



Food and Agriculture
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United Nations

Silage making for **smallholders**



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1. INTRODUCTION

Nowadays, the meaning of preparedness for emergencies is particularly significant. Movement of people is restricted, and this affects the availability of animal production inputs as well, including animal feed. To be prepared for leaner times, and for cold and dry periods, livestock farmers can prepare a sufficient amount of quality animal feed to use when other animal feed products are not available.

Silage making is one of several methods used for conserving animal feed for those times when there is less animal feed available. The process of silage making includes cutting fresh (green) fodder, compacting it, and storing and fermenting it under controlled conditions in a silo, where air cannot come in contact with the silage. Any green forage crop can be made into silage. For example:

- Fresh grass;
- Legumes, including alfalfa (*Lucerne*), clovers, vetches, cowpeas, or a mixture of these;
- Fodder crops like maize, millet, oats, rye, wheat, and varieties of sorghum;
- Crop residues, including fruit residues and other waste products;
- Other locally available crops.

Advantages

- Will keep forage in good condition for a very long time without an excessive loss of feed nutrients (e.g. compared to hay).
- Provides high-quality ruminant feed during the dry or cold periods.
- Allows for other products to be added (e.g. molasses) to prepare a more complete feed ration.
- Can be made when it is not possible to make hay due to weather conditions such as rain.
- Increases palatability and digestibility of most fodder crops.
- Requires less storage space compared to hay.
- Can enable fields to be cleared early for other crops to be planted.

Limitations

- Requires equipment and labour;
- Needs to be prepared quickly and correctly
- Can spoil if not prepared correctly;
- Can only be marketed if made in easy-to-transport containers.

Steps in silage making

The silage making process can be divided into six steps:

1. Determine the amount of silage you need.
2. Build the silo.
3. Harvest and chop the forage.
4. Dry the crop to the correct moisture levels.
5. Fill the silo and compact the silage as much as possible.
6. Seal the silo.

Tips:

Heating (caused by exposure to air) is one of the main causes of loss in feeding quality of the silage.

Sometimes farmers may have a maize field that is not expected to give a good harvest. This maize can be harvested early or thinned out and used as fodder when it is still green.

It is better to prepare smaller amounts of good silage, rather than large volumes of low- quality silage that may not be eaten and have to be discarded.

2. CHOOSING SILAGE INGREDIENTS

You can use any green forage crops for silage, preferably those with a high nutritional value. It is essential to avoid silage ingredients to which herbicides or pesticides have been recently applied. Some commonly used crops for silage making are described in the paragraphs that follow.

Grass

You can make an excellent silage from the grasses or mixtures of grasses and clovers that are ordinarily used in pasture or for hay. Ideally, grass is properly pre-dried before ensiling. Grass that is cut too low increases the risk of contamination with soil and causes the occurrence of the disease clostridiosis among animals. To achieve high-quality grass silage, it is crucial to harvest pasture grass at the preferable time of maturity (55-70% moisture content).

Maize (corn)

Maize is a common silage crop wherever it can be grown successfully. Silage made from corn is very tasty, and average yields are 10 tonnes of silage from 20 tonnes of maize per hectare. Maize needs to be cut at 15 cm from the ground and chopped into pieces of around 1 cm. The kernels are the primary source of starch in maize silage, and they must be cracked before being placed in the silo. Newly made maize silage contains about 10 percent sugar, which can cause acidosis, where too much acid forms in the stomach, so it is best to wait at least two months before using the maize silage as feed.

Sorghum

Various varieties of sorghum, including the forage sorghum (*S. sudanense*), are suitable for silage. Sorghum, in general, contains less grain than maize and thus has less feeding value. Sorghum has a higher water content, and therefore it might need to be dried longer than other crops. Sorghum can be grown under less favourable conditions than maize.

Legumes

You can successfully make silage from all legumes – alfalfa, clovers, vetches, cowpeas, etc. Legumes contain a low fermentable sugar content, and a high protein and calcium content. Therefore, you must take extra care to ensure that you chop it very finely, pack it tightly, cover and drain it adequately. It is also important that you harvest the legumes at the correct water content.



