High Quality Silage for Sheep and Cattle Production

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1. SUMMARY

To make high quality silage

- Cut pastures 4 - 6 weeks before hay (vegetative to very early ear emergence)
- To increase wilting rate, cut light crops, use tedder immediately after mowing, use flail or tyned-type mower-conditioner and leaving swaths wide
- Harvest within 24 – 48 hours of mowing
- Sheep utilise silage best if it is chopped at ensiling OR at feed out, especially if its quality is low
- Short chop length of silage results in increased intake and production with young cattle but is not an issue for older beef cattle unless it constitutes a large proportion of the diet
- Use appropriate silage additive (Fermentation enhancers or Aerobic spoilage inhibitors)
- Sheep also utilise silage better with some grain added to the diet, less being needed as quality increases
- Seal storage (stacks & bales) airtight ASAP after harvest operations are completed
- Inspect storages regularly and repair holes with silage specific tape as soon as noticed
- If silage is mouldy, too wet, heats at feed out, animals perform below expectations, etc. find out the reasons why and overcome them
- NEVER feed mouldy silage to sheep
- Silage is an excellent drought storage if air and water is kept out

2. INTRODUCTION

Wilted silage, and particularly round/square baled silage, has increased in popularity in recent years with many sheep and beef farmers in Victoria. Past research has proven the benefits of

high quality silage for the dairying industry. For grazing enterprises, overseas and some Australian research along with farmer and experiences of feedlot managers confirm similar findings, i.e. better the silage nutritive value, the better the animal performance.

Feeding high quality silage has allowed:-

- animals to be turned off out of season thereby receiving higher prices such as:-
  - later at heavier weights for a different market
  - small lambs finished earlier so not carried over
- animals to maintain or put on weight when they might normally be losing it
- pregnant and lactating ewes to produce more milk and so heavier lambs
- wool quality to be improved by better grazing management and strategic supplementation of high quality silage to avoid sudden feed changes, affecting staple length.
- older, cull sheep to be "finished"
- weed seed burden to be reduced, except for hard seeded weeds in baled silage
- "unseen" benefits of high quality pasture regrowth, increased pasture utilisation, improved pasture quality further into spring

To achieve these benefits economically, the silage must be of high quality. As with hay, silage can vary greatly in its quality, but it has the potential to be a far higher quality supplement than most hay that is made! However, vetch, annual clovers and lucerne hay have the potential to produce high quality hay. In recent years, when making hay has been very difficult if not impossible due to inclement weather conditions, many farmers have been prompted to make wilted silage. Even farmers in "good hay making areas" have also experienced the benefits of wilted silage in its various forms.

However, many farmers have experienced problems when they have tried to make silage (stacks and bales), had their fingers burnt, and have gone from baled silage back to pit silage, or back to hay, and out came the excuses!

Silage?

Silage is twice the cost of hay!
I made a big stack and it all "went off"!
You can't make silage "that" early!
I cooked my silage well, the cows loved it, but they didn't "do well"!
Silage is not as good as hay!
Silage stinks, is hard work and has effluent run-off!
My wife won't come near me when I'm feeding silage!

Baloney!

Farmers who have persisted and overcome their initial teething problems in harvesting, storing, and feeding silage, are usually very happy with the product. Their animals are actually producing milk, meat, and wool in periods of the year when animals are traditionally maintaining, or even losing weight.
Most of the above comments would not exist if farmers were to:

- Make high quality silage by cutting pastures and crops at the right growth stage
- Use the correct management and techniques to harvest, store and feed out the silage.

3. WHAT IS GOOD QUALITY SILAGE?

Silage of high nutritive value is:

- **made early in the growing season**, approximately 3 - 5 weeks before hay is normally made. In West Gippsland, from approximately mid-October, a delay in harvesting silage every 10 days results in a drop of pasture quality by approximately 3-4 digestibility units which results in a drop in milk production of ~1 litre/cow/day. This would equate to a reduction in live weight gain of about 0.1 - 0.2 kg/day in meat producing cattle.

- made from pastures in the **vegetative stage** with high clover content and little seed head emergence of the grasses.

- composed of the following **quality characteristics**:
  - *Digestibility* greater than 70% (ie. over 10.5 MJ ME/kg DM)
  - *Crude protein* greater than 14%
  - *Forage harvested silage* - approx. 30% - 35% DM
  - *Round baled silage* - approx. 40% - 50% DM
  - *Large square baled silage* – approx. 45% – 60% DM

- **capable of producing about**:
  - 1300 kg milk/t DM silage
  - 125 – 135 kg beef/t DM beef yearlings
  - 140 – 150 kg beef/t DM beef weaners
  - 120 – 130 kg lamb/t DM
  - 140 – 150 kg lamb/t DM with some grain added, ewes and wethers produced extra wool and higher lambing percentages.

4. IMPORTANCE OF QUALITY and SUPPLEMENTATION

The following tables show the importance of quality of silage fed to a range of sheep classes and also, for sheep in many cases, the improved performance by adding grain in addition to the silage. Over recent years the importance of having silage of quality for improved production is much better understood and accepted although still not by enough farmers and contractors as yet. When looking at each table, carefully examine the silage characteristics as these can have large impacts on lamb and sheep production.

Table 1 shows the impact of increasing the quality of silage and also reducing the storage and feed out losses when the higher quality silage or the silage saved by reducing losses is converted to beef. Yes, yield of forage harvested will be down and cost/t DM harvested will cost more but the extra cost will be more than offset by the higher quality silage producing more and higher quality beef. Bulkier lower quality crops incur higher cost overall due to more bales or tonnes being harvested, requiring extra twine, netwrap, plastic, transport in/out, etc. Less obvious is that the animals need to eat substantially more to produce the same level of production, and won't if quality is too low (<8.5 MJ ME/kg DM).

