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SMALL GRAIN PRODUCTION MANUAL PART 10

Small Grain Forages

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This publication, *Small Grain Forages,* is the tenth in a fourteen-part series of University of California Cooperative Extension online publications that comprise the *Small Grain Production Manual*. The other parts cover specific aspects of small grain production practices in California:

- *Part 1: Importance of Small Grain Crops in California Agriculture*, Publication 8164
- *Part 2: Growth and Development*, Publication 8165
- *Part 3: Seedbed Preparation, Sowing, and Residue Management*, Publication 8166
- *Part 4: Fertilization*, Publication 8167
- *Part 5: Irrigation and Water Relations*, Publication 8168
- *Part 6: Pest Management—Diseases*, Publication 8169
- *Part 7: Pest Management—Insects*, Publication 8170
- *Part 8: Pest Management—Vertebrates*, Publication 8171
- *Part 9: Pest Management—Weeds*, Publication 8172
- *Part 11: Small Grain Cover Crops*, Publication 8174
- *Part 12: Small Grains in Crop Rotations*, Publication 8175
- *Part 13: Harvesting and Storage*, Publication 8176
- *Part 14: Troubleshooting Small Grain Production*, Publication 8177

Small grains are important forages in California. They are fed to a wide range of livestock classes, including dairy cows, beef cows, horses, sheep, and goats. The nutritional requirements of these livestock classes vary, as do the species and quality of small grain forage grown to feed them. The main small grain forages are wheat, triticale, oat, barley, and rye. Each forage type has many cultivars with unique agronomic characteristics and nutritional attributes that makes it suitable to a particular region and end use. As a winter crop, small grain forages make efficient use of soil moisture and are less vulnerable to drought than are summer forages. If rains are timely, a crop can be produced with little or no irrigation. Although some small grain cultivars have been developed specifically for forage production, many of the cultivars used for forage in California are the same as those grown for grain. This gives growers the option of harvesting the crop as grain or forage, depending on market opportunities. Annually, about 600,000 acres (243,000 ha) of small grains are harvested as forage in California.

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USES OF SMALL GRAIN FORAGES

Small grain forages are versatile. They can be harvested as silage, hay, green chop, or grazed. In the Central Valley, home to the majority of the state's dairy cows, small grain forages are typically ensiled in large covered stacks. The resulting silage is an important and economical component of rations for milk cows, dry cows, and heifers. Planting takes place in November and December, and harvest occurs in April or May. Small grain "winter" forages fit well in double cropping systems that include corn for silage (a summer crop). Together, the corn and winter forage crops recycle manure nutrients and water from dairy farms and provide feed all year long. Wheat is the most common forage choice among dairy producers in the southern San Joaquin Valley; wheat, oat, and forage mixes are common farther north in the Central Valley. Triticale is accepted for use as silage, hay, or even grazing. Now that disease-resistant cultivars are available, barley is also a valuable forage.

Compared to dairy farms, other animal enterprises tend to be smaller and less intensive, so forage is more often used in the form of hay and pasture. Oat hay is commonly produced throughout the state, especially in the coastal and mountain foothill regions, and sold for consumption by horses. A variety of small grain forages are produced for beef cattle. In the northern part of the state and the intermountain region, triticale or other small grains are planted in early fall for late-fall and early-spring grazing and for hay production. Some small grain forages are fed to sheep, goats, and even zoo animals, but these uses are relatively minor compared with use by dairy and beef cows and horses.

CHOOSING A SMALL GRAIN FORAGE

Agronomic characteristics such as tolerance to drought, salt, and manure, as well as resistance to diseases and pests, are important attributes for forage cultivars. Crop production plans, growing conditions of the region, and the nutritional requirements of the livestock to which the forage will be fed should also be considered. The intended market—whether the crop will be sold or used on-farm—is another important consideration.

Cultivars differ greatly in time of maturity, which affects the timing of harvest. Select a cultivar that is likely to be in the desired stage of development during the optimal harvest window. For example, in the Central Valley, if boot stage forage is desired, choose a mid- to late-maturing cultivar that does not reach boot stage until the risk of rain is reduced (because the cut forage must be field-wilted for a few days). For dough stage forage, an earlier-maturing cultivar that allows adequate time to prepare for a following corn crop is a better choice.

