Hay Making Equipment

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Harvesting hay is the process of mowing a forage grass or legume, allowing it to air dry thoroughly, then baling it into a round or rectangular "package". There are many variations and designs of machines that perform each step in this process and some that perform optional steps that may speed up or improve the process of drying. Selecting appropriate designs, sizes, or systems can be confusing and complicated. This publication will provide a basis for understanding the purpose of each machine, factors to consider for selection, and some safety considerations.

MACHINE TYPES

Hay harvesting begins with some type of mowing machine that cuts that forage. Once the forage has dried for a period of time, the hay may be fluffed up or spread out to decrease drying time before it is raked. The final step is the actual baling of the hay.

Mowers

Mower - These machines are used to mow the hay. There are basically two types of mowers: sickle bar and disc or rotary..

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The sickle bar type of mower provides a neat, clean cut of the forage. Speed limits how much forage can be cut in a given period of time because this type of mower can clog or may miss portions of the field if the tractor speed is too fast. The sickle bar type mowers have a low power requirement so smaller tractors can be used to run them.

The disc or rotary type mower is good to use in lodged crops (crops that have fallen over). Speed is not an issue with this type of mower because it almost never plugs. One drawback however is that it has a higher power requirement than the sickle bar type mower.

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Conditioners

The conditioner performs a rolling or crimping function to the forage that will speed drying and is generally a part of the mowing machine (mower-conditioner). There are two basic types of roll conditioners: rubber rolls or steel rolls. The rubber rolls and the steel rolls both crimp and crush the hay stems with pressure. This process breaks open the waxy covering over the hay stem and allows the moisture inside to evaporate more rapidly. Hence, the hay crop dries down faster and is ready to bale in a shorter period of time. Regardless of the type of conditioner, the more aggressive the setting, the faster the forage will dry, but at a cost of increased forage loss. This is more of an issue with legume forages than with grasses.

These rolls crimp and crush the hay stems to allow the crop to dry faster. The rubber type rolls are on the left and the steel type rolls are on the right.

Another type of conditioning machine is the flail, impeller or tine. These machines cut the forage with a scuffing action. Because it doesn't leave a clean cut, the forage plant can take longer to repair itself before beginning to grow again.

Some mowers come equipped with a variety of extra features. Some of those features could include side windrow attachments for wider units, split swaths on wider units, cutter bar angle tilt adjustment, variable reel speed or suspension of cutter bar.

This flail type conditioner processes the forage with a scuffing action.

Tedders or Inverters

Tedders are machines that spread the hay in the field for better air circulation. Inverters flip the swath over so the damp bottom is exposed to the sun and air for drying. This is an optional piece of equipment that farmers can use to speed drying of the hay crop. It is typically used when adverse weather conditions slow drying so that the hay can not be baled before the next rainfall.

Hay Rakes

Rakes gather and roll the partially dry hay into a "windrow", allowing the underside of the hay to dry. It also allows the baler to efficiently pick up the crop for harvest. There are three types of hay rakes: parallel bar, rotary and wheel. The parallel bar has the lowest amount of hay loss, particularly with legumes. They run on a ground or variable speed hydraulic drive system.Rotary rakes will sometimes come with dual functions. They can be used to rake or ted the hay. Wheel rakes can save time because they can be operated at a higher speed than other rake types. One drawback to the wheel rake is that it has a higher potential for rock collection.

The parallel bar rake is a very common type of rake that rolls the hay into a windrow for easy pick up by the baler.

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Balers

Balers pick up the crop in the field and compress it into either a rectangular bale or a round bale. Sizes of bales can vary depending on the machine. Small rectangular bales weigh approximately 38 to 40 lbs. Round bales can vary from 500 lbs. to 2000 lbs. There are also very large rectangular balers that make bales weighing a ton or more.

This small rectangular baler produces bales that weigh between 38 and 40 pounds.

Small rectangular balers come in a variety of sizes: 14" X 18", 16" X 18" and 15" X 22." Some small balers require manual bale stacking on the hay wagon, while others have a bale thrower that tosses bales into a hay wagon. Features you might find are hydraulic tension control, various pick up heads, and a pre-pack chamber. Tractor horsepower needed to run a small baler starts at a minimum of 36 hp, but you could use up to a 100 hp tractor.

Large round balers come in a number of different sizes also. Typical sizes (width by maximum diameter) include 4' X 39", 4' X 4', 4' X 5", 5' X 5', or 5' X 6'. The fixed chamber models have a soft bale core with high density on the outside. The variable chamber models have a more uniform bale density. The tractor horsepower needed to run a 4' width round baler would range from 45 to 65 hp. For 5' width bales, a tractor should have 70 to 100 hp.

This large round baler rolls the hay and wraps string around the outside to maintain bale shape.

MACHINE CAPACITY

There are four different factors which can limit the capacity of a machine to harvest hay. Depending on field conditions, power, throughput capacity, speed, or traction can limit the field capacity of a machine. Actually, in systems where machines must interact (such as harvest, transport, and unloading), machines capacity can be limited by other machines. These limits to capacity are important concepts because harvesting quality hay can depend largely on timing.

