CONSERVATION FOR PROFIT:

THE ROLE FOR SILAGE IN MORE INTENSIVE GRAZING SYSTEMS

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Abstract. The need to focus on meeting specifications for particular markets, and growing economic pressure on producers to increase productivity from pastures will lead to continued intensification of grazing systems for milk, beef and lamb production. In this context, the role of silage, and its potential to support high levels of animal production are discussed. Two of the key factors contributing to increased animal production, and therefore profit from silage, are the need to target high quality and minimise losses. Research is required on the need for silage additives to improve silage quality, and means of reducing silage losses during storage. Producers need a comprehensive economic appraisal of alternative silage production systems, and need more information on the production and feeding of baled silage. The integration of silage cutting with grazing management could improve the economic returns from pastures. The effects of silage cuts on pasture productivity and composition need to be investigated for a range of pastures.

Within Australia's grazing industries there is now a much stronger focus on the product specifications required for a range of domestic and export markets. These markets require a consistent supply of high quality product, and livestock and product prices usually reflect how well producers have been able to meet the market.

Animal production from pastures is heavily dependent on the seasonality of pasture production, and year-to-year variation in rainfall, so producers are unable to reliably meet market requirements on a year-round basis. This has led to the development of supplementary feeding systems. This is most developed within the dairy industry where forage crops, conserved forages, concentrates and strategic application of fertilizer nitrogen are used to provide a uniform supply of high quality feed. Within the beef and lamb industries there is growing use of supplementary feeding, and the most intensive feeding system, feedlotting, is growing rapidly within the beef industry.

These trends together with the growing economic pressure on producers to increase the productivity of their farms will lead to continued intensification of our grazing systems for milk, beef and lamb production. There will be greater use of supplements for production rather than maintenance feeding.

Animal production from silage

The profitability of a feeding system is largely determined by feed costs. For example, in a study of the USA cattle feedlot industry, after buying and selling prices, feed cost (grain price) was the next most important variable accounting for net profit per head (Lee, 1993). It was considerably more important than feed conversion efficiency and daily gain, although obviously minimum liveweight gain standards will have to be met if animals are to be finished to meet market specifications. The economics of grazing/supplementary feeding systems are likely to be similar. The profitability of supplementary feeding will be influenced by supplement costs and this should be the most important factor determining choice of supplement.

In grazing enterprises hay and silage can be produced at relatively low cost on-farm, and there is also the opportunity to integrate forage conservation cuts with grazing management. Producers owning their own equipment and producing over 200t DM/year can probably produce high quality precision-chopped pasture silage for $40 to $60/t DM. This is considerably below the cost of grain or other purchased feed.

Although hay is currently the principal method of conservation in beef and lamb enterprises, this paper will focus mostly on silage. With good management, DM and quality losses are lower for silage, which is also considerably less prone to weather damage (Kaiser and Curll, 1987). It is also possible to cut silage earlier in the season, producing a higher quality product and providing greater flexibility when integrating silage cuts with grazing management. A comparison between conventional hay and earlier cut silage (single chop forage wagon) was recently made in Western

Table 1. Beef production from hay and silage produced from similar pasture in Western Australia (Jacobs *et al.*, 1992).

Forage type and cutting date	Grain in diet[1] (% of liveweight)	Liveweight gain[2]		Carcase fat depth, P8 (mm)
		(kg/day)	(kg/t DM)	
Hay: Close 13 Aug.	0.5	0.33	45	2.7
Cut 6 Nov.	1.0	0.62	86	4.8
	1.5	0.87	114	6.8
Silage: Close 5 Aug.	0.5	0.79	129	5.6
Cut 10 Oct.	1.0	1.10	153	6.3
	1.5	1.21	146	7.4

[1] Grain mix 70% barley/30% lupins; [2] Steers initially 280kg and fed for 90 days.

Australia (Table 1). The estimated metabolizable energy values (MJ/kg DM) and crude protein (%) were higher for silage (9.7 and 14.9) than for hay (8.6 and 8.2), and cattle performance was clearly superior on the silage.

