

## CONTRACT REVIEW

### FORAGE MAIZE FOR AUSTRALIAN LIVESTOCK SYSTEMS

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#### INTRODUCTION

Maize silage is used widely for feeding cattle in Europe and North America but in Australia, the production of forage maize is essentially in its infancy. Forage maize is now the most important arable crop grown in Europe where areas have increased 5-fold over the last 20 years and now total 2.5 million ha. Nearly 3 million ha are grown in the US, while in the USSR over 18 million ha (or 80% the size of Victoria) are sown to forage maize every year. By contrast, less than 10,000 ha is sown in Australia each year.

However there has been an upsurge in interest in forage maize over recent years in Australia, particularly for supplementing grazing dairy cows and for lot-feeding beef steers. Forage maize is not a new crop in Australia but in the past our traditional low input/low output livestock systems have relied mainly on grazed pastures. As prices for livestock products rise, the proportion of total production costs devoted to nutrition can be increased. Many producers now look beyond grazed pastures to feed their animals and, for them, forage maize may have a role.

Currently the Meat Research Corporation and the Dairy Research and Development Corporation are funding many research and 'on-farm' development projects to assess the role for forage maize in improving animal performance per head and per hectare of grazed pasture. The First Australian Maize Conference was held in southern NSW in 1991 and this led to the formation of the Maize Association of Australia. This industry body will convene regular national conferences which should improve co-ordination of national R and D on maize forage.

This review assesses the role and potential for forage maize in Australia and briefly describes some of the projects reported and issues raised in the proceedings of the First Australian Maize Conference (Moran 1991). Summaries of Australian research are also reported by Moran *et al.* (1990) and in the legume contract by Stockdale in these proceedings.

### BEEF PRODUCTION FROM FORAGE MAIZE

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Currently the principal users of maize silage for beef production are the feedlots located in NSW and southern Queensland. However with a growing awareness of the potential of the maize crop, its use by other sectors of the beef industry is likely to expand.

#### THE NUTRITIVE VALUE OF FORAGE MAIZE

##### *In vivo estimates*

An important attribute of maize silage is its high energy content. A mean metabolisable energy (ME) content of 10.5 MJ/kg DM was determined for 26 maize silages in the U.K. (MAFF 1990) while Margan and Moran (1991) reported a value of 10.9 MJ/kg DM for a maize silage produced at Kyabram. Furthermore, Wagga Wagga data indicate that our maize silages can support cattle growth rates similar to those in Europe and North America. For 20 different maize silages, young growing cattle averaged 1.01 kg/day (Kaiser and Piltz, unpublished data). A potential growth rate of 1 kg/day is consistent with a ME content of approximately 10.5 MJ/kg DM.

##### *Variability in nutritive value*

Laboratory studies have shown that forage maize and silages with a predicted ME  $\geq 10$  MJ/kg DM can be produced in a wide range of Australian environments (Kaiser *et al.* 1991), but there is evidence of significant variation. Similar variation has been observed in *in vivo* studies with sheep, where DM

digestibilities varied from 58.9 to 70.5% for 20 maize silages (Kaiser and Piltz, unpublished data). It is apparent from these and overseas studies (Schmidt *et al.* 1975; MAFF 1990) that maize silage can vary widely in quality.

#### *Sources of variation in nutritive value*

Some progress has been made in determining the sources of variation in digestibility. The effects of maize genotype and crop management have been reviewed recently (Kaiser *et al.* 1991). Less is known about the influence of environment and climate. For dryland crops, moisture stress is likely to depress digestibility by reducing crop grain content. However, the effect of other climatic factors (e.g. temperature, humidity, solar radiation) on the nutritive value of forage maize in the diverse Australian environment is unknown and should be investigated.

Variations in experimental methods have undoubtedly contributed to some of the above differences. In feeding trials, animal performance and forage nutritive value could be depressed by low levels of nitrogen or minerals, poor ensiling technique and aerobic deterioration of the silage during feeding out (Wilkinson 1991). Digestibility could also be influenced by class of animal, level of feeding, silage chop length and failure to use true rather than oven DM content when calculating digestibility values. A large number of analytical procedures have been used to estimate *in vitro* digestibility and it is difficult to find any consensus in the literature on the most accurate method. Predicting ME content from digestibility also presents problems as the various recommended equations yield different results and may not even apply to forage maize. For example, at Wagga we have used the MAFF (1975) equation:  $ME = 0.16 \text{ DOMD}\%$ , while a more recent equation:  $ME = 0.18 \text{ DOMD}\% - 1.8$  (Australian Agricultural Council 1990), where DOMD is the content of digestible organic matter in the feed, yields results approximately 0.5 MJ/kg DM lower. In both cases, DOMD can be estimated from digestibility of the dry matter or organic matter assuming an ash content of 5%.

#### **BEEF PRODUCTION FROM MAIZE SILAGE**

Maize silage plus supplementary urea and minerals can support growth rates of 1.0 kg/day in both weaner and yearling steers (Moran *et al.* 1990; Kaiser and Piltz unpublished data). Earlier work in South Australia (Hawthorne 1978) yielded lower growth rates (0.6–0.7 kg/day) but these silages were made from immature crops with DM contents of only 23%. Low DM contents can depress silage intake and hence animal performance (Wilkinson 1991).

#### *Maize silage–grain finishing diets*

Many studies have investigated the use of maize silage in finishing diets for steers and it is evident that carcasses and meat of similar quality can be produced on either high grain or high silage rations (Brennan *et al.* 1987). However, increasing grain levels on such diets have yielded variable results. For cattle under 350 kg, responses to additional grain have been disappointing, often not exceeding 1.2 kg/day on high grain diets (e.g. Brennan *et al.* 1987). With heavier cattle, growth rates up to 1.4 kg/day have been reported on maize silage/high grain diets. In recent Australian studies, the addition of 50% grain to maize silage/urea diets has raised growth rates to 1.2 kg/day (Kaiser, unpublished data; Wales and Moran, unpublished data).

#### *Protein levels in finishing diets*

The low protein content of maize silage can limit liveweight gain and this may account for some of the variation in animal responses to additional grain feeding. Most feeding standards indicate that rapidly growing steers, 300 kg or more liveweight, require no more than 11–12% dietary protein with a rumen degradability of about 90%. Some authors recommend protein levels up to 13.5%, but there are few data to support this higher level, especially once steers have reached 400 kg (Mowat *et al.* 1977). It is worth noting that soybean meal has been used in most work with maize silage and that few comparisons have been made with protein sources of varying rumen degradability.

