Silage maker's handbook

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Why conserve fodder?

In South Australia with its winter and spring rainfall, the legume-based improved pastures produce three quarters of their annual production as high quality herbage during the spring months. In early summer the standing herbage becomes dry, low-quality feed. More than 50 per cent of this pasture is lost by trampling, respiration and rotting before the animal is able to eat it.

Surplus fodder may be conserved as hay or silage to prevent this wastage. The conserved fodder can then be used as either drought reserve or feed supplement.

On dairy farms, conserved fodder complements irrigated pasture to maintain milk and fat production during summer, autumn and winter. The role of conserved fodder is particularly important to whole-milk suppliers in the Adelaide Hills region. With beef and wool production, research in western Victoria has shown that conserving and feeding fodder may increase the liveweight gain of steers by 24 per cent, and the wool production of Merino wethers by 12 per cent above the level achieved when no conserved fodder is fed. High quality conserved fodder is also suitable to feed calves and lambs when there is inadequate pasture growth. Under-nutrition of young animals may reduce their production capacity as mature animals.

Relative merits of hay and silage

With hay-making, the herbage is preserved by drying to below a moisture level at which bacteria and fungi are able to grow. In silage-

A maize crop being cut with a double-chop forage harvester.

making, herbage is preserved in the organic acids produced during fermentation of the herbage.

Well made hay and silage may both have very high feeding values. Feeding value is technically defined as nutritive value, which is a measure of how much animal production can be obtained from the feed. Experiments at the Northfield Research Centre have shown that both hay and silage made from the same crop at the same time have similar digestibilities. Experiments elsewhere have shown that dairy cows produce the same amount of milk, and fattening steers grow at the same rate whether fed hay or silage. Sheep generally eat less silage dry matter than hay, and so sheep fed silage may produce less wool and may lose weight.

In practice, silage is normally cut earlier in the season than hay. Therefore, wilted or formic acid silage will have a higher feeding value than hay.

The climatic conditions during early summer in southern Australia are sometimes ideal for hay making. However, statistics for the Adelaide Hills show that rain can interfere with hay-making and reduce the quality and the amount of hay in two out of every three years. On the other hand, it is possible to make silage during less favourable weather conditions. Therefore, silage may have a more consistent, high quality each year than hay.

Silage generally costs less to produce per food unit than baled hay. The capital expenditure on machinery may be less for silage-making than for hay-making. Total labour requirements for silage-making are usually less than for hay-making. More than 50 per cent of the labour in hay-making is involved in picking up the hay-bales and stacking them. However, the costs of storing and feeding silage exceed the costs for hay if tower silos are used, or if the silage is fed out by hand fork. The use of covered pits or walled clamps and silage grabs reduces these silage costs considerably.

In summary, well made silage has a higher, more consistent feeding value than hay. The costs and labour requirements for making silage are generally less than those for making hay.

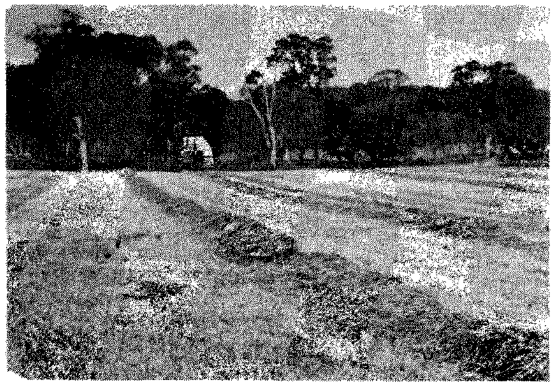
The chemistry of silage-making

The object of storing green crops as silage is to preserve the material with a minimum loss of nutrients. The first essential step is to achieve and maintain oxygen-free conditions. This prevents loss of nutrients with the wrong type of fermentation. The second step is to prevent protein destruction by clostridia bacteria which can grow in an oxygen-free environment. Clostridial activity in silage can be inhibited in two ways. The most direct method is to reduce the moisture content of the crop. If the dry matter is increased to about 30 per cent by wilting in the field, subsequent clostridial activity in silage is slight because these bacteria require very wet conditions for active growth.