Other attributes to consider are tillering, leaf to stem ratio, grain to stem ratio, and nutrient content. If the forage will be harvested at boot stage, choose tall, leafy, heavily tillered cultivars. Grain production is not important in this case, since the crop will be harvested long before it produces grain. If the forage is to be harvested at the soft dough stage for milk cows, grain to stem ratio is very important: the most nutrient-dense component of the plant at this stage is the grain, so a short-stature, heavy-grain-producing cultivar is a good choice for this use. For dry cows and heifers, cultivars that have high total plant yields at the soft dough stage are appropriate.

The presence of awns after the late heading stage can present a palatability problem if forage is fed as hay or grazed after heading. Therefore, awnless, awnletted, or hooded cultivars of wheat, triticale, and barley are preferred. Another trait to consider for hay is stem diameter. Fine-stemmed cultivars dry more uniformly than thick-stemmed cultivars and are preferred in the marketplace. Small grain cultivars selected for grazing should produce heavy growth of tillers and leaves, withstand trampling, and regrow well after grazing. Growth rate also is important since forage for grazing must be available at the desired times. Forages that are planted early in order to provide late-fall and spring cuttings (double-cut winter forage) are at greater risk from barley yellow dwarf disease; plant resistant cultivars for these uses. Another important trait for double-cut forages is regrowth following the first cutting. Characteristics of current California small grain cultivars (updated annually) are given in *UC IPM Pest Management Guidelines: Small Grains*, available online at the UC IPM Web site, http://www.ipm.ucdavis.edu/PMG/selectnewpest.small-grains.html.

TWO HARVEST STAGES: BOOT AND SOFT DOUGH

The yield and nutritional value of forages are greatly affected by the stage of development at harvest. Two primary growth stages, boot and soft dough, are the optimal times to harvest. Each harvest stage produces a uniquely different product to meet the nutritional needs of different types of animals. Dairy cows producing large volumes of milk require nutrient-dense feeds that can supply needed energy. The forage needs of high-producing milk cows can best be matched by cultivars that are suited for boot stage harvest or cultivars with high grain yields and high grain to stem ratio at the soft dough stage. Dry dairy cows and growing heifers have much lower nutritional requirements. The most economical forage match for the needs of dry cows and heifers are cultivars that have high total plant yields when harvested at the soft dough stage.

HARVEST METHODS AND END PRODUCTS

Silage production involves swathing, chopping, and stacking the forage in a large pile, or "bunk," for ensiling. This harvest method works well for large dairies in the Central Valley where the forage crop is produced in close proximity to its final destination. Producing silage from the crop enables large quantities of nutrients to be preserved, stored, and fed throughout the year. If the harvest is at boot stage, field wilting to about 65 to 70 percent moisture is required after swathing before the forage can be chopped and ensiled. Soft dough stage forage is usually already at optimal moisture for ensiling at harvest, so it can be direct-chopped or swathed and then immediately chopped for ensiling.

Other harvest options include green chopping, baling, and pasturing. Green chop is forage that is taken directly to animals for feeding as soon as it is harvested. During green chopping, only as much forage as will be fed to the animals that day is harvested at a time. This harvest method is more commonly used for alfalfa or crops that have multiple harvests than it is for small grain forages. However, some producers green chop early-planted oat or triticale in the late fall and make another cutting in the spring (double-cut winter forage). Oat is the most common small grain used for baled hay, although other small grains can also be baled. The advantage of harvesting forage as hay is that the product can be hauled longer distances more economically. Grazing forage is an option where animals are close to the pasture and fencing is available. Grazing is common among beef and sheep producers statewide and among dairy producers in Northern California. Rye and triticale are the small grains most commonly grown in pastures.