For younger cattle (150–300 kg), higher protein levels (13–15%) are recommended, especially for animals with high growth potential. For animals above 180 kg liveweight and gaining at 1 kg/day, urea can supply all the supplementary nitrogen for maize silage and UK recommendations are for urea to replace protein meals in maize silage-based finishing rations for steers greater than 250 kg (Wilkinson 1991).

It is difficult to ascertain how reliably such North American and European data apply under Australian conditions because of differences in our crops and also the management of our feeder steers. Available evidence suggests that our higher yielding forage maize crops have lower protein contents (5–8%) than those produced overseas (i.e. 8–10%). It is also likely that, prior to feedlot finishing, our feeder steers are maintained on lower (and more variable) planes of nutrition than their North American

and European counterparts. This could have important implications when formulating finishing diets as their protein requirements could be greater, especially if they are lighter than 450 kg. Mowat *et al.* (1977) found steers in poorer condition at feedlot entry to require supplemental protein through to heavier liveweights than steers starting in good condition. It is then important to establish the level and type of protein supplements required in maize silage-based diets under Australian conditions to achieve growth rates of at least 1.2 kg/day.

#### *Maize silage to supplement grazing cattle*

Strategic supplementation with maize silage offers a means of finishing steers during periods of low pasture growth and at higher stocking rates. This was recently achieved at Kyabram (Wales *et al.* 1991) where steers given 2.4 kg DM/day of maize silage and grazing annual pastures at 5 steers/ha gained at similar rates to unsupplemented cattle grazing at 2.5 steers/ha. However, it was necessary to feed lucerne hay to all steers due to an exceptionally wet winter. In a more recent trial, cattle grazing perennial pastures in autumn at 4 steers/ha and given 0.6 kg DM/day of maize silage gained at 0.80 kg/day compared with 0.59 kg/day for unsupplemented steers grazed at 2.7 steers/ha (Wales and Moran, unpublished data). Clearly, maize silage has considerable potential to supplement steers grazing good quality pasture.

#### THE FUTURE

In view of its high yield and nutritive value, utilisation of the maize crop within various sectors of the beef industry should expand. Satisfactory liveweight gain, feed conversion efficiency and carcass and meat quality (Brennan *et al.* 1987) can be achieved on maize silage-based diets. In addition, maize silage feeding does not influenced fat colour on either maize silage/grain (Kaiser and Auldred 1991) or maize silage-pasture systems (Wales *et al.* 1991).

Two major issues which need to be addressed are firstly, management strategies to produce high yielding crops and high nutritive value silages and secondly, diet formulation (especially protein) to achieve high growth rates (in excess of 1.2 kg/day) in steers on maize silage/grain diets.

### DAIRY PRODUCTION FROM FORAGE MAIZE IN QUEENSLAND

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The potential for maize silage in dairy feeding systems in northern Australia has been recognised for many years. Forage maize is well suited to major sub-tropical dairying areas, particularly where irrigation is used, and where farmers have a tradition of cropping. Milk yield in nearly all situations is well below cow potential and the production of large amounts of maize silage should substantially increase farm productivity. Furthermore, this extra milk attracts a stable and relatively attractive price.

Why then has adoption been slow? The adoption of other technologies, such as irrigation, temperate pasture and nitrogen fertiliser, has been much more rapid. We believe farmers see maize silage as changing their whole way of life, that it is introducing a new system of production. It is not sufficient to point to advantages in some aspects, such as forage yield or effects on milk quality, but we need to provide data on how the system as a whole works. The financial restraints and returns, the replacement of grazed pasture or crop, feeding out and supplementation are some of the more important aspects which need to be linked together in giving advice.

#### ON-FARM PRODUCTIVITY

Because the use of maize silage stimulates a large number of changes in a farming system, it is not possible to obtain realistic estimates of productivity increases from small, isolated studies. We have developed a computer model based on time series analysis and using historical records of individual farms. This model can predict production if a major change in management had not been made. This value is, in effect, a control to compare with present production. Comparisons of these 2 values then give an estimate of change in production due to the use of maize silage. It is necessary that no other major changes in management occur during the period of study, in our case from 5 to 10 years.

Three farms in south-east Queensland were studied, with an individual model being developed for each farm. In each case, there was substantial seasonal variation but a consistent increase in milk production, ranging from 21 000 to 150 000 L/farm.year. In addition to increases in production, there

have been substantial changes in the pattern of milk output with the introduction of silage (Kerr *et al.* 1991). Milk output during autumn and winter, periods when yields had previously been low, increased twofold compared with increases of about 20% during spring and summer.

Another method of assessing the effects of maize silage on farm productivity is to compare those farms utilising this resource to those without. Several factors contribute to differences between these groups, but such comparisons are useful in describing the types of farms which have been successful in incorporating maize silage. For example among suppliers to the South Coast and Warwick Co-operative dairy factory in Queensland, 4 farms have consistently used large quantities of conserved maize, either as silage or haylage. They have larger herd sizes, higher milk production/cow and hence greater total outputs of milk than the average farm (Cowan *et al.* 1991).

#### CASH FLOW

Many farmers recognise the nutritional qualities of maize silage and the high yields obtained. However, it is clear that adoption will not be universal. Major concerns include: alternative technology may be easier, e.g. fertiliser on pasture, paddocks are out of production for up to 6 months while maize is being grown and harvested, machinery and equipment costs are relatively high, and organising labour at harvest time.

Taking these 4 points together, farms which are not developed to their potential under grazing should not be modified to include maize silage. There is alternative technology available to increase their milk yields profitably, the costs for machinery are very low and there is no disruption to the farm routine.

By contrast, farms which have developed to their potential under grazing have no alternative technology, but they often have a high cash flow and the versatility to remove an area from grazing without major disruption. Also the investment in machinery is a smaller proportion of turnover than it is in less developed farms. Consequently we see maize silage fitting a continuum of technology, where pasture development proceeds towards its potential before maize silage becomes relevant. Once relevant, maize silage is able to sustain continued increases in milk output.

The cost of maize silage was obtained by surveying 4 farms using maize silage (Kerr unpublished data). Capital costs in the first year varied from \$A6000 to \$22 000. The cost of growing and ensiling the crop varied from \$15 to \$22/t of fresh silage. The total cost, including depreciation on machinery, was from 6 to 8 cents/kg DM. These values compare favourably with those used for many grazed forages as shown in Table 1.

