to continue to ensure innovation is delivered we need:

- Acknowledged and respected leaders who can inspire a vision for the future of pastoral agriculture in New Zealand, and provide a unified voice into Wellington
- Practitioners who can deliver that vision
- An infrastructure that permits researchers to respond efficiently to farmer issues
- A process for attracting the best and brightest of our young people into pastoral agricultural research and the innovation cycle
- A consolidated and unified approach to solving problems and developing new technologies where industry, R & D providers and investors are equal partners, and each is respected for their contribution in working towards common and agreed goals
- An enlightened regulatory process that allows facts to overcome emotion and opinion; and common sense to prevail over political agendas

Funding of R & D has always been an issue. Even back in 1931, Hudson commented that "something like 6d to 1/- per £100 value (i.e. 0.05%) of our grassland exports is being spent in grassland research. When the importance of grassland is considered and the small amount compared with what is being spent on research into other primary industries, it is obvious that there is enormous scope for development of grassland research."

Today the R & D investment is somewhat larger, but over the past 15 years, the Government has reduced the proportion of its on-farm pastoral R & D investment aimed at 'sustaining and extending competitive and comparative advantage' (FRST 2004). Table 3 shows that dairy farmers contribute significantly to R & D in their sector, with on-farm R & D funded by industry and industry levy organisations (totalling 1.5% of sector GDP). This is about three times higher than the average business investment in R & D for NZ as a whole (estimated at 0.44% of GDP). Public funding of on-farm R & D is only 65% of business-funded R & D, considerably less than the 1.7:1 ratio applying at the aggregate level.

The Future

The pastoral sectors have been working hard to ensure that decision makers in Wellington understand that pastoral agriculture is New Zealand's knowledge economy and is the major existing and new wealth creator for our economy.

Furthermore the pastoral sectors have set ambitious productivity goals – these are efficiency goals, rather than value propositions. Achieving these goals will mean that we continue to seek ways to produce more output, primarily milk and meat, for less effort or input. Should this really be the way forward? New Zealand's

Table 3 The funding of on-farm and pastoral R&D relative to comparators

R&D investment	Government	Dairy industry
On-farm dairy RD&E*	NZD 31m	NZD 49m
– as % of farmer revenue (i.e. payout)*	0.59%	0.92%
– as % of direct contribution to GDP*	0.98%	1.5%
NZ overall R&D investment as % of GDP**	0.76%	0.44%

* 2003/04 ** 2005 Economic Development Indicators Report

wealth is created from exporting products that others will buy. The New Zealand Institute published a report (2006), "Dancing with the Stars", which states that over the period 1971 to 2002 New Zealand's exports grew 7.8% in value compared with the world trade growth of 9.5% a year. This means that our economic well being is declining relative to the rest of the world.

Environment

As production and productivity increases are sought, continued and improved environmental sustainability will be needed. Pastoral sector leaders are committed to improving the environment and taking a proactive stance, on the basis that:

- It is the 'right' and responsible action to take for the country
- It ensures 'freedom to operate' for the industry
- Resources are finite and must be used effectively and efficiently.

This will also require assistance from the research community and will simply not be a case of isolated technologies but rather a more integrated solution that seeks new systems and ways of managing waste and utilising inputs.

Environmental issues may be the biggest threat to future productivity targets. The 4% p.a. productivity target is legitimate and needed, but it is not the sole answer. The industry strategies equate these productivity targets to increases in pasture production rather than in the value of each kg of dry matter produced. The proposed increases in pasture production will, without a management change, cause unacceptable environmental damage. Despite some success with the Clean Streams Accord, nutrient management aspects appear to be seriously lagging. At a conference this year, 'Good for Growing ', organised by NZIAHS in Napier, a 10 person representative panel of environmentalists, dairy sector, farmers, MAF policy makers, and fertiliser industry agreed that current farming practices do not meet the needs of current and future generations of New Zealanders. A middle path is going to be very difficult to achieve because, as land values continue their inexorable rise, a viable return is only possible by using more and more unsustainable practices, without a radical change in approach.

Added value

More added value products have been proposed as the answer to provide adequate returns for on-farm investment for many years. Yet very little changes. Fonterra's shareholders council recently voiced their displeasure with the company's performance in this area. So is it just too hard? Do the strategies of maintaining our competitive international selling position through processing efficiencies simply lead to continued commodity production rather than adding value? Is there a lack of appropriate research and have we completely failed to improve "quality'" in pasture feeding and thus raise the value of each kg of dry matter

On the basis of what has happened over the past 25 years it cannot simply be more of the same. We must find ways to increase the value of what we export. Much of this must be market lead innovation and not simply science and research driven innovation. The issue is that the research community is not receiving clear messages that would inspire them to provide innovative value added products for our major exporting companies. This is unlikely to be resolved until exporters and scientists agree on common goals. However, when resolution is reached, the legacy we have achieved in supporting our pastoral export industries to create value through commodities will continue to play out through increased value added products.

There is much before us to do. Our legacy as grassland researchers, extension specialists and farmers is impressive, but opportunities to improve our performance, and that of the industry, exist. The future of grassland farming will require continued innovation and knowledge creation to remain not just competitive but also capable of creating new wealth.

REFERENCES

Anon. 2005a. Strategic Framework for New Zealand's Future Dairy Farming and Industry 2005-2015.

Anon. 2005b. Strategic Framework for New Zealand's Future Meat and Fibre Production Research 2005-2015.

Baars, J.A. 1990. A rational approach to feed planning on farm. *Proceedings of the New Zealand Grassland Association 51*: 75–78.

Baker, C.J. 1969. The present methods of pasture establishment. *Proceedings of the New Zealand Grassland Association 31*: 52–59.

Ball, R. 1969. Legume and fertiliser nitrogen in New Zealand pastoral farming. *Proceedings of the New Zealand Grassland Association 31*: 117–126.

Ball, R.; Inglis, J.A.H.; Mauger, J.H. 1975. Tactical application of fertiliser nitrogen to offset a season feed shortage on a heavily stocked sheep farm in southern Hawke's Bay. *Proceedings of the New Zealand Grassland Association 37*: 166–181.

Barioni, L.G.; Dake, C.J.; Parker, W.J. 1997. A stochastic model to study the control of grazing systems. *Proceedings of the New Zealand Grassland Association 59*: 73–78.

Barker, D.J.; Baars, J.A. 1993. Comparing the seasonal productivity of cocksfoot and resident pastures in hill country farms using a system model. *Proceedings of the New Zealand Grassland Association 55*: 81–85.

Barker, D.J.; Clark, D.A.; Thom, E. R.; Couchman, J.N.; Burton, R.N.; Dymock, N. 1998. Pasture species and drought impacts on milk yield 2. Predicted farm milk yield at four sites. *Proceedings of the New Zealand Grassland Association 60*: 45–50.

Barrett, B.A.; Griffiths, A.; Mercer, C.; Ellison, N.; Faville, M.; Easton, S.; Woodfield, D.R. 2001. Marker-assisted selection to accelerate forage improvement. *Proceedings of the New Zealand Grassland Association 63*: 241–245.

Barrett, B.A.; Baird, I.J.; Woodfield, D.R. 2004. Genetic tools for increased white clover seed production. *Proceedings of the New Zealand Grassland Association 66*: 119-126.

Beukes, P.C.; Palliser, C.C.; Prewer, W.E.; Levy, G.; Folkers, C.; Meal, M.; Wastney, M.E.; Thorrold, B.S. 2005. Comparing risk for different dairy farm management systems in Taranaki using the Dexcel Whole Farm Model. *Proceedings of the New Zealand Grassland Association 67*: 103–107.

Bray, A. 2004. More lamb from less. *Journal of Primary Industry Management 7*: 32–33.

Brock, J.L.; Kane, G.J. 2003. Variability in establishing white clover in pastures on farm. *Proceedings of the New Zealand Grassland Association 65*: 223–228.

Brougham, R.W. 1969. Present position of pasture establishment research in New Zealand. *Proceedings of the New Zealand Grassland Association 31*: 43–51.

Brougham, R.W. 1970. Frequency and intensity of grazing and their effects on pasture. *Proceedings of the New Zealand Grassland Association 32*: 137–144.

Brougham, R.W. 1976. Some aspects of pasture development and management in New Zealand. *Proceedings of the New Zealand Grassland Association 38*: 38–46.

Bryan, G.T. 2001. Biotechnology in forage crops – capturing our potential. *Proceedings of the New Zealand Grassland Association 63*: 235–239.

Bryant, A.M.; MacDonald, K.A.; Clayton, D.G. 1981. Effects of nitrogen fertiliser on production of milk solids from grazed pasture. *Proceedings of the New Zealand Grassland Association 43*: 58–63.

Buxton, D.A.L. 1981. Economics of nitrogen use in dairying. *Proceedings of the New Zealand Grassland Association* 43: 70–75.

Callaghan, F.R. 1935. The probable utilisation of New Zealand grassland. *Proceedings of the New Zealand Grassland Association 4*: 78-83.

Candy, R.A. 1934. The economic use of pastures in dairying. *Proceedings of the New Zealand Grassland Association 3*: Paper 18.

Caradus, J. R. 2005. Productivity – What is it? Pp 110–112 *In*: Proceedings of 2nd International Large Herds Conference – Dairying towards 2020..

Cochrane, G.R. 1976. Remote sensing applications in pasture analysis. *Proceedings of the New Zealand Grassland Association 38*: 226–245.

Connell, R.P. 1933. Some aspects of problems relative to increased application of knowledge of grassland farming. *Proceedings of the New Zealand Grassland Association 2*: Paper 9.

Connell, R.P. 1938. Some features of current land use. *Proceedings of the New Zealand Grassland Association 7*: Paper 5.

Cullen, N.A. 1969. Oversowing grasses and clovers. *Proceedings of the New Zealand Grassland Association 31*: 110–116.

Davis, K.L.; Thomson, N.A.; McLean, N.R.; McCallum, D.A.; Hainsworth, R.J.; Wards, A.J.; Barton, R.G. 1998. Pasture growth on dairy farms in the Golden Bay and West Coast of the South Island. *Proceedings of the New Zealand Grassland Association 60*: 9-4.

Devantier, B.P.; Lambert, M.G.; Brookes, I.M.; Hawkins, C.L. 1998. Measuring production of continuously grazed hill pasture. *Proceedings of the New Zealand Grassland Association 60*: 157–160.

Elliott, I.L.; Karlovsky, J. 1954. The use of phosphates on some major Waikato soil types. *Proceedings of the New Zealand Grassland Association 16*: 176–185.

Ellis, P.J. 1977. Remote sensing data from spacecraft and aircraft: their processing and application. *Proceedings of the New Zealand Grassland Association 39*: 174–189.

Fiorelli, C.F.; Woodward, S.J.R.; Wasteny, M.E.; Thom, E.R.; Bahmani, I. 2001. Modelling factors affecting reproductive development of perennial ryegrass in Waikato dairy pastures. *Proceedings of the New Zealand Grassland Association 63*: 165–170.

Flaville, M.; Barrett, B.; Griffiths, A.; Schreiber, M.; Mercer, C.; Baird, I.; Ellison, N.; Bryan, G.; Woodfield, D.; Forster, J.; Ong, B.; Sawbridge, T.; Spangenberg, G.; Easton, H.S. 2003. Implementing molecular marker technology in forage improvement. *Proceedings of the New Zealand Grassland Association 65*: 229–238.

FRST 2004. Investing in Our Future, Progress and Achievements Report, FRST, 2004, Table 2.2, p.23.

Garland, C. 1993. Technology transfer: systems used by a Wairarapa farm consultancy firm. *Proceedings of the New Zealand Grassland Association 55*: 7–9.

Hall, J.; Scobie, G.M. 2006. The role of R & D in productivity growth: the case of agriculture in New Zealand: 1927 to 2001. New Zealand Treasury Working Paper 06/01.

Hamblyn, C.J. 1947. A critical review of present day trends in grasslands farming. *Proceedings of the New Zealand Grassland Association 9*: 28-30.

Harris, W. 1968. Pasture seeds mixtures, competition and productivity. *Proceedings of the New Zealand Grassland Association 30*: 143–153.

Holford, G.H. 1934. Five years' experience in the use of nitrogen on pastures in New Zealand. *Proceedings of the New Zealand Grassland Association 3*: Paper 22.

Hudson, A.W. 1931. The use of fertilizers on grassland and the technique and scope of experimental work. *Proceedings of the New Zealand Grassland Association 1*: 21–23.

Hunger, W.C. 1951. Higher production on dairy farms. *Proceedings of the New Zealand Grassland Association 13*: 98 – 100.

Lancashire, J.A. 1985. Some factors affecting the rate of adoption of new herbage cultivars. *Using Herbage Cultivars. Grassland Research and Practice Series 3*: 79-87.