High levels of cattle performance were recently measured at Wagga Wagga using a range of precision-chopped silages. Silages were prepared from subterranean clover, maize, grain sorghum, lucerne and oats/vetch and offered alone or with 27, 54 or 80% grain (barley/lupin) in the diet (Table 2). The mean estimated metabolizable energy content of the five silages was 9.9 MJ/kg DM.

These experiments showed that high quality silages could be used to replace a substantial proportion of the grain in finishing diets for cattle, without any adverse effects on carcase composition or meat characteristics. Net returns per head increased as the proportion of grain in the diet was reduced, and the results showed that cattle can be finished on a silage-only diet.

In our experience, a realistic target liveweight gain of 0.85 to 1 kg/day should be achievable on high quality silages. The subterranean clover silage in the above study supported a liveweight gain of 1.14 kg/day when fed as the sole diet to steers. This silage was also fed with various grain supplements to 31 kg lambs in a collaborative study with Charles Sturt University (Table 3). The results show that high quality silage can be used to reduce the proportion of grain in feedlot diets for lambs. It is interesting to compare these lamb results with our cattle data derived from the same silage. The yearling steers gained at 1.14, 1.42, 1.34 and 1.20 kg/day on 0, 27, 54 and 80% grain (88% barley/12% lupins) respectively. It is apparent that the lambs were more responsive to energy and have a higher protein requirement than yearling cattle.

The above studies with high quality silages highlight their potential as production feeds. The examples provided cover the full feeding of steers and lambs on silage based diets. However, silage can also be used as a supplement for grazing animals and this strategy is now well developed in the dairy industry. At this stage the use of high quality silages for production feeding of breeders is not well developed in the beef and lamb industries. As grazing enterprises for milk and meat production become more intensive, with increased stocking rates and strategic supplementary feeding, more farmers will use silages as an integral part of their grazing system.

Efficient silage production

Targeting high quality

Time of cut: To maximise the animal production potential of silage it is imperative that silages are made from high quality pastures, and that these are ensiled to produce a well fermented product. Animal production increases with silage digestibility, and the most important factor controlling digestibility is time of cut.

The relationship between silage digestibility and

Table 2. Performance of steers on silage-based diets varying in grain content.[1] (Kaiser unpublished).

Proportion of grain in diet (%)	Liveweight gain[2]		Eye muscle area (cm^2)	Carcase fat	
	(kg/day)	(kg/t DM)		At P8 (mm)	In rib joint (%)
0	0.96	115	62	9.0	28
27	1.08	122	62	9.7	31
54	1.17	134	61	10.1	31
80	1.14	139	64	11.4	32

[1] Mean data for five silages. Steers initially 270-290 kg and slaughtered at 380-400 kg; [2] From full liveweights at start and finish of experiments.

Table 3. Performance of lambs on a subclover silage diet supplemented with barley and lupins (Graham *et al.*, 1992).

Diet	CP (%)	LWG[1] (g.day)	FCE (kg feed/ kg gain)
Silage alone	17.9	108	10.1
Silage 75% + barley 25%	16.8	163	7.3
50% + barley 50%	15.6	197	6.1
25% + barley 75%	14.5	208	6.0
Silage 75% + barley/lupin[2] 25%	17.9	194	6.7
50% + barley/lupin 50%	17.9	253	5.6
25% + barley/lupin 75%	17.9	243	5.2

[1] Lambs initially 31kg and slaughtered at approximately 45 kg; [2] Barley 79%/lupin 21%

milk production has been investigated by a number of researchers, and Gordon (1989) reported an increase in milk production of 0.37 kg/day for each 1% unit increase in grass silage digestibility. With growing cattle, Steen (1988) reported an increase in liveweight gain of 45 g/day for each 1% unit increase in grass silage digestibility. A number of studies have shown the importance of time of cut on the liveweight gain of cattle and lambs on silage (Tables 4 and 5). In the experiment conducted by Apolant and Chestnutt (1985, Table 5), silage intakes were 38%, 8% and 41% higher on the earlier cut silages during mid-pregnancy, late pregnancy and early lactation respectively. Although the sheep were given concentrates throughout most of this experiment, the differences in production from the early and late cut silages were still clearcut.

