

Unit D: Agricultural Equipment Systems

Lesson 6: Operating, Calibrating, and Maintaining Forage Harvesting and Handling Systems

Student Learning Objectives:

Instruction in this lesson should result in students achieving the following objectives:

1. Describe the operating principles of forage harvesting and handling systems.
2. Explain the operation and preparation of cutting equipment used in forage management.
3. Explain the operation and preparation of raking equipment used in forage management.
4. Explain the operation and preparation of baling equipment used in forage management.
5. Describe the operation and preparation of forage harvesting equipment.
6. Identify the equipment used for forage handling systems.

Recommended Teaching Time: 2 hours

Recommended Resources: The following resources may be useful in teaching this lesson:

Fundamentals of Machine Operation: Hay and Forage Harvesting. Moline, Illinois; Deere & Company, 1993.

List of Equipment, Tools, Supplies, and Facilities:

- Writing surface
- PowerPoint Projector
- PowerPoint Slides
- Transparency Masters
- Copies of student worksheets
- Samples of different forages
- Forage harvesting and handling equipment

Terms: The following terms are presented in this lesson (shown in bold italics and on PowerPoint Slide 2):

- Baling
- Cutterbar lead
- Direct cut silage
- Green chop
- Hay
- Haylage
- Knife register
- Mower
- Rakes
- Silage
- Wilted silage
- Windrow

Interest Approach:

Display different types of forages. Ask students to examine the samples and record the characteristics of each. Lead a discussion of each of the samples and relate the good and/or bad qualities of each. Ask them what it takes to make a high quality forage.

SUMMARY OF CONTENT AND TEACHING STRATEGIES

Objective 1: Describe the operating principles of forage harvesting and handling systems.

Anticipated Problem: What are the operating principles of forage harvesting and handling systems?

(PowerPoint Slides 3 and 4)

- I. Good hay and forage management requires a complete understanding of the many machines that handle cereal and legume crops from cutting to storage.
 - A. Forage management requires preservation of as much of the nutritional value in the crop as possible, with the lowest investment of labor and money.
 - B. The type of forage system used will depend on the forage itself.

(PowerPoint Slide 5)

1. **Green chop**, not less than 70 percent moisture, is cut, chopped, and fed directly without being stored.
2. **Hay** is a green forage crop harvested for livestock feed and stored at low moisture levels, 12 to 22 percent. No special storage structures or preservatives are required.

(PowerPoint Slide 6)

- a. The crop is cut and cured in the field before harvesting and packaging into bales or stacks. Small bales are round or square. They generally weigh less than 45 kilograms. Large bales can be round or square and weigh 450 kilograms or more. Stacks are rectangular with a dome top. They generally weigh 1000 to 5000 kilograms.

(PowerPoint Slides 7 and 8)

- b. Climate determines how the bale is stored, whether it is in a barn, under temporary cover, or in the field. **Silage** is fermented green forage that is harvested in a high-moisture condition to prevent excessive leaf loss. It is stored in an oxygen-limiting unit. **Direct cut silage**, not less than 70 percent moisture, is cut, chopped, and immediately ensiled. **Wilted silage** has 50 to 70 percent moisture content. The crop is cut and field dried to the desired moisture content, then chopped and ensiled. **Haylage** contains 40 to 50 percent moisture. It is typically an on-grain crop that is chopped and field dried to the desired moisture content, and ensiled.

Use TM: 6-1 (PowerPoint Slide 9) to assist in discussing the choices that need to be considered when handling and harvesting forages. TM: 6-2 (PowerPoint Slide 10) illustrates the different types of forage harvesting. Discuss the differences in machinery, processes, and harvested product.

Objective 2: Explain the operation and preparation of cutting equipment used in forage management.

Anticipated Problem: How is cutting equipment operated and prepared for use in forage management?

(PowerPoint Slide 11)

- II. In some parts of the world mowers, mower conditioners, and windrowers are used to cut forage.

(PowerPoint Slide 12)

- A. The purpose of a **mower** is to cut standing vegetation. A mower cuts standing vegetation by either shearing or through impact. Cutting should be clean and sharp, without clogging. An impact occurs when a blade hits a stem.

(PowerPoint Slides 13 and 14)

1. A rotary mower has one or more rotating blades and is commonly used to cut weeds, stalks, grass, and brush. They have a low profile and are closely coupled to the tractor.
2. Rotary disk mowers hug and float over the ground. They have high speed rotating disks that cut at a high rpm.

(PowerPoint Slide 15)

3. Flail cutters have flails attached to a rotating horizontal shaft and are used to clip grass, weeds, and brush. Because of their chopping action, they are not used very much for cutting hay crops due to their tendency to shred and pulverize the hay.
4. The sickle cutterbar is equipped with a reciprocating knife that shears plant stems. It is the most commonly used hay-cutting device. These cutterbars are also called sicklebars or sicklebar mowers.

(PowerPoint Slide 16)

- B. Mowers are classified as trailed, semi-mounted, rear-mounted, or side-mounted. They are powered by the tractor PTO or a hydraulic motor. Older mowers were ground-driven. Each mower has a different preparation and attachment procedure. For complete details on each mower, consult the operator's manual. Ground speed, cutting height, knife selection and register, cutterbar tilt, and lead all affect mower efficiency. Each must be adjusted to match crop and field conditions.

(PowerPoint Slide 17)

1. Correct cutting angle in relation to the ground and direction of travel is necessary for clean cutting and is referred to as cutterbar tilt.
2. During operation the resistance of plants being cut pushes the outer end of the cutterbar to the rear. To compensate for this drag force, position

the outer end of the cutterbar slightly ahead of the inner end when the mower is stopped. This is referred to as **cutterbar lead**.

3. **Knife register** refers to when the knife sections are an equal distance from the centerline of the guards at each end of the stroke.

(PowerPoint Slide 18)

C. Mower-conditioners and windrowers combine a mower and a conditioner. They save manpower and time. They cut, condition, and windrow hay in one operation. Mower-conditioners and windrowers mechanically condition hay by cracking, crushing, or bruising stems as the hay is mowed.

1. Conditioning permits more rapid moisture loss from inside the stems. This allows for stems and leaves to dry at approximately the same rate which reduces the time needed for field curing.