Table 1. Impact of improvement in quality or reduced losses on the additional value of beef produced		
Quantity of fodder stored p.a.	300	tonne DM
Existing quality	9.5	MJ ME/kg DM
Target quality	10.5	MJ ME/kg DM
Existing losses estimate	25%	of total storage
Target losses	13%	of total storage
Value of beef: existing quality	175	cents per kg/liveweight
Value of beef: target quality	185	cents per kg/liveweight
Conversion to beef: existing quality	101	kg gain per tonne DM
Conversion to beef: target quality	142	kg gain per tonne DM

Loss range (%)	**Quality range (MJ/kg DM)**		
	9.5		**10.5**
25%	$0		$21,600
13%	$3,700		$27,200

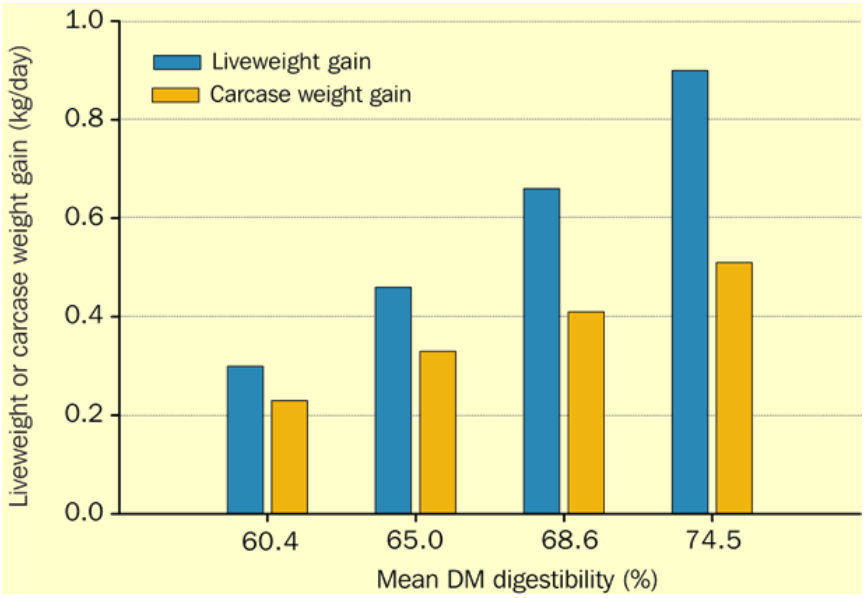
If 300 tonne dry matter of silage was made at 10.5 MJ ME/kg DM and losses of 13% are achieved there is an increase in the value of beef produced of about $27,000 compared to producing silage of 9.5 MJ ME/kg DM with 25% losses.

Table 2 shows the potential daily liveweight gain when young cattle are fed well-made silages of varying nutritive values.

Table 2. Approx. weight gains from young cattle fed well-preserved silages

Silage Quality (MJ/kg DM)	Potential liveweight gain (kg/day)
11	1.1 - 1.2
10	0.9 - 1.0
9	0.6 - 0.7

A summary of 40 experiments where liveweight gains were divided into four classes: <0.35, 0.36 - 0.55, 0.56 - 0.75 and >0.75 kg/day resulting from silage fed with average digestibilities of 60.4, 65.0, 68.6 and 74.5 % respectively, shows the liveweight and carcase gains per day **(Figure 1).**



Source: Flynn and Wilson (1978)

Figure 1. Effect of silage digestibility on beef cattle production (n = 40 experiments)

Table 3 shows the effect of cutting pasture early or only 2 weeks or 4 weeks after the early cutting time on intake, silage nutritive value and animal performance. The silages were well preserved, precision chopped

Table 3. Effect of time of cut on the production from steers fed grass silages*

Measurement	Time of cut		
	Early**	Mid	Late
Days from early cut	-	14	28
Intake (kg DM/day)	7.55	6.3	6.65
Organic matter digestibility (%)	70.7	62.8	58.3
Liveweight gain (kg/day)	1.14	0.65	0.44
Feed efficiency (kg lwt gain/t DM feed)	1.51	101	58

* Steers provided with protein/mineral supplement at 4.2% of diet, implanted with growth hormone, Initial liveweight 292 kg

** Early cut pastures at boot stage of growth

Source: Bertiaume et al, (1996)

Table 4 shows an Irish study where lambs were fed perennial ryegrass silages cut at three stages of growth. The silages were well preserved although wet by Australian standards. Although yield increased (doubled from the leafy stage) as pasture matured its nutritive value (ME and CP) decreased substantially. When fed to lambs intakes of all silages were low as reflected by their live weight gain and low crude protein content, even at the leafy stage.

When barley grain was added to the diet lamb production increased but less so as pasture matured.

Table 4. Effect of growth stage on the quality of perennial ryegrass silage and subsequent lamb production

	Leafy		Ear Emergence		Flowering	
Forage Characteristic						
Length of closure (Weeks)	6		8		10	
Yield (t DM/ha)	3.9		5.7		8.0	
DM content (%)	18.5		19.8		19.5	
Crude Protein (% DM)	12.7		9.7		8.3	
DM Digestibility (%)	**74.9**		**71.6**		**65.7**	
Silage Characteristic						
pH	3.7		3.7		3.7	
Volatile N(% of total N)	5.9		4.8		7.9	
Crude Protein (% DM)	12.4		8.9		8.9	
Estimated ME (MJ ME/kg DM)	**11.2**		**10.0**		**9.8**	
Animal Production						
	Silage	**Sil + Barley**	**Silage**	**Sil + Barley**	**Silage**	**Sil + Barley**
Silage Intake (g DM/day)	787	737	559	587	437	468
Barley intake (kg DM/day)	0	256	0	256	0	256
Liveweight gain (g/day)	12	92	-17	55	-56	28
Carcase weight gain (g/day)	**21**	**68**	**-13**	**44**	**-40**	**19**
Carcase gain/ha cut (kg/ha)		288		342		260

Source: Fitzgerald (1987)

Ryegrass ensiled with 2.5 L/t fresh forage formic acid. Barley supplement fed at 300 g/day. Lambs initially 38.5 kg liveweight. Carcase wt gain/ha assumes a total of 20% losses ensiling b/w mowing and feedout

Table 5 shows some Wagga Wagga research crossbred lambs were fed sub clover on its own or supplemented with various rates of barley grain or barley/Lupin mixes. Grain supplies readily fermentable (available) energy to the sheep's rumen, which will increase utilisation of excess nitrogen due to the degraded protein by rumen micro-organisms, resulting in increased intake and production.

The lupin replaced some of the barley to maintain diet crude protein content at a similar level to the sub clover silage and lead to increased intake and lamb liveweight gain. Although liveweight gain should be similar with all diets, the lambs responded to protein nitrogen that was not supplied by the silage.

Table 5. Production from lambs fed sub-clover and grain diets

Grain in the diets (%)	Nil	Barley			Barley/Lupin			
	0	25	50	75	25 (79:21)*	50 (79:21)	75 (79:21)	100 (66:34)
Diet Crude Protein (%)	17.9	16.8	15.6	14.5	17.9	17.9	17.9	20
Diet ME (MJ ME/kg DM)	10.2	10.8	11.3	11.9	10.8	11.4	12.0	12.1
Total Intake (kg DM/day)	1.09	1.16	1.18	1.14	1.27	1.42	1.24	1.16
Liveweight Gain (g/day)	108	163	197	208	194	253	243	236
Feed Efficiency								
(kg feed DM/kg LWt gain)	10.11	7.27	6.09	5.99	6.72	5.64	5.36	4.95
(kg LWt gain/t feed DM)	99	138	164	167	149	177	194	202

Source: Graham et al, 1992

* Ratio of barley:lupins in brackets. Lambs initially 31 kg liveweight

Protein supplements such as lupins can be used to supply bypass, or undegradable protein (UDP) or a source of rumen degradable protein (RDP). The crude protein content of the silage and the extent to which it has been degraded during silage fermentation phase will determine the extent of response by sheep on silage diets to protein supplements.