**Table 1. Major forage types in Queensland, their potential milk production (L/ha) and cost (mean and range) in terms of milk produced (c/L) (Davison 1990)**

Forage type	Milk production (L/ha)	Cost (c/L)
<i>Summer</i>		
Tropical grass (300 kg N/ha.year)	3000–6000	8 (6–13)
Tropical grass/legume	3000–5000	4 (3–5)
Maize silage (dryland)	7000–10 000	9 (6–13)
Maize silage (irrigated)	13 000–15 000	9 (6–11)
Lucerne hay (irrigated)	12 000–15 000	9 (7–11)
<i>Winter</i>		
Oats (150 kg N/ha.year)	2000–4000	5 (3–10)
Ryegrass (400 kg N/ha.year, irrigated)	9000–11 000	10 (9–11)
Persian clover (50 kg N/ha.year, irrigated)	10 000–13 000	8 (6–10)

#### FEEDING SYSTEMS INCORPORATING FORAGE MAIZE

Maize silage is deficient in protein and several minerals essential for milking cows. Minerals can be readily added as a supplement, usually in the grain-based concentrate given to cows, but the source of protein is critical. The most efficient source is grazed legume. A number of farms in Queensland have used the combination of grazing clover or lucerne at night and feeding maize silage during the day. This offers a number of advantages including efficient use of grazed pasture, a supply of protein to complement maize silage, the opportunity to feed large amounts of maize silage and to reduce heat

stress during hot weather. This system largely involves the provision of shade though there is now interest in the use of sprinklers.

Urea is often used to increase the protein content of maize silage. Urea is usually added at ensiling although similar responses have been obtained when included with the silage at feeding. We have also observed responses to the inclusion of sodium bicarbonate in very wet diets. Where maize silage and irrigated pasture were the major dietary components, sodium bicarbonate increased yields of both milk and milk fat.

Increasing the productivity of grazed forages will continue to boost milk output on the majority of northern Australian dairy farms. However the integration of maize silage into feeding systems is relevant to a steadily increasing number of farms where the potential under grazing is close to being **realised**. We would expect maize silage to be seen as a means of increasing total productivity and stabilising output. Herds will graze for approximately half the day then feed from a trough during the remaining time. Key characteristics of this system will be high milk production per cow and high total farm output of milk.

## DAIRY PRODUCTION FROM FORAGE MAIZE ON IRRIGATED FARMS IN NORTHERN VICTORIA AND THE **RIVERINA**

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Maize silage has the potential to significantly increase the productivity of irrigated dairy farms in northern Victoria and the **Riverina** by allowing farmers to increase stocking rates and hence grazing pressures. It is, however, but one of many options for intensification competing for scarce farm resources. Therefore it is important for its adoption that on-farm limitations are identified, and that we identify how and where it can be used to maximise benefits to the dairy farmer.

Much of the past Australian research has concentrated on the growing, storing and feeding maize silage in conjunction with high quality legume pastures. These and overseas studies have clearly identified a potential for maize silage to improve milk production in Australia. However this potential cannot be fully realised until the technology has been further developed and proven effective on-farm in our environment. Farmers are traditionally cautious in adopting new technology. This combined with their scarce financial resources, has resulted in a relatively slow rate of adoption of feeding maize silage.

The issue of slow rates of adoption and the need to develop practical farming systems integrating maize silage is currently being investigated through a dairy industry funded Maize Development Project at Kyabram. It was established following consultation between Victorian government research and extension officers, local dairy farmers and private consultants. The project involves a multi-disciplinary team of dairy nutritionists, pasture specialists, dairy extension officers and producers. Dairy farmers are involved at all levels of the development process extending from the organisational level through to invaluable field-based feedback.

The aim of the project is to identify on-farm limitations to the feeding of maize fodder and to assist dairy farmers currently feeding maize silage to use it more effectively. This is being attempted through maize feeding discussion groups, a quarterly newsletter (Maize Team News) and on-farm monitoring. The project not only complements past and current research but is likely to influence future research priorities.

### ON-FARM LIMITATIONS

Barriers identified to date include the capital investment required, the extra workload and the need to more precisely balance the total diet of grazing cows, particularly those grazing mixed pastures. Cost competitiveness with alternative intensification options also has a major impact on the use of maize **on-farm**.

#### *Capital investment*

The capital investment needed to feed maize is the first and most obvious barrier to adoption. Although many dairy farmers **recognise** the need to improve productivity, they believe that this should be by the lowest cost system possible. They are often deterred from feeding maize silage by the need to purchase a front-end loader (\$2500) and **feedout** wagon (\$2000 to \$16 000) and to construct storage

bunkers (\$500 to \$5000) and a **feedpad** (\$5000), the latter to avoid excessive wastage. Earle (1991) has, however, shown that reducing total farm costs does not necessarily lower the unit cost of production. Once farmers invest in a system, there are economies of scale. Therefore when feeding maize silage, farmers should not dabble but do it properly. Furthermore, these investments can be utilised for other farm operations, such as storing pasture silage in the bunkers and feeding out pasture hay or silage on the **feedpad**.

The maize feeding discussion groups provide a useful forum for farmers to discuss issues relating to capital investment and for the transfer of some very handy tips as a result of other's experiences. Newsletter articles also provide technical advice on bunker and **feedpad** designs.

### *Labour input*

Undeniably feeding maize silage involves more work than simply feeding pasture or grain in the dairy. A well designed farm with storage bunkers close to the feed area, all weather access and reliable equipment will considerably reduce time spent feeding out maize silage. It is not uncommon for farmers to require only 30 to 45 min to feed their 150- to 200-cow herd each day.

### *Nutritional knowledge*

Probably the greatest barrier to adoption is the variable on-farm milk responses to maize silage feeding. All too often the comment is made that the cows liked the maize and 'did well on it', but for very little, if any, extra milk. Farmers expect additional milk through feeding supplements. Consequently poor milk responses have generated considerable disillusionment amongst farmers.

These poor on-farm milk responses can generally be attributed to the nutritional limitations of feeding maize silage to cows grazing mixed grass-clover pastures of variable protein content. Research at Kyabram (Stockdale and Beavis 1988) has shown improved milk responses when feeding maize silage in conjunction with Persian clover (21% protein) pastures than on mixed 75% ryegrass-25% white clover (16% protein) pastures. Pasture protein *per se* therefore has a big effect on milk responses to maize silage (6-8% protein). The situation is further complicated by the fact that maize silage is generally fed during autumn when pasture protein levels are at their lowest. Protein deficiency can be further exaggerated if the silage is fed together with a low protein cereal grain.

To overcome variable milk responses, farmers need a better understanding of cow nutrient requirements at different stages of lactation and, more importantly, how to provide them from their available feed supplies. Unfortunately a history of an almost complete reliance on pasture-based production systems often means that such skills are lacking. Only recently have farmers begun to feed supplements, namely grain (and now maize silage) to their milking herds. As more and more pasture (a relatively well balanced feed) is replaced by supplements, there is a greater need to ensure that the herd's diet is nutritionally balanced. This places increasing demands on managerial skills and often requires a whole new way of thinking. Consequently within the discussion groups and in the newsletter, a great deal of attention is given to the fundamentals of dairy nutrition and feed quality.