(PowerPoint Slide 19)

2. The types of conditioners are crimpers, crushers, and impellers.
 - a. A crimper has two corrugated rolls which mesh like gears that bend and crack the stems every 2 to 8 centimeters.
 - b. A crusher uses molded urethane or rubber rollers with wide intermeshing cleats that provide both crimping and crushing.
 - c. An impeller system has impeller-conditioner times that pick up plants and cause them to rub against a conditioner hood and other plants. This rubbing action removes much of the waxy covering and bruises the plant for faster drying.

Use TM: 6-3 (PowerPoint Slide 20) to illustrate different mower components. TM: 6-4 (PowerPoint Slide 21) illustrates hay conditioner components. TM: 6-5 (PowerPoint Slide 22) illustrates types of conditioner rolls. Use these to lead a discussion about how equipment differs for different forage harvesting procedures and what the reason for differences is. Use TM: 6-6 (PowerPoint Slide 22) to discuss the process of conditioning hay and the reasons for doing so.

Objective 3: Explain the operation and preparation of raking equipment used in forage management.

Anticipated Problem: How is raking equipment operated and prepared for use in forage management?

(PowerPoint Slide 23)

III. Raking is an important operation in the haymaking process. Unless care is exercised in raking, many of the nutrient-rich leaves are lost.

(PowerPoint Slide 24)

A. **Rakes** gather newly-cut hay into small piles or windrows to make collection easier.

1. Rakes lift mowed hay from the swath and place it in a loose, fluffy windrow with the green leaves inside, protected from the sun's rays. A **windrow** is a row of hay or forage to be picked up later by a harvesting machine.

There are several types and sizes of rakes.

(PowerPoint Slides 25, 26, and 27)

- a. Parallel-bar rakes require a power source to drive the rake reel and bars. Parallel-bar rakes may be trailed or rear-mounted.
- b. Wheel rakes are simpler than parallel-bar rakes because no chains, belts, or gears are needed to drive the wheels. The raking wheels are turned by the rake teeth on the ground. The windrow is tight and rope-like, and dries relatively slowly. Individual wheel floatation provides clean raking on tough terrain. Because the wheel rake teeth travel slower, they are gentler on hay.
- c. Tedders, sometimes called fluffers are specialized rakes used in damp climates to raise, loosen, and partially turn hay in the field so the hay will dry faster.

(PowerPoint Slide 28)

- B. Field operation considerations for raking hay include:
 - 1. When the hay has wilted slightly, it is ready for raking. If crop moisture falls below 40 percent before raking, leaf loss may be excessive.
 - 2. For the most efficient raking, the rake must travel in the same direction as the mower. Raking the same way the mower traveled places most of the leaves inside the windrow.
 - 3. To speed curing, use the rake to turn the windrow upside down.
 - 4. Field adjustments are made to suit specific crop and field conditions. Proper ground speed and tooth height are two common adjustments to be made.

Use TM: 6-7 (PowerPoint Slide 29) to illustrate types of rakes. Rake components are illustrated on TM: 6-8 (PowerPoint Slide 30). Use these to lead a discussion relating rakes to other equipment already discussed.

Objective 4: Explain the operation and preparation of baling equipment used in forage management.

Anticipated Problem: How is baling equipment operated and prepared for use in forage management?

(PowerPoint Slides 31 and 32)

IV. **Baling** is essentially a packaging operation.

- A. A baler lifts windrowed hay, compacts it into a dense package, and ties wire or twine around the bale. Tightly-bound bales have a box shape, which makes them easy to stack, transport, store, and feed. The disadvantage of baled hay is the amount of labor required for hauling bales from the field to storage.

(PowerPoint Slide 33)

- B. There are different types of bale handling equipment available. They reduce labor, but are expensive to initially purchase.
 - 1. Direct loading bales is a simple method of adding an extension chute to the bale chamber and pull a wagon behind the baler. Bales are then stacked by hand on the wagon.

2. Automatic bale ejectors eliminate manually loading bales. The ejector attaches to the rear of the bale chamber and throws bales into a trailing wagon.
3. Bale accumulators bunch bales and drop them in the field to be picked up by a tractor. There are several types and sizes of balers.
 - a. All hay balers are field balers with automatic tying mechanics.
 - b. Tractor drawn balers are powered by the tractor PTO or an auxiliary engine mounted on the baler.
 - c. The size or weight of the bale produced depends on baler design, bale dimensions, type of hay, and moisture content. Bales range from 25 kilograms for small rectangular or round balers to 900 kilograms for large or round bales.

(PowerPoint Slide 34)

- C. Field operation considerations for baling hay include:
1. Before taking the baler to the field, make preliminary adjustments to avoid unnecessary wear or breaking of baler components. Follow the guidelines presented in the owner's manual.
 2. Make adjustments in the field to match crop and field requirements. Adjust the pickup height for clean pickup. Normally, teeth are set to operate just below the top of the stubble, but not low enough to hit the ground. Bale weight is affected by the size of windrows, moisture content, and the quality of the hay. Bale weight should be checked regularly during operation.

Illustrate types of baling equipment using TM: 6-9 (PowerPoint Slide 35). TM: 6:10 (PowerPoint Slide 36) shows the components of a large round baler. Large round bale formation is illustrated in TM: 6-11 (PowerPoint Slide 37). Use these for a discussion of the different points.

Objective 5: Describe the operation and preparation of forage harvesting equipment.

Anticipated Problem: How is forage harvesting equipment operated and prepared?

(PowerPoint Slide 38)

V. Chopped forage is an established alternative to hay and stover.

(PowerPoint Slide 39)

- A. Forage harvesters chop crops into short uniform lengths for storage in silos. Forage harvesters fall into three distinct types, depending upon the methods of chopping the forage and discharging chopping material.

(PowerPoint Slide 40)

1. On cut-and-throw harvesters, the cutterhead or flywheel does the cutting and delivers the crop to a wagon or truck. Most forage harvesters use rotating knives and a stationary knife or shear bar to chop material as it is fed into the cutterhead.
2. Cut-and-blow harvesters have a separate blower mounted behind or to the side of the cutterhead to deliver the crop to a wagon or truck.

3. Flail harvesters cut and chop standing forage in a single operation. They can also harvest windrowed crops and stover.
- B. There are several classifications of forage harvesters.
 1. Tractor mounted harvesters are cut-and-throw type. They attach to the tractor's three-point hitch and are usually equipped with a single-row, row-crop head, or a windrow pick-up head.
 2. Pulled forage harvesters may be either the cut-and-throw or cut-and-blow type. Pulled harvesters come in a variety of heads: direct-cut sickle cutterbar, windrow pickup, and one- to three-row, row-crop heads.
 3. Self-propelled forage harvesters are equipped with their own engines. They generally offer high capacity, good maneuverability, and many operator conveniences. They provide the high capacity and productivity needed by large feeding operations and by custom operators.