Ledgard, S.F.; Edgecombe, G.A.; Roberts, A.H.C. 1999. Application of the nutrient budgeting model OVERSEER™ to assess management options and regional council consent requirements on a Hawke's Bay dairy farm. *Proceedings of the New Zealand Grassland Association 61*: 227–231.

Levy, E.B. 1948. Developments in grassland farming. *Proceedings of the New Zealand Grassland Association 10*: 35–44.

Lewis, C.A.; Garrity, B. 1993. Application of a computer dairy model on farm. *Proceedings of the New Zealand Grassland Association 55*: 217–218.

Luscombe, P.C. 1979. Nitrogen fertilizer responses on hill country pastures. *Proceedings of the New Zealand Grassland Association 41*: 155–162.

Luscombe, P.C.; Fletcher, R.H. 1981. Nitrogen fertiliser on grazed hill pasture. *Proceedings of the New Zealand Grassland Association 43*: 171–181.

Lynch, P.B. 1959. Pasture production estimates by measures other than cutting. *Proceedings of the New Zealand Grassland Association 21*: 99–107.

MacClean, J.; Penno, J.; Howse, S. 1997. Current information and technology priorities of dairy farmers. A challenge for agricultural researchers. *Proceedings of the New Zealand Grassland Association 59*: 215–220.

Manson, P. 1999. The McRae Trust sustainable land management project: A community based approach to sustainable hill country farming. *Proceedings of the New Zealand Grassland Association 61*: 185–188.

Marshall, P.R.; McCall, D.G.; Johns, K.L. 1991. STOCKPOL: A decision support model for livestock farms. *Proceedings of the New Zealand Grassland Association 53*: 137–140.

Martins da Silva, J.A.; Parker, W.J.; Shadbolt, N.M.; Dake, C.K. 1997. Pasture development revisited: A model to analyse the physical and financial risk of developing pastures on sheep and beef cattle farms. *Proceedings of the New Zealand Grassland Association 59*: 67–72.

McCall, D.G.; Townsley, R.J.; Bircham, J.S.; Sheath, G.W. 1986. The interdependence of animal intake, pre- and post-grazing pasture mass ad stocking density. *Proceedings of the New Zealand Grassland Association 47*: 255–261.

McKenzie, S.A. 1980. The changing pattern of advisory work. *Proceedings of the New Zealand Grassland Association 42*: 191–193.

McRae, A.F. 1992. Farmers' needs for management, research and extension, and policy - findings of a farmers' workshop and their implications. *Proceedings of the New Zealand Grassland Association 54*: 7–10.

Metherell, A.K.; Thorrold, B.S.; Woodward, S.J.R.; McCall, D.G.; Marshall, J.D.; Morton, J.D.; Johns, K.L. 1997. A decision support model for fertiliser recommendations for grazed pasture. *Proceedings of the New Zealand Grassland Association 59*: 137–140.

Monaghan, R.M.; Smeaton, D.; Hyslop, M.G.; Stevens, D.R.; de Klein, C.A.M.; Smith, L.C.; Drewry, J.J.; Thorrold, B.S. 2004. A desktop evaluation of the environmental and economic performance of model dairy farming systems within four New Zealand catchments. *Proceedings of the New Zealand Grassland Association 66*: 57–67.

Moore, A.B. 1953. Increasing production from Northland hill country. *Proceedings of the New Zealand Grassland Association 15*: 68–78.

Morris, S.T.; McRae, A.F. 1990. Evaluation of nitrogen fertiliser in a beef production system. *Proceedings of the New Zealand Grassland Association 51*: 89–92.

O'Connor, M.B.; Gregg, P.E.H. 1971. Nitrogen fertilizer trials on pastures. *Proceedings of the New Zealand Grassland Association 33*: 26-34.

Ogle, G.I.; Tither, P. 2000. An analysis of the risks and benefits of beef intensification. *Proceedings of the New Zealand Grassland Association 62*: 25–29.

Ogle, G.I.; Allan, B.E.; Campbell, A.; Bates, J.R. 2000. Financial analysis of pasture improvement on Earnscleugh Station. *Proceedings of the New Zealand Grassland Association 62*: 167–172.

Prewer, W.E.; van Bysterveldt, A. 2004. The Pasture Quality Poster – a learning tool for farmers. *Proceedings of the New Zealand Grassland Association 66*: 183–186.

Riddet, W. 1938. The relation of pasture species to quantity and quality of milk. *Proceedings of the New Zealand Grassland Association 7*: Paper 11.

Ridler, B.J.; Rendel, J.M.; Baker, A. 2001. Driving innovation: Application of linear programming to improving farm systems. *Proceedings of the New Zealand Grassland Association 63*: 295–298.

Robertson, B.T. 1980. The effective publication of grassland research. *Proceedings of the New Zealand Grassland Association 42*: 194–200.

Rollo, M.D.; McCall, D.G.; Boom, C.J.; Sheath, G.W. 1996. Evaluation of a beef growth model for use in beef finishing decisions. *Proceedings of the New Zealand Grassland Association 57*: 95–99.

Savage, J.; Lewis, C. 2005. Applying science as a tool for dairy farmers. *Proceedings of the New Zealand Grassland Association 67*: 61–66.

Saxby, S.H. 1954. The New Zealand Grassland Association. *Proceedings of the New Zealand Grassland Association 16*: 24 – 34.

Scott, A.; Woodfield, D.R.; Allan, A.; Maher, D.; White D.W.R. 1996. Inheritance and expression of transgenes in white clover. *White Clover: New Zealand's Competitive Edge. Agronomy Society of New Zealand Special Publication 11/ Grassland Research and Practice Series 6*: 131-135.

Sheath, G.W.; Boom, C.J.; Webby, R.W. 1991. Nitrogen fertiliser use in early lambing systems. *Proceedings of the New Zealand Grassland Association 53*: 123–128.

Sherlock, R.R.; O'Connor, M.B. 1973. The use of nitrogen on hill country. *Proceedings of the New Zealand Grassland Association 35*: 52–62.

Smith, B.A.J. 1964. Pasture management for high production on dairy farms. *Proceedings of the New Zealand Grassland Association 26*: 129–136.

Stewart, J.D. 1968. Profitability and economics of cropping. *Proceedings of the New Zealand Grassland Association 30*: 72–80.

Thomson, N.A.; Roberts, A.H.C. 1981. Response to nitrogen fertiliser applied to dairy pastures in autumn and spring in Taranaki. *Proceedings of the New Zealand Grassland Association 43*: 44–52.

Thomson, N.A.; Roberts, A.H.C.; Judd, T.G.; Clough, J.S. 1991. Maximising dairy production by using nitrogen fertiliser and calving early. *Proceedings of the New Zealand Grassland Association 53*: 85–90.

Thorrold, B.S.; Bright, K.P.; Palmer, C.A.; Wastney, M.E. 2004. Modelling the effects of irrigation reliability on pasture growth in a dairy system in Canterbury. *Proceedings of the New Zealand Grassland Association 66*: 31–34.

Trim, P.N. 1980. Agricultural information: New Zealand's forgotten fuel. *Proceedings of the New Zealand Grassland Association 42*: 201–204.

van der Geest, C. 2002. Sources and uses of information on a West Coast dairy farm. *Proceedings of the New Zealand Grassland Association 64*: 31–32.

Wallace, L.R. 1961. Modern trends in grassland farming. *Proceedings of the New Zealand Grassland Association 23*: 75–84.

Webby, R.W. 2002. The value of decision support models for farmer learning. *Proceedings of the New Zealand Grassland Association 64*: 45-47.

Webby, R.W.; Sheath, G.W. 1991. Group monitoring, a basis for decision making and technology transfer on sheep and beef farms. *Proceedings of the New Zealand Grassland Association 53*: 13–16.

Wheeler, D.M.; Thorrold, B.S. 1997. Pasture yield response to different sulphur fertiliser strategies and its application to modelling. *Proceedings of the New Zealand Grassland Association 59*: 39–43.

Wheeler, D.M.; Ledgard, S.F.; de Klein, C.A.M.; Monaghan, R.M.; Carey, P.L.; McDowell, R.W.; Johns, K.L. 2003. OVERSEER® nutrient budgets – moving towards on-farm resource accounting. *Proceedings of the New Zealand Grassland Association 65*: 191–194.

White, D.W.R. 1988. Use of cell and molecular genetic manipulation to improve pasture plants. *Proceedings of the New Zealand Grassland Association 49*: 67–72.

Willocks, M.J. 1999. Commercialisation of genetically modified crops in New Zealand. *Proceedings of the New Zealand Grassland Association 61*: 117–119.

Woodfield, D.R.; White, D.W.R. 1996. Breeding strategies for developing transgenic white clover cultivars. *White Clover: New Zealand's Competitive Edge. Agronomy Society of New Zealand Special Publication 11/ Grassland Research and Practice Series 6*: 125-130.

Woodward, S.J.R.; Webby, R.W.; Johnstone, L.J.C. 2000. A decision tool for calculating herbage mass and metabolisable energy requirements of growing cattle and sheep. *Proceedings of the New Zealand Grassland Association 62*: 13–18.

Zhang, B.S.; Valentine, I.; Kemp, P.D. 2004. Modelling hill country pasture production: a decision tree approach. *Proceedings of the New Zealand Grassland Association 66*: 195–201.

APPENDIX 1

Technological advances impacting on grassland farming

Technology/advance	Impact/significance	Date – NZGA Proceedings
Strain development in herbage plants	Elite cultivars	Levy 1931 – NZGA Vol. 1
Economic value of phosphatic fertilisers	Improved productivity and production	Hudson 1931 – NZGA Vol. 1
Grazing management systems – rotational grazing for dairy farms	Better utilisation of grown pasture	Connell 1931 – NZGA Vol. 1
Seed certification	Quality seeds assurance	Hadfield 1933 - NZGA Vol. 2
Use of irrigation	Increase the area of economically viable agricultural land	Tennent 1933 - NZGA Vol. 2
Using social sciences to improve uptake and adoption of new knowledge	Use of best knowledge and technologies by farmers	Connell 1933 – NZGA Vol. 2
Improved grazing management of hill country	Reduce reversion back to weeds and scrub – maintain or improve productivity	McCulloch 1933 - NZGA Vol. 2
Importance of trace elements in animal nutrition	Stopped "bush sickness"	Riggs & Askew 1933 - NZGA Vol. 2
Concept of grass as a crop	Better utilisation of pasture	Callaghan 1933 - NZGA Vol. 2
Aligning production to market needs, including the need for diversification	Improved profitability	Williams 1933 - NZGA Vol. 2
Use of heterosis in forage plant breeding	Improved pasture production	Frankel 1934 - NZGA Vol. 3
Soil surveys	Understanding soil impacts on pasture production	Grand & Taylor 1934 - NZGA Vol. 3
Interaction between pasture nutritional value and animal metabolism	Realisation that not all pasture feed is equal	Franklin 1934 - NZGA Vol. 3
Differing palatability of pasture species	Animals have different preferences for different pasture types	Cunningham 1934 - NZGA Vol. 3
Adapting farm business to economic adversity	Balancing farming as a cash flow business and land asset business	Candy 1934 - NZGA Vol. 3
Impact of stocking rate on pasture composition and production	Improved productivity	Levy 1934 - NZGA Vol. 3
Use of N fertiliser to improve pasture production	Improved productivity	Holford 1934 - NZGA Vol. 3
Use of lime	Improved pasture production and seasonality of production	Woodcock 1935 - NZGA Vol. 4
Supplementary feed crops	Aid to pasture improvement and management	Connell 1935 - NZGA Vol. 4
Need for better extension methods for adopting knowledge	Improved productivity	Callaghan 1935 - NZGA Vol. 4
Use of fluorescents and	Uniform seed lines	Foy & Hyde 1935 - NZGA Vol.

