UNIT IX - FORAGE PRODUCTION

Lesson 7: Harvesting for Feed

**Competency/Objective:** Identify the principles for harvesting and storing forages for feed.

**Study Questions**

1. What factors determine harvest timing?
2. What factors affect forage quality at or during harvesting?
3. What are the advantages and disadvantages of various harvesting methods?
4. What forage quality factors are affected during storage?
5. What are the advantages and disadvantages of various storage methods?
6. What methods are used to enhance poor quality forage?

**References**

1. *Advanced Crop Science* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 2000, Unit IX.
2. Activity Sheet
   a) AS 7.1: Testing Forages for Moisture Content
UNIT IX - FORAGE PRODUCTION

Lesson 7: Harvesting for Feed

TEACHING PROCEDURES

A. **Review**

The importance of seed production to develop high-quality forages for use in livestock production was previously discussed. This lesson will focus upon proper harvesting of those forages.

B. **Motivation**

Bring in samples of harvested forages (hay or silage). Make sure the samples are a sampling of good, fair, and poor quality. Have students visually evaluate the samples and suggest explanations for the differences in quality.

C. **Assignment**

D. **Supervised Study**

E. **Discussion**

1. One of the most critical factors in determining the quality of harvested forages is that of harvest timing. Discuss with the students the factors that determine the best time to harvest.

   **What factors determine harvest timing?**

   a) **Stage of maturity**
   
   1) Harvest based upon vegetative and seed productive stages of the plant
   2) Harvest occurring at the onset of the reproductive stage
      (a) Plant should be actively growing vegetatively.
      (b) Plant should not be expending energy toward reproductive growth.
   3) Recommended stages of maturity for harvest
      (a) Alfalfa - bud to 1/10th bloom (1 in every 10 buds is in bloom)
      (b) Red clover - 1/4 to 1/2 bloom
      (c) Timothy - Late boot stage (inflorescence enclosed within the sheath of the uppermost leaf)
      (d) Bromegrass - seed heads emerged
      (e) Orchardgrass - blooms emerged
      (f) Reed canarygrass - seed heads emerged
      (g) Tall fescue - boot stage
      (h) Grass/legume mixes
         (1) Harvest at the desired stage of the legumes’ growth regardless of the grass.
         (2) Legumes are higher in nutrient value, so increased awareness is placed upon them in a mixture.
   b) **Weather patterns** - for optimum forage harvest, should be dry and warm
      1) Minimum of 3 days of dry weather is needed from cutting to baling.
      2) Humidity increases the length of drying time.
      3) Warm breezes and sunshine will shorten the days required to dry.
      4) Silage and haylage will not require as long to dry down to storable moisture content.
2. Losses in nutrient quality are found in forage crops harvested only 10 days past prime harvest. Therefore, it is critical to time harvesting operations to meet this crucial stage of growth. Discuss the forage quality factors for harvesting. Have students complete AS 7.1

**What factors affect forage quality at or during harvesting?**

a) **Growth stage**
   1) Harvested after the prime growth stage
      (a) Drop in total digestible nutrients (TDN)
      (b) Decrease in protein content and other available nutrients
   2) Harvested before the prime growth stage
      (a) Reduced quantity of forage harvested
      (b) Nutrient storage in leaves and stems not maximized

b) **Mechanical damage**
   1) Dry matter losses occur during raking and baling processes
   2) Primarily affect leaves (highest quality part of the plants)

c) **Climatic losses**
   1) Rain - Downed hay (cut hay prior to baling and storing) is susceptible to nutrient losses from leaching.
   2) Sun - Hay left down for too long can experience significant losses from blanching (the bleaching away of nutrients from the leaf and stem of the plant).

d) **Moisture content**
   1) Harvest plants continue to respire after cutting, losing up to 60 percent moisture.
      (a) Dry matter (DM) loses up to 15%.
      (b) DM loss averages 5 to 6%.
      (c) Losses are nonrecoverable.
   2) Hay should be baled between 18 to 22% moisture content.
      (a) Hay is safe for storage inside at 15 to 18% moisture content.
      (b) Moisture levels higher than 22% lead to dry matter and quality loss due to heating and molding of the hay.
   3) Forage is ensiled two ways.
      (a) Haylage - Forage is stored at 40 to 50% moisture.
      (b) Silage - Forage is stored at 60 to 65% moisture.
      (c) Most green chop forages (grasses and legumes) are stored typically as haylage.