The indirect method of preventing clostridial activity is to allow an acidic fermentation to take place. Fortunately this occurs naturally; bacteria that produce lactic acid are normally present in grass, forming a mixture of acetic and lactic acids from the plant sugars. The combined effects of decreased pH (increased acidity) and the toxic nature of these acids at a low pH prevent the growth of clostridia. The pH is a measure of acidity; the lower the pH, the higher the acidity. Distilled water has a pH of 7.

Clostridia will tolerate lower pH levels and higher concentrations of organic acids under very wet conditions. Consequently, the wetter the material, the lower will be the critical pH value for preservation. Silage with a 20 per cent dry matter content should have a pH below four.

After placing the crop in the silage stack respiration of the plant cells continues until the oxygen is exhausted. In the presence of oxygen, plant sugars are broken down and carbon dioxide and water are produced. The outward sign of this destruction of sugars is a rise in temperatures of the ensiled crop. The more rapid and greater the rise in



Wilting improves silage quality.

temperature, the greater is the loss of nutrients. If the temperature should rise above $113^{o}F$ ($45^{o}C$) the digestibility of the protein is reduced.

Once all the oxygen has been used, the naturally occurring lactic acid bacteria will ferment the sugars to produce lactic acid. This process takes about 20 days. If sufficient lactic acid is produced to prevent the growth of clostridial bacteria, or the silage has a dry matter content above 30 per cent, the fermentation will stop. However, if clostridial growth does occur, residual sugars and lactic acid will be converted to butyric and acetic acids and proteins will be broken down. The presence of clostridial end-products gives the silage a putrid smell and indicates a poor quality silage.

Objectives of good silage-making

The objectives of successful silage-making are:

- to preserve the herbage with the minimum loss of nutrients;
- to produce a silage with a high feeding value or nutritive value, and,
- to achieve these objectives at the lowest possible cost.

Therefore, it is necessary to rapidly fill the silage stack, effectively compact the material, and then to seal the stack immediately. The higher the dry matter content of silage (up to 35 per cent dry matter) the more silage the sheep and cattle will eat and so the higher the feeding value. Bulk handling of the herbage while making the silage, the use of low cost storage facilities, and the bulk handling of silage when feeding out, are all required to keep costs to a low level.

How to make silage

1. The crop to use

Good quality pasture or crop must be used to make a good quality silage. The digestibility of the silage will be similar to the digestibility of the original crop. Therefore, the claim that good silage can be made from useless herbage is not correct.

Grasses, grass-clover mixtures, clover, medics, lucerne and cereal crops can all be used to make good quality silages.

However, grass and legume silages have several advantages over cereal silage. They are generally more digestible, have a higher protein content, and animals will consume larger amounts of them.

Grasses and legumes should be cut during the early or middle stages of flowering. If cut before this, it is desirable to wilt the lush immature herbage. After flowering, pasture plants rapidly mature and decrease in digestibility and feeding value.

Legumes are inherently difficult to ensile because of the combination of a high protein level and a low sugar content. It is therefore necessary to wilt the legume to a dry matter content of 30 per cent, or to use an ensiling additive.

Experiments at the Northfield Research Centre have shown that an oat crop should be cut for silage at the late flowering or early milky stage.

With special crops such as maize and sorghum, up to 24 tons of silage may be cut per acre (60 metric tons per hectare). A double chop forage harvester with a special attachment may be necessary to cut maize. Maize should be cut when the grain in the cobs is at the "doughy" stage. However, the maize silage produced will have a low protein content

2. Wilting

The higher the dry matter content of the crop cut for silage, the more the ensiling fermentation is inhibited. Low fermentation silage is consumed in greater quantities by sheep and cattle than silage that has undergone more extensive fermentation.

