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# Using Cool-Season Annual Grasses for Hay and Silage

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## Introduction

Cool-season annual grasses, such as annual ryegrass or the small grains wheat, oats and cereal rye, are routinely planted to provide forage for livestock. This can occur in dedicated crop fields or by interseeding into a warm-season grass sod. These plants provide excellent forage quality while in vegetative or stem elongation stages of growth, but protein and digestibility can quickly decline following emergence of the seed head. In the Southeastern U.S., harvest of small grains for hay in the spring is often delayed by spring rains. Maturity at harvest has a large impact on quality; as forages mature, concentrations of protein decrease while fiber content increases. The fiber contained in these mature forages also contains more lignin cross-linkages. Highly lignified forages remain in the rumen longer because of their slow rate of digestion, decreasing dry matter intake, which reduces animal performance. Producers have increasingly turned to production of round bale silage to improve the timeliness of harvest operations.

## Plant Characteristics and Nutritive Quality

For most applications, a high leaf-to-stem ratio in the forage we produce is desirable and is an excellent indicator of forage quality. A study in North Carolina determined the leaf, stem and grain content of oats, wheat, barley and cereal rye throughout each stage of development from vegetative through hard dough grain stage (Table 1). Cereal rye produced a larger percentage of stem than the other small grains at every stage of development. In all cases, leaf content declined with increases in stem up through heading. After heading, grain content increased and provided the bulk of the yield in barley, oats and wheat at the hard dough grain stage.

These results are supported by research at the University of Arkansas System Division of Agriculture Livestock and Forestry Research Station at Batesville. In this research, wheat, oats and cereal rye were harvested on five dates between early March and early June, with maturity ranging from vegetative or early stem elongation to ripe grain (Table 2). The seed head provided 40% to 60% of the total dry matter weight at the ripe grain stage. As the forage increased in maturity, fiber digestibility decreased from around 60% to 30% or less. Yet, because of the digestibility of the seed and the high percentage of the plant made up by the seed head as the plants neared maturity, the decline in overall dry matter digestibility leveled off after the small grains reached the milk stage.

Research at the University of Arkansas System Division of Agriculture Southwest Research and Extension Center at Hope (Table 3) indicates that dry matter yield is more than doubled when harvested at the hard dough grain stage of maturity compared with at the boot stage. Crude protein was decreased by 6 percentage units, but fiber content was only increased by about 3 percentage units because of the increase in non-fiber carbohydrates with increasing maturity. There was a shift in the type of non-fiber carbohydrates (NFC) with increasing maturity. Non-fiber carbohydrates of forage harvested in the boot stage consisted of soluble sugars and plant cell

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**Table 1. Percentages of plant dry matter found in the leaf, stem and grain for four cereal grains harvested on six dates in North Carolina (adapted from Edmisten, et al., 1998; Commun. Soil Sci. Plant Anal. 29:867-879). Values are summarized from two years of data.**

| | | Growth Stage at Harvest | | | | | |
|---|---|---|---|---|---|---|---|
| **Species** | **Plant Part** | **Vegetative** | **Boot** | **Heading** | **Milk** | **Soft Dough** | **Hard Dough** |
| **Barley** | leaf | 81.4 | 44.8 | 23.8 | 15.0 | 11.9 | 8.6 |
| | stem | 18.6 | 55.2 | 61.9 | 55.7 | 50.3 | 40.1 |
| | grain | 0.0 | 0.0 | 14.3 | 29.3 | 37.8 | 51.3 |
| **Oats** | leaf | 82.4 | 43.8 | 17.7 | 14.2 | 8.6 | 8.0 |
| | stem | 17.6 | 56.2 | 54.4 | 50.0 | 35.3 | 37.7 |
| | grain | 0.0 | 0.0 | 27.9 | 35.8 | 54.1 | 56.3 |
| **Cereal Rye** | leaf | 70.4 | 39.1 | 17.7 | 7.1 | 4.8 | 2.2 |
| | stem | 29.6 | 60.9 | 71.6 | 70.5 | 67.0 | 52.3 |
| | grain | 0.0 | 0.0 | 10.7 | 22.4 | 28.2 | 45.5 |
| **Wheat** | leaf | 82.8 | 44.2 | 23.5 | 14.2 | 9.9 | 7.7 |
| | stem | 17.2 | 55.8 | 58.7 | 55.9 | 43.8 | 36.3 |
| | grain | 0.0 | 0.0 | 17.8 | 29.9 | 46.3 | 56.0 |

