MEAT & LIVESTOCK AUSTRALIA

On farm

High ME Silages

as an alternative feed source for the Australian Feedlot Industry.

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GRM International Pty Ltd
In association with
NSW Agriculture
And QSS Pty Ltd

Meat and Livestock Australia Ltd
Locked Bag 991
North Sydney NSW 2059

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Feedlots

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REVIEW TEAM

1. Mr Patrick Houlahan - Principal Livestock Consultant, GRM International Pty Ltd
   Team Leader

2. Dr Alan Kaiser - NSW Agricultural Research Institute, Wagga Wagga
   Research Specialist in Cattle Nutrition and Silage Production / Utilisation

3. Mr Lloyd Davies - NSW Agriculture Maitland.
   Senior Economist specialising in Farm Business Management and On-farm Enterprise Evaluation

4. Mr Ian Blackwood - NSW Agriculture Maitland
   Extension Specialist in Beef Cattle Nutrition

5. Mr Ken Rich - Managing Director QSS
   Consultant in Production and Utilisation of Silage

EXCUTIVE SUMMARY

Recent and current Australian silage research and development.

Over the last 15 years silage research and development throughout the country has been limited particularly in the fields of production and utilisation applied research. A definitive project for the beef industry funded by MRC and conducted by New South Wales Agriculture was carried out over a four year period (1989 - 1993). This involved finishing yearling steers on rations containing nil, 27, 54 or 80% grain in the three large scale animal house experiments. In addition a series of on-farm studies were conducted to assess cattle performance on high silage diets under commercial conditions. This project has demonstrated:

- that high quality silage diets could sustain live-weight gains in the range of 0.8 to 1.1 kg per day when fed as a sole diet to yearling steers.
- High silage - low grain diets gave better net returns per head than high grain diets.
- Carcases suitable for domestic trade were produced from steers on all diets (it took a little longer to finish silage only steers).
- There were no adverse affects of silage feeding on fat colour, meat colour, marbling or the physical properties of the meat associated with tenderness.

These findings have particular ramifications for the feedlot sector as they indicate that high quality silages ($\geq$ 9.5 MJ/Kg DM) have the ability to replace a certain amount of grain in feedlot rations. This must have direct financial implications especially during periods of high grain prices.

Silage research for the beef industry has been conducted in NSW, WA and Victoria. At the Agricultural Research Institute Wagga Wagga, a wide range of silage production and utilisation issues have been studied, including the composition of silage parent materials, cereal and legume crops, the production of silage from sub-clover based pastures, and other legumes, and silage production from maize, forage sorghums and millets etc.

Beef cattle work at Bunbury in Western Australia has focused on the use of pasture silage plus grain supplements to finish cattle. The superiority of silage compared to hay made from the same pasture has been clearly demonstrated. In Victoria in recent years cattle have been successfully fed various maize silage supplements. The role of silage fed as a supplement to pasture in finishing systems for steers destined for the Japanese Ox market has been studied at Hamilton.

There has been a deal of research on silage in the dairy industry carried out particularly in New South Wales and Victoria which has important implications for the beef industry. A substantial research effort has also been put into the production and nutritive value of maize silage in both States. New South Wales has focused on the quality of the parent forage for silage production, with emphasis on maize and kikuyu grass. It can be expected that the agronomic studies and plant breeding programs carried out here on maize will be of particular importance to the feedlot industry. Silage research in the dairy industry has been carried out in Victoria since the late 1970s where emphasis is on the production of pasture silages examining the degree of wilting for silage production along with silage chop lengths. The development of the round bale silage system, including optimum bale density, has been carried out at Ellinbank. Maize silage research has been conducted at Kyabram examining the agronomy and management of irrigated maize crops and the use of this silage for backgrounding activities in the beef industry is being undertaken there.

Silage produced from cereal crops and annual pasture is being used in lamb finishing diets in Western Australia while the MRC are about to finance further research under the Lamb Consistency Key Program in NSW into production from lambs on silage diets.

There is no doubt that the Australian silage research programs have demonstrated that cattle live weight gain in the range of 0.9-1.1 kg/day can be achieved feeding silage (ME ≥9.5MJ/kg DM) alone and these gains can be increased by the addition of grain and protein supplements in the ration. Work with maize silage has been carried out both with dairy and beef cattle showing that it has much to offer as high metabolisable energy source. The potential of sorghum silage both grain and fodder varieties have been identified but further applied research needs to be carried out to select those varieties which have the greatest potential to produce under rainfed conditions in the feedlot regions of Northern NSW and S.E. Queensland.

Current Silage Making and Feeding Practices in the Major Feedlot Areas

To up-date our understanding on the use of silage in the feedlot industry a survey was conducted by facsimile and phone in early January 1997, concentrating on the three major feedlot areas previously identified in Eastern Australia, and estimated to account for more than 85% of animals being lotfed annually. A satisfactory 66% response totaling 73 feedlots was obtained and of these some 22 (30%) were using silage in their rations. Of these 50% were in South East Queensland (Region 3), 28% in North West New South Wales (Region 2) and 22% in Southern NSW/Victoria (Region 1). Some 71% of those feedlots surveyed with a capacity greater than 5,000 head used silage as an important component of their rations.

Where irrigation was available the silage parent material of choice was maize. Both grain and forage sorghums were important crops grown for silage particularly in Regions 2 and 3. Eighty-two percent of silage users engaged contractors to cut and make their silage with this task being carried out exclusively with precision chop forage harvesters. The majority of feedlots (82%) fed silage at all three stages in the feeding program while 18% used it only in the introduction stage.

The main advantage given for feeding silage was its high palatability resulting in less feeding problems (59% of users). Lower ration costs were also considered to be of importance by 43% of respondents. The main disadvantages were seen as:

- Overall losses in the pit and at feeding out;
- Handling problems with increased bulk of ration;
- Problems with high moisture content adding to feeding out problems.

A major problem cited by smaller feedlots was with the requirement of additional labour, especially with the need to feed rations containing silage twice a day. The major constraints to increasing the use of silage was considered to be the difficulty in producing a consistent product in large quantities, the possible effects on carcase quality and containing product losses in storing and feeding out.

Some 40 respondents gave reasons for not using silage. This included:

- Their feedlot not being set up to handle silage because of the types of feeders and equipment now in use;
- Their feedlot being situated in a relatively low rainfall area and unable to produce or access regular quantities of suitable material.

The importance of contractors as the major operatives in silage making is highlighted. Until recently these people may have provided both silage and hay making services using round balers which resulted in silage being costly and not acceptable in the feedlot industry. In Region 3 there are a number of contractors using self propelled precision chop machinery and they are prepared to travel long distances to carry out silage making operations. As the future of silage making in the industry lies with these contractors working closely with feedlot managers there is an important need to plan growing and harvesting of silage materials over an extended period of time so that these operations can be carried out more efficiently and at less cost.

While the difficult circumstances under which feedlots have been operating over the last 2 years has meant that the number using silage have remained about the same, there are definite indications that commercial feedlots are very conscious of the cost effects of high grain prices and are examining closely the use of silage as a major source of energy which can be substituted for grain. Already 71% of feedlots with capacity >5000 head use silage in their rations and of these 30% supply the important Japanese B_3 market.

The smaller feedlots are also examining the possibilities of introducing silage into their ration but for many it would now mean a sizable capital outlay for storage and feeding out systems. This will not happen until meat prices, and future demand for both the export and domestic markets improve considerably. Often their location in the wheat/sheep zone with a limited land resource for their own cropping programs mean they may not be able to have regular access to a source of good silage material, although an obvious oversight by the industry is the capacity of cereal crops to supply high ME forage for silage production.

Having reviewed Australian Silage Research and Development since 1980 and identified key issues arising from these programs we have then considered the main findings of the survey and taken common issues arising from both for further consideration. These are discussed in Section 4. In particular relevant overseas R&D and commercial experiences are also compared.

Effect of High Silage Diets on Carcase and Meat Quality

Attention has to be focused on feeding silage and its possible effects on carcase and meat quality. Detailed observations and measurements carried out in MRC Project DAN 040 indicate very little difference across the various level of grain and silage in the rations varying from 0 to 80% grain, except that there was a little more fat in the cascases from animals maintained on high grain diets. There was no effect on fat colour, meat colour, marbling, yield of retail cuts, and predicted tenderness. Other Australian research measuring some of these traits have not found any significant difference when feeding high silage diets. The American work of Young and Kauffman indicates no affects of high silage diet on meat colour, fat colour, marbling, tenderness, juiciness, or flavour, the last three being the major components of eating quality. Work in Japan showed that maize grain produced more yellow fat in carcases than animals fed with barley and these results may have been incorrectly extrapolated to maize silage.

Very little work has been done in Australia or the USA on eating qualities of steers finished on high silage versus high grain diets and it is an important issue needing to be directly measured in taste panel tests so as to provide reliable data on tenderness, juiciness and flavour.

More Effective Utilisation of Silage in Feedlot Diets

- **The production and utilisation of sorghum silage**. There are large areas in northern New South Wales and south east Queensland, (Regions 2 & 3) where both grain and forage sorghums have the potential to be a major source of silage parent material under rain fed conditions. Work at the Kansas State University has highlighted the potential of forage sorghums particularly those with a high grain content. There is a need for further R&D and extension to be carried out in these regions to make feedlots aware of these possible sources of high ME energy.

- **Silage as an alternate use for winter cereal crops.** In the light of United Kingdom and European research together with some initial Australian work with oats and cereal legume mixes further R&D is required on the production and utilisation of cereal silages. This should include ammoniated whole crop cereals and earlage. Silage is likely to be an economically competitive alternative to grain (see Table 29).

- **Manipulating the high quality harvest window for winter cereal silages.** Inadequate information is available on the strategic use of varieties with various maturity ratings and sowing time to extend the high quality harvest window for winter cereal silages. The present narrow harvest window is responsible for a high proportion of cereal silages having an ME content < 9.5 MJ/kg DM.

- **Legume silages to reduce dietary energy and protein costs.** The advantages of growing legumes as a ready source of high ME silage are listed including its higher intake potential, higher protein content, and its effect on soil fertility in crop rotations. It has been demonstrated that high liveweight gains can be obtained on legume silages. More care has to be taken with legume silage making and there is potential for their greater use in feedlots in providing opportunities for reducing expensive protein meals in feedlot rations.

- **Optimum grain/silage ratio during the introductory feeding stage**. Most feedlots using silage are aware of its high palatability and the positive role it can play in bringing animals onto a high grain diet (see feedlot survey). The management implications for feeding silage to cattle on short fed regimes are discussed in the light of liveweight gains being depressed during the first month on feed under commercial conditions. High ME silages allow grain to be introduced more slowly, and this is likely to lead to improved animal production and profitability.

- **Silage in backgrounding diets** is considered. Two issues are raised. (i) The effect of feeding systems on the response to silage; (ii) the use of silage based diets to grow out light weight weaners. In

Queensland and northern New South Wales there is a problem with the low quality of available pasture for most of the year. Options to overcome this problem include supplementary feeding during the pre-weaning period; placing the weaners on a high energy diet after weaning for a period of live-weight recovery. Satisfactory liveweight gains could be achieved cost effectively by maintaining the weaners on diets based on high ME silage.

- **Reliability of laboratory methods for estimating silage ME** is called into question. Especially in the light of work recently carried out in Europe. A case is made that R&D needs to be carried out in Australia to assist in developing national standards and to provide industry with more reliable feed testing services. We need standards with known digestibilities to calibrate laboratory methods: there is widespread concern across all ruminant industries regarding the reliability of methods used by feed testing services to predict the quality of silage.

- **Sunflowers for silage.** Work carried out in the USA and Australia shows that there is no advantage in feeding sunflowers and sunflower/maize silage when compared to maize silage for milk production. The yields are not as high as maize and it has an overall nutritive value of about 80% of maize silage. The comparative yield of sunflower vs sorghum for silage under rain fed conditions in Regions 2 and 3 could be evaluated. Sunflowers are more likely to be an alternative to dryland grain sorghum for silage. There is a need for more agronomic and forage quality data to assess the economics of sunflowers vs grain sorghum.

An Assessment of Silage Costs of Production.

Figures just released by the Kondinin group shows clearly that on dairy farms there is a wide range of costs of production for the various forms of forage conservation. Direct chop silage is the cheapest method of storing and feeding material in the dairy situation with average costs of $52 per tonne dry matter. The most expensive method of silage production is wrapped round bales at an average cost of $138 per tonne. These costs do not include the cost of growing the crop or the opportunity costs foregone in harvesting and selling grain from the crop instead of making it into silage. Similar costs should be applicable in the feedlot industry, although with economies of scale costs may be lower on feedlots.

In the benchmark silage project DAN 040 a detailed economic analysis showed that the higher the proportion of high quality silage in the ration the greater the net return when yearling beasts were fattened for the domestic market. These figures were calculated on barley as the major grain source being fed at $120 per tonne. An exercise in costing silage on a per unit of MJ basis is set out followed by a comparison of the relative cost of silage to grain in a feedlot rations. These calculations show that maize silage at a total cost of $88 per tonne made, stored and fed out with a 15% wastage is equivalent to grain at approximately $108 per tonne landed. The costs of making and storing silage in our survey was at an average of $42.15 per tonne on a fresh basis. With an estimated dry matter content of 35%, costs per tonne of dry matter is $110 which on an ME basis is equal to approximately $147.50 per tonne grain landed at feedlot. Processing costs would need to be added. This demonstrates that with the use of silage as an energy source in feedlot rations the overall costs of production must be calculated carefully and that losses especially in the range of 10 - 15% become an important part of these calculations. This also indicates the need to examine the economics of using dryland crops for silage instead of irrigated maize.

Recommendation for Further Research & Development

The areas believed to require special attention have been categorised into three broad priority groups. Whether further additional work on meat quality should be ranked as first priority is open to question. There is certainly a strong case to be made for substantial applied research program to be put in place on grain and forage sorghums particularly in Northern NSW and Southern Queensland. Specific extension programs should be drawn up for forage contractors, other service providers, and feedlot operators to bring about an awareness of the requirements for the production and utilisation of silage with acceptable high metabolisable energy so that it becomes economically feasible to be used in place of a proportion of grain in feedlot rations. This will call for key economic field studies to be initiated to determine present feedlot costs of silage production.

We believe that R&D on all 10 topics listed in Section 6 are worthy of consideration. The important issues likely to have immediate impact on the feedlot industry are:

- More Effective Utilisation of Sorghum Crops for Silage
- Special Extension Programs and Economic Studies
- More Effective Utilisation of Winter Cereal Crops for Silage
- Reducing Silage Losses
- More Reliable Feed Tests for Silage

1.0 BACKGROUND TO THIS STUDY

From the mid 1980s through until late 1994 there was a rapid expansion of the Australian feedlot industry brought about by the liberalisation of the Japanese market through a reduction in tariffs; and the increasing demand for quality beef in Australia's domestic market, particularly through the supermarket and food service sectors. Since that time the effect of drought, high grain prices, and recent low meat prices have resulted in overall feedlot throughput being curtailed especially those cattle being fed for the B_1 and B_2 export markets. This has resulted in a number of feedlots, especially those in the informal or opportunity sub-sector, being temporarily closed down.

Research carried out into The Inputs Requirements to the Cattle Feedlot Industry in 1994 (MRC Project M.544) indicated that in future feedlots would have to compete strongly with the poultry, pig and dairy industries for limited feed grain supplies as Australian farmers concentrated their resources on producing wheat and other more profitable crops such as malting barley, oil seeds and dryland cotton. While it was recommended that continued efforts be made for increased liberalisation of import regulations for feed grains so that they could be available at world parity prices, it has not been possible to put these protocols in place.

This research also indicated that silage was becoming an important component of some feedlot rations particularly in South East Queensland and Northern New South Wales where sources of roughage especially hay were difficult to procure. A number of large feedlots (>10,000 head capacity) were using maize silage as an energy source in their rations especially where irrigation was available to grow maize crops on a regular basis.

In 1996 the Feedlot Consistency and Sustainability Key Program (FCSKP) was drawn up with its overall goal to "enhance Australia's throughput of lot finished cattle, and thereby the national capacity to supply a consistent beef product by increasing feedlot operating efficiency and profitability, by developing the most cost efficient solutions to food safety, animal welfare and environment imperatives, and by implementing risk management procedures". One of the specific objectives identified in meeting this goal is to reduce feeding rations costs and secure an energy-dense feedstuff supply. It has been postulated that Australia's cattle feedlot industry could improve profitability by substituting feedgrains with more high metabolisable energy silage and feeding it at different stages in the feedlot regime particularly in the introduction stage. This will only come about if the production, storage and feeding out costs of this material is at a price less than the cost of comparable metabolisable energy supplied by various feed grains. The overall size of the feedlot operation may also influence the composition of rations and the amount of silage that can be fed.