### *Balancing the diet*

One major difficulty encountered when calculating total diets for grazing cows is knowing the quantity and quality of grazed pasture. The project is assessing methods to overcome this limitation. Pasture metres are used in the discussion groups to estimate pasture intake (kg DM actually eaten). Harvesting pasture **quadrats** (pre and post grazing) for protein and energy analyses helps farmers to more accurately estimate pasture quality. The level of supplement fed is relatively easy to determine while its quality can be obtained using commercial feed testing services.

Feedback to date has been very encouraging with more farmers now aware of the importance of total dietary protein. Many farmers are experimenting with feeding more protein during periods of maize silage feeding by grazing cows on subclover pastures or supplementing them with subclover silage, high protein grains or pellets. Some are also incorporating urea into their maize silage.

### **ON-FARM MONITORING**

One important aspect of the project has been the information collected from 5 monitor farms across the northern Victorian irrigation area. Total feed inputs and milk production were recorded on each farm over 1 full week in spring (October), summer (January-February), autumn (April) and winter (June) during the 1990-91 lactation. Daily pasture allocation and intakes have been calculated from pre and post grazing pasture yields, paddock area and herd size. From data on intake and quality of pasture and supplements, together with changes in pasture protein due to grazing, dietary protein can be calculated.

The monitoring is providing valuable on-farm data to help understand how farmers are integrating maize silage into their particular farming system. To date, 2 aspects that stand out as having a major

impact on its efficiency on-farm are, firstly, *the* quality of feedstuffs and, secondly, *the* utilisation of available pasture.

#### *Feed quality*

The dramatic effect of feed quality on milk responses to feeding maize silage observed in the monitoring reinforces the importance of balancing diets for protein as well as energy. There is a wide range of supplements fed throughout the year and their quality and ability to meet herd requirements are receiving close attention. The ability of grazing cows to select diets higher in quality than those available is of particular interest.

#### *Pasture utilisation*

For efficient use of supplements, it is essential that the pasture is well utilised and that substitution of the supplement for pasture is minimised. Pasture utilisation is calculated from the amount of pasture eaten as a proportion of that on offer. This must also take into account the pasture too close to ground level for effective grazing.

Pasture utilisation on the monitor farms averaged 60% which is similar to that recorded on other dairy farms in northern Victoria; an efficient level is 70% or better. Utilisation is influenced by stocking rate, season and the level of supplementation.

Utilisation was measured on 1 farm in spring to be 81% with cows producing 22 L milk/day and fed no supplements. At the same time, supplements were fed on a second monitor farm which recorded only 54% pasture utilisation and milk yields of 21.8 L/day milk. Clearly pasture, the cheapest feed resource, was being wasted on the second farm. In autumn, both farms fed maize silage and had 70% utilised pasture.

### CONCLUSIONS

It is too early to draw final conclusions, but it appears that protein in the total diet and pasture utilisation are likely to be problem areas when feeding maize silage on farm. Aspects such as these are central to the successful integration of maize silage into dairy operations in irrigated southern Australia.

### DEVELOPING A FUTURE FOR FORAGE MAIZE

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Basic research into the successful integration of maize silage into Australian pasture-based dairy and beef systems has still to be done. For example, at Kyabram we are currently measuring milk production and rumen metabolism in dairy cows fed white clover-based pastures together with maize silage and additional energy and protein supplements. We are also determining optimum levels of maize silage to feed during different seasons for year-round, pasture-based beef production. Furthermore, our on-farm dairy project has identified the importance of farmers being able to describe pasture quality more accurately to optimise levels of maize silage feeding to grazing cows. Other Kyabram scientists are developing lower cost systems for growing forage maize to help overcome one of the greatest limitations to its acceptance by the cattle industry, namely high production costs.

Contract grown forage maize is available in certain areas, such as in the beef feedlots regions of southern Queensland and northern NSW and in the irrigated dairying areas in northern Victoria. Although more expensive than 'home grown' maize, it allows producers to concentrate on their livestock rather than to diversify into cropping. In Davison's paper in this contract, the total cost in Queensland, including depreciation of machinery, for maize silage was \$60–80/t DM while in Victoria, Donohue (1991) costs forage maize (in the bunker) at \$81/t DM, including the opportunity cost of lost pasture production. In contrast, Earle (1991) quotes a purchase price of \$70/t DM for the standing crop plus an additional \$40–50/t DM for harvesting and cartage, making a total of \$110–120/t DM to get maize into the buyer's silage bunker. The purchase price of contract grown maize forage will vary with the returns from other cash crops but it should reflect the costs of alternative supplements as well as the supply and demand for maize greenchop in the area.

Whether it is cheaper for small dairy farms to grow or purchase their forage maize requirements depends on many factors, such as the size of their operation, the number of labour units, the seasonality of their milk production, the availability of contract growers and of most importance, the cost of the

purchased forage maize and other feedstuffs. The availability of contractors to sow and harvest the crop could well be the deciding factor. Unfortunately contractors will not commit themselves to buying specialist machinery without being assured of customers and potential new growers often don't start because there are no suitable contractors in their area.

The above papers highlight some of the pitfalls faced by farmers wanting to feed forage maize prior to more effectively utilising their cheapest feed, namely their pastures, and also trying to 'do it on the cheap'. Optimum stocking rates will vary in different regions depending on whether the dairy farm is supplying 'quota' milk, the climatic constraints and the pasture species. However to minimise pasture substitution, farms should be well stocked. Grazing management for beef cattle is less precise than for dairy cows and hence pasture substitution would be more of an issue, although in most cases an **unrecognised** one.

These papers also show the short lead time between much of the industry supported research and its application by producers. What took decades to develop in North America and Europe is being condensed into years in Australia.

The future for forage maize in Australia is promising, particularly as cereal grains are becoming more expensive and the beef **feedlots** are increasing their capacity. Research has clearly shown that maize silage complements high legume pastures. The profitability of this complementation under the vastly different cost/price structures of our northern and southern dairy industries and the diversity of pasture types grazed by cattle will eventually determine whether and where more forage maize will be grown for livestock.

