Alfalfa management guide

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Alfalfa management guide

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Profitable forage production depends on high yields. Land, machinery, and most other operating costs stay the same whether harvesting 3 tons per acre or 6 tons per acre. Top yields in the northern United States have approached 10 tons per acre while average yields are around 3 tons per acre. This booklet describes what it takes to move from a 3-ton yield to 6 or 9 tons per acre.
Establishment

A vigorously growing, dense stand of alfalfa forms the basis for profitable forage production. Profitable stands are the result of carefully selecting fields with well-drained soil, adding lime and nutrients if needed, selecting a good variety, and using appropriate planting practices to ensure germination and establishment.
SELECT A FIELD CAREFULLY

Soil type, drainage, and slope

Alfalfa requires a well-drained soil for optimum production. Wet soils create conditions suitable for diseases that may kill seedlings, reduce forage yield, and kill established plants. You can reduce some disease problems associated with poor drainage by selecting varieties with high levels of resistance and by using fungicides for establishment. Poor soil drainage also reduces soil oxygen movement to roots. Poor surface drainage can cause soil crust and ponding which may cause poor soil aeration, micronutrient toxicity, or ice damage over winter. Even sloping fields may have low spots where water stands, making it difficult to maintain alfalfa stands.

Soils should be deep enough to have adequate water-holding capacity. Alfalfa has a long taproot that penetrates more deeply into the soil than crops such as corn or wheat which have more fibrous, shallow roots. Under favorable conditions, alfalfa roots may penetrate over 20 feet deep. This great rooting depth gives alfalfa excellent drought tolerance.

Sloping fields where erosion is a problem may require use of erosion control practices such as planting with a companion crop or using reduced tillage to keep soil and seed in place until seedlings are well rooted.

Control perennial weeds

Fields should be free of perennial weeds such as quackgrass. If not controlled before seeding, these weeds may re-establish faster than the new alfalfa seedlings and reduce stand density. Weed management is discussed in more detail in the Production section.

Fields should be free from herbicide carryover that may affect growth of the new alfalfa and/or companion crop. This is especially important during droughts or on fields where high herbicide application rates or late-season applications of long-acting herbicides were used.

Autotoxicity

Alfalfa plants produce a toxin that can reduce germination and growth of new alfalfa seedlings. This phenomenon is known as autotoxicity. The extent of the toxin's influence increases with the age and density of the previous stand and the amount of residue incorporated prior to seeding.

The autotoxic compound, medicarpin, is water soluble and is concentrated mainly in the leaves. A waiting period after destroying the old stand is necessary to allow this toxic compound to degrade or move out of the root zone of the new seedlings. Weather conditions influence the speed with which the toxins are removed. Breakdown is more rapid under warm, moist soil conditions.

Ideally, grow a different crop for one season after plowing down or chemically killing a 2-year or older stand before seeding alfalfa again in the same field. This is the best and safest way to manage new seedings of alfalfa.

Alfalfa planted, left, in soil from a corn field (no autotoxicity) and, right, in soil from an alfalfa field (autotoxicity).
TEST SOIL BEFORE PLANTING

Proper fertility management, including an adequate liming program, is the key to optimum economic yields. Proper fertilization of alfalfa allows for good stand establishment and promotes early growth, increases yield and quality, and improves winterhardiness and stand persistence. Adequate fertility also improves alfalfa’s ability to compete with weeds and strengthens disease and insect resistance.

Fields differ in their fertilizer needs. Soil testing is the most convenient and economical method of evaluating the fertility levels of a soil and accurately assessing nutrient requirements.

Most soil testing programs make recommendations for pH and lime, phosphorus, potassium, and several of the secondary nutrients and micronutrients. Optimal soil test levels for alfalfa differ among states due to varying subsoil fertility, nutrient buffering capacities, soil yield potentials, and different management assumptions. For more detailed information on soil test recommendations, contact your local Extension office.

To assure good stands, calibrate seeding depths and rates carefully and plant in a firm, moist soil.

ADVANCED TECHNIQUES

Reseeding recommendations

Consider the following if you cannot wait 1 year after killing an alfalfa stand before reseeding.

- Disk down a seeding failure and reseed either in the late summer after a spring seeding or the following spring. Autotoxic compounds are not present the first year.

- Reseed gaps in new seedings as soon as possible.

- Never interseed to thicken a stand. Young plants that have been interseeded often look good early but die out over summer because of competition for light and moisture from the established plants.

- Fields with stands 2 or more years old may have autotoxicity. Till or use herbicides to kill alfalfa and perennial weeds in the fall and seed the next spring (preferred) or spring kill and seed in late summer.

- Some research has suggested that alfalfa can be planted back into fields as soon as 3 weeks after killing the old stand. This may not be practical on most farms because it can result in plantings being made too late in the spring.

- Select varieties that have high levels of disease resistance and are treated with fungicide to reduce seeding diseases. This is particularly important when seeding alfalfa back into fields that have had alfalfa within the past year, as diseases tend to build up in old stands and reduce new seeding growth.
Apply lime before seeding

Liming is the single most important fertility concern for establishing and maintaining high yielding, high quality alfalfa stands. Benefits of liming alfalfa include:

- increased stand establishment and persistence,
- more activity of nitrogen-fixing *Rhizobium* bacteria,
- added calcium and magnesium,
- improved soil structure and tilth,
- increased availability of phosphorus and molybdenum (figure 1), and
- decreased manganese, iron and aluminum toxicity (figure 1).

For maximum returns, lime fields to at least pH 6.7 to 6.9. Field trials performed in southwestern Wisconsin show that yields drop sharply when soil pH falls below 6.7 (figure 2).

Because lime reacts very slowly with soil acids, it should be applied 12 months—preferably longer—before seeding. For typical 4- to 6-year crop rotations, the best time to apply the recommended amount of lime is when coming out of alfalfa. This allows more time for reaction with the soil. The accompanying tillage for rotation crops may result in two or three remixings of the lime with the soil. This should raise the pH to the desired level by the time alfalfa is replanted.

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**Figure 1.** Available nutrients in relation to pH

**Figure 2.** First-cutting alfalfa yield relative to soil pH

*Source: Wollenhaupt and Undersander, University of Wisconsin, 1991*
Lime effectiveness is determined by its chemical purity and the fineness to which it is ground. Figure 3 illustrates the greater effectiveness of more finely ground lime. To achieve the same pH change, coarse aglime must be applied further in advance and at higher rates than fine aglime but is usually less expensive per ton. It may not be necessary to re-lime as often where some coarse lime is used.