Study Objective

The objective of Phase 1 of this study as set out in the Terms of Reference is as follows:

Review past and concurrent R&D and commercial experience in the production and feeding of high ME silage and on the basis of this

(a) Determine if it would be feasible for the cattle feedlot industry in Australia, under a high feedgrain price scenario and, given projected target markets and existing spatial distribution of existing feedlots, to substitute in part feedgrains with high ME silage, and

(b) identify any specific areas for R&D which may be required to facilitate the expanded use of high ME silage in the cattle feedlot industry.

2. AN OVERVIEW OF RECENT AND CURRENT AUSTRALIAN RESEARCH & DEVELOPMENT.

This study involved a telephone survey of Research, Development and Extension (R,D & E) personnel in each State and a survey of recent literature and reports. The review period covered the last 10-15 years. We have identified the relevant research work being undertaken and the current silage R, D & E expertise in Australia. Our definition of specialist silage expertise is at least 5 years experience, spending a large proportion of that time working in this technical field.

The survey shows that Australia's human R & D resources in the silage field are very limited, particularly in the areas of the production and utilization of silage. Work in these fields underpin work in the utilization of silage in beef, dairy and lamb diets. There is also a deficiency of extension specialists with silage expertise, and it is evident that most silage researchers are carrying a heavy extension load. This has important implications for technology transfer which we believe has slowed down due to the lack of funding for full-time development and extension activities. The results of the survey of current R, D & E personnel with specialist silage expertise is presented in Annex 1.

2.1 The Beef industry

In recent years silage R & D for the beef industry has been conducted in NSW, WA and Victoria. The two largest research programs were conducted in NSW (Kaiser *et al.*) and WA (Jacobs *et al.*) both funded by MRC.

NSW

At Wagga Wagga (DAN 40), the role for high quality silages ($\geq$ 9.5 MJ/kg DM) in finishing diets for yearling steers was assessed in terms of cattle performance, carcase quality, meat quality and net profit per head. Yearling steers were given diets containing nil, 27, 54 or 80% grain. In addition a series of on-farm studies were conducted to assess cattle performance on high silage diets under commercial conditions. Aspects of the results of this work will be covered in greater detail under section 4. However, in summary the project showed that:-

- High quality silages could sustain liveweight gains in the range 0.8 to 1.1 kg/day when given as the sole diet to yearling steers (Table 1).

- High silage / low grain diets gave better net returns per head than the high grain diets.

- While it took a little longer to finish silage only steers, carcases suitable for the domestic trade were produced from all diets.

- There was no adverse effect of silage feeding on fat colour, meat colour, marbling or the physical properties of the meat associated with tenderness.

These findings have important implications for the feedlot sector as they indicate that high quality silages ($\geq$ 9.5 MJ/kg DM), can replace a proportion of the grain in the diet to reduce feed costs and improve profits without adversely affecting carcase quality.

TABLE 1 Effect of proportion of grain in the diet on the performance of yearling steers on silage-based diets at Wagga Wagga*.

	Proportion of grain in the diet (%)			
	0	27	54	80
Days to gain 100 kg	106	92	85	85
Feed intake (kg DM/day)	7.6	8.3	8.3	7.9
Liveweight gain (kg/day)				
Full to full	0.94	1.09	1.17	1.18
Empty to full**	1.04	1.21	1.29	1.30
Feed conversion (kg feed DM/kg gain)	8.1	7.8	7.3	7.1

* Mean results for subclover, maize, grain sorghum, lucerne and oat/vetch silage. Hereford x Angus steers initially 285 kg and slaughtered at 396 kg. No implants.

** 12 kg difference between full and empty initial weights.

A number of other aspects of silage production and utilization have been studied at Wagga Wagga:-

- Production of cereal/legume mixed crops for silage - species and time of cut effects on yield and quality.
- Production of silages from forage legume crops (peas, vetch, clover mix) and the liveweight gain of lambs and cattle on these silages is being studied in a current project.
- Development of analytical procedures to determine the true dry matter content of silage.
- Microflora in Australian silages during the fermentation and aerobic spoilage stages.
- Production of silage from subclover based pastures

  - wilting procedures

  - weed contamination
- Effect of grain addition at ensiling on the silage fermentation.
- Silage production from forage sorghum (sorghum x Sudan grass) and millets at various stages of growth.
- Fate of prussic acid in forage sorghum silages.
- Production of silages from sweet sorghums
- Production of silages from sunflowers.
- The response to silage inoculants, in terms of digestibility, intake and liveweight gain is being studied in a current project.
- Production of ammoniated forages from temperate annual grasses and kikuyu grass.

Western Australia

At Bunbury in WA, research by Jacobs *et al.* and subsequently Tudor *et al.* focused on the use of pasture silage plus grain supplements to finish cattle. The superiority of silage compared to hay made from the same pasture was clearly demonstrated in one experiment (Table 2). In this study hay was made at the normal cutting time in that environment (Nov. 6) whereas the silage was made one month earlier (Oct. 10) at a higher quality stage of growth. Other experiments evaluated protein supplements for steers given silage or silage + grain diets. In diets containing approximately 40% grain, growth rates of 1.1 to 1.2 kg/day were obtained when an undegraded dietary protein (bypass) supplement was included in the diet, compared to approximately 1 kg/day on diets containing grain + urea or grain + lupins. In a more recent experiment with pasture silage + barley, no difference was observed between three dietary protein sources - urea, lupins or canola meal (Tudor *et al.* 1996).

TABLE 2 Liveweight gain of cattle on hay and silage made from the same pasture (Jacobs *et al.* 1992).

Grain in the diet (% of liveweight)	Liveweight gain (kg/day)	
	Hay	Silage
0	0.33	0.79
1.0	0.62	1.10
1.5	0.87	1.21

Grain addition at ensiling was also investigated. Whole barley was added to pasture at the time of ensiling. The results from this study were not promising as a proportion of the grain was undigested by the cattle, and the silages tended to be unstable (prone to heating) during feedout. Given the potential savings in grain processing and mixing of diets more work is required in this area.

Victoria

In recent years two silage feeding projects have been conducted in Victoria. At Kyabram, the response by steers grazing perennial or annual pastures, to maize silage supplements was examined in a number of experiments and on-farm case studies (Wales and Moran 1992). In addition the performance of steers on maize silage based diets was studied in two experiments. Steers, initially 245 kg were maintained on two diets:-

	Liveweight gain (kg/day)
Maize silage (83%) + wheat (15%) + urea (2%)	1.22
Maize silage (83%) + cottonseed meal (17%)	1.33

Both diets included minerals and vitamins. The steers had lost weight over the previous 45 days before the experiment so some compensatory growth would have occurred. Nevertheless better gains were observed on the diet containing cottonseed meal. In the second experiment steers initially 349 kg were maintained on the following diets:-

Maize silage (96.7%) + urea (1.7%)	0.93
Maize silage (46.9%) + wheat (48.1%) + cottonseed meal (1.7%) + urea (0.85%)	1.33

Steers on the high grain diet produced carcases with a higher fat content but there were no other differences in carcase attributes or the physical properties of the meat. These results are in agreement with the results from maize silage studies with young cattle at Wagga Wagga.

The role of silage in finishing systems for steers destined for the Japanese market was examined in a series of on-farm studies in Victoria and at the Pastoral and Veterinary Institute at Hamilton (Spark 1996; Cummins *et al.* 1996). In most cases where silage was evaluated it was a supplement to pasture. In a comparison of ten supplementary feeding systems the silage supplement treatment gave the highest profit / head.

2.2 The Dairy industry

Queensland

In recent years there has been little work in Queensland on the production and utilization of silage. Most of the research on silage production from tropical pastures was conducted during the 1970's and early 1980's. This work highlighted the difficulties in making silage from tropical pastures, and in most cases the silages had only low to medium estimated ME values. Other than a Ph.D study on silage microbiology little additional work has been conducted over the 1980's and 1990's.

Some work has been conducted on responses by grazing dairy cows to maize silage supplements and the importance of balancing the diet with a protein supplement (eg. Moss *et al.* 1994). Agronomic studies have been conducted on the yield and quality of soybeans grown for silage production.

NSW

Silage research for the dairy industry in NSW has focused on the quality of the parent forage for silage production, wilting strategies for pasture silage production and aerobic stability of silages. This research has been conducted pre-dominantly with summer growing pastures and crops.

A substantial research effort has been put into the production and nutritive value of maize silage. This work has included:-

- Agronomic studies, predominantly with coastal dryland crops evaluating varieties, plant populations and the development of management strategies to optimise yield.

- A breeding program to develop higher digestibility forage maize varieties using the brown midrib gene (Kaiser *et al.* 1993). In a recently completed study, the estimated ME content of experimental brown midrib hybrids was 0.7 MJ/kg DM higher than that of normal commercial hybrids.

- A study of the plant characteristics influencing the nutritive value of maize silage, and the optimum stage of harvest for maize silage production. This work has included feeding experiments to assess the nutritive value of maize silage and also the digestion of the whole grain component of the silage. These experiments were conducted with weaner steers initially 190 kg, and the mean intakes and liveweight gains obtained from 25 maize silages were 2.9% of liveweight and 1.03 kg/day respectively. This work also showed that 97.1% of the whole grain in maize silage was digested by the cattle.

- The development of a milk line scoring system to identify the stage of crop development for silage production.

- Factors influencing the aerobic stability of maize silage and the use of additives to improve stability.

- Two experiments were conducted at Wollongbar in northern NSW to examine the response by grazing dairy cows to maize silage supplements.

The other major research area has been identifying optimum ensiling procedures for the production of kikuyu grass silage. Like other tropical grasses kikuyu grass has a low DM content and low sugar content so is more difficult to ensile than most temperate grasses. Digestibility declines rapidly with advancing maturity. The research program on kikuyu is continuing and is focusing on:-

- Optimum regrowth interval to achieve digestibilities above 65%.

- Compositional and quality changes during the wilting process (between mowing and harvest) and the effects of the time of day when cut.

- Chemical and mechanical treatments to manipulate wilting rates.

- Wilting and silage additive effects on silage quality.

Yield, plant composition, forage quality and silage production studies have also been conducted with sweet sorghums and sorghum x Sudan grass hybrids (see later discussion in Section 4).

Finally, in a recent collaborative project with the Kondinin Group, a comprehensive survey of silage and hay use on Australian dairy farms was conducted. Information was collected on quantities made and used, forage sources used for hay silage, and production, storage and feedout system. The project also investigated the cost of hay and silage production from cutting through to feeding, using a series of case studies.

Victoria
Silage research for the dairy industry has been underway in Victoria since the late 1970's. This work started at Ellinbank where the main emphasis was on the production of silages from ryegrass - white clover pastures in spring to feed back to cows in mid to late lactation. The main areas covered by this research were:-

- Optimum time of cut for silage. Manipulation of closure and cutting dates and the effects on total spring pasture production and quality.

- Optimum degree of wilting for silage production.

- Silage chop length and the effect on milk production.

- Development of round bale silage system including optimum bale density and degree of wilt. Losses from round bale silage systems were also investigated.

- Response by cows to silage supplements and the role of silage in dairy production system - farmlet studies.

Little silage research has been conducted at Ellinbank since the late 1980's.

During the 1980's significant maize silage research was conducted at Kyabram in northern Victoria. This work included detailed studies on the agronomy and management of irrigated maize crops, and the response by grazing dairy cows to maize silage supplements. The dairy work included studies on:-

- Responses to maize silage supplements on various pasture types. Excellent responses to maize silage were obtained when cows grazed legume pastures (eg. Persian clover).

- The need for protein supplementation and the interaction between protein supplementation and the proportion of maize silage in the diet.

- Detailed digestion studies on pasture: maize silage diets, and collaborative studies with CSIRO to determine the ME content (*in vivo*) of one maize silage.

Other research at Kyabram has looked at the production and nutritive value of legume silages.

In recent years a new silage research project has commenced in the western districts of Victoria (J. Jacobs). This project is focusing on factors affecting pasture silage quality (ryegrass / white clover) on dairy farms. The relationships between management factors such as closure date, cutting date, wilting level, time taken to wilt, silage harvesting and storage system, and feedout system, and silage quality are being quantified. One of the important sources of loss identified in this work to date are those that occur during the field wilting stage. Any management practice that speeds up the wilting process has been shown to improve silage quality. Similar results have been obtained with kikuyu grass in NSW. Although forage yield and weather conditions are key factors influencing wilting rates, the farmer can speed up wilting by leaving the cut forage 'on the flat' (ie. not in a windrow) and by tedding.

2.3 *The Lamb Industry*

Limited silage research has been conducted for the lamb industry, although the MRC is about to fund some research under the Lamb Consistency Key Program. The main centres of research in this field have been at Wagga Wagga, NSW and at the University of Western Australia. Some on-farm monitoring of silage use in sheep enterprises has been conducted in the western district of Victoria.

At Wagga Wagga lamb liveweight gains were obtained in studies investigating factors influencing the nutritive value of maize silage (Piltz 1993). The mean liveweight gain on six maize silages was 122 g/day. In another project examining the nutritive value of pasture legumes (Mulholland and Scott, 1992) pure legume silages were fed to lambs in three experiments. The results from these experiments show some variation in nutritive value and are presented in Table 3.

TABLE 3 Lamb liveweight gains on legume silages at Wagga Wagga (Mulholland and Scott 1992).

Legume		No. of silages	Liveweight gain (g/day)
Arrowleaf clover		3	67
Balansa clover		3	147
Berseem clover		3	94
Medics - barrel		6	108
- snail		2	51
- Murex		3	77
Serradella	- compressus	3	82
	- sativus	3	121
Subclover	-subterranean	11	122
	-brachicalycinum	3	81
	-yanninnicum	6	96
	Mean	46	102

In a collaborative study between Charles Sturt University and NSW Agriculture at Wagga Wagga, feedlot diets for lambs based on subclover silage, barley and lupins were evaluated (Graham et al 1992). The response to increasing barley or barley/lupins in the diet was investigated. Lambs on silage alone gained at 108 g/day while liveweight gains in excess of 190 g/day were obtained on the 50% barley and the 25% barley / lupin diets. Best gains (253 g/day) were obtained on the 50% barley/lupin diet.

The use of silage produced from cereal crops and annual pasture in lamb finishing diets was evaluated in W.A. (J. Milton). In these on-farm studies, the silages have been produced using both a forage harvester or a round baler, and were fed in combination with barley and lupins. The results from a study comparing cereal silage (forage harvested) + lupins and cereal hay + lupins showed silage to be a more cost-effective feed source.

2.4 *Some Major Issues Arising from These Programs*

The Australian research with cattle has shown that liveweight gains in the range of 0.9 to 1.1 kg/day can be achieved on silage alone. However this is dependent on high silage ME contents, equal to or greater than 9.5 MJ/kg DM. These findings are supported by research in Europe, where silage is used extensively in finishing diets at levels higher than those used in north America.

Crop selection, stage of harvest and good silage management are the three key factors that determine the beef production per tonne of silage. The forage sources suitable for silage production for the feedlot sector are summarised below:-

Forage source	Comment
Summer crops	
Maize	Suitable for higher rainfall environments or irrigation. Excellent agronomy and management information. High ME but low in protein. Higher cost than other crops but an industry benchmark.
Grain sorghum	High ME, low protein. Considerable potential but inadequate information on varietal selection and variation in nutritive value. Digestion of whole grain component an issue. Need higher yields.
Sweet sorghum	High yield potential and wider harvest window where there is little change in quality. Can approach grain sorghum in ME content but need to identify higher ME varieties. Adapted to range of environments but lodging can be a problem.
Tall grain sorghum (= US "forage sorghum")	Not grown in Australia at present but appears to have considerable potential. ME can approach grain sorghum, but no information on management or factors affecting quality under Australia conditions.
Sorghum x Sudan grass and Sudan grass	High yield but multiple cuts. Needs to be wilted. Harvest window when quality is high very narrow. Unlikely that a feedlot could rely on consistently high quality. Development of higher ME brown midrib hybrids could enhance the role for these crops.
Millets	Can be as productive as forage sorghums with higher ME, but need to be cut early. Multiple cuts. Wilting essential.
Sunflowers	Very limited information but quality appears to be high if cut before petal fall. May be an alternative to grain sorghum but need yield data to confirm this. Taller birdseed types might be more suitable as higher oil content in oilseed types could cause digestive problem.
Legumes	No convincing data that summer forage legume crops will consistently provide high yield with high ME. Need more work to identify suitable crops and stage of harvest. Wilting essential. Legumes likely to become increasingly important in sustainable cropping rotations.
Winter crops/ pastures	
Lucerne	Excellent high ME, high protein crop if cut late bud/early flower stage. Needs wilting. Provides high quality forage for silage production through a large part of the year.

Forage source	Comment
Pastures	Can be a highly variable product. Difficult to guarantee a large supply of high ME product on an annual basis. Narrow harvest window when quality is high. However quality can be very high in legume dominant pastures. Suitable forage source (opportunistic) for smaller feedlots.
Cereal crops	Considerable potential but a variety x sowing date x management package not yet available to consistently deliver a high ME product. High yield potential and high ME if cut early. Four options need to be explored:- i) early cut cereal silage ii) early cut cereal/legume mix iii) ammoniated whole crop cereal cut at dough stage iv) earlage (grain head) cut at dough stage.
Forage legumes	Considerable potential. High yield, high ME and high protein. Wider harvest window than cereals. Need more information on species, varieties, time of cut and agronomic management.