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## LEGUMES IN DAIRY FARMING IN VICTORIA

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### INTRODUCTION

Dairy farmers have always been faced with the prospect of having to continually improve farm productivity to counteract increases in costs. Researchers and advisers have aided them by the development of innovations. During this century, there have been a number of major developments, including the discovery of super-phosphate, the adaption of subterranean clover to a large proportion of Australia and, of course, the inventions of tractors and milking machines. In addition, there have been many improvements in feeding and breeding which, although often of little consequence by themselves, have all helped to keep dairy farmers viable and competitive. As an example, developments in feeding and breeding have resulted in increases of 70% in stocking rates, and 30 and 120% in milk fat production per cow and per hectare, in the last 20 years in northern Victoria.

With the continual search for opportunities to improve animal productivity, a lot of interest has centred on the use of legumes in farming systems in the last decade. The attention of research has been focused on improving the quality of forage offered to grazing dairy cows. This is based on the strong positive relationship that exists between feed quality and intake (Freer and Jones 1984). There are 2 principal aims when using legumes; the first is to utilize feed resources to their limits, and the second is to maximise animal productivity. These aims are opposing and a balance must be struck between the two.

The Dairy Research and Development Corporation has supported legume research at Victoria's 2 dairy research centres in recent years. A number of relevant aspects have been investigated at Ellinbank and Kyabram, including **herbage** and animal productivity and the use of supplements. This review reports on these aspects and also considers how dairy farmers view the increased use of legumes in their farming systems. The research reported has concentrated on the major legumes that might find current application in the Victorian dairy industry: these are the perennials, white clover, red clover and lucerne, and the annuals, subterranean clover and Persian clover.

### MANAGEMENT OF LEGUMES FOR HIGH **HERBAGE** PRODUCTION

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### TOTAL AND SEASONAL PRODUCTION

The traditional dairy pastures in Victoria incorporate a mixture of grasses and white clover, with white clover generally being the minority species (often less than 20%). Research in Gippsland (O'Brien 1987a) has shown that increasing the clover proportion in high rainfall pasture resulted in a decrease in autumn growth and an increase in summer growth while winter and spring growth were relatively unaffected; annual yields were not greatly altered as clover proportion increased. A similar result was obtained in northern Victoria. In a cutting experiment conducted for 4 years with high input levels and ideal irrigation management at Kyabram, annual yields of 23.7 and 22.7 t **DM/ha** from pure swards of perennial **ryegrass** and white clover were measured (Mason *et al.* 1987); these yields were only slightly less than the **mixture**. Results in Table 1 indicate that the same conclusion applies to grazing. This research demonstrates that pure legume pastures need not lead to large yield losses.

Research with irrigated subterranean clover and Wimmera **ryegrass** confirms that the same situation applies for annual pastures in northern Victoria (Kelly and Stockdale 1985). Annual yields of 11 t **DM/ha** were obtained from both mixed pastures and pure swards of subterranean clover. Persian clover and subterranean clover are likely to be similar in this respect (Kelly and Mason 1986).

## MANAGEMENT OF PURE CLOVER SWARDS

*Grazing management*

*White clover:* An experiment at Kyabram studied the effects of a range of grazing managements, based on quantity of pasture before grazing and remaining after grazing, on white clover productivity (Kelly *et al.* 1989a). Grazing treatments selected (Table 1) translate to rotations of about 14 days (3/2 t DM/ha, pre/post grazing) up to 45 days (4/1 t DM/ha, pre/post grazing) in the peak growth periods.

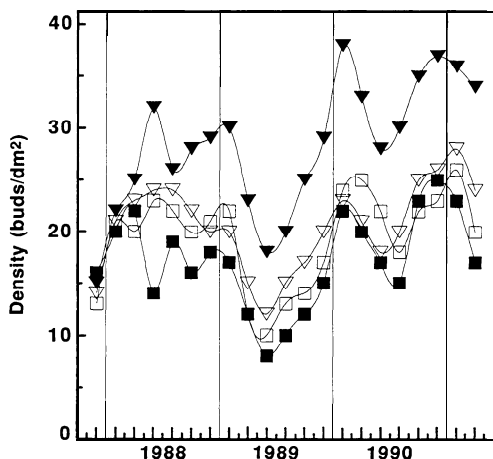
The data in Table 1 show that frequent intense grazing of irrigated white clover was the most productive treatment. In addition, there appears to be no evidence of a decline in productivity over time.

**Table 1. Species, grazing treatment and amount of pasture removed by grazing (t DM/ha) with the number of grazing events each year in parentheses. Yields are for the period from mid September to mid September for the first 3 years, with yield for 1990-91 from mid September to late March**

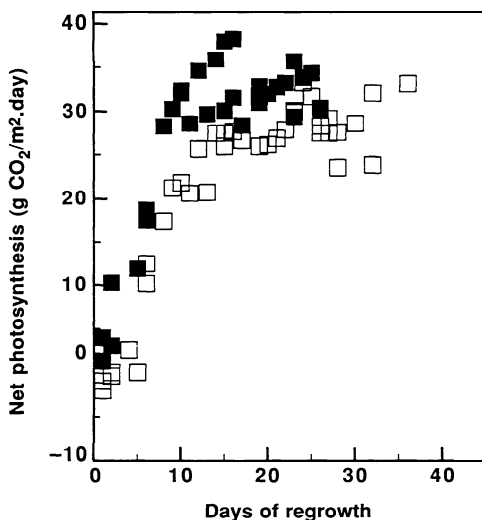
Pasture	Grazing treatments (t DM/ha)		1987-88	1988-89	1989-90	1990-91
	pre	post				
White clover	3	2	13.32 (11)	12.37 (11)	14.66 (14)	11.21 (8)
White clover	3	1	14.20 (9)	12.78 (8)	14.72 (11)	12.25 (8)
White clover	4	2	11.85 (6)	12.51 (6)	14.33 (10)	10.39 (6)
White clover	4	1	10.61 (5)	11.82 (6)	13.55 (7)	9.68 (5)
White clover/perennial ryegrass	3.5	2	11.66 (9)	12.62 (8)	14.20 (13)	11.54 (8)
l.s.d. ( $P = 0.05$ )			1.0	0.9	1.1	0.9

Sward structure was also influenced by grazing treatment with the lowest yielding treatment having the lowest density of stolon tips (vegetative buds) (Fig. 1). To some extent, low stolon tip density is compensated for by larger leaf size, however, data from intensive regrowth studies in summer (Fig. 2) show effects of both residual leaf area and bud density on daily net photosynthesis. That is to say, the 3/1 grazing treatment (Table 1) with higher bud density showed higher levels of photosynthesis (growth) immediately after grazing.

Clearly, therefore, grazing management can influence the productivity of white clover, principally by effects on sward structure which will influence the rate of leaf development during regrowth.