Mower conditioner capacity limits may be power, throughput, or speed. With disc cutters, often the tractor hp can be limiting field capacity. That is, if there were more power available, more acres per hour could be covered. In conditions with high yield and plenty of tractor power, the flail or roll conditioning system may be the limit to capacity. In light yield conditions with adequate tractor power, speed may be the limit. This can particularly be the case with sickle cutters which do not perform well if travel speed exceeds 6 or 7 mph.

Raking, tedding and other swatch manipulation equipment doesn't require much power and in most cases can handle a tremendous volume rate of forage. There can be a tradeoff, though, with excessive loss if you try to operate this equipment too fast or after the forage is below 35% moisture.

Like the mower-conditioners, baler capacity may be limited by power, capacity of the baler to "eat" and package forage, or merely speed (especially if the field is rough).

TYPICAL EQUIPMENT SETS

Matching equipment sizes and needs to the number of acres harvested can have a direct impact and the economics of making hay. Included below is a description of the machinery as well as labor requirement and cost per unit harvested for varying sizes of hay acreage.

Small Rectangular Bales: 100 to 300 tons dry matter (DM)/year (20 to 60 acres)

- 9' Mower-conditioner
- Rake
- Small baler
- 2 wagons
- Labor: 1.4 - 2.1 hours per ton of DM
- Cost: $40 - 70 per ton of DM

Starting small with small rectangular bales, small machinery is sufficient. Try to remember the labor requirement is about 1 ½ to 2 hours per ton of dry matter. Cost is $40 to $70 per ton dry matter.

Small Rectangular Bales: 200 to 400 tons DM/year (40 to 80 acres)

- 8-12' Mower-conditioner
- Tandem Rake
- Medium baler
- 3 wagons
- Labor: 1.0 - 1.4 hours per ton of DM
- Cost: $35 - 50 per ton of DM

This section may seem repetitive, but notice the reduction in labor and cost per ton.
With more to harvest and larger machinery, the labor requirement decreases somewhat and the cost decreases from $40 to $70 per ton of dry matter down to about $35 to $50 per ton of dry matter.

Small Rectangular Bales: 300 to 600 tons DM/year (60 to 120 acres)

- 12-14' Mower-conditioner
- Tandem Rake
- Large baler
- 4 wagons or automatic bale wagon

- Labor: 0.5 - 1.0 h / t DM
- Cost: $30 - 40 / t DM

An even larger, more automated system can reduce the labor requirement to ½ to 1 hour per ton of dry matter and cost in the range of $30 to $40 per ton of dry matter.

Large Round Bales: 100 to 300 tons DM/year (20 to 60 acres)

- 9' Mower-conditioner
- Rake
- Small baler
- 1 wagons
- Labor: 1.2 - 1.4 h/t DM
- Cost: $44 - 67 / t DM

When moving from a small rectangular baler to a large round baler, we can see a decrease in the labor requirement. Compare the labor of about 1.3 hours per ton of DM for a large round baler to about 1.8 for small square bales for a similar farm size. Cost is comparable between the two systems.

Large Round Bales: 200 to 400 tons DM/year (40 to 80 acres)

- 8-12' Mower-conditioner
- Tandem Rake
- Medium baler
- 1-2 wagons
- Labor: 0.9 - 1.1 h / t DM
- Cost: $36 - 43 / t DM

Labor for large round bales continues to decrease with larger acreage: .9 to 1.1 h/t DM compared to 1.0 to 1.4 h/t DM for small square bales Cost is still comparable between the two systems.

Large Round Bales 300 to 600 tons DM/year (60 to 120 acres)

- 12-14' Mower-conditioner
- Tandem Rake
- Large baler
- 2 wagons or truck
- Labor: 0.7 - 0.9 h / t DM
- Cost: $28 - 33 / t DM

As the acreage continues to increase we see a lower cost and less labor with large round bales and lots of forage compared to small square bales handled manually.

CUSTOM RATES

Machinery costs for forage production are significant. Following are custom rates for various hay making operations:

State	Mowing/conditioning	Raking	Rectangular baling	Round baling
PA	$11.90/acre	$6.30/acre	$.48/bale	$6.40/bale
DE	$10.00/acre	$3.70/acre	$.32/bale	$8.45/bale
OH	$10.00/acre	$5.00/acre	$.47/bale	$7.50/bale
IN	$10.25/acre	$5.00/acre	$.46/bale	$7.70/bale
VA	$12.70/acre	$6.75/acre	$.47/bale	$7.15/bale

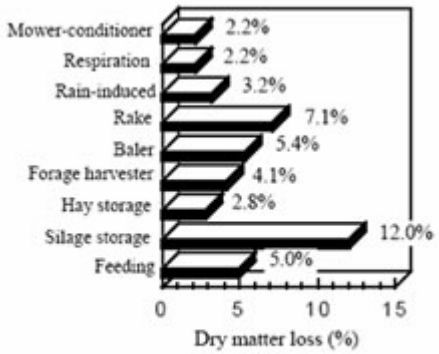
Combined custom rates to mow-rake-bale-store small rectangular bales is:

PA: $1.15/Bale
DE: $.85 /Bale
OH: $26.00/Ton ($.80/Bale)
VA: $1.11/Bale
Information can also be found on custom harvest rates for PA at http://www.nass.usda.gov/pa/custrate.htm

HARVEST LOSSES

No matter how carefully you harvest your hay, there will always be a portion of the hay that is lost during the harvesting process. The chart below shows some of the typical losses that we can expect with alfalfa harvest. These are long term averages for a well-managed farm. Note that the rain loss is sometimes 0% and sometimes 100%. This long term average DM loss may appear optimistic to some farmers.

Typical Forage System



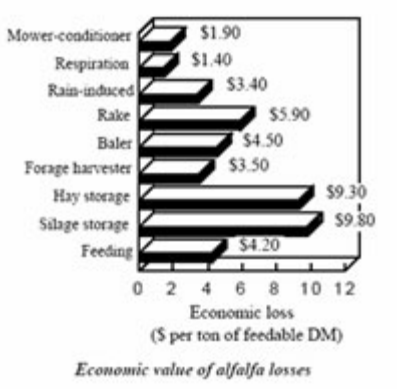
Typical alfalfa dry matter losses

Losses

DM isn't everything. Quality matters. When DM is lost, it is often the best part (leaves shattered, cell solubles leached). This chart puts the value of these losses into perspective.

Typical Forage Value

During mowing-conditioning we lose 1 to 5% DM, mostly from loss of leaves. The conditioner design/setting can have a large effect on how much is lost. There is a trade off in more loss for the faster drying rate. Flail mowers often cause more leaf loss in legumes as compared to other mower types.



Economic value of alfalfa losses

Losses

Hay harvest losses from raking will increase as the hay dries. Losses are highest when the field is low yielding and after tedding. Losses can be as high as 20% in some fields. Wheel and rotary rakes will cause more loss than parallel bar type rakes. The best practice is to rake the hay once only and that should occur on the day of baling.

We can also expect to see losses from respiration and rain. These losses are highly variable and can range from as low as 2% to as high as 100%. These losses are typically a loss of the most digestible plant components. To minimize respiration and rain losses we can use two strategies: try to always avoid rain and try to optimize the annual harvest.

TIMING THE HARVEST OPERATIONS

Mowing-conditioning is the first step in hay making and should occur based on the maturity of the crop and the weather. The crop maturity decision is based on finding an optimum between yield and growth stage. Alfalfa hay should be mowed before the crop is in bloom while grass hay crops should be mowed when or shortly after the plants shoot up seed heads. Crops such as orchardgrass must be cut before the seeds develop as the quality of orchardgrass drops very quickly after the seed head emerges.

Most hay crops will take two to three days to dry in the spring when the plant is high in moisture and less time during the summer. Listen to the weather report to find a time period when no rain is expected for several days. The other option to allowing hay to dry completely is to harvest the hay in a wilted stage and prepare it for silage.

Tedding is often done at the start of the second day after mowing in order to speed the drying time. Tedding or swatch inversion can also be done after a rain to help the hay to dry more rapidly.

Raking should be done when the hay has dried down to 35 to 45% moisture. It is best done on the day of baling, but may need to occur after a rain if the hay needs turned over to dry more quickly on the bottom of the

swath.

Baling should occur only after the hay has reached the proper moisture levels. Proper small bale baling moistures for dry hay should range from 18 to 20% moisture. For large bales, the moisture should range 16% or lower.

Baling should occur only after the hay has reached the proper moisture for storage. There are products available on the market to apply to hay that has to be baled before it reaches the appropriate moisture levels. These products help to prevent molding and heating when hay is baled too wet. Often this occurs when rain is expected before the hay is dry enough to bale. These products can be used on legume hay at up to 25% moisture. Proper small bale baling moistures for dry hay should range from 18 to 20% moisture. For large bales, the moisture should be 16% or lower.

HAY MAKING SAFETY CONSIDERATIONS

Hay making can be a dangerous activity and so proper precautions should always be followed. Here are a few considerations to keep in mind:

- Shield disc mowers properly (knife tip speeds are 160 to 190 mph)
- Always use a tractor with cab or at least a rollover protection system
- Never stand behind conditioning rolls or flails
- Remember that baler flywheels and hydraulic accumulators store energy
- Keep fingers out of moving knotters (even if they are temporarily manually powered)
- Do not ride the wagon when a bale thrower is used
- Handle bales safely
- Keep equipment "harvest ready"
- Keep guards & shields in proper order
- Securely block hydraulically-raised equipment before working around or under the machine
- Disengage power and shut off engine before unplugging clogged equipment
- Keep a fire extinguisher on all powered equipment
- Do not allow kids or other riders on the equipment

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