A wet lush crop produces silage with high effluent losses from the stack and encourages clostridial fermentation. Avoid excess moisture by wilting the material, or by cutting more mature herbage free from rain or dew.

When wilting the herbage, the crop should be cut with a sickle-bar or rotary mower. A rotary mower can have the advantage of windrowing a wide cut into a width suitable for the forage harvester. This then allows one passage of a 40 in. (1.0 metre) forage harvester to cover an 80 in. (2.0 metre) width.

Although wilting adds an extra operation to silage-making, it is possible to complete mowing and gathering in the same time as it takes to cut directly with the forage harvester. This is because the effective cutting width of the mower whether of the rotary or sickle bar type, can be several feet greater than the width of the forage harvester and yet still form a windrow small enough to be picked-up by a narrow forage harvester. In addition,

Picking up wilted herbage and loading into a four ton forage trailer.

when picking-up windrows, forage harvesters can travel at twice the speed possible when cutting the crop directly.

A further advantage of wilting is that it greatly increases the weight of dry matter that can be carried in the trailer.

The herbage should be wilted to a dry matter content of 30 to 35 per cent. A lush pasture should be left to wilt for 12 hours under hot, dry weather conditions and up to 48 hours under cool, overcast conditions.

The dry matter content of the pasture may be estimated by the GRAB TEST. Chopped material is tightly squeezed into a ball between the hands for about one minute. If the hands have juice on them when unclasped, the pasture has a dry matter content of less than 25 per cent. If the ball of herbage holds its shape and your hands are not wet, the dry matter content is between 25 and 30 per cent. If the ball falls apart, especially if it springs apart, the dry matter content is above 30 per cent.

Excess wilting of herbage will make compaction in the stack difficult, thus encouraging mould growth and lowering of digestibility.

3. Cutting and carting the crop

The objective when cutting the crop is to chop and lacerate the herbage and then to bulk handle it to the stack. The best equipment to buy and the best system to use vary from farm to farm. In order to decide on the most suitable machinery for a particular farm, the following factors must be considered.

- **The quantity of silage to be made.** If the quantity to be made is less than 60 tons, a buck-rake may be sufficient. For larger amounts, the use of a forage harvester is recommended.

- **The amount of money which can be spent.** Forage harvesters and trailers vary greatly in costs and working capacities. Buck-rakes are cheap. If wilting, a mower may already be on hand for hay-making.

- **The distance between field and silo.** The buck-rake is suitable only for very short hauls. Where forage harvesters are used, larger trailer sizes should be used for increased carting distances.

- **The number and types of tractors available.** It is a serious mistake to buy a forage harvester which is too large for the tractor that has to drive it.

- **The type of crop to be ensiled.** Stemmy material, such as maize, must be chopped before ensiling. The buck-rake is not suitable for ensiling very short grass.

- **The type of land on which the crop is grown.** The buck-rake requires an even surface and rolled ground for full efficiency. Sickle-bar mowers cannot be used on rough ground covered with stones and sticks.

There are three basic methods of cutting and carting the crop. The advantages and disadvantages for each method are set out in Table 1.

To make good silage the crop should be well chopped and lacerated. This can be achieved only with a forage harvester, and preferably a double-chop machine. Finely chopped herbage allows more to be compacted into the trailer, allows easier consolidation and exclusion of air in the silage stack, and finally, allows easier removal from the stack.

It is wrong to try to get maximum yield by cutting as low to the ground as possible. This usually results in soil contamination and a slow recovery. A one to two inch (2.5 to 5.0 cm) stubble should be left after cutting.

For an efficient silage-making system, the trailer capacity should be large and the distance from the crop to the silage stack should be as short as possible. The capacity of the trailer depends upon its volume and the density of the load. Different materials and trailer volumes are indicated in Table 2.

Increasing the percentage of dry matter and chopping the crop can almost double the dry

Table 1: Advantages and disadvantages of the three commonly used silage making techniques.