Legume content: Legume content of the silage is another factor likely to influence silage quality and animal production. At similar digestibility, legume silages will support higher intake and animal production than grass silages (McIlmoyle and Steen, 1980). Thus, high legume pastures would be expected to produce a higher quality silage than grass dominant pasture.

Silage fermentation: Good silage preservation depends on adequate air exclusion and a silage fermentation dominated by lactic acid bacteria. An undesirable silage fermentation, resulting in the production of volatile fatty acids and extensive degradation of the protein fraction, can result in a severe depression of silage intake and animal production (Kaiser, 1984). Producers have two strategies available for ensuring adequate preservation of pasture silage - wilting and silage additives. Wilting of pasture to a DM content of at least 30% will not only improve silage fermentation but also eliminate silage effluent losses. Wilting beyond 45% DM is likely to be of little advantage in terms of animal production, and drier forage is more difficult to consolidate to exclude air from the silo or bale.

Wilting generally improves silage fermentation and silage intake and, given favourable weather conditions, has little effect on digestibility. But the effects on animal production are variable (McDonald *et al.*, 1991). Improved animal production usually occurs where the direct cut silage would otherwise be poorly preserved. Wilting is unlikely to improve animal production when compared with an additive-treated control, or when adverse weather conditions do not allow a rapid wilt. In Europe, silage additives are essentially the standard industry practice against which wilting is compared. In Australia, I believe wilting will become our standard practice, as we generally have a more favourable environment for wilting. However, where rapid wilting cannot be achieved, silage additives may well produce a higher quality silage, although they will not reduce (and may even increase) effluent losses.

Few silage additives are available on the Australian market at present. In 1990, Wilkinson (1990) listed

Table 4. Effect of time of cut on the growth of steers on perennial ryegrass silage (Steen, 1992).

	Time of cut		
	Early	Mid-season	Late
Experiment 1: Silage only			
Cutting date[1]	-	9	17
Silage digestibility (DOMD %)	70.7	68.3	65.3
LWG (kg/day)	0.92	0.78	0.60
(kg/t silage DM)[2]	129	112	90
Experiment 2: Silage + concentrates[3]			
Cutting date[1]	-	8	16
Silage digestibility (DOMD %)	73.9	70.3	68.8
LWG (kg/day)	1.13	0.90	0.88
(kg/t silage DM)[2]	143	123	122

[1]Days after early cut; [2] Estimated from intake and liveweight gain data; [3] Concentrates given to all cattle at 1.7 kg/day.

Table 5. Effect of time of cut on ewe and lamb performance on perennial ryegrass silage[1] (Apolant and Chestnutt, 1985).

	Time of cut	
	Early	Late
Cutting date	May 17	June 5
Silage digestibility (DOMD %)	74.8	63.4
Ewe liveweight change		
Week 10 of pregnancy to lambing (kg)	1.3	-6.1
Week 1 to 4 of lactation (g/day)	-46	-193
Lamb birth weight (kg)	5.5	5.2
Milk production (kg/day)[2]	2.67	2.17
Lamb liveweight gain (g/day)[2]	254	199

[1] Silages were precision-chopped; [2] Ewes fed silages from week 7 of pregnancy and during the first month of lactation. Concentrates were fed from week 15 of pregnancy and at 800g/day during the first month of lactation.

126 commercial silage additives being sold on the U.K. market, and this did not include the carbohydrate sources and other nutrients that are sometimes added to forage at ensiling. Large numbers of silage additives are also available on the USA market, so it is likely that the number of products available will increase rapidly in Australia. Henderson (1993) has recently reviewed the literature on silage additives. With wet forages, where there is a risk of poor fermentation, acid and acid salt additives appear to be useful in improving silage fermentation, quality and animal production. The results with enzyme additives (cell wall degrading) are not encouraging, and those with silage inoculants have been highly variable. There is certainly some evidence of reduced in-silo losses and improvements in animal production when silage inoculants are used. However, more research is required to identity those situations where farmers can reliably expect an economic response.

Reducing losses

Losses (DM and quality) in the field during storage and feeding out can have an important effect on animal production and profit from silage. Field losses during wilting vary with the forage type and the number and type of machinery operations, but weather conditions are likely to have the greatest impact. With good management, and weather conditions favouring a rapid wilt, DM losses should be under 6%, which is less than the effluent losses that occur with low DM direct-cut silage (Wilkinson, 1981).