The major issues that need to be addressed and are likely to significantly improve the production and utilisation of high ME silages for the feedlot sector are covered in detail in Section 4. They are:-

1. The effect of high silage diets on carcase and meat quality.

Despite Australian and overseas data that indicate no negative effects of silage feed on carcase and meat quality there is still industry concern that product quality will suffer. More detailed research is required in this area specifically to look at the effects of silage *vs* grain based diets on the eating quality of beef using taste panel tests. At the same time the effects of diet on the offal component should also be investigated.

2 The production and utilisation of sorghum silage.

Sorghums have considerable potential for silage production. Inadequate information is available on varieties and management to optimise yield and ME content.

3. Alternative uses for winter cereal crops.

To spread silage production options for cereal crops and provide more management flexibility, work is required on the relative beef production from early cut cereal silage, cereal/legume mixtures or later cutting at the dough stage for ammoniated whole crop cereal or earlage.

4. Manipulating the high quality harvest window for winter cereal silages.

Inadequate information is available on the strategic use of varieties with various maturity ratings and sowing time to extend the high quality harvest window for winter cereal silages. The present narrow harvest window is responsible for a high proportion of cereal silages having an ME content < 9.5 MJ/kg DM.

5. Improved silage management to reduce losses.

Silage making losses can increase the cost of silage and reduce ME content. Little is known about these losses in the warmer Australian environment, and what management strategies can be used to minimise them. The efficacy of silage additives is one specific area that needs to be addressed.

6. Legume silages

Most legume silages combine high ME with high protein content. This provides opportunities for reducing the proportion of expensive protein meals in feedlot diets. Research should focus on high yielding temperate legume crops. These also have a role to play in sustainable cropping rotations.

7. Optimum grain/silage ratios in the introductory feeding stage.

There is a special role for high ME silages in the first month of feeding for short-fed cattle. Current industry practice involves the rapid introduction of grain with the risk of greater animal health problems and reduced liveweight gain. The use of high ME silages with more gradual introduction of grain should improve efficiency and profit.

8. Silage in backgrounding diets.

Apart from providing a valuable supplementary feed in backgrounding systems, the full feeding of high ME silages to lighter weight weaners could provide a period of rapid liveweight recovery providing more animals of suitable weight-for-age for feedlots.

9. Reliable laboratory methods for estimating ME of silage.

Having a reliable feed testing service is critical to the effective formulation of least cost rations for feedlot cattle. There is some concern that current methods are not accurately predicting ME content.

10. Sunflowers

Sunflowers may be used for the production of high ME silages in northern NSW and in Queensland. Information is required on the relative productivity of sunflowers and grain sorghum for silage, most suitable varieties, crop management for silage and cattle performance on sunflower silage.

3.0 A REVIEW OF CURRENT SILAGE MAKING AND FEEDING PRACTICES IN THE MAJOR FEEDLOT AREAS

3.1 Background

During research into the Input Requirements for the Cattle Feedlot Industry (MRC Project No. M544) carried out in 1994 three well defined regions of commercial feedlot activity were identified. (a) Southeast Queensland particularly the Darling Downs, (b) the Northwest and Central Slopes of New South Wales in the Wheat/Sheep zone (c) Murrumbidgee/Riverina area of New South Wales. At that stage Southeast Queensland accounted for some 52% of all cattle on feed in Commercial feedlots in Australia, while the two regions in New South Wales accounted for approximately 37% of cattle on feed. As at December 1996 the numbers of cattle on feed in Australia were estimated by ALFA as 366,146 of which 50.5% were in Queensland and 41.5% in New South Wales with Victoria accounting for 4% and the rest of Australia 4%. In 1994 it was estimated that further expansion of the commercial feedlot sector was likely to take place within these identified regions with Southern New South Wales becoming a major focal point for further large scale feedlot development.

During the research carried out in 1994 the important roughage component of feedlot rations was found difficult to provide on a regular basis in many feedlots especially in South East Queensland and Northern New South Wales. Some of the larger feedlots were using silage produced on a contracted basis to provide a major portion of the roughage and energy requirement in their rations. In these northern regions byproducts of the cotton industry especially cotton seed hulls were also playing an important role in providing the roughage component. The use of silage as a source of high metabolisable energy especially that made from maize and to a lesser extent sorghums (both grain and forage) was being explored by some of the larger feedlots (>5,000 head capacity). Just how much silage could be used in the total ration was being examined.

3.2 *Findings of the survey*

3.2.1 *Survey Methodology*

To update information on the use of silage in the feedlot industry it was decided to conduct a survey concentrating on the three major regions previously identified and including some feedlots in close proximity to these areas such as Northern Victoria in the Southern Region. In selecting our sample the National Feedlot Accreditation Scheme membership list was considered as the most comprehensive and up-to-date record of Australian feedlots. An Ausmeat paper indicated that some 42% of accredited feedlots had a capacity of less than 100 SCU's (Standard Cattle Units) and as these accounted for less than 2.5% of the total feedlot capacity and as they would be predominantly opportunity feedlots, it was decided to select a stratified sample from feedlots with a capacity above this level.

A full list of feedlots along with their addresses was made available for the whole membership list. Ausmeat then provided the feedlot capacities for our randomly selected groups from each region. A minor problem was encountered with the South East Queensland list in eliminating so many that were found to have a capacity of less than 100 SCU. Finally a faxed questionnaire accompanied by explanation sheets setting out the purpose of the survey (Annex 2) was sent to 31 feedlots in Southern New South Wales and Northern Victoria (Region 1), 36 feedlots in North West/Central Slopes New south Wales (Region 2), and 42 feedlots in South East Queensland (Region 3) on the 6th and 7th of January 1997. Follow up phone calls were made on the 9th and 10th of January and during the following week. This resulted in 73 replies being received either by fax or details taken over the phone; giving a 66 % return rate which is considered to be quite satisfactory especially as there were a number of people away during January. A total of 46 replies were received in Regions 1 and 2 which together has a total accredited number of 112 feedlots above 100 SCU capacity. In SE Queensland 27 replies were received from an area involving some 250 feedlots (> 100 SCU) including some 11 of 39 feedlots with a capacity greater than 1,000 head. Unfortunately a number of feedlots in excess of 5,000 head in each region declined to fill in the questionnaire, most were known to be using silage as an important component of their rations.

3.2.2 *Summary of Results*

TABLE 4 Feedlot capacity by region

Feedlot Capacity (SCU)*	Region 1 SNSW & Vic	Region 2 N/NW NSW	Region 3 SE Qld	Total
100 - 999	18	9	16	43
1000 - 4999	2	7	7	16
5000 - 9999	2	3	2	7
>10000	3	2	2	7
Total	**25**	**21**	**27**	**73**

* Standard Cattle Units

Of the 73 feedlots sampled some 23 (32% were classed as opportunity feedlots and all of these fell in the capacity range of 100 to 999 SCUs. The 43 responding in this category comprised 60% of the total sample. The corresponding proportion in the Ausmeat Report for New South Wales, and Victoria is about the same while for Queensland is somewhat higher with this group accounting for 80%. Of interest was that the number of feedlots not operating during 1996 involving a total of 9 of the 73 (12.5%) of which two-thirds were in Region 2.

The main sources of energy in feedlots was barley with 63% of feedlots in Region 1, 53% in Region 2 and 59% in Region 3 using it as the major source of feed. In Region 1 Triticale was the main source of energy in 25% of feedlots while grain sorghum was used in 48% of feedlots of Region 2 and 70% of operations in Region 3.

There was a large variety of roughages used particularly in Region 3 where cereal hay, cotton seed hulls, silage, pasture hay, soy bean hay and sunflower hulls were all used. In Region 2 Cotton seed hulls and cereal hay were equally popular being preferred roughage on 43% of feedlots. In Region 1 63% of feedlots used cereal hay and 17% lucerne hay.

TABLE 5 Feedlots Using Silage

Capacity	Region 1	Region 2	Region 3	Total	% of Group Capacity
100 - 999	1	1	3	5	12%
1000 - 4999	1	2	4	7	43%
5000 - 9999	1	1	2	4	57%
>10000	2	2	2	6	86%
Total	**5**	**6**	**11**	**22**	**30%**
% Total	**20**	**28.5**	**52.5**	**100**	

Of the total of 73 responding some 22 feedlots (30%) were using silage in their rations. Eleven (50%) of these were from Region 3 (South East Queensland) 27% Region 2 N/NSW and 23% from Region 1 (Southern New South Wales and Victoria). Six feedlots (27%) had only used silage in one of the last four years while six (27%) had used silage in each of the four years. As only one of these regular users was in Region 3 it is possibly more a reflection of the variable weather conditions over this period along with the fact that there is more irrigation available especially in Region 1.

The main source of parent material used in the making of silage shows that in Region 1 irrigated maize was used in three of the five feedlots, in Region 2 forage sorghum was the main crop in four of the six feedlots while in Region 3 forage sorghum or grain sorghum was used in seven of the 11 feedlots. Of the other four, two used Lucerne as their main parent material and two relied on maize as their main source of silage. Thirty-two percent of all feedlots used irrigated maize as the main source of parent material. There was little change of parent material in each feedlot from year to year.

Of the two systems of silage production with baler or forage harvester 18 (82%) used the forage harvester and 4 relied on the baled method. In the case of the latter in three situations these were smaller feedlots of less than 400 SCU capacity. 82% of all feedlots feeding silage used a contractor to cut and make it. In six of these feedlots some silage is produced on outside farms and transported to the feedlot. In the four cases where silage is made by the feedlot operators two are large producers of maize silage with their own irrigation and two small producers are making baled silage.

In feeding out silage 18 feedlots (82%) fed through all three stages of the program, (introduction, intermediate and finishing stages). The other four feedlots fed it only in the introduction phase. Estimated silage losses varied from 5% to 20% with an average of 9.5%. It would seem that these losses mainly occur in the pit and at feeding out. Estimated cost of silage on a fresh basis varied from $25 up to $50 with an average over the 22 feedlots of $42.15. This includes the cost of growing the material.

In question 6 of the Questionnaire the Feedlot Operators were asked to give their ideas on what they considered to be

(a) the main advantages of feeding silage;

(b) the main disadvantages of feeding silage, and

(c) major constraints preventing expanded use of silage.

Their answers to these questions are summarised in the following tables:

TABLE 6 Main Advantages of Feeding Silage

		% Users
1	High palatability leading to less feeding problems especially at introduction stage	59%
2	Reduction in overall ration costs	43%
3	Minimal processing of roughage components	24%
4	Good substitute for hay when providing roughage component - improves quality	19%
5	Most rations easier to feed - less dust problems	16%
6	Product stores well - long shelf life	14%
7	Less animal health problems	10%

The major advantage given for feeding silage was its perceived high palatability resulting in less feeding problems as far as the animals are concerned; 59% of silage users rated this as the main advantage. This is also linked with the fourth advantage as silage is considered as a good substitute for hay when addressing the roughage component of the total ration. This can also be indirectly linked to the third most popular advantage, of minimal processing needed of the roughage component as far as handling and mixing is concerned. These particular advantages are put forward as sound reasons why silage can be considered as both a desirable roughage and a high energy component of feedlot rations.

The second major advantage listed by 43% users is that overall ration costs can be reduced indicating that there are a number of feedlots which are prepared to consider it also as an alternative source of energy and these are the feedlots which are prepared to use it through all three stages of the feeding program.

TABLE 7 Main Disadvantages With Silage Use

		% of Users
1	Overall losses in pit and at feeding out	38%
2	High moisture content adds to feeding out problems - more moisture in yards - more manure - more cleaning	29%
3	Handling problems with increased bulk of ration	29%
4	Difficulty in making a consistent product on a regular basis especially in dryer areas	19%
5	More labour intensive	14%
6	Corrosion problems with equipment	10%

The main disadvantage given when feeding silage is the overall losses involved with storing and feeding out material. This is not reflected in the estimates in the previous question when silage losses were estimated to vary from 5 to 16% with the average over all users being 9.5%. The experience of the consultants is that this average figure should be closer to 12 - 15% (with good management) and that losses here have been underestimated. Handling problems relating to the overall ration bulk linked as it is to a higher moisture content and the problems arising from manure and additional yard cleaning were seen as two major disadvantages. This also has an association with the third major problem the requirement of additional labour especially with the need to feed rations containing silage twice a day and the handling of the additional bulk that is involved.

TABLE 8 Major Constraints to Increasing the Use of Silage

		% of Users
1	Difficulty in producing a consistent product in large quantities	25%
2	Concerned with quality especially fat colour on export markets	22%
3	Containing product losses in storage and feeding out	19%
4	Labour intensive time factor in feeding out	19%
5	Difficulty in feeding out baled silage	14%
6	Relative Price to grain on a Dry Matter Basis	10%

There is a strong association here with the main disadvantages listed in Table 7. The major constraint identified by 25% of users was the difficulty of producing a consistent product when making large amounts of silage each year. This could be for a number of reasons including:

- not being able to have the services of a contractor when a particular crop is ready to handle;
- finding it difficult to be able to spread production over a particular time frame by using different species and varieties.
- the trouble imposed by inclement weather when trying to make silage, there is no doubt that this can be a major problem for all silage users.

Some 38% of producers indicated that product losses and increased labour requirements were also major constraints to increasing the use of silage. This emphasises the point that those people using silage must have the right equipment and sufficient labour to handle the task well.

The problem of fat colour and meat quality was raised by 19% of silage users as a constraint to using more silage. All these people were feeding cattle primarily for the export market and listed it as a major constraint.

TABLE 9 Reasons For Not Using Silage

		% of Response
1	Not set up to handle silage because of the type of feeders and equipment now in use	35%
2	Feedlot situated in relatively low rainfall area - unable to produce regular quantities of material	25%
3	Capital cost of providing suitable equipment to store and feed out silage	23%
4	No experience with the making or feeding of silage	10%
5	Wish to continue with proven rations	10%

Some 40 of the feedlot operators not using silage took the opportunity when answering the questionnaire to give reasons why this was so. The above table summarises their reasons:

Nine of these people (22.5%) not using silage indicated that they were going to investigate the possibility of using it in the near future. Ten percent said it was their stated intention to make silage in 1997.

The major reason given for not using silage was that they were really not set up to be able to handle it. The type of feeders they were using and the equipment that they have for making their roughage components was not suitable for silage.

The second major reason is that their feedlots are situated in relatively low rainfall areas and that it is difficult to produce sufficient quantities of select material specifically for silage on an annual basis unless irrigation is available. The third reason involves the capital cost of providing suitable storage and special equipment for feeding out silage. Such costs are difficult to justify unless feedlots have ready access to annual supplies of suitable silage material.

3.3 *Current Commercial Silage Making Practices*

The survey highlights the importance of contractors as the major operatives in the silage making process with 18 of the 22 feedlots (82%) feeding silage using the services of these commercial operators who provide a paddock to pit service for their clients. In Region 1 there are a number of local contractors with round bale equipment which is also used for hay making. In recent times a number of these contractors have changed to large rectangular bales which are much easier to handle and store. In many cases the bales are held on cattle properties as drought reserves although there is an awareness of the product's mobility for sale. Contractors in this region also service the dairy farmers in the Murray and Goulburn Valleys and are prepared to travel distances of 200 to 300 km to service clients.

Region 2 is not well serviced by local contractors and a number come in from Southern Queensland to the North West Slopes while the Liverpool Plains area is catered for by coastal contractors who also service their local dairy industry. These contractors have usually worked with round balers but some have changed to precision chop machinery the preferred silage making equipment of the feedlot industry.

In South East Queensland Region 3 contractors service nine of the 11 silage users in the survey with three of the feedlots using baled silage and the other six precision chop material. Most of the contractors are situated on the Darling Downs and are prepared to travel long distances to provide all silage making services. A proportion have large self propelled machines with accompanying equipment involving a value in the vicinity of $300,000. These operators are looking to cut and stack at least 50,000 tonnes of silage a year. Timing of operations in particular districts, both locally and interstate, is all important to them being able to carry out a sizable program.

New technology adopted by contractors in Regions 1 and 2 has seen the large rectangular baled silage being introduced thus giving more flexibility in the storage and handling of material which has the potential for being used as a drought reserve especially on cattle breeding properties. The problem of long chop material makes baled silage less desirable in feedlots because in feeding for production this type of silage can restrict daily intake. New chopper balers have been developed in Europe and these cut forage at a much shorter length of between 100 - 150mm prior to it entering the bale chamber. While this silage can be used in feedlots, production costs could be the problem. Figures set out in Chapter 5 from the Kondinin work show that baled fodder as silage is much more expensive than precision chop material. So this new technology may have limited application.

It would appear that the future for making silage in the industry will be with contractors working closely with the feedlot managers to control their crop production so that the contractor has an extended period of time over which to operate their machinery to produce additional tonnages. As is pointed out earlier in this chapter the difficulty in producing a constant product in large quantities is considered the major constraint to increasing the use of silage in feedlots.