Technology/advance	Impact/significance	Date – NZGA Proceedings
cyanogenesis to identify germplasm types		4
Lucerne breeding for NZ begins	Lucerne cultivars	Calder 1935 - NZGA Vol. 4
White and red clover cause feed flavour effects in milk	Understanding of impact of feed on milk flavour and probably composition	Riddet *et al.* 1936 - NZGA Vol. 5
Indication of mineral deficiencies in NZ pasture on animal health and production	Importance of Co, I, and Fe	Hopkirk 1936 - NZGA Vol. 5
Investigation of paspalum as a forage	Impact of C_4 grasses in NZ pasture	Hamblyn 1936 - NZGA Vol. 5
Investigation of the use of subterranean clover cultivars in pasture	Impact of annual clovers in NZ pastures	Levy & Gorman 1936 - NZGA Vol. 5
Identification of excessive protein levels in NZ pastures	Impact on animal fertility	Webster 1936 - NZGA Vol. 5
Lack of demonstration and research stations in the South Island	Missed opportunities to adopt advances in the South Island	Macassey 1936 - NZGA Vol. 5
Acknowledgement of seed mixture differences for wet and dry areas of NZ	Seed mixtures tailored to need and climate	Stuart 1937; Flay 1937 - NZGA Vol. 6
Seed sold to legislated standard in Australia, but not NZ	Free market alive in NZ	Foy 1937 - NZGA Vol. 6
Irrigation expands in the South Island	Improved production and productivity	Stafford 1937 - NZGA Vol. 6
Link of root health and vigour to leaf growth in pasture	Acknowledgment of importance of root systems	Jacques 1937 - NZGA Vol. 6
Link between condition of grassland and internal parasite prevalence	Management of internal parasites through management of pastures	Cole 1937 - NZGA Vol. 6
I deficiency in domesticated animals grazing on alluvial soils	Need for supplementation	Day-us 1937 - NZGA Vol. 6
Critical analysis of phosphate fertiliser use and place of rock phosphate	Understand the long term impacts of phosphate fertilisation and technologies for using rock phosphate	Hudson & Woodcock 1937 - NZGA Vol. 6
Impact of shelter trees on farm production	Concerns about shelter belt removal, particularly on the South Island. Recognition of importance of on-farm shelter for animal production	Dolamore 1937 - NZGA Vol. 6
Understanding the link between forest removal and increased erosion	Impact of replacing forest with grassland on soil erosion	Taylor 1938 - NZGA Vol. 7
The importance of feed value rather than feed amount	Impact of feed quality on animal product quality and composition	Riddet 1938 - NZGA Vol. 7
Pasture re-sowing rates are too low	At rates used it would take 35 to 40 years to re-sow the farmland	Connell 1938 - NZGA Vol. 7

Technology/advance	Impact/significance	Date – NZGA Proceedings
	being used	
Seed certification and purity assurance schemes	Farmers are assured of getting a quality seed product	Gorman 1947 - NZGA Vol. 9
Pasture management affects on sward composition	Importance of managing pastures to keep white clover content high	Long 1947 - NZGA Vol. 9
Importance of mechanisation to increase on-farm productivity, e.g. replacing horses with tractors, aerial topdressing	Improved on-farm productivity- more output per effort of input	Saxby 1947 - NZGA Vol. 9
Replacing set stocking with mob grazing on hill country	Improved sward composition and production	Linklater 1947 - NZGA Vol. 9
Importance of effective technology transfer	Realisation that uptake of current knowledge on pasture development and utilisation by farmers is slow	Hamblyn 1947 - NZGA Vol. 9
Subdivision	Improved control of stock grazing pasture to improve pasture yield and utilisation	Levy 1948 - NZGA Vol. 10
Development of short rotation (H1) ryegrass	Increased palatability, production and early spring growth	Corkill 1949 - NZGA Vol. 11
Use of lucerne grass mixtures	Improved seasonality of production on 'light' land	Bevan 1949 - NZGA Vol. 11
Survival of hard white clover seed through the rumen	Opportunity to use the animal to disseminate clover around the farm	Suckling 1950 - NZGA Vol. 12
Use of electric fencing to vary paddock size and improve pasture utilisation – "break grazing"	Better pasture utilisation	Allo 1951 - NZGA Vol. 13
Special purpose pastures and seasonal spread of production	Improved seasonal spread of feed	Smallfield 1951 - NZGA Vol. 13
A well bred cow is only half the story – pasturage must equal pedigree	Quality feed supply is as important as cow pedigree	Hunger 1951 - NZGA Vol. 13
The importance of draining land	Improved production	Hudson 1951 - NZGA Vol. 13
Integration of forage crops into pastoral agriculture	Improved winter and summer feed and process for re-sowing pasture	Bevin 1951 - NZGA Vol. 13
Earthworms appear beneficial to pasture growth	Improved ryegrass production	Water 1951 - NZGA Vol. 13
The need for Mo as a trace element in fertiliser	Improved N-fixation and fodder crop growth	Davies 1952 - NZGA Vol. 14 Adams 1952 - NZGA Vol. 14
Understanding of the role of statistics in pasture trials	Reliable results and analysis	Glenday 1952 - NZGA Vol. 14
Development of the roller drill	Better contact between seed and fertiliser at a constant sowing depth	Blackmore 1952 - NZGA Vol. 14
Need to attract people back to farming	Labour limiting pastoral farming productivity	Moore 1953 - NZGA Vol. 15

Technology/advance	Impact/significance	Date – NZGA Proceedings
Methods for managing C_4 grasses in northern NZ	Improved seasonal pasture production	Ballinger 1953 – NZGA Vol. 15
Mechanisation for draining land	Improved productivity	Scott 1953 - NZGA Vol. 15
19 t DM/ha produced	Upper limit of pasture production measured in NZ – at Dargaville Demonstration Farm	Lynch 1953 - NZGA Vol. 15
Surface drains	Used to drain land not suitable for underground drains, e.g. Hauraki Plains	Banfield 1953 - NZGA Vol. 15
Identification of temperature optima for our major pasture species	Better understanding of temperature limitations to pasture growth	Mitchell 1954 - NZGA Vol. 16
Soil and water conservation	Realisation of the importance of protecting natural resources that drive agricultural production	Wilkie 1954 - NZGA Vol. 16
Importance of maintaining soil phosphorus levels – heavy reliance of NZ pastoral agriculture on fertiliser inputs	The need for discrimination to be exercised when recommending fertiliser inputs, but in general NZ soils need increased levels of P and K and possibly N inputs	Elliott & Karlovsky 1954 - NZGA Vol. 16
Use of selective chemical herbicides to manage pasture weed	Improved sward composition and production	Matthews 1954 - NZGA Vol. 16
Pasture spelling	Increased stocking rate and production	Hamblyn 1954 - NZGA Vol. 16
Bloat caused by foam from natural fermentation of feed in the rumen – use of anti-foaming agents	Management of bloat using emulsifiers	Reid 1955 - NZGA Vol. 17
Ovine rickets in winter due to green feed (cereals) diet	Mitigated using an appropriate drench	Grant 1955 - NZGA Vol. 17
Soils deficient in cobalt characterised; use of vitamin B_{12} testing to determine Co deficiency in sheep	Appropriate management of soils and reduction in severity and incidence of Co deficiency in sheep	Andrews 1955 - NZGA Vol. 17
Over drilling of pastures	Sward rejuvenation	Blackmore 1955 - NZGA Vol. 17
Use of effective rhizobium strains to nodulate clovers	Improved white clover survival, growth and N-fixation	Sears & Greenwood 1955 - NZGA Vol. 17
Trace element deficiencies limited to defined soil types – deficiencies of major elements are more widespread for P,K and S	Appropriate use of trace and major elements as fertilisers	During 1955 - NZGA Vol. 17
Link between grazing behaviour and production	Individuality of cows in relation to selectivity of diet from pasture	Brumby 1955 - NZGA Vol. 17
Nutrition related disorders	Understanding causes for hypo-magnesaemia	Allcroft 1956 - NZGA Vol. 18
Economics of irrigation of "light land" in Canterbury	Improved production and profitability, but at a cost – irrigation schemes are expensive	Scott & Stuart 1956; Hilgendorf 1956 - NZGA Vol. 18

Technology/advance	Impact/significance	Date – NZGA Proceedings
	to implement	
Deterioration of quality and quantity in NZ tussock grasslands	Loss of production	Hercus 1956 - NZGA Vol. 18
Sowing rates for pasture seed mixtures	40 lb/ac was unnecessary; 20 lb/ac was all that was needed	Allo & Jordan 1957 - NZGA Vol. 19
Use of herbicides in pasture re-sowing	Direct drilling into herbicide treated pasture	Matthews 1957 - NZGA Vol. 19
Impact of treading damage on pasture growth	Treading reduced pasture yield irrespective of soil condition – exacerbated by wet conditions	Edmond 1957 - NZGA Vol. 19
S deficiency in the South Island	Need for a range of fertiliser with varying ratios of S and P	Walker 1957 - NZGA Vol. 19
Early example of gauging uptake of technology by farmers – use of H1 short rotation ryegrass	Over 90% of farmers in some regions (Otago and Southland) were using H1	Scott 1957 - NZGA Vol. 19
Breeding of *Lotus uliginosus*	Lead to the production of Maku lotus	Barclay 1957 - NZGA Vol. 19
Impact of light into pastures on growth rate	Influence of defoliation height on net assimilation rate and therefore ability of plants to 'harvest' light energy	Brougham 1957 - NZGA Vol. 19
Commercialisation of legume seed coating with rhizobia	Improved nodulation of pasture legumes	Callaghan 1958 - NZGA Vol. 20
Sowing rates of perennial ryegrass pastures are generally too high, suppressing the establishment of other sown species	Sowing rates can be reduced with negative effects on pasture establishment	Cullen 1958 - NZGA Vol. 20
Residual effect of applied phosphatic fertilisers	Residual effects can last many years, but they can vary with soil type and fertiliser type. Fresh applications are more effective,	Karlovsky 1959 - NZGA Vol. 21
Reviewing plant breeding targets	Identified seasonality of production, water use efficiency, competitive ability, and quality as the main breeding targets	Barclay 1959 - NZGA Vol. 21
Increased incidence of animal disorders on improved pasture and incidence of Se deficiency	Awareness of cause of some animal disorders and need for Se administration	Hartley 1959 - NZGA Vol. 21
Use of the forage harvester to cut and collect silage	Improved productivity – labour efficiency	Hopewell 1960 - NZGA Vol. 22
Use of Se, Cu, Co and I as micronutrients for sheep health in Southland	Improved production and profitability	Andrews 1960 - NZGA Vol. 22
Depletion and erosion of pastoral tussock country – remediation measures	Improved sustainability of production	Sly 1960 - NZGA Vol. 22
Discovery (1959) of Argentine stem weevil and	Prairie grass suggested as an alternative	Pantall 1961 - NZGA Vol. 23

Technology/advance	Impact/significance	Date – NZGA Proceedings
its impact on ryegrass survival		
Leaching loss from high concentrations of N and K in sheep urine	Use plant species that are productive and can utilise these nutrients	Dale 1961 - NZGA Vol. 23
Controlled versus uncontrolled grazing in dairy (McMeekan trials)	Better pasture utilisation and per cow production	Wallace 1961 - NZGA Vol. 23
Sheep electric fence	More flexible and cheaper subdivision	Currie 1961 - NZGA Vol. 23
Integrating topdressing of fertiliser with appropriate subdivision	More efficient use of additional grass produced by fertiliser	Currie 1961 - NZGA Vol. 23
Bulldozed tracks onto farms	Allowed vehicles into otherwise inaccessible parts of the farm – improved subdivision and management	Currie 1961 - NZGA Vol. 23
Mg deficiency of some NZ pasture soils	Improved production	Moody 1962 - NZGA Vol. 24
Use of Yorkshire Fog on hill country	Breeding programme began at Massey	Jacques 1962 - NZGA Vol. 24
On pumice soils lucerne nodulation only occurred with liming	Improved N-fixation and yield	Parle 1962 - NZGA Vol. 24
Significance of lucerne in dry land areas for hay and grazing	Higher feed production in dry land areas	Flay 1962 - NZGA Vol. 24
Integration of sheep and cattle grazing on hill country	Improved productivity from sheep	Ward 1962 - NZGA Vol. 24
Herbicide alone will not control weed problems	Need for improved fertiliser inputs ad pasture management – also mentioned possible impact of biocontrol	Leonard 1962 - NZGA Vol. 24
Complementary nutrient status of clovers and grass in pasture	Need to keep an appropriately balanced grass:clover ratio	Johns 1963 - NZGA Vol. 25
Widespread use of DDT to control grass grub	Potential residue issues mentioned	Cottier 1963 - NZGA Vol. 25
Integration of pasture management and animal husbandry for improved pasture utilisation	Improved pasture utilisation and yield per hectare	Campbell 1963 - NZGA Vol. 25
Release of Ariki – the new long rotation ryegrass or hybrid ryegrass	Improved seasonal growth, particularly in summer	Barclay 1963 - NZGA Vol. 25
Improved pelleting of clover seed with rhizobium	Improved nodulation and establishment of clover	Hastings 1964 - NZGA Vol. 26
Rhizobium strain specificity among pasture legume species	Requirement to use the right rhizobium strain with the appropriate legume species	Greenwood 1964 - NZGA Vol. 26
Discovery of *Pithomyces chartarum* fungus as the cause of facial eczema	Methods for reducing dead matter in pasture for the fungus to grow on	Lancashire & Keogh 1964 - NZGA Vol. 26