When comparing prices, be sure to evaluate materials on the basis of amounts of lime needed to achieve similar effectiveness. The relative effectiveness of various liming materials is given by its lime grade, effective calcium carbonate equivalency (ECCE), effective neutralizing power (ENP), or total neutralizing power (TNP).

Aglime should be broadcast on the surface of the soil, disked in, and then plowed under for maximum distribution and neutralization of acids in the entire plow layer. Plowing without diskig may deposit the lime in a layer at the plow sole. For high rates of lime (>6 tons/acre), apply half before working the field; work the remaining half into the soil after plowing or other field preparation.

Liming materials come in several forms. Calcitic products contain calcium-based neutralizers while dolomitic sources contain both calcium and magnesium. Both are equally effective for changing soil pH. Some claims are made that when the calcium to magnesium ratios in the soil are low, calcitic limestone should be used. Research evidence does not support these claims, as virtually all midwestern and northeastern soils have ratios within the optimal range. Dolomitic limestone itself has a calcium to magnesium ratio within the normal range for plant growth. The addition of calcitic limestone or gypsum for the purpose of adding calcium or changing the calcium/magnesium ratio is neither recommended nor cost effective.

Several by-products, such as papermill lime sludge and water treatment plant sludge may be used as liming materials. Since the relative effectiveness of some of these materials is highly variable, be sure you know its effective neutralizing power.

**Figure 3.** Lime availability at different particle sizes.
**Nutrient needs during establishment**

Tillage during establishment provides the last opportunity to incorporate relatively immobile nutrients during the life of the stand. Typical nutrient additions tend to include phosphorus, potassium, and sulfur.

**Phosphorus.** Adequate soil phosphorus levels increase seeding success by encouraging root growth. Phosphorus is very immobile in most soils. Wisconsin research confirms that at low to medium soil test levels incorporated phosphorus is more than twice as efficient as topdressed phosphorus.

**Potassium.** Research has shown that although potassium has relatively little influence on improving stand establishment, yield and stand survival are highly dependent on an adequate potassium supply. When soil tests are in the medium range or below, sufficient potassium should be added to meet the needs of the seeding-year crop including the companion crop.

**Sulfur.** Elemental sulfur, where needed, can be used as the sulfur source and may be applied at seeding. Elemental sulfur must be converted to sulfate-sulfur before it can be used by plants. This process is relatively slow, especially when sulfur is topdressed. Therefore, incorporating moderately high rates (50 lb/acre sulfur) of elemental sulfur at establishment will usually satisfy alfalfa sulfur requirements for the life of the stand. The cost of this treatment should be compared to the cost of annual topdressed applications of sulfate-sulfur.

**Nitrogen.** Recent research has shown that small additions of nitrogen may enhance establishment and first-year yields. Apply 25 to 30 lb/acre nitrogen when alfalfa is direct seeded on coarse-textured soils with low organic matter contents (<2%). Apply 20 to 35 lb/acre nitrogen when seeding alfalfa with a companion crop and apply 40 to 55 lb/acre nitrogen if you will be harvesting the companion crop as silage.

**Manure.** Manure may be successfully applied prior to alfalfa establishment if adequate weed control practices are followed. Recent Minnesota and Wisconsin research has shown that preplant manure application can maintain or even increase yields the first two years. When spreading manure avoid compacting soil and be sure that the manure is adequately incorporated so that seed is not planted directly into high-manure application zones.

**SELECT A GOOD VARIETY**

Plant breeders have developed alfalfa varieties with greater yield potential and disease resistance and improved forage quality. But with over 250 varieties available, how does one select an alfalfa variety? The major factors leading to profitability are:

- yield potential,
- persistence (percent stand remaining or estimated from winterhardiness and disease resistance ratings),
- winterhardiness,
- disease resistance, and
- forage quality.

As illustrated in table 1, yield has the largest effect on profitability, persistence next, and other factors have a lesser effect.

**Table 1.** Factors influencing dollar return per acre for alfalfa from milk production.

<table>
<thead>
<tr>
<th>factors</th>
<th>return per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>standard yield</td>
<td>$778</td>
</tr>
<tr>
<td>(18% CP&lt;sup&gt;1&lt;/sup&gt;, 33% ADF, 45% NDF) assuming 5 ton/acre yield and $10/cwt milk</td>
<td></td>
</tr>
<tr>
<td>yield potential effect</td>
<td>$-50</td>
</tr>
<tr>
<td>0.2 ton/acre lower yield</td>
<td></td>
</tr>
<tr>
<td>persistence effect</td>
<td>$-24</td>
</tr>
<tr>
<td>shorter stand life (3 vs 4 yr)</td>
<td></td>
</tr>
<tr>
<td>forage quality effect</td>
<td>$+15</td>
</tr>
<tr>
<td>higher quality forage (+1% CP, -1% ADF, -1% NDF)</td>
<td></td>
</tr>
<tr>
<td>seed cost effect</td>
<td>$-4</td>
</tr>
<tr>
<td>$1/lb higher at 15 lb/acre seed</td>
<td></td>
</tr>
</tbody>
</table>

Source: Undersander, University of Wisconsin, 1991

<sup>1</sup>CP = crude protein; ADF = acid detergent fiber; NDF = neutral detergent fiber.
Winterhardiness is dependent on cold tolerance, fall dormancy, and resistance to root and crown diseases. Lack of winterhardiness may result in winter injury and winterkill. Winter injury slows spring growth—meaning fewer shoots for first cutting and a lower yield. The best indicator of winterhardiness is stand survival ratings (count of live plants) the spring following a severe winter. Generally, varieties with less winterhardiness have greater yield potential because of faster regrowth. Planting several fields of alfalfa, each with different winterhardiness ratings ensures stand survival of some fields in severe winters and increases yield potential in others.

Figure 5. Winterhardiness zones. Source: USDA

![Winterhardiness zones map](image)

The two plants on right show severe winter injury. Damaged plants are slow to regrow and produce few stems.
Disease resistance

Diseases may cause seedling death, reduce stand density, lower yields, and shorten stand life. The best disease management strategy is to select varieties with high levels of disease resistance. Determine potential for diseases on your farm and select alfalfa varieties with resistance to as many of them as possible. Knowing which diseases have occurred in your fields will help you choose varieties with the appropriate resistance. Look over the descriptions and pictures in the disease section of this booklet, learn to recognize them and select resistant varieties if the disease is occurring in your field. To estimate the potential for each disease to occur in your area, refer to the maps in the disease management section.