4.0 SPECIAL TECHNICAL ISSUES ARISING FROM SURVEY AND REVIEWS

4.1 Effect of high silage diets on carcase and meat quality.

Research in the MRC project DAN 040 provided some detailed observations on the effects of replacing some of the grain with high ME silage in finishing diets for yearling steers. Carcase and meat quality data are presented in Table 4.1. The steers were slaughtered to produce 200-220 kg carcases. While it took up to 20 days longer to finish the silage only animals the effects on carcase and meat quality were minimal. The only differences were a little more fat in the carcases from animals maintained on the high grain diets. Grain level did not affect dressing percentage or yield of retail cuts.

There has been on-going debate as to whether high silage diets affect carcase or meat quality. These quality criteria are important as they have a significant effect on the economic value of the carcase. Consequently the industry has understandingly adopted a conservative approach with the benchmark being the product quality produced on high grain diets.

TABLE 10 Effect of proportion of grain in silage/grain diets on carcase and meat quality in yearling steers (Kaiser 1993).

	Proportion of grain in the diet (%)			
	0	27	54	80
Hot carcase weight (kg)	212	215	215	218
Dressing percentage	57	57	57	57
Eye muscle area (cm^2)	62	62	61	64
Fat depth, P8 site (mm)	9	10	10	11
Fat dissected from 9-10-11 rib joint (%)	28	31	31	32
Fat colour (0 = white to 9 = yellow)	1.2	1.0	1.0	1.1
Meat colour (1 = light to 9 = dark)	1.0	1.0	1.0	1.0
Marbling (1 = nil to 12 = heavy)	1.3	1.5	1.4	1.4
Yield of retail cuts (% cold carcase weight)	78	79	78	79
Predicted tenderness (0 = excellent to 15 = very tough)	5.3	5.2	5.3	4.9

Meat Colour

The results with yearling steers at Wagga Wagga (Table 10) and with steers from various studies in Victoria and WA have indicated that replacing grain with silage, either as the full diet or as a supplement to pasture, does not adversely affect meat colour. Earlier, there was some concern in WA that silage-fed steers may be more likely to have dark coloured meat. It was postulated that dark cutting could be due to insufficient glycogen in the muscle at slaughter. However a recent study showed no adverse effect of silage, and that any reduction in glycogen level is more likely to be associated with low nutritional status (Tudor *et al*) 1996).

In the USA, Young and Kauffman (1978) compared carcases from steers fed on grain (67%), maize silage or maize silage/haylage (53%/43%) and found no effect of diet on meat colour (Table 11). Consequently most available data indicates that meat colour is not adversely affected by silage feeding.

TABLE 11 Effect of diet on performance and carcase and meat quality of feedlot steers (Young and Kauffman, 1978).

	Grain (67%)	Maize silage	Maize silage/haylage (53/43%)
Days on feed	84	125	181
Liveweight gain (kg/day)	1.44	1.09	0.91
Hot carcase weight (kg)	285	274	289
Fat colour (1 to 5)	3.9	3.3	3.9
Meat colour (1 to 5)	3.2	3.2	3.3
Marbling score	4.8	4.8	4.7
Tenderness (steaks)	4.6	4.3	4.5
Juiciness (steaks)	4.9	4.6	4.6
Flavour intensity (steaks)	5.1	5.3	5.2

Fat Colour

There has been some concern that silage based diets might produce yellow fat, and maize silage appears to have been especially singled out for this concern. This may have arisen from the results of Japanese work (Mitsukashi *et al* 1988) that showed that maize grain produced yellow fat in the carcases of Japanese Black steers when compared to a barley grain control. These results may have been incorrectly extrapolated to maize silage, creating concern that maize silage may produce yellow fat. This has not been the case in Australian (eg. Table 10) or USA studies. For example in a recent USA study (Allen *et al* 1996) steers finished on maize silage had fat that was "near white" (mean score 1.2 on a scale of 1= white to 5= yellow).

Marbling

Australian research with yearling steers and heavier steers (340-360 kg carcases) has shown that replacing grain with high ME silages does not adversely affect marbling. A number of studies in the USA have also shown that the proportion of grain in the finishing diet did not influence marbling (Vance *et al* 1972; Jesse *et al* 1976; Young and Kauffman 1978; Woody *et al* 1983). Inconsistent effects were however observed in some other studies.

Eating Quality

Very little work has been conducted on the eating quality of meat from steers finished on high silage *vs* high grain diets. In the DAN 040 experiments (Table 10) taste panel tenderness scores were estimated using equations developed by CSIRO, Cannon Hill, and based on Warner-Bratzler Peak Force, Instron Compression and Cooking Loss. These results showed no significant differences in predicted tenderness.

Clearly, eating quality is an important issue and needs to be directly measured in taste panel tests that provide reliable data on tenderness, juiciness and flavour. Until these data are available it will be difficult to convince the industry that high ME silage based diets will produce meat with similar eating quality to grainfed beef. However data from the USA indicates that replacing grain with high quality silages does not adversely affect meat quality (e.g. Table 11). In two studies where cattle were finished at similar liveweights, high silage diets produced beef with similar eating qualities to that produced on high grain diets (Young and Kauffman 1978; Brennan *et al* 1987).

A recent review (Melton 1990) investigated the effects of feeds on the flavour of red meat. Little work has been reported on the flavour of beef from silage based diets, but in one study comparing a maize grain based diet, maize silage diet and a lucerne/cocksfoot silage diet, flavour intensity was higher on the grain diet (5-7) than the two silage diets (5-3 and 5-0 respectively). The scoring system used was a scale of 1 (extremely bland) to 8 (extremely intense). Although the differences are quite small, most observers would have expected that flavour might have been more intense on the high silage diets. However choice of grain could be important. In Australia barley and sorghum are more important grains than maize in feedlot diets. Clearly more work is required in this area, and this should take account of the fact that flavour scoring and preferences may well vary between consumer groups.

In conclusion the more extensive use of high ME silages in feedlot diets is unlikely to result in any deterioration in carcase or meat quality. However more research is required in this area, with particular emphasis on eating quality. At the same time more detailed observations are required on the quality of offal produced from cattle finished on high grain *vs* high silage diets.

4.2 Silage Production Systems

4.2.1 Production And Utilisation Of Sorghum Silage

While maize is the summer crop of first choice for silage production where irrigation is available or in a favourable higher rainfall environment, there are large tracts of northern NSW and Queensland where maize cannot be reliably grown. In these marginal areas for maize, yields will be depressed, and where poor grain set occurs ME content can fall below 9.5 MJ/kg DM. Sorghums tolerate dry conditions better than maize, and will become increasingly important as the main silage source in drier areas. This is particularly important to the feedlot sector where a consistent supply and quality of silage is required from summer crops.

Grain Sorghum

Sorghums or forage sorghums cover a range of crops with quite different characteristics (Figure 4.1). Grain sorghum silage has been shown to have a high nutritive value, and at Wagga Wagga a growth rate of 0.92 kg/day was observed in yearling steers given a sorghum silage + urea diet. Our experience and that in the USA indicates that grain sorghum silage is likely to sustain at least 90% of the liveweight gain possible on maize silage. Limited Australian data are available on the production of grain sorghum silage from dryland crops, but a recent study showed that silage (6 tonnes + DM/ha) could provide higher gross margins than grain (3t/ha). The results of this work (Cole *et al.* 1996) are presented in Table 12.

TABLE 12 Yield and quality of grain sorghum crops grown for silage at Moree (Cole *et al.* 1996).

Season	Yield (DM/ha)		ME (MJ/kg DM)[1]	
	Grain	Dual purpose[2]	Grain	Dual purpose
1993/94 Dry year	4.2	4.2	10.0	9.9
1994/95 Good year	6.2	7.0	10.2	10.3

1 Estimated from *in vitro* digestibilities

2 Grain / grazing crops

An interesting feature of the results is that although yield was considerably lower in the dry year there was no major impact on ME content. This is important to beef producers as it appears that they can rely on producing a high ME silage in dry years. This would not be possible with dryland maize.

While it is clear that there is considerable potential to produce high ME silage from grain sorghums a number of issues need to resolved:-

(i) Can we use taller growing grain types to improve silage yield.

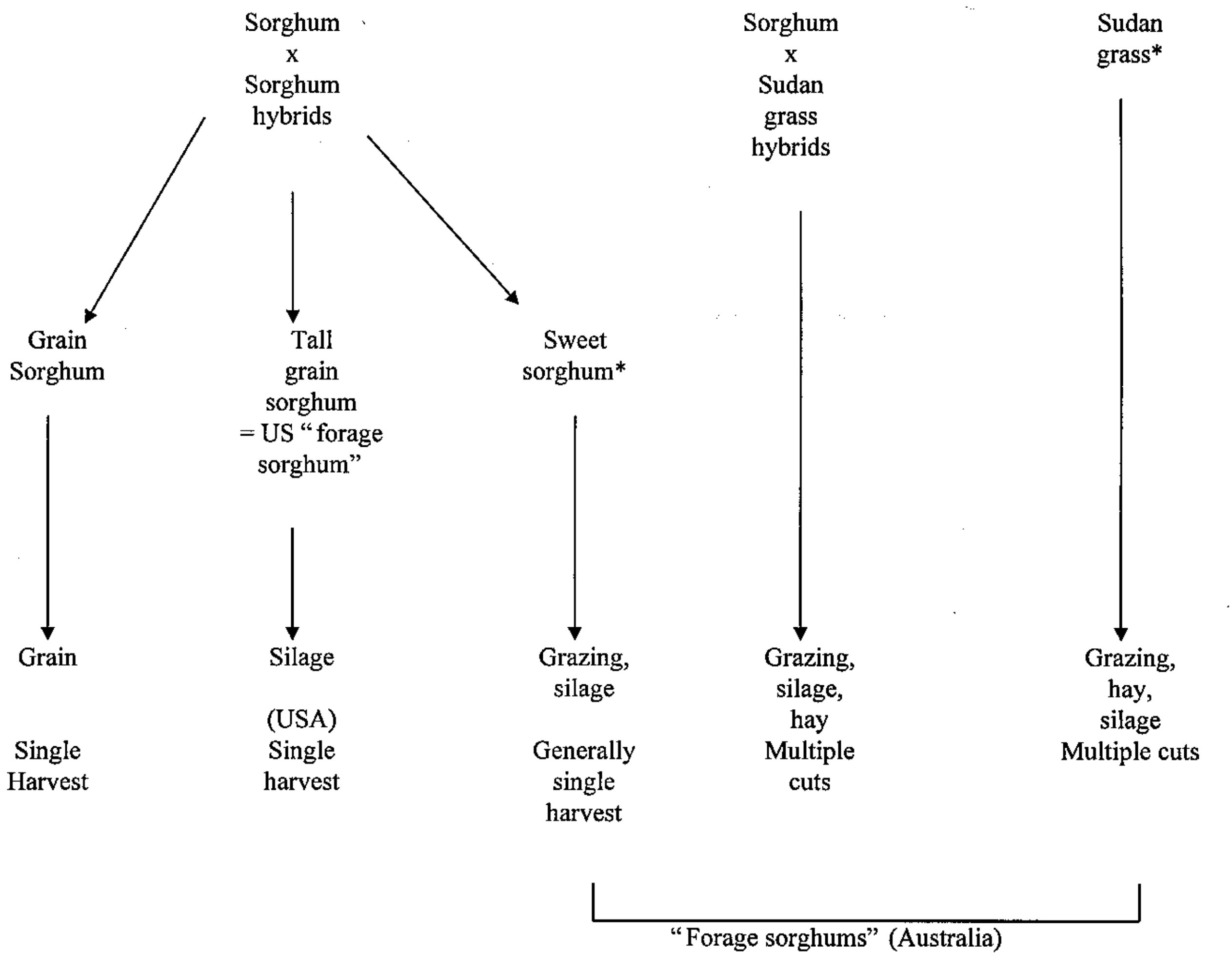
(ii) To what extent do crop characteristics influence ME content.

(iii) Can the high quality harvest window be manipulated by varying sowing time and varietal selection.

(iv) What is the optimum stage of harvest to optimise yield, DM and ME content, and what is the effect on whole grain digestion.

In the USA the main type of sorghum used for silage production is a tall growing grain sorghum (= forage" sorghum in the USA). Considerable research has been conducted on this crop at Kansas State University by Bolsen, and a comparison with grain sorghum is provided in Table 13.

Figure 1. Classification of sorghums.



*Some open-pollinated varieties available

TABLE 13. Comparison of grain sorghum and "forage" sorghums, Kansas, USA (Bolsen and Young 1995).

	Yield (tDM/ha)	Grain content (%)	Plant height (cm)	ADF (%)
1992				
Grain sorghum	13.4	43	1.35	28.2
Forage sorghum	18.3	36	2.64	34.4
1994				
Grain sorghum	12.5	51	1.10	30.7
Forage sorghum	18.1	34	2.23	35.1

This work has shown a considerable yield advantage in favour of the forage types (+41%) although there appears to be a quality trade-off as indicated by the lower ADF. However they observed considerable genetic / phenotypic variation among the forage sorghums in both yield and quality (and maturity) so it is possible to select varieties with higher quality. The KSU work suggests that the shorter earlier maturing varieties are likely to have the highest quality (White *et al.* 1988). This is similar to the results with maize in Australia (Kaiser and Havilah 1989)

Clearly these crops offer considerable potential for silage production. At present suitable varieties are not available on the Australian market although the seed companies are working on them at present. Apart from identifying plant characteristics (grain content, stem digestibilities, sugar content, tannin content, maturity rating) that optimise ME content we also need research on management factors such as optimum plant population for yield, quality and resistance to logging. The extent to which the high quality harvest window can be extended by judicious selection of variety and sowing time (as is the case with maize) also needs to be resolved if large areas of these crops are to be grown for silage production for feedlots.

Management of the crop to achieve high ME is a key objective for beef producers. A summary of the Kansas State University data on grain vs forage sorghums shows that high grain content in forage sorghums is important (Table 13). Adequate digestion of the grain component appears to be important for the effective utilization of grain sorghum silage. Processing or cracking of the grain during or after harvesting (prior to feeding) has improved performance in USA studies. At Kansas State University rolling the silage before feeding increased liveweight gain from 1.02 to 1.12 kg/day, the effect being greater in crops harvested later at the hard grain stage. Hence the utilization of the grain component is likely to be improved by using forage harvesters that have the capacity to provide a cracking / rolling process during harvest. Varietal differences, as already indicated, are likely to have a significant impact on grain and forage sorghum quality.

TABLE 14 Liveweight gain of steers on grain sorghum and forage sorghum silage (Bolsen, Kansas State University Reports, various years).*

Grain sorghum	Forage sorghum		
	Non-heading	low grain	Moderate to high grain
1.09	0.50	0.68	0.93

* Silage comprised 89% of the diet

An additional varietal characteristic that could be important is the composition of the seed coat of the grain. Grain digestion may be more efficient in varieties which have low levels of tannins or phenolic compounds in the seed coat. This should be investigated.

Sweet Sorghums

Sweet Sorghums have a considerably higher yield potential than grain sorghums and can probably match the USA yields for their tall grain ("forage") sorghums. At Moree sweet sorghum yields of 17-21t DM/ha were obtained (Cole *et al.*1996), and similar high yields have been recorded in a number of other studies in NSW and Queensland.

Estimated ME contents in the 9.1 to 10.1 MJ/kg DM were observed, with highest ME contents being observed in varieties with high sugar content. Sweet sorghums have a wide harvest window as digestibility changes little as the crop approaches maturity (Kaiser *et al.* 1993). It should be possible to target sweet sorghums with high yield potential and an ME content $\geq$ 9.5 MJ/kgDM. Research is required to identify high

ME varieties and the crop management (region x fertilizer x plant population) required to minimise losses due to lodging prior to harvest. It is apparent that there is considerable variation between varieties in susceptibility to lodging. However the problem could be exacerbated by excessive plant population and by broadcasting seed rather than sowing it in similar row spacings to maize.

Other sorghums

The sorghum x Sudan grass hybrids and Sudan grasses have limited capacity to consistently produce silages with an ME content $\geq$ 9.5 MJ/kg DM. The main problem is the very narrow harvest window when quality is high - even the slightest delay in harvest due to wet weather can result in a significant decline in digestibility. The probability of cutting the crop at the optimum stage of growth for each of the 2 to 4 cuts is not high.

Selection for higher digestibility will provide the only opportunity for producing high ME silages for the feedlot sector from Sudan grass and sorghum x Sudan grass. Higher sugar lower lignin and lower tannin content could improve digestibility (Kaiser *et al.* 1993). Lower lignin sorghums can be produced by incorporating the brown midrib (Kaiser *et al.* 1993). In a recent study at Moree, three cuts from a brown midrib Sudan grass had estimated ME contents in the range of 9.8 to 10.2 MJ/kg DM (Cole et al 1996).

4.2.2 *Alternative Uses for Winter Cereal Crops*

In order to provide management flexibility and extend the harvest period for winter cereal crops, alternative systems for conserving these crops need to be investigated.