Technology/advance	Impact/significance	Date – NZGA Proceedings
(Thornton and Percival 1959) through production of sporidesmin		
Identification of cellulose content and leaf strength as an important component of pasture quality	Indicates need for breeding targets for increased grass feed quality	Bailey 1964 - NZGA Vol. 26
Management strategy for high production from hill country	Maintained improved production	Suckling 1964 - NZGA Vol. 26
Use of popular trees to stabilise steep land	Soil conservation	Hogg 1965 – NZGA Vol. 27
Use of brassicas and cereals as feed (in the North Island)	Increased production	Smith 1965 - NZGA Vol. 27
Sulphurised superphosphate	Improved nutrition of pasture grasses and legumes	Ludecke 1965 - NZGA Vol. 27
Vacuum silage	Better silage conservation and more efficient meat and wool production	Monteath 1966 - NZGA Vol. 28
Use of computers signalled in keeping farm records and decision making	Improved productivity	Banfield 1966 - NZGA Vol. 28
Grasslands 4707 tetraploid Westerwolds ryegrass	Improved annual ryegrass	Barclay & Vartha 1966 - NZGA Vol. 28
The importance of earthworms in maintaining good soil structure	Improved production	Stockdill 1966 - NZGA Vol. 28
Lime pelleting of legume seed	Improved nodulation on acid soil	Cullen & Ludecke 1966 - NZGA Vol. 28
Use of non-toxic tall fescue in NZ	A safe alternative to toxic fescue	All & Southon 1967 - NZGA Vol. 29
Demonstration of differing nutritive value of ryegrass cultivars	Higher milk yields associated with low crude fibre content and high organic matter digestibility of ryegrass cultivars	Wilson 1967 - NZGA Vol. 29
Importance of pasture utilisation	Increased productivity per hectare	Edmond 1967 - NZGA Vol. 29
Economic success of NZ pasture seed industry reliant on export sales	Need to get cultivars adopted to overseas markets and improve seed yields to improve efficiency	Shillito 1968 - NZGA Vol. 30
Crown rust limiting pasture production	Need for cultivars selected for rust resistance	Lancashire & Latch 1968 - NZGA Vol. 30
Improved technology for inoculating clover seed with rhizobia	Improved nodulation	Taylor & Lloyd 1968 - NZGA Vol. 30
Mangere ecotype of ryegrass identified	Higher production and drought tolerance	Rumball 1969 - NZGA Vol. 31
Grasslands 4700 (Pitau) white clover	Improved winter growth	Barclay 1969 - NZGA Vol. 31
Light rates of paraquat spraying onto pasture	Improved clover content	Williams & Palmer 1969 - NZGA Vol. 31
Length of recovery period more important than cutting	Improved yields and persistence from lucerne	Langer & Keoghan 1970 - NZGA Vol. 32

Technology/advance	Impact/significance	Date – NZGA Proceedings
height for lucerne survival		
Researchers encouraged to evaluate the cost of maximising production, not just the likely return	Importance of economics in introducing new technologies to increase production	Campbell 1970 - NZGA Vol. 32
Over-drilling annual ryegrasses into lucerne	Improved total and seasonal forage yields	Vartha 1971 - NZGA Vol. 33
Using fertiliser N to overcome seasonal shortages in N supply from N-fixation	Improved seasonal forage yields	O'Connor 1971 - NZGA Vol. 33
Lucerne identified as a valuable crop in the humid North Island	Highly value feed	Robinson & Abbott 1971 - NZGA Vol. 33
Electronic capacitance meter	Measurement of pasture yields – although reliability was an issue	Bryant *et al.* 1971; Stephen & Revfeim 1971 - NZGA Vol. 33
Weighted disc grass meter	Measurement of pasture yields	Phillips & Clarke 1971 - NZGA Vol. 33
All grass wintering in Southland	Overcame dissatisfaction with swedes	Brown & Harris 1972; Miller 1972; Halford 1972 - NZGA Vol. 34
Feed budgeting on dairy farms	Improved feeding, productivity and production leading increased economic returns	Parker 1972 - NZGA Vol. 34
Use of cereal forage with annual ryegrass	Improved forage yield on summer dry areas	Vartha & Rae 1972 - NZGA Vol. 34
"Block" or "long rotation" wintering	Improved winter production	Parker & Willis 1972 - NZGA Vol. 34
Grasses are more effective in obtaining soil P than white clover	Better understanding of nutrition requirements of white clover	Jackman & Mouat 1973 - NZGA Vol. 35
Lax grazing can cause browntop to be suppressed	Means of managing browntop ingress	Harris 1973 - NZGA Vol. 35
Use of mineral N on hill country	Identified as an economic option	Sherlock & O'Connor 1973 - NZGA Vol. 35
Mangere ecotype ryegrass identified as superior to certified strains	Improved pasture production	Ellett 1973 - NZGA Vol. 35
Spring grazing management of lucerne	Improved lucerne growth on light soils	Janson 1974 - NZGA Vol. 36
Browse shrubs	Increase production on low producing hill country	Hill 1974 - NZGA Vol. 36
Irrigated lucerne	Improved feed in spring/summer on irrigated light soils	Janson 1974 - NZGA Vol. 36
Tall fescue in dryland	Improved production	Watkins 1974 - NZGA Vol. 36
Tall fescue as a companion grass to lucerne	Improved production	Allen & Cullen 1974 - NZGA Vol. 36
Release G4710 tall fescue (Grasslands Roa)	Better adapted tall fescue germplasm	Anderson 1974 - NZGA Vol. 36
Establishment of alkali and leafcutter bees in NZ	Improved pollination of lucerne	Donovan 1974 - NZGA Vol. 36
Plant Breeders Rights	Intellectual property protection of bred cultivars	Lancashire 1976 - NZGA Vol. 37

Technology/advance	Impact/significance	Date – NZGA Proceedings
Integrating forestry and pasture grazing	Improved profitability	Gillingham *et al.* 1976; Farnsworth *et al.* 1976 - NZGA Vol. 37
Identification of chemical deterrents in roots of lucerne and lotus	Grass grub and black beetle resistance	Sutherland 1976 - NZGA Vol. 37
Over-drilled cereal forages	Improved yields	McLeod & Douglas 1976 - NZGA Vol. 37
Lotus for high land acid soils	Legume adapted to acid soils	Nordmeyer & Davis 1977 - NZGA Vol. 38
Tannins in some legume	Reduction in incidence of bloat and improved nutritive value	Ulyatt *et al.* 1977 - NZGA Vol. 38
Tetraploid red clover – Grasslands Pawera	Productive late flowering red clover	Anderson 1977 - NZGA Vol. 38
Remote sensing to measure pasture production	Improved pasture growth analysis	Cochrane 1977 - NZGA Vol. 38
Matua prairie grass	Special purpose pasture grass option	Rys *et al.* 1978 - NZGA Vol. 39
Lucerne and lucerne/prairie grass swards on pumice soils	High yield, high quality pasture	Marsh & Brunswick 1978 - NZGA Vol. 39
Use of green feeds (cereal forages) in Southland	Improved winter feed supply	Hay & Ryan 1978 - NZGA Vol. 39
Water harvesting	Improved water supply in summer – method of rationalising natural water supply	Lowe 1978; Bowler & Turner 1978 - NZGA Vol. 39
Importance of 'safe' pasture (low levels of parasitic larvae) for lamb growth rates	Improved lamb growth rate	Jagger 1979 - NZGA Vol. 40
N provision through mineralisation and N-fixation	Two major processes for N provision for grass growth	Carran 1979 - NZGA Vol. 40
Direct drilling of grasses	Cost effective pasture renovation	Ryan *et al.* 1979 - NZGA Vol. 40
Association between black beetle presence and paspalum	Increased pasture pest burden	Watson & Wrenn 1980 - NZGA Vol. 41
Forest farming	Integration of different production systems	Hawke *et al.* 1980 - NZGA Vol. 41
Competitive ability of naturalised rhizobium strains	Explanation for the often poor nodulation of rhizobium inoculated legume seed	Hale 1980 - NZGA Vol. 41
Grasslands Roa tall fescue	Improved late summer early autumn production	Goold *et al.* 1980 - NZGA Vol. 41
Susceptibility of white clover and ryegrass to grass grub	Option to use resistant species – lucerne, lotus and fescue	East *et al.* 1980 - NZGA Vol. 41
Intensity of pasture grazing to manipulate paspalum content	Option to reduce paspalum content	Baars *et al.* 1980 - NZGA Vol. 41
Use of grazing to 'control' aphid populations on lucerne	Reduced damage from aphids and viruses	Smallfield *et al.* 1980 - NZGA Vol. 41
Procedure for high grass seed yields	Improved grass seed yields	Brown 1980; Moore 1980; Lancashire *et al.* 1980 - R&PS[3] Vol. 1
Amenity seed production	Improved amenity grass seed	Corkill & Rumball 1980 -

Technology/advance	Impact/significance	Date – NZGA Proceedings
strategy	yields	GR&PS Vol.1
Procedure for high white clover seed yields	Improved white clover seed yield	Clifford 1980; Wright 1980; Lay 1980 - GR&PS Vol.1
Procedure for high red clover seed yields	Improved red clover seed yield	Clifford & Anderson - GR&PS Vol.1
Procedure for high lotus seed yields	Improved lotus seed yields	Lancashire *et al.* 1980 - GR&PS Vol.1
Procedure for high lucerne seed yields	Improved lucerne seed yields	Palmer & Donovan 1980 - GR&PS Vol.1
The role of lotus as a pioneer species	Better pastures on difficult soils	Morton 1980; Scott & Mills 1981 - NZGA Vol. 42
Legume oversowing and fertiliser reduced *Hieracium*	Reduction of an invasive weed	Lucas *et al.* 1981 - NZGA Vol. 42
High feeding value of tannin containing legumes	Better quality feed	John & Lancashire 1981 - NZGA Vol. 42
Reliance on overseas germplasm for NZ pasture improvement	Improved pasture cultivars	Corkill *et al.* 1981 - NZGA Vol. 42
Selective fertiliser application	Improved efficiency of superphosphate use	Lambert *et al.* 1982 - NZGA Vol. 43
Fungicide seed treatment to aid grass establishment	Improved establishment of pastures	Falloon 1982 - NZGA Vol. 43
Value of Grasslands Nui and Ellet ryegrasses on fertile soils	Improved productivity	Goold 1982 - NZGA Vol. 43
N cycle in pasture quantified with losses from urine patches identified as an inefficiency	Understanding of where N losses occur	Field & Ball 1982 - NZGA Vol. 43
MCPB and mechanical topping to control Californian thistle	Improved pastures and production	Hartley & Thomson 1982 - NZGA Vol. 43
Hill country white clover selected and released	Improved clover content and persistence in hill country	Williams *et al.* 1982 - NZGA Vol. 43
Hill country management complements pasture quality	Improved production	Clark *et al.* 1982 - NZGA Vol. 43
Gorse control through goat/sheep mob grazing	Improved pasture quality	Rolston *et al.* 1982 - NZGA Vol. 43
Use of phalaris, tall fescue, cocksfoot and chicory in dryland pastures	Improved production in dry regions	Lancashire & Brock 1983 - NZGA Vol. 44
Grasslands Roa tall fescue	Improved tall fescue for dryland regions	Brock 1983 - NZGA Vol. 44
Grasslands Rere and Grasslands Oranga lucerne	Aphid resistant cultivars adapted to NZ conditions	Easton & Stiefel 1983 - NZGA Vol. 44
Matua/Nui/Pawera pastures	Improved cool season activity, drought tolerance and summer growth	Hay & Ryan 1983 - NZGA Vol. 44
Association of ryegrass endophyte with ryegrass staggers	Identification of the likely cause of ryegrass staggers	Mortimer & di Menna 1983; Harvey 1983; Fletcher 1983 - NZGA Vol. 44
Endophyte in ryegrass associated with resistance to	Improved persistence and production of ryegrass swards	Gaynor & Hunt 1983 - NZGA Vol. 44

