

HARVESTING MAXIMUM VALUE FROM SMALL GRAIN CEREAL FORAGES

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ABSTRACT

As small grains grow and develop, they change from a “vegetative” forage like other immature grasses to a “grain” forage like corn silage. This transition initially brings with it a decline in digestibility as the plant heads out and progresses to milk stage, then a leveling off or partial rebound in digestibility as the grain fills. Small grains are outstanding products for grazing, especially prior to heading. For silage and hay, boot and soft dough stages are the two recommended stages at which to harvest because of their superior combination of yield and digestibility compared to other stages of development. Choice of variety for silage and hay can be guided by knowledge of when varieties are expected to reach boot and dough stages, and how much they would be expected to yield at each of those stages.

Key Words: small grain forage, cereal forage, growth stages, pasture, silage, hay

INTRODUCTION

Small grain cereal forages – wheat, triticale, barley, oats, and rye – are widely adapted, highly versatile forages used for pasture, green chop, silage, and hay. Cereal forages are a major crop in many parts of the U.S. and world, and their importance is increasing because of their significant economic and environmental benefits (Braunwart et al.). Small grain cereals are used for forage at all stages of growth, from the grazing of small plants early in the growing season, to harvest of mature plants for hay at the end of the season. The diversity of types and uses of small grain cereal forages complicates the choosing of varieties and decisions about management of the crop. A key to harvesting maximum value from cereal forages is to understand their growth and development. That understanding can guide the choice of varieties and management practices to produce a forage crop that best meets the need for which it is being grown.

GROWTH AND DEVELOPMENT OF SMALL GRAINS

As the cereal plant grows through the season it accumulates dry matter and progresses through a series of growth stages (Figure 1 and Appendix). As the plant grows early in the season it accumulates harvestable dry matter entirely in the form of leaves. As the plant approaches heading, stems develop and account for an increasing proportion of plant dry matter. At boot stage, just prior to heading, a typical small grain plant will have reached approximately one half of the dry matter weight that it will eventually attain at full maturity, although that ratio may vary from one third to two thirds depending on variety and growing conditions. At this stage, leaves still account for more than two thirds of the harvestable plant. Leaf dry matter typically continues to increase slightly through heading and up to the flower stage, but then decreases as leaves senesce and nutrients are translocated to the developing grain. As the plant matures

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beyond flower stage, leaves become a smaller proportion of total harvestable dry matter and the stem and head become a larger proportion. 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. During that transition the plant increasingly becomes a combination of grain and stem. At full maturity, leaves account for only about 20% of harvestable dry matter, while heads account for approximately half, with grain typically accounting for most of the weight of the heads.