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Maiz silage

Alfalfa

You do not need to chop alfalfa in order to make silage. You should carefully dry and ensile it at around 60 percent water content. You might need more durable plastic for sealing, as the more robust alfalfa plants might puncture the plastic, which will lead to rotting.

Combined silage

The optimum grass-to-legume mixture is about 70 percent to 30 percent. The best way to obtain proper mixing of the two components is to introduce them into the chopper at the same time. You can ensile several crops together.

For other crops that cannot be ensiled on their own, such as fruits and leaves of sugar beet and sunflower, you can combine them with higher-quality components, such as maize and alfalfa. The optimal ratio is up to 30 percent of high-quality components and 70 percent of low-quality ingredients.

Additives

Sometimes you can use additives, such as sugar supplements (e.g. molasses), bacterial inoculants, enzymes, and acids to help increase acidity and the fermentation process.

Molasses

You can add molasses (9 kilograms (kg) of molasses per 500 kg of silage) to provide fermentable sugar to favour the development of the correct bacteria and speed up the fermentation process. Molasses can also be used to improve the tastiness and smell of the silage, which will increase the amount of silage eaten.



3. CALCULATING THE AMOUNT OF SILAGE REQUIRED

The amount of silage required, and therefore the size of the silo, depends on the following factors:

- Number and type of livestock to feed;
- Length of the feeding period;
- Percentage of silage in the full ration;
- Water content of the silage;
- Losses in percentage;
- Density of the silage.

Let's take a look at an example, using the following details:

- One cow;
- Feeding period of 90 days;
- 50% of the total animal ration of 40 kg of feed;
- 75% water content for the silage;
- On average 15% losses due to spoilage etc.;
- Density of 0.8 metric tonnes/m³.

Therefore, the amount of silage and silo space you will need would be as follows:

• **Kg feed required:** 1 cow x (50% of 40 kg) x 90 days = 1 800 kg of feed;

• **Total minus losses:** In general, there are about 15% losses due to spoilage etc.

Therefore, you would need 15% more silage, which means 115% x 1 800 kg = 2 070 kg of fresh silage for each cow for 90 days.

• **Silo space required:** Density of 400 kg per m³; therefore 2 070 kg/400 kg = 5.2 m³ of silo capacity per animal.

For 10 cows at 50% of the diet over 90 days, you would therefore need:

10 x 2 070 kg = 20 700 kg of silage; and

10 x 5.2 m³ = 52 m³ of silage space.

Therefore, a trench, stack or bunker silo that is 8.5 metres long by 3.5 metres wide and 1.8 metres high would be sufficient. However, it is recommended that a slightly larger permanent silo be made to allow for future expansion.



©FAO/James Airey

Silage preparation

4. CONSTRUCTING A SILO

Type of silos

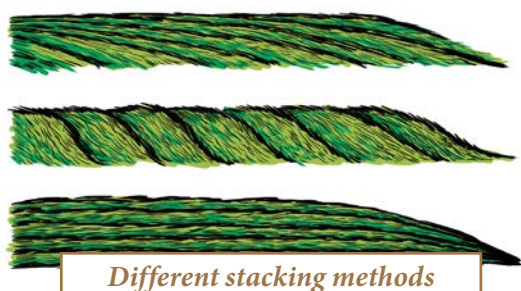
The silos applicable to smallholders are stack, trench or bunker silos; small containers and bags can be used as well.

Small containers and bags

Containers with a capacity of up to 200 litres that are filled manually can be very effective silos. For this, you can use plastic bags, drums or other containers. In all cases, the material must be packed extra tightly compared to other types of silos and kept under strict anaerobic conditions, meaning no air should be allowed to enter. Plastic bags with a thickness of about 0.1 mm can be used; bags must be tied at the top. Using containers and bags can be more economical. In addition, they can be stored anywhere on the farm, the distribution of feed to your animals is easier, and there is generally less waste. However, you must make sure to repair any damage to the bags as quickly as possible.