Technology/advance	Impact/significance	Date – NZGA Proceedings
Argentine stem weevil		
Use of fungicides to kill endophytes in ryegrass plants and seed	Reduce impact of endophyte on animal health	Latch 1983 - NZGA Vol. 44
Breeding for staggers resistance in sheep	Reduce impact of ryegrass staggers	Hewett 1983 – NZGA Vol. 44
Need for testing endophyte levels in ryegrass commercial seed	Prediction of impact on stock health	Scott 1983 - NZGA Vol. 44
Use of supplementary feed to improve ewe flushing	Improved ovulation rate	Hayman & Munro 1983 - NZGA Vol. 44
Lotus corniculatus for dry hill and high country	Legume for dryland regions	Scott & Charlton 1983 - NZGA Vol. 44
Complementary grazing of sheep and goats on hill country	Improved meat and fibre production	Clark *et al.* 1984 - NZGA Vol. 45
Sulla for soil conservation	Renovation of slips and gullies	Douglas 1984 - NZGA Vol. 45
Differing rates of volatilisation for N fertilisers	Less ammonia lost from ammonium sulphate than urea	Theobald & Ball 1984 - NZGA Vol. 45
Glyphosate herbicide as a means of better pasture management and establishment on hill country	Improved pasture quality and animal production	Arnst & Park 1984 - NZGA Vol. 45
White clover stolon burial peaks in early spring	Understanding of the impact of grazing on stolon damage	Hay & Chapman 1984 - NZGA Vol. 45
Reactive phosphate rock	Viable option when the effective P cost is lower than that of superphosphate	Percival *et al.* 1984 - NZGA Vol. 45
Use of fungicides and growth retardants to increase grass seed production	Increased grass seed yield	Hampton *et al.* 1985 - GR&PS Vol. 2
Herbicide and fertiliser recommendations for grass seed crops	Increased grass seed yield	Rolston *et al* 1985 - GR&PS Vol. 2
Relationship of leaf size to seed yield in white clover	Processes for reducing leaf size in seed crops	Clifford 1985 - GR&PS Vol. 2
Process for following cropping with white clover	Successful white clovers seed crop establishment	McCartin 1985 - GR&PS Vol. 2
Field heating and drying damage impacts on seed quality	Need to avoid field heating and drying damage	Hill & Johnstone 1985 - GR&PS Vol. 2
Process for successful cultivar change for white clover	Reduced contamination of white clover seed crops	Clifford *et al.* 1985 - GR&PS Vol. 2
Ecology of forage species in South Is. hill and high country	Species aligned for fitness of purpose	Scott *et al.* 1985 - GR&PS Vol. 3
Process for establishing pastures in high country	Improved establishment and management of high country pastures	Allan *et al.* 1985 - GR&PS Vol. 3
Process for establishing pastures in hill country	Improved establishment and management of hill country pastures	Chapman & Macfarlane 1985; Lambert *et al.* 1985 - GR&PS Vol. 3

Technology/advance	Impact/significance	Date – NZGA Proceedings
Process for establishing pastures in dryland	Improved establishment and management of dryland pastures	Hoglund & White 1985; Hume & Fraser 1985 - GR&PS Vol. 3
Process for establishing pastures on summer wet finishing country	Improved establishment and management of finishing pastures	Harris & Chu 1985; Cosgrove *et al.* 1985 - GR&PS Vol. 3
Process for establishing pastures for dairying	Improved establishment and management of dairy grazing pastures	Goold *et al.*1985; Thom *et al.* 1985 - GR&PS Vol. 3
Large N leaching losses under intensive grazing	Implications for ground water quality	Field *et al.* 1985 - NZGA Vol. 46
Grasslands Demand white clover	White clover for southern NZ	Widdup 1985 - NZGA Vol. 46
Annual cycle of white clover stolon burial and re-emergence	Understanding clover growth in grazed pastures	Hay 1985 - NZGA Vol. 46
Increased flow rate and reduced strip length improve water use efficiency	Better irrigation in water use	Taylor *et al.* 1985 - NZGA Vol. 46
Shelter belts	Improved pasture production	Radcliffe 1985 - NZGA Vol. 46
Negative relationship between grazing intensity and litter loss	Increased N loss with reduced litter accumulation	Hoglund 1985 - NZGA Vol. 46
Integrating red clover and ryegrass	Increased yield of high quality pasture	Cosgrove & Brougham 1985 - NZGA Vol. 46
Chemical manipulation of hill country pastures	Improved clover content	Rolston *et al.* 1985 - NZGA Vol. 46
Use of Maku lotus at high altitude	Improved legume content in swards	Dunbar & Costello 1985 - NZGA Vol. 46
Zn dosing, avoidance of toxic pastures and use of fungicides to combat facial eczema	Strategy for reducing impact of facial eczema	Towers 1986 - NZGA Vol. 47
Peramine, the endophyte alkaloid offering resistance to Argentine stem weevil	Understanding of endophyte mediated resistance to the weevil	Gaynor & Rowan 1986 - NZGA Vol. 47
Autumn and winter lambing in Northland	Increased flexibility in lamb production	Andrewes & Taylor 1986 - NZGA Vol. 47
Rapid stock rotation	Means of minimising impacts of fungal toxins in pasture	Keogh 1986 - NZGA Vol. 47
Earthworm activity increases water soluble phosphate in soil	Improved phosphate availability	Mouat & Keogh 1986 - NZGA Vol. 47
Earthworm content and pasture productivity positively correlated in hill country	Method for increasing earthworm population density	Lambert 1986 - NZGA Vol. 47
Set stocking reduces grass grub, but increased porina and earthworm numbers	Methods for managing pests and earthworm population density	Brock 1986 - NZGA Vol. 47
Distribution of clover cyst and root knot nematodes in pastures	Understanding of their distribution and importance in clover survival and production	Mercer & Woodfield 1986 - NZGA Vol. 47
Significance of cricket	Cause of significant pasture	Blank 1986 - NZGA Vol. 47

Technology/advance	Impact/significance	Date – NZGA Proceedings
damage in Northland pastures	production losses	
Pasture disappearance model shows importance of pre-grazing green pasture mass	Means of achieving intake rate targets	McCall *et al.* 1986 - NZGA Vol. 47
Pasture height as a measure of pasture mass and animal performance	Assistance with management decisions	Webby & Pengelly 1986 - NZGA Vol. 47
Reducing paspalum content and increasing grazing interval increased ryegrass seedling establishment	Improved ryegrass establishment when overdrilled	Thom *et al.* 1986 – NZGA Vol. 47
MAF Fertiliser Advisory Service	Improved recommendation for fertiliser use	Cornforth & Sinclair 1986 - NZGA Vol. 47
No tillage and direct drilling	Introduction of productive cultivars into old pasture	Ritchie 1986 - NZGA Vol. 47
Grasslands Kopu white clover	Large leaved cultivar for intensive lowland pastures	van den Bosch *et al.* 1986 - NZGA Vol. 47
Browse shrubs	Vegetation for low producing sunny faces in the high country	Wills *et al.* 1987 - NZGA Vol. 48
Tagasaste	Browse shrub for dryland regions	Townsend & Radcliffe 1987 - NZGA Vol. 48
Caucasian and Zigzag clovers	Persistent clovers in grazed swards	Daly & Mason 1987 - NZGA Vol. 48
Yatsyn 1	High yielding endophyte containing ryegrass cultivar	Kerr 1987 - NZGA Vol. 48
Lotus corniculatus	Legume for South Island tussock country	Widdup *et al.* 1987 - NZGA Vol. 48
Off farm winter grazing for dairy farming	Strategy for bridging the winter feed gap	Wilson 1988 - NZGA Vol. 49
Microcomputers	Pasture growth predictions to aid management decisions	Baars 1988 - NZGA Vol. 49
Genetic engineering of animals, plants and microbes	Potential for improved growth rates and adaptation	Forrest & Broad 1988; White 1988; Davis *et al.* 1988 - NZGA Vol. 49
Grasslands Puna chicory	High quality forage giving high animal growth rates	Fraser *et al.* 1988 - NZGA Vol. 49
Grasslands Matua prairie grass	Grass for drier summers and cooler winters	Ridler *et al.* 1988 - NZGA Vol. 49
Annual growth cycle of white clover plants understood	Assisting with grazing strategies to enhance clover production and persistence	Hay *et al.* 1988 - NZGA Vol. 49
Pasture probe	Improved accuracy in measuring pasture mass	L'Huillier & Thomson 1988 - NZGA Vol. 49
Assessment of pasture utilisation	Framework for analysing differences in productivity	Brookes & Holmes 1988 - NZGA Vol. 49
Controlled release Se granules	Reduced incidence of Se deficiency of sheep	Watkinson 1989 - NZGA Vol. 50
NaCl applications to Waikato soils	Improved Na nutrition of cows	O'Connor *et al.* 1989 - NZGA Vol. 50
Tiller life cycle dynamics of ryegrass	Understanding ryegrass renewal and implications for management	Matthew *et al.* 1989 - NZGA Vol. 50

Technology/advance	Impact/significance	Date – NZGA Proceedings
Corvette annual ryegrass	Able to co-exist with perennial ryegrass in Northland	Percival *et al.* 1989 - NZGA Vol. 50
Grasslands Moata tetraploid annual ryegrass	Improved lamb growth in Southland	Hickey & Baxter 1989 - NZGA Vol. 50
Herbicide use before oversowing	Improved establishment of oversown species	Frengley & Andersen 1989 - NZGA Vol. 50
Grasslands Demand white clover	Improved white clover cultivar bred for southern NZ	Widdup *et al.* 1989 - NZGA Vol. 50
Grasslands Maru phalaris	Increased flexibility and improved production in hill country	Stevens *et al.* 1989 - NZGA Vol. 50
Effects of withholding phosphate application on hill country	Decline in measured pasture production. Slower regrowth after grazing. Less white clover and more weeds. Reduced liveweight gains. Possible strategy for periods of low product price:fertiliser cost ratio.	Gillingham *et al.* 1990; Rowarth & Gillingham 1990; O'Connor *et al.* 1990; Lambert *et al.* 1990; Clark *et al.* 1990 - NZGA Vol. 51
Reactive rock phosphate	Cheaper effective phosphate fertiliser	Sinclair 1990 - NZGA Vol. 51 Mackay 1990 - NZGA Vol. 51
Trees for shelter and erosion control on hill country	Soil conservation and improved animal welfare	Sturrock 1990 - NZGA Vol. 51
Phalaris and tall fescue for grass grub and drought prone parts of Taranaki	Improved pasture production	Judd *et al.* 1990 - NZGA Vol. 51
Tannins reduce bloat and increase nutritive value	Increased meat and milk production	Waghorn *et al.* 1990 - NZGA Vol. 51
Off – farm wintering of cows	Improved profitability	Morton & Jensen 1990 - NZGA Vol. 52
Effect of spacing density and grazing on seed production of grasses	Process for maximising grass seed production	Hare 1990 - GR&PS Vol. 5
Efficacy of herbicides and fertilisers for seed production	Best practice for use for grass seed production	Rolston 1990 - GR&PS Vol. 5
Efficacy of fungicides for seed production	Best practice for use for grass seed production	Falloon 1990 - GR&PS Vol. 5
Grass seed crop management	Best practice management for grass seed crops	Brown *et al.* 1990a,b,c,d; Brown & McIntosh 1990; Brown & Lill 1990 - GR&PS Vol. 5
Potential of nil lolitrem endophytes is indicated	No staggers on ryegrass with endophyte that gives resistance to Argentine stem weevil	Fletcher *et al.* 1990 - NZGA Vol. 52
Serratia entomophila to control grass grub	Biological control option	Jackson 1990 - NZGA Vol. 52
Necton sulla	A high quality non-bloating feed	Krishna *et al.* 1990 - NZGA Vol. 52
Mediterranean saltbush	Forage shrub for South Island dry hill country	Wills *et al.* 1990 - NZGA Vol. 52
Grasslands Pacific ryegrass	Improved summer and winter growth	Pennell *et al.* 1990 - NZGA Vol. 52
StockPol	Farm scale decision support model to analyse long term policy changes or short term	Marshall *et al.* 1991- NZGA Vol. 53

Technology/advance	Impact/significance	Date – NZGA Proceedings
	feed budgets	
Policies for breeding beef cows to improve winter feed conversion efficiency	Aim for older rather than younger herd age structures, use breeds of bull with high growth rate and high survival rate progeny, and winter only pregnant heifers and cows.	McMillan & McCall 1991- NZGA Vol. 53
Fertiliser index	Predictive model for economic use of fertiliser	McCall & Thorrold 1991 - NZGA Vol. 53
N leaching from urine spots	Major source of N for grass growth and loss to the system	Ruz-Jerez *et al.* 1991 - NZGA Vol. 53
Endosafe ryegrass	Staggers free (zero lolitrem B) endophyte giving protection against Argentine stem weevil	Fletcher *et al.* 1991 - NZGA Vol. 53
Herbal ley	A specialist pasture providing high quality feed in summer	Ruz-Jerez *et al.* 1991 - NZGA Vol. 53
Yatsyn-1 ryegrass	Recommended for environments prone to summer dryness to increase annual dry matter production	Hainsworth *et al.* 1991 - NZGA Vol. 53
Pastoral fallow	Improved white clover vigour and N-fixation	MacKay *et al.* 1991 - NZGA Vol. 53
Group farm monitoring	Improved technology transfer	Webby & Sheath 1991 - NZGA Vol. 53
Pathogenic fungi and parasitic wasp	Control options for Argentine stem weevil	Prestidge *et al.* 1991 - NZGA Vol. 53
Strip seeder	For introducing grasses and legumes into semi-arid and montane environments	Horrell *et al.* 1991; Lowther *et al.* 1991 - NZGA Vol. 53
Grazing management system to minimise effect of parasitic nematodes	Improved lamb health and live weight gains	Thomson & Power 1991 - NZGA Vol. 53
Deferred grazing	Non-mechanical method of pasture conservation	McCallum *et al.* 1991 - NZGA Vol. 53
Larger leaved white clover germplasm with high stolon densities	Improved clover contents and yields	Caradus 1991 - NZGA Vol. 53
Ryegrass life cycle	Understanding management impacts on yield and survival	Brock & Thomas 1991 - NZGA Vol. 53
Preferential feeding of thin ewes	Reduced range of liveweights at mating	Morton 1992 - NZGA Vol. 54
Increased inoculation rates for *Lotus corniculatus* rhizobium inoculation	Improved nodulation	Patrick & Lowther 1992 - NZGA Vol. 54
Caucasian clover, hairy canary clover, birdsfoot trefoil, lucerne, crown vetch	Legumes for drought prone landscapes	Woodman *et al.* 1992 - NZGA Vol. 54
Liming type and intensity to ameliorate soil acidification	Differential impact on legumes and grasses	Carran 1992 - NZGA Vol. 54
Coating grass seed	Improved establishment	Scott *et al.* 1992 - NZGA Vol. 54
Vegetative propagation of rhizomes to establish some	Improved establishment	Scott & Mason 1992 - NZGA Vol. 54