(a) Silage

Of the moist preservation systems, silage is the most common conservation strategy for oats, wheat and barley. It has been common practice to cut these crops at the milk to dough stage of growth, often without wilting. However, recent data from Wagga Wagga, NSW and Western Australia indicate that at least for oats, this is too late and that the optimum stage of growth is between the boot stage and flowering. At this stage (i.e. milk to dough) ME content should be 9.5 MJ/kg DM, while at the boot stage an ME of 10 MJ/kg DM might be expected.

Little is known about the difference in yield potential and digestibility between cereal species, and between varieties within a species. Apart from oats, most other cereal varieties grown tend to be those suitable for grain production, yet these varieties may not be the most suitable one for silage production. In the UK there is evidence that barley has a superior digestibility to wheat, with oats and rye having lower digestibility than wheat (Corrall *et al.* ;1977; Tetlow 1992). There is also evidence from the oat breeding program in WA of significant variation between oat varieties in digestibility (Table 15). The combined effects of species and variety could account for 0.5 to 1.0 MJ/kg DM (or even greater) variation in ME content.

TABLE 15 Variation in the DM digestibility of oat crops grown at Mount Barker, 1985-88 (McLean, unpublished)

	Stage of growth		
	Ear emergence	Early milk	Milky dough
Mean DM digestibility (%)	71.2	66.8	62.2
Range in digestibility (% units)	12.0	8.6	8.2

We need adequate data on the yield / quality tradeoff for silage production in spring for the full range of winter cereals. The bottom line in terms of the profitability of silage production is the potential beef production per ha of crop. Hence feeding experiments that generate production and feed efficiency data will be valuable in assessing optimal stage of harvest, and how this influences the quantity of grain required in the finishing diet.

The other important development in cereal silage production is the use of cereal/legume mixtures. Silage produced from these crops have been used for cattle feeding in NSW (DAN 040) and to feed sheep in WA. Legumes not only provide a high ME forage, they also supply valuable protein. This is particularly important as observations in the eastern States have shown that the crude protein content of cereal crops can be very low (eg. Table 16). As can be seen from the results from Wagga Wagga in Table 4.2, the addition of the legume component improved yield and protein content, and in the case of peas improved estimated ME content. Inadequate data are available on the most suitable companion legumes, or on the agronomic management of the mixed crops in the different regions. It is clear that they have considerable potential. For example at Wagga Wagga it is estimated that these crops when harvested for silage are likely to produce more than 1500 kg beef (liveweight gain) / hectare. Clearly they warrant further research.

TABLE 16 Comparison of oat, oat/vetch and oat/pea crops grown for silage at Wagga Wagga (Kaiser and Dear, unpublished).

	Oat**	Oat/vetch	Oat/pea
Legume content	-	42	48
Yield (t DM/ha)	11.9	13.6	14.8
Predicted ME content (MJ/kg DM)	8.9	8.9	9.6
Crude protein (%)	4.4	10.4	12.2

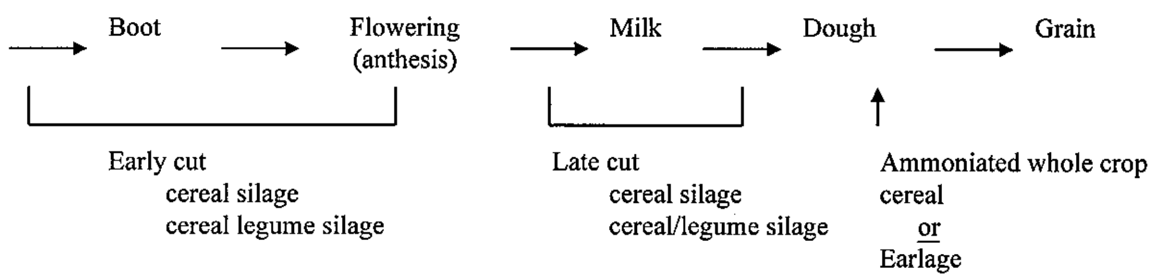
* Crops harvested at flowering

** Oat crop received an additional 40 kgN/ha

(b) Ammoniated whole crop cereals

Apart from silage, there are two alternative uses for cereal crops - ammoniated whole crop cereals and earlage (Figure 2).

Figure 2 Alternative uses for winter cereal crops



Ammoniated whole crop cereals are harvested at the dough stage of crop development (at maximum yield), treated with urea and stored in a similar manner to silage. The urea is rapidly converted to ammonia which causes a rise in pH to 8 to 9. As they are not a fermented product, which would be characterised by a fall in pH (to 4 to 5), ammoniated whole crop cereals are not silages. There is widespread use of ammoniated whole crop cereals in Europe and the UK, but they have not been evaluated in Australia.

Potential advantages of this system are:-

- Cereal crops harvested at maximum yield
- Higher quality than cereal silages. A survey in the UK showed the following mean results for wheaten silages and urea treated whole crop wheat:-

	Wheaten silage	Ammoniated whole crop wheat
DM content (%)	33.7	54.9
Crude protein (%)	10.2	24.4
pH	4.0	7.7
Estimated ME (MJ/kg DM)	9.3	10.3

* (Adamson & Reeve 1992)

Ammoniated whole crop cereals have been found to have a similar ME content to maize silage, with a considerably higher crude protein content.

- Improved aerobic stability (reduced heating) during feedout.
- Storage losses 8 - 10% units lower than those from wheaten silage.

Cattle production for ammoniated whole crop cereals (predominantly wheat) are presented in Table

17.**TABLE 17 Cattle performance on ammoniated whole crop cereals (Tetlow and Wilkinson (1992)*.**

Liveweight of cattle	Barley in diet (% liveweight)	DM intake (% liveweight)	Liveweight gain (kg/day)
Calves, 120 kg	0	2.95	0.83
Calves, 150 to 220 kg	0	2.37	0.73
	0.4 to 0.8	2.59	0.99
Steers, 300 to 400 kg	0	1.85	0.89
	0.4 to 0.6	2.22	1.03

* Summary of results from 5 experiments.

These forages clearly have considerable potential for sustaining good liveweight gains with only low levels of supplementary grain. Leaver and Hill (1992) reported growth rates in young cattle over 1.2 kg/day on ammoniated whole crop cereal + 20% concentrate in the diet.

Ammoniated whole crops cereals could provide the Australian feedlot industry with an additional high ME forage option. At the same time they provide greater management flexibility for cereal crops and extend the harvest period.

(c) Earlage

Earlage is the ensiled grain head/ear component of the crop, and because of its high grain content has a high ME content. In the USA, earlage is currently produced from maize crops but is probably less important than high moisture corn. Some earlage is also produced from maize crops in Europe but in most cases they have found that from an economic viewpoint harvesting the whole crop is generally a more profitable strategy.

In the 1970's some research was conducted in the USA (eg. Kansas State University) on the production of earlage from other crops. Wheat earlage (wheat head silage containing 35% grain) was found to be a suitable replacement for maize silage as the roughage component (10 to 20%) of a high grain feedlot diet. An alternative strategy tested was to replace the entire grain + roughage components of the diet with earlage (70 to 75% grain) produced from a sorghum crop ('milage'). Again satisfactory liveweight gains of 1.1 kg/day were obtained, and there was evidence that rolling the sorghum earlage could further improve liveweight gain.

Since this work little research has been conducted on the production of earlage from winter cereals. Without a significant body of research data on relative crop yields for silage, earlage and grain, and cattle data that provides relative feed efficiency data in terms of liveweight gain / ha crop for the three options, it is difficult to ascertain whether there is a role for earlage production for the Australian feedlot industry. However a number of factors need to be considered:-

- If very high grain intakes are required, earlage could replace the roughage component of the diet.
- Alternatively, because of its likely high ME content, earlage could replace some or all of the grain component of the diet.
- Earlage could be classified as partially 'grain' for accreditation purposes.
- Replacement of some of the grain with earlage would reduce grain processing costs
- The ME content of earlage (and grain content) could be manipulated by varying cutting height.
- The relative price and yield of grain vs earlage yield and production costs will largely determine the relative profitability of the two strategies.

When considering alternative uses for cereal crops, earlage should not be overlooked. At the very least some R & D is required with our crops to provide the basis for a sound economic analysis.

4.2.3 *Manipulating The Optimum High Quality Harvest Windows For Winter Cereals Silage*

The comprehensive management package available for maize allows silage producers to manipulate sowing date and hybrid selection to provide a steady supply of forage maize, at the optimum stage of growth, over an extended harvest period of say 6 to 10 weeks (depending on environment). A similar management package needs to be developed for other crops.

With winter cereal crops, the current high quality harvest window is small, making it difficult for silage makers to achieve high quality. This is particularly true where large quantities are made. Hence much of the cereal silage made is of variable quality, with a high proportion being <9MJ/kg DM. So with current information winter cereals cannot be effectively managed to consistently produce a high quality product. One of the main problems appears to be varietal selection – most cereal silages are made from current shorter season (often semi-dwarf) grain varieties and the full range of maturity groups has not been utilised. The longer season varieties in many cases are not suitable for grain production but could be suitable for extending the silage season. In addition, there are the hay-type wheats which are both late-maturing and also produce more forage than modern grain varieties. Selection of a range of cereal species and varieties should provide feedlots with greater flexibility to produce high quality silage. There is also potential to increase forage yield.

The other management tool available for manipulating the harvest window is time of sowing – both earlier and later than that used for conventional grain crops. With forage production there is considerably more flexibility with time of sowing because the adverse effects of frost on grain yield from earlier sowings, and the poorer grain yield from late sown crops are not an issue for forage production.

Other crop management decisions could also influence yield and quality. Some observers believe that higher plant populations can be used to produce thinner stems and higher digestibility forage. In addition late applications of fertiliser N may increase the proportion of leaf. Both these strategies have been tried successfully on farms in WA for round bale silage production from wheat (J. Milton, pers. comm.).

Discussions with cereal breeders has confirmed that judicious use of cereal species/varieties and sowing dates could be used to manipulate harvest date by 4 to 6 weeks. There is also likely to be significant capacity to increase yield and perhaps quality (see section 4.2.2.). Research in this area will provide the feedlot sector with an opportunity to more effectively utilise winter cereal silages in their production systems.

4.2.4 *Improved Silage Management to Reduce Losses and Increase Silage Quality.*

Silage losses can have a major impact on the cost of silage. For example, increasing the losses of silage from 12% to 30% can increase the cost of maize silage from $108 to $136, per tonne DM. This is only the 'tip of the iceberg' as DM losses are invariably accompanied by a loss in quality, leading to a further reduction in liveweight gain/tonne of crop ensiled.

For example if we assume that the feed efficiency changes from 7.0 to 7.5 kg DM/kg gain, then the combined effect of DM and quality losses in our example is equivalent to 32.4 kg liveweight gain for each tonne of DM ensiled (viz. 125.7 *vs* 93.3).

The economic consequences of these losses are clearcut, yet often overlooked by producers, largely because they are not clearly seen and are difficult to quantify under commercial conditions.

The two greatest sources of losses are:-

(i) inadequate consolidation and sealing during storage.

(ii) aerobic spoilage during feedout.

Producers often relate storage losses to the depth of visible waste on top of the silage stack. However this is always an underestimate of losses as the depth of waste is invariably derived from a considerably greater depth of unspoiled silage at the commencement of the storage period. As already indicated visual appraisal of losses fails to take account of the significant deterioration in nutritive value that can also occur.

Top spoilage losses of DM have been measured in maize silage in the USA (Table 18). In this study most of the losses over a 180 day storage period occurred in the top 0.5m. Failure to seal the silo / bunker resulted in significantly higher DM losses - an additional loss of more than 300 kg DM for every 10m^2 of top surface area.

TABLE 18 Effect of sealing and depth from original surface on DM losses(%) from maize silage in bunker silos (Bolsen *et al* 1993)

Sealing treatment	Depth from original surface (cm)		
	25	50	75
Unsealed	80	29	19
Sealed immediately with plastic	23	9	12
Sealed immediately + mould inhibitor	25	15	15
Sealed after 7 days + mould inhibitor	32	16	12

This study was conducted in the USA. One could expect that the very cold weather during a significant proportion of the storage period would alleviate some losses. In Australia our warmer environment is likely to exacerbate the problem, as the growth of spoilage microflora would be more rapid during warm weather.

The other main source of losses is during feedout. Once the silage is opened and exposed to air, aerobic spoilage commences. This is due to the growth of yeasts, bacteria and moulds, and leads to a significant loss of DM and a decline in nutritive value. The first sign of aerobic spoilage is heating of the silage stack and an 'off flavour'. Intake is often depressed and aerobically unstable silage can also result in the rapid spoilage of the total mixed diet in the feed bunk.

Unfortunately, aerobic spoilage proceeds more rapidly in warmer weather owing to higher microbial growth rates. Silages vary in their susceptibility to aerobic spoilage, and management is also important. For example, where silage is fed out slowly and the silage face is loose due to disturbance by unloading equipment losses are increased (Table 19). It is evident that DM losses can be high, and are again likely to be accompanied by a significant decline in nutritive value. Silage additives may help to improve silage stability and reduce these aerobic spoilage losses.

TABLE 19 Dry matter losses (%) from trench silos with difference face characteristics (Zublena *et al.* 1987)*

Face characteristics	Exposure period (days)			
	1	2	3	4
Very loose	2	7	12	15
Loose	1	3	6	11
Firm	0	1	3	6

* As cited in Roth & Undersander 1995

The question often arises as to whether there is a role for silage additives under Australian conditions. Most of the crops we ensile either have an adequate DM content, or can be wilted to a DM content > 30%, so there is not an obvious role for the chemical additives, although their use may improve aerobic stability during feedout. The role for silage inoculants is uncertain, and although overseas results have been variable, there is sufficient evidence that given favourable conditions (yet to be adequately defined) worthwhile responses might be obtained.

A recent review of the literature (Bolsen 1994) summarised recent experimentation on inoculants (Table 20) - clearly further research is required.

TABLE 20 Responses to silage inoculants - a summary (Bolsen 1994).

	Studies recording a positive response (%)	Mean response in these studies (%)
Fermentation characteristics	65-75	-
Reduced in-silo losses	74	2.5
Improved aerobic stability	42	-
DM intake	25	11
Liveweight gain	25	11
Milk production	40	5
Feed efficiency	50	9
Digestibility	60	-

At present there are no Australian data on the response to silage inoculants - this area certainly warrants research. Of greater significance is the whole area of silage losses. These need to be quantified under Australian conditions and related back to silage management, so that 'best practice' recommendations can be developed to reduce losses. In addition the development of simple laboratory tests, on parent forage and resulting silage, that allow producers to estimate silage losses would be a useful tool in monitoring silage management.

4.2.5 Legume Silages to Reduce Dietary Energy and Protein Costs.

While legumes can satisfy the high ME silage goal targeted in this review, they also provide two additional advantages:-

i) A higher intake potential than grass (including cereals) silages

ii) Considerably higher protein content than most other silages.

The higher intake capacity will lead to increases in animal production, while the high protein content will help to reduce the requirement for supplementary protein, reducing feed costs. Most temperate legumes have crude protein contents in the range 15 to 25% when at a vegetative stage of growth.

Ensiling legumes

Owing to their lower sugar content and higher buffering capacity more care needs to be taken with the ensiling of legumes. Problems with a poor fermentation (and subsequently depressed silage intake) are only likely to occur if legumes are ensiled at a low DM content. Wilting to a DM content of at least 30%, but preferably 35%, will generally ensure excellent preservation. At the Agricultural Research Institute, Wagga Wagga, this strategy has proved to be successful with some 40-50 pure legume silages produced over the last 10 years. There is little advantage in wilting beyond a DM content of 45%, as field losses are increased and it is more difficult to consolidate heavily wilted forage when filling the silo.

Legume options

Where large quantities of legume forage are required by feedlots, this will need to be supplied from legume forage crops rather than legume based pasture. The latter are less likely to supply a reliable quantity of a uniform product on an annual basis. There are two crop options – the perennial crop lucerne and annual forage crops.

Lucerne is a particularly useful crop with capacity to provide high quality forage from a number of cuts over an extended period. This provides management flexibility and the opportunity to spread harvesting operations so that silages with a consistently high ME and CP content can be produced over the period September to March (or April). Fewer cuts would be expected from dryland crops in the south. Research in the USA has shown that stage of crop development has an important effect on forage quality, and that the optimum stage for silage production is late bud/first flower.

Annual legume forage crops have not been widely used for silage production in Australia, but are popular in parts of Europe. Their use in cropping rotations as replacements for grain legumes is currently being investigated in southern and central NSW. Farmers are disappointed with the yield and returns from grain legumes, and are looking to forage legumes for weed control, N fixation and a disease break, as well as providing a high quality forage for animal production. If development of these crops is successful, as expected, they are likely to play an increasingly important role in cropping rotation. But they also have an important silage (or hay) production role in their own right.

