SMALL GRAIN CEREAL FORAGES: TIPS FOR EVALUATING VARIETIES AND TEST RESULTS

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ABSTRACT

The attributes of small grain cereal forages that increase their versatility and value also can complicate their evaluation and use. Knowledge about the growth and development of small grains, and about the limitations of commonly used measures of quality like ADF and NDF, can aid in variety evaluation. As it matures, the small grain plant transforms from a "vegetative "forage like other immature grasses, to a "grain" forage like corn silage. Small grains at the boot stage of maturity typically are higher in % protein and digestible fiber (as measured by NDFD) than those harvested at the soft dough stage, while those at soft dough have higher yield and % non fiber carbohydrates. Protein and digestibility of boot and soft dough stage forages compare favorably with benchmark values for alfalfa and corn silage, respectively. Harvest stage and moisture content can complicate comparisons of dry matter yield. Yield, quality, rate of maturation, and fitness for the production area are key factors for choosing varieties.

Key Words: small grain forage, cereal forage, growth stages, forage quality, yield

INTRODUCTION

Small grain cereals (triticale, wheat, oats, barley, and rye) are grown for grazing, green chop, silage, and hay over a wide range of production conditions. They are harvested at various stages of maturity, and fed to diverse types of livestock. This diversity of varieties, uses, and production conditions complicates the evaluation and choice of small grain cereal forages. Understanding the growth and development of small grain cereal plants, and the methods used to evaluate them, can help in choosing and managing varieties that are best suited for specific production conditions and end uses.

EVALUATING NUTRITIONAL QUALITY

One obstacle to evaluating small grain cereal forages is the inadequacy of some of the commonly used measures of nutritional composition for reflecting actual feed value. Four of the nutritional measures most often used to characterize the nutritional value of small grain forages are crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), and lignin (L). Along with dry matter, these four values were the four most frequently requested analyses of small grain cereal forages (identified and grouped by species or collectively as "Small Grain") for samples submitted for analysis to Dairy One Forage Lab in the year concluded April 30, 2006. Evaluating small grain forages on the

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basis of these four measures alone can be misleading, especially for comparing varieties harvested at different stages of maturity.

For example, a comparison of the nutritional characteristics of small grain forages harvested in the boot stage compared to those harvested in the soft dough stage illustrates the inadequacy of these commonly used measures of nutritional composition (Table 1).

Table 1. Forage Quality Measures for Boot and Soft Dough Stages

	Boot-stage Varieties at Boot Stage n = 6	Soft-Dough Varieties at Soft Dough Stage n = 20
	% of Dry Matter	
Crude Protein	18.7	10.6
ADF	33.0	29.2
NDF	57.2	46.6
Lignin	4.3	3.9
NDFD	63.3	46.9
Digestible NDF	36.2	21.9
IVTD	78.8	75.5
Sugar	8.4	12.2
NFC	17.9	34.2

ADF: Acid Detergent Fiber
NDF: Neutral Detergent Fiber
NDFD: NDF Digestibility (as a % of NDF) at 24 hours
Digestible NDF: NDF multiplied by NDFD.
IVTD: In Vitro True Digestibility at 24 hours
NFC: Non Fiber Carbohydrates (Sugar, Starch, Pectin, Fermentation Acids)

The values reported for the boot stage forage are an average of varieties developed for production in California for harvest at boot stage, for which high tillering, later maturity, and dense leafy vegetative growth are key. The values for soft dough are an average of varieties developed for soft-dough harvest, for which key traits include high grain yield and grain-to-stem ratio, earlier maturity, and extended “stay-green”. Consequently these values reflect differences in the nutritional composition of small grains that are well suited to be harvested in the boot stage compared to different varieties that are well suited to be harvested in the soft dough state, rather than a comparison of the boot and soft dough stages for the same varieties.