**Fig. 1.** White clover bud density (buds/dm<sup>2</sup>) for 3/2 (▼), 3/1(▲), 4/2(□) and 4/1(■) grazing treatments. [Pre/post grazing pasture yield (t DM/ha)]



**Fig. 2.** Daily net photosynthesis (g CO<sub>2</sub>/m<sup>2</sup>.day) for summer regrowth for 3/1(■) and 4/1(□) grazing treatments.

**Red clover.** The grazing management of red clover was included as additional treatments in the white clover experiment described above (Kelly *et al.* 1989a). Red clover was the most productive legume early in the experiment. However, its productivity was severely reduced by grazing prior to flowering, with plant density reduced by 80% after 15 months compared with only a 30% reduction when grazed at flowering. The rapid decline in plant density, and concomitant invasion by weeds, resulted in the frequently grazed red clover treatment being terminated after 15 months; however, extending grazing interval to flowering only extended sward longevity to 18 months. Without remedial treatment, a similar response would also probably have been recorded in Gippsland (G.N. O'Brien, unpublished results).

#### *Irrigation management*

The success of pure legume pastures under irrigation will, in part, be dependent on the development of suitable irrigation management strategies. An experiment was done at Kyabram in which white clover, red clover and lucerne were subjected to 3 irrigation frequencies (based on 40, 80 and 120 mm of cumulative Class A pan evaporation less rainfall, (i.e. E-R)) (Kelly *et al.* 1989b). Yield data showed the importance of very frequent irrigation (i.e. 40 mm E-R) on the productivity of white clover. When irrigated at 80 mm E-R, yield of white clover was reduced by 28%; this reduction was 43% when irrigated at 120 mm E-R. With red clover, it was only the infrequent irrigation interval (120 mm E-R) that reduced yield while the productivity of lucerne was not affected by this range of irrigation frequency.

#### IMPROVEMENT OF LEGUME CONTENT IN ESTABLISHED PASTURES

Although white clover research has indicated the potential of such pastures, they can be very difficult to maintain. An alternative approach is to increase the clover content of established grass-dominant pastures. In northern Victoria, it appears that frequency of grazing in winter may offer potential to influence clover content, with the aim being to improve the competitiveness of white clover at this time (K. B. Kelly, unpublished results). In addition, it has been demonstrated that high grazing intensity throughout the year (i.e. stocking rate) will also increase the white clover content of a sward (Stockdale and King 1980). In contrast to these findings, lax grazing of dryland pastures over summer has been found to increase clover content (J. Stewart, unpublished results).

An aspect of legumes that has not been specifically addressed in Victoria, but one which has been of some concern elsewhere, is that of nitrogen fixation. Legumes fix considerable quantities of nitrogen (Hoglund *et al.* 1979) and their presence reduces the need for fertiliser N. This attribute of legumes may indicate a need for companion grasses to utilise efficiently the nitrogen that is produced.

Finally, studies at Ellinbank have shown that herbicides can influence clover content of established pastures (O'Brien 1987b). However, when using herbicides, improvements in clover content must be balanced against reductions in herbage growth occurring immediately after herbicide application. Furthermore, environmental issues cannot be ignored.

Clearly, there are already strategies that will result in improvement in clover content of existing swards. Research must continue to refine and extend the application of these techniques into farming systems.

#### THE VALUE OF LEGUMES FOR DAIRY PRODUCTION

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#### WHITE CLOVER *v.* RYEGRASS

##### *Direct comparisons*

At Ellinbank considerable research has investigated comparative animal production from white clover and ryegrass (e.g. Rogers *et al.* 1982). In in-door feeding studies, dairy cows consuming white clover to appetite ate 33% more food and produced 25% more milk than those offered ryegrass. Fat and protein concentrations were generally similar but the milk fat of cows fed white clover contained a greater proportion of short chain fatty acids. Regression analysis showed that at the same level of digestible intake, milk production was significantly higher with white clover indicating that the efficiency of conversion of herbage to milk was higher for clover than for grass. Therefore, increased

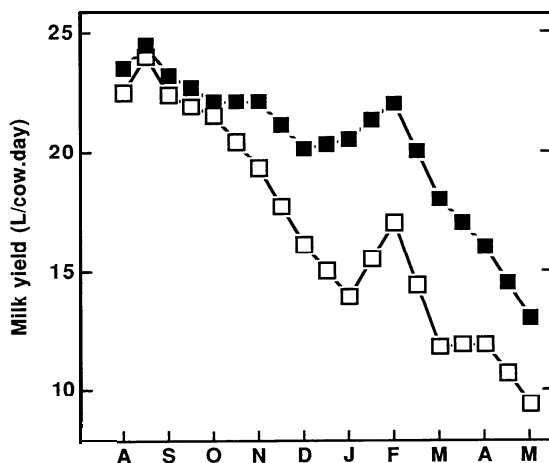
production from white clover was due to both increased consumption of food and a higher efficiency of utilisation of digested nutrients.

Specifically in relation to grazing cows, Rogers (1988) found that cows will graze white clover pastures harder than ryegrass pastures, especially when restricted (Table 2). This results in greater utilisation of the herbage on offer.

**Table 2. Effects of species and allowance on herbage utilisation by grazing dairy cows**

	White clover		Ryegrass	
	<i>Ad lib.</i>	Restricted	<i>Ad lib.</i>	Restricted
Pasture on offer(t DM/ha)	2.62	2.58	2.52	2.51
Allowance (kg DM/cow.day)	39.6	13.4	39.2	13.5
Residual yield (t DM/ha)	1.52	0.87	1.73	1.34
Percentage utilisation	42	66	31	47

While most experiments have been for short periods only, Rogers *et al.* (1986) have reported comparative results for a full lactation. Cows grazing white clover or ryegrass to appetite (80 kg DM/cow.day on offer) for a whole lactation produced 5750 and 4740 L of milk (Fig. 3) and gained 85 and 80 kg liveweight, respectively. The rate of decline in milk production after the peak was much slower with white clover than with ryegrass.



**Fig. 3.** Milk yield of cows grazing white clover (■) or ryegrass (□) to appetite throughout lactation.

#### *Why the difference?*

Research at Ellinbank has attempted to explain why these major differences occurred. With cows in late lactation, increased milk production was associated with apparent differences in rumen digestion and possibly differences in nutrient partitioning and utilisation, as well as large differences in feed intake. However, in follow-up research, arteriovenous differences, which indicate the utilisation of key metabolites by the mammary gland, were similar for both white clover and ryegrass diets (Moate *et al.* 1987). This occurred despite higher arterial concentrations of these metabolites in cows on the clover diets in both early and late lactation.