Stack silos

Stack silos are silos without walls and do not require permanent construction. However, they are the most prone to damage to the covering material, which would then lead to exposure to air. Like all silos, you will need to cover it with plastic and pack it tightly to exclude air. The advantage of a stack silo is the low



cost of investment, but you will need a greater surface area (piece of land) to stack the same amount of silage as compared to bunker or trench silos.

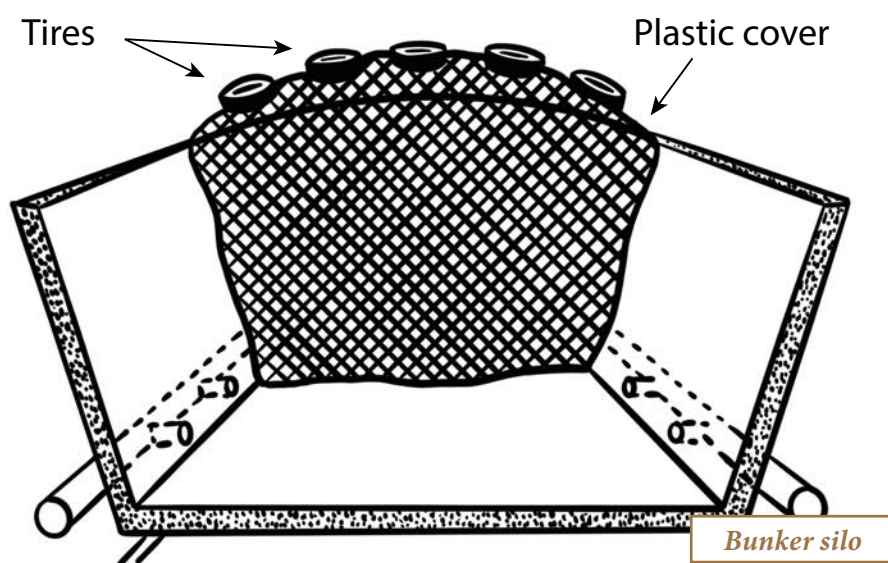
Trench silos

Trench silos are underground bunker silos. Make extra sure that these trench silos have sufficient drainage (especially when using dirt walls), as water can affect the quality of the silage. A sloping floor will also assist with drainage. If you use dirt walls, you must cover them with a plastic sheet to avoid soil contamination to the silage. The advantages of trench silos are that they are generally easier and cheaper to construct compared to bunker silos.



Bunker silos

A bunker silo is a silo with walls but open at the top. You will need to dig a ditch around the base of the wall and add drainage to avoid water damage. A sloping floor will also assist with drainage. You must build the walls solidly to sustain the sideways pressure from the silage, and the walls



must be sloped outward by making the top slightly wider than the base, allowing for easier compaction right up to the walls. The advantages of a bunker silo are easier feed-out, less spoilage and easy filling. However, a bunker silo requires a more significant investment compared to most other silos.

Siting of the silo

The bunker or stack should be built on a firm base away from hedges, trees, water sources, residential areas and major drains. Make sure there is sufficient drainage and, if possible, that the silo is on slightly higher ground to avoid flooding. A somewhat sloping site will assist with water drainage. The site should be accessible all year round. Feed-out costs will be reduced if the bunker or stack is built close to where the silage will be fed.

Size and number of silos

To calculate the size of the silo required, you can determine how much silage you need/make (see section 3) and estimate around 400 kg DM per cubic metre. Consider using several silos instead of one; it is recommended that not all the silage be kept in only one silo, in order to minimize losses and the risk of silage going bad.

It is better to make a long and narrow silage pit to minimize exposure to air and therefore avoid warming up when you open the silo for feeding.