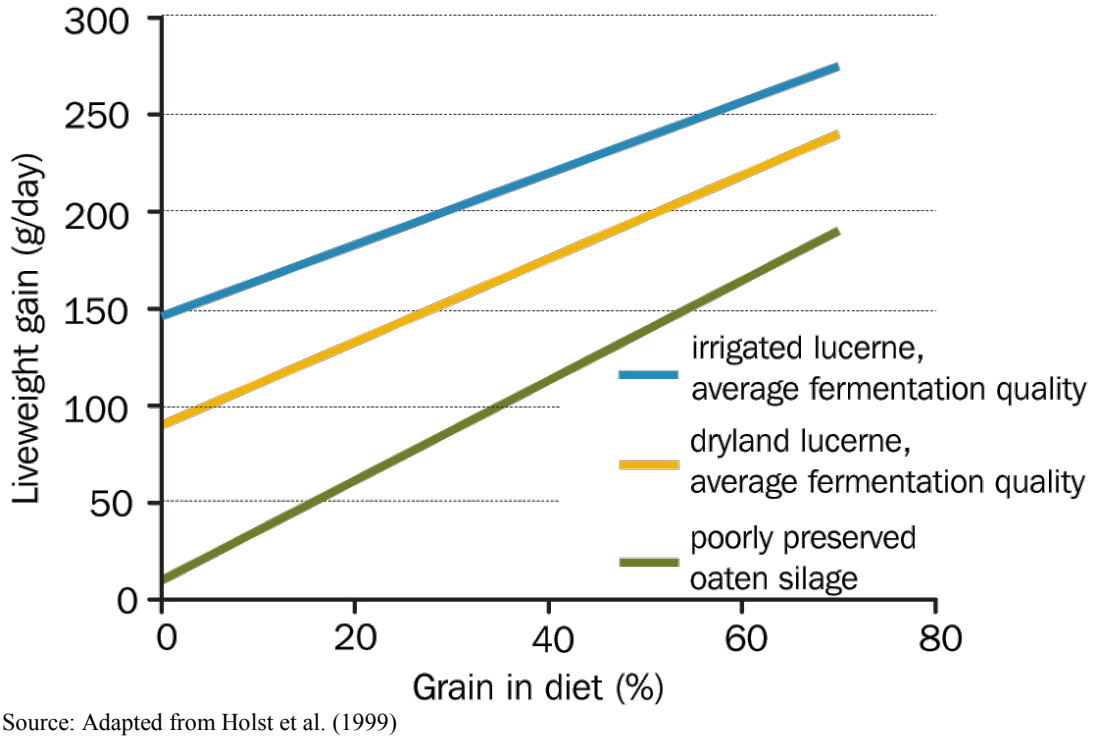
Sheep perform well on a range of silages although silages in **Table 6** were all past the ideal stage of cutting for high production but their ME values and CP contents were good in all but the mature pasture silage. Poorer performance of the kale silage was probably due to its extremely low DM content, poorer quality fermentation and/or degraded silage protein.

Table 6. Effect of different silages on the performance of finishing lambs over 8 weeks

Measurement	Ryegrass	Red Clover	Lucerne	Kale
	75% flowered	Flowering	Late bud	16 weeks
Dry Matter (%)	47	41	50.8	18.7
Crude Protein (%)	11.6	18.8	22.2	16.1
Metabolisable Energy (MJ ME/kg DM)	10.0	10.6	10.4	11.2
DM Intake (kg/day)	0.65[b]	1.01[a]	1.05[a]	0.74[b]
Liveweight gain (g/day)	36[c]	135[a]	135[a]	100[b]
Feed Conv. Efficiency (kg Lwg/kg DM)	0.053[b]	0.133[a]	0.130[a]	0.136[a]
Final liveweight, Day 56 (kg)	30.9[c]	38.3[a]	37.2[a]	34[b]
Final body condition score (Day 56)	2.3[b]	2.6[a]	2.7[a]	2.6[a]
Source: Marley el al. 2007, IGER, Aberystwyth				
8 mth old Suffolk-cross lambs, Silage wilted 24 hrs, inoculated & Round baled				
Numberes with different letter are significantly different				

Figure 2 shows the range of expected growth rates for a range of diets for finishing crossbred lambs in a feedlot. Less grain is needed to produce a certain liveweight gain as silage quality increases and increases as the level of grain in the diets increases. Obviously, there will be a limit as to how much grain is fed and will vary from season to season based on the cost of grain.

Figure 2. Live weight gain of cross-bred (Border Leicester x Merino) lambs fed different silages with varying proportions of grain in a feedlot situation



Source: Adapted from Holst et al. (1999)

Lambs with live weight under 30 kg require a source of bypass protein (UDP) in the diet but once above 35 kg, rumen microbial protein synthesis will meet lamb requirements. In poorly preserved silage where degradation of the protein fraction is more extensive, additional protein supplements may be required by all lambs.

The higher the nutritive value of well-preserved silage, the higher the animal performance.
To achieve this:-

- cut pasture silage early in the season or crops at the right stage of growth
- harvest quickly
- store within 1 to 2 days, if possible
- seal airtight!
- monitor storages regularly and repair holes with silage specific tape

5. IMPORTANCE OF LENGTH OF CHOP

Dairy and beef cattle do not necessarily respond to short cut vs long chop silage, unless it constitutes a high proportion of the diet, and more so with younger animals than adults. The advantage of short chop silage is its slightly better fermentation, less air entrapped at harvest, less cost to seal per tonne DM and easier to feed out, depending on equipment available.

However, research has shown that sheep generally will perform better when silage is cut short at harvest or if chopped before feeding. **Table 7** shows the increased intakes and substantially increased production from reduced chop length.

Table 7. Effect of Silage Chop Length on Lamb Production

LAMBS	Chop Length	
	Long	Short
Experiment 1		
Silage Intake (kg DM/day)	0.57	1.13
Live weight Gain (g/day)	-6	150
Experiment 2		
Silage Intake(kg DM/day)	0.45	0.72
Live weight Gain(g/day)	37	100

2 Experiments Silage only

Table 8 shows the effect of length of chop of pasture silage on performance when offered *ad libitum* to pregnant ewes and castrated lambs. Mean daily silage DM intake of ewes was 0·99 kg and 1·28 kg in mid-pregnancy, and 0·85 kg and 1·10 kg in late pregnancy with flail-harvested (long

chop) and precision-chop (very short chop) silages respectively. Silage was supplemented with various levels of concentrate in late pregnancy and an increasing level of concentrates did not reduce silage intake.