Some losses due to respiration and fermentation during the storage period are unavoidable, but are generally below 6% provided the desired lactic acid fermentation occurs. If the silage has been adequately consolidated and sealed, other storage losses should be minimised. So, with good management total losses during silage conservation (field + storage) should be kept to 15% DM. Energy losses will be a little lower at about 12%.

Storage losses: Where silage has been inadequately consolidated in the silo (or bale densities are low), and where sealing is inadequate, storage losses can be very high. Such losses can substantially reduce the animal production per tonne forage ensiled, and are avoidable. Most of these losses occur as surface spoilage and, when it is considered that 20 to 25% of the silage in bunkers or stacks is within the top one metre, total losses can be large.

The situation is similar with baled silage. In a survey of unsealed and sealed (with polyethylene sheeting) horizontal silos on farms in the USA, Dickerson *et al.* (1992) found that sealing reduced estimated DM losses by 27% in the 0 to 50cm layer, and 9% in the 50cm to 100cm layer. The efficiency of sealing in the "sealed" silos varied considerably - the situation in Australia is similar. In controlled studies where DM losses have been measured more accurately, losses have been shown to be very high near exposed surfaces (Table 6). The rate of loss in the surface layer in these two experiments with lucerne silage was 0.7 to 0.8%/day in unsealed silage. Further from the surface there was a delay in the onset of DM losses, which subsequently appeared to proceed at the same rate.

Apart from DM losses, significant silage quality losses occur when silage is not covered, or is inadequately sealed. These additional losses lead to reduced animal performance from the remaining silage (Table 7). The data in Table 7 were obtained with low and medium quality lucerne silages. Larger animal production losses could be expected when higher quality silages are left uncovered. It is clear that DM and quality losses from uncovered silages are very large. While losses from inadequately sealed silages will be lower than those from uncovered silage, they will still be large. Our warmer Australian environment is likely to accelerate the rate of aerobic spoilage during storage when compared to Europe and North America. It is also likely that the rate of aerobic spoilage (characterised by heating of the silage) during feeding out will be more rapid in Australia. Therefore, it is important that farmers focus on good silo/bale management and ensure that silage is adequately sealed.

Silage production systems

In recent years there has been rapid growth of baled silage production, both in big round and big square bales. While these systems are generally more expensive than forage harvested silage (Kaiser *et al.*, 1991), they are convenient and flexible and have proved popular with farmers. With good management, baled silage systems can produce high quality, well preserved silages. However, where bales are inadequately sealed or where the seal is damaged, storage losses can be very high. When comparing baled silage with conventional systems there are three issues that need to be considered:

- the economics of alternative systems through to feeding;

Table 6. Storage losses (% of DM) from sealed and unsealed lucerne silage over 84 days.[1] (Bolsen *et al.*, 1993).

Depth from surface (cm)	Silo type			
	Bunker (farm scale)		208 L drums	
	Unsealed	Sealed	Unsealed	Sealed
25	78	7	66	8
50	23	2	41	8
75	15	6	36	8

[1] Lucerne wilted to DM of 36.5% and 33.0% for bunker and drum silos respectively

Table 7. Cattle performance on wilted lucerne silages stored with and without covering.

	Covered	Uncovered
McGuffey and Owens (1979)[1]		
Wilted to DM = 34%		
LWG (kg/day)	0.30	0.12
Feed conversion (kg DM/kg gain)	16.8	40.0
OMD in sheep (%)	60.3	58.2
Wilted to DM = 43%		
LWG (kg/day)	0.39	0.29
Feed conversion (kg DM/kg gain)	14.5	16.4
OMD in sheep (%)	60.1	57.4
Oelberg et al. *(1983)*[2]		
Wilted to DM = 44%		
Liveweight gain (kg/day)	0.64	0.57
Feed conversion (kg DM/kg gain)	11.0	11.9

[1] 38 days storage prior to opening. Top waste removed prior to feeding; [2] Results estimated for treatments without application of a surface spray.

- the effect of chop length on animal production; and,
- the effect of feedout management on animal production.

