Farm Mechanization
FACTSHEET

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FORAGE HANDLING SYSTEMS

INTRODUCTION

The objective in forage production is to provide a quality livestock feed that will ultimately result in an economical livestock product (e.g. meat, calves, milk). The large number of forage handling systems available and, the lack of information on these, make the choice of the **best** one "mind boggling".

The difficulty of the decision is complicated by many factors including:

- availability of capital and labour.
- amount and type of crop to be harvested.
- amount of time available to harvest.
- kind of livestock to be fed.
- travel distances to storage, feeding area and market.
- operator skill.
- storage requirements.
- feeding method.
- equipment availability.

The system must fit the **farm and the farmer**. No single method will be right for everyone.

Regardless of the type of handling system, all require that the crop be cut and prepared for the harvest machine.

CUTTING-TO-WINDROW OPERATION

The cutting method used can be crucial to the success of the whole system. It can affect the yield, rate of drying or wilting and quality of the forage before baling, stacking or ensiling. Basically, two principles are used in cutting machines today:

1. **SHEAR** – The most common cutting machine used today is the **sickle-bar mower**, which uses a shearing action to cut the crop stem.
2. **IMPACT** – the **rotary mower** has one or more horizontal blades rotating at high-speed. They are very popular in the Lower Mainland.

The **flail cutter** has flails or knives attached to a rotating horizontal shaft. Because flails tend to shred and pulverize rather than cut, they have not been used extensively for hay.

Conditioning by crushing or crimping hay does two things:

1. Equalizes the drying time of the stems and leaves.
2. Speeds drying by fluffing the crop to allow better air movement.

There appears to be no significant differences in drying time between crushing and crimping.

Raking is usually only required if the hay has been cut with a mower or mower-conditioner, or a windrow has been rained on. Raking losses increase with a decrease in the crop moisture content. Losses average 15% - 20% in tame hay.

The windrower combines the mowing, conditioning and windrowing operations into a one-pass operation. Compared to mowing and raking, between 50% and 75% of the labour and time involved in forming windrows can be saved using a windrower. Net hay crop yield should improve as well.

HAY SYSTEMS

Hay is forage preserved as a result of a sufficiently low moisture content in the crop such that all biological activity effectively ceases in the presence of oxygen.

1. BASIC REQUIREMENTS FOR QUALITY HAY

a) a quality forage crop cut at the right stage of maturity.
b) careful handling to minimize harvesting losses.
c) appropriate storage to minimize weathering and storage losses.

2. CONVENTIONAL BALING SYSTEMS

Conventional square baling systems are still the most common among hay harvesting methods. Numerous bale handling machines are available today to reduce the back-breaking labour requirements of earlier systems.

A bale chute extension for direct wagon loading requires two men in the field, a reduction from the previous minimum of five required to bale, load and haul simultaneously. A bale thrower requires only one man to bale and load.

Stookers and bale accumulators "build loads" and as a result reduce field travel distances when hauling.

Mechanical bale wagons reduce hauling and stacking labour to a minimum, however, operator skill for baling and stacking is high.

Baling systems involving high equipment cost generally require large crop volumes to justify the investment.

3. BIG PACKAGE HAY SYSTEMS

Big package hay systems include large round bales weighing from 1000 to 3000 lbs. (avg. 1200 lbs) or semi-automatically formed loose haystacks weighing from 1 to 12 tons.

Advantages

- high capacity (5 – 10 tons/hr).
- one man harvest operation.
- big packages suitable for self-feeding.
- some stacks and bales can be weather resistant.
- stacks and some large bales require no twine.

Disadvantages

- high operator skill required to form weather resistant packages.
- special equipment usually required for handling and feeding.
- more storage area is required as packages are generally not stackable.
- if self-seeding is used, feeding losses can be high.

(a) LARGE ROUND BALES

Two types of large round balers are available.

(i) **Pickup** balers pick up the windrow with conventional tooth pickups and move the hay into the bale chamber where it is rolled and compressed by belts and/or rollers. Twine is wrapped around the bale after the desired size is reached. It is then discharged out the rear of the machine.

(ii) **Ground Roll** balers roll the hay along the ground until the desired size is reached. Twine wrapping is optional. These bales are generally less dense than others and hence less weather resistant, however, the baler is less susceptible to damage under rough field conditions.

(b) MECHANICAL STACKING WAGONS

Two basic types of loose hay stackers are currently available:

(i) **Compaction** stackers use some form of mechanical force such as a packing roller (e.g. Haybuster) or a hydraulically lowered roof (e.g. Hesston Stack Hand) to physically compact the collected hay into a round or rectangular stack.

(ii) **Non-compaction** stackers pickup, chop and blow the hay into a loaf-shaped stack chamber (e.g. McKee Stack-n-Mover). Experience indicates that it is almost impossible to avoid moldy or rotten pockets in these stacks, as unevenness in the stack tops tends to funnel water into the stacks.