Technology/advance	Impact/significance	Date – NZGA Proceedings
legume species in high country		
Grasslands Kara cocksfoot	Improved cocksfoot with high feeding value	Stevens *et al.* 1992 - NZGA Vol. 54
Summer fallowing and double glyphosate spraying to establish lolitrem-free ryegrasses	Methodology to reduce wild-type endophyte contamination in novel endophyte sown swards	Hume & Lyons 1992 - NZGA Vol. 54
Nil endophyte effect in Southland	Endophyte not required in ryegrass sown in Southland	Eerens *et al.* 1992 - NZGA Vol. 54
High water use efficiency of Grasslands Hakari brome and Grasslands Maru phalaris	Species with improved water use efficiency for dryland regions	Parry *et al.* 1992 - NZGA Vol. 54
Winter treading detrimentally affects soil macroporosity	Reduced drainage and increased soil structural damage	Greenwood & McNamara 1992 - NZGA Vol. 54
Once bred heifer and exotic x bull beef breeding	Improved returns compared to traditional beef breeding policies	Morris *et al.* 1992 - NZGA Vol. 54
Tall fescue with clover and chicory for feeding deer	Improved carrying capacity compared with ryegrass	Stevens *et al.* 1992 - NZGA Vol. 54
'Longlife' phosphatic fertiliser	Suitable for use where conditions are appropriate for reactive phosphate rock use	Ledgard *et al.* 1992 - NZGA Vol. 54
Different S oxidation rates on sunny and shady faces	Finer particle size of S fertiliser required on shady faces	Boswell *et al.* 1992 - NZGA Vol. 54
Frequency of phosphatic fertiliser application on developed pastures	Flexibility in rate of application	Risk *et al.* 1992 - NZGA Vol. 54
Immobilisation of P as organic P reduced availability of inorganic P for plant use	Reduce plant available P	Perrott 1992 - NZGA Vol. 54
Fertiliser requirements of lucerne cut for hay	Maximising yields of lucerne	Risk & Smith 1992 - NZGA Vol. 54
Undersowing to renovate pugged pastures	Improved pasture recovery from damage	Johnson *et al.* 1993 - NZGA Vol. 55
Lax spring grazing	Increased grass tiller appearance rate	Hernandez-Garay *et al.* 1993 - NZGA Vol. 55
Timothy	Forage of high feeding value	Stevens *et al.* 1993 - NZGA Vol. 55
Summer fallowing to establish ryegrass and tall fescue in dryland environments	Improved sward establishment	Hume & Lyons 1993 - NZGA Vol. 55
Association of lamb parasitism with species of grass	Higher rates of clinical parasitism on browntop and fescue than ryegrass and Yorkshire fog	Niezen *et al.* 1993 - NZGA Vol. 55
Indicator paddocks	Using a small sample of paddocks to provide average pasture cover estimates for management decisions	De Freitas *et al.* 1993 - NZGA Vol. 55
Establishment protcol for chicory	Improved establishment of chicory	Moloney & Milne 1993 - NZGA Vol. 55

Technology/advance	Impact/significance	Date – NZGA Proceedings
Zero grazing and use of clovers and lotus to re-vegetate slips	Protocol for re-vegetating slips	Lambert *et al.* 1993; Quilter *et al.* 1993 - NZGA Vol. 55
FarmTracker	Routines for setting stock, paddock and feed targets	Butler 1993 - NZGA Vol. 55
UDDER	Improves on-farm decision making through modelling grass growth and animal performance	Lewis & Garrity 1993 - NZGA Vol. 55
Monitor Farms	Improved on-farm performance through adoption of new technologies and knowledge	Rhodes & Aspin 1993 - NZGA Vol. 55
COWPLAN and EWEPLAN	Feed budget models	Brookes *et al.* 1993 - NZGA Vol. 55
Dryland pasture species	Improved establishment of pastures in dryland areas	Milne *et al.* 1993; Korte & Rhodes 1993 - NZGA Vol. 55
Diammonium phosphate (DAP)	Associated with high animal and financial performance	Morton *et al.* 1993; Daniell 1993 - NZGA Vol. 55
Farm Improvement Club	Farmer improvement programme	Baker 1993 - NZGA Vol. 55
Late flowering subterranean clover	For improved regeneration in wetter than normal seasons	Smetham *et al.* 1994 - NZGA Vol. 56
Strip seeding of Caucasian clover	Improved establishment rate	Moorhead *et al.* 1994 - NZGA Vol. 56
Methodology for inoculation of Caucasian clover	Improved nodulation	Patrick *et al.* 1994 - NZGA Vol. 56
G50 Alsike clover	Improved yield and persistence of Alsike clover for South Is. high country	Widdup & Ryan 1994 - NZGA Vol. 56
Complementary effects of sowing phalaris and cocksfoot	Improved yields	Johnson *et al.* 1994 - NZGA Vol. 56
Italian and brassicas as a winter feed	Improved hogget liveweight gains	Stevens *et al.* 1994 - NZGA Vol. 56
Grasslands Advance tall fescue	Improved animal performance in warm seasons	Fraser & Lyons 1994 - NZGA Vol. 56
Grasslands Gala grazing brome	Desirable option for South Is dryland environments	Sutherland 1994 - NZGA Vol. 56
Double spraying and Massey University bioblade drill	Improved establishment of grasses using direct drilling on erosion prone dryland soils	Fraser & Hewson 1994 - NZGA Vol. 56
Sclerotinia sclerotiorum mycoherbicide	Control of Californian thistle	Bourdot & Harvey 1994 - NZGA Vol. 56
Grazing management to increase stolon density of white clover	Improved ability to withstand drought	Brock & Kim 1994 - NZGA Vol. 56
Parasitoid for Argentine stem weevil	Reduced impact of Argentine stem weevil	Goldson *et al.* 1994 - NZGA Vol. 56
Impact of ergovaline from grass endophytes on thermo-regulation in lambs.	Increased heat stress	Fletcher *et al.* 1994 - NZGA Vol. 56
Risk management for tactical N applications	Improved economics to the use of N	Parker *et al.* 1994 - NZGA Vol. 56
Tall oat grass and Caucasian	Improved South Is. high country	Allan & Keoghan 1994 - NZGA

Technology/advance	Impact/significance	Date – NZGA Proceedings
clover for high country	pastures	Vol. 56
Winter feed crops for high country	Improved marginal land use	Maunsell & Scott 1994 - NZGA Vol. 56
Fertiliser borate FB48 to control *Hieracium*	Control of *Hieracium*	Miller 1994 - NZGA Vol. 56
Soil compaction to improve irrigation efficiency	Increased efficiency of irrigation water use	Paton & Greenwood 1994 - NZGA Vol. 56
Dryland forage species	Improved production on dryland soils	Hunter *et al.* 1994 - NZGA Vol. 56
Modifying stocking rates and conservation policies with use of high N inputs	Improved animal performance on dairy farms with high N use	Harris *et al.* 1994 - NZGA Vol. 56
Process for establishment and management of high country pastures	Improved understanding of establishing and managing high country pastures	Scott *et al.* 1995 - GR&PS Vol. 4
White clover cultivar change seed production procedure	5-year break required for successful cultivar change	Clifford *et al.* 1996; Allen 1996 - GR&PS Vol. 6
Positioning of 10 current white clover cultivars	Description of agronomic performance	Caradus *et al.* 1996 - GR&PS Vol. 6
Managing grass/clover associations	Limitations and opportunities of clover in grazed pastures	Chapman *et al.* 1996 - GR&PS Vol. 6
Clonal growth process of white clover	Management strategies for improved clover growth	Brock & Hay 1996 - GR&PS Vol. 6
Grassland Demand white clover	Value to Southland sheep farmer	Gardyne 1996 - GR&PS Vol. 6
Pastoral fallowing	Increased white clover growth post-fallow	Nie *et al.* 1996 - GR&PS Vol. 6
Principal environmental impacts of N identified	Risk of N fertiliser use	Carran & Clough 1996 - GR&PS Vol. 6
Cattle tend to graze white clover from 35 to 65% of the time depending on season	Preference of cattle for white clover	Cosgrove *et al.* 1996 - GR&PS Vol. 6
Mineral N fertiliser	Moderate N fertiliser use (200-300 kg N/ha/yr) give most profitable outcome	Barr 1996 - GR&PS Vol. 6
Mineral N and clover N	Clover contents of 30-40% and N fertiliser rates of 100-200 kg N/ha/yr recommended	Clark & Harris 1996 - GR&PS Vol. 6
White clover fixes 4.5m tonnes N annually	Most cost effective N – need only 50 kg fertiliser N/ha/yr	Walker 1996 - GR&PS Vol. 6
Deferred grazing from October to February	Improved clover content	Watson *et al.* 1996 - GR&PS Vol. 6
Cow lifetime nutrition can permanently affect calf live weight	Identification of nutrition required in early life for appropriate calf live weights	Smeaton *et al.* 1996 - NZGA Vol. 57
BoVision	Decision support system for beef finishing	Rollo *et al.* 1996 - NZGA Vol. 57
Yorkshire fog impact on larval worm counts	Lower worm counts for lambs grazing Yorkshire fog	Hodgson *et al.* 1996 - NZGA Vol. 57
Importance of high stolon density for drought survival of white clover	Identification of more drought tolerant white clover cultivars	Wang *et al.* 1996 - NZGA Vol. 57
Setaria – a C_4 grass	Specialist pasture for use in	Boom & Sheath 1996 - NZGA

Technology/advance	Impact/significance	Date – NZGA Proceedings
	drought conditions	Vol. 57
Leaching of N significant at 400 kg N/ha input	Indication of potential issues at high N inputs	Ledgard *et al.* 1996 - NZGA Vol. 57
Seed bank surveys	Method for assessing potential changes in sward composition	Bell 1996 - NZGA Vol. 57
MRDC-ANZ monitor farm programme	Improved farm productivity and profitability	Ussher *et al.* 1996 - NZGA Vol. 57
Farm monitoring	Improved production and income	Page *et al.* 1996 - NZGA Vol. 57
Lower nutritive value of subtropical grasses	Decreased animal production	Jackson *et al.* 1996 - NZGA Vol. 57
Split calving	Increased production and profit	Taylor 1996 - NZGA Vol. 57
Silage quality targets	Most NZ silages do not achieve targets	Howse *et al.* 1996 - NZGA Vol. 57
Feed effects on milk composition	Manipulate milk composition by changing pasture composition	Johnson & Thomson 1996 - NZGA Vol. 57
Caucasian clover for irrigated pastures in Canterbury	Improved sward quality	Moss *et al.* 1996 - NZGA Vol. 58
Caucasian clover in dryland dairying	Once established a good legume fro drought prone areas	Watson *et al.* 1996 - NZGA Vol. 58
Nutrient budgets	Improved nutrient management	O'Connor *et al.* 1996 - NZGA Vol. 58
Fertiliser and seed mixture recommendations for conversions to dairy in Canterbury	N and P recommendations for increased production	Rowarth *et al.* 1996 - NZGA Vol. 58
Spreading red clovers	Improved persistence	Hyslop *et al.* 1996 - NZGA Vol. 58
Perennial lupin, tall oat grass and cocksfoot	Best suited species for drought prone soils of the MacKenzie Basin	Woodman *et al.* 1996 - NZGA Vol. 58
G27 red clover	Low formononetin red clover that does not affect reproductive performance of ewes	Keogh *et al.* 1996 - NZGA Vol. 58
Red clover	Increased ewe milk production and lamb growth rates compared to ryegrass/white clover pastures	Keogh & Thomson 1996 - NZGA Vol. 58
Selcote Ultra prills	Supply of Se for wethers for 24 months	Metherell *et al.* 1996 - NZGA Vol. 58
Decision support system for predicting rainfall in semi arid environments	Assist with management decisions	Hutchinson 1996 - NZGA Vol. 58
Feed quality more important than intake alone	Improved animal performance	Fraser & Rowarth 1996 - NZGA Vol. 58
Multi-species pastures	Improved performance in dryland conditions	Daly *et al.* 1996 - NZGA Vol. 58
Pure chicory effects on internal parasite populations	Reduces gastro-intestinal nematode larvae	Knight *et al.* 1996 - NZGA Vol. 58
Plantain	Component of mixed swards	Stewart 1996 - NZGA Vol. 58
Willow	Possible fodder tree	Oppong *et al.* 1996 - NZGA Vol. 58
Maize	Supplementary feed to overcome feed limitations of pasture	Penno *et al.* 1996 - NZGA Vol. 58