(PowerPoint Slide 41)

- C. Field operation considerations for forage harvesters include:
 1. Operating the harvester at a ground speed which uses its full capacity, but does not overload the machine.
 2. At the end of the row or windrow, raise the forage head or flail before turning.
 3. Controlling the wagon loading process by adjusting the spout and deflector cap to fill the wagon evenly from the rear to the front. Turn the blower spout as each turn is made to keep material flowing into the wagon or truck.

Use TM: 6-12 (PowerPoint Slide 40) to assist in the discussion of the different types of forage harvesters.

Objective 6: Identify the equipment used for forage handling systems.

Anticipated Problem: What equipment is used in forage handling systems?

(PowerPoint Slide 42)

VI. Handling forage starts when the crop has been packaged. The process of transporting harvested forage from field to storage depends on the type of forage.

- A. There are a variety of ways baled hay is transported, depending on the size of the package.

(PowerPoint Slide 43)

1. Small rectangular or round bales are handled in many ways.
 - a. Bales can be loaded on bale wagons or hayracks by hand, through the use of bale ejectors, bale loaders, or accumulators.
 - b. At the storage site, small bales may be moved with bale elevators and conveyors. To reduce labor requirements, bales can be dropped from the conveyor in a random stack. If labor is plentiful and storage space is at a premium, bales are stacked by hand.
2. Large square and round bales must be handled carefully due to their heavy weight.

- a. A round bale mover is an integral component in a round bale system. Some bale movers lift, haul, and unload bales. Others are used to lift and load bales on trucks, wagons, and feeders.
- b. Mounted bale movers are attached either to tractors or pickup trucks.
- c. Most towed bale movers are attached to a tractor or truck. Round bale movers lift, haul, and unload round bales.

(PowerPoint Slide 44)

- B. Silage and haylage are handled with self-unloading forage boxes or high-dump wagons.
 - 1. Self-unloading forage boxes have many uses in forage harvesting and feeding. Most forage boxes unload into a front chamber and discharge material out one side. The material is moved forward by a chain and slat system.
 - 2. High dump wagons raise the bin of material high in the air to dump the contents into a waiting vehicle through the use of hydraulic cylinders. High dump wagons offer two major advantages in field operations.
 - a. They decrease the number of transport vehicles by quickly transferring material into higher-speed vehicles for road transport.
 - b. They transfer material to trucks which cannot enter the field due to soft or rough conditions.

(PowerPoint Slide 45)

- C. The type of storage system used will determine the way the forage is moved into storage.
 - 1. With bunkers and trench silos, the material is unloaded on the pile and is moved around by a bulldozer or tractor and blade. As the material is moved, the weight of the bulldozer or tractor packs the material to create an air free environment.
 - 2. Upright silos require a forage blower to move the material into storage.
 - a. Forage blowers are basically throwing devices with the “throwing” or propelling unit being a fan with paddles. Material enters the blower housing near the outer edge of the fan. It is then moved by centrifugal force to the end of the blower blades, and accelerated by the fan. When material reaches the blower spout, it is thrown upward through the discharge pipe.
 - b. The performance of a forage blower is influenced by available power, fan speed, fan-blade tip clearance, type of material, delivery pipe size, and arrangement and feed rate of the material.

Use TM: 6-13 (PowerPoint Slide 46) to illustrate equipment for handling silage and haylage. Use TM: 6-14 (PowerPoint Slide 47) to illustrate transferring material from a high dump wagon to a truck. Discuss how forage harvesting processes and equipment differs from grain harvesting processes and equipment.

Review/Summary: Review should be focused around the lesson's student learning objectives. **(PowerPoint Slide 48)** Use classroom discussion to determine content that may need to be covered in more detail.

Application: The following lab activity will be helpful to students in applying the lesson's content:

LS: 6-1 Forage Harvesting and Handling Equipment

Educator's note: Suggested websites include

www.deere.com

www.caseih.com

Evaluation: Objectives should be reviewed by the students. Laboratory activities should be performed before the written test is given to students.

Answers to Sample Test:

Matching

1. E
2. B
3. H
4. C
5. A
6. D
7. F
8. G

Fill-in-the-blank

1. Conditioning
2. Cutterbar head
3. Wilted silage
4. Shearing or impact

Short Answer

1. Places most of the leaves inside the windrow.
2. Baler design, bale dimensions, type of hay, and moisture content

Operating, Calibrating, and Maintaining Forage Harvesting and Handling Systems

Name: _____

Matching: Match each word with the correct definition.