Equipment	Advantages	Disadvantages
Mower and buck-rake	Low capital outlay. Low maintenance and running costs. Low powered tractor is suitable. Allows wilting.	Slow rate of work. Two operations. Suitable to make only 60 tons per year. Ground must be smooth. No chopping or laceration. Distance from crop to stack must be short.
Forage harvester	Efficient use of labour. One operation only. Mechanical application of additive is possible. Chops the herbage. Suitable for rough ground.	Does not allow wilting. Higher capital outlay. High powered tractor is required
Mower and forage harvester	Efficient use of labour Allows wilting. Mechanical application of additive is possible. Chops the herbage.	Two operations. High capital outlay Medium powered tractor is required. Requires smooth ground. Danger of crop deterioration

Table 2: Capacities of various trailer sizes with material of different dry matter content.

Trailer Size	Direct Cut 20% Dry Matter		Wilted				
			30% Dry Matter			40% Dry Matter	
	Flail	Double Chop	Flail	Double Chop	Precision Chop	Double Chop	Precision Chop
		cwt	cwt	cwt	cwt	cwt	cwt
10 ft x 6 ft x 6 ft	20–25	45–50	20–25	40–45	45–50	25–30	30–35
12 ft x 7 ft x 6 ft	30–35	50–60	30–35	45–50	50–55	30–35	40–45
16 ft x 6 ft x 6 ft	50–55	75–80	50–55	70–75	80–90	40–50	50–60

matter weight carried by the trailer, even though the wet load weighs less. For example, a 10 ton per acre crop at 20 per cent dry matter and double chopped, will fill four trailer loads of a 10 ft x 6 ft x 6 ft trailer. But at 30 per cent dry matter the crop weighs only 6.6 tons per acre and fills only three trailer loads. Four trailer loads of 30 per cent dry matter material would be removed from 1.33 acres – an increase of 33 per cent.

Work by the Victorian Department of Agriculture has shown that if the distance from the crop to the stack averages 300 yards, and for most types of forage harvester machines the time spent travelling exceeds the time used in cutting. Here, at least a quarter of the fuel is used for travelling, and illustrates the importance of placing the silage stack close to the crop.

Details on forage trailers are given in Machinery page 15. However, the trailer purchased should have a large volume and a rapid unloading mechanism.

4. What silage additives should be used?

The purpose of a silage additive is to help preserve the herbage during storage. While a large number of additives have been recommended and sold as successful preserving agents, recent research has shown that many of these additives reduce the feeding value of the silage. However, some additives improve both the preservation and feeding value of the silage.

The two main additives available in South Australia are molasses and formic acid (Add-F (R)). Molasses works by providing readily-available sugar which acts as a food for the beneficial lactic acid bacteria. The lactic acid formed prevents the growth of spoilage bacteria. However, molasses is very messy to handle and difficult to apply and is an inferior additive to formic acid. If used, molasses should be applied at the rate of three gallons (13.6 litres) per ton of fresh grass.

(R) = Registered trade name.

Formic acid is applied as an 85 per cent solution to the herbage at either the point of cutting, or while compacting the herbage in the stack. At cutting the formic acid is applied through a simple gravity drip-feed applicator fitted to the forage harvester. The applicator can be purchased for approximately $60 with the formic acid. The formic acid solution should be applied at a rate of one half gallon (2.3 litres) per ton of fresh grass. The cost of the formic acid is $2.00 per gallon or $1.00 per ton of silage.

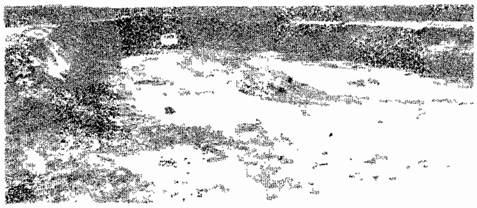
Use of formic acid can be economically justified if the dry matter content of the herbage is less than 25 per cent, especially with legume crops. Experiments have shown that cows fed formic acid silage produce 0.25 gallons more milk per day than cows fed untreated silage.