Forage quality

Many new varieties coming on the market have improved forage quality. Evaluate alfalfa varieties based on estimated digestibility, intake and relative feed value compared to Vernal, the standard variety.

Intended use

Most alfalfa is planted for harvest as hay or haylage with plans to keep stands as long as they are productive. Special situations may require different variety selection criteria. For example, when a short rotation is desired or when nitrogen for other crops is needed, yield is more important than persistence so select varieties with high yields in the first two years; when the field will be used for grazing, select grazing-tolerant varieties.

PLANTING

Time of seeding

Spring seeding is preferred over late-summer seeding in northern states due to a greater chance of successful stand establishment. Better growing conditions, such as a longer growing season, adequate soil moisture, and cool temperatures, enhance seed germination and establishment. Late-summer seeding is preferred in southern states because of the opportunity to establish alfalfa after growing another crop. Herbicides are not generally required for late-summer seeding. Irrigation allows late-summer seedings in all areas.

Spring seeding of alfalfa can begin as soon as the potential for damage from spring frosts has passed. At emergence, alfalfa is extremely cold tolerant. At second trifoliate leaf stage (figure 6) seedlings become more susceptible to cold injury and may be killed by four or more hours at 26°F or lower temperatures. Alfalfa seeded with a companion crop survives lower temperatures and longer exposure times before showing frost damage. Frost damage is usually not a problem by the time farmers can get fields tilled in the spring and ready to seed. Early seedings have less weed competition and less moisture stress during germination because of cooler temperatures.

The spring seeding dates shown on the map (figure 7) are averages for the region. Seeding may be earlier on light soils, when a companion crop is used, or when forages are established using reduced-tillage or no-till methods. Irrigation may extend the seeding period later into the spring. Successful stand establishment can be made outside the recommended dates, but the likelihood of consistent success is low.
Figure 7. Spring and late-summer seeding dates.

- Spring seeding preferred
- Late-summer seeding preferred

Spring seeding dates:
- May 1-30
- April 15-May 15
- April 1-30
- March 15-April 15

Late-summer seeding dates:
- July 20-August 1
- August 1-15
- August 15-Sept. 1
- September 1-15

Successful late-summer seeding depends on soil moisture during the establishment period and sufficient plant growth before a killing frost (figure 7). Do not seed unless good soil moisture is present. A preplant herbicide is usually not needed for light infestations because annual weeds will be killed by frost. Postemergence herbicides are available if severe weed pressure or volunteer grain problems develop. Use of a companion crop is not recommended, especially where the seeding date is August 15 or earlier, because it competes with alfalfa for moisture. In many regions, Sclerotinia crown rot may be prevalent in late-summer seeding.

Alfalfa needs at least 6 weeks growth after germination to survive the winter. The plant will generally survive winter if it develops a crown before a killing frost. This allows the plant to store root reserves for winter survival and spring regrowth. Fields with less seedling development before a killing frost may have a greater problem with winter annual weeds, particularly in southern areas.

Figure 8. Effect of weed pressure on late-summer seedings.

Source: Budler, University of Minnesota, 1993
Minimizing competition from volunteer small grains or weeds is critical in northern regions to ensure adequate development of summer-seeded alfalfa prior to killing frost (figure 8). Failure to do so cuts seedling establishment and lowers yields.

**Field preparation**

Field preparation should begin the year before seeding. Scout fields for perennial weeds and use appropriate control measures. For example, if quackgrass is in a field where corn will be planted, use a pretilleage application of Roundup or a postemergence application of Accent or Beacon. Cultivate when corn is 14 to 18 inches tall. For control of Canada thistle, dandelion, and other perennial weeds, use an effective management program before seeding alfalfa. These weeds can be particularly competitive both during the seeding year and in subsequent years. Controlling them prior to seeding will help ensure a long-lasting, productive stand.

Conventional tillage practices vary from farm to farm but should consist of a primary tillage (moldboard plowing or chiseling) followed by disking. Primary tillage loosens the soil and helps control perennial weeds while disking provides weed control, helps level the land, and breaks up large soil clods. The final tillage should be some type of smoothing operation. On level ground, primary tillage is best done in the fall as winter freeze-thaw cycles help break down clods and reduces field operations in spring. On erosive soils, fall tillage may not be an option.

The ideal soil condition for conventional seeding should be a smooth, firm, clod-free soil (see picture) for optimum seed placement with drills or cultipacker seeders. Avoid overworking the soil as rainfall following seeding may crust the surface, preventing seedling emergence.

**Seed inoculation**

*Rhizobium* bacteria nodulate alfalfa roots so the bacteria can fix nitrogen, making it available to the plant. While many soils contain some *Rhizobium* bacteria from previous alfalfa crops, not all fields have adequate numbers. To ensure the presence of the needed bacteria, purchase preinoculated seed or treat the seed using commercial inoculum available from seed dealers. Most varieties are preinoculated. These inoculant treatments often contain Apron fungicide as well, which protects against diseases that reduce seedling emergence and kill young seedlings. If treating seed yourself, use a sticker—an adhesive compound to attach the *Rhizobia* to the seed—and thoroughly mix inoculum and seed before planting.

Soil should be firm enough at planting for a footprint to sink no deeper than ⅜ inch.
Alfalfa is a small-seeded crop and correct seeding depth is very important. Seed should be covered with enough soil to provide moist conditions for germination while allowing the small shoot to reach the surface (figure 9). Optimum seeding depths vary depending on soil types. Plant seed ¼- to ½-inch deep on medium and heavy textured soils and ½- to 1-inch deep on sandy soils. Shallower depths may be used when moisture is adequate while the deeper depths should be used in drier soils.

**Seeding depth and rate**

Seeding rates should be between 12 and 15 lb/acre with good soil conditions and seeding equipment (table 2). Higher seeding rates do not produce higher yields except under poor seeding conditions. Lower rates are normally used in arid regions. While these rates may be higher than needed for good stands under ideal conditions, the wide range of field and environmental conditions experienced at seeding make this necessary to obtain consistently good stands. Extended periods of cool, wet weather can cause high seedling mortality (this can be reduced by planting Apronto-treated seed). Hot dry weather at seeding time likewise may reduce germination and seedling establishment. Under normal conditions, only about 60% of the seeds germinate and nearly 60 to 80% of the seedlings die the first year (figure 10).

An important and often overlooked aspect of planting alfalfa is seeder calibration. Seed size can vary between varieties and between seed lots of the same variety. Calibrate seeding implements each time you use a new variety or a new seed lot, or if you use lime- or clay-coated seed. Regular calibration can help to avoid over- or underseeding.