4. HAY DRYING SYSTEMS

The production of good quality hay is often hampered by unfavorable weather. Artificially drying the hay, partially or completely offers the possibility of making good hay most years. Also, if all the field handling operations are carried out at moisture levels above 35%, harvesting losses can be significantly reduced.

(a) PARTIAL FIELD CURING / MOW DRYING

This system complements a conventional baling system. The high moisture baled hay is placed in a mow equipped with drying ducts and equipment where curing is completed. Usually this mow is not the final storage location and the hay must be moved again.

(b) HAY TOWER

A hay tower is a structure designed to receive chopped hay, form it into a vertical, cylindrical stack, provide for aeration and drying and mechanically unload the hay for feeding. This system has been popular in Central Europe for almost two decades. Farmers are using it as a complement to a silage system utilizing much of the same machinery for both.

The system can be fully mechanized and automated, however, it is expensive and likely approaches the cost of a tower silo. Basically, the same type of equipment as for silage is required for harvesting. Therefore, the system complements a silage setup rather than a dry hay system.

The energy requirements for heating and drying operations in all hay drying systems make them increasingly difficult to justify.

5. HAY PRESERVATIVES

Hay preservatives are effective only in the 20% to 40% moisture content range acting to "sterilize" the hay so that none of the molds and bacteria present can cause heating and destruction.

Salt was probably the first preservative and, if enough is used, it will kill the microorganisms.

Recently, organic acids (e.g. propionic and acetic acids) have been found to be effective. However, good coverage of the crop is necessary because the material must actually contact the organisms in order to be effective.

The main problems with hay preservative uses are:

- obtaining good uniform coverage of the crop with existing equipment.
- applying the correct concentration of the preservative appropriate to the moisture content of the crop.

6. STORING HAY

No hay package is totally weatherproof. Because of the high labour requirements of hay harvest systems, bales and stacks often tend to remain in the field waiting for a "slow" day to move them to storage. As a result, significant weathering losses after baling are common. Uncovered stacks stored through the winter may result in substantial losses.

Clearspan pole type buildings tend to be the most versatile and economical form of storage for conventional bales. If an automatic bale wagon is to be used, ensure that the height and width clearances allow for convenient operation of the machine.

Round bales and stacks are often promoted as "weather-resistant". Losses in uncovered large packages can be quite variable, and depend on how skillfully they were packed and where they were stored.

Uncovered, they should be stored on a well-drained site, not touching each other.

Large packages make poor use of covered storage buildings because they are difficult to stack. Round bales can be stacked using front end loading equipment for better storage utilization.

7. FEEDING HAY

Hay is commonly fed "on the ground" with a widely varying report of the amount of losses encountered. Bunk feeding often allows some control over hay losses and can serve to separate the feeding area from the feed storage or feeding alley.

Chopped hay is required for maximum utilization of the nutrient content of the hay. This high energy, time-consuming operation is usually performed prior to the day's feeding. Often several days chopped hay can be stored and fed in the self-feeders.

A variety of feeding arrangements and feeder designs have been developed for large packages:

- pasture bunks.
- electric fences.
- mechanical feeding equipment for fence line feeding.

SILAGE SYSTEMS

Silage is forage preserved by the by-products of natural fermentation of the crop in the absence of oxygen (i.e. the forage is effectively "pickled" in the "juice" that results from its own fermentation.

Advantages

- less weather dependent than hay.
- minimal harvesting losses are possible.
- easy to completely mechanize.
- handles a variety of crops.

Disadvantages

- high power requirements for some farm operations.
- requires specialized storage structures (silos).
- high immediate labour requirements during harvest.

Dissatisfaction with silage and poor quality silage often results from poor planning, inadequate equipment and silos and improper harvesting methods.

1. BASIC REQUIREMENTS FOR QUALITY SILAGE

(a) a quality forage crop cut at the right stage of maturity.
(b) ensile the forage at the **correct moisture content**.
(c) **exclude the air** from the forage as **quickly** as possible, and **keep it out**.

2. HARVEST MACHINERY REQUIREMENTS

(a) Wilting the Crop

If forage is harvested at moisture contents above 70%, storage losses from seepage and improper fermentation will result. High moisture levels may also result in freezing in winter and an inability for cattle to eat enough dry matter for maximum production.

The recommended moisture contents for harvest are:

- grass or legume silage, 55% to 65%. If these crops are cut at the proper stage of maturity, **some wilting will be** necessary before harvesting.
- cereal silage at the soft to hard dough stage should be between 55% and 65%.
- corn silage should be harvested at 62% to 70% moisture with the best being 65% to 68%.

(b) Forage Harvesters

All silage systems centre around the forage harvester. These machines either **pick up** the swathed crop or **direct cut** the crop for themselves. The most common type of forage harvester uses a "cylinder cutter-head" which chops the forage into short uniform lengths which are then blown through a spout to the box of the truck or wagon which is being used to haul it to the silo.