Formalin (40 per cent formaldehyde), which must not be confused with formic acid, is being tested as a silage additive at the Northfield Research Centre. Initial trials have shown formalin to adequately preserve the silage, but the formalin adversely affects the animals. Therefore, until further trials are completed, formalin is NOT recommended as an additive.

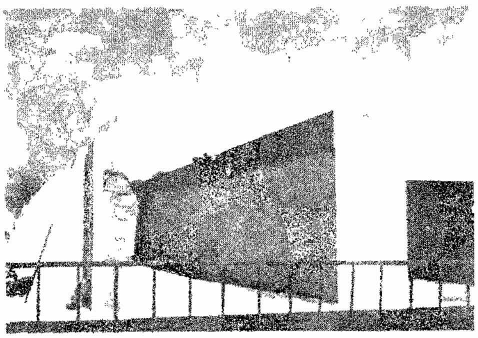
5. Silage storage

The type of silage storage used determines the efficiency and cost of storage. Methods of storage range from an inexpensive uncovered silage heap on top of the ground in which up to 70 per cent of the silage may be wasted, to an expensive glass-lined harvestor where no losses may occur. Different storage methods and the advantages and disadvantages of each are listed in Table 3.

Under Australian conditions where the storage is used only once annually, the capital outlay for tower silos cannot be justified. The capital cost of vacuum tents is approximately $2 per ton of silage stored



A 2,500 ton capacity pit silo.



A 500 ton capacity walled clamp silo

and usually these tents cannot be used for more than one or two seasons without replacement. Hence, economically the vacuum tent cannot be justified. The high dry matter losses which occur with silage stacks considerably increase the cost of producing each ton of silage eaten. Therefore, the walled clamp or bunker and the pit are the most economical and suitable methods of storing silage.

(a) Pit and clamp construction

Pits should be sited on ground which is well drained, preferably on the side of a hill. Excavation costs are approximately 25 cents per cubic yard or 50 cents per ton. But such costs can be depreciated over many years. The floor of the pit should be slightly mounded down the centre with an outlet fall of 1 in 50 along the crest of the mound. Drainage tiles may also be used along either side of the floor. The floor must be firm under wet conditions and therefore may be lined with concrete, gravel, or sleepers or be lime-stabilised. The walls should have an outwards slope of one foot for each eight feet of height. The walls should be smooth and may be lined with concrete. The width of the pit should be 12 ft. or more. The higher the walls the lower is the amount of silage wasted. For pits on flat ground, the ends should have a gentle slope which can easily be negotiated with a light tractor - a rise of one foot in five feet is the maximum. The excavated soil can be heaped along the sides to increase the height of the sides.

A walled clamp should also have a firm mounded floor with a slope of 1 in 50. The walls are usually made of concrete or timber. Walls should be **high** (at least six feet and preferably more), **strong** (to withstand the enormous pressures and to make it safe for the tractor driver to consolidate the clamp), **sloping** (a slope of one in eight), and **smooth**. A wall at one end as well as sides turns the clamp into a wedge.

(b) Filling and sealing the pit and clamp

Recent research has shown that the quantity of air included **within** the ensiled crop is of little significance because the oxygen is quickly used by the respiring plant material. What is important is to prevent fresh air entering. The main way in which air enters is by suction due to convection currents caused by the heating. It is important to prevent this positive current with some consolidation and by quickly sealing the sides and top of the pit or clamp. This is done by using the Dorset Wedge System, which is explained in Figure 1. One end of the pit or wedge is filled first, and each night, plastic sheeting is drawn over the silage.

The cut herbage may be dumped directly onto the silage heap from the forage trailer by either driving onto the heap or by backing the trailer to the side of the pit. Otherwise, the cut crop is dumped from the trailer near the heap and is then loaded onto the heap with a tractor and buck-rake.

Table 3: Advantages and disadvantages of various ensiling techniques.