It was suggested that a critical attribute of white clover responsible for its nutritional superiority over ryegrass is that it contains more protein. A number of researchers overseas have measured greater amounts of protein reaching the small intestines of cows grazing white clover compared with cows grazing ryegrass. White clover generally contains more L-arginine than does ryegrass, and intravenous infusions of L-arginine have been shown to elevate plasma concentrations of somatotrophin. This could elicit a growth hormone response and thereby stimulate the higher milk yields of cows fed white clover.

Therefore, an experiment was done to determine if protein may account for the superior nutritive quality of white clover (P. J. Moate, unpublished data).

The surprising findings from this experiment (Table 3) were that there were greater production responses when **casein** was fed as a supplement to cows offered white clover rather than ryegrass. Despite an elevation in plasma L-arginine with white clover and **casein**, plasma somatotrophin was not affected by **casein** and was in fact depressed by white clover. These findings suggest that the higher protein content of white clover may not be a principal cause for the higher nutritive value of white clover compared with ryegrass.

**Table 3. Effects of pasture species and formaldehyde treated casein (1.0 kg/cow.day) on responses in lactating dairy cows**

	Ryegrass	Ryegrass and casein	Clover	Clover and casein	l.s.d. ( <i>P</i> = 0.05)
Pasture intake (kg DM/cow.day)	13.1	12.9	14.9	15.2	0.4
Milk yield (L/cow.day)	17.4	18.3	20.9	22.7	0.9
Plasma L-arginine ( $\mu$ M)	156	190	222	258	22
Plasma somatotrophin	9.2	8.7	7.2	7.7	1.6

#### *White clover systems*

The superiority of white clover over **ryegrass** needed to be demonstrated at the farm level for better acceptance by dairyfarmers. Systems research at Ellinbank showed that a high white clover system can be more productive than a traditional pasture system. The average of 3 years of this research showed that milk fat production was increased by 10%, protein by 6%, lactose by 6% and milk volume by 3% as a consequence of increasing white clover content from 20 up to 40% (O'Brien 1989). This research has highlighted some areas that need further development. Modifications under consideration include better weed control, reduced use of herbicides, improved grazing management to maintain a high white clover content, improved cultivars and development of **techniques** for utilising the build up of soil nitrogen associated with maintaining high clover pasture in the long term.

#### ANNUAL CLOVERS

Subterranean clover and Persian clover are both often grown under irrigation in northern Victoria. Research at Kyabram indicates that pure swards of these annual legumes have much higher nutritive values than current pasture mixtures (Stockdale 1990). Maximum daily intakes of 22 kg **DM/cow**, which approximate to 4.5 % of body **weight**, have been obtained and these resulted in milk yields approaching 30 kg/cow. Marginal returns reached a maximum of 1.4 kg milk for each additional kg of DM eaten. However, while milk protein responded in a similar manner to whole milk, responses in milk fat were much less because the cows fed at low planes of nutrition produced milk with a substantially higher fat content than did better fed cows.

#### USE OF SUPPLEMENTS WITH LEGUMES

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The level of production achieved by Victorian dairy herds is low compared with many other countries. This occurs principally because dairy farming in Victoria is based on grazed pastures and research has shown that cows will be underfed on pasture alone if the **herbage** is to be adequately utilised (Stockdale 1985); this means that stocking rates must be high. In addition, there are periods of the year when pasture growth rates are too low to meet herd requirements (Stockdale 1983). A practice that allows cows to be fed well while achieving a high level of utilisation of pasture involves feeding a supplement.

The superiority of white clover over **ryegrass** as a feed for lactating cows has been clearly demonstrated. However, **rumen** metabolism of protein in many immature legumes can result in very high concentrations of **rumen** ammonia, much of which will be lost as urea in urine unless additional energy is offered to utilise it more efficiently. The use of starchy supplements is one option to overcome this.

**OATS AS A SUPPLEMENT**

An experiment was done at Ellinbank to determine whether energy was a factor limiting the nutritive value of **ryegrass** compared with white clover (Moate and Rogers, unpublished results). Cows were either offered a restricted level of **ryegrass** or white clover; some cows on each were also given oats as a supplement (Table 4).

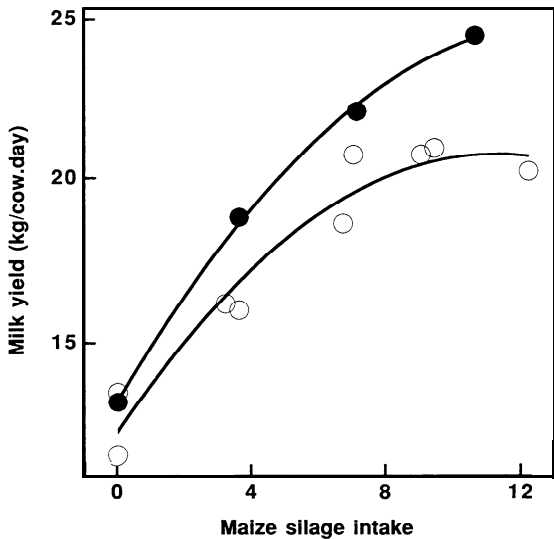
**Table 4. The effect of the type of basal pasture on the response in feed intake, milk yield and composition and liveweight change obtained from feeding oats as a supplement to pasture for dairy cows**

	Ryegrass	Ryegrass and oats	Clover	Clover and oats	l.s.d. ( <i>P</i> = 0.05)
Pasture intake (kg DM/cow.day)	9.9	9.4	9.9	9.7	0.8
Oats intake (kg DM/cow.day)	—	4.3	—	4.3	—
Milk yield (kg/cow.day)	14.1	15.4	15.5	18.9	1.7
Milk fat content (%)	4.41	4.32	4.66	4.49	0.27
Milk protein content (%)	3.00	3.09	3.08	3.05	0.13
Liveweight change (g/cow.day)	-375	+105	-515	-15	550

The major new result from this experiment was the greater response obtained when oats were fed with white clover than when fed with ryegrass. The marginal responses were 0.3 kg milk for each additional kg DM of oats eaten when **ryegrass** was the basal feed compared with 0.8 kg milk when clover was the basal feed. While these results suggest that energy is not the principle limiting nutritional factor in ryegrass, they do indicate that the potential of clover for lactating cows may be even greater than previously thought.

**MAIZE SILAGE AS A SUPPLEMENT**

When feeding high quality pasture to lactating cows, there is a limit to how much cereal grain supplement can be fed before a shortage of dietary fibre will cause a severe reduction in milk fat content



**Fig. 4.** Milk yield responses from cows fed 7.4 kg DM/day of **ryegrass/clover** (○), or **Persian clover** (●) and supplemented with maize silage.