There are two types of annual forage legume crops. The single harvest crops produced from the large-seeded legumes such as peas, vetch, and field beans, generally produce a higher yield of forage from one harvest. They are also a suitable companion species in cereal/legume mixed crops. The dual purpose forage legumes provide greater management flexibility with the capacity to supply forage for grazing in winter, silage production in spring and a regrowth that can be used for grazing, silage or as a green manure. The dual purpose legumes are generally late-maturing and small-seeded and sown at high seeding rates (10-15 kg/ha). The species and varieties used will vary with the environment, but at Wagga Wagga a mixture of berseem, arrowleaf and Persian clovers has been found to be highly productive.

Yield and quality of peas and vetch grown for silage production has been studied at Wagga Wagga (Table 21). These crops were highly productive and quality was high. An interesting feature of the results was that the digestibility of peas declined little over the harvest period (organic matter digestibility 71.4%, Oct 2 to 70.2% Nov 6). If this is confirmed in later studies, this would be a major advantage as it would provide silage makers with a large harvest window when quality is high. In Europe, peas are generally harvested at the pod filling stage.

TABLE 21. Yield and quality of peas and vetch grown for silage at Wagga Wagga (Kaiser and Dear, unpublished)*

	Yield (tDM/ha)	Digestibility (OM%)	Estimated ME content (MJ/kg DM)	Crude protein (%)
Peas (Dundale)	11.7	72.7	10.6	18.3
Vetch (Popany, Golden Tares)	8.6	68.7	10.0	23.2

*Harvested Oct 23, 1996

In comparison with the results with peas and vetch at Wagga Wagga, a range of smalled-seeded legumes (clovers and medics) produced 6.7 t DM/ha, with an estimated ME content of 10.4 MJ/kg DM and a crude protein content of 14.1%.

Summer growing legume crops (eg. soybeans, cowpeas) are another option in northern NSW and Queensland. At present there are few clear candidates that combine the attributes of high yield and high quality (ME $\geq$ 9.5 MJ/kg DM). Soybeans are currently being evaluated in a dairy research program and there is evidence of varietal variation in yield and quality. Phasey beans and peanut may also be useful and appear to have some regrowth potential.

Animal performance

High liveweight gains can be obtained on legume silages. At Wagga Wagga yearling steers given subclover and lucerne silage gained 1.14 and 0.85 kg/day respectively. European work has shown that legume silages often support better liveweight gains than grass silages. A number of dairy experiments have shown superior milk production on cereal/legume and legume silages when compared with cereal silages (see Table 22). In the study reported in Table 22, both milk production and liveweight gain of the cows were higher when the pure legume silages were fed.

TABLE 22 Milk production from cows given diets based on barley, barley/legume and legume silages (Kristensen 1992)

	Barley	Barley + field beans	Field beans	Peas
DM content (%)	37.2	38.2	27.1	31.0
Crude protein (% of DM)	8.3	12.6	15.5	14.9
ME (estimated, MJ/kg DM)	9.5	9.3	10.5	11.3
Silage DM intake (kg/day)	9.2	8.9	10.1	10.6
Milk yield (kg FCM/day)	23.6	23.5	24.4	25.9
Liveweight gain (kg/day)	0.25	0.34	0.49	0.49

Future use by feedlots

There is considerable potential for greater use of legume silages by feedlots, to provide both high ME and high CP forage. There are currently inadequate data on the agronomic management of these crops, but it is evident that they have a high yield potential, particularly the large-seeded single harvest crops (peas, vetch). The rotational benefits of forage legumes are likely to foster their more widespread use in the cropping belt.

4.2.6 *Optimum Grain/Silage Ratio During the Introductory Feeding Stage*

On most feedlots, particularly those with short term finishing programs (100-120 days), grain is introduced rapidly into the diet with an 80% grain level being reached in 14-20 days. This management regime relies on rapid adaptation to a high grain diet. If this does not occur digestive problems will depress animal performance, particularly over the first 30 days on feed.

At Wagga Wagga, steers were given high ME silage based diets with the proportion of grain in the diet varying from 0 to 80%. On the 80% grain diet, the grain proportion was increased over a period of 20 days. The liveweight gain data for the first 30 days and the whole finishing period (90-120 days depending on diet) are presented in Table 23. With two of the five silages poorest gains over the first 30 days were obtained on the high grain diet, while on three of the five silages liveweight gains on the high grain diets were less than those on the intermediate level of grain.

TABLE 23 Liveweight gain of yearling steers given silage and various proportions of grain in the diet (Kaiser, unpublished).

Silage	Proportion grain in diet (%)	Liveweight gain (kg/day)	
		First 30 days	Whole finishing period
Subclover	0	1.23	1.14
	54	1.27	1.34
	80	0.77	1.20
Maize	0	0.80	1.04
	54	0.87	1.13
	80	0.50	0.98
Grain sorghum	0	0.68	0.96
	54	0.98	1.22
	80	0.83	1.23
Oat/Vetch	0	0.84	0.85
	54	1.21	1.11
	80	1.25	1.15
Lucerne	0	0.94	0.85
	54	1.12	1.11
	80	1.17	1.12

In all cases liveweight gains on the 80% grain diets over the whole finishing period were either less or similar to those on the 54% grain diets. Hence these yearling steers did not respond to the higher grain diets. To what extent this is due to poor adaptation to high grain diets is uncertain, but a number of questions arise:-

- In no case was there any benefit in putting these yearling cattle on to a high grain diet during the first month on feed. Indeed in some cases this was a major disadvantage.
- When high levels of grain are to be fed to cattle should the silage component have a lower ME or have a longer chop length?
- Are finely chopped high ME silages suitable for use with high grain (>70%) diets? Of course research data show that when high ME silages are used there is no need to use high grain diets.

- Should grain be introduced more slowly to allow more gradual adaptation to high grain diets? If high ME silages are used liveweight gains should not suffer.

These management issues could have important implications for short fed cattle. The extent to which liveweight gains are depressed during the first month on feed under commercial conditions is uncertain as no industry surveys have been conducted. It might not be easy to detect a problem on commercial feedlots as cattle are usually weighed in empty. With the yearling cattle (283 kg) in Table 13, the difference between full and empty weights was 12 kg.

Consequently if cattle are weighed in empty, then 0.4 kg/day of the liveweight gain during the first 30 days would be due to differences in gut fill alone. This value would need to be deducted to get an indication of true liveweight gain. Considerably larger differences in gut fill occur with heavier cattle.

Perhaps another benchmark as to how well cattle have adapted to high grain diets is the extent of liver damage detected at slaughter. Industry and research experience indicates that the incidence of liver damage can be high in cattle maintained on high grain diets.

4.2.7 Silage in Backgrounding Diets

There is clear evidence from Australian and overseas studies that if high quality silage is produced, it will sustain liveweight gains in steers of >0.85 kg/day. So as a full feed, or a supplement to pasture, high quality silages can be used to sustain growth targets in backgrounded steers. Clearly, to achieve these targets in a supplementary feeding situation, the level of silage feeding (and any nutrients required to balance the diet) will need to match the pasture supply and quality. Where high total intakes of pasture + silage have been achieved liveweight gains ≥0.75 kg/day have been achieved with maize silage (Wales and Moran 1992) supplements given to yearling steers, and high quality pastures silages supplements given to heavier steers (480 kg, Cummins *et al* 1996).

Two issues concerning the utilisation of silage in background diets need to be addressed:-

i) The effect of feeding system on the response to silage

ii) The use of silage based diets to grow out light weight weaners

Feedout system

While feeding standards together with feed test data on silage quality may provide a guide to likely cattle performance on silage-based diets, they do not take account of feedout system and the impact that this has on silage intake. There are occasional reports from producers feeding high quality silages that liveweight gains are significantly below expectations. This is often the case where silage is self-fed either in the whole form or from a silage bunker face using a feeding barrier. Where animals need to work to remove silage from the bale/feeding face there is a risk of a depression of intake. This problem may be exacerbated where animals have to compete for feeding space. Furthermore, in the case of baled silage, the long particle length could further reduce intake. It is important that these effects be quantified so that producers can be provided with silage feeding recommendations that yield predictable animal responses. These issues are relevant to both beef and lamb producers and may be addressed under MRC's Southern Beef Consistency and Lamb Consistency Key Programs.

Feeding Light Weight Weaners

A large proportion of the weaners produced in Queensland, northern NSW, and coastal NSW have low weaning and turnoff weights 150 to 200 kg and are considered unsuitable to enter backgrounding programs for feedlots. Unless this problem is addressed, it is likely that in the future there will be a shortage of suitable cattle for backgrounding.

The underlying problem in these regions is the low quality of the available pasture for most of the year. To increase the liveweight of weaners entering the backgrounding phase there are two options. The first is to provide supplementary feed during the pre-weaning period. While this approach is technically feasible the economics are uncertain. It could also be argued that the first priority for supplementary feed in these breeding enterprises should be to increase reproduction rate, with increased weaning weight a second priority. There is not necessarily a positive link between reproduction rate and weaning weight. Indeed there are situations (eg changed calving time) where an increase in reproduction rate may be accompanied by a decline in turnoff weight. This is an important area for research; while some work is being funded by the CRC at Grafton more research is required to identify the most cost-effective supplements, feeding systems (eg feed cow or creep feed calf) and critical periods for supplementary feeding.

The second option is to place weaners on a high energy diet after weaning for a period of liveweight recovery. This could be achieved cost-effectively by maintaining the weaners on diets based on high ME silages. Weaner producers or specialist backgrounders could grow out these light weight weaners. Evidence that this approach is feasible comes from research at Wagga Wagga that investigated factors influencing maize silage quality. The cattle used in these experiments were light weaners from the North Coast of NSW, and the maize silages were offered to appetite with urea at 2% of DM intake (see Table 24).

TABLE 24 Liveweight gain of weaner steers on maize silages (Kaiser and Piltz, unpublished)

Experiment	No. of silages	Initial liveweight (kg)	Mean silage DM content (%)	Liveweight gain (kg/DM)	
				Range	Mean
1	6	159	35	0.97-1.12	1.04
2	6	201	41	1.00-1.17	1.11
3	2	193	35	0.99-1.00	1.00
4	5	191	43	0.81-0.95	0.86
5	6	209	37	1.01-1.22	1.11

These silages supported high intakes and liveweight gains and excellent feed conversion efficiencies (6.24 kg DM/kg liveweight gain). Given the higher protein requirement of young cattle, and the need for undegraded dietary protein in the diet (see lucerne pellet response in Table 25) it is likely that urea alone may not meet their protein requirements. Hence better liveweight gains may have been achieved with a protein supplement. Clearly this is an important area for research - at present no work is being conducted in this field. It is also important to compare the relative profitability of the pre-weaning and post-weaning feeding options, and to monitor any carryover effects (feed efficiency and carcase composition) into the feedlot phase.

TABLE 25 Growth Rate Response (Kg/day) of cattle of different ages to increasing the crude protein content of maize silage (Thomas *et al* 1975).

Diet and protein source	Crude protein content (%)	Initial age (months) and liveweight (kg) of cattle		
		3 mth (107)	6 mth (180)	9 mth (249)
Maize silage alone	10.7	0.39	0.59	0.95
Maize silage + 1% urea	13.2	0.48	0.94	0.90
Maize silage + 2% urea	16.0	0.56	1.03	1.04
Maize silage +1% urea + 2% lucerne pellets	15.5	0.98	1.12	1.01

4.2.8 *Reliability of Laboratory Methods for Estimating Silage ME.*

In a recent study comparing inter-laboratory variation in the analysis of maize silages (Beever *et al* 1996), significant variation in ME and crude protein estimates were observed:-

	Silage 1	Silage 2
DM (%)	27.6 ± 0.9	33.5 ± 0.9
ME (MJ/kg DM)	11.2 ± 0.5	11.5 ± 0.6
range	10.5 to 12.1	10.7 to 12.3
Crude protein (%DM)	10.1 ± 1.8	10.1 ± 0.8

The two samples were sent to 6 laboratories in the UK, 3 in Europe, and 1 in USA. Beever *et al* (1996) concluded that these results showed that current feed analysis provide unacceptable variation and that this problem needs to be addressed through the establishment of national standards.

These results are sobering. It is likely similarly variable analyses would be obtained from Australian laboratories, creating uncertainty amongst producers attempting to formulate diets for specific ME contents. The underlying problems are the variation in analytical methods used to estimate digestibility, and subsequently variation in the equations used to calculate ME content from digestibility. In the UK there is clear evidence that the commonly accepted equations for predicting *in vivo* digestibility of silages from modified acid detergent fibre are inadequate (Adamson and Givens 1989). The most recent development is to use Near Infrared Spectroscopy (NIRS) to directly estimate *in vivo* digestibility, by calibrating for standards of known digestibility (organic matter digestibility). The digestibility estimates are then used to calculate ME content, with adjustment for silage volatiles.

This approach is limited by the lack of standards of known digestibility in Australia. Our different climatic conditions and the range of forage species used require the development of "local" calibrations. A national approach is required if we are to develop national standards, and provide industry with more reliable feed testing services.

The issues concerning ME prediction also apply to other analyses. For example with crude protein content, many laboratories conduct these analyses, on oven-dried samples even though it is well known that oven drying results in losses of the volatile nitrogen component. Reliable crude protein data can only be obtained by conducting the analyses of fresh/frozen silage samples.

4.2.9 Sunflowers for Silage

Early studies with sunflowers were conducted with taller varieties with low grain content, and indicated that sunflower silage had a nutritive value of about 80% of that of maize silage. The development of high grain, high oil content varieties stimulated further interest in sunflower silage in the USA, particularly for dairy cattle. This work showed that while sunflowers produced silage with a higher crude protein and oil content than maize, yields were lower. Generally most of the research showed that there was no advantage in feeding sunflower and sunflower/maize silage when compared to maize silage (Kaiser *et al* 1993) for milk production. In addition, reductions in milk fat or milk protein were observed in a number of studies, leading to the recommendation that sunflower silage should not be used as the sole forage source in the diet. However, it is unclear whether this recommendation was confined to oilseed varieties - high oil content in the diet could adversely affect digestion in the rumen.

The role of sunflower silage in the feedlot industry is unclear. On the basis of yield it is unlikely to compete with maize in favourable rainfall environments or where irrigation is available. However there are many areas in northern NSW and Queensland suitable for both sorghum and sunflowers, and it is likely that the yield and quality differences between these crops will be quite small. Few Australian data are available on yield and quality of sunflowers, but the results from irrigated crops at Wagga Wagga (Table 26) show that digestibility can be high, provided the crop is cut before the late petal fall stage. The digestibility estimates are probably conservative as the *in vitro* procedure does not take account of the oil content in silage.

TABLE 26 Composition of whole crop sunflowers cut for silage (Kaiser, unpublished data)

Variety	Stage of growth	Days from sowing	Grain(%)	DM content (%)	Digestibility (%)*
Hysun 22 (oilseed)	Mid-flower	66	0	15	69.6
	Early petal fall	75	11	16	71.1
	Mid petal fall	89	15	19	67.5
	Maturity	103	37	22	65.6
Hysun 33 (oilseed)	Mid flower	75	0	18	71.2
	Early petal fall	89	21	21	69.5
	Late petal fall	103	32	24	64.7
	Maturity	115	35	27	64.3
Sunbird 2 (birdseed)	Mid flower	75	0	18	69.3
	Early petal fall	89	26	21	69.3
	Late petal fall	103	33	26	63.7
	Maturity	115	36	29	60.4

**In vitro* organic matter digestibility.

Comparisons of sunflowers and sorghum are required to establish the relative potential of these crops in terms of yield and ME content. Based on USA work it appears that the nutritive value of sunflower silage is likely to approach that of maize. Of particular interest is the oil content of the oilseed varieties, and its impact on intake, ME content and carcase composition.

5.0 AN ASSESSMENT OF SILAGE COSTS OF PRODUCTION

5.1 Costs of Various Silage Systems

5.1.1 Review of DRDC Kondinin Work

There are significant differences between the costs of various silage systems. Costs of any system are influenced significantly by the economies of scale with costs reducing as the amount of silage made increases. However, recent research by the Kondinin group (1997) (funded by Dairy Research and Development Corporation) into the costs of fodder conservation systems on dairy farms has indicated the following average costs for silage making systems from mowing through to feeding out, (Kondinin Group, 1997).

TABLE 27 Range in costs of forage conservation systems ($/tonne dry matter)

System	Low	Average incl feedout cost	High	Average excl feedout cost
Small square bales of hay	60	92	119	69
Round Bale Hay	23	82	167	48
Direct chop silage	19	52	122	22
Pick-up chopped silage	38	67	121	34
Self loading forage wagon	37	109	173	47
Wrapped round bales of silage	82	138	210	105

Source: Kondinin Group (1997 pp. 82-85)

Results from this study (Table 27) show:

- Substantial variation in costs of production and feeding. The lowest cost for an individual system was $19/tDM for a precision chopped silage system, and the highest cost was $210/tDM for round bales of wrapped silage.

- Direct chopped crops were the cheapest system to use, costing an average $52.28 per tonne of dry matter (tDM) from chopping to feed out.

- Other forms of precision chopped silage were less than half the price of other systems, costing an average $66.50/tDM to mow, chop, cart, roll, store and feed out.

- The most expensive system was round bales of wrapped silage, costing an average $138.85/tDM.