**Table 2. Growth stage, plant height and percentage of dry matter partitioned within the grain head for three fall-seeded cereal grains harvested on five dates in spring 1998 at Batesville, Arkansas (J. Dairy Sci. 83:2499-2511).**

| Species | Harvest Date | Growth Stage | Plant Height (inches) | Head Weight (% dry matter) | Dry Matter Digestibility (% of DM) | Neutral Detergent Fiber Digestibility (% of NDF) |
|---|---|---|---|---|---|---|
| **Oats** | March 24 | vegetative | 7.1 | . . . | 77.8 | 56.3 |
| | April 15 | early boot | 16.2 | . . . | 71.9 | 52.2 |
| | May 4 | head emerged | 25.6 | . . . | 57.8 | 40.4 |
| | May 26 | late milk | 34.7 | 53.6 | 57.6 | 34.8 |
| | June 5 | ripe grain | 31.9 | 55.1 | 55.0 | 32.4 |
| **Wheat** | March 24 | stem elongation | 9.9 | . . . | 78.5 | 61.5 |
| | April 15 | tip of head emerged | 21.7 | . . . | 67.8 | 45.9 |
| | May 4 | early milk | 28.0 | . . . | 57.5 | 37.7 |
| | May 26 | soft dough | 27.6 | 57.9 | 53.1 | 27.2 |
| | June 5 | ripe grain | 26.0 | 60.1 | 53.6 | 26.0 |
| **Cereal Rye** | March 24 | stem elongation | 11.8 | . . . | 80.0 | 62.6 |
| | April 15 | head emerged | 39.4 | . . . | 54.2 | 37.5 |
| | May 4 | early milk | 59.9 | . . . | 41.1 | 28.2 |
| | May 26 | early dough | 57.9 | 36.1 | 44.1 | 23.2 |
| | June 5 | ripe grain | 56.0 | 41.4 | 43.4 | 19.9 |

**Table 3. Effect of maturity at harvest of wheat forage on DM yield and nutritive characteristics in spring 2007 at Hope, Arkansas (J. Anim. Sci. 87:4133-4142).**

| | Maturity at Harvest | |
|---|---|---|
| **Item** | **Boot** | **Hard Dough Grain** |
| **DM Yield, lb/acre** | 2,447 | 5,510 |
| | **Nutrient Content, % DM basis** | |
| **Crude Protein** | 15.2 | 8.9 |
| **Neutral Detergent Fiber** | 59.9 | 62.4 |
| **Acid Detergent Fiber** | 36.6 | 38.8 |
| **Non-Fiber Carbohydrate** | 18.7 | 21.3 |
| **Dry Matter Digestibility** | 58.7 | 57.3 |

contents, while non-fiber carbohydrates in the forage harvested at hard dough stage consisted of starch content of the grain. Thus, dry matter digestibility was only 1.4% lower for forage harvested in hard dough stage compared with boot stage. Research in Kansas reported that wheat silage harvested in the dough stage of maturity contained 10.3% crude protein (CP) and 35.6% acid detergent fiber (ADF) compared to 8.8% CP and 38.0% ADF for wheat silage harvested in the milk stage of maturity. This difference indicates a considerable contribution to overall nutritive quality of small grain forage by the seeds following head emergence during the grain filling process.

## Baling Cool-Season Annual Grasses as Silage or Hay

For more information on the process of baling silage, refer to FSA3051, Baled Silage for Livestock. Because the harvest of cool-season annual forage at the optimal quality occurs at the time of our most frequent rainfall, hay production is frequently delayed until later stages of maturity. Producers have increasingly turned to production of round bale silage to improve timeliness.

**Moisture content.** The moisture content of cool-season annual forages declines as the plant matures. A typical recommendation for ensiling forage crops is to ensure moisture content is < 70%. This is necessary to decrease the amount of effluent loss and to avoid undesirable fermentation that occurs with excessively wet silage. Work from North Carolina (summarized in Table 4) illustrates the relationship between plant maturity and forage moisture content. Based on these data, small grain forage can often be direct cut for silage chopping or baling after it reaches the milk stage of maturity.