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5. HARVESTING AND CHOPPING

Harvesting time

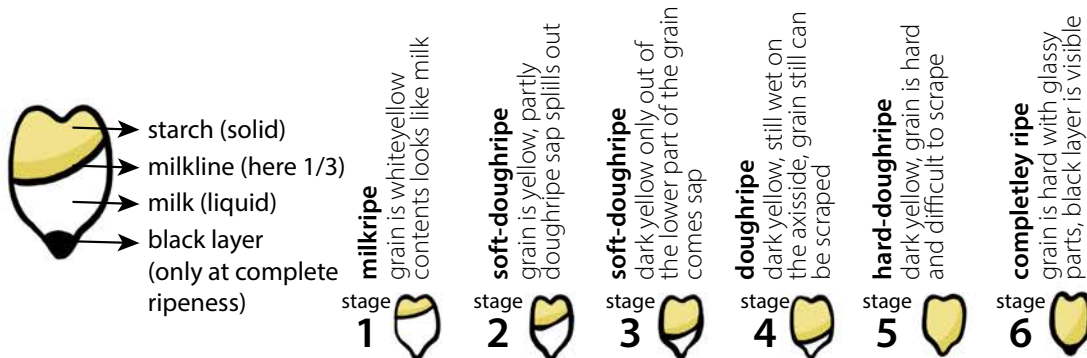
The quality of the forage depends on the season. In spring and autumn, the forage will have a higher protein and sugar content, and a lower fibre content, and therefore the quality will be higher.

As a general rule of thumb, legumes and grass-legume mixtures should be harvested when the legumes reach the 10 percent bloom stage. The best time for maize harvesting is when the maize is at least at stage 3 or 4 (see illustration below).

Let's take full grass silage as an example:

- Harvest at 20 to 30 cm tall (longer than two fists and a thumb, see picture)
- Mow in the afternoon (more sugars)
- Mow at 5 to 6 cm above the ground
- Shake the grass two or three times at least once a day to ensure drying
- Dry the grass until about 30% DM
- Rake the grass
- Collect the grass and transport to the silo.

The shorter the field drying time, the lower the risk of rain damage.



Moisture levels

The proper moisture content is essential to producing high-quality silage. Moisture content that is too high will increase the risk of nutrient losses and the formation of butyric acid, which creates a foul smell.

There are many techniques you can use for measuring the moisture content, but a crude and simple test is the hand method (or grab/squeeze test):

1. Take a handful of chopped forage.
2. Squeeze it into a ball for 20 to 30 seconds.
3. Release.

The palm of your hand should feel a bit wet after applying pressure. Chopped forage is too wet to ensile if the ball stays together (or if you squeeze water out of the ball) and too dry



The "ball method"

if it quickly falls apart. Forage that slowly falls apart is ready to be ensiled. It takes some time to perfect the hand method, but the more you use it, the better you will get at it. If the chop length is too long, the ball might also fall apart, so keep an eye on the correct height of the chop.

The microwave oven method¹ provides reasonably accurate forage moisture results in a relatively short time. For this method, you will need:

- A microwave oven;
- A scale (weight in grams);
- A microwave-safe plate;
- Around 400 ml of water.

The procedure is as follows:

- **Take a representative** forage sample (whole plant material).
- **Cut the sample** into 2.5 cm pieces; keep leaves and stems uniformly mixed.
- **Place a paper** towel on the plate and weigh the plate; record this as plate weight (P).
- **Add approximately 100** grams of the forage sample to the plate. Spread the sample as evenly as possible.
- **Weigh the plate** with the forage sample and record it as initial weight (I).
- **Place the cup** of water in the corner of the oven to capture unabsorbed microwaves as the plant tissue dries.
- **Place the sample** on the plate in the centre of the oven.
- **Set the oven** on HIGH for 3 minutes and "cook" the sample.
- **Remove the sample** and plate, weigh and record the weight.
- **Change the water** in the cup to prevent the water from boiling over.

- **Set the oven** on HIGH for 2 minutes and "recook" the sample.

Remove the sample and plate, weigh, and record the weight.

Repeat steps 7 through 10 until the weight does not change more than 1 gram (this means the sample is dry); record as final weight (F).