Most economic analyses of silage production systems focus only on costs of production. There is a need for more detailed studies that take account of losses associated with different systems, risk, the role for contractors, a complete breakdown of costs including feedout, animal production differences between systems, feeding strategy (full feeding *vs* supplementary feeding; maintenance *vs* production feeding), and the integration of forage conservation into whole farm management systems. There are many gaps in information on forage conservation under Australian conditions and this makes it difficult to conduct a comprehensive economic appraisal. Nevertheless this should be our long-term goal.

Silage chop length: Silage chop length can influence intake in ruminants either directly, or indirectly by influencing the silage fermentation (Kaiser and Havilah, 1989). Finer chopping of wet forage can improve the silage fermentation and hence intake and animal production. However the direct effect is generally more important, particularly for sheep where finer chopping can substantially improve intake and production (Table 8). With young growing cattle, the response to finer chopping does not appear to be as great, and in dairy cattle the response has been highly variable. These results indicate that the performance of sheep may be lower on baled than on conventional silage. However, few direct comparisons are available.

With growing cattle, a small liveweight gain advantage might be expected in favour of precision chopped silage. A summary of U.K. data from seven experiments by Kennedy (1989) showed similar intakes and liveweight gains on baled and conventional silages. However, a Canadian experiment with wilted lucerne silage showed lower performance on baled silage (Nicholson *et al.*, 1991). The 217 kg calves used in this experiment were given 1.5 kg/day of a barley supplement and the intakes (5.4 *vs* 6.1 kg DM/day) and liveweight gains (0.65 *vs* 0.92 kg/day) were lower on the baled silage. There was evidence of a poorer fermentation in the baled silage and this would have certainly accounted for some of the difference in animal production.

At this stage, more comparisons of baled *vs* conventional silages are required for a range of pastures and forages before any conclusions can be drawn on the effect of silage system on cattle production. One factor that needs to be considered is that crop characteristics will affect particle length in baled silage. For example, where silage is made from short highly digestible pasture there may be little difference between baled and conventional silage.

Feedout management: In experiments with baled *vs* conventional silage, the baled silage is usually removed from the bale and fed in the loose form. This may simulate the feeding system that is used on some farms, but there is a growing trend for farmers to feed baled silage from self-feeders. This system is becoming popular because of the low labour requirements and reduction in feedout losses. But what is the effect on silage intake? No studies have been conducted to compare feeding systems, but it is possible that in a production feeding (but perhaps not a maintenance feeding) situation silage intake, and therefore animal performance, may be enhanced by feeding baled silage

Table 8. Effect of silage chop length on production in sheep.

	Long	Short
	Lambs[1]	
Fitzgerald (1984)		
Silage intake (kg DM/day)	0.57	1.13
Liveweight gain (g/day)	-6	150
Apolant and Chestnutt (1985)		
Silage intake (kg DM/day)	0.45	0.72
Liveweight gain (g/day)	37	100
	Ewes and lambs[2]	
Apolant and Chestnutt (1985)		
Silage intake		
- late pregnancy (kg DM/day)	0.85	1.11
- weeks 1-4 lactation (kg DM/day)	1.03	1.42
Milk production (kg/day)	2.0	2.6
Lamb growth (g/day)	185	239

[1] Silage only diet; [2] Silage + concentrates. Mean data from three experiments.

in the loose form or after processing through a bale chopper.

Work with dairy cattle provides supporting evidence of an interaction between silage harvesting and feeding systems. Murphy (1983) compared long (230 mm) silage, produced by a forage wagon, with precision chop silage (52 mm) in an experiment where cows were either self-fed or given the silages in the loose ('easy fed') form. Milk production was similar when the two silages were 'easy fed', but significantly lower on the long silage when self fed. In another study, Gordon (1985) observed no interaction between feeding system and silage harvesting system (flail *vs* precision chop), but his flail silage was produced from short, leafy grass so the chop length was relatively short.

Clearly, if we are to be able to advise farmers on how to effectively utilize baled silage, more research is required on silage harvesting x feeding system interactions. This work should take account of the feeding space/head and the duration of access.