**Table 2.** Effect of seeding rate on first-year alfalfa dry matter yields.

<table>
<thead>
<tr>
<th>seeding rate (lb/acre)</th>
<th>dry matter yield (tons/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>3.4</td>
</tr>
<tr>
<td>15</td>
<td>3.6</td>
</tr>
<tr>
<td>18</td>
<td>3.6</td>
</tr>
</tbody>
</table>

*Source: Buhler, Proost, and Mueller, University of Wisconsin, 1988*

**Figure 9.** Alfalfa emergence from various seeding depths

![Alfalfa emergence from various seeding depths](image)

*Source: Sund et al., University of Wisconsin, 1966*

**Figure 10.** Stand density during first 12 months (seeded at 12 lb/acre).

![Stand density during first 12 months](image)
Seeding with and without a companion crop

Direct seeding alfalfa (planting without a companion crop) allows growers to harvest up to two extra cuttings of alfalfa and produce higher quality forage in the seeding year as compared to seeding with a companion crop. However, total forage tonnage may be reduced relative to companion-crop seedings. Some important management considerations are:

- Select level fields with low erosion potential for direct seedings and use companion seedings where the erosion potential is greater. Erosive soils can be direct seeded using reduced or no-till methods that leave adequate residue on the surface.

- Effective weed management is critical in direct seeding (as no companion crop is present). See the section on weed management for details.

- Harvest the first cutting after 60 days of growth, regardless of maturity stage. This eliminates many annual weeds and allows the second cutting to reach the ⅔ bloom stage by September 1 in areas with short growing seasons.

Companion crops, such as oats, spring barley and spring triticale, help control erosion, reduce seedling damage from blowing sands, and minimize weed competition during establishment. Companion crops also provide additional forage when harvested as oatlage or additional income if harvested as dry grain. Straw produced by the companion crop is also valued as livestock bedding. When companion crop growth is dense and allowed to grow to grain, alfalfa underneath is often damaged either by competition or by lodging of the small grain which smothers the alfalfa seedlings. Winter wheat, spring wheat, and rye usually compete too strongly with alfalfa seedlings and are less desirable as companion crops.

Figure 11. First-season yield of alfalfa using different establishment methods.

ADVANCED TECHNIQUES

Getting direct seeding benefits while controlling erosion

Where the benefits of direct seeding are desired, yet the need for erosion control suggests a companion crop, it may be practical to seed oats as a companion crop and kill it with Poast Plus herbicide when 4 to 8 inches tall. The oats will control weeds early; provide erosion control and protect seedlings from wind damage. When the oats have been killed, alfalfa will perform about the same as in a direct seeding (figure 11). While more expensive because both a companion crop and herbicide are used, this practice can produce forage yields in quantity and quality to direct seeding
For good alfalfa stands with companion seedings, manage the field to the advantage of the alfalfa rather than for the companion crop. Some important management considerations are:

- Select companion crop varieties that are short, stiff strawed, and early maturing to avoid lodging and smothering the alfalfa.
- Seed the companion crop at 1 to 1 1/2 bushels/acre on heavy soils and 1 bushel/acre on sandy soils to reduce competition for light and moisture with the alfalfa seedlings.
- Limit nitrogen applications to no more than 30 lb/acre to avoid excessive competition and lodging of the companion crop.
- Harvest the companion crop at the boot stage rather than leaving it for grain. Harvesting at the boot stage reduces competition with alfalfa and minimizes the chance for lodging and smothering the alfalfa crop. This harvest stage provides optimum forage quality and yield of the companion crop.

If you do harvest the companion crop for grain, cut it as early as possible to minimize lodging damage. Remove straw as quickly as possible to avoid smothering the alfalfa stand. Harvesting companion crops for grain is not recommended for good alfalfa stand establishment.

**Seeding equipment**

Many different types of drills and seeders are used to seed alfalfa. All will produce good stands when planting to an accurate seeding depth in a firm, moist soil.

Cultipacker seeders, such as the Brillion seeder, broadcast the seed on the soil surface and then press it into the soil with rollers. These seeders have been a mainstay of alfalfa establishment because they give consistently even seed depth placement and good seed-soil contact for most soils.

Band seeders place the seed in rows, usually with 7- to 9-inch spacings, and can place fertilizer below the seed where it's most effective. To improve establishment, use press wheels mounted on the seeder or some other packing device, such as a cultipacker, pulled behind the seeder or used in a separate pass (figure 12). The most common band seeders are grain drills that can seed a companion crop simultaneously with the alfalfa. However, grain drills have poor depth control of seed placement. Band seeders adapted for forages have depth bands to overcome this problem. Alfalfa and companion crop seed must be put in separate seed boxes. Companion crops should be seeded 1 to 2 inches deeper than alfalfa. This can be done in a single pass by placing the drop tubes for the companion crop between coulters and for alfalfa behind coulters (see picture).

![Figure 12. Comparison of seeders for stand establishment](image-url)
Reduced and no-till

Due to the high potential for erosion on slopes using conventional tillage, a great deal of interest has been generated in reduced tillage alfalfa establishment. These practices include the use of a chisel plow rather than a moldboard plow, a single pass with a secondary tillage tool, or no tillage at all. Reduced tillage practices are generally successful when careful, timely management is used.

Crop residue management is an important factor in reduced-tillage seeding. Chisel plowing or disking typically chops the residue finely enough for conventional seeding implements to be used. In corn residue, single disking may give the same result. Cultipacker seeders will not perform well with residue levels above 35% so a no-till seeder is recommended. Chopping stalks helps even the residue in the field and can reduce the amount of residue in the first alfalfa harvest.

Special attention must be given to weed management in reduced tillage systems. Oats can still be used as a companion crop. When direct seeding, weed control is more difficult as there is less tillage to decrease weed populations. Perennial weeds are the most difficult to control. Lack of deep tillage may give some perennial weeds a head start on the alfalfa. The use of a nonselective herbicide such as glyphosate to control perennial weeds (preferably in the previous fall) is critical prior to reduced or no-till seeding. Other weed control options are similar to conventional direct seeding and are discussed later in this publication.

An additional consideration in no-till alfalfa establishment is soil fertility and pH. As no tillage is done in the seeding year, materials that work best when incorporated, such as phosphorus fertilizers and lime, should be applied and worked into the soil prior to entering into no-till systems. If incorporation is not feasible, apply the finest grade of lime obtainable 1 to 2 years ahead of seeding to raise soil pH in the top inch of soil. (Lime moves downward at about ½ inch per year on silt loam soils and somewhat faster on coarser soils.) Fine-grade alternative liming materials such as papermill lime sludge or cement plant kiln dust can also be used.