Technology/advance	Impact/significance	Date – NZGA Proceedings
Urea	Most economical form of N for pasture growth	Rogers & Putt 1997 - NZGA Vol. 59
Nitrate leaching similar for mineral and biologically fixed N	N source has no impact on amount of nitrate-N leached	Sprosen *et al.* 1997 - NZGA Vol. 59
Grasslands Challenge white clover	Large leaved clover with cool season growth	Cooper *et al.* 1997 - NZGA Vol. 59
Pugging reduces feed available and re-growth rates	Management systems need to reduce impact of pugging on wet soils	Sheath & Boom 1997 - NZGA Vol. 59
Fertiliser S response model	Calculation of effective S fertiliser rate	Wheeler & Thorrold 1997 - NZGA Vol. 59
50% white clover content	Target for maximum milk yield from pasture	Harris *et al.* 1997 - NZGA Vol. 59
Aries HD ryegrass	Improved lamb live weight gains	Bluett *et al.* 1997 - NZGA Vol. 59
National Forage Variety Trials	Objective means of rating cultivars	Easton *et al.* 1997 - NZGA Vol. 59
Financial risk model	Provide insights into financial consequences of pasture development	Martins *et al.* 1997 - NZGA Vol. 59
Grazing system model	Decision support model	Barioni *et al.* 1997 - NZGA Vol. 59
Model for determining P and S inputs	Decision support for fertiliser recommendations	Metherell *et al.* 1997 - NZGA Vol. 59
Double spraying in autumn to resow with novel endophyte grasses	Effective means of reducing contamination from wild type endophyte	Van Vught & Thom 1997 - NZGA Vol. 59
Management package for winter milk production	Maximising profit from winter milk production	Jones *et al.* 1997 - NZGA Vol. 59
N fertiliser for increases summer feed	More profitable milk production	Shaw *et al.* 1997 - NZGA Vol. 59
GrassView	Computer programme that demonstrates the form and function of a grass plant	Ashley *et al.* 1997 - NZGA Vol. 59
AgFACT – pastoral agriculture information base	Relevant information for farmers	Ogle *et al.* 1997 - NZGA Vol. 59
Tall fescue	Recommended for dairying areas where summer growth and quality of ryegrass is low	Milne *et al.* 1997 - NZGA Vol. 59
Pine for agroforestry	Most profitable tree species	Thorrold *et al.* 1997 - NZGA Vol. 59
Conservation trees on hill soils	Reduced soil loss and improved land stability	Wall *et al.* 1997 - NZGA Vol. 59
Lotus corniculatus	Increased milk production and protein yield per kg eaten	Harris *et al.* 1998 - NZGA Vol. 60
Sulla silage	High quality silage	Niezen *et al.* 1998 - NZGA Vol. 60
N & P applications by aspect on hill country	Maximising production from fertiliser inputs	Gillingham *et al.* 1998 - NZGA Vol. 60
High cattle to sheep ratio for chemical free farming systems	Parasite free pastures	Mackay *et al.* 1998 - NZGA Vol. 60

Technology/advance	Impact/significance	Date – NZGA Proceedings
Clover nutrient ratios	Accurate indicator of nutrient fertiliser needs	Morton *et al.* 1998 - NZGA Vol. 60
Modelling animal treading effects on infiltration rate	Impacts of soil compaction on catchment water movement	Tian *et al.* 1998 - NZGA Vol. 60
Forages with condensed tannins	Improved animal productive performance	Waghorn *et al.* 1998 - NZGA Vol. 60
S input into high country	Related to sheep performance	Scott 1998 - NZGA Vol. 60
Annual herbage accumulation rate	Best predictor of farm milk yield	Barker *et al.* 1998 - NZGA Vol. 60
Chicory supplemented with pasture	High quality summer-autumn crop for dairying	Waugh *et al.* 1998 - NZGA Vol. 60
Predictive relationship between pasture Cu and liver Cu concentrations	Recommendations for Cu fertiliser inputs	Knowles *et al.* 1998 - NZGA Vol. 60
Effect of closure time and post grazing residuals on silage quality	Improved silage quality	McGrath *et al.* 1998 - NZGA Vol. 60
Tall fescue and chicory in summer dry areas	Production advantages in dry years	Rollo *et al.* 1998 - NZGA Vol. 60
Wheat grass for dryland agriculture	Potential for increased production	Wills *et al.* 1998 - NZGA Vol. 60
Tagasaste	Drought tolerant shrub/tree legume	Douglas *et al.* 1998 - NZGA Vol. 60
Copper topdressing onto pastures and copper capsules elevated liver Cu levels at slaughter	Increased Cu uptake by ruminants	West & Sargison 1998 - NZGA Vol. 60
Osmia coerulescens an alternative pollinator for forage legumes	A bee that is resistant to varroa mite	Purves *et al.* 1998 - NZGA Vol. 60
Maintaining adequate pasture allowance for dairy cows	Positive impact on milk yield and processing for cheese	Auldist *et al.* 1998 - NZGA Vol. 60
Restricting beef cows for first 65 days of lactation	Better integration of beef and sheep breeding operations	Peachey & Morris 1998 - NZGA Vol. 60
Ryegrass endophytes	Protection against insect pests	Easton 1999 - GR&PS Vol. 7
Endophyte toxicoses	Adverse effects on animal health and production	Fletcher *et al.* 1999; Watson *et al.* 1999 - GR&PS Vol. 7
Animal genetic component to ryegrass staggers	Potential for selecting for tolerance to ryegrass staggers	Morris *et al.* 1999 - GR&PS Vol. 7
Negative correlation between ergovaline containing pastures and milksolids production in Northland	Need to use low ergovaline producing endophytes in humid environments	Blackwell & Keogh 1999 - GR&PS Vol. 7
Chemical complexity of endophyte metabolites	Requirement to consider more than just lolitrem, peramine and ergovaline for biological activity from endophytes	Lane 1999; Lane *et al.* 1999 - GR&PS Vol. 7
Identification and inoculation of endophytes that reduce/eliminate grazing animal toxicoses	Use of these endophytes in pastoral agriculture	Tapper & Latch 1999; Fletcher 1999 - GR&PS Vol. 7
Insect resistances associated with various endophyte	Toxin free endophytes identified	Popay *et al.* 1999 - GR&PS Vol. 7

Technology/advance	Impact/significance	Date – NZGA Proceedings
strains		
Process for maintaining a toxin free pasture	Reduced risk of animal toxicoses	Hume 1999 - GR&PS Vol. 7
Proposed commercialisation of AR1	Reduced animal toxicoses and persistent pastures	Green & McKenzie 1999 - GR&PS Vol. 7
Ryegrass seed and endophyte can survive longer than 12 months in soil	Likely contamination of endophyte free pastures with wild type endophyte seedlings	Hume *et al.* 1999 - GR&PS Vol. 7
Wide spaced poplars on hill country farms	Improved soil conservation	McGregor *et al.* 1999 - NZGA Vol. 61
Pre-lamb shearing	Increased lamb survival at birth	Morris *et al.* 1999 - NZGA Vol. 61
Land Management Units	A means of evaluating sustainability of land use practices	Rhodes *et al.* 1999 - NZGA Vol. 61
Se application to pastures	Elevated blood Se levels in sheep	Moorhouse *et al.* 1999 - NZGA Vol. 61
Tannin containing forages	Reduced development of parasitic nematodes in sheep	Molan *et al.* 1999 - NZGA Vol. 61
Identification of factors causing dags	Reduced incidence of dags	Waghorn *et al.* 1999 - NZGA Vol. 61
Quality pasture species for dryland	Improved animal performance	Fraser *et al.* 1999 - NZGA Vol. 61
Vegetatively reproduced red clovers	Improved persistency of red clover	Hyslop *et al.* 1999 - NZGA Vol. 61
Lotus corniculatus grazing for sheep	Improved ovulation rate in ewes	Barry *et al.* 1999 - NZGA Vol. 61
Reducing dags to reduce incidence of fly strike and lice in sheep	Improved animal performance	Cole & Heath 1999 - NZGA Vol. 61
OVERSEER nutrient budget model	Estimates inputs, outputs and balances N,P, K and S	Ledgard *et al.* 1999 - NZGA Vol. 61
NIRS for predicting feed composition	Improved feed ration balancing	Corson *et al.* 1999 - NZGA Vol. 61
Geographical positioning system (GPS) and Geographic information system (GIS)	Increased accuracy of fertiliser topdressing application	Gillingham *et al.* 1999 - NZGA Vol. 61
Precision Farming	Increased profit	Yule 1999 - NZGA Vol. 61
Shelterbelts	Diversification and possible animal welfare improvements	Hawke *et al.* 1999 - NZGA Vol. 61
Mowing or topping pasture	Improved summer milk yields but negligible annual benefits	Kolver *et al.* 1999 - NZGA Vol. 61
Spreadmark standards for fertiliser evenness	Improved effectiveness of fertiliser application	Horrell *et al.* 1999 - NZGA Vol. 61
Interaction of soil Mn status and Co availability	High Mn levels reduced Co availability	Zheng *et al.* 1999 - NZGA Vol. 61
109 forage cultivars	Proprietary cultivars for NZ farmers	Charlton & Stewart 1999 - NZGA Vol 61
National Climate Centre	Improved climate information	Daw 1999 - NZGA Vol. 61
Collated list of pasture and forage cultivars	Assistance in identifying appropriate seed mixtures	Charlton & Stewart 2000 - GR&PS Vol. 8

Technology/advance	Impact/significance	Date – NZGA Proceedings
Once-a-day milk feeding system	Successful and cost effective method of rearing calves	Muir *et al.* 2000 - NZGA Vol. 62
QuickFeed	Predicts intake ad performance of cattle and sheep on pasture	Woodward *et al.* 2000 - NZGA Vol. 62
Strip seeder technique	Improved establishment in drought prone soils	Wills & Trainor 2000 - NZGA Vol. 62
Pasture resowing	Improved profitability	Stevens *et al.* 2000 - NZGA Vol. 62
Caucasian clover	More tolerant of drought than white clover	Black & Lucas 2000 - NZGA Vol. 62
Land application of dairy effluent	Growth responses similar to urea at same N input rates, but increased K concentrations in pasture	Roach *et al.* 2000 - NZGA Vol. 62
Denmark and Leura subterranean clover	Improved re-establishment and late winter-spring growth	Widdup & Pennell 2000 - NZGA Vol. 62
Low rates of glyphosate use on pastures	Improved pasture quality and reduced weeds	Casey *et al.* 2000 - NZGA Vol. 62
Single N application in March or August	Increased pasture production in Southland	Smith *et al.* 2000 - NZGA Vol. 62
Strategic destocking	Reduced pugging and nitrate leaching	de Klein *et al.* 2000 - NZGA Vol. 62
AR1 endophyte	Enhanced livestock production and resistance to Argentine stem weevil	Easton *et al.* 2001 - NZGA Vol. 63
TechnoGrazing	Increased pasture utilisation and profits	Charlton & Weir 2001 - NZGA Vol. 63
Grasslands Tahora and Prop white clovers	Cultivars adapted to moist and dry hill country	Dodd *et al.* 2001 - NZGA Vol. 63
Grasslands Kopu II and Crusader white clovers	Clover cultivars for national and international markets	Woodfield *et al.* 2001 - NZGA Vol. 63
Browse willows	Nutritive feed for cattle	Kemp *et al.* 2001 - NZGA Vol. 63
Low toxin endophytes	Improved pasture quality and increased milksolids production	Keogh & Blackwell 2001 - NZGA Vol. 63
Maize silage	Cost effective supplementary feed	Densley *et al.* 2001 - NZGA Vol. 63
Protocols for low chemical farming systems	Organic farming options	Mackay *et al.* 2001 - NZGA Vol. 63
Tannins in erect *Dorycnium*	Disrupts the gastro-intestinal parasite life cycle	Waghorn & Molan 2001 - NZGA Vol. 63
Protocol for sowing novel endophyte ryegrass	Reduced contamination from wild type endophyte ryegrass	Bluett *et al.* 2001 - NZGA Vol. 63
Parasitoid for Argentine stem weevil	Biological control option	McNeill *et al.* 2001 - NZGA Vol. 63
Clover content	Trends in milksolids production follow clover content	Thom *et al.* 2001 - NZGA Vol. 63
Pasture utilisation efficiency increases with LWT/t DM	Optimum economic farm surplus occurs at less than maximum feed efficiency	MacDonald *et al.* 2001 - NZGA Vol. 63
Targets for good maize silage quality	Improved nutritive value	Kolver *et al.* 2001 - NZGA Vol. 63
Rising plate meter	Inexpensive tool to aid farm	Lile *et al.* 2001 - NZGA Vol.