Producers should pay particular attention to the moisture content of forage at the time of ensiling. Excessively dry forages are hard to pack, and maturing small grains contain hollow stems, which makes it difficult to exclude oxygen and increases the probability of spontaneous heating of the silage. Producers should monitor moisture content closely and not allow forages to become excessively dry prior to ensiling. When cereal grains are harvested at advanced stages of maturity, such as the soft dough stage, weather conditions may demand these forages be direct cut or that the mower-conditioner is operated immediately in front of forage chopper or silage baler.

Moisture content can be crudely estimated hand grabs, oven drying, microwaves, or air dryers. Accurate moisture content is an essential component of determining when and how to process these forages. Please refer to FSA3155,

**Table 4. Percentages of moisture found in four cereal grains harvested on six dates in North Carolina (adapted from Edmisten, et al., 1998; Comm. Soil Sci. Plant Anal. 29:867-879).**

| | Growth Stage at Harvest | | | | | |
|---|---|---|---|---|---|---|
| | **Vegetative** | **Boot** | **Heading** | **Milk** | **Soft Dough** | **Hard Dough** |
| **Species** | **Moisture** | | | | | |
| **Barley** | 83.5 | 82.7 | 77.9 | 72.4 | 62.2 | 55.5 |
| **Oats** | 76.5 | 80.0 | 72.2 | 67.9 | 56.1 | 48.3 |
| **Rye** | 78.2 | 82.71 | 75.3 | 58.5 | 57.2 | 39.9 |
| **Wheat** | 80.9 | 75.4 | 75.5 | 59.3 | 57.9 | 42.2 |

Testing Forage Moisture Content Using an Air Fryer, for more information.

The moisture content of forage intended for hay has a large impact on the curing time required for baling. Research at the University of Arkansas University of Arkansas System Division of Agriculture Southwest Research and Extension Center investigated the impact of maturity at harvest and preservation method on nutritive quality and dry matter loss of harvested forage. One-half of three separate wheat fields were cut on April 5 at the boot stage of maturity with a disc mower. Alternating windrows of wheat forage cut in the boot stage of maturity were baled into round packages following 24-hour wilt and wrapped with four layers of 25 µm plastic with a silage wrapper for preservation as silage or allowed to cure and baled as hay on April 17. During the 12-day curing process, the hay harvested in the boot stage was rained on three times totaling 1 inch of precipitation.

The other half of the wheat forage in each field was cut on May 15 at the hard dough stage of maturity. Alternating rows of wheat forage cut in the hard-dough stage of maturity were baled following 6-hour wilt and wrapped as described above for silage or allowed to cure and baled as hay on May 21.

The form of the NFC in wheat forage in the boot stage of maturity would primarily be associated with soluble cell contents, whereas the form of the NFC in dough stage wheat forage is primarily associated with starch in the grain. Moisture concentration of boot silage was considerably greater (78.5%) than normally recommended for round-bale silage, whereas moisture concentration of dough silage (53.3%) was within the optimal range of 40% to 65%. Detergent fiber of boot hay was greater and NFC concentration was less compared with boot silage, presumably because of the rainfall washing out soluble carbohydrates and soluble carbohydrates being consumed in the curing process and incorporated into the NDF (neutral detergent fiber) component due to chemical reactions during the heating process. Dry matter digestibility of boot hay was reduced considerably compared to boot silage due to these changes in detergent fiber distributions and concentrations. This change in detergent fiber distribution was not present in the forage harvested in the dough stage because the NFC component is in a more stable form as starches are incorporated into grain and the curing process was accelerated with the reduced DM concentration at harvest. Dry matter losses associated with curing and storage were 24% with boot hay, 0.5% with boot silage, 2.8% with dough silage and 6.8% with dough hay.