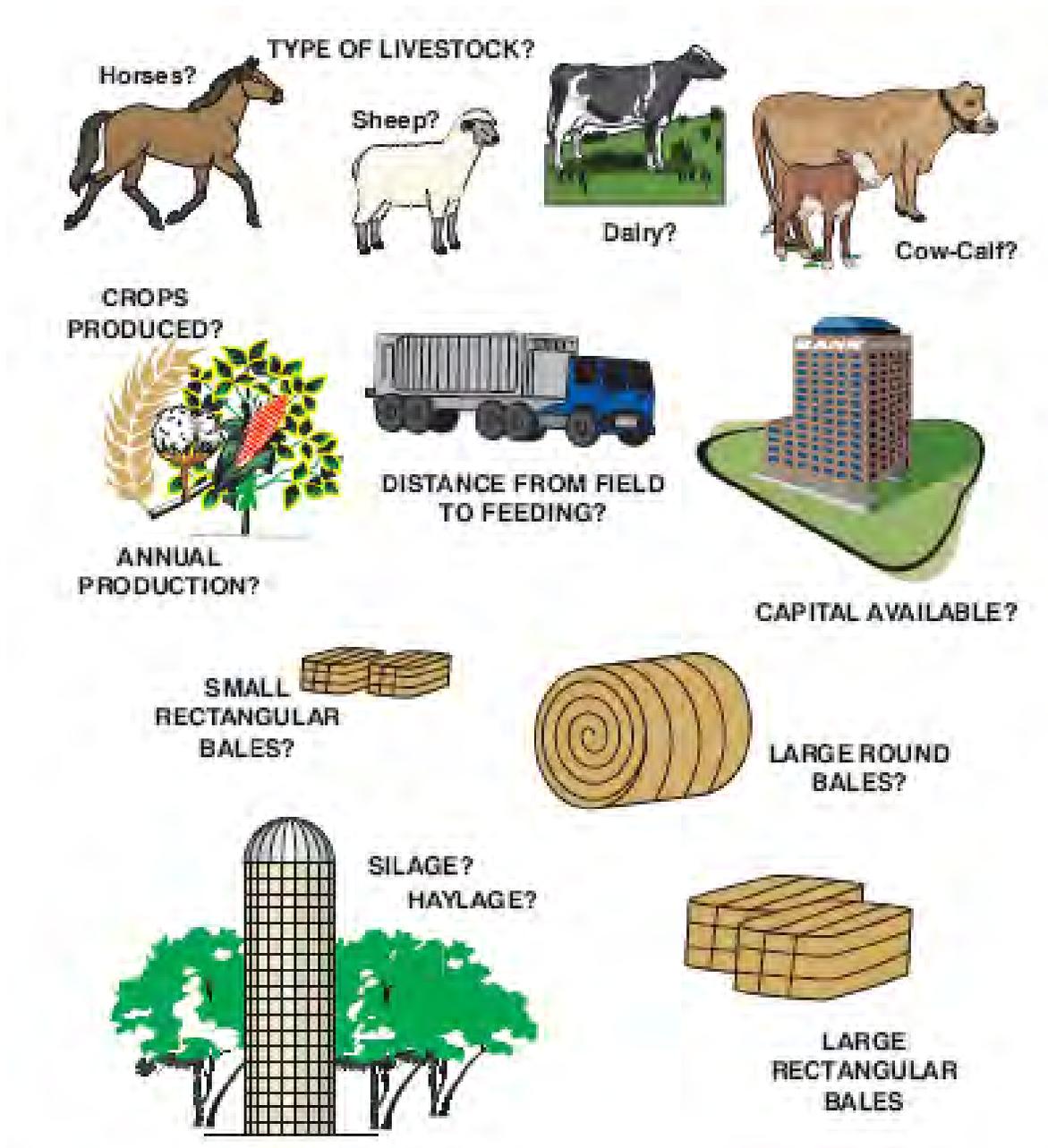
- | | | |
|---------------|-------------------|------------|
| a. baling | d. haylage | g. silage |
| b. green chop | e. knife register | h. windrow |
| c. hay | f. mower | |

- _____ 1. Knife sections are an equal distance from the centerline of the guards at each end of the stroke.
- _____ 2. Cut, chopped and fed directly without being stored.
- _____ 3. A row of hay or forage to be picked up later by a harvesting machine.
- _____ 4. Green forage crop harvested for livestock feed and stored at low moisture levels, with no special storage structures or preservatives used.
- _____ 5. A packaging operation.
- _____ 6. On-grain crop, chopped and field dried to the desired moisture content, and then ensiled.
- _____ 7. Used to cut standing vegetation.
- _____ 8. Fermented green forage, harvested in a high-moisture condition to prevent excessive leaf loss and stored in an oxygen-limiting unit.

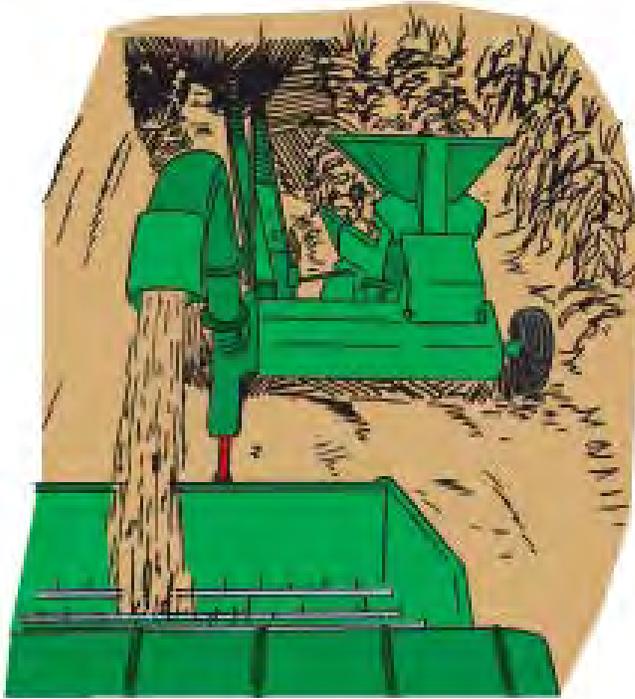
Fill-in-the-blank: Complete the following statements.

1. _____ permits rapid moisture loss from inside the stems allowing for stems and leaves to dry at approximately the same rate reducing the time needed for field curing.
2. To compensate for drag force, the position of the outer end of the cutterbar is slightly ahead of the inner end when the mower is stopped, this referred to as _____.
3. The crop is cut and field dried to 50 to 70 percent moisture content the desired moisture content, then chopped and ensiled, it is known as _____.