Type	Advantages	Disadvantages
Stack An above-ground heap which is consolidated, but without sides. It may or may not be covered.	No capital cost. No drainage problems.	Poor quality silage. Losses may be as high as 75 per cent. Unsafe to consolidate.
Vacuum tent An above-ground cylindrical heap which is covered with a plastic tent and evacuated.	Low losses. No drainage problems.	Stacks less than 40 tons. High cost for plastic tents. High losses if plastic is torn.
Walled clamp and bunker An above-ground heap between two near-vertical walls. Either wedge or run-over. Covered or uncovered and tractor-consolidated.	Low to high losses. No drainage problems. Safer to consolidate. Large volume possible.	Some capital cost. High waste if uncovered.
Pit Below-ground heap which is tractor consolidated. Bare soil or lined near-vertical sides. Lined or bare bottom. Covered or uncovered.	Low losses. Safer to consolidate. Large volume possible.	Some capital cost. Drainage problems, unless sited on side of hill.
Tower silo Concrete or lined-metal tower. Loaded with blower. Unloaded either by hand or mechanically.	Low losses. No consolidation problems.	High capital cost. Unloading by hand is difficult.

[illegible] (based on [illegible] cubic feet per ton)

Width of ditch at bottom	Width of ditch at top	Depth of ditch at filling	[illegible] length of [illegible] at the [illegible]			
			[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	None	None	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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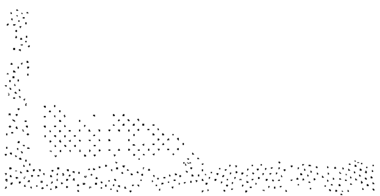

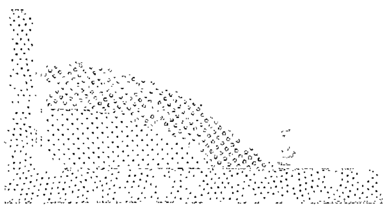

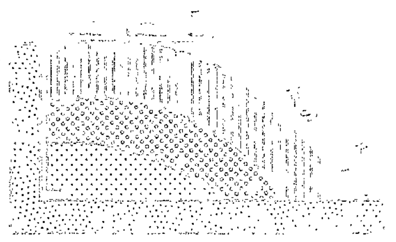

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flywheel or cylindrical chopper. The degree of chopping can be adjusted. The machine is expensive to buy and maintain and has a high power requirement. The resulting chopped herbage compacts readily into the forage trailer and silage stack, which increases the trailer capacity and minimises the degree of compaction required. The costs range from $2,000 to $2,500 without a trailer.

(c) **Precise-chop machine.** This machine has a sickle-bar attachment to cut the crop and then a flywheel or cylindrical chopper to chop the crop. These machines are very expensive to buy and maintain, but have a high capacity. With special attachments they are particularly suitable for such crops as maize and sorghum. The cost is generally above $4,000.

All three machines are suitable for picking up cut, wilted herbage. Forage harvesters differ in the width of cut (from 40 to 72 in.), the type of attachment to the tractor (three-point linkage or trailed), the line of attachment (in-line or off-set machines), the number and type of flails and their mode of attachment, the designated rotor speed (1400 to 2000 r.p.m.), and the height of discharge (from 56 in. to 120 in.).

The output of a forage harvester depends on the tractor power and the system of operation. The figures in Table 5 are an approximate guide only and vary according to the weight of crop per acre.

2. Silage trailers

The two important features of a suitable silage trailer are large capacity and rapid unloading. Many of the advertisements on silage trailers overstate the capacity of the trailer. A "V" shaped trailer will probably hold no more than 0.5 to 0.75 tons under normal working conditions with a flail forage harvester. The "V" shaped trailer can be unloaded rapidly with a hinged gate at the back.

The box-type trailers are slower to unload because they involve chains and slats moving along the floor. However, they have a capacity of 160 to 440 cubic feet and can carry from two to five tons. They have either two or four wheels. Many of the box trailers can also be used to side-deliver the herbage into troughs when feeding out.