In early lactation, when 800 g concentrate was given daily, ewes consumed 1·00 kg flail-harvested silage and 1·39 kg precision-chop silage. Compared with flail-harvested silage, precision-chop silage increased ewe body weight immediately post lambing by 5·1 kg, lamb birth weight by 0·27 kg and lamb growth rate by 58 g/day. Increases in intake of precision-chop silages by hoggets were on average greater, though more variable, than by ewes and were reflected in increased carcass weight.

It appears that the major factor for the increased intake of the finely-chopped silage due to the physical size of particle. However, there was some evidence that indicated that improved fermentation resulting from short chopping may have been partly responsible for increased intake.

Table 8. Effect of Silage Chop Length on Sheep Production

EWES & LAMBS	**Chop Length**	
	Long	**Short**
Experiment 1 & 2		
Silage Intake - Late preg.(kg DM/day)	0.85	1.11
-Weeks 1- 4 lact.(kg DM/day)	1.03	1.42
Experiment 3		
Milk Production (kg/day)	2	2.6
Lamb Growth (g/day)	185	239
3 Experiments Silage + Concentrates		

S. M. Apolant and D. M. B. Chestnutt (1984) Agric. Research Inst. of Northern Ireland, Hillsborough, Co. Down

Table 9 shows French results of several experiments where sheep were fed flail harvested silage as harvested (without chopping) or the same silage chopped before feeding. In all experiments chopping silage before feeding increased intakes.

Table 9. Influence of chopping flail harvested silage just before feeding on DM intake

Silage Type	Number of comparisons	Relative DM intake (%)	
		Without chopping	With chopping
Grass	2	100	150
Lucerne	4	100	129

Demarquilly and Dulphy (1997)

More details about most of the above tables and figure can be found at the following website which also contains much information about all aspects of silage production for all classes of stock. This is the home of the Topfodder Silage "Successful Silage" manual http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/294053/successful-silage-topfodder-complete.pdf

6. HOW TO MAKE GOOD QUALITY SILAGE

Harvest pasture early in the season, after a short shut-up period.

Wilt the pasture to the required dry matter content as quickly as possible.

Harvest as quickly as possible, preferably within 24 – 48 hours.

Why must the mown pasture be wilted and harvested, as quickly as possible?

The forage continues to respire ("live") rapidly after mowing but decreases substantially once it is wilted to above 40% dry matter before they "die". Until this level of dryness is reached, the plant wants to, and is able to survive. When a plant is growing in the soil it is collecting water and nutrients and uses atmospheric carbon dioxide to produce sugars and proteins (+ other plant parts). When it has been mown the plant is cut off from its supplies. It then goes into survival mode!

- After mowing the plant greatly reduces its rate of water loss through the holes or stomata in its leaves (within 2 – 4 hours).
- It will then use its own sugars and proteins (plant material) as food (energy) to survive (this is what you are putting away for your animals).
- The longer this goes on, the more nutrients it uses and the lower will be the quality of your silage, along with some loss of forage dry matter.
- Also, the longer the wilting period, the greater the chance of rain, and if it rains, this could result in a longer plant respiration period, leaching of nutrients, leaf shatter loss, growth of mould, etc.
- **Therefore wilt quickly**.

Doing the job - Be prepared! Be aware that many factors will cause you to change tack from

your predetermined plan. You must be prepared to be flexible and be ready to move when the weather clears. Weather changes are frequent and often unpredictable in the early-mid spring period. Well before harvest starts ensure that equipment and labour availability/suitability is sorted, that contractor timing/availability has been communicated in advance, twine and plastic is on hand, storage sites are cleared, etc. Crop types, soil conditions, quality of silage required, etc. must also be considered in advance.

Rough guide for harvesting pasture or crop as forage harvested or baled silage

When harvesting early to make high quality silage, temperature may be low (20 - 22^{0}C), possibly overcast, and the ground probably damp. The following guidelines may need to vary according to changing circumstances such as unexpected rain, equipment breakdowns, etc.

Day 1

Mowing:

Mow mid-late morning, after the dew has lifted, when the weather forecast or your own experience indicates 2-3 days of fine weather approaching. Mowing an early season crop (3 - 5 weeks before hay), or one which has a short shut up period (3 - 5 weeks), usually means that the crop is light (less than 3 t DM/ha). This crop will be about 25-30 cm in height or about ½ - ⅔ the way up your gumboot. This ensures a quicker wilt at a time when the ground is still moist and drying weather is warm rather than hot.

Heavy crops (crop near tops of gumboots and/or well in head) produce high yields but are extremely difficult to wilt quickly, are very low in nutritive value, and regrowth is negligible or sparse at best. **Mow** only the area of the crop that you can safely harvest the next day or so within the limits of machinery, labour, weather, etc.

Spreading (Tedding):

Spread (ted) the crop immediately after mowing if you have access to a tedder or tedder rake **(Figure 3).** This will increase the rate of wilting by 30% - 60%. Travel slowly (5 - 6 kph) for this first tedding to ensure all the mown pasture is spread evenly, and to avoid lumps being formed. In mown in late spring - early summer the first day turns out hot, the grass will wilt very quickly and may enable you to begin harvesting on the same afternoon as mowing.

Figure 3. Tedder spreading mown pasture

Day 2

Respreading:

Early in the season a **second spreading,** after the dew has lifted, is often required as drying conditions at this time of year are not conducive to fast wilting. The plants will still be quite durable so that losses/damage of leaves will be negligible. This tedding can be carried out at a much faster speed than the first tedding (7 - 10 kph). Tedding can be safely carried out up to approximately 50% DM content without too much leaf loss.

Raking:

After lunch, or later in the day, when the crop is near the desirable dry matter content, **rake** the wilted pasture into windrows to suit the forager or baler . Light crops may require raking in one direction, and then raking in the reverse direction, on the opposite side, to produce a good sized windrow. However wide thin, windrows results in more densely compacted bales, with less air trapped in the bale.

Harvesting:

If you plan to **forage** (Loader Wagon or Precision Chop) the crop then start when the dry matter percentage of the wilting pasture is approaching 28% - 30% DM. You may have to start harvesting before 28% DM if the weather forecast is for a hot day, bad weather is approaching, or you have a lot of pasture on the ground. As the crop dries, you will be able to shift up 1 - 2 gears. You may be able to dispense with the second tedding if the crop is light, or if the crop had a good wilt the day before, or the day of harvest is expected to be hot.