The varieties developed for and harvested in the boot stage had higher CP, ADF, NDF and L compared to those developed for and harvested in the soft dough. A common interpretation of these results would be that the boot stage forage was superior in terms of

protein but inferior in terms of predicted animal intake and digestibility due to the higher ADF, NDF, and L. Other less commonly used measures of forage composition, however, provide a different, more complete view. The digestibility (IVTD) of the boot stage forages actually was 3% higher than the soft dough forages. The higher protein of the boot stage forages contributed to that advantage, but the biggest contributor was the higher amount of digestible fiber (NDF multiplied by NDFD) of the boot stage forage compared to the soft dough forage. In addition to exemplifying the limitations of ADF and NDF as indicators of nutritional quality of small grain cereal forage, these data reflect the fundamental differences between the less mature small grains that are richer in digestible fiber, and the more mature small grains that are richer in starch, as reflected in the amount of non fiber carbohydrates.

PLANT MATURITY, QUALITY, AND HARVEST STAGE

An understanding of the growth stages of small grain cereals provides insights about these important nutritional differences between the boot and soft dough stages, and can help extend those insights to other growth stages (Cherney and Marten, Collar et al., and Appendix).

As the small grain plant grows early in the season, it accumulates harvestable dry matter entirely in the form of leaves. As the plant progresses toward heading, stems develop and account for an increasing proportion of plant dry matter. At boot stage, just prior to heading, leaves typically still account for more than two thirds of the harvestable plant. The transition from boot to heading marks the beginning of a transition from a "vegetative" forage like other immature grasses, to a "grain" forage like corn silage.

The nutrient composition and forage quality of small grain plants change significantly as the plants develop. Leaves are more digestible and higher protein than stems, so the decreasing proportion of leaves and increasing proportion of stem as the plant develops reduce the digestibility and protein of the harvestable crop. At the same time that the leaf-to-stem ratio is decreasing, so is the nutritional quality of each of those parts. The digestibility and protein of leaves and stems decline as the plant proceeds through heading, flowering, and grain development. Digestibility of the head drops through milk stage, and then rebounds as grain fills with highly digestible starch and protein. This rebound is an important aspect of small grains that distinguishes them from those forage grasses and legumes for which seed weight never becomes a significant portion of the forage crop. Varieties of small grains that have high grain yield and grain-to-stem ratios are the most likely to have the biggest rebound in digestibility as the plant reaches maturity.

For silage and hay, the boot and dough stages are two key stages for evaluating, choosing, and managing small grain forages. Boot stage is the final stage of development prior to heading. At this stage, yield is higher than any of the preceding "vegetative" stages, yet the plant remains leafy and highly digestible. At dough stage, grain fill is virtually complete, resulting in higher yield than the preceding flower and milk stages, and digestibility that is approximately equal to or higher than those preceding stages,

depending primarily on the plant's grain-to-stem ratio. Because of their superior combination of yield and digestibility compared to other stages of development, boot and soft dough stages are desirable stages at which to harvest for silage and hay. The choice between boot and soft dough forage is a function of the end use for which the forage is going to be used, and agronomic and climatic factors that affect desired harvest time.

QUALITY COMPARED TO FAMILIAR BENCHMARKS

The results of nutritional analyses of the boot stage and soft dough stage forages reflect the decline in percent protein and fiber digestibility and increase in starch that occur as the plant matures. A comparison of these results with typical values for alfalfa hay and corn silage as benchmarks reflects the diversity and value of small grain cereal forages, and underscores this distinction between small grain cereal forages that are "vegetative" forages from those that are "grain" forages.

Compared to averages for alfalfa hay from data compiled by Dairy One Forage Lab for the 2005 crop year, the average CP of the previously reported samples of boot stage forage was lower than that of the alfalfa, but the digestibility was higher (Table 2). The biggest difference in the reported measures between the alfalfa and boot stage cereal forage was in NFC and in the amount and digestibility of NDF. Boot stage cereal forage is a notable source of digestible fiber, almost 40% of the total plant weight for this set of samples harvested in the boot stage, while alfalfa has higher NFC due to its higher pectin.