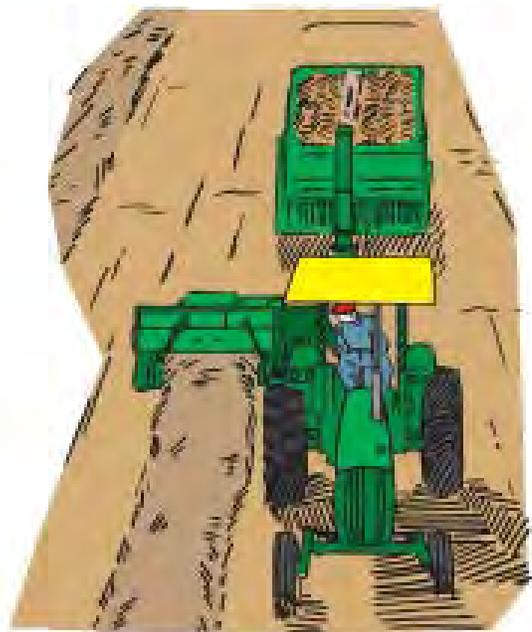
QUESTIONS ASSOCIATED WITH A FORAGE MANAGEMENT PROGRAM



TWO TYPES OF FORAGE HARVESTING



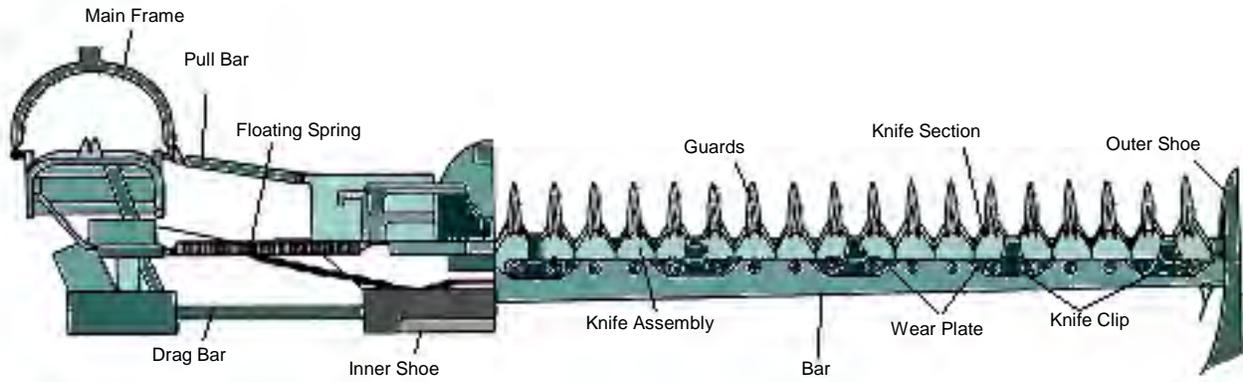
Direct-Cut-Forage Harvesting



Wilted-Forage Harvesting

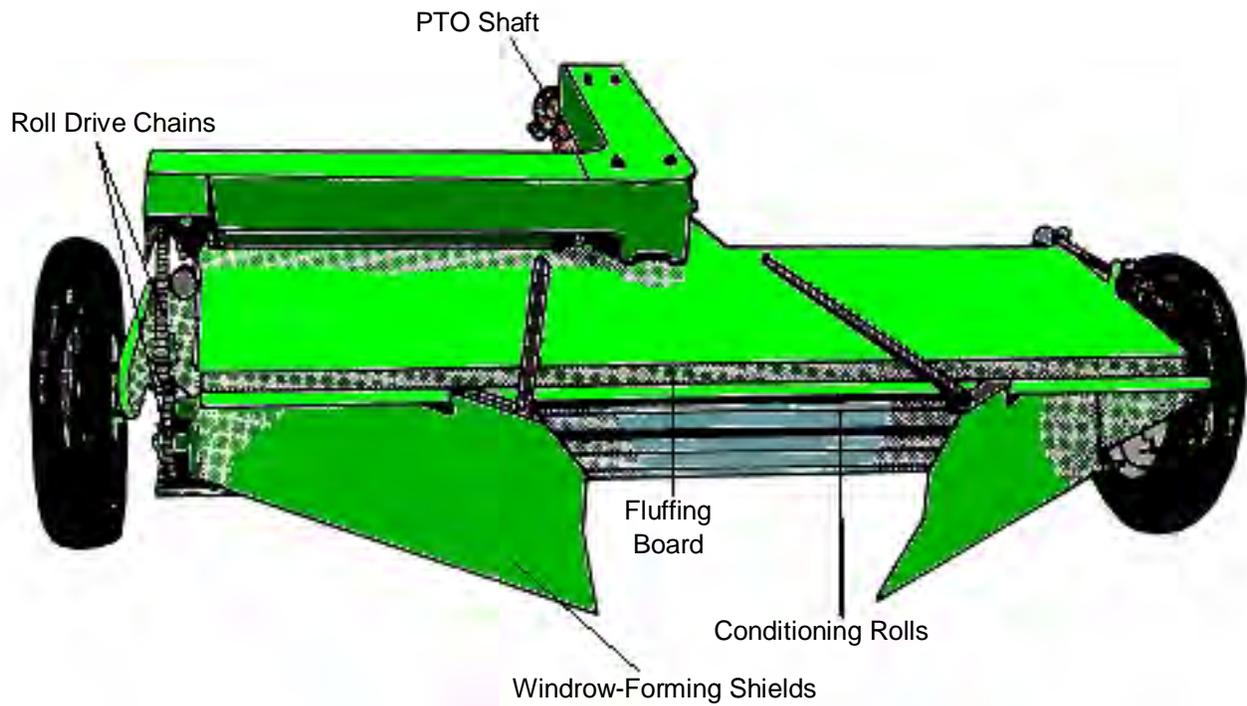
TM: 6-3

MOWER COMPONENTS



TM: 6-4

HAY CONDITIONER COMPONENTS

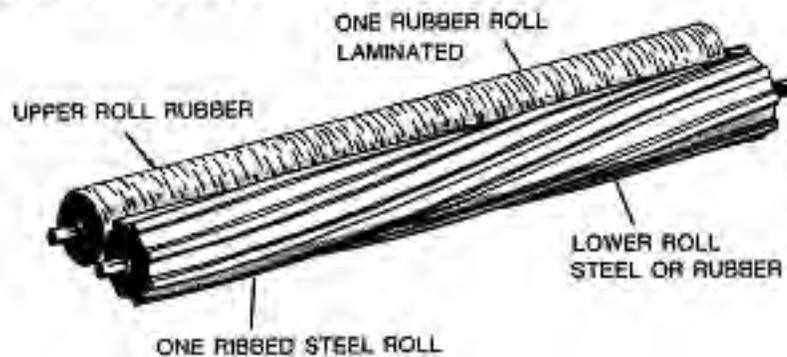


TYPES OF CONDITIONER ROLLS

CRIMPER ROLLS



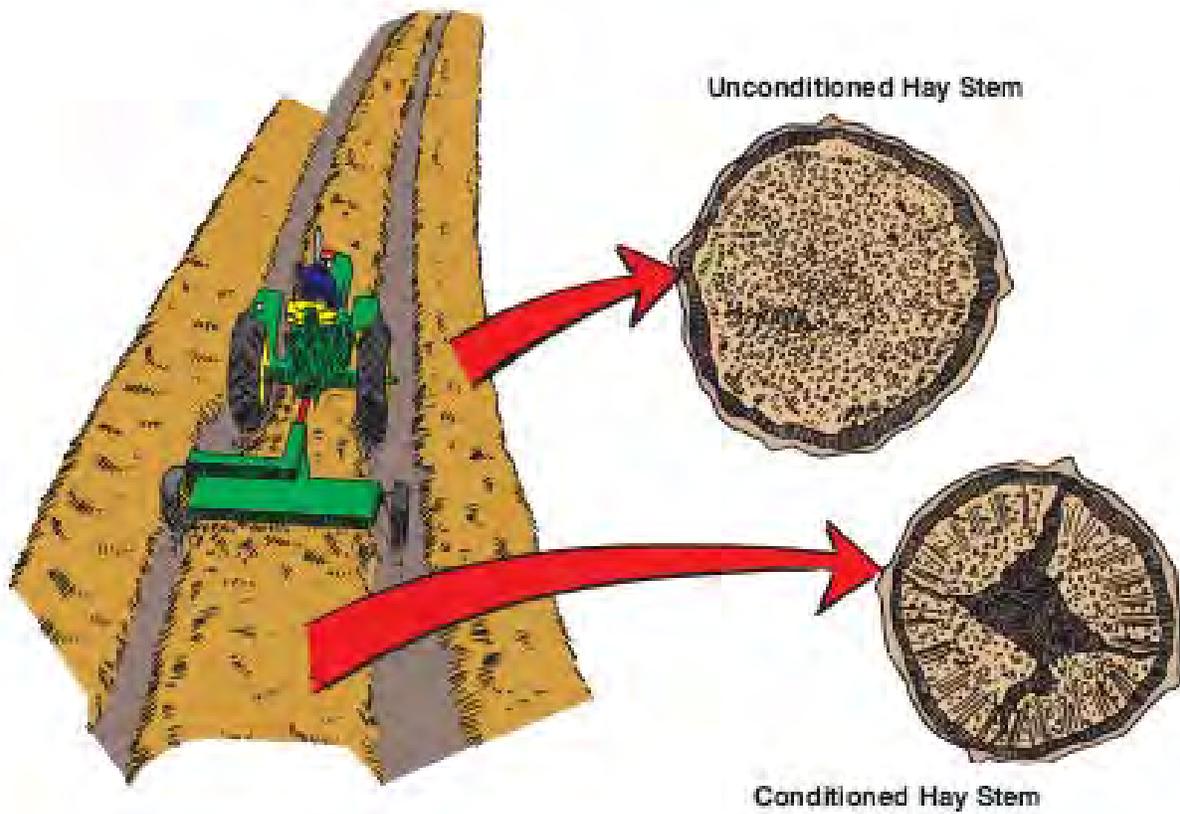
CRUSHER ROLLS



**MOLDED RUBBER
CRUSHING/CRIMPING ROLLS**



CONDITIONERS SPEED DRYING



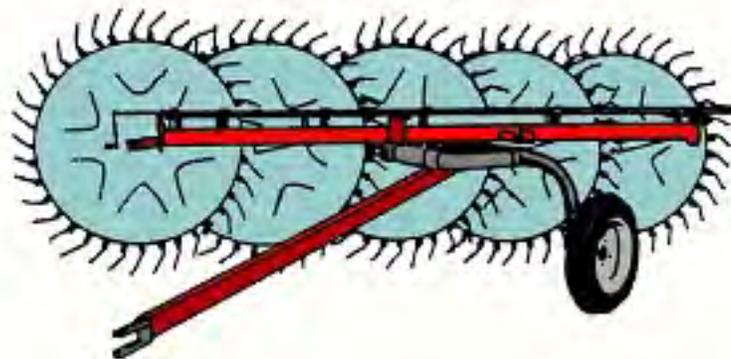