If you plan to **bale** (round or square) start when the dry matter content is approaching 40% DM. This should be about mid-day or mid-afternoon of Day 2. Occasionally you may need to respread the grass a third time and bale later on Day 2 or on Day 3. This might occur if the weather turns cloudy, misty and/or the crop is very heavy (> 4,000 kg DM/ha, i.e. near the gumboot top).

If you do not have access to tedder equipment, consider these options.

1. Mower- conditioner or conditioner only:

If you use a mower-conditioner to drop the crop, it is preferable to leave the swath boards open fully or completely removed. This will promote a substantially faster wilt. If wide cutting widths, are conditioned into narrow windrows, only the outer 2 - 3 cm of the windrow will be dry after several hours. Meanwhile the plant in the rest of the thick dense windrow continues to "survive", i.e. respire, by using the very nutrients you are conserving for your animals. The longer this occurs, the more quality that is lost!

The abrasive (flail/tyned) type of mower conditioners **(Figure 4)** are better for pastures than the crushing (roller) type because a higher proportion of the stems are left intact, thus promoting a higher, fluffier, more open windrow for sunlight and wind movement. The stems and leaves are abraded or scuffed. The roller type is necessary for legumes (lucerne, clovers, faba beans, peas,

etc.) and summer forages (sorghums, sudax, etc,) to crush the succulent stems. There is a danger of nutrient loss due to leaching if rain falls on conditioned crops. This is more than offset by the reduction in the drying period and the reduced risk of rain.

Figure 4. Tyned-type mower conditioner suitable for pastures.

2. Rake only:

If you cannot beg, borrow or steal a tedder or a tedder rake, try to use your existing rake to flip the swath over. This will increase the drying rate to some extent. This could be done in the late afternoon of DAY 1 or mid-morning of DAY 2. Foraging may be possible late on DAY 2, but making round (or square) baled silage would be unlikely until at least DAY 3. Avoid ropy windrows - this will decrease the drying rate and promote uneven drying.

7. SILAGE ADDITIVES

Silage additives include a wide range of products which serve to increase the efficiency of the fermentation process and/or to delay spoilage by aerobic deterioration micro-organisms. These operate by various modes of action.

Silage additives can be classified into 3 main categories:

1. Fermentation enhancers/stimulants
2. Anaerobic fermentation inhibitors
3. Aerobic spoilage inhibitors
4. Combined additives

1. Fermentation enhancers/stimulants

These products, bacterial inoculants and substrate suppliers such as molasses, enhance the fermentation process so that the required acidity (pH) level is reached more quickly and efficiently to produce the desirable sweet smelling highly palatable lactic acid silages. This results in less dry matter and quality loss. Bacterial inoculants make up the majority of this

group and are manufactured populations of specific strains of desirable lactic acid producing bacteria. These "good guy" bacteria are mainly the *Lactobacillus* and *Pediococcus* species.

When added to the harvested crop, these inoculants increase their own population to support the naturally-occurring good guys and may (but not always) help to out-compete the less desirable bacteria. Some inoculants also contain enzymes, some contain sugars and some now contain a strain that can slow down aerobic deterioration.

2. Anaerobic fermentation inhibitors

These tend to restrict undesirable bacteria (clostridia), plant enzymes (proteases) and possibly even lactic acid bacteria. These products are organic acids such as propionic, formic and sulphuric. They have been used extensively and effectively overseas but are dangerous to use and can corrode equipment. These have been replaced by buffered acid derivatives of the same organic acids and are much less dangerous and much less corrosive. Another product, sulphur-based and includes amylase to break down lignin, also achieves the same effect.

3. Aerobic spoilage inhibitors

These additives suppress the growth of yeasts, moulds and aerobic bacteria which extends the bunklife of stored silage and delays spoilage (moulding, aerobic deterioration) and heating at feed out. Within this group of silage additive are:-

- Organic acid salts (benzoate, propionate, formate, sorbate). These products kill or severely restrict growth of all micro-organisms, yeasts and moulds in silage.
- *Lactobacillus buchneri 40788,* a specific heterofermentative Lactic Acid Bacteria inoculant, produces acetic acid during the fermentation process which restricts yeast and mould growth.
  L. buchneri require 45 – 60 days before the bacteria becomes effective so is not useful:-
    - If holed plastic is left unpatched for several days
    - Around poorly sealed stack perimeters
    - Against bunker walls if poorly sealed
    - If a stack is opened within weeks of harvesting
- Other bacterial aerobic spoilage inhibitors are currently being researched.
- A product incorporating Sulphur bearing compounds + amylase enzymes which produce sulphur-type gases within the mass of silage which limit plant cell respiration and reduce the number of undesirable bacteria, yeasts and moulds.

They are most useful in maize and whole-crop cereal silage cut at the late milk-soft dough stage, excessively wilted pasture silage, silage stacks which heat up due to slow feed out rate and large square baled silage stored in modules under sheets of plastic.

4. Combined additives

There are some additives which have been combined to carry out two modes of action. A major group of these are the fermentation enhancer and aerobic spoilage inhibitors which act to enhance the fermentation and delay spoilage at opening.

Are silage additives cost effective?

Research into silage additives over many years has resulted in their refinement to the extent that products from reputable companies are robust, effective and reliable if managed correctly. Most silage in the USA and many European countries are treated with some form of silage additive. A review of 12 years of trial work in Ireland showed the following average responses to inoculants:

- ✓ 5% increase in silage intakes
- ✓ 7% increase dairy cattle performance
- ✓ 14 % increase in beef performance
- ✓ Reduces in silo DM losses by 2-3%

Silage additives should be considered for application in most silage harvests in Australia. To get the best returns from silage treated with an additive, it should be applied to forage of high quality, fed to responsive animals (i.e. to produce milk or meat, grow young stock, etc.) and be a significant proportion of a diet.

It is generally agreed that for every $1 spent on silage additives, the returns will be about $3 - $5, sometimes a bit more, sometimes a bit less.

When should silage additives be used?

1. Low DM in forage, low in Water Soluble Carbohydrate (WSC) forages, and when wilting is not possible.
   Molasses (+/- inoculant), acid or acid salt
2. Low DM in forage, or lightly wilted, moderate to high WSC, poor wilting conditions.
   Fermentation enhancing additive, sulphur based compound + enzyme, acid or acid salt
3. High ME silage, good preservation expected, no stability problem expected.
   Nil additive or Fermentation enhancing additive
4. Significant risk of aerobic spoilage during feed out.
   Anaerobic spoilage inhibitors, organic acid salt or combined additive

Be aware, silage additives will not "fix up" a stuff up!