Table 2. Forage Quality Measures for Boot Stage Cereal Forage and Alfalfa Hay

	Boot-stage Varieties at Boot Stage	Alfalfa & Other Legume Hay California Samples	Alfalfa & Other Legume Hay U.S. Samples
		% of Dry Matter	
Crude Protein	18.7	22.0	21.5
ADF	33.0	29.9	30.6
NDF	57.2	38.1	39.3
Lignin	4.3	7.4	7.5
NDFD	63.3	29.5	32.8
Digestible NDF	36.2	11.2	12.9
IVTD	78.8	NA	73.5
Sugar	8.4	9.0	9.0
NFC	17.9	30.7	30.2

NDFD: NDF Digestibility (as a % of NDF) at 24 hours
IVTD: In Vitro True Digestibility at 24 hours

The quality measures for small grain cereal forages harvested in the soft dough stage are more similar to those of corn silage than they are to the small grains harvested in the boot stage. These soft dough forages compare favorably with corn silage in key measures including protein, digestibility, and digestible fiber (Table 3).

Table 3. Forage Quality Measures for Soft Dough Cereal Forage and Corn Silage

	Soft-Dough Varieties at Soft Dough Stage	Corn Silage California Samples	U.S. Corn Silage U.S. Samples
		% of Dry Matter	
Crude Protein	10.6	8.4	8.3
ADF	29.2	29.6	25.9
NDF	46.6	47.5	43.8
Lignin	3.9	3.9	3.5
NDFD	46.9	36.4	36.7
Digestible NDF	21.9	17.3	16.1
IVTD	75.5	NA	72.7
Sugar	12.2	3.5	3.6
NFC	34.2	36.3	41.3

NDFD: NDF Digestibility (as a % of NDF) at 24 hours
IVTD: In Vitro True Digestibility at 24 hours

EVALUATING YIELD POTENTIAL FOR SILAGE AND HAY

Growth stage has a major impact on yield as well as on quality. Dry matter weight of a typical small grain plant will approximately double from boot to soft dough stage, although that increase may vary from a 50% to a 200% increase depending on variety and growing conditions.

In some forage yield tests, all entries are harvested on the same date regardless of stage of maturity. In other tests, the entries are harvested at approximately the same stage of maturity, but at different dates. In either case, yield data reported by harvest date and growth stage can be more helpful than yield data alone for choosing among varieties. Forage yield data from Virginia for twenty five varieties of barley, oats, triticale, and wheat harvested in the boot and soft dough stages, and rye harvested in the boot and flower stages, exhibit a common tradeoff among yield, earliness to harvest, and stage of maturity (Figure 1). Varieties that take longer to reach a chosen stage of maturity tend to yield more at that stage than those that reach the same maturity stage more quickly, although charting out the yield results in this way can reveal superior varieties that are above the “trend line”.

