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Adoption of forage technologies by New Zealand farmers – case studies

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Abstract. Pastoral farmers seek to continue to increase on-farm productivity and to do this they need new forage options that they can adopt into their current management strategies. The less disruptive these technologies are to accepted farmer management strategies the greater the likelihood of adoption. Four case studies show that New Zealand farmers have rapidly adopted new technologies that include forage herbs, white clovers with improved stolon growing point densities, and novel endophyte technologies.

Keywords: Forage technologies, adoption, chicory, white clover, endophytes.

Introduction

The large majority of New Zealand's NZ\$21.1 billion in agriculture exports for the 2012 calendar year (adding together meat, wool, dairy, livestock and processed agricultural export) is derived from animals that consume pasture, despite recent increases in the amount of supplementary feeding. Such reliance on pasture production has resulted in farmers continuing to seek technologies that improve both production and pasture persistence. New Zealand farmers have been rapid adopters of new forage technologies, such as the herb chicory, and novel endophytes that have been shown to improve perennial ryegrass persistence and reduced animal health problems. Plant breeders have also attempted to achieve the compromise of high production and good persistence in important species such as white clover. This paper attempts to show how important these developments have been and how willing farmers have been to adopt them into their farming systems.

Chicory use in NZ - Case study

Although chicory originated in southern Europe it was in New Zealand that chicory was first widely used as forage (Li and Kemp 2005). The advantages of chicory include:

- It is a deep tap-rooted leafy herb that provides high quality summer forage, giving excellent animal performance levels in lambs, dairy cows, beef, and deer.
- It is best suited to fertile free draining soils, and can be sown in mixes with legumes and other herbs such as plantain.
- Having a high mineral content and the ability, through its deep root system, to take up minerals and nutrients from the soil that ends up in the leaves and stems.

Chicory has developed from a herb that was not used in NZ forage systems 28 years ago to where it is now a key component of high performance mixes for sheep, beef,

dairy, and deer operations. In a dry environment cows can produce up to 90% more milk when fed on chicory containing pasture relative to perennial ryegrass (Tharamaj *et al.* 2005). Reasons for this improved milk production include:

- high protein levels (up to 26% CP which may improve protein supply to dairy cows),
- high digestibility and rapid passage through the rumen allowing high daily intake (Burke 2000).

The quality of chicory does not deteriorate as much over summer as it can for ryegrass so that in late-summer and autumn, quality differences between the two species can be large. With reasonable summer moisture chicory can produce over 20,000 kg DM/ha /year, and have daily growth rates of 80-100 kg DM/ha/day in summer/autumn. Chicory can be incorporated into pasture in three ways:

- Chicory seed is mixed at the rate of 1 to 4 kg/ha into grass seed mixes;
- As a special purpose crop sown at 4 to 6 kg/ha with white and red clover; and
- Oversown into pasture by spreading seed just prior to grazing in spring.

Puna chicory, bred by AgResearch, was the first proprietary forage herb commercialised in New Zealand (Rumball 1986). By the early 1990s between 8000 and 10 000 ha of Grasslands Puna chicory was sown annually in New Zealand (Moloney and Milne 1993). Now this novel science concept has developed into a 250-300MT/year business worth NZ\$1,700,000 to the NZ seed industry (Fig. 1 – based on royalty returns). This compares to traditional forage species tall fescue NZ\$600,000; white clover NZ\$2,900,000; cocksfoot NZ\$200,000; red clover \$860,000; and lucerne NZ\$330,000. The more modern cultivars Grasslands Puna II and Grasslands Choice were bred from Puna (Rumball *et al.* 2003) and began to take over from Puna from 2003 onwards.

Based on the higher quality of dry matter production of

chicory compared with typical ryegrass/clover pastures, the amount of chicory seed sold each year, and the reported yield of milk from chicory, at an assumed farmgate milk price of NZ\$6.00/kg milksolids, the additional farmgate value due to sowing Puna can be estimated at \$196 million from 1988 to 2012, peaking at NZ\$20 million in 2003 and averaging NZ\$8 million per year. The decline in Puna sowing from the early 2000s onwards was due to the increase in sowing other chicory cultivars, suggesting that the total value of chicory to the New Zealand pastoral sector is likely to still be above NZ\$20 million per year.

Chicory is now used in many temperate areas of the world as pasture forage, including the USA (Ball 1997), Australia and South America.