8. STORAGE (Stack & Baled Silage)

Air is the greatest enemy of wilted silage

**** Seal the silage storage airtight ASAP after harvest and maintain the airtight seal***

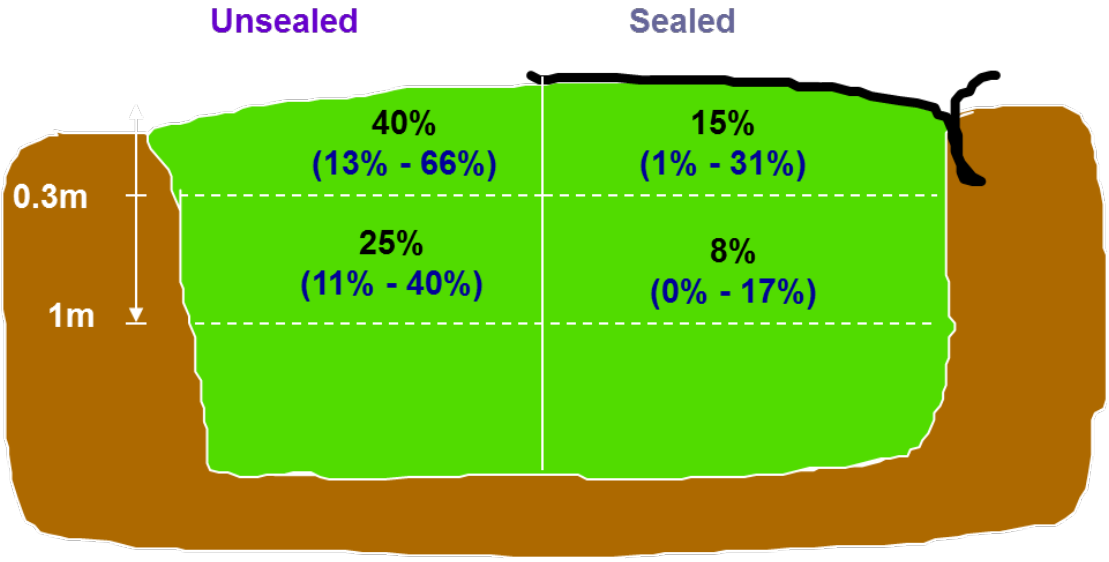
Bales and stacks must be compacted as much as possible to expel as much air as possible to minimise losses during the early stages of the fermentation process. The plastic seal (sheet or stretchwrap film) must form an airtight seal and the seal maintained throughout the entire storage period. If air does enter the stack or bales; the longer the chop, the drier the silage, the warmer the air temperature, the longer that air can enter left unsealed, the larger the hole and **increasingly greater is the air penetration and silage deterioration**.

STACK SILAGE - Bunkers, pits, clamps, single/double wedges, buns

- Stacks should be long, narrow and deep. This results in less surface area per volume of silage requiring less plastic sheeting. Silage in pits and bunkers allows greater compaction than above ground stack and safer to roll.
- Bun stacks have a large surface : volume areas, are more expensive to seal, and more dangerous to make.
- Spread the chopped material in thin layers (less than 0.2 m depth) and evenly over the stack surface to allow good compaction when rolled.
- Roll **slowly** to allow time for the vehicle's weight to provide maximum compaction.
- The stack has not been rolled well enough if it is hot the following day.
- Preferably use one sheet to cover the entire stack. If several sheets are used seal plastic sheet joints with plastic tape specific for silage plastic or overlap by 0.5 - 0.8 m and lay sand bags along the join.
- The plastic sheet around the perimeter of the stack should be covered with soil or sand containing clay to form an airtight seal **(Figure 5).** Two overlapping rows of woven plastic socks filled with pea gravel or washed sand form an excellent easy to use seal. A single or double row of tires is NOT an airtight seal**.**

Figure 5. A well-sealed, airtight silage stack

- **Figure 6** shows the DM losses of unsealed and sealed stacks at 0.3 and 1.0 m depth as measured in stacks in Gippsland.



Source: Ertiro & Clarke , Ellinbank

Figure 6. Effect of sealing on chopped silage DM losses

- Recent developments in plastic technology such as the oxygen barrier one or two step system should be investigated **(Figure 7)**. Despite their extra cost, the reduced DM and quality losses more than cover the extra cost.
- Cover the stack each night and weight the perimeter heavily with tyres or gravel socks to minimise cycling of hot air leaving the stack to be replaced by cold air. Weight the rest of the stack lightly depending on amount of wind.
- Seal the storage airtight as soon as possible after harvesting is completed. Place white side up of black/white sheets. If using gravel socks, overlap two rows around the perimeter as end to end joins won't be airtight. Single row **(Figure 7) is** not be airtight.

Figure 7. Two step (oxygen barrier clear film + UV treated tarp) sealing system

BALED SILAGE - Round/Square Bales

Round baled silage can be stored as:-

1. Individually wrapped bales or
2. Continuous In-line wrapped with stretch wrap film
3. Group storage of large square bales

1. Individually Wrapped Bales (Stretch Wrap Film)

- Most effective baled storage system with 6% - 10% DM losses unless plastic is holed leading to very high losses if not repaired immediately. Monitor regularly. Losses have not been measured in large square bales but should be similar, if not less.
- Bales should be tight, even and barrel shaped (rounds), or square (rectangular).
- Wrap round bales with at least 4 layers of film (2 + 2 with 50% overlap i.e. overlap by ½ width of film and if not, a "window" will occur which will allow air to pass into the bale, resulting in DM and nutritive value loss and mould growth **(Figure 8).**

Figure 8. Underlapped wrapping with only 3 layers after the final wrap is applied.

- Wrap large square bales with at least 6 layers of stretchwrap film (2 + 2 + 2, 50% overlap due to sharper corners than round bales.
- Until recently all films in Australia were stretched 55% as it was being applied to the bale. Recently, and increasingly so, more companies are supplying film that requires a 70% stretch and 6 layers applied. Check specifications and recommendations with the film supplier.
- To check what per cent stretch is being applied, mark 10 cm on the roll on the pre-stretching unit and remeasure once applied to the bale. If 55% stretch, measurement will now be 15.5 cm **(Figure 9).**
- Bale diameters vary so to ensure adequate amount of film is applied count the number of revolutions to apply the first two layers PLUS add one more revolution. Repeat once more for 4 layers, or twice for 6 layers.