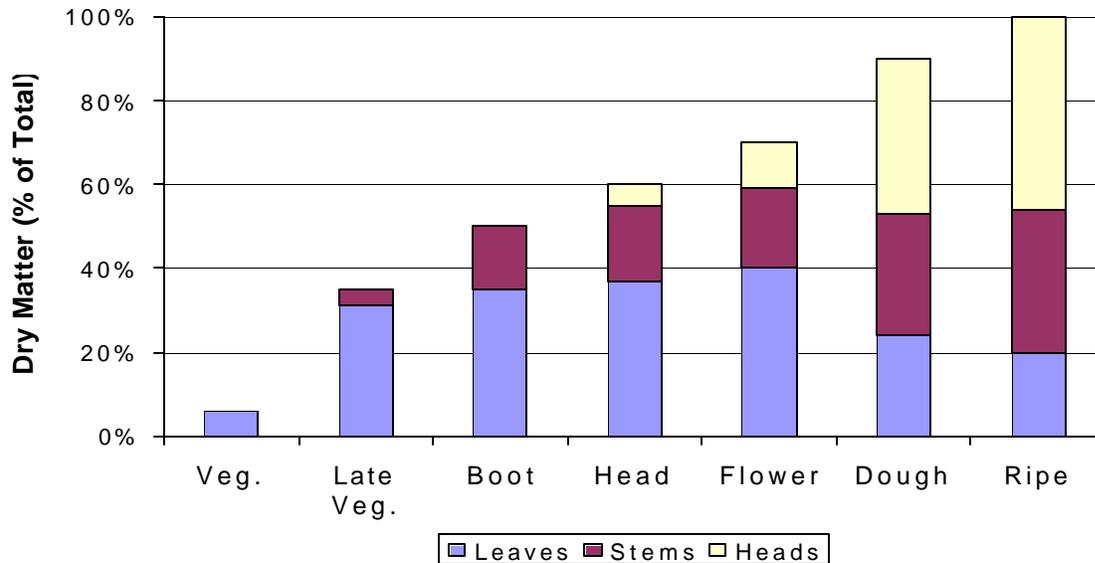


Figure 1. Dry Matter Accumulation During Plant Development. Source: Cook and Veseth.

CHANGES IN DIGESTIBILITY AND PROTEIN

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 (Figure 2). At the flag leaf stage, leaves are approximately 90% digestible, while stems are approximately 75% digestible, and the small, developing head still inside the stem is virtually 100% digestible. The digestibility of leaves and stems decline as the plant proceeds through heading, flowering, and grain development. Digestibility of the head drops to below that of the leaves through milk stage, then rebounds as grain fills with highly digestible starch and protein. The pattern for protein for the three plant parts is similar to that for digestibility. Protein content is highest in the leaves throughout plant development, and decreases in the leaves, stems, and head as the plant develops.

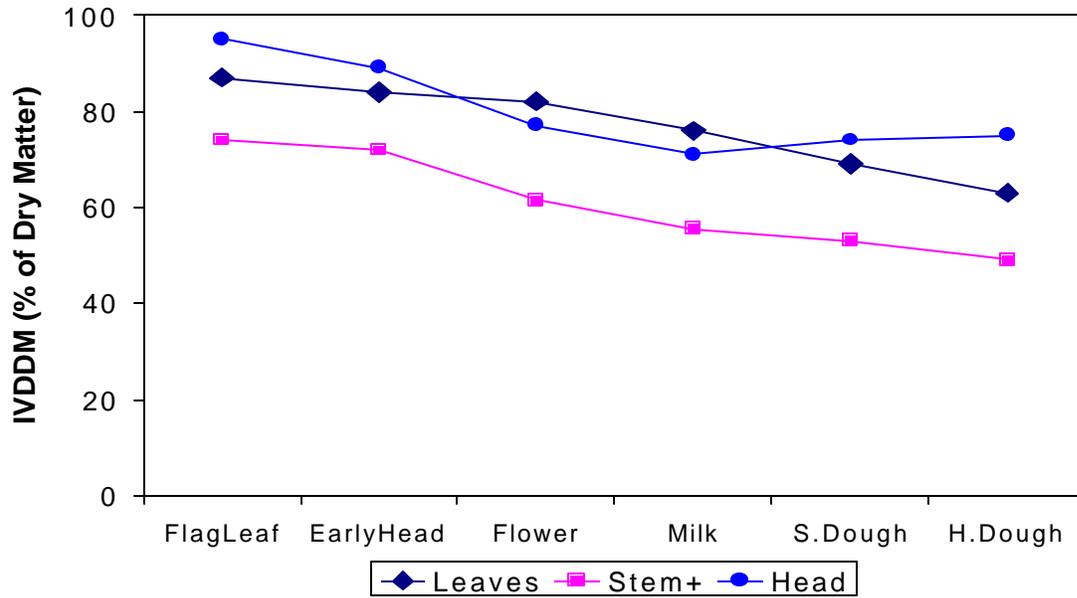


Figure 2. In Vitro Digestible Dry Matter (IVDDM) for Leaves, Stems, and Heads at Different Stages of Development. Source: Adapted from Cherney and Marten.

The combined effects of the changes in the proportion of leaves, stems, and heads, and changes in the nutritional quality of each of those parts, results in an overall steep decline in whole-plant digestibility as the plant heads out (Figure 3). That decline is followed by a more gradual decline between the flower and milk stages of development, then a leveling off or partial rebound in digestibility as the grain fills between milk and soft dough. This leveling off or rebound during the later stages of development as a result of grain fill is one characteristic of small grain cereal forages that differs from alfalfa and other forages that exhibit a steady decline in digestibility as the plant matures.