Costs vary from $600 for the "V" shaped trailers to $1,800 for the intermediate box trailers and $4,000 for the largest box trailers.

A suitable silage trailer may be constructed from an existing trailer or from a tip-truck. The tray and chassis of an old tip-truck may be used as the basis of a four wheeled trailer. It is important to incorporate a rapid unloading mechanism. Such trailers may involve only small additional costs.

Table 5: Power requirements and output for various sizes and types of forage harvesters.

Type of forage harvester	Tractor h.p.	Output (acre/hr.)
40 in. flail (1 metre)	under 40	0.6 – 0.8
40 in. flail (1 metre)	over 40	0.9 – 1.2
48–60 in. flail (1.2–1.5 m)	over 40	1.2 – 1.6
60 in. double chop (1.5 m)	over 40	1.0 – 1.8
Precision chop	over 40	1.4 – 2.4

3. Buck-rakes

Buck-rakes are handy for shifting the cut forage on the stack. They may also be used for picking-up forage from windrows.

Buck-rakes are mounted on the three-point-linkage and vary in length (42 to 54 in.) and number of tines (10 to 13) and their overall width (eight to nine feet). The cost of a buck-rake may vary from $90 to $180.

4. Silage-grabs

The principle advantage of silage is that it can be handled in the bulk form. It is therefore essential to feed out silage with a mechanical grab rather than a hand-fork. Silage-grabs may be either mounted on the three-point-linkage system or worked from a front end hydraulic system. Grabs working from the three-point-linkage system have restricted manipulation and lifting height and cost about $270. Front-end mounted grabs are safer to use and can lift to a greater height while costing only $330 for a double-acting cylinder grab.

5. Mowers for wilting

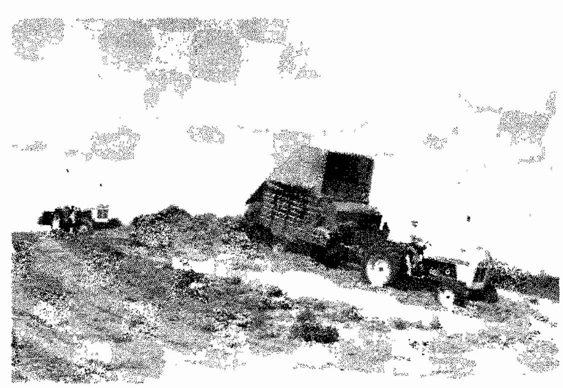
A suitable mower may have been purchased already for hay-making. If not, the mower may be either of the rotary or sickle-bar type. A mower is necessary only if the crop is being wilted.

Sickle-bar mowers vary in width from five to seven feet with either a belt or pitman drive and cost from $400 to $850. These mowers can be used only on ground that is free from large sticks and stones. Swath boards should be fitted so the cut herbage falls into a swath narrower than the forage harvester cut.

Rotary mowers are suitable for use on rough ground. The cutting width may vary from 5 to 15 ft., forming one or two wind-rows. These mowers may be operated at high speeds and have low maintenance costs, hence they are ideal for silage making. The cost of the mower varies from $600 to $1,700.

Silage making systems

The silage making system used and the combination of machinery purchased will require careful planning, and the following points should be considered.



Unloading a 200 cu. ft. trailer load of chopped maize onto a pit silo.

Flail forage harvester with a mounted V trailer.

Amount of silage to be made. The capacity of the silage making machinery should match the quantity of silage being made, otherwise the costs will be excessive. Considerations should take into account the amount of time available to make this silage. High output systems generally need specialised equipment.

Labour available. The labour available determines the number of tractors used and the number of simultaneous operations which can be performed.

Wilted or direct cutting. Wilted grass is more likely to make better silage, but it must be ensiled quickly and sealed immediately. If the grass is wilted, a mower and an extra operation are required, although no extra time may be involved.