Use the following equation to determine the percent of water content of the forage sample:

Percent of water content

$$(\%) = \frac{(I - F) \times 100}{I - P}$$

Harvesting equipment

You can harvest the crop either by hand or with mechanical equipment. Harvesting equipment includes machetes, scythes, and manually or mechanically operated rotary choppers. The maximum rate that you can achieve by hand-cutting is around 500 kg per person per hour.

Chopping

As mentioned before, the fodder needs to be chopped to ensure a proper ensiling process. Make sure that the chopper blade is sharp.

A chopped length of the forage between 2 and 4 cm is desirable; shorter lengths will not stimulate the rumen (the cow's stomach) activity sufficiently, and longer lengths will make it more challenging to achieve a proper ensiling process. You can cut shorter more mature crops, while younger forage can be cut larger.

¹ <https://www.pubs.ext.vt.edu/442/442-106/442-106.html>

6. FILLING, COMPACTING AND COVERING THE SILO

Preparation and planning

Plan to carry out any maintenance of the silos well before harvest. Clean the silo as much as possible. If there is crumbling, dirt walls should be re-cut to give a straight, clean edge. Repair any damage to the floor of the stack that may have occurred while feeding out during the previous season.

For small-scale silage – for example, to prepare 2 000 kg of silage with two people, one animal traction cart and a stationary chopper – the estimated duration of silage making is as follows:

- Manual harvesting: 3 hours;
- Loading: 1 hour;
- Transporting: 1 hour;
- Chopping: 1 hour;
- Filling and compacting: 3 hours;
- Sealing: 1 hour.

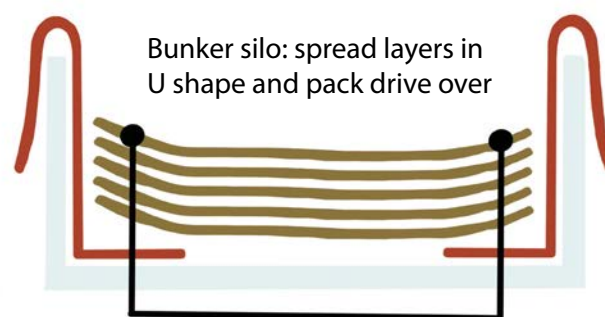
Therefore, the total time needed is around 10 hours; this does not include the time you will need for drying/wilting the forage. Make sure you have this time available before you start filling the silo.

Filling

You will need to fill the silo and compact it as quickly as possible, and without interruptions. Never leave the silo uncovered for more than a day.

In a bunker silo, before you start filling, spread the plastic on the outer edge of the floor and the walls and let it hang over the sides so you can cover the silo later (see figure).

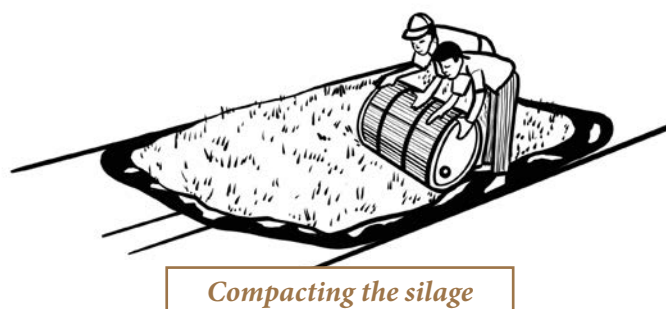
It is best to fill the silo at the coldest time of the day, and as quickly as possible to minimize exposure to the air. Deposit the forage at the beginning of the silo and spread the material in a thin layer (max 15 cm) throughout the silo. The thin layer will make it easier to compact the silo. Compact the layer and repeat the process until the silo is filled.



If you want to use additives like molasses, place them on top of each layer once compacting has been completed.

Compacting

Proper compaction is the key to making top-quality silage, and it is crucial to get as much of the air out as possible. Good compaction is especially essential when using forage with lower moisture content.



Compact the silo lengthways several times until fully compacted. For compacting, you can use:

- Weight of humans or stones for small-scale silage pits;
- Barrels filled with water or sand (for small-scale pits and stacks);
- Vehicles like tractors;
- Livestock;
- Any other heavy object that can be moved easily.