- Wrapped bale silage can only be relied to maintain its quality for about 12 months. If you desire to store bales past one season:-
  - Place an old plastic sheet over the bales but lay bait for rodents
  - Bury in an old silage pit for long term storage but wrap first
  - Apply 6 layers when wrapping.

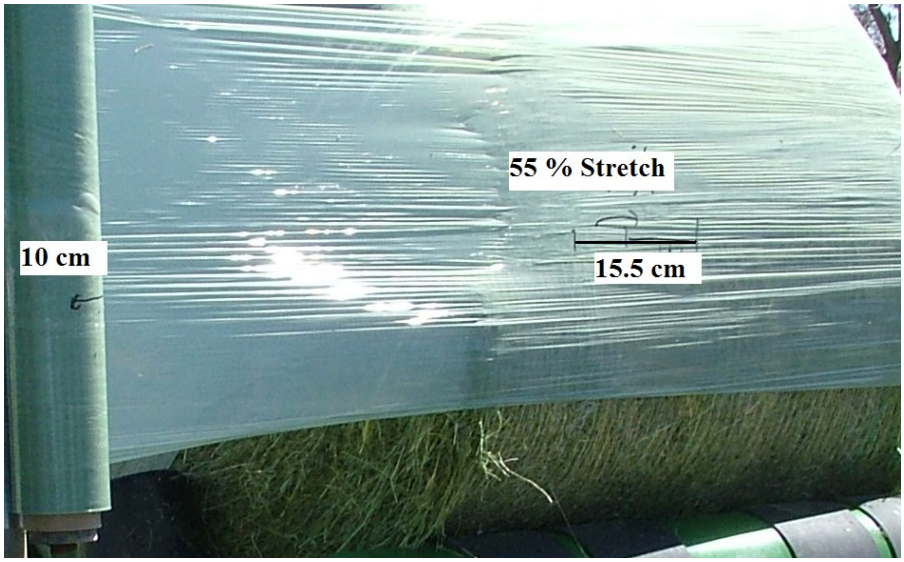


Figure 9. 10 cm on roll stretches to 15.5 cm on bale at 55% stretch.

- Preferably store wrapped round bales on their ends:-
  - bales will maintain their shape
  - may be stacked two high if firm, even shaped and over 40% DM
  - less likelihood of bird, grub and mice damage
  - extra layers of film on bale ends so that if breakdown of the film (due to ultra-violet rays of the sun) occurs, damage will be reduced substantially

- Holes, even small holes, can lead to substantial losses. Use specific stretch film patching tape for immediate repair of all holes. Ensure the stretchwrap film is clean, dry, cool and repair tape is of similar colour before applying tape.

- Watch out for and counter attack against mice, cats, possums, cats, sugar ants, Oxycanus grass caterpillars, seagulls, cockatoos, kids, etc. Various methods have been employed by farmers to combat these problems.
  Birds: Humming wires, plastic foil tied on tight wire/string, tyres on bales, move bales off the paddock of harvest or to storage area quickly, stretch bale netwrap or netting over bales, etc.
  Rodents: Bait storage area before storage starts, and away from storage site, ring of lime around bales, place on sand base.

2. Continuous In-line Wrapped Bales (Stretch Wrap Film)

- Round and square bales are continuously wrapped in a long sausage with no film attached to the ends of the bales which contains excess film on individually wrapped bales.
- A “plug” such as an individually wrapped bale or piece of plastic sheet, is incorporated at either end to form an airtight.
- Most manufacturers recommend wrapping with at least 6 layers of film. Some even recommend 8 layers at the bale joins as different diameter bales can cause overstretching of the film and similarly at the bale bottom as it comes off the wrapping platform, often resulting in film breakdown.
- The advantage of less film being required than individually wrapped bales is now largely negated due to the requirement of extra layers.
- If bales are not similar in diameter overstretching of the film can occur and eventually allow air entry and deterioration of the bales in both directions **(Figure 10).**

Figure 10. Bale deterioration due to overstretch of film at the join

- Large square bales when wrapped in a double row can allow air to travel along the sausage at the top/bottom bale interface **(Figure 11).**
- Install “plugs” to prevent air travelling down the line but will also act as a more permanent plug if the entire line is not required for feeding.
- Less flexibility for selling or transporting tubeline bales unless used immediately.

Figure 11. Mould growth at top/bottom bale interface due to air moving down the tubeline

3. Group storage of large square bales - Stacks under Plastic Sheets or in Pits

- Round bales should not be stacked and sealed under sheets of plastic as they trap too much air between the bales and invariably the stack becomes compost due to even the smallest hole/split in the plastic cover.
- Large square bales are suited to storage under sheets of plastic in *modules* or in *pits*.
- Losses of DM can range from about 8% - 15% in modules but higher if holes/splits occur in the film or feeding out from the module takes several weeks.
- **Modules:** Store enough bales per module for about 2 – 3 weeks feed. Seal the stack edges with soil to form an airtight seal **(Figure 12).** Place weight over or on module to prevent plastic flapping, causing splits and allowing air entry leading to silage deterioration. Apply an aerobic spoilage inhibitor silage additive to delay onset of spoilage at opening.

Figure 12. Large square bale module, sealed airtight, well weighted

- **Pits:** Try to construct pit with straight sides and back. Produce even length bales to make stacking easier and to minimise air pockets. Place bales hard against the back and one side of the pit **(Figure 13).** Fill the inevitable gap on the opposite bank with soil/sand etc. to expel air.

  Compartmentalise the pit stack into sections to prevent air seeping too far back when pit is opened. Make sure the front of the stack is sealed airtight

  Apply aerobic spoilage inhibitor additive at harvest to delay heating and deterioration upon opening and feed out. Will not protect against deterioration if plastic damaged.

  Weight the top of the stack with tyres or gravel socks and seal entire perimeter airtight. A light covering of soil sprinkled with grass seed will provide a good weight and easily removed by grabbing the grass.

Figure 13. Large square bales packed tightly into a well-shaped pit

9. FEEDING OUT

Air penetration of the feeding face in stacks must be minimised

Baled silage should be eaten by day 3

Do not feed mouldy silage to sheep (or horses)

Silage must be fed in such a way as to avoid fouling by faeces, urine and mud. Lamb production can also be lost by inadequate access to the silage at feeding. Lambs need about 15 – 20 cm/head trough space for grain, or 200 lambs can feed from a 2.4 m self-feeder if feeding from both sides. Consider allowing larger spacing at the trough to prevent shy feeders missing out.

Provide access to 25% of the sheep to feed at any one time. There is some evidence from Cowra research that feeding silage and grain separately (in self-feeders) is more efficient and lower capital cost to mixer wagons.