3. Ask students to discuss methods of harvesting forages they have observed or been involved with. Have them discuss the advantages and disadvantages of those methods.

**What are the advantages and disadvantages of various harvesting methods?**

a) **Mowing** - cutting off plants about 3 to 6 inches above the ground level
   1) If a plant is harvested below 3 inches, the plant is weakened by removing valuable leaf tissue necessary for regrowth.
   2) Plants cut over 6 inches do not maximize the amount of forage harvested.

b) **Conditioning** - method to speed up the drying process
   1) Mechanical
      (a) Roller system that crushes the plant stems
      (b) More surface area exposed to evaporation and drying
      (c) Advantages
         (1) Effectively crushes coarse plant stems, opening more surface area to moisture loss
         (2) Effectively increases drying rate by up to 80 percent in first cuttings
      (d) Disadvantages
(1) Slight loss in dry matter may occur.
(2) Finer stemmed plants may slide through rollers without being crushed, thus voiding effects of conditioning.

2) Chemical
(a) Removes waxy coating on plants so moisture can escape easily
(b) Applied at the time of mowing; primarily used with alfalfa
(c) Advantages
   (1) Efficient with legume crops
   (2) Increases drying rates in second and third cuttings
(d) Disadvantages
   (1) Additional equipment needed to apply chemical during cutting
   (2) Does not work well with grasses

(c) Mower conditioner - mowing and conditioning process in one machine
1) Advantages
   (a) Less damage to forage due to single cutting/crimping process
   (b) Fewer trips across field saving on fuel, maintenance, and labor costs
2) Disadvantage -
   (a) Rollers adjusted incorrectly - great losses in dry matter
   (b) More costly than a mower

d) Swath manipulation - mechanical turning or spreading of forage to enhance even drying
1) Raking - hay crop mechanically inverted into tight windrows
   (a) Advantages
      (1) Efficiently inverts and fluffs windrows for drying
      (2) Rolls windrows for better pickup with the baler
   (b) Disadvantages
      (1) If crop is thick, wet sections in the middle may not dry completely.
      (2) There is loss of dry matter, especially leaves in legumes.
2) Swath inversion - (similar to raking) mowed swath moved on belts and inverted with the bottom moving to the top and the top to bottom
   (a) Advantages
      (1) Gentler method, does not “beat” hay during pickup, knocking leaves off of legumes
      (2) Inverts and fluffs windrows
   (b) Disadvantage - not as efficient as tedding in drying time
3) Tedding - a machine with rotating tines that stirs, spreads, and fluffs the hay
   (a) Advantages
      (1) Allows for uniform drying by spreading out the hay
      (2) Spreads swaths and may decrease drying time by up to 2 days
   (b) Disadvantages
      (1) Beating action is more damaging to legumes with fragile leaf structures.
      (2) Leaf loss leads to nutritional loss.

e) Baling
1) Rectangular bales
   (a) Common size - 14 x 18 x 48-50 inches; weighing between 80 and 120 pounds
      (1) Advantages
         a. Ease of handling in stacking and feeding
         b. Easier in transportation and marketing operations
      (2) Disadvantages
         a. More labor intensive in hauling and stacking
         b. Indoor storage needed to maintain highest quality
   (b) Large, high density bales - sizes ranging from 24 to 50 inches wide and tall by 48 to 98 inches long; weighing 440 to 2000 pounds
      (1) Advantage - harvested and transported more efficiently
      (2) Disadvantages
a. More specialized equipment is needed for harvest and feeding, which increases the cost.

b. Wind damage can occur if bales are not covered.

2) Round bales - typically used for on-farm use; sizes range from 36 to 72 inches in diameter, 48 to 64 inches in length; weighing 440 to 2000 pounds

   (a) Advantages
       (1) Less labor intensive than small rectangular bales
       (2) Can be stored outside in convenient locations for consumption

   (b) Disadvantages
       (1) Not easily transported or stored indoors
       (2) Can lose nutritional value with extended outside storage unless wrapped or bagged
       (3) Disposal of used plastic wrap or bags can create environmental concern

f) Silage chopping - forage harvester used to chop the crop

   1) Advantage - Less labor required than hay harvest

   2) Disadvantages
       (a) Losses can occur from drift between the blower and the trailing vehicle
       (b) More power to operate equipment

4. Ask students what factors they believe are important to storage quality. Discuss how the moisture content and nutritional quality affect overall profitability.