Compacting the silage

Once all the material is in the silo, continue compacting (e.g. 30 minutes up to 1 hour for large-scale silage pits) until the silage contains no soft patches. Critical areas for the silage are on the sides of the silo pit, so make sure these areas are compacted as much as possible.

Covering

You will need cover the silo immediately after completing the filling and compacting. The cover needs to be made of an airtight material to avoid exposure to air as much as possible. A plastic sheet is the standard type of cover used. Ideally, use plastic that is at least 5 mm thick and keep the plastic sheet in contact with the silage over the entire area. Make sure the

plastic does not have holes. For alfalfa and more robust stubby plants, you might need to use a more durable type of plastic to prevent it from being punctured. If you have to use several pieces of plastic, make sure there is sufficient overlap. If you use cheaper or thinner plastic sheets, you might want to consider using multiple layers to cover your silo.

Weigh down your silage cover firmly with tyres, bags of sand, mounds of sand or other material placed closely together. Make sure the cover is airtight and watertight, and that there is no air under the cover.

Keep checking the silo

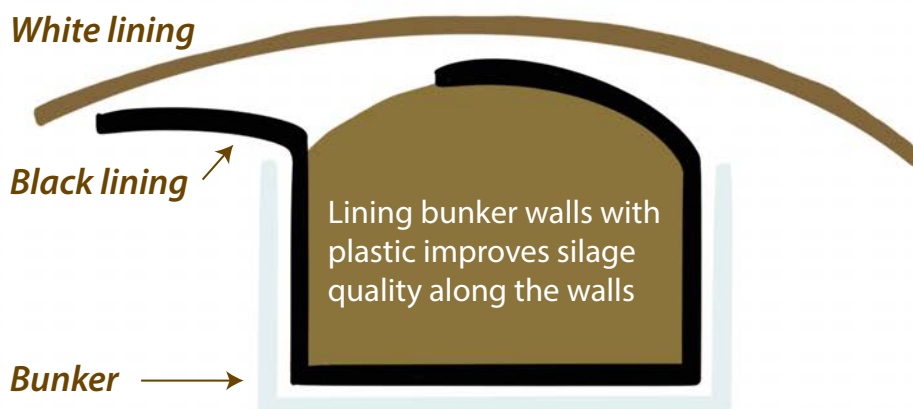
After you have covered the silo, inspect it regularly (e.g. at least once a week) for damage and heating. In particular, inspect the plastic covers carefully for tears, holes or damage by animals or rodents. Make sure the edges and seams are weighted down.

If you notice high temperatures developing after one to four days, this means you did not follow the ensiling procedures correctly. You should not let the temperature rise above 40°C. Overheating can signify that the moisture content is too low, the forage was too mature or too long, or the compacting was insufficient.

Step 1:
When filling, leave a flap of black plastic over the silo walls

Step 2:
Fold excess black plastic over top of bunker pile after filling/packing

Step 3:
Cover bunker with additional piece of white plastic



7. FEEDING SILAGE

When is the silage ready?

The silage should be ready at least three weeks after preparation, but as a rule of thumb, 60 to 70 days produces an optimum fermentation. The length of time before feeding, however, depends on the quality of the forage used and the availability of forage to be ensiled.

For example, newly made maize silage contains about 10 percent sugar, and since this could cause acidosis, it is especially important not to feed newly made maize silage too early.

Quality assessment

Before you feed the silage to your animals, it is crucial to assess the quality first. To do this, you should evaluate the silage based on appearance, texture, smell and colour. Several factors can affect quality negatively:

- Rot;
- Mould;
- Heat;
- Foul smell;
- Soil residues;
- Moisture.

The silage should smell pleasantly acidic, e.g. the smell of sour milk or yoghurt. If there is a foul odour, it could mean that a specific acid, butyric acid, has formed. The silage is often wet and slimy as well; this means that the silage is poorly fermented.

The presence of mould or rot indicates that air has entered the silage. If you can squeeze water out of a handful of silage, then this could mean that the forage

contained too much moisture during ensiling or that water has entered the pit.