Lambs will accept high quality silage as a sole diet but introducing grain to the diet needs to be managed to avoid acidosis (grain poisoning) if cereal grain is fed to unconditioned lambs. Introduce increasing quantities of grain daily to the lambs over 2 weeks. Start at 20% of the ration or daily intake and increase by 15% every second day. Ideally, introduce lambs to the silage and supplementation process before weaning so that the feeds are not new notwithstanding grain still needs slow introduction at a later date.

Following are suggested management practices at feeding out

Stacks:

- Remove a minimum of 250 - 300 mm depth from the stack face each day or 300 - 450 mm every 3 days. This amount of silage removal minimises secondary fermentation losses. If the stack feels warm when silage is removed, then the feedout rate is too slow.
- The stack face can be left uncovered if not facing prevailing winds, and is being fed from daily. Pulling the plastic sheet down actually provides a warm, moist environment encouraging increased activity of bacteria, yeasts, mould growth, etc.
- Reseal the stack airtight if silage feeding is no longer necessary.
- Use a block cutter, shear grab or a silage grab in such a way as to minimise disturbance of the silage face. This reduces air penetration further back into the stack.
- Feed out in thin lines to minimise fouling by trampling and manure/urine. Bales fed in feeding rings should be gone by day 3, removing any residuals to prevent mould/spoilage build up.
- Self-feeding from stacks: losses may be quite high - a solid base is needed if feeding out in the late autumn/winter period. A moveable barrier will minimise silage wastage. Continually clean away the fouled silage. It is often cleaned up by stock if fed out in the paddock.

Stack height should be no more than approximately 1.5 times the height of the animals being self-fed. Allow 5 - 6 animals per metre of feeding face if on 24 hour access but reduce to 2 - 3 animals per metre if on limited access.

An electric fence wire on the ends of steel posts driven end on into the stack is often used for cattle. Tombstone style feeding frames are very efficient and minimise wastage. Framed weldmesh with some wires cut out are suitable for sheep. Watch for wool removal near the neck.

Bales:

- Feed out in narrow windrows in the paddock, under fenced lines **(Figure 14)** or troughs if using a bale buggy type feedout cart

Figure 14. Feeding silage to sheep in a controlled manner

- Whole, round bales should be fed in a feeder at 1 bale/60 – 70 lambs. This will provide about 50% of daily intake and last about 3 days.
- Bales being fed from feeder rings should be eaten by the end of the 2nd day to avoid heating and silage deteriorating.
- Bales fed without a feeder ring result in much waste and spoilage **(Figure 15)**
- Large square bales can be broken into biscuits for good access.

Figure 15. Silage being is wasted when fed without feeder ring

10. GUIDE TO DRY MATTER ESTIMATION OF PASTURE

1. Hand Squeeze Method

Take a representative sample of pasture ready for ensiling. Cut it into 2 - 3 cm lengths and **tightly** squeeze a handful for ~60 seconds. Then quickly open your hand. The table below gives a rough indication of the DM % of the material.

Using this technique, in conjunction with the Microwave Oven Drying Method will allow you to calibrate yourself with this Hand Squeeze Method, which is faster, but not as accurate.

Dry Matter Content	Condition of the sample after squeezing
Below 25%	Ball holds its shape. Lots of free juice. Hand is wet or moist.
25% - 30%	Ball just holds it shape. Hand barely moist. Ideal for wilted silage.
30% - 40%	Ball falls apart slowly. No free juices. Makes excellent silage, but because of its springiness, requires fine chopping or extra care to exclude air.
Over 40%	Ball springs apart quickly. Suitable for round bale silage but total air exclusion is essential.

Microwave Oven Method

1. Collect representative samples from the crop and thoroughly mix them together - sub sample to get a test sample.
2. Weigh out approximately 100 g sample of the chopped forage **taring** the weight of the container. Exactly 100 gm makes calculation simple. Weigh to the nearest gram.
3. Spread the weighed forage sample on a paper tray and put it in the microwave oven.
4. Place a 250ml glass three-quarters full of water at the rear of the oven to prevent the sample igniting and to absorb some of the odour. Replace water during oven use.
5. Heat at 80% to 90% of maximum power for 4 minutes if sample is estimated to be 30% - 50% dry matter. Wetter the sample, longer the oven drying periods required.
6. Remove the sample, reweigh, mix and place in oven.
7. Continue to re-heat for 1 - 2 minute intervals, re-weighing each time. To prevent burning, use lower heat and 30 second time intervals as the sample approaches being dry. If the sample chars use the last weight recorded. This will be within 1 – 2% of its final dry weight.

8. Calculate dry matter content as follows:-

Dry weight (g) x 100 = ...% Dry Matter ***eg. 38 x 100 = 38% DM***

Initial Weight (g) 1 ***100 1***

11. RECOMMENDED DRY MATTER CONTENTS FOR GOOD FERMENTATION and SILAGE STORAGE

What is the correct Dry Matter (DM) content for each form of silage?

The recommended DM contents of a range of crops harvested with long and short chop forage harvesters or baled and storage types are summarised in Table 1.

Table 1: Target DM contents for various crop, harvesting methods and storage types

Crop type (Stage to cut)	Pit/stack (DM %)	Bale (DM %)[2]
Pastures (Vegetative - very early heading)		
Long chopped	30 - 35	40 – 50
Precision chopped	30 - 40	
Lucerne (Bud - <10% flowering)		
Long chopped	33 - 35	40 –50
Precision chopped	33 - 45	
Other pasture legumes (early – mid-flowering)		
Long chopped	33 - 35	40 –50
Precision chopped	35 - 45	
Whole-crop cereals (Vegetative – Must be wilted) (Oats[1], ryecorn[1], barley, wheat, triticale)		
Flag leaf – Boot stage	33 - 40	38 – 50
Whole-crop cereals (Direct harvest standing crop) (Barley, wheat, triticale)		
Late milk - Soft dough stage	36 - 42	38 – 45
Whole-crop cereals as **Alkalage** (Direct harvest + "Home'n'Dry®") (Barley wheat, triticale)		
Early – late hard dough stage	65 - 85	
Maize		
Precision chopped	33 - 36	
Summer Forages (Sweet sorghums, millets)		
Long chopped	30 - 35	35 – 45
Precision chopped	30 - 40	
Brassicas/Chicory	33 - 35	35 – 45

[1] Oats and rye corn not recommended to be baled at the soft dough stage as quality is low, exclusion of air is difficult often resulting in poorer fermentation causing a severe decrease in quality and increased mould growth.

[2] Large rectangular baled silage could be 5 – 10% DM higher at the high end of each range but, if too dry, fermentation will be very restricted and losses due to yeasts, moulds and aerobic bacteria activity will be very substantial if plastic is holed! Stretch wrap these.