What forage quality factors are affected during storage?

a) Moisture content

   1) Levels more than 22% in baled hay lead to dry matter and quality loss from heating and molding.
   2) Levels below 40% in haylage decrease the anaerobic fermentation processes.
   3) Levels over 50% can lead to spoilage in ensiled forage.

b) Nutritional quality

   1) Maintained for approximately 1 year without noticeable losses if properly stored
   2) Decreasing dry matter as more drying occurs, thus reducing some nutritional value
   3) Forages stored outside or without protection from the elements
        (a) Subject to greater losses from nutrients being leached out from rain
        (b) Losses resulting from mold and spoilage

5. Have students once again refer to the samples brought in for the motivation exercise. Ask them if storage could have affected the quality of the samples.

What are the advantages and disadvantages of various storage methods?

a) Inside storage - rectangular baled hay typically stored in livestock barns or specialized pole hay barns at 18 to 20% moisture

   1) Advantages
        (a) Less exposure to weather; maintains higher quality longer
        (b) May be more accessible for feeding (in livestock barns or during bad weather)

   2) Disadvantages
        (a) More labor intensive
        (b) Increased costs for buildings, labor, and maintenance
        (c) Wet hay
            (1) Experiences loss from microbial activity, spoilage, and mold
            (2) Could cause fire from internal heating

b) Outside storage - baled hay

*Advanced Crop Science, IX-74*
1) Round bales stored outside due to size and handling needs; rectangular bales, outside

2) Advantages
   (a) Less labor intensive
   (b) Does not require the capital outlay of barns

3) Disadvantages
   (a) Additional protection requiring specialized equipment
      (1) Round bales should be wrapped with a protective plastic covering.
      (2) All bales should be tarped to be protected from the weather.
      (3) Gravel, old tires, etc. must be placed on the ground to protect the hay from spoilage and loss due to soil contact.
   (b) More difficult to move; requires specialized equipment
   (c) Expensive to move long distances
   (d) Nutritional value lost quicker due to exposure to weather

C) Methods of storing silage and haylage

1) Tower silos
   (a) Constructed of concrete or steel
   (b) Range in capacity from 50 to 4000 tons
   (c) Storing crops at 50 to 65% moisture
   (d) Weight of the silage packing forage to reduce trapped air
   (e) Advantages
      (1) Good maintenance of forage quality
      (2) Protection from weather
      (3) Take up less ground space than other options
      (4) Easily adaptable to automated feeding equipment
   (f) Disadvantages
      (1) Some loss to spoilage at top of silo
      (2) Inconvenient to load/unload; requires some labor inside of silo
      (3) Gas buildup
      (4) Higher cost

2) Silage bunkers
   (a) Usually made of concrete, with concrete floor and sidewalls
   (b) Sidewalls vary from 10 to 20 feet high
   (c) Storing crops between 50 to 75% moisture
   (d) Forage packing by tractor to reduce trapped air
   (e) Unloading by a front-end loader or tractor
   (f) Advantages
      (1) Economical
      (2) Easy to store and remove forage for feeding
   (g) Disadvantages
      (1) Typically not protected from environment, unless covered with plastic, which adds additional cost to storage
      (2) Does not allow for fermentation as well as other storage methods

3) Silage bags
   (a) Made of plastic that encloses the forage
   (b) Average bag size - 150-200 feet long and approximately 9 feet in diameter
   (c) Often used as short-term method of storage
   (d) Front-end loader or tractor needed for unloading
   (e) Advantages
      (1) Does not require permanent structures
      (2) Different types and qualities of forages can be stored separately
   (f) Disadvantages
      (1) They take up more storage space than tower silo.
      (2) Specialized equipment is required for bagging forage.
(3) Bags must be maintained to minimize damage.
(4) Spoilage can reach 50%.
(5) Additional labor is required to dispose of bags and plastic remnants.

6. To improve lower quality forages, the producer must understand what constitutes quality forage and how quality can be improved.

**What methods are used to enhance poor quality forage?**

a) Quality forage is defined in terms of the value of pasture grasses and legumes for grazing animals.
   1) Forage quality is described in terms of protein, fiber, and other components.
   2) High-quality forage is one with high protein and low fiber.

b) Three major factors affect the quality of forage.
   1) Plant species - Legumes are higher in quality than grasses.
   2) Plant maturity - As plants becomes mature, the leafy vegetative stage changes into more stems, resulting in lower protein and higher fiber.
   3) Plant part - The leaves are more nutritious than the stems. Raking and baling techniques may save leaves, increasing its value.

c) Other factors that affect quality are climate and biological stress.
   1) Cooler temperatures result in lower fiber concentrations yielding higher digestibility.
   2) Diseases and insects usually cause leaf loss and lower nutritive value.

d) Stored forage value can be increased.
   1) Cover or wrap bales and place inside a facility to decrease nutrient loss due to expose to sun and moisture.
   2) Inject anhydrous ammonia into the bale to break down lignin and increase digestibility. This also neutralizes the toxic effect of some compounds in the plant and increases daily gain.