(Stockdale *et al.* 1987). One way of overcoming this is to use maize silage instead of cereal grains. Maize silage provides energy as starch to utilise excess rumen ammonia; and fibre for maintenance of rumen function and prevention of low milk fat concentration.

#### *Persian clover*

At Kyabram, Persian clover was compared with irrigated perennial pasture as the base feed and maize silage was used as a supplement (Stockdale and Beavis 1988). The response to maize silage was better when cows were offered Persian clover rather than perennial pasture; each kg DM of maize silage resulted in 1.4 kg milk when Persian clover was fed, but only 0.9 kg milk when fed with perennial pasture (Fig.4.). This was true for both in-door feeding and grazing (Stockdale 1991).

These responses can only be explained if positive associative effects on digestion and/or tissue metabolism of absorbed nutrients occurred to improve utilisation of one or both of the feeds. The Persian clover provided large quantities of water soluble carbohydrates and protein while maize silage added energy, as starch, and fibre. This research suggests that it is probably the combination of these dietary ingredients that promotes the high animal production reported. The protein in Persian clover was used more efficiently in the rumen when there was some maize silage in the diet but the energy from maize starch was just as important. One instance of using immature maize with little grain in it resulted in poor milk responses (C. R. Stockdale, unpublished results).

#### *Red clover and lucerne*

When red clover was fed as the base forage, the marginal return was only 0.9 kg milk from each additional kg DM of maize silage eaten in early lactation (Robertson and Lemerle 1991); this is only as good as that obtained from mixed perennial pasture. This happened because the lignin content of red clover greatly increases at flowering and its soluble protein decreases, thereby limiting its digestion in the rumen. If red clover is to be seriously considered as a feed for dairy cows, it must be utilised before flowering; and agronomic theory suggests that this is an ideal way to severely reduce DM production and longevity of a red clover sward.

A similar situation exists with lucerne. Lucerne needs to be fed in an immature state for it to be seriously considered as a potential feed for highly productive dairy cows.

#### *White clover*

Research with white clover and maize silage is continuing at the present time. Unlike red clover and lucerne, white clover does not need extended periods between grazing for maintenance of sward productivity; in fact, it performs best with frequent, severe grazing. If white clover is left to flower prolifically, as it can in spring and summer, the responses from maize silage are no better than those reported for red clover and lucerne. At flowering, the protein content of the plant drops and the lignin content doubles. In addition, the tannins in white clover flowers ties up much of the soluble protein in the plant. We hypothesise that if flowering of white clover can be reduced or prevented, good responses from maize silage are likely to result.

## THE POTENTIAL OF LEGUMES IN PRACTICE

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In Victoria it is no longer uncommon to find dairy herds averaging 30 L per cow, and individual cows often producing above 40 L of milk per day. Often these herds are run at high stocking rates and the cows are of high genetic merit, although this is not always true.

We find that the 2 major factors consistently associated with high performance are good cow condition at calving and the feeding of high quality legume dominant pastures throughout lactation. Both of these are prerequisites for achieving high production. Unlike grasses, legumes continue to grow and maintain high quality in late spring and summer.

Producing milk off pasture after peak milk yield is achieved is critical to profitability as milk payment increases at this time. For example, spring payments are about 18c/L rising to 22–23c in the summer, and 3 lc in autumn/winter. A 10c differential over, say, 1500L per day represents \$150 per day in extra income.

Information and management practices are being utilised which enable good operators to produce high milk yields from legumes during and after the spring. Under irrigation, this principally means maintaining good drainage and using watering schedules which permit a legume to display its ability to grow rapidly during high summer temperatures. Legumes must be watered, but not drowned. High soil phosphorus levels are also required, however, this is secondary to drainage.

On dry land, top farmers manage pastures by preventing grasses from smothering out the legumes. This is achieved by maintaining grazing pressure by manipulating the rotation to present the cows with leafy pasture while at the same time keeping the pastures in a growing state. Genuine surpluses of spring pasture are removed early for conservation after short periods of closure. It is also important to keep fertilizer levels above traditional maintenance levels for legumes to grow into the summer. Although it is not often discussed, large gains can be made on dry land farms if pastures are well drained. It would also be advantageous, particularly in the marginal dairying areas, if deep rooted perennial clovers that will survive dry summers could be developed.

If a new technology is to be adopted, it must be clearly profitable and preferably easier than current practices. Farmers know their cows will produce more milk from legumes and make more money, but they are fearful of bloat. They dread the trauma of dealing with bloat and the stress associated with stock losses. Bloat prevention systems need to be developed that are 100% effective and easy to administer. This is seen as very important because, not only do farmers want their cows to survive, they also recognise that subclinical bloat may reduce appetite and milk yields year round. Anti-bloat capsules are a start in this direction.

Clearly, the agronomy and pathology of legumes need to be improved, both in monocultures and in mixed pastures. What are the grazing management requirements in different seasons for optimum production and persistence of legumes? What are the fertilizer requirements of legumes in grazing systems? Do research results represent whole paddock dynamics of nutrient requirements under grazing situations? These and other questions need answers.

There have been suggestions that herd fertility may suffer with intense use of legumes on dairy farms. We have no evidence that, by feeding legumes, the current levels of herd fertility cannot be maintained. Suffice to say that many successful farmers who are using legumes are maintaining tight calving patterns.

The potential for legumes in Victorian dairy farming systems is highly exciting. With legumes, cows eat more food and produce more milk very economically at all times of lactation. With legumes, farmers can challenge herds whose genetic potential has outstripped the capacity of traditional pastures to feed them properly. In essence, with legumes we see effects which can be seen as an Australian equivalent to bovine somatotrophin. However, before there is widespread adoption of legume pastures by Victorian dairy farmers, we believe there needs to be an effective system of bloat control and the key issues leading to the persistence and high productivity of legume pastures need to be better understood.

## CONCLUSIONS

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Herbage production will not be penalised if legumes assume a much greater proportion of a sward than they currently do. Providing substantial areas of legumes can be maintained on dairy farms, animal productivity will increase because cows will eat more herbage, they will utilise it better and they will graze harder than they do on grass - dominant swards. Dairy farmers will also get greater value from their supplements if legumes constitute the basal ration, but only if these legumes are grazed appropriately; and this varies from legume to legume.

Although the nutritional advantages of using legumes are great, there are some disadvantages which may make farmers wary of committing themselves to the new technology. Bloat is an obvious area of concern although the feeding of supplements provides an ideal vehicle for the delivery of antibloat chemicals. Longevity of legume swards can also be a major problem. These swards are susceptible to anything other than ideal management. Research needs to address these problems. If the above concerns can be attended to, the increasing use of legumes on dairy farms in Victoria can provide exciting prospects for the industry as it moves into the next century.



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