Many implement companies produce specialized no-till seeders for alfalfa and other crops. The design of these seeders differs among companies but should have the following features to ensure success:

- heavy down pressure,
- coulter ahead of disk openers to cut trash,
- double disc openers or an angled single disc opener,
- press wheels,
- small-seed box, and
- depth control mechanism.

Set seeding depths carefully as these implements are very heavy and may easily place seed deeper than optimum.

No-till seeders are often available for rent through Land Conservation offices, the Soil Conservation Service or local fertilizer dealers and elevators.

To plant companion crops 1 to 2 inches deeper than alfalfa in a single pass, place the drop tube for alfalfa behind coulters but before the packer wheel and place the drop tube for the cover crop between coulters.
Once a good stand has been established, continued production and stand life depends on good management practices. Good management includes maintaining soil nutrients, applying manure judiciously, and controlling weeds and insects. Monitor diseases to estimate stand life and to determine resistance needed in future plantings. Finally, optimum production involves deciding when to rotate from stands that are no longer profitable.
Soil tests are the most reliable method for preventing nutrient deficiencies. Visual symptoms (table 5 and pictures) can be used to help assess nutrient needs for future yield. However, by the time visual symptoms appear on a crop, nutrient deficiency may be so severe that significant yield losses have already occurred. Visual symptoms can also reflect environmental conditions, restricted root growth, diseases or other problems not related to a soil nutrient shortage.

Plant tissue analysis can determine the nutritional status of your crop before any visual symptoms appear. While this method does not measure nutrient amounts for making a fertilizer recommendation, combining this with a soil test makes for a comprehensive nutrient management system.

### Table 3. Pounds of nutrient removed per ton of alfalfa produced, dry matter basis.

<table>
<thead>
<tr>
<th>nutrient</th>
<th>dry matter removed (lb/ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>phosphorus (P)</td>
<td>6</td>
</tr>
<tr>
<td>phosphate (P₂O₅)</td>
<td>14</td>
</tr>
<tr>
<td>potassium (K)</td>
<td>48</td>
</tr>
<tr>
<td>potash (K₂O)</td>
<td>58</td>
</tr>
<tr>
<td>calcium (Ca)</td>
<td>30</td>
</tr>
<tr>
<td>magnesium (Mg)</td>
<td>6</td>
</tr>
<tr>
<td>sulfur (S)</td>
<td>6</td>
</tr>
<tr>
<td>boron (B)</td>
<td>0.08</td>
</tr>
<tr>
<td>manganese (Mn)</td>
<td>0.12</td>
</tr>
<tr>
<td>iron (Fe)</td>
<td>0.33</td>
</tr>
<tr>
<td>zinc (Zn)</td>
<td>0.05</td>
</tr>
<tr>
<td>copper (Cu)</td>
<td>0.01</td>
</tr>
<tr>
<td>molybdenum (Mo)</td>
<td>0.002</td>
</tr>
</tbody>
</table>

### Table 4. Sufficiency levels of nutrients, top 6 inches of alfalfa at first flower.

<table>
<thead>
<tr>
<th>nutrient</th>
<th>low</th>
<th>sufficient</th>
<th>high</th>
</tr>
</thead>
<tbody>
<tr>
<td>nitrogen</td>
<td>&lt; 3.00</td>
<td>3.00–5.00</td>
<td>&gt; 5.00</td>
</tr>
<tr>
<td>phosphorus</td>
<td>&lt; 0.26</td>
<td>0.26–0.70</td>
<td>&gt; 0.70</td>
</tr>
<tr>
<td>potassium</td>
<td>&lt; 2.41</td>
<td>2.41–3.80</td>
<td>&gt; 3.80</td>
</tr>
<tr>
<td>calcium</td>
<td>&lt; 0.50</td>
<td>0.50–3.00</td>
<td>&gt; 3.00</td>
</tr>
<tr>
<td>magnesium</td>
<td>&lt; 0.31</td>
<td>0.31–1.00</td>
<td>&gt; 1.00</td>
</tr>
<tr>
<td>sulfur</td>
<td>&lt; 0.26</td>
<td>0.26–0.50</td>
<td>&gt; 0.50</td>
</tr>
<tr>
<td>boron</td>
<td>&lt; 30</td>
<td>30–80</td>
<td>&gt; 80</td>
</tr>
<tr>
<td>manganese</td>
<td>&lt; 25</td>
<td>25–200</td>
<td>&gt; 200</td>
</tr>
<tr>
<td>iron</td>
<td>&lt; 30</td>
<td>30–250</td>
<td>&gt; 250</td>
</tr>
<tr>
<td>zinc</td>
<td>&lt; 20</td>
<td>20–70</td>
<td>&gt; 70</td>
</tr>
<tr>
<td>copper</td>
<td>&lt; 5</td>
<td>5–30</td>
<td>&gt; 30</td>
</tr>
<tr>
<td>molybdenum</td>
<td>&lt; 1</td>
<td>1–5</td>
<td>&gt; 5</td>
</tr>
</tbody>
</table>
Table 5. Nutrient deficiency symptoms for alfalfa.

<table>
<thead>
<tr>
<th>nutrient</th>
<th>deficiency symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>nitrogen</td>
<td>Light green to yellow color, spindly growth.</td>
</tr>
<tr>
<td>phosphorus</td>
<td>Blue-green color, stiff, stunted and erect growth. Leaflets often fold together, and the undersides and stems may be red or purplish.</td>
</tr>
<tr>
<td>potassium</td>
<td>White spots around edge of leaf starting with lower leaves. In advanced cases, leaves turn completely yellow and die.</td>
</tr>
<tr>
<td>calcium</td>
<td>Impaired root growth or rotting. Petioles collapse on youngest mature leaves.</td>
</tr>
<tr>
<td>magnesium</td>
<td>Interverinal chlorosis of lower leaves, margins initially remain green.</td>
</tr>
<tr>
<td>sulfur</td>
<td>Light green, similar to nitrogen deficiency, spindly stems and weak growth.</td>
</tr>
<tr>
<td>boron</td>
<td>Yellowing of leaves, shortened main stem growth between upper portion of shoots, dense top. Often confused with leafhopper damage.</td>
</tr>
<tr>
<td>manganese</td>
<td>Interverinal chlorosis of younger leaves.</td>
</tr>
<tr>
<td>iron</td>
<td>Interverinal chlorosis of youngest leaves, bleached appearance.</td>
</tr>
<tr>
<td>zinc</td>
<td>Reduced leaf size and upward curling of youngest leaves.</td>
</tr>
<tr>
<td>copper</td>
<td>Severe curvature of petioles, grayish spots in midleaf.</td>
</tr>
<tr>
<td>molybdenum</td>
<td>Pale green and stunted as with nitrogen deficiency.</td>
</tr>
</tbody>
</table>

Phosphorus deficiency
Deficient plants have blue-green leaves and stunted growth.
Leaflets often fold together, and the undersides may be red or purplish (left).