RELATIONSHIP BETWEEN GROWTH STAGE AT HARVEST AND YIELD AND FORAGE QUALITY

The nutritional value of a small grain crop is generally greatest at boot stage, and it drops rapidly as the plant matures to the flower and milk stage. After the flower and milk stage, the forage quality of many cultivars improves as the grain spikes fill with starch at the dough stage and the energy-rich seed begins to dilute the fibrous stems and leaves (see figs. 1 and 2). As the plant matures through flower and seed production, the total yield also increases. As with most forages, growers often trade yield for quality. Nevertheless, small grain forages represent a diverse pool of feeds that can be selected and managed to fit a wide variety of uses. Some cultivars may be better suited to boot stage harvest and others to dough stage harvest. For example, a short, high-grain-yielding wheat cultivar may produce extremely low yields at boot stage but exceptional yields of high-energy forage at dough stage. The grain component dilutes the less-digestible fiber, enabling the forage to fit in a milk ration. At the other end of the spectrum, a tall, late-maturing triticale cultivar may produce respectable yields of lush, superb-quality boot stage forage, but the dough stage does not occur until June, when the forage quality is likely to be unacceptable. Boot stage small grain forage has not been widely accepted by the livestock industry. An important reason for this may be that its feeding value has been underestimated by standard forage quality tests that predict energy from fiber.

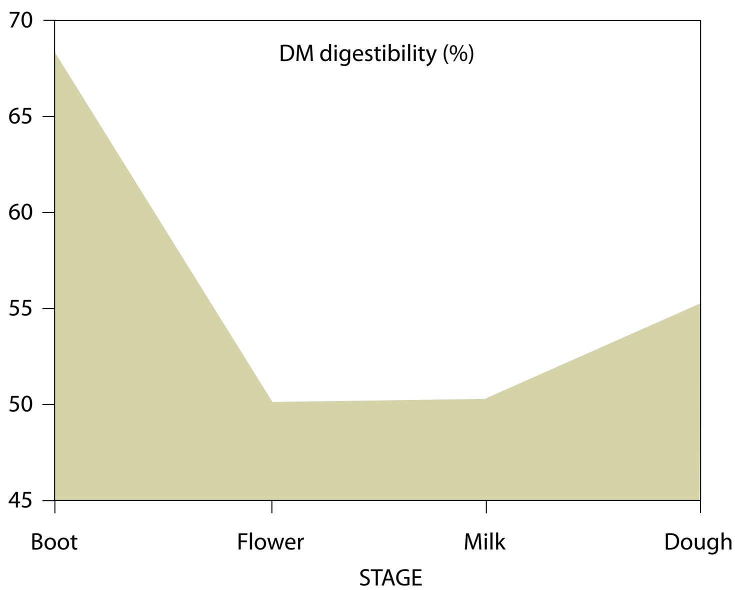

Figure 1. Effect of small grain forage growth stage on apparent dry matter digestibility.

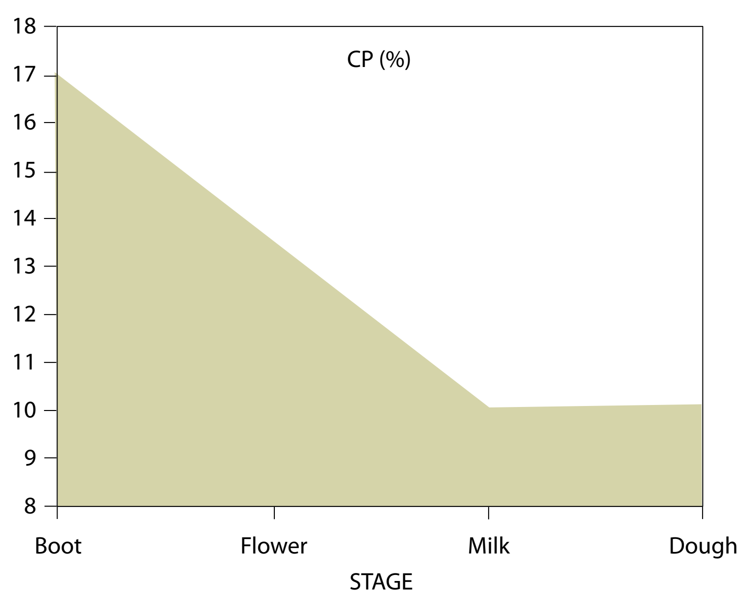

Figure 2. Effect of small grain forage growth stage on crude protein.