High cost systems are generally associated with low throughput dairies. In a feedlot situation contractors should be considered in most cases before owners provide their own harvesting equipment. If scale is sufficient to justify silage harvesting machinery ownership, feedlotters must ensure good utilisation by extending the harvest period as long as possible. This does not mean that some crops should be harvested earlier or later than the optimal, but harvest time may be lengthened by having a range of crops and sowing times.

5.1.2 Silage costs in a feedlotting system

In a feedlotting situation the above costs are only relevant if the feedlotters choose to own and operate the machinery themselves. The costs reported by Kondinin in Table 27 ignore the costs of growing a crop, it simply considers the costs from point of harvest to when it is fed out.. In a situation where a feedlotter owns cropping land and wants to grow the silage themselves, they must consider the cost of growing the crop as well. The true cost in this case is the income it would earn in the next best alternative use for the land. Another consideration on a feedlot is the need to dispose of feedlot waste on to land to recycle nutrients. This requirement will significantly reduce the cost of crop production.

An example of the price required for maize silage to break even with irrigated maize production.

To compare with the cost of using a grain based system, the opportunity cost of the alternative use for the paddock must be considered as well as the harvest and feeding out costs. In a pasture system where there is ample spring growth, the opportunity cost of pasture could be zero because if the pasture is not conserved it would be wasted. In a maize silage system the cost comparison should be the opportunity cost of harvesting and selling the grain. This would be the gross margin per hectare for a grain crop less machinery overhead costs in growing and harvesting the grain. As a maize crop is harvested earlier as silage there may be advantages over grain because the land can be prepared earlier for another crop. There may also be additional costs in a grain situation of disposing of the stubble. As an example a maize crop yielding 10 tonnes per hectare would at $120 per tonne be worth $1200 per hectare. Subtracting a harvest cost of $10 per tonne, a further $3 per tonne for carting costs to the feedlot storage, and $90 per hectare to cover machinery overhead costs, the opportunity cost of a maize crop is $1200 less $220 [10*($10+$3)]+ $90 = $980. If this crop was expected to yield 21 tonnes dry matter from silage, the opportunity cost of the silage is $46 ($980÷21). At 35% dry matter this is equivalent to $16 per tonne wet. Harvesting, cartage and storage costs would have to be added to this figure to arrive at a total cost per tonne.

Rather than produce their own silage, some feedlots have contracted other growers to produce their silage for them. On the Darling Downs these contract prices have varied from $40 - $50 per tonne delivered feedlot and into pit (average $42 - $43 per tonne). This is equivalent to $125 - $156 per tonne DM (32%). Costs for chopping, carting and rolling, and inoculant average $12.50 per tonne wet ($39 t/DM) which contrasts to the figure of $22 tDM indicated in the Kondinin survey (Table 27).

Other reasons for the major differences are varied. It could be that as the distance around a feedlot from which the silage can be drawn is limited, surrounding farmers do not face full competition in supplying feedlots and can thus charge a higher price. It could also be that as silage production is a relatively unknown enterprise that some farmers are not aware of the income potential and are not competing to supply the feedlots. In the case of irrigation crops in the northern areas, cotton could be the best alternative. 1996 gross margins for northern NSW (Scott 1996), estimated a gross margin for cotton of $1399 per hectare and for irrigated maize, $974 per hectare when contract harvesting costs of $100 per hectare are allowed. Returns from maize silage yielding 65 tonne wet (21 tDM) and priced at $35/tonne would give a gross margin of $1564 per hectare. The advantage is even greater when you consider that there is no stubble to dispose of and you get your money earlier. In addition the prices used in the 1996 budgets of $180 per tonne for maize and $470 per bale for cotton represents above average prices paid for these commodities.

While the feedlots are currently paying relatively high prices for maize silage, it is argued that these prices should tend to be on the upper limit of prices paid in the longer term. If silage is to be an alternative, future feedlots should give careful consideration to selecting sites that have ample opportunities to grow silage material within a close proximity of the feedlot. For logistical reasons it is desirable that ample land is available within 25 km of the feedlot. Feedlots would have the option of growing their own silage by buying nearby land or by leasing land. This also raises the need to give careful consideration to the opportunities of recycling nutrients from effluent disposal through silage production.

There are also options of obtaining silage from dryland crops. Table 28 contains a comparison of selected dryland crops and their likely returns from grain production and silage production.

TABLE 28 A comparison of dryland cropping returns from grain production and for silage production and break even prices

Dryland crop	Grain yield (t/ha)	Grain income less harvest costs ($/ha) [1]	Silage yield (tDM/ha)	Silage income @ $100/tDM ($ha)[2]	Break even price required for silage to match grain returns ($/tDM)
Grain sorghum, northern NSW	2.3t/ha	$276	6tDM/ha	$600	$46
Barley Riverina (good crop)	4t/ha	$480	12tDM/ha	$1200	$40

[1] Based on an on farm price of $130 for grain sorghum and barley. A figure of $10 per tonne is subtracted to represent harvest costs. .Net price is thus $120 per tonne.
[2] A return of $100/tDM is used because it represents 1997 prices that have been paid for maize forage. The breakeven price in the adjacent column indicates the competitive price compared to grain.

It can be clearly concluded from the above discussions that if competitive forces are working adequately, that the prices quoted on the Darling Downs are at the upper end of those that feedlotters should be prepared to pay. Essentially feedlots on the Darling Downs are paying too much for their forage maize and may need to seek alternative sources of high ME silage. Crop dry matter content is critical and to demonstrate this Table 29 assumes a wide range of possible prices per tonne wet and a range of dry matter contents from 25% to 40%. Thus it is extremely costly and wasteful to harvest maize crops below 35% dry matter.

TABLE 29 Cost of silage $/tDM given cost per tonne wet and dry matter percentage.

Dry matter %	Cost per tonne wet matter					
	$10	$15	$20	$25	$30	$35	$40
25%	$40	$60	$80	$100	$120	$140	$160
30%	$33	$50	$67	$83	$100	$117	$133
35%	$29	$43	$57	$71	$86	$100	$114
40%	$25	$38	$50	$60	$75	$88	$100

5.1.3 *Review of DAN 040 Work*

Kaiser (1993) reported on an analysis completed by NSW Agriculture economist John Brennan where four different silage crops combined with four different proportions of grain in the diet (0%, 27% 54% and 80%) were compared (Table 30). This analysis was based on analysing all costs including growing costs of pasture or crop, machinery costs including overhead costs and feed out costs. Barley prices used in this analysis was $120/t delivered on farm in southern NSW, and $125/t in northern NSW. This would be close to current price expectations which means the relative results between diets should be similar even though meat prices have fallen substantially.

TABLE 30. Summary of costs and returns for silage-based finishing systems where producers finish their own steers and use their own machinery for silage making.

Silage system[1]	Proportion of grain in diet (%)			
	0	27	54	80
Winter cereal/legume crop				
Costs ($/head)	104	113	122	125
Net returns ($/head)	69	60	51	48
Annual pasture				
Costs ($/head)	100	113	127	133
Net returns ($/head)	74	60	47	40
Irrigated maize, northern NSW				
Costs ($/head)	108	125	140	148
Net returns ($/head)	65	49	33	26
Dryland maize, north coast NSW				
Costs ($/head)	122	136	150	156
Net returns ($/head)	51	37	23	17

[1] Gross returns per head for every diet = $173. Net return reduced by $17/head where purchased store cattle are used.
Source: Kaiser (1993) p16.

Table 30 clearly shows that for all silage systems examined, costs for the 100% silage diet was the cheapest and that costs increased and net returns per head fell the higher the proportion of grain in the diet. The differences in costs would be more marked if higher grain prices are used.

Kaiser (1993) p.17 also reported on the components of costs for a cereal /legume silage with 27% grain with the producer finishing store cattle (Table 31). Major costs were the contract harvest, interest costs and capital costs (interest and depreciation) of machinery. Costs would be higher if the opportunity cost of the land involved in growing the silage were taken into account.

TABLE 31 Components of the costs of finishing store cattle[1].

Component	Contribution to cost ($/head)
Tractor and machinery operating	5.08
Seed, fertiliser	5.45
Contract silage making	29.30
Own labour	6.66
Interest on working capital : silage	3.01
Interest on working capital : cattle	12.64
Capital (tractor, machinery)	11.80
Grain + lupins	32.51
Supplements	11.25
Other cattle inputs	4.02
Selling costs	4.00
TOTAL	125.67

[1] Cereal/legume crop silage with 27% grain in diet, producer finishing his own cattle and using a silage contractor to make silage.

Source: Kaiser (1993) p17

5.1.4 A Review of Possible Losses in a Silage System

The economics of using either silage or grain in a feedlotting situation should also consider losses. Losses can occur at harvest time due to inefficient harvesting methods or more likely due to weather. The greatest losses can occur during storage, particularly if the silage is not adequately sealed. Kaiser (1997) states that storage losses even with careful management are at least 6% with silage and for hay stored in a shed 3-5%., but hay stored outside would have considerably higher losses. There are also losses in the feeding out process and some of the feed is not consumed by the target animal. The amount of wastage will be dependent on the feedout system. Kaiser estimates that total paddock and storage losses in a well managed silage system should be kept to 15% of DM.

5.2 Costing Silage on a per unit of ME Basis

Feeds should generally be costed according to the most limiting factor. In most feedlot situations this would generally be energy, however, it is possible that other factors such as protein could be more important in particular circumstances. The measure of energy in feeds is the Megajoule (MJ) and is measured in feed as an estimated metabolizable energy (ME) by the number of MJ per kg of dry matter, ME = MJ/kg DM

To demonstrate the importance of valuing energy in a feed, take a situation where two feeds are available one costing $160/tDM with a ME of 12 MJ/kg/DM compared to a feed costing $100/tDM with a ME of 7 MJ/kg/DM. These feeds need to be costed in terms of cost per MJ. One tonne of feed will provide 12,000 MJ and 7,000 MJ of energy respectively. Therefore the cost per MJ for each feed is as per Table 33.

TABLE 32 Costing two feeds on a per MJ basis

	Feed 1	Feed 2
Cost of feed $/tonne	$160	$100
MJ/kg/DM	12	7
MJ per tonne of feed	12000	7000
Cost of feed per MJ	1.33 cents per MJ	1.43 cents per MJ

Table 32 clearly demonstrates that feed 1 while more expensive in terms of $/tDM is actually cheaper in terms of cost per MJ. The potential beef production per tonne of DM would also differ substantiality.

The cost of feed on an energy basis is used in least cost ration formulation. For silage a minimum level of inclusion (10-20%) will be required to supply a roughage source. Where high ME silages are used, and the cost per MJ of ME is lower than grain then there is potential for silage to replace some of the grain in that diet. The extent of grain replacement will depend on production goals and market requirements.

5.3 Adjusting Silage Value for Protein

Energy is not the only important feed ingredient. Protein should also be considered in costing a ration. In some silages particularly maize silage, there may not be sufficient protein and this will need to be balanced by a high protein source to achieve the desired protein level. If a silage has to be balanced by a high protein source such as cotton seed meal, the percentage of the high protein meal must firstly be determined and then the price should be weighted to take account of the higher cost addition to the ration.

The proportion of a high protein source required can be determined by the following formula, where protein levels are expressed in crude protein (CP) terms.

$$\text{Proportion of high protein meal} = \frac{(\text{Desired CP level \%} - \text{CP level in silage})}{\text{\% CP in high source} - \text{\% CP in silage}}$$

For example if the desired protein level is 12% CP and maize silage is 6.5%, and a high protein mix consisting of 88% cottonseed and 12% urea[1] and containing 67% CP is available, the proportion of this mix required is

$$\frac{(12-6.5)}{(67-6.5)}$$

$$= 9.1\%$$

This is the proportion of protein supplement that needs to be used with the maize silage to bring the maize silage component of the diet to the desired whole diet CP level (12%).

Maize silage should then be costed at weighted price. In the above example if urea is worth $470 per tonne and cotton seed $400tDM, the combined cost where there is 88% cottonseed and 12% urea is $408tDM. If silage is worth $80tDM, the cost that should be attached to the silage is $80*.909 +$408 * .091 = $109.85/tDM. Additional protein would be cheaper if a higher proportion of urea can be used or when the protein in the silage source is higher. The figure used in the example of 6.5% CP is close to the lower range of CP in silages.

For lucerne and other legume silages CP is likely to be above that required for the ration. This would mean that it would be possible for a feedlot to include a cheaper, lower protein grain in the diet. In this situation the cost of the silage should be reduced by the value of the savings in other feed costs using the reverse of the method described above.

[1] This combination has been worked out on the basis that cottonseed is 38% CP and Urea is 287%CP. A 50:50 ration on a nitrogen basis means that the mix is 88% cotton seed and 12% urea.

5.4 Comparing Costs of Silage to Grain in Feedlot Rations

In order to compare silage with grain the full costs need to be compared on a per unit of energy basis. Costs include growing/purchasing the feed, storage and feeding out. Better still the feed cost per kg of weight gain should be compared. Taking a situation of comparing maize silage to an alternate grain let us look at some likely costs. Estimates are provided for comparison purposes in Table 33.

TABLE 33 Comparison of Maize Silage and Grain Costs for Feedlotting

	Maize Silage (low price)	Maize silage most likely estimate	Maize silage (high price)	Grain Alternative
Cost of silage ($/tDM)	$71[a]	$80	$150[b]	$144[c]
Cost of harvesting/ feed out ($5/DM)	$19[d]	$35	$52[e]	$15[f]
Total cost of feed ($/tDM)	$90	$115	$202	$159
ME of feed (MJ/kgDM)	10.7	10.7	10.7	13.3
Cost per MJ of energy (cents)	0.84 cents	1.07 cents	1.89 cents	1.20 cents
Cost per MJ of useable feed if wastage is 15% in silage and 5% in grain	0.96 cents	1.23 cents	2.17 cents	1.26 cents

[a] Based on calculations in Section 5.1.2 plus an additional $20/t maize silage DM for additional protein. This cost would be lower for higher CP crops.
[b] Based on silage cost of $130tDM plus $20/t for additional protein
[c] Grain valued at $130 per tonne landed feedlot and 90% dry matter (assume CP=12%)
[d] Low price for direct chop silage in Kondinin survey (see Table 27)
[e] Average price for direct chop silage in Kondinin survey (see Table 27)
[f] Mixing and feedout costs (Storage, milling, mixing and feedout costs)

Using the above assumptions it can be shown that low cost maize silage is a consideration for a feedlotter, however, high cost maize silage is out of the question and even using more typical costs silage making can be too expensive to justify unless grain prices are high. Low cost maize silage can only be achieved where the feedlotters are growing the silage themselves or where competition between farmers to supply feedlots with silage is considerable (alternatively part of the growing costs can be offset against the need to recycle feedlot waste). It also assumes that the feedlot has a low cost machinery harvesting operation to gather the silage. This implies economies of scale only achieved with a large throughput. In the low cost situation silage wastage losses could be as high as 50%(and losses in grain remain at 5%) before silage would become more expensive. The higher the grain prices, the more attractive will be the silage alternative. If the above low cost estimate is something that can be achieved by well situated feedlots, maize silage will not be economic when delivered feedlot grain prices fall below $106.60 ($96/t as fed). In a situation where most likely costs are used, price of grain would have to fall to $140.80 ($126.72 as fed) before grain is cheaper. The exception would be where silage can be made at even lower costs or there is a lower opportunity cost of making the silage, for example from pasture silage which, if not made into silage would have gone to waste.

Other forms of silage such as lucerne silage could also be considered using the same methodology. In this case the opportunity cost of the silage is likely to be linked to the price that it would have bought as lucerne hay.

5.5 Silage Handling Equipment Costs

Machinery costs were calculated for a range of case study dairy farms on a $/tDM basis. Table 34 provides details of the costs $/tDM for eight different operations. Costs are influenced by the work rate, reported repair costs and overhead costs including interest and depreciation. Overhead costs are influenced by the scale of operation. The larger the volume handled, the smaller the overhead costs on a $/tDM basis.

TABLE 34 Example costs $/tonne DM of silage machinery on dairy case study farms (1996) using forage harvester silage systems .

Machine	Maize	Lucerne	Maize	Pasture	Maize	Barley & Lab Lab	Maize	Pasture
mow		5		1		3		3
rake		2						
chop	5	4	17	14	39[1]	5	19	15
cart	4	4	3	4		9	8	8
roll pit	2	2	4	2	1	1	2	3
store	0	0	2	2	8	0	1	1
feedout	9	9	49	49	14	10	11	11
Total machinery	20	28	75	73	62	28	41	41
Total Labour	14	25	46	46	12	12	17	19
Total Cost $tDM	34	53	121	119	74	40	58	60

[1] chop and cart included together
Source: Kondinin Group 1997

Table 34 illustrates the large range of costs that can occur with various systems. In order to have low costs farmers must have a high throughput. Of particular note however, are the considerable feedout costs sometimes incurred with silage. This generally occurs with inefficient feedout systems which handle relatively small quantities of silage. Machinery involved with feedout can be expensive and quite specialised. Machines such as mixer wagons are very expensive but in some cases feedlots considering a change to silage will already have the majority of the equipment. Labour costs can also be quite high, especially with small capacity machinery.