Integrating silage with grazing management

The conversion of pasture to animal product under grazing conditions is usually well below that which would be theoretically possible if all the pasture grown had been utilized by animals. For example, over two years Curll (1977) recorded beef production of 520 kg/ha on phalaris/subterranean clover pastures stocked at 1.85 steers/ha and fertilized with 250 kg superphosphate/ha. These pastures produced 13.4 t/ha DM which would have supported a potential liveweight gain of 1581 kg/ha if fully utilized at a high quality stage of growth. Hence, actual production was only 33% of the theoretical potential. Obviously it would be unrealistic to set the theoretical potential as an achievable target, but there is certainly considerable scope for an improvement in pasture utilization on improved pastures.

Effective utilization of surplus pasture as high quality silage is one strategy for increasing animal production. As shown earlier, this silage could be used to finish cattle or lambs sooner to meet market specifications, releasing pasture for the breeding herd/flock. Alternatively, silage can be used as a supplement for the breeding herd/flock with the animal production responses being obtained as an increase in stocking rate, improved calf/lamb growth, and improved fertility.

Effect on pasture

Previous discussion has focused on the role of silage for production feeding, and to improve pasture utilization. But what impact do silage cuts have on the pasture? Are there penalties? Can strategic silage cutting be used to increase pasture production, increase clover content and reduce weed content? These questions are largely unresolved, and the outcome could vary with pasture type - perennial grass/perennial legume, perennial grass/annual legume, annual grass/annual legume.

There is evidence that time of closure and time of cut could be important in terms of both total forage yield and silage quality. In the study presented in Table 9, earlier closure and earlier cutting both increased total forage yield during spring, and silage digestibility. There was no Grazing-Only control to compare with the four silage treatments. Total pasture yield over the same period from an uncut, ungrazed area was greater (7.6 t/ha DM) but this comparison is of no practical value. In another study, Curll (1984) compared conservation, and grazing + conservation systems. He concluded that a combination of grazing + silage cuts was likely to support higher forage production than grazing only (or silage cutting only).

In perennial grass/perennial legume pastures grazed by sheep or cattle, silage cutting promoted an increase in legume content (Curll, 1984; Laidlaw and Steen 1988). However, work with a perennial

Table 9. Effect of spring management of perennial ryegrass pasture on pasture, silage and milk yield. (Rogers, 1984; Rogers and Robinson, 1984).

	Early closure (23/9)		Late closure (10/10)	
Duration of closure (weeks)	4	6	4	6
Pasture and silage yield (t DM/ha)				
Pre-closure (23/9 to 10/10)	-	-	1.8	1.9
Silage yield	2.4	3.4	1.6	2.0
Regrowth to 16/12	4.1	1.9	0.8	0.4
Total (23/9 to 16/12)	6.5	5.3	4.2	4.3
Silage digestibility (%)	73.5	71.6	69.2	66.1
Milk yield (L/cow/day)[1]	12.3	11.5	11.4	9.9

[1] Silages given to mid-lactation cows. Diet comprised 75% silage and 25% high quality pasture.

grass/annual legume pasture in Western Australia showed that repeated cutting of the same paddock for silage each spring reduced clover content and increased weed content (Greathead, 1984). This result is contrary to farmer experience in southern NSW, where silage production has often been observed to be associated with a reduction in annual weed content. Greathead's study was conducted on a low potassium soil, and the decline in clover content was attributed to the lower soil potassium levels in the area cut for silage. Clearly we have a lot to learn about the effect of silage cuts on pasture productivity and composition. Timing of the cut is likely to be critical in terms of the recovery of pastures prior to summer, particularly on annual pastures where seed set could be reduced by late cutting.

Conclusions

Much of the technology is now available for farmers to consistently produce high quality silage from pastures. These silages can support high levels of animal production, and can be used to finish animals for specific markets, for supplementary feeding, to improve pasture utilization and to increase stocking rate. Targeting high quality and reducing losses are key factors influencing animal production per tonne silage and therefore profit. A number of areas require research. These include the role for silage additives and the extent of storage losses under Australian conditions. Economic comparisons of different silage systems are required. In particular more research is required on the production and feeding of baled silage. The integration of silage cutting with pasture management, and the effects of silage cutting on pasture productivity and composition needs to be investigated for a range of pasture types.

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