Potassium deficiency
Leaves of severely deficient plants turn completely yellow.
Lower leaves of deficient plants are edged with white spots (left).

Sulfur deficiency
Stems are spindly with weak growth
Leaves turn light green (left). Symptoms are similar to nitrogen deficiency.

Boron deficiency
Deficient plants have yellowed leaves on shortened stems.
Yellow coloring turns reddish to purplish between veins.
Nitrogen

Alfalfa typically gets enough nitrogen from its symbiotic relationship with nitrogen-fixing Rhizobium bacteria and from soil organic matter, which releases nitrogen as it decomposes. On established stands, topdressed nitrogen does not improve yields, quality or stand vigor. Adding nitrogen may in fact lower yield and/or quality by stimulating growth of grasses and weeds.

Phosphate and potash

Alfalfa needs relatively large amounts of phosphate and potash. Adequate phosphorus is important for successful establishment and good root development. Potash is essential for maintaining yields, reducing susceptibility to certain diseases, and increasing winterhardiness and stand survival. In the eastern portion of the Midwest, potassium is likely the most limiting nutrient to alfalfa production.

Phosphate and potash are relatively immobile when added to the soil. Phosphate bonds tightly on acidic clayey soils (pH < 5.5) or on very high pH soils (pH > 7.5) making it unavailable to plants. Potash can leach on some extremely sandy soils and on organic soils (peat or muck). Applications of phosphate and potash should be based on recommendations from a recent, well-calibrated soil test.

Alfalfa absorbs most nutrients, including phosphate and potash, from the top 6 to 8 inches of soil. However, because phosphorus is immobile, alfalfa responds better to incorporated applications than to topdressed applications. Guidelines for annual phosphate and potash application include the following:

1. Apply topdress nutrients immediately after harvest before regrowth resumes. Avoid contact with wet foliage.
2. Topdress following first cutting to stimulate second and third cutting regrowth or in early September to increase winter hardiness.
3. Avoid application when soils are soft (such as early spring) when physical damage to the alfalfa crown is likely.
4. Split the application to avoid salt damage if more than 500 lb/acre of material (irrespective of grade) is to be used in any year.
5. Base fertilizer purchases on cost per unit of plant food provided and need for all nutrients contained in fertilizer. For example, since there is no difference in nutrient availability with red versus white potash or with ortho- versus polyphosphate on most soils, the best choice is the least expensive product. Potassium-magnesium sulfate may be a superior potassium source where sulfur is needed and not supplied from another fertilizer material.

6. Foliar application should not be used for applying moderate to high rates of macronutrients, although it is an excellent method for applying micronutrients.

Secondary nutrients

Calcium and magnesium deficiencies are very rare, especially where soil pH has been maintained in the desired range for alfalfa. Symptoms of magnesium deficiency appear when the soil test drops below 50 to 100 ppm magnesium. Magnesium can drop below that level on acidic, sandy soils where repeated high amounts of potassium have been applied; on soils where only calcitic liming materials have been used; and on calcareous organic soils. The most economical way to avoid calcium or magnesium problems is to follow a good liming program with dolomitic limestone. Where soil pH is adequate and extra magnesium is needed, apply magnesium sulfate (epsom salts) or potassium-magnesium sulfate (Sul-Po-Mag or K-Mag) at 20 to 50 lb/acre magnesium per year.

Sulfur deficiencies are likely when high sulfur-demanding crops such as alfalfa are grown on sandy soils or on other soils low in organic matter far from urbanized areas and which have not received manure within the last 2 years. Use of coal, fuel oil, and other fossil fuels in industrial areas releases sulfur into the atmosphere that is deposited on the land in precipitation. In general, precipitation contains enough sulfur to take care of crop needs in most regions (10 to 25 lb/acre each year). The amount of sulfur in manure depends on the kind of animal manure (table 6). Some subsoils, especially those that are acidic and clayey, may contain enough sulfur for high-yielding crops even though the plow layer may test low.
Where the sulfur need has been established, either elemental sulfur or sulfate forms can be used on alfalfa. Sulfate-sulfur is immediately available to the crop, whereas elemental sulfur must be biochemically converted to sulfate before it can be used. When applied at 25 to 50 lb/acre, sulfate-sulfur will generally be adequate for one or two years of alfalfa production. In contrast, elemental sulfur applied at that rate should last for the term of the stand. Elemental sulfur converts to sulfate more rapidly when incorporated.

**Micronutrients**

Plants need only very small amounts of micronutrients for maximum growth. While a deficiency of any essential element will reduce plant growth, overapplication of micronutrients can produce a harmful level of these nutrients in the soil that is difficult to correct, especially on coarse-textured soils. Soil tests are available for some micronutrients, but plant analysis is generally more reliable for identifying micronutrient problems.

Boron is usually the only micronutrient that is needed in a fertilizer program for alfalfa. Boron management depends on the texture of the soil. Sandy soils do not hold boron as tightly as clayey soils. A high test in a sandy soil may be only medium in a silt loam. For alfalfa where the soil test is very low or low on medium-textured soils, apply 2 to 3 lb/acre boron once in the rotation. On sandy soils apply 0.5 to 1 lb/acre boron each year. Due to the low rate of material needed, boron is often mixed with other fertilizers such as potash. Do not apply boron near germinating seeds.

Alfalfa has a relatively high requirement for molybdenum. However, since molybdenum availability increases as pH increases, liming to optimal pH levels usually eliminates molybdenum problems. Manganese, zinc, iron, and copper are rarely deficient in alfalfa. In special situations where deficiencies are suspected, contact your county Extension office or consultant before treating.

**MANURE MANAGEMENT**

Manure is a complete nutrient source, containing all of the major nutrients, secondary nutrients, and micronutrients. In addition, manure promotes biological activity and enhances the soil physical properties. While manure may be beneficial to soil, applying manure on alfalfa fields can create problems. Manure can burn leaves, reducing yield and quality. The mechanics of applying manure can compact soil and damage crowns which in turn lowers yields and shortens stand life. Also, nitrogen in manure can stimulate weed and grass growth.