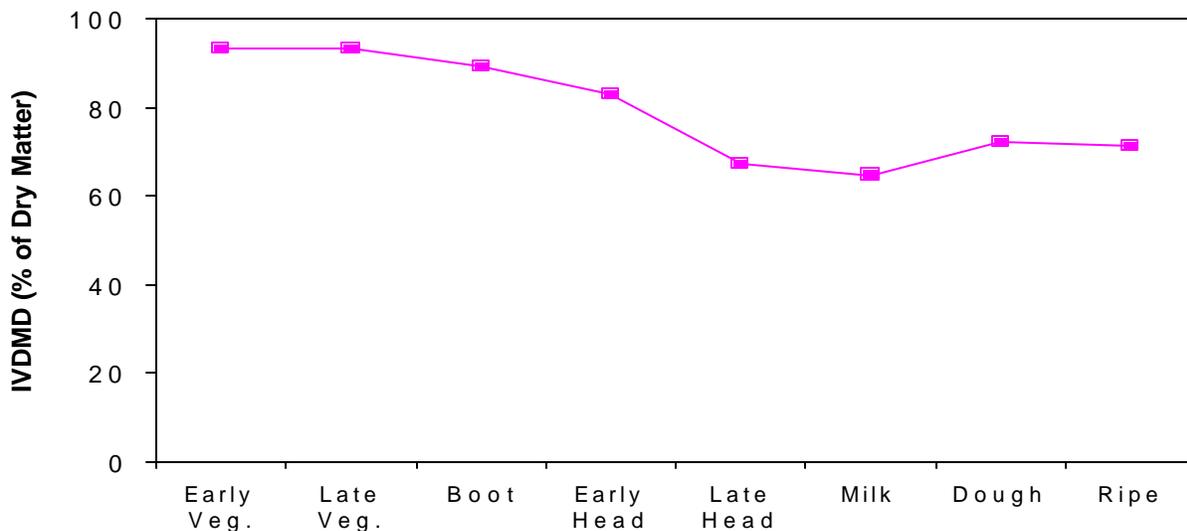


Figure 3. In Vitro Dry Matter Digestibility (IVDMD) of Plants at Different Stages of Development. Source: Richardson.

MANAGEMENT IMPLICATIONS

All small grains have the same general pattern of dry matter accumulation and maturation, but varieties differ in the timing of growth and development, and in the relative yield and quality of different stages of growth. Choosing and managing varieties based on the timing of their growth stages and on yield and quality at those stages are the key to maximizing value.

During early stages of growth up through boot stage, small grains have excellent digestibility and protein, and are outstanding products for grazing and green chop. Small grains can still be grazed after heading with satisfactory results, but palatability, nutritional quality, and wastage of forage may become significantly less favorable than before heading. The ideal small grain for grazing has rapid early growth and a long period of vegetative growth prior to heading and maturation. Knowledge of varietal growth patterns can guide the choosing of a variety for grazing that best produces the maximum amount of vegetative growth, extending over the longest possible time, particularly during the time of year when the forage is most needed.

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 is still 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 the two recommended stages at which to harvest for silage and hay. In general, boot stage will be significantly higher in digestibility and protein than

| | Boot | Dough | Ratio |
|-----------------|-------------------------|-------|-------|
| | <u>D.M. Tons / Acre</u> | | |
| TRICAL® 102 | 4.1 | 6.7 | 1.6 |
| TRICAL® 498 | 2.6 | 6.5 | 2.5 |
| Jackson Wheat | 3.3 | 6.2 | 1.9 |
| Roane Wheat | 3.4 | 5.7 | 1.7 |
| Starling Barley | 2.7 | 5.5 | 2.1 |
| Nomini Barley | 2.3 | 5.4 | 2.4 |

Source: VPI, N. Piedmont Ag. Res. & Ext. Ctr., Orange, VA. Small Grain Forage Test results 1999-2002.

dough stage, but significantly lower in yield (Table 1), although the choosing of boot harvest versus dough harvest should include comparing the best variety for boot stage versus the best variety for dough stage, not necessarily the boot versus dough for any one variety. In general, the best varieties for boot stage harvest are high tillering varieties that are later maturing and produce dense leafy growth, while the best choice for dough stage harvest are early maturing varieties with a high grain yield and high grain-to-stem ratio.