Technology/advance	Impact/significance	Date – NZGA Proceedings
	monitoring and decision making	63
Standard calibration for rising plate meter	Improved reliability of pasture mass measurement	Thomson *et al.* 2001 - NZGA Vol. 63
Best practice calf rearing	Successful calf rearing	Muir *et al.* 2002 – NZGA Vol. 64
Effect of breed and milking frequency on milksolids production and productivity	Jersey cow better suited to once a day milking	Tong *et al.* 2002 - NZGA Vol. 64
Automatic milking systems (AMS)	Potential indicated for using AMS in extensive grazed systems	Jago & Woolford 2002 - NZGA Vol. 64
Kuriwao Farm Action Group	Faster progress and less costly mistakes in uptake of knowledge and technologies	Cock *et al.* 2002 - NZGA Vol. 64
Close frequent grazing to remove Californian thistle	Reduced thistle presence	Mitchell *et al.* 2002 - NZGA Vol. 64
Mycoherbicide – *Sclerotinia sclerotiorum*	Biological control of giant buttercup	Bourdot & Lamoureaux 2002 - NZGA Vol. 64
Lotus silage	Improved summer-autumn milksolids	Woodward *et al.* 2002 - NZGA Vol. 64
Weekly estimates of pasture growth rate	Increased accuracy of monthly growth rates	Prewer *et al.* 2002 - NZGA Vol. 64
2 day spell for animals grazing high endophyte before moving to paddocks with nil or novel endophyte	Reduced contamination of nil and novel endophyte swards	Burggraaf &Thom 2002 - NZGA Vol. 64
High quality lamb specific pasture	Enhancing lamb growth rates prior to weaning	Moffat *et al.* 2002 - NZGA Vol. 64
Condition scoring of beef cows	Improved monitoring of feed regimes	Morris *et al.* 2002 - NZGA Vol. 64
Sulla silage	Increased digestion rate and rumen clearance	Chaves *et al.* 2002 - NZGA Vol. 64
Longer pasture residuals	Reduced weed problems	Eerens *et al.* 2002 - NZGA Vol. 64
Ragwort flee beetle	Biocontrol of ragwort	Betteridge & Costall 2002 - NZGA Vol. 64
Cereal silage and stand-off pads	Reduced greenhouse gas emissions	de Klein *et al.* 2002 - NZGA Vol. 64
Condensed tannin forages	Reduced methane production	Waghorn *et al.* 2002 - NZGA Vol. 64
Whole crop cereals	South Is high quality feed option	de Ruiter *et al.* 2002 - NZGA Vol. 64
NaCl use	Reduced Na deficiency	Hawke *et al.* 2002 - NZGA Vol. 64
Updated list of pasture and forage cultivars	Assistance in identifying appropriate seed mixtures	Charlton & Stewart 2003 - GR&PS Vol. 8 2nd edition
Grazing behaviour of deer related to pasture height and mass	Maximum levels of deer production achieved at a pasture height of 8 cm	Nicol & Barry 2003 - GR&PS Vol. 9
Deer have salivary proteins that bind condensed tannins	Deer can consume forages with high concentrations of condensed tannins	Hoskin *et al.* 2003 - GR&PS Vol. 9

Technology/advance	Impact/significance	Date – NZGA Proceedings
Fodder trees	Fodder trees can provide useful feed in drought	Charlton *et al.* 2003; Olsen & Charlton 2003; Kemp *et al.* 2003 - GR&PS Vol. 10
Poplar and willow feed increase reproductive rate of ewes	Increased reproductive performance	McWilliam *et al.* 2003; Orsborn *et al.* 2003 - GR&PS Vol. 10
Tangoio tree willow	Tree clone for fodder production	Douglas *et al.* 2003 - GR&PS Vol. 10
Tree shelter	Increased animal production	Hawke & Dodd 2003 - GR&PS Vol. 10
Farm Forestry Calculators	Decision support system to assist with farm forestry management	Halliday & Knowles 2003 - GR&PS Vol. 10
Subterranean clover	Legume for dry hill country	Smetham 2003 - GR&PS Vol. 11
Caucasian clover	Legume with potential for increased spring and summer production	Black *et al.* 2003 - GR&PS Vol. 11
Rooting depth of lucerne	Access to more water during summer/autumn	Brown *et al.* 2003 - GR&PS Vol. 11
Lotus corniculatus	Potential as a specialist feed in dryland environments	Barry *et al.* 2003; Ramirez-Restrepo *et al.* 2003 - GR&PS Vol. 11
Persian, balansa and subterranean clovers	Winter active legumes preferred by hoggets	Hyslop *et al.* 2003 - GR&PS Vol. 11
Grass suppression using the herbicide Gallant	Improved legume content	Hepp *et al.* 2003 - GR&PS Vol. 11
Trifolium repens x *T. ambiguum* hybrid	Potential for improved drought tolerance	Widdup *et al.* 2003 - GR&PS Vol. 11
Reduce grazing pressure on subterranean clover during flowering and seed maturation	Increased subterranean clover seed production in grazed pastures	Smetham & Dear 2003 - GR&PS Vol. 11
Lucerne provides extra summer feed on North Is. hill country	Improved lamb production	McGowan *et al.* 2003 - GR&PS Vol. 11
Strategy for managing lucerne	Improved lucerne growth	Moot *et al.* 2003 - GR&PS Vol. 11
Subterranean clover autumn sward management	Increased subterranean clover yields	Moot *et al.* 2003 - GR&PS Vol. 11
Maximising pasture growth and utilisation of all year round grass farming	Improved efficiency of bull beef production	Cosgrove *et al.* 2003 - NZGA Vol. 65
High N fertiliser inputs on hill country	Economically viable option but long term sustainability not confirmed	Lambert *et al.* 2003 - NZGA Vol. 65
Combining genetics, good milk production and pasture growth rates	Best practice individual and mob live weight gains	Muir *et al.* 2003 - NZGA Vol. 65
Growing ryegrass and white clovers separately	Higher average daily weight gains of lambs and hoggets	Cosgrove *et al.* 2003 - NZGA Vol. 65
AR1 endophyte for dairying	Higher milksolids production compared to wild type endophyte	Bluett *et al.* 2003 - NZGA Vol. 65

Technology/advance	Impact/significance	Date – NZGA Proceedings
"Standing off" pasture management in winter	Reduced pugging	Drewry 2003 - NZGA Vol. 65
Soil P movement greater in low anion storage capacity soils	Impact on P enrichment of water bodies	Morton *et al.* 2003 - NZGA Vol. 65
Lifting maize populations from 115,000 to 130,000 plants per ha	Profitable increase in maize yields	Densley *et al.* 2003 - NZGA Vol. 65
Integrating winter and summer crops and minimising N leaching	Increased yields without increasing N leaching	Judge *et al.* 2003 - NZGA Vol. 65
Isotopic composition of cow tail switch hair	Information archive of animal environment	Schwertl *et al.* 2003 - NZGA Vol. 65
Red clover	Tolerant of clover root weevil	Cooper *et al.* 2003 - NZGA Vol. 65
Grasslands Tribute white clover	Medium large leaved cultivar with wide adaptation	Woodfield *et al.* 2003 - NZGA Vol. 65
DNA finger printing	Application for identification of white clover cultivars	Jahufer *et al.* 2003 - NZGA Vol. 65
Deferred effluent irrigation	Reduced leaching of nutrients	Houlbrooke *et al.* 2003 - NZGA Vol. 65
Life cycle assessment	Whole system approach to resource use and environmental emissions	Ledgard *et al.* 2003 - NZGA Vol. 65
OVERSEER nutrient budgets	On-farm resource accounting	Wheeler *et al.* 2003 - NZGA Vol. 65
Cocksfoot in ryegrass pastures	Reduced incidence of ryegrass staggers	Hyslop *et al.* 2003 - NZGA Vol. 65
Differential fertiliser application	More accurate application of fertiliser	Gillingham *et al.* 2003 - NZGA Vol. 65
Maintaining soil structure	Nitrous oxide emissions increased with increased soil compaction	Bhandral *et al.* 2003 - NZGA Vol. 65
High levels of specific flavonoids in clover	Increased UV-B stress tolerance	Hoffman *et al.* 2003 - NZGA Vol. 65
Groundwater allocation	Management of water resources for irrigated farming	Miller & Veltman 2004 - NZGA Vol. 66
Improving grazing management to reduce dead material reduces lime requirement to lower Mn levels in herbage below the animal health threshold	Less lime required to lower Mn in herbage	Smith *et al.* 2004 - NZGA Vol. 66
Whole crop cereal silages	An alternative for supplementing pasture silage	Stevens *et al.* 2004 - NZGA Vol. 66
Integrating multi-graze crops with summer legume/cereal crop	Achieve an excess of 25 t/ha dry matter per year	Fraser *et al.* 2004 - NZGA Vol. 66
Plant growth regulators and new generation fungicides	Improved seed yields of ryegrass and tall fescue	Rolston *et al.* 2004 - NZGA Vol. 66
Direct drilling winter forages crops and avoid grazing on wet soils	Reduced nitrous oxide emission	Thomas *et al.* 2004 - NZGA Vol. 66

Technology/advance	Impact/significance	Date – NZGA Proceedings
Reduce volume of irrigation run-off	Reduced loss of nutrients and faecal bacteria to waterways	Carey *et al.* 2004 - NZGA Vol. 66
Increasing proportion of clover in diet	Reduced methane per kg milksolids and increased milksolids production	Lee *et al.* 2004 - NZGA Vol. 66
Protocol for turnip production	Higher yields	Eerens & Lane 2004 - NZGA Vol. 66
Forage Master	A decision tool for selecting and managing forages for sheep and beef farms	Finlayson *et al.* 2004 - NZGA Vol. 66
High floral tannin clover	Reduced rumen ammonia concentrations	Burggraaf *et al.* 2004 - NZGA Vol. 66
Chicory and plantain	Natrophiles that provide high Na	Aspinall *et al.* 2004 - NZGA Vol. 66
Kieserite – MgSO4	Quicker acting Mg fertiliser than MgO	O'Connor *et al.* 2004 - NZGA Vol. 66
Modifying forage lipid concentration and fatty acid profile	Feed-sparing effect and improved human health effects (in meat)	Cosgrove *et al.* 2004 - NZGA Vol. 66
High sugar grasses	Low temperatures required to stimulate high water soluble carbohydrates in harvestable components of ryegrass	Parsons *et al.* 2004 - NZGA Vol. 66
Crop before grass sowing and parasitoid	Reduced impact of clover root weevil	Eerens *et al.* 2005 - NZGA Vol. 67
Vigorous white clovers and red clover	Improved tolerance of clover root weevil	Crush *et al.* 2005 - NZGA Vol. 67
Nematode resistant white clover selections	Improved ability to withstand nematodes	Mercer *et al.* 2005 - NZGA Vol. 67
Soil consolidation	Improved white clover establishment	Brock *et al.* 2005 - NZGA Vol. 67
Maize silage	Improved milksolids production and depending on payout improved profitability	Dalley *et al.* 2005 - NZGA Vol. 67
Dairy Systems Monitoring	Extension tool to highlight the impact of new technologies or management practices	Savage & Lewis 2005 - NZGA Vol. 67
Roller drill and double sowing rates	Improved establishment when sowing into flood damaged pastures	Wilson & Valentine 2005 - NZGA Vol. 67
Timothy/white clover pastures	Improved milksolids production on irrigated soils free of Argentine stem weevil	Thomson & Kay 2005 - NZGA Vol. 67
Maize sowing between 15 and 24 October	Improved yields in Taranaki	Densley *et al.* 2005 - NZGA Vol. 67
Paddock feed out rate of 4 kg silage DM per linear m	Reduced waste	Stevens & Platfoot 2005 - NZGA Vol. 67
Conventional maize hybrids	More milksolids and profit per ha than when using leafy maize hybrids	Densley *et al.* 2005 - NZGA Vol. 67
AR542 endophyte	Increased resistance of tall fescue to Argentine stem weevil and black beetle	Popay *et al.* 2005 - NZGA Vol. 67