The pH and lactic and acetic concentrations of the silages indicated the fermentations were within optimal ranges and adequate for the forage conditions at harvest. Compared to optimal concentrations, boot silage contained

**Table 5. Effect of maturity at harvest of wheat forage and preservation method on nutritive characteristics and DM loss following storage at Hope, Arkansas (J. Anim. Sci. 87:4133-4142).**

| | Maturity at Harvest | | | |
|---|---|---|---|---|
| | Boot | | Hard Dough Grain | |
| | Silage | Hay | Silage | Hay |
| Item | % Dry Matter Basis | | | |
| Dry Matter | 21.5 | 91.3 | 46.7 | 91.4 |
| Crude Protein | 16.8 | 14.9 | 9.5 | 8.9 |
| Neutral Detergent Fiber | 58.5 | 77.0 | 60.4 | 63.0 |
| Acid Detergent Fiber | 37.1 | 44.2 | 38.9 | 38.3 |
| Non-Fiber Carbohydrate | 18.4 | 5.5 | 18.4 | 21.5 |
| Dry Matter Digestibility | 60.0 | 53.0 | 54.0 | 56.0 |
| Lactic Acid | 9.9 | . . . | 2.6 | . . . |
| Acetic Acid | 0.9 | . . . | 0.2 | . . . |
| Proprionic Acid | 0.2 | . . . | 0.0 | . . . |
| Butric Acid | 0.8 | . . . | 0.1 | . . . |
| Iso-Butyric Acid | 3.0 | . . . | 0.0 | . . . |
| Ammonia | 23.0 | . . . | 8.0 | . . . |
| pH | 4.8 | . . . | 5.1 | . . . |
| Dry Matter Loss | 0.5 | 24.4 | 2.8 | 6.8 |

excessive butyric acid, isobutyric acid, propionic acid and ammonia concentrations, indicating possible clostridial fermentation, which would be common to forage containing high CP concentration and ensiled at DM concentrations of < 30%.

## Adding Annual Ryegrass to Forage Mixtures

Adding ryegrass to wheat and other small grains at seeding has been shown to increase the percentage of leaf in the sward, which is often assumed to have a positive effect on forage quality. In the case of small grains, the digestibility of monocultures commonly has the same digestibility as mixtures with ryegrass until grain fill of the small grains is initiated. At this time, the digestibility of small grain forage improves with the filling of the grains while ryegrass digestibility continues to decline, negating the improvement in digestibility from grain filling. The improved quality associated with addition of ryegrass is completely dependent on maturity of the ryegrass, so care should be taken to ensure proper harvest timing of swards containing ryegrass.

## Mechanical Conditioning

Cereal grains and ryegrass that have reached the dough stage of maturity should not be conditioned using crushing-type or roller-type conditioners. At this stage of maturity, the grains are easily shattered and lost. Since the most digestible portion of the plant in this stage of maturity is contained in the seed head, this can result in loss of forage quality. Producers should widen the gap between rollers or otherwise remove conditioners to limit grain shatter.

## Late Winter Planting Opportunities

Most cool-season annual grasses are planted in the fall, but drought may preclude planting in that window. Late winter plantings can produce a sizable amount of forage in spring. A three-year trial, conducted in Jonesboro found that spring oats or annual ryegrass are the optimal forages to plant. Additionally, these forages should be planted between late February and mid-March. These forages will ready for harvest in April or May. Please refer to FSA3151, Planting Oats for Forage, for more information.

## Implications

Clearly, forage quality characteristics of cereal grains and annual ryegrass are excellent in the early spring. If yield is of secondary importance and quality is of primary importance, then harvest should be conducted in the boot stage of maturity, if weather conditions warrant. Quality characteristics of cereal rye deteriorate more rapidly with increasing maturity than in other small grains, and annual ryegrass tends to retain quality longer into the spring. The difficulty of managing cereal rye as a hay or silage crop is, therefore, exaggerated by its accelerated developmental characteristics and unique growth habit, which result in taller plants with more stem, greater fiber concentrations and lower proportions of grain. If the narrow window of acceptable harvest maturity in the boot stage is missed, then the movement of plant sugars away from the leaf and stem to the grain during the early heading and milk stages of maturity decreases forage digestibility. Thus harvest may be delayed until grain filling is nearing completion in the dough stage of maturity. Harvest at the dough stage results in lower protein content but increased yield and acceptable digestibility.

## Recommendations

- Make every attempt to harvest at boot stage of maturity for optimal forage quality.
- If forage quality is of secondary concern and greater yield is required, harvesting at the dough grain stage of maturity may be acceptable.
- Use good silage or hay making techniques.
- Open or disengage the conditioner if cereal grains contain grain that can shatter and be lost.
- If considerable forage acreage is to be harvested, producers may want to plant several fields to differing species to lengthen acceptable harvest window and increase flexibility to weather conditions.

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