If possible, spread manure on other crops that can benefit from the nitrogen. Alfalfa will use applied nitrogen but does not need it due to its ability to fix nitrogen. When too much manure and/or too little cropland force application of manure to alfalfa, top management is required.

When alfalfa fields are the only land available for spreading manure, use the following guidelines to reduce damage to the alfalfa stand:

1. Choose fields that have the most grass, usually the oldest stands, since these will benefit most from nitrogen in manure.

2. Apply no more than 3,000 gallons of liquid manure or 10 tons of solid manure per acre. Applying more may cause salt burn, and damage or suffocate plants. Use supplemental fertilizer if additional nutrients are required.

3. Spread manure immediately after removing a cutting so manure contacts the soil instead of the foliage. This reduces the risk of salt burn and minimizes palatability problems.

4. Adjust the spreader to break up large chunks of manure that can smother regrowth.

5. Spread manure only when soils are firm to limit soil compaction and to avoid damaging crowns.

**WEED MANAGEMENT**

Weeds reduce alfalfa production during establishment by competing with and choking out young alfalfa seedlings. Weeds also invade established alfalfa fields and reduce forage quality and yield. Effective weed control begins before seeding and continues throughout the life of the stand. The most important factor in weed control is to establish and maintain a vigorous alfalfa crop.

Proper soil fertility and pH, varietal selection, and seedbed preparation cannot be over-emphasized to prevent weed encroachment. If using a herbicide, remember that application timing and rates vary—always read the product label for application instructions.

**Weed management before planting**

Most alfalfa stands are left in production for several years. The absence of tillage during the life of the stand naturally favors invasion by perennial weeds. It is very important to eliminate weeds before establishing
Weed management in the seeding year

Tillage is an important part of a weed management program when establishing alfalfa. Thorough tillage helps uproot existing annual weeds and sets back established perennial weeds. Final tillage should be done as near planting as possible to allow alfalfa a head start on weed growth.

Most alfalfa in the Midwest is planted with a companion crop to control weeds and soil erosion. Herbicides are seldom needed in these systems, especially if the small grain is harvested as silage. For direct-seeded alfalfa planted in the spring, herbicides are needed. Herbicides for weed control are usually necessary. Several herbicides are currently labeled for use in new alfalfa seedings. This section describes the most commonly used options. Performance ratings for each herbicide are listed in table 7.

Herbicides for perennial weed control may be applied in spring or fall. Fall application is recommended in most cases for more consistent control. Applying nonselective herbicides to perennial weeds at the proper growth stage in spring may delay alfalfa planting past the optimum time.

Herbicides for perennial weed control the year before seeding alfalfa include Banvel, Roundup, 2,4-D, and tank mixes of these herbicides. Banvel carryover will damage alfalfa seedlings unless used far enough in advance of alfalfa planting. Consult labels for specific recommendations.

One of the most serious perennial weed problems in alfalfa stands in northern states is quackgrass. Fall application of Roundup is more effective than spring application. Quackgrass should be actively growing when Roundup is applied.

<table>
<thead>
<tr>
<th>Grasses control</th>
<th>preplant incorporated</th>
<th>postemergence</th>
</tr>
</thead>
<tbody>
<tr>
<td>barnyard grass</td>
<td>G</td>
<td>F</td>
</tr>
<tr>
<td>foxtail</td>
<td>G</td>
<td>F</td>
</tr>
<tr>
<td>quackgrass</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>wild oats</td>
<td>P</td>
<td>F</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Broadleaf weeds control</th>
<th>preplant incorporated</th>
<th>postemergence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern black nightshade</td>
<td>P</td>
<td>F/G</td>
</tr>
<tr>
<td>hoary alyssum*</td>
<td>N</td>
<td>F/G</td>
</tr>
<tr>
<td>kochia</td>
<td>G</td>
<td>F/G</td>
</tr>
<tr>
<td>lambquarters</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>night-flowering catchfly</td>
<td>G</td>
<td>F/G</td>
</tr>
<tr>
<td>pigweed spp.</td>
<td>G</td>
<td>F/G</td>
</tr>
<tr>
<td>ragweed, common</td>
<td>N</td>
<td>G</td>
</tr>
<tr>
<td>smartweed spp.</td>
<td>P</td>
<td>G</td>
</tr>
<tr>
<td>velvetleaf</td>
<td>N</td>
<td>F/G</td>
</tr>
<tr>
<td>wild mustard</td>
<td>N</td>
<td>G</td>
</tr>
</tbody>
</table>

Source: Adapted from Becker, University of Minnesota, 1994

1G = good; F = fair; P = poor; N = no control.
2Control ratings for annual seedlings only.
disk or other suitable implement working the field in two different directions. Eptam can temporarily stunt alfalfa and the first leaves may not unfold properly. Injury may be more pronounced when applied under cool, wet weather, when high rates have been applied, or when poorly incorporated. Do not use Eptam if any atrazine was used in the previous 12 months as severe injury may result. Do not use Eptam if planting a forage grass crop as it will be killed by Eptam.

Direct-seeded plantings—postemergence treatments

**Buctril (bromoxynil)** is a post-emergence contact herbicide that controls many common broadleaf weeds. For best results, treat when alfalfa has at least four trifoliate leaves and when weeds are 2 inches or less in height and have no more than four leaves. Buctril gives fair to good pigweed control if plants are small and actively growing when applied. Alfalfa injury may occur if the temperature exceeds 70°F within 3 days after application. Do not treat alfalfa stressed by moisture shortage or excess, insect injury, or other causes. Treated fields cannot be harvested or fed for 30 days after spring application.

**Butyrac (2,4-DB)** is a post-emergence systemic herbicide that controls many annual broadleaf weeds but is weak on larger mustards and smartweed and will not control grasses. It suppresses some perennial broadleaf weeds. Apply when seedling weeds are small and actively growing. Correct timing is critical as control is less effective on larger weeds. Check the label for specific rates according to weed species and size. Treated forage cannot be harvested or grazed for 60 days after application.

**Poast Plus (sethoxydim)** is a selective postemergence systemic herbicide that controls most annual grasses present in alfalfa. Apply to annual grasses according to label instructions. Grasses must be actively growing for best results. Poast Plus gives some suppression of quackgrass. Alfalfa can be harvested 7 days after Poast Plus treatment if the forage is green chopped or ensiled, and 14 days after treatment if harvested as dry hay. Use Poast Plus to control volunteer grains that emerge following wheat or oat harvest. Treat when cereals are 2 to 4 inches tall and before tillering has started.