Breaking the stolon density by leaf size relationship in white clover – Case study

In white clover, yield and persistence were often negatively associated because leaf size and upright habit contributes to yield potential while stolon growing point density contributes to persistence. In general large leaved white clover genotypes have lower growing point densities than small leaved less productive genotypes. In a world first, the cultivar Grasslands Sustain was developed to increase stolon growing point density (and hence persistence) while maintaining a medium large leaf size (Caradus *et al.* 1996). This increased stolon growing point density resulted from a high proportion of stolon nodes producing branch stolons which themselves rapidly produced nodes.

Lee *et al.* (1994) used cluster analysis to identify populations that were both high yielding and persistent, and found Grasslands Sustain and Grasslands Prestige were the best among 24 populations evaluated. Both of these cultivars were bred for higher stolon growing point densities but without reducing the respective leaf size of the base population from which they were selected (Caradus *et al.* 1996). Improved persistence was achieved through higher nodal populations while maintaining the greater yield potential of larger leaf sizes. Grasslands Sustain became the market-leading white clover cultivar in New Zealand the late 1990s and early 2000s (Fig. 2). It was eventually superseded by new cultivars.

AR1 endophyte - Case study

The perennial ryegrass on which much of New Zealand's pastoral agriculture depends uses a symbiosis with a fungus that grows within the plant, known as an "endophyte" to protect itself from insect pests. Unfortunately, some of the toxins produced to do this can cause animal health problems and reduce the amount of meat or milk produced by grazing animals. AgResearch scientists have discovered considerable variation in the alkaloid profile of endophyte strains.

AR1 was the second novel endophyte commercialised in New Zealand. The first was Endosafe, commercialised in 1992 and then withdrawn in one cultivar due to its production of ergovaline, but continued in another where the host plant cultivar moderated the ergovaline expression. AR1 was released to provide an endophyte that provided resistance to Argentine Stem Weevil but did not cause ryegrass staggers (which results from the presence of

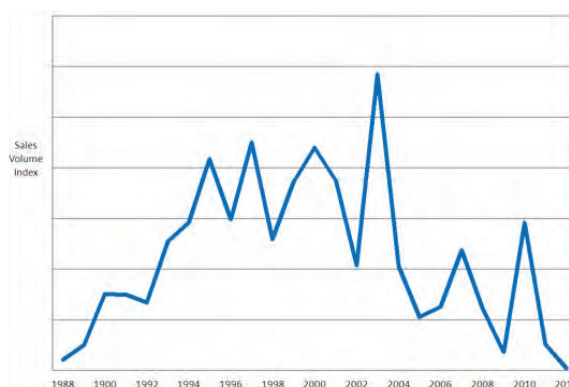


Figure 1. Puna chicory sales in New Zealand.

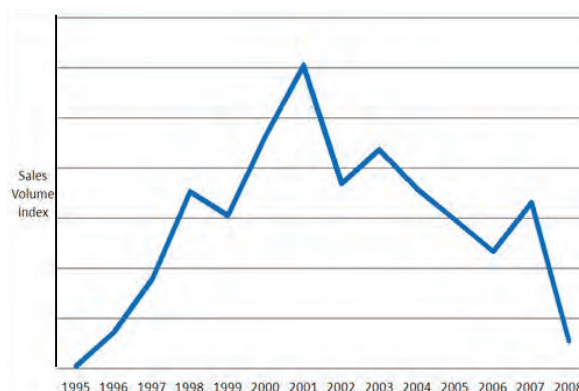


Figure 2. White clover by farmers in New Zealand.

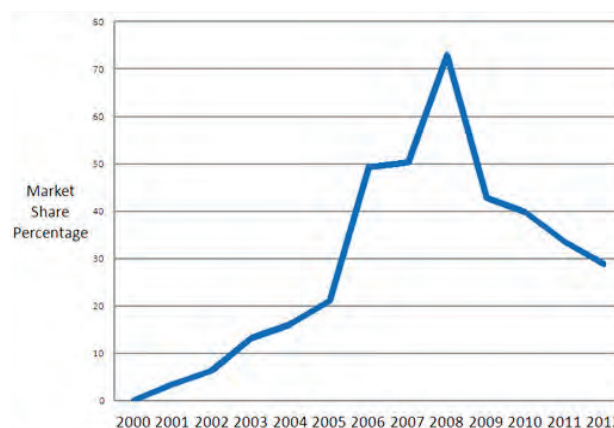


Figure 3. Uptake of AR1 endophyte ryegrasses by New Zealand farmers.

lolitrem B) or heat stress (which results from the presence of ergovaline). It was a non-exclusive release and had a rapid uptake in New Zealand. AR1 is now licensed into 31 cultivars through 10 companies, exported off shore into Australia and Chile, and is being evaluated in USA, Europe, Uruguay and Argentina.