5.6 Other Issues

Even in situations where silage is a lower cost option, there are a number of issues that will explain why there is a reluctance for beef feedlots to use silage in their system. Some of these reasons are:

- The purchase of silage handling equipment and pits results in further capital outlays. If equipment is already owned for a grain based feeding system, feedlotters may view this investment as "sunk" and therefore not attribute any overhead costs to owning the equipment. If variable costs are the only costs allocated to a grain based system it would be hard to justify a silage system where overhead costs have to be considered. This logic is faulty as overhead costs should still be calculated on existing machinery based on the market value of that machinery.

- Silage making technology will be unknown to some feedlot operators. There is an education role for various agencies to ensure that feedlotters and their contractors are more aware of the full range of options.

- Overhead costs are a very important cost in any silage system. Overhead costs are greatly influenced by quantities made. It is very difficult for small feedlots to justify investment in specialised equipment if quantity of silage made is small. However, if these feedlots produce their own silage, costs can be reduced considerably if they use contract harvesting and do not over capitalise on feed out equipment.

- Some people have an aversion to silage. Smell can be a factor, but lack of knowledge is probably more important.

6.0 SUMMARY OF REQUIREMENTS FOR FURTHER RESEARCH AND DEVELOPMENT

Should the price of feedgrains in the medium to long term continue to rise as predicted in the Terms of Reference then there is going to be a concerted effort made by the feedlot industry to keep the feed costs under control and one of the main ways in which this can be achieved is by introducing a cheaper source of high metabolisable energy. Some 30% of the industry are already feeding silage in their rations and they have made it known to this study what they consider to be the advantages and disadvantages of using it both as a roughage and an energy source. They have given their ideas on the major constraints to increasing the use of silage and others have given reasons for not using it . We have then identified the main technical issues arising from this survey in our review of research and development. All these factors must be taken into account when attempting to set out priorities for further research and development and included in development must be extension activities. The following are our ideas on priorities for research and extension activities in the short term.

6.1 Eating Quality of Beef From Animals Finished on High Silage Diets is an Industry Issue.

Australian research shows no difference with animals fed on high silage rations. USA work suggests there are no meat quality problems but their grain control is based on maize. Apart from grain differences we use a range of silage sources and there are likely to be differences in consumer preferences. There may be a need to convince customers in our domestic and export markets that eating quality is not affected. So we need feeding studies to compare the effects of high grain vs. high silage diets on eating quality of the meat taking this through to taste testing. There are also observations that there could be different effects on the offal recovery rates. This should be further investigated.

Potential Outcome. To demonstrate conclusively that a high proportion of silage in feedlot rations does not affect meat quality, and so give to feedlot operators the opportunity of formulating low cost rations. It is important to have this accepted both on the domestic and export markets.

6.2 Opportunities for Using More Sorghum Silage in Feedlot Rations

Especially in the northern summer rainfall areas sorghums have been identified as needing attention and this should be followed up with a considerable applied research effort on grain sorghum silage including

- varietal selection (yield and quality)
- crop management (including manipulating harvest window)
- optimum stage of harvest and processing of grain during harvest

Potential Payoff. There is a clearly identified need in regions 2 and 3 to have competitive sources of silage material which can be produced under dryland conditions and used in place of maize silage. There are a number of high quality grain and forage sorghums of American origin that should be evaluated as they show considerable potential. There is also need for work on high ME sweet sorghums - agronomy, lodging, and quality. Diversification of forage sources for silage production will provide greater management flexibility and lower risk.

6.3 Special Extension Programs and Economic Studies

Our survey shows that there is a direct requirement for specific extension programs to increase awareness of the opportunities for using silage in feedlot rations as they contribute to both the roughage and high energy component of the diet. There are 3 groups which should be targeted in this program. Contractors, service providers, and feedlotters. The subjects that could be covered include making quality silage, preventing losses in the paddock, in storage, and in feeding out, and the economics of silage production. In Regions 2 and 3 the use of summer crops for silage and grain production should be addressed. In these regions there is real potential for silage production from the sorghums and other selected crops including lucerne under dryland conditions. In all Regions possible use of winter cereals and legume crops should be covered.

Many lot feeders have had little experience in making or feeding out silage. They would benefit from attending well planned workshops and field days especially if it were possible to arrange hands on experience. These events would be aimed at improving skills and knowledge levels of silage production and utilisation.

With silage contractors set to become an important link in the expanding use of silage it would be opportune to keep them up to date with new production developments especially improving silage quality and reducing spoilage in the paddock and in storage. Already successful workshops for silage producers and contractors have been run in NSW. This program should be given priority.

There is often considerable debate on the economic role for high quality silages on feedlots. This is due to the wide variation in the cost of silage. Some of the economic issues were addressed in Section 5, but there is a clear need for more comprehensive case studies to identify the most important factors influencing the profitable use of high ME silages. These studies need to take account of the effects of:-

- geographic location of the feedlot
- silage crop(s) used
- silage production/storage systems
- transportation costs
- feedlot waste disposal integration with silage production
- economies of scale
- impact of losses
- feedout costs
- protein costs

Potential Payoff. Such programs and studies would be expected to result in more efficient production of silage by reducing losses both in the field and in storage and in improving product quality. A better understanding of the potential for high ME silage as a substitute for some of the grain in feedlot rations would be gained by demonstrating the accurate costing of silage production systems.

6.4 Winter Cereals

Winter cereals will become a very important silage source for the feedlot industry. They will diversify the forage base (flexibility, risk) and spread the silage harvesting period. They are relatively cheap crops to grow and have a higher protein content that summer crops (even higher when cereal / legume mixtures are grown). There are alternative end uses for cereals that need to be investigated:

- early cut for high ME, with or without a legume
- ammoniated whole crop cereals
- cut for earlage at the late dough stage - this product would approach high moisture grain in ME content.

If producers are to consistently make silages with a high ME content we need to expand the high quality harvest window by manipulating variety and sowing date. Varietal differences in quality also need to be investigated.

Potential Payoff. It has been difficult for farmers and feedlot operators to recognise the opportunity for using winter cereals as a silage source. Once their potential to provide a more diverse high quality forage base and bring about a reduction in ration costs is clearly demonstrated, this situation will change.

6.5 Silage Losses.

A critical area affecting silage costs, silage quality and gain per tonne of silage. Losses in our warmer Australian climate are likely to be higher than those in North America and Europe. Issues that need to be addressed are:

- quantify losses that occur on Australian feedlots
- relate losses to management practices; define best practice
- develop simple laboratory tests to measure possible DM losses
- determine the role for silage additives/ inoculants to reduce in-silo losses, improve silage quality, and improve stability during feedout.

Potential Payoff. Our survey indicated that silage losses at all stages of production storage and feeding out were not fully appreciated. An on-feedlot study would quantify present losses in each of the regions so that strategic programs could be drawn up to reduce these costly losses. Studies on the response to silage additives/innoculants will allow feedlot operators to determine if their use is profitable.

6.6 Legume Silages.

As legume crops are an integral part of the crop rotations, there could be an important role for legume silages to provide a high ME, high CP forage. The need for expensive protein supplements can be offset by providing silage protein. Lucerne is an obvious candidate but special forage legume crops will become increasing important (especially in the cropping belt). Areas requiring research are:-

- productivity and quality of legume crops in various regions
- crop management to optimise yield and quality'
- effect of replacing protein meals with silage protein on cattle performance and carcase quality.

Potential Payoff. Applied research here should result in the identification of cheaper sources of ration protein, a high ME silage source, and a more diversified cropping base for silage production.

6.7 Optimum Grain Introduction Practices for Short Fed Cattle.

Where high ME silages are used, grain can be introduced more slowly without adversely affecting (and probably improving) cattle performance due to a reduction in digestive problems. This will also reduce costs. These different grain introduction regimes need to be evaluated in feeding experiments and the effects on the carcase and offal need to be monitored in this work.

Potential Payoff. The use of high levels of high ME silage when introducing cattle on to a full feedlot ration could be expected to reduce digestive problems and result in higher liveweight gains during the first month of lot feeding. This should result in improved profitability of the whole operation.

6.8 Backgrounding.

An important role for silage. One special area requiring research is the use of high ME silages to grow out light-weight weaners rapidly so that they can reach a suitable weight for age for the feedlot industry.

Potential Payoff. An improvement of the supply of quality feeder cattle ready for intensive feeding could be expected to result from the strategic use of silage during the backgrounding operation.

6.9 Feed Testing.

An important issue that affects the evaluation of silage for all ruminant industries. MRC needs to get together with other RIRF's to organise a joint approach to this problem because effective least cost ration formulation relies on accurate feed test data for silages.

Potential Payoff. A large payoff if all ruminant industries could have access to more reliable tests allowing more cost effective utilisation of silage.

6.10 Sunflowers.

This crop should be evaluated for silage production. The following areas need research in northern NSW and Queensland: comparative yield and quality of sunflowers vs sorghum

- sunflower types most suitable for silage production (eg. birdseed vs oilseed)
- importance of oil content of sunflower silage on ME content, cattle performance and carcase quality (fat composition and marbling).

Potential Payoff. The identification of suitable varieties of sunflower would broaden the choice of silage material available to the northern feedlots.

6.11 *Priorities*

We believe all the topics listed above are important and will lead to more effective utilisation of high ME silages by feedlots. We have culled areas where sufficient R&D has been conducted, that are less relevant to the feedlot sectors, and where the payoff from R,D&E is likely to be low.

We have scored the topics on our list taking account of the criteria in Table 32, and have derived the following "priority groups".

1. Important issues likely to have an immediate impact on the feedlot industry,

   Topics, 2, 3, 4, 5 and 9.

2. Important issues likely to have a medium to longer term impact.

   Topics 1, 6 and 7

3. Other important silage production/utilisation issues

   Topics 8 and 10. Topic 8 is particularly important to the backgrounding sector of the industry.

TABLE 35 Likely impact of R,D&E on aspects of silage production and utilisation in the feedlot industry

		Chances of R,D&E yielding significant gains in productivity	Likely economic benefit to FL sector (includes market access)	Ease of adoption
1	Eating quality (esp longfed cattle)	*	*** (If market barriers exist)	N/A
2.	More effective utilisation of sorghum crops for silage	**	** (North only)	**
3.	Special extension programs and economic studies	***	***	**
4.	More effective utilisation of winter cereal crops for silage	***	**	**
5.	Reducing silage losses	**	***	**
6.	Greater use of legumes for silage (high ME/high CP)	**	**	**
7.	More effective use of high ME silages during the introductory feeding phase for short-fed cattle	**	***	**
8.	Greater use of silage for backgrounding	***	**	** (For feedlot's, backgrounding own cattle)
9.	More reliable feed tests for silage	**	**	***
10.	Evaluate sunflowers for silage	**	*	**

* = low *** = high

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Annex One

Table A – Current Specialist Expertise in Australia.

ANNEX 1

TABLE A Current Specialist Silage Expertise in Australia.*

	Research and development				Extension	
	Production / utilization silage	Silage in beef diets	Silage in dairy diets	Silage in sheep diets	Government	Commercial
Queensland	-	-	-	-	-	K.Rich, Quality Silage Systems, P. Kleinhanns
NSW	A. Kaiser & J. Piltz, NSW Agriculture	A. Kaiser & J. Piltz, NSW Agriculture	A. Kaiser & J. Piltz, NSW Agriculture	A. Kaiser & J. Piltz, NSW Agriculture	I. Blackwood & N. Griffiths NSW Agriculture	G. Ralph & R. Haig, Pioneer C. Russell, Cobbett
Victoria	J. Jacobs, Dept. N R & E	J. Jacobs, Dept. N R & E	J. Jacobs, J Moran, & C.R. Stockdale Dept. N R & E	-	F. Mickan & J Lawson Dept. N R & E	G. Rogers, Bonlac
Tasmania	-	-	-	-	-	-
S.A.	-	-	-	-	-	-
W.A.	-	-	-	J. Milton, Uni. W.A.	-	-

* Technical specialists with at least 5 years full time experience.

The table categorises personnel into research (all in Government sector) and extension and the latter category includes those in both the Government and Private/Commercial sectors. Within the R & D category those listed under the Production/utilization of silage are working specifically on silage technology, namely the parent forage, the silage production process, factors influencing silage quality and losses, etc. The other three R & D categories include people working on the utilization of silage in beef, dairy or lamb diets.

Annex Two

MRC Feedlot Study and Questionnaire.

MRC FEEDLOT STUDY

The Expanded Use of High Metabolisable Energy-based Silage (Phase I).

The Meat Research Corporation (MRC) through the Feedlot Consistency and Sustainability Key Program have commissioned GRM International in association with NSW Agriculture and QSS Pty Ltd to carry out the above study which is to review past research and commercial experiences with the aim of increasing feedlot efficiency by trying to reduce feedlot ration costs while still meeting meat market requirements.

As an important part of the study, it has been decided to survey approximately 30-40 feedlots of varying sizes in each of three regions:

- The Darling Downs and South East Queensland
- The Northern and Central slopes of NSW
- The Riverina and Northern Victoria

The **confidential information** gained from such a survey will help us and the industry to identify the importance of silage as part of rations in each of the regions, and whether its use is likely to significantly increase should the prices of other forms of energy such as cereal grains etc continue to rise.

This survey is most important in the total frame work of providing answers on the future use of high ME silage in feedlot rations. It will also be used to assist in setting priorities for future Research and Development Programs.

QUESTIONNAIRE (Attached)

The reason for requesting data over a four year period is to try and establish trends and to take into account the widely variable weather conditions, feed prices and cattle prices that have arisen over this period. Should accurate figures be difficult to extract, then your best estimates up or down in relation to the current figures would be of great help. What we don't want is for you to spend much valuable time trying to get everything "just right". As you see in Questions 3 and 4, there are a number of boxes which can be ticked or left blank.

We are sending this by fax today 6 January, so that you may care to fill out the questions over the next 4-5 days. We will then ring you towards the end of the week to discuss the questionnaire, and to collect the answers.

Thank you for your cooperation.

Yours sincerely

GRM INTERNATIONAL PTY LTD

PAT HOULAHAN Team Leader

NB ***All information given will be treated in the strictest confidence by our consultants and then destroyed once it is collated into the overall results.***

MRC
HIGH ME BASED SILAGE STUDY
PHONE SURVEY QUESTIONNAIRE

Please return to Fax No. 07 38591555

1. Feedlot Name or (Tail tag Number) ……………………………………………………………………………………

Contact Name ……………………………………Phone No. ……………………Fax No. …………………………

Region (see cover note) ……………………………………………………………………………………………

Capacity ……

	Calendar Year			
	1996	**1995**	**1994**	**1993**
2. Approx Throughput (Total)				
a. Domestic Market No. or %				
Av No of days on Feed				
b. Export Market No. or %				
Av. No of Days on Feed				
3. Feeding Programmes a. Main Source Energy (in each year)				
b. Main Source Roughage				
4. Use of Silage (Yes/No)				
Quantity used each year				
Tonnes fresh; or				
Tonnes dry matter				
Main Source Parent Material				
Silage System - Baled or (☯)				
- with Forage Harvester (☯)				
Made by -self (☯)				
- Contractor (☯)				
Forage Source on own property (☯)				
- on another farm (☯)				

Continued

MRC
HIGH ME BASED SILAGE STUDY
PHONE SURVEY QUESTIONNAIRE

	Calendar Year			
	1996	1995	1994	1993
At what stage during feeding program did you use silage				
- Introduction (☯)				
- Intermediate (☯)				
- Finishing (☯)				
Estimated Silage Losses (%)				
5. Relative Costs: Estimates ($ per tonnes)				
Fresh Basis (☯) or				
Dry Matter Basis (☯)				
6. Main advantages with silage use:				
Main disadvantages with silage use:				
Major Constraints preventing you from using more silage				
7. What are your future intentions re silage use				

Notes:

Annex Three

The Importance of Silage Dry Matter Content.

THE IMPORTANCE OF SILAGE DRY MATTER CONTENT

The important principles of silage Dry Matter content rate

(i) Harvesting and transportation costs are higher when DM is low

(ii) When DM falls below 30%, significant effluent losses (DM and nutrients) can occur.

(iii) There is a greater risk of poor fermentation when forages are ensiled below 30% DM, particularly with legumes.

(iv) Silage intake increases with DM content up to about 450% DM. Beyond that the change in intake is small and variable.

(v) With some direct cut crops (eg. maize) harvesting at low DM content could lead to a reduction in crop yield (tDM/ha).

For the above reasons the following guidelines should be followed:

DIRECT CUT CROPS

- Maize. Harvest at ½ milkline (milkline score 2.5) when DM should be 303 to 37%.
- Grain Sorghum. DM 32 to 38%.
- Sweet and dual purpose sorghums. DM content tends to be lower with these crops. The target should be 30 to 34%.

WILTED CROPS

The target should be 30 to 45% DM. For legumes the range 35 to 45% is preferable.