Standard forage quality tests are not accurate for small grains

Dairy producers have long recognized the difference in feeding value between alfalfa harvested at bud stage and alfalfa harvested at mid-bloom or full-bloom. Quality testing programs for alfalfa have been in place for decades based on research that has shown greater digestibility, faster weight gains, and higher milk production in cattle fed alfalfa harvested at an immature stage. The maturity of alfalfa is positively correlated to its fiber content: as the stage of maturity increases, so does its fiber content. However, for alfalfa, there is a negative correlation between digestibility and fiber content: as fiber content rises the alfalfa becomes less digestible. Laboratories that test alfalfa hay often predict TDN (total digestible nutrients) and energy from its fiber content, and these values are used to establish the relative economic value of different lots of hay.

Small grain forages are very different from alfalfa in that the percentage of fiber does not always increase with increasing maturity. In fact, the fiber level is usually lower or about the same at the soft dough stage as it is at the boot stage. As the plant matures, grain development contributes nonstructural carbohydrates (starch) that dilute the fiber component. Digestibility is greatest at immature stages, when fiber levels may be highest. Digestibility is positively correlated with fiber content, the opposite of the relationship seen in alfalfa: as the fiber content rises, small grains become more digestible. Energy prediction equations used for alfalfa can't be used to accurately describe the TDN or energy value for small grain forages. Other methods have been developed that predict the energy value of small grain forages more reliably.

These methods involve in vitro digestion, a procedure in which samples of the forage are incubated with rumen fluid from a cow.

Effects of maturity at harvest on yield

Dry matter yields of small grain forages are 30 to 60 percent lower at boot or early harvest stages than they are at the soft dough stage. This relationship is highly dependent on the cultivar. Late-maturing cultivars tend to have higher boot stage yields because they have more time to accumulate dry matter. The tremendous yield difference is the main reason for the reluctance to harvest at boot stage despite its superior feeding value. Unless growers are compensated for the higher quality, they have little incentive to suffer such a large reduction in yield.

Other challenges to boot stage harvest or use of boot stage forage include

- difficulty with field wilting because of unfavorable weather
- potentially high nitrate content
- potentially high potassium content
- poor ensiling characteristics

Cool temperatures and rain often occur in early spring. Unlike forage in the soft dough stage, which can be direct-chopped for silage, boot stage forage is very wet (80 to 85% moisture), so it must be field-wilted prior to ensiling. The weather, however, is not always conducive to field wilting; selecting a late-maturing forage may help. Boot stage forage swathed in mid-April has better weather conditions for field wilting than does boot stage forage swathed in March.

Small grain crops, especially oats, may contain high levels of nitrate. High levels of nitrate can be toxic to cattle, sheep, goats, and other ruminant animals. Sudangrass and certain weeds, such as lambsquarters and pigweed, can also accumulate toxic levels of nitrate. How does this happen? Plants take up nitrate from the soil and convert it to protein, but weather conditions may slow down or prevent this conversion, causing nitrate to accumulate to high levels in the leaves and stems. Forage grown in fields that receive heavy applications of manure or high levels of commercial fertilizer, as well as forage that is harvested at boot stage, have a greater risk for accumulating potentially toxic levels of nitrate. Cool, cloudy weather at harvest can contribute to the problem, since these conditions reduce the ability of the plant to convert nitrate to protein.

Certain management practices can be followed to prevent exposing livestock to nitrate toxicity. Routine analysis for nitrate concentration of all diet components, but especially of the forages, is highly recommended before feeding. Nitrate levels in forage up to 1,000 ppm on a wet basis are generally safe to feed. Nitrate levels from 1,000 to 4,000 ppm require limiting the amount of high-nitrate forage fed, especially for pregnant animals. Forage containing nitrate levels over 4,000 ppm is potentially toxic. There are several ways to express nitrate concentration, so laboratory reports should be carefully reviewed. To reduce the risk of high levels of nitrate in harvested forages, do not overapply nitrogen from fertilizer or manure. If the weather at harvest has suddenly turned cool and overcast, foggy, or rainy, wait for a few days of sunshine before cutting or allowing animals to graze the forage. Ensiling is the best method for low-

SMALL GRAIN FORAGE FACTS

The yield and nutritional value of small grain forages vary tremendously depending on which growth stage is chosen for harvest. The following generalizations can be made.