Uptake by New Zealand farmers since AR1's full commercial release in 2003 has been extraordinary, such that, by 2008, AR1 was used in 70% of the proprietary perennial ryegrass seed sold (Fig. 3). After 2008, AR37 and NEA2 entered the market and AR1's share declined. AR1 now holds close to 30% of the proprietary perennial ryegrass endophytic seed sold. This decline in market share came through the uptake of AR37 and NEA2 endophytes, which provided greater resistance to insect pests.

AR37 endophyte - Case study

The AR37 endophyte was identified along with a number of other endophyte strains during the 1980s and early 1990s. Subsequent research found that AR37 did not produce the alkaloid compounds lolitrem, peramine or ergovaline, but it did produce a unique indole diterpene-like compound epoxy-janthitrem. Epoxy-janthitrems were found to confer a wide range of tolerance to insect pests, including Argentine stem weevil, black beetle, root aphid, pasture mealy bug and porina. AR37 also provided increased ryegrass tiller numbers, root mass and depth, persistence and higher yields at critical times of the year.

The overall cost to a farmer of re-grassing has been estimated at NZ\$386/ha for AR37 and NZ\$350/ha for AR1. Two benefits of upgrading from an existing (usually standard endophyte) ryegrass pasture have been identified:

- The greater persistence of ryegrass with AR37 means that re-grassing would be required once every 8 years compared to once every 5 years for AR1 or standard endophyte ryegrass. The annual cost of re-grassing was therefore estimated at NZ\$48/ha/yr for AR37, compared to NZ\$70/ha/yr for AR1 or standard endophyte.
- The average of 12% increased grass dry matter production resulting from AR37 on a dairy farm, if fully converted into milksolids (MS), was estimated at 114 kg MS/ha over AR1 and 200 kg MS/ha over standard endophyte ryegrass. At an assumed milk payout of NZ\$6.00/kg MS, this gave a value of NZ\$686/ha/yr over AR1 and \$1199/ha/yr over standard endophyte.

According to trials at AgResearch's Lincoln campus, growth during the summer and autumn for lambs on pure ryegrass pasture averaged 71 g/day for the standard endophyte, 133 g/day for nil-endophyte or AR1 and 146 g/day for AR37, representing increases in lamb growth during this part of the year of 87% for AR1 and 106% for AR37.

In early 2008, trials were planned to determine whether the undoubted increases in dry matter production through using AR37 were being converted into additional milksolids or meat. Trials by industry research organisation DairyNZ have shown total MS production over three consecutive lactations was not affected by endophyte treatment – AR1, AR37 or standard endophyte. (Thom *et al.* 2012). AgResearch and DairyNZ scientists identified that, even if AR37 did seem to produce the same level of milksolids from the same pasture yield compared with AR1, there was evidence that AR37 would persist and yield more dry matter than AR1 over the medium term (AgResearch, 2008). Therefore, where persistence of AR1 ryegrass was a problem, sowing AR37 ryegrass was recommended as the best option in areas where pasture pest pressure was high.

The novel endophyte AR37 provides ryegrass with improved insect protection advantages and plant persistence than those delivered by standard endophytes but has fewer adverse effects on animal health. Since its first release in 2006, AR37 has been included in eleven ryegrass

cultivars and its uptake has been very strong. An impact analysis of AR37 to New Zealand pastoral agriculture indicates from 2007 to 2011 the value of re-grassing with AR37 is estimated to have delivered value of NZ\$42 million to the pastoral sector.

Conclusion

New Zealand grassland farmers have embraced many new technologies developed by the research community because these have targeted either of the two priorities of high quality feed and/or pasture persistence. Some technologies that did not perhaps meet these needs have made less of an impact. These include proprietary cultivars of prairie grass, tall fescue, and lucerne. In each case these species provided high yield opportunities in certain environments but required different management options from those typically used for their benefits to be realised. Disruption to standard management practices will only be accepted if the potential benefits are significant.

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