TM: 6-7

TYPES OF RAKES

Rear-Mounted, Parallel Bar Rake



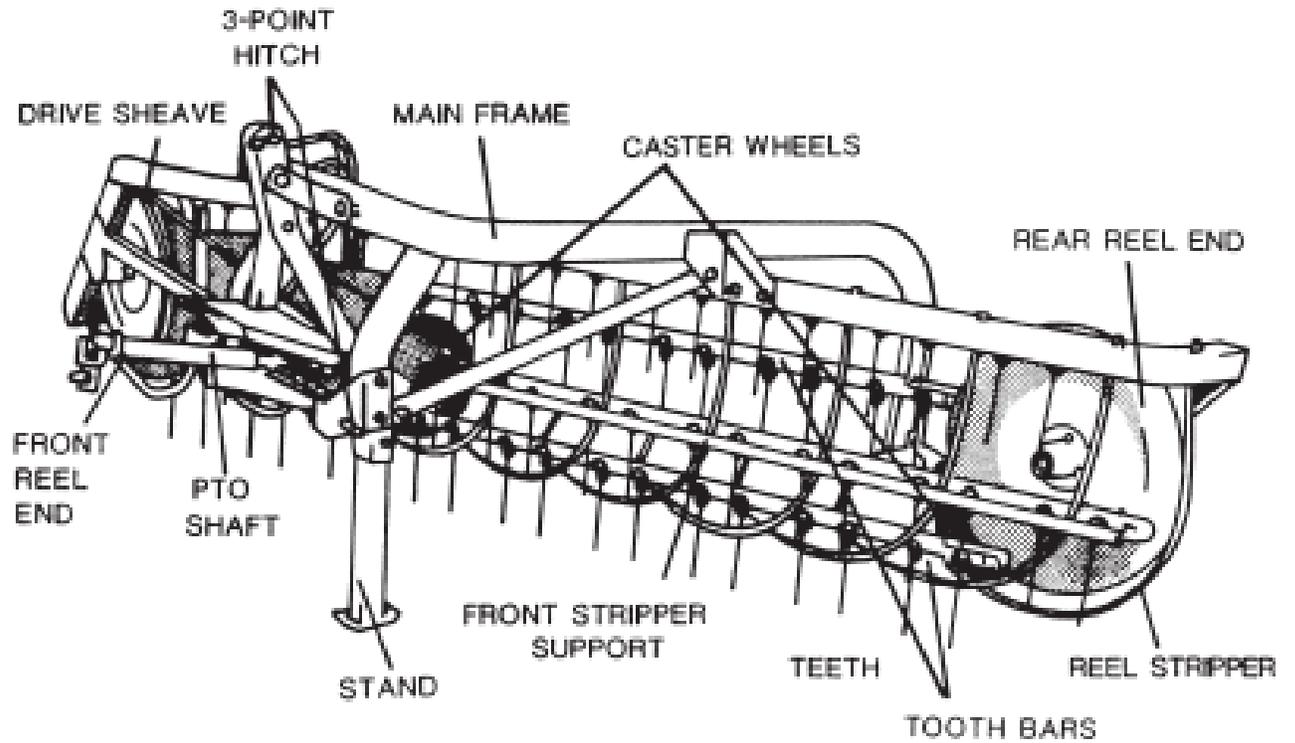
Rear-Mounted, Wheel Rake



Two Rakes with Tandem Hitch

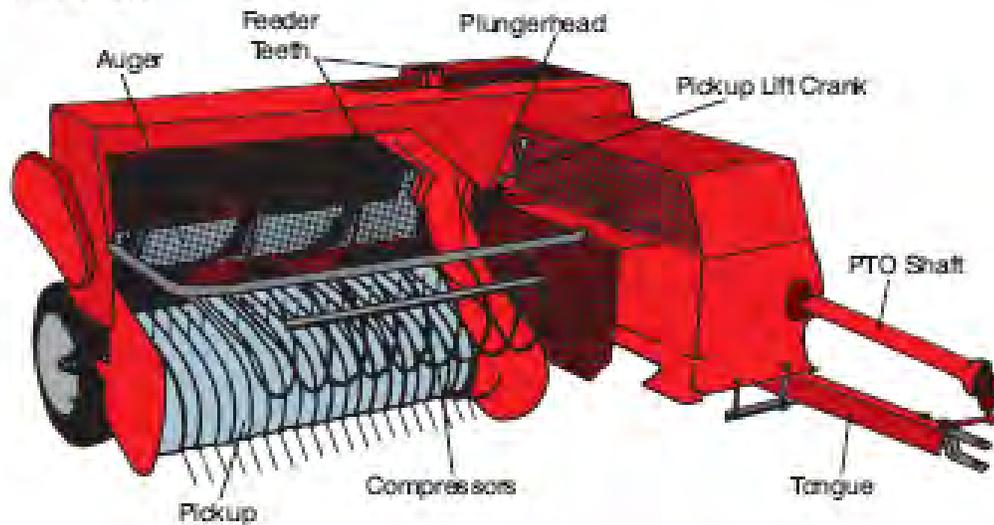


RAKE COMPONENTS

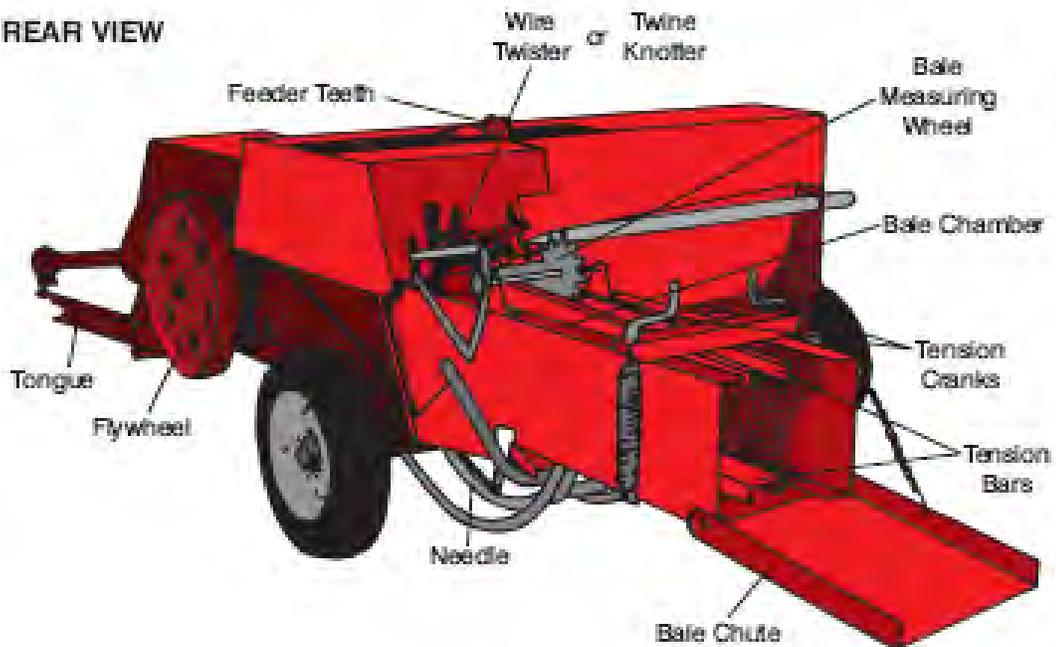


TYPES OF BALING EQUIPMENT

FRONT VIEW

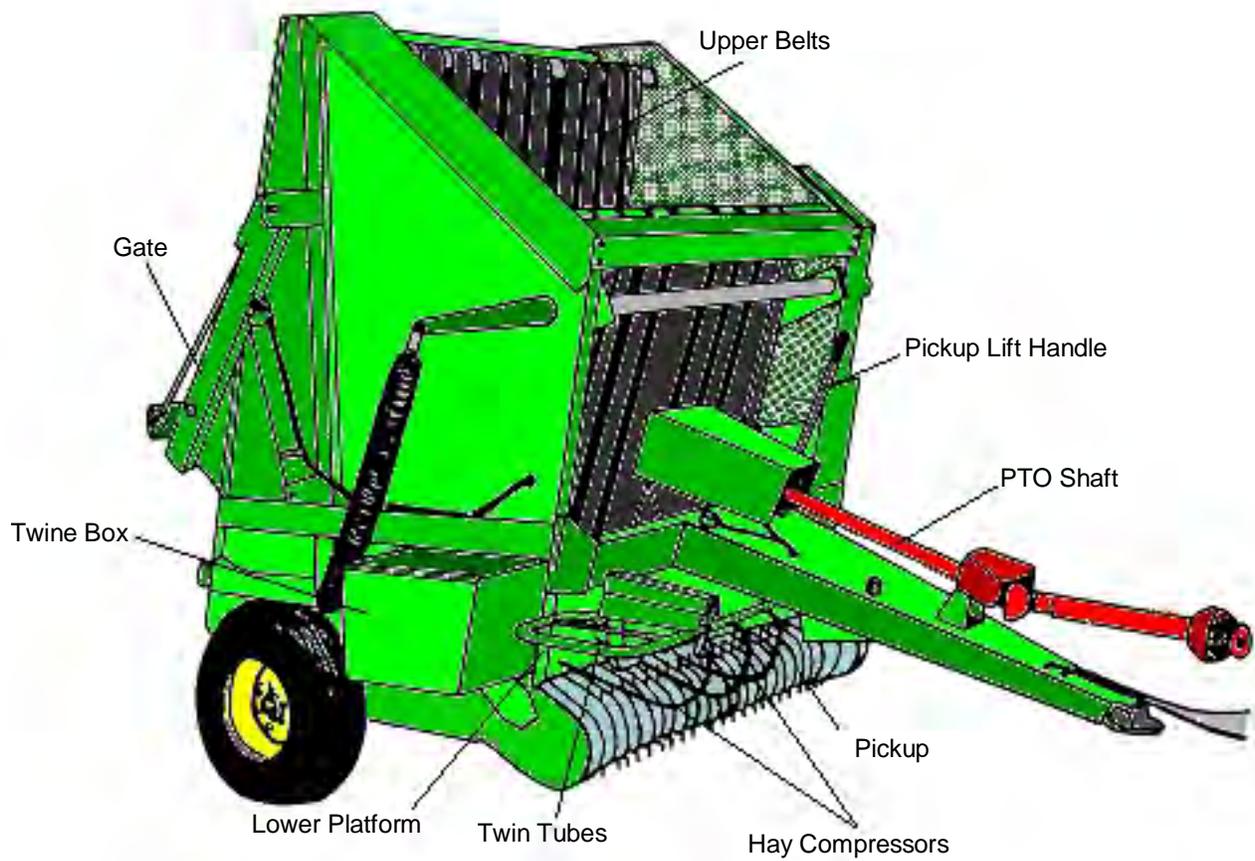


REAR VIEW



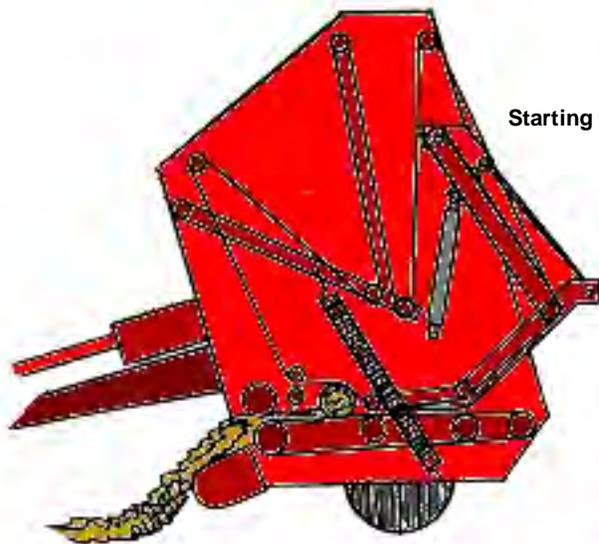
TM: 6-10

LARGE ROUND BALER COMPONENTS

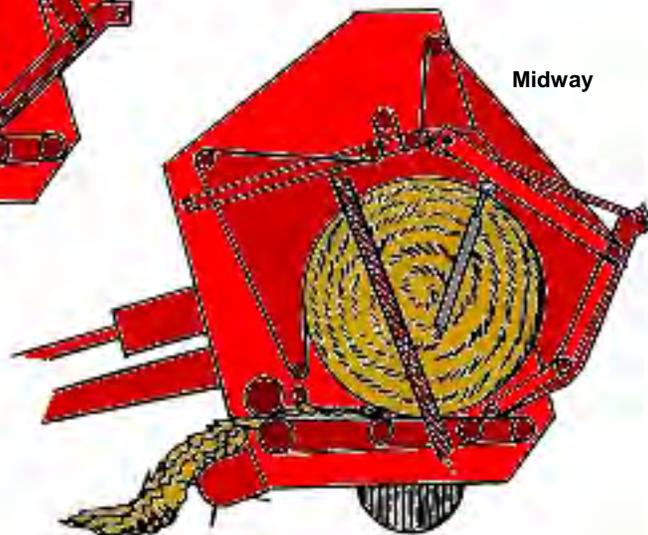


TM: 6-11

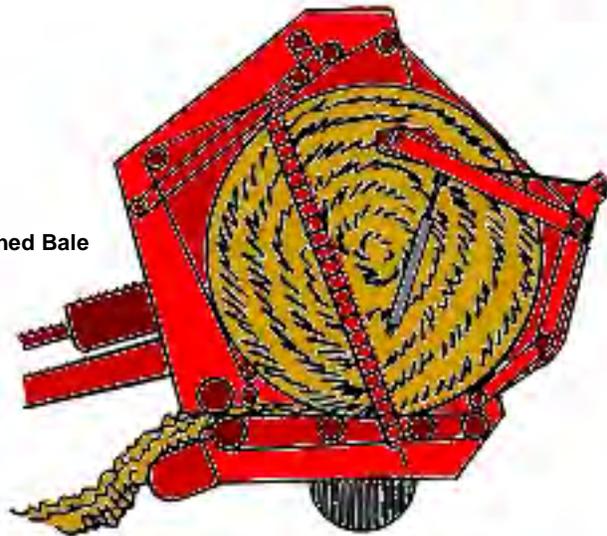
FORMING LARGE ROUND BALES



Starting the Bale



Midway



Finished Bale



THREE DISTINCT TYPES OF FORAGE HARVESTERS

- Cut-and-throw harvesters—cutterhead or flywheel does the cutting and delivers the crop to a wagon or truck.
- Cut-and-blow harvesters—a separate blower mounted behind or to the side of the cutterhead delivers the crop to a wagon or truck.
- Flail harvesters—cut and chop standing forage in a single operation.

TM: 6-13

EQUIPMENT USED FOR HANDLING SILAGE AND HAYLAGE



Forage Box

(Courtesy, John Deere)



High-Dump Wagon

TM: 6-14

TRANSFERRING MATERIAL FROM A HIGH DUMP WAGON TO A TRUCK



**Transferring the material to a truck allows for
quicker transport.**

LS: 6-1

Forage Harvesting and Handling Equipment

Using a search engine on the internet, find three different types of forage harvesting or handling equipment. Prepare a five to eight minute presentation about the information you explored. A visual aid must be created using PowerPoint.

Complete the following information on the forage harvesting or handling equipment you explored.

1. Picture
2. Brand
3. Make
4. Key features
5. Safety features
6. Pickup mechanism
7. Forming mechanism
8. Twine pattern
9. Bale ejection
10. Other interesting information
11. Sources of information