Degree of chop. The length of grass ensiled affects its consolidation and may limit the method of feeding, especially with self-feeding. Finely chopped grass can be achieved only with a double-chop or precision-chop forage harvester.

After considering these factors one of the following three systems may be selected. There are, of course, numerous combinations of labour and machinery which may be used to make up these systems.

1. System for a small farm

On a small farm only 100 to 300 tons of silage may be required and only one tractor and one man may be available. It is therefore necessary to select a simple system.

The grass may be wilted if a mower is already available, but the purchase of a mower solely for this purpose is not warranted. If the grass is wilted, then a large area should be cut at the one time to reduce the number of implement changes required with the one tractor. If the grass is not wilted, it should be sprayed with formic acid.

A 40 in. flail forage harvester with a 200 cu. ft., 3.5 ton forage trailer is suitable for harvesting a 100 to 300 ton crop. The heap should be made in a walled clamp or pit and covered with polythene sheeting. A front-end grab is used to feed out the silage.

When building the heap, a large number of trailer loads of grass should be dumped near or preferably on the heap. If the grass is dumped near the heap the tractor must be transferred to the buck-rake periodically to carry the grass to the desired spot. Much of the consolidation is done as the grass is carried on to the heap.

Machinery costs:

	$
Forage harvester (40 in. flail)	650
Forage box (200 cu. ft.)	1,800
Buck-rake	140
Front-end silage grab	330
TOTAL	$2,920

Alternatively, by using a smaller "V" shaped trailer and by eliminating the need for a buck-rake, the total cost can be reduced to $1,580. The use of an existing trailer may reduce the total cost to $980.

2. System for a medium farm

On such a farm, from 300 to 1,000 tons of silage may be made. It is assumed that two tractors and two men are available.

The grass may be either wilted or treated with formic acid. The purchase of a mower for wilting is justified with this amount of silage.

Either a 60 in. flail or a 60 in. double chop forage harvester is suitable. The forage trailer should be of the box-type with a capacity of between 200 to 450 cu. ft. or 3.5 to 5.0 tons. The silage is placed in one or more pits or walled clamps and covered with polythene sheeting.

One tractor is used to alternatively mow the crop for wilting and to buck-rake the grass on to the silage heap. The other tractor operates the forage harvester full time, dumping the grass on or near the silage heap. A front-end grab is used to feed out the silage.

Machinery costs:

	$
Forage harvester (60 in. flail)	800
Forage trailer (340 cu. ft.)	2,000
Buck-rake	180
Front-end silage grab	330
TOTAL	$3,310

If an existing tip-truck or trailer can be used in place of the forage trailer, the cost is $1,310. Alternatively, with a 60 in. double-chop machine and a five ton forage trailer, the cost is $5,810.

3. System for a large farm, a contractor, or a co-operative group of farmers

On a large farm, over 1,000 tons of silage may be made. It is assumed that three tractors and three men are available.

The grass is either sprayed with formic acid or wilted. If the grass is wilted a large rotary mower is necessary to keep ahead of the forage harvester.

Either a 72 in. double-chop or precision-chop forage harvester is suitable. Two box-type forage trailers each of 3.5 to 5 ton capacity are required. The silage is made in either large pits or walled clamps and covered with polythene sheeting. A front-end grab is used to feed out the silage.

One tractor is used to tow the full forage trailer from the forage harvester to the stack empty the trailer and then return to the forage harvester. The third tractor is used to mow the crop and for loading the dumped grass on to the heap.

Machinery costs:

	$
Double-chop forage harvester	2,500
15 ft. rotary mower	1,700
2 forage trailers (340 cu. ft.)	4,000
Buck-rake	180
Front-end grab	330
TOTAL	$8,710

However, cheaper alternative systems may be used. For specialised silage making, a precision chop forage harvester with a windrow pick-up attachment may be justified. Use of formic acid instead of wilting the crop reduces this cost to $6,500.

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