Chopping the forage into the short, uniform pieces required to make good silage is a power intensive operation. In BC, the PTO horsepower available to the harvester is usually the harvest rate limiting factor. Typically, a 95 HP tractor is required for a medium sized forage harvester. The PTO load requires about 65 HP, the remaining power being required to pull the harvester and the forage wagon. Harvesting rates can be between 15 and 16 tons of grass-legume silage per hour (about 7 tons per hour hay equivalent).

(c) Hauling Equipment

A variety of equipment is available for hauling and unloading forage:

Forage Boxes

Forage boxes can be mounted on a truck chassis for a 4-wheel wagon.

Some models are equipped with a cross conveyor to unload the forage from the side. They can be used for feeding silage into fence-line feed bunks or to unload into a forage blower to fill upright silos.

Hi-Dump Wagons

These wagons have hydraulically operated side-dumping boxes. Forage is collected and, when the box is full, the whole load is dumped into a dump truck box. Dumping requires less than a one-minute interruption in the harvesting operation.

Power requirements for pulling a wagon depend on soil conditions, topography and wagon capacity. The average varies from 10 to 20 HP.

Dump Trucks

Trucks equipped with hydraulic dump boxes are ideal for hauling forage to the silo. The height of the box sides may have to be increased.

(d) Packing Equipment

Spreading and packing in a horizontal silo is both a critically important operation and one requiring a high degree of operator skill. Heavy rubber tired tractors are best for spreading and packing. "Duals" are preferred. Tractors should be equipped with roll-over protection.

3. SILOS

The type of silo determines the amount of management required to keep the air out, **not** the quality of the silage. Under good management conditions, little if any practical differences in nutritive feed value can be attributed directly to the silo used.

Generally speaking, the degree of management required to make good silage and the amount of dry matter lost in storage decrease with an increase in the cost of a storage system. In increasing order of required capital investment, there are four general areas of silo structures:

1. plastic covered stacks.
2. horizontal bunker silos.
3. tower silos (concrete stave or poured uprights).
4. oxygen-limiting.

(a) Plastic Covered Stacks

Practically speaking, covered stack silos should be used only as emergency storage. They require basically no investment apart from the cost of the polyethylene cover. Dry matter losses are highly dependent upon management and can vary from less than 20% to over 40%.

(b) Horizontal Bunker Silos

A horizontal silo is the predominant method of storing silage in BC. Dry matter losses are again highly management dependent and may vary from 9% to 20% (average 15%).

Advantages

- lowest initial cost, especially for large tonnages.
- can be constructed with on-farm labour.
- fits in well with large volume feeding and bulk handling systems (e.g. self-unloading wagons and fence-line feeders).
- self-feeding is possible.
- silo can be filled and unloaded quickly.

Disadvantages

- high level of management skill required.
- higher dry matter losses, depending upon management.
- location requirements are critical (drainage, snow drifting, etc.).

(c) Conventional Tower Silos

A tower silo is a popular method of storing silage. The most common types are the concrete stave and cast-in-place. There is no noticeable performance difference between the two provided that good construction practice is used and good management practiced. Dry matter losses average 6% to 12% (average 10%).

Advantages

- moderate in initial and operating costs.
- fits in well with mechanical feeding.
- reduced labour requirements relative to bunker silos.

Disadvantages

- soil bearing capacity and foundation design is critical.

- not suitable for high moisture content material due to high seepage losses.
- usually top loading, top unloading (i.e. first material is the last material out).

(d) Oxygen-Limiting Tower Silos

The glass-lined steel silo is the most predominant oxygen-limiting silo, however, concrete silos can often be adapted for the same function. Dry matter losses average 2% to 7% (averages 5%). There is no "magic" involved in the use of these silos. The quality of the feed out can be no better than the quality of the forage put in.

Advantages

- bottom unloading
  - allows use of silo during feeding.
  - no need to climb silo for unloader servicing.
- lowest dry matter storage losses.
- will store wider range of moisture contents (40% - 60%).
- Moderate level of management skills required.

Disadvantages

- very high initial cost.
- higher field losses result from lower moisture forages recommended for these silos.

4. SILAGE FEEDING SYSTEMS

Self-feeding is a common method of feeding silage from horizontal silos. It involves the feeding of the livestock at will across the face of the silo, being limited only by the position of a feeding fence. The main advantage is that it requires a minimum of equipment. Self-feeding, however, requires a great deal of labour and supervision to ensure that it works properly. The feeding face must be maintained as well as the position of the feeding fence. The silo floor must be kept clean; a concrete floor is desirable.

Silage, as with hay, can be fed on the ground or in bunks. Commonly a front-end loader is used to unload the silo and distribute the feed directly, or the loader will fill a power feed box for distribution into fence-line bunks. These power feed boxes can be equipped with mixing equipment and electronic scales for the addition of supplements and mixing feeds.

Mechanical bunk feeders are best suited for use in conjunction with tower silos. Their convenience is tempered by their high cost and lack of flexibility for expansion.

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