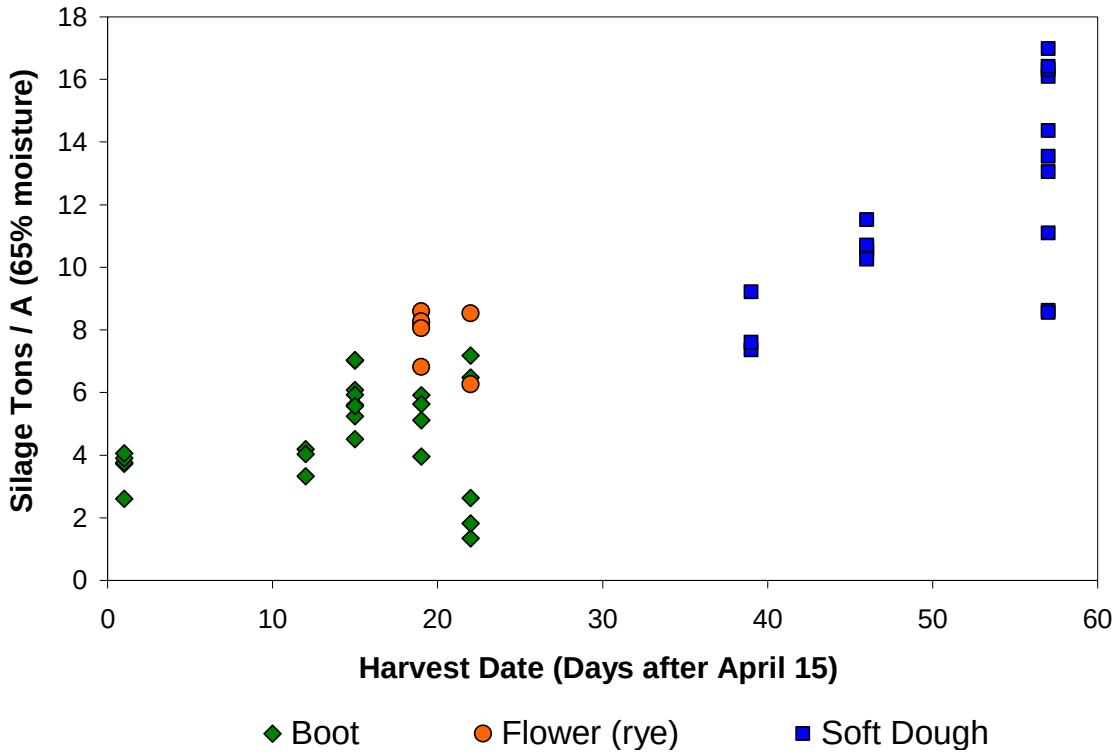

Figure 1. Silage Yield by Harvest Date and Stage of Maturity. Source: VPI, N. Piedmont Ag. Res. & Ext. Center, Orange, VA. Small Grain Forage Test, 2001.

In addition to the issue of harvest timing, the issue of moisture content can complicate the measurement of yields of small grain cereal forages. Sampling variability or errors in the measurement of forage moisture can result in erroneous conclusions about differences in yield among varieties. At boot stage, for example, a small grain plant is typically around 85% moisture. If two varieties produce the same amount of wet weight forage in a yield trial and in fact are both actually at 85% moisture at harvest, then clearly the true dry matter yields of the two varieties in the trial are equal. If, however, moisture is estimated through sampling and drying to be 86% for one variety and 84% for the other, then the variety estimated to be drier at harvest will be calculated to have yielded over 14% more dry matter forage than the variety estimated to be wetter (Table 4). The numerical impact of a 1% error in the measurement of moisture content is greater for forages at the earlier

Table 4. Impact of estimates of moisture content on estimated dry matter yield.

	Wet Weight Yield / Plot	Estimated Moisture	Estimated Dry Matter Yield / Plot	Estimated Yield Advantage
	LBS	%	LBS	
Variety 1	10	84	1.6	+ 14%
Variety 2	10	86	1.4	

stages of maturity because their dry matter content is lower, but the chance of such an error may be higher for the more mature stages such as soft dough for which sampling

variability and drying may be more problematic because of the mix of vegetative and grain parts of the plant.

CHOOSING THE BEST VARIETIES

Stage of maturity has a dominant effect on forage quality and yield, so comparing the yield of two varieties that differ in maturity requires comparing yields of different quality forage at the same harvest date, or comparing yields of similar quality harvested at different dates. In either case, the choice between the two varieties is likely to involve tradeoffs among yield, quality, and harvest timing. Key considerations in addressing those tradeoffs are the end use for which the forage is going to be used, and agronomic and climatic factors that affect desired harvest time.

Regardless of the stage at which they will be harvested, the candidate varieties should be well adapted to the climate and soils of the area, and tolerate diseases and other pests that are likely to occur. For silage and hay, standability is an important attribute, one that can be hard to achieve in combination with high yield, quality, and vigorous growth. In many cases, yield is the ultimate indicator of agronomic strength or weakness, but yield test results from any one year, location, or testing procedure can give an incomplete and perhaps misleading view. Whether relying on results from a single test, or multiple ones, knowledge about the plant characteristics and maturation process that affect yield and quality can lead to better decisions about variety selection than those based on commonly used measures of yield and quality alone.

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APPENDIX

Notable growth stages of small grains.

- Boot: Just prior to heading (appearance of grain head or spike), with the flag leaf (top most leaf) fully expanded. The grain head is not yet visible, but can be felt near the top of the plant inside the sheath of the flag leaf.

- Heading: Grain head (spike) emerges from the sheath of the flag leaf.
- Flower: Grain head and supporting stem have fully emerged from the sheath of the flag leaf; anthers have emerged from the grain head and are shedding pollen.
- Milk: Grain kernels are developing and are filled with a white, milky liquid.
- Soft Dough: Grain kernels are well formed and have the consistency of a rubbery dough.

Source: Adapted from Collar and Aksland.