- Percent crude protein (CP) and digestibility are higher at the earlier, less-mature growth stages.
- Percent acid detergent fiber (ADF) and neutral detergent fiber (NDF) are higher at boot stage than at soft dough stage; the digestibility of these constituents also is much higher at boot stage.
- Standard forage quality tests that predict energy from fiber are not accurate for small grain forages.
- Percent starch, or nonstructural carbohydrate (NSC), is lowest at the early growth stages and highest at the soft dough stage.
- Percent lignin is lowest at the early growth stages and highest at the soft dough stage.
- Dry matter yields are low at the boot stage and higher at the soft dough stage.
- Depending on the type of feed needed, the best stage to harvest a small grain is either boot or soft dough.

ering plant nitrate levels after harvest; the extent to which the nitrate concentration is reduced varies with the crop and the length of time in the silo. Nitrate concentrations cannot be lowered in forage that is cut for hay. Hay or silage that has been found to be high in nitrates can be blended in a mixed ration with low-nitrate feeds to keep the overall nitrate in the diet below toxic levels.

Forage from fields that receive heavy manure applications may contain relatively high levels of potassium. A high potassium level in dairy forage is a concern for managing milk fever, a metabolic disorder in dairy cows that occurs around calving time. Dairy producers can adjust minerals in the dry cow ration to counteract high potassium levels and reduce the risk of milk fever, but identifying forages that are low in potassium may be more economical and effective. High potassium levels are not unique to boot stage forage; soft dough forage can have high levels as well.

Fermentation of boot stage forage during ensiling may be poor if moisture levels are too high. Ideally, the forage should field-wilt from about 85 percent moisture to around 70 percent moisture before chopping. This requires warm, dry weather. If a grower has an especially high-yielding boot stage crop, field wilting may be especially difficult because of the large mass of forage in each swath. Poorly fermented forage is more apt to spoil and cause feed intake problems.

SUMMARY

Small grain forages in California are extremely versatile and economical sources of feed. The tremendous diversity of forage types and cultivars provides growers throughout the state with numerous options for matching the feed to the nutrient requirements of cattle, horses, sheep, and goats. Yield and feeding value are greatly affected by stage of maturity at harvest. The end use of the forage determines the optimal harvest time, either the boot stage or the soft dough stage of maturity. Opportunities for varied harvest and storage methods (silage or hay) contribute to the versatility of these forages. Improved methods for predicting energy value can help producers and nutritionists develop rations for animals to take full advantage of the nutritional attributes of small grain forages.

REFERENCES

Flint, M. L., ed. 2003. UC IPM pest management guidelines: Small grains. UC ANR Publication 3466. UC IPM Web site, http://www.ipm.ucdavis.edu/PMG/selectnewpest.small-grains.html.

George, M. R., T. E. Kearney, and C. A. Schoner. 1982. Oat hay and silage production. Oakland: University of California Division of Agriculture and Natural Resources Leaflet 21265.

James, L., M. Ralphs, and D. Nielsen, eds. 1990. The ecology and economic impact of poisonous plants on livestock production. Boulder, CO: Westview Press.

Mathews, M. C. 2001. Timing nitrogen applications in corn and winter forage. In Proceedings, 31st California Alfalfa and Forage Symposium, December 12–13, 2001. UC Alfalfa and Forages Workgroup Web site, http://alfalfa.ucdavis.edu/+symposium/proceedings/2001.html.

———. 2002a. Nitrogen fertilization of winter forage. Stanislaus Forage Farmer (January 2002). University of California Cooperative Extension, Stanislaus County.

———. 2002b. Overview of infrastructure design for a liquid manure system. Stanislaus Forage Farmer (November 2002). University of California Cooperative Extension, Stanislaus County.

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