F. **Other Activities**

1. Have the students determine the ground space requirements of storage methods for silage and haylage. Information for space requirements for tower silos, bunkers, and bags can be found on the Crop Storage Institute’s web page at <http://www.cropstorage.com/home.html>.

2. Use the evaluation score card hay from contests and have the students evaluate different samples of hay.

G. **Conclusion**

Although it is important to have high-quality forages from good seedstock, this will not matter if the forage is not properly harvested and stored. For maximization of harvested forages, the producer must know at what point harvesting should occur, use those methods for harvesting that will maximize resources while decreasing drying time, and store the forages for maximum retention of quality and nutrition.

H. **Answers to Activity Sheet**

Answers will vary.

I. **Answers to Evaluation**

1. b
2. e
3. f
4. d
5. a
6. d
7. c
8. Primary growth stage; mechanical damage; climatic losses; moisture content
9. It is gentler and does not damage legume leaves as much
10. 22
11. 1 year
12. Outside
13. Tower silos
14. Reduce trapped air
15. Plant species, plant maturity, and plant part
16. Lower temperatures will promote vegetative leaf growth, reducing fiber, increasing digestibility. Insects and diseases cause leaf loss, lowering the nutritive value of forages.
17. Ammoniation is the process of injecting anhydrous ammonia into the bale of hay. The hay should be covered with a wrap or tarp when this process is done. The ammonia helps break down the fiber, increasing digestibility and reducing toxic compound effects.
EVALUATION

Match the following forages to the ideal stage of maturity for harvest.
(Answers may be used more than once.)

_____ 1. Alfalfa
_____ 2. Red clover
_____ 3. Timothy
_____ 4. Bromegrass
_____ 5. Orchardgrass
_____ 6. Reed canarygrass
_____ 7. Tall fescue

a. Blooms emerged
b. Bud to 1/10th bloom
c. Boot stage
d. Seed heads emerged
e. ¼ to ½ bloom
f. Late boot stage

Answer the following short answer questions.

8. What are the four factors that affect forage quality at harvesting?
   a. 
   b. 
   c. 
   d. 

9. Why is swath inversion preferred over raking?

10. Moisture levels over ______ % in baled hay lead to dry matter and quality loss.

11. Nutritional values of properly stored forges will be maintained for approximately ______________ without noticeable losses.

12. Is nutritional value lost quicker in baled hay that is stored inside or outside?

13. Which method of storage for silage or haylage provides the best protection from the weather?
14. Packing the forage in silage bunkers is usually done by a tractor to ______________________
________________.

15. What are the three major plant factors that affect the quality of forages?
   a. 
   b. 
   c. 

16. Explain how climate and biological factors may affect forage quality.

17. Explain what is meant by “ammoniation” of forages and its value to forages.
Testing Forage for Moisture Content

Objective: Students will be able to test forage samples for moisture content

Materials:

Small scale (grams)
Paper plate
Glass or jar
Microwave oven
Forage samples

Directions:

1. Weigh paper plate and record weight.
2. Place 100 grams of selected forage (fresh cut, haylage, silage) on the plate and scale.
3. Spread out the forage evenly on the plate.
4. Fill the glass or jar 3/4 full with water.
5. Place the glass in the back corner of the microwave. (NOTE: Keep water level constant during testing.)
6. Set the microwave to 80 to 90% power.
7. Place the forage sample in the microwave and heat for 8 minutes.
8. Remove the sample, weigh, and record the weight, then mix the sample.
9. Check water level, then place sample in microwave and dry for 2 minutes.
10. Remove the sample and check weight. If the weight has not changed by more than 1 gram, record weight as dry weight. If there is a change of greater than 1 gram, repeat step 9 until a change of less than 1 gram is obtained.
11. Use the following calculation to determine percent moisture (remember to subtract weight of plate):
   
   percent moisture = (wet weight) - (dry weight)/wet weight * 100

12. Record sample percent moisture.