The choice of which variety to grow for silage or hay, and the decision whether to harvest in the boot or dough stage of development, are interrelated and mutually dependent on the resources available for production and the purpose for which the crop is being grown. The choice of variety and harvest time will be broadly constrained by the timing and duration of the growing season suitable for producing small grain forage. Weather conditions, resource availability, and cropping patterns may dictate when the crop must be planted and when it must be harvested. Within those constraints, the objective is to choose a variety and harvest stage to maximize the value of the harvested crop.

Choice of variety can be guided by knowledge of when varieties are expected to reach boot and dough stages, and how much they are expected to yield at each of those stages. In general, the longer a variety takes to reach a given stage of development, the higher the variety's forage yield will be at that stage. For example, plotting yield at the boot and soft dough stages for six varieties grown for forage in the San Joaquin Valley of California reveals a linear relationship between days to harvest and yield across both the boot and dough stages of development (Figure 4). Similar linear relationships are apparent for other varieties in other production areas.

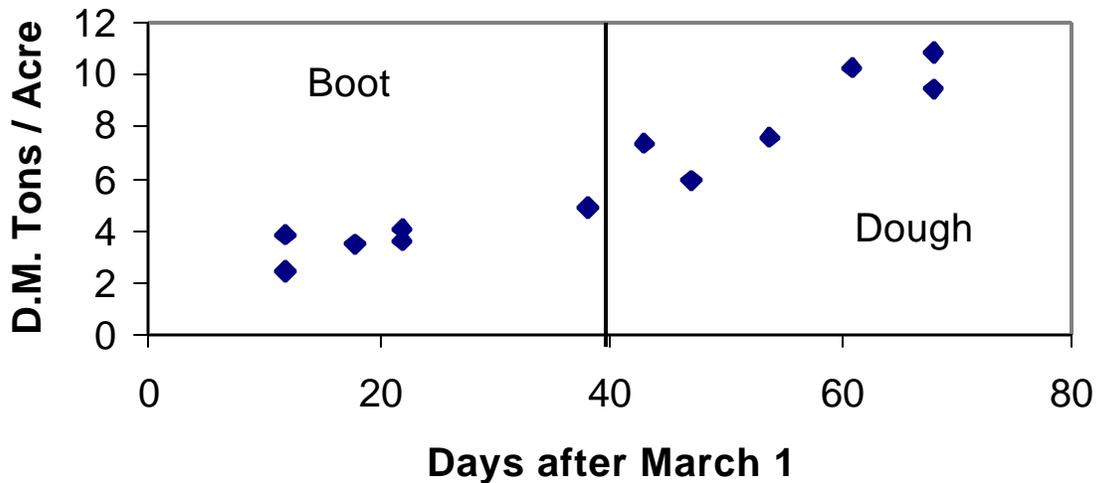


Figure 4. Dry Matter Forage Yield for Six Varieties at Boot and Dough Stages. Source: Collar et al., 1993.

These six varieties reach boot and dough stages from mid March through mid May, within the broad harvest window for the area, although all but one of these varieties reached the boot stage in March, when drying conditions may not be good. The last variety to reach boot stage did so in April, when drying conditions may be improved, and also produced the highest yield at that stage. For dough stage harvest, the six varieties offer a range of possible combinations of expected harvest date and yield. Two of the varieties would appear to be less desirable choices for dough stage harvest because other varieties produced more forage in less time, but any of the other four could be a good choice depending on the desired combination of yield and harvest date.

SUMMARY

Harvesting maximum value from small grain cereal forages involves choosing varieties that provide the highest yield of the desired quality within the desired harvest window, guided by the following steps.

- Determine what type or types of forage are needed for on-farm use or marketing, for example, pasture, or leafy boot-stage forage, or grain-rich dough-stage forage.

- Determine the planting and harvest windows for the crop based on typical weather conditions, resource availability, and cropping patterns.
- Based on research results, prior observations, or information about growth pattern and plant characteristics, identify the variety that will provide the best combination of yield and quality given the forage need and resources available.

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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.