If the silage is brown or dark brown, this could be an indication that air has entered the silage and that the silage has warmed up due to inadequate compacting or sealing.

Opening and closing the silo

Try to open only the part of the silo that you will use in three or four days and cover as best as possible between feedings.

During the feeding of the silage, the area exposed to air should be as small as possible and the time between opening and closing the silo as short as possible. Uncover and remove just the silage that you need and not more to avoid any exposure to air and heating. Unnecessary exposure to the air and heat will spoil the silage with mould. After feeding, keep the leading edge of the plastic sufficiently weighted down to prevent air from entering.



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University of Florida

Feeding silage

Most silage has a high feeding quality and you should therefore feed it to the top-producing animals as a priority. In the ideal situation, cows eat 7 to 12 meals per day indoors; each meal lasts about 30 minutes, with a total eating time of about five hours per day. This means you need to provide new feed at least two or three times per day. Start feeding when there is about 5 percent feed left. Try to provide feed at the same times each day.

Some additional points of attention for feeding silage:

- Make sure you remove all spoiled silage and do not feed it to your animals.
- Be very careful when removing silage from an earth pit; avoid feeding soil residues to your animals.
- Feed any concentrates at the same time as when you are feeding the silage.

Cows might need to get used to the silage in the initial period of feeding silage because of the smell; this hesitation will usually disappear after a few days. You can add a bit of molasses or other desirable feed ingredients to the silage to stimulate eating.



8. THE COSTS AND BENEFITS OF SILAGE MAKING

You can obtain the most economical results in silage making with low-quality components. These are crops that you will not be able to ensile on their own, such as fruits and leaves of sugar beet and sunflower. You can combine them with higher-quality components, such as maize and alfalfa. As previously mentioned, the optimal ratio is up to 30 percent of high-quality components and 70 percent of low-quality ingredients.

Costs

Two types of costs need to be taken into account:

1. Capital costs: building the silo, machinery and equipment.
2. Running costs: labour, fuel, materials, silo maintenance.

When you calculate the costs versus the benefits of silage, you should also take into account certain losses that occur during the silage making process. As a rule of thumb, you can estimate all these losses together to be at least 20 percent, from field to cow. Note: these losses can be much higher if the ensiling process has not been very successful.

Benefits

If the ensiling process has been successful, you will have an increased amount of high-quality feed with higher digestibility. This high-quality feed is available at any time of the season, and therefore you will have a higher production throughout the seasons.

The benefits of feeding your herd well with silage include:

- Higher production (meat, milk);
- Better body condition;
- Better fertility of your animals;
- Fewer animal health issues;
- Higher prices for your animals;
- Higher income.

Most importantly, the availability of silage in the dry or cold season means that the productivity of your livestock will continue even in the leaner months.

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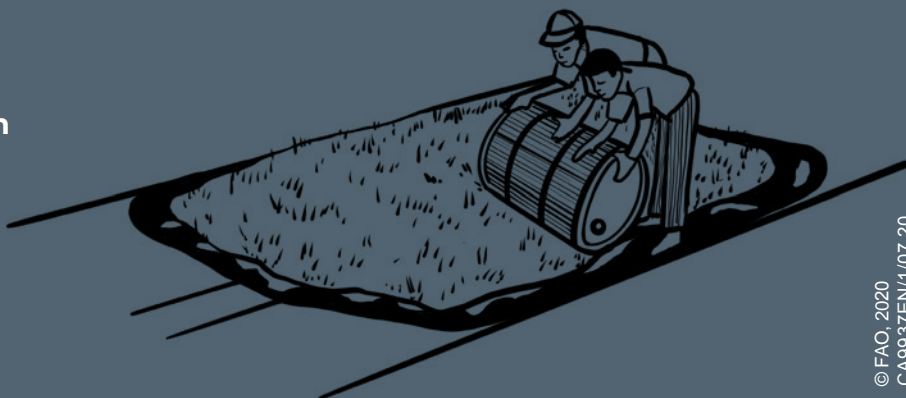
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