Poast Plus and Butyrac can be tank mixed and applied to newly seeded alfalfa to control a mixture of grass and broadleaf weeds. With a tank mix, the possibility of crop injury increases because the oil concentrate increases Butyrac uptake. Use the rate of product as indicated for the weed species present. Do not tank mix UAN or ammonia sulfate with Butyrac. Treated forage cannot be harvested or grazed for 60 days following application. It may be difficult to apply this tank mix at the proper time to adequately control both grasses and broadleaf weeds because each may not be at the best stage for control at the same time.

**Companion-crop seeded plantings**

**Buctril (bromoxynil)** can be used in companion seedings to control several broadleaf weeds. It is very effective on wild mustard and common lambsquarters. Buctril may cause serious alfalfa injury if temperatures exceed 70°F within 3 days after application and if the alfalfa has fewer than four trifoliate leaves.

**Weed management in established alfalfa**

Weeds encroach on alfalfa as stand growth slows due to poor fertility, disease and insect problems, and winter injury. Removing weeds from alfalfa seldom increases the tonnage of harvested forage. Rather, the propor-

---

**Table 8. Impact of common weeds on forage quality.**

<table>
<thead>
<tr>
<th>Weed Type</th>
<th>Serious</th>
<th>Relative Seriousness</th>
<th>Slight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual weeds</td>
<td>cocklebur</td>
<td>green foxtail</td>
<td>lambsquarers</td>
</tr>
<tr>
<td></td>
<td>Eastern black nightshade</td>
<td>pennycress</td>
<td>pigweeds</td>
</tr>
<tr>
<td></td>
<td>giant foxtail</td>
<td>shepherd's purse</td>
<td>ragweed, common</td>
</tr>
<tr>
<td></td>
<td>giant ragweed</td>
<td>velvetleaf</td>
<td></td>
</tr>
<tr>
<td></td>
<td>smartweeds</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>yellow foxtail</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perennial weeds</td>
<td>curly dock</td>
<td>Canada thistle</td>
<td>dandelion</td>
</tr>
<tr>
<td></td>
<td>hoary alyssum</td>
<td>quackgrass and</td>
<td>white cockle</td>
</tr>
<tr>
<td></td>
<td>yellow rocket</td>
<td>other grasses</td>
<td></td>
</tr>
</tbody>
</table>

Source: Doll, University of Wisconsin, 1993
tion of alfalfa in the harvested forage increases. Whether this affects forage quality depends upon the weed species and their stage of growth. Dandelions and white cockle, for instance, have very little effect on forage quality and animal intake while other weeds such as yellow rocket and hoary alyssum decrease animal intake due to their unpalatability. The higher fiber content of grassy weeds also decreases intake. Refer to Table 8 for a comparison of the relative impact of weeds on forage quality.

The decision to use herbicides for weed control in established alfalfa stands should be based on the degree of the weed infestation, the type of weeds present and most importantly the density of the existing alfalfa stand. For treatment to be economical, weed infestations must be severe enough and of species that reduce forage quality, and alfalfa stand density must be high enough to respond to the decreased competition upon weed removal. Herbicide application to thin alfalfa stands severely infested with weeds will increase forage quality but can decrease forage yield. Alfalfa does not spread into open areas, so removing weeds in thin stands often means reinfestation. The cost of herbicide treatments such as Velpar, Sencor, and Lexone can generally be spread over 2 years because weeds will be suppressed for that length of time. Table 9 compares the herbicides available for established stands. The paragraphs below describe the herbicides and when to apply them.

**Butyrac (2,4-DB)** may be applied to established stands to control several broadleaf weeds but is weak on larger mustards and smartweed and will not control grasses. It gives some suppression of perennial broadleaf weeds. Apply when seedling weeds are small and actively growing. Correct timing is critical as control is less effective on larger weeds. Check the label for specific rates according to weed species and size. Treated forage cannot be harvested or grazed for 30 days after application.

**Lexone or Sencor (metribuzin)** control a broad range of annual and perennial weeds, including fair to good control of dandelion and quackgrass. Alfalfa must be established for at least 1 year before using these products. Apply in spring while alfalfa is dormant to avoid injury or impregnate the herbicide onto dry fertilizer and apply when alfalfa is less than 3 inches tall and the foliage is dry. Rates vary with soil type and weed infestation. Consult label for appropriate rates as well as for rotational restrictions. Treated alfalfa may be harvested 28 days after application.

### Table 9. Alfalfa tolerance and herbicide effectiveness on common weeds in established stands

<table>
<thead>
<tr>
<th>Weed Species</th>
<th>Butyrac (2,4-DB)</th>
<th>Lexone/Sencor (metribuzin)</th>
<th>Post Plus (sethoxydim)</th>
<th>Velpar (hexazinone)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual weed control</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field pennycress</td>
<td>F</td>
<td>F</td>
<td>G</td>
<td>F</td>
</tr>
<tr>
<td>Foxtail spp.</td>
<td>N</td>
<td>G</td>
<td>N</td>
<td>G</td>
</tr>
<tr>
<td>Night-flowering catchfly</td>
<td>P</td>
<td>G</td>
<td>N</td>
<td>G</td>
</tr>
<tr>
<td>Shepherd's-purse</td>
<td>F</td>
<td>G</td>
<td>N</td>
<td>G</td>
</tr>
<tr>
<td>Virginia pepperweed</td>
<td>F</td>
<td>G</td>
<td>N</td>
<td>G</td>
</tr>
<tr>
<td>Biennial weed control</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spotted knapweed</td>
<td>F</td>
<td>F</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Perennial weed control</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada thistle</td>
<td>P</td>
<td>P</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Curly dock</td>
<td>P</td>
<td>F</td>
<td>N</td>
<td>F</td>
</tr>
<tr>
<td>Dandelion</td>
<td>P</td>
<td>F/G</td>
<td>N</td>
<td>F/G</td>
</tr>
<tr>
<td>Hemp dogbane</td>
<td>N</td>
<td>P</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Hoary alyssum</td>
<td>F</td>
<td>F/G</td>
<td>N</td>
<td>G</td>
</tr>
<tr>
<td>Orange hawkweed</td>
<td>N</td>
<td>F/G</td>
<td>F/G</td>
<td>F/G</td>
</tr>
<tr>
<td>Quackgrass</td>
<td>N</td>
<td>F/G</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Sowthistle, perennial</td>
<td>P</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>White cockle</td>
<td>P</td>
<td>F</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>Western mugly</td>
<td>N</td>
<td>P</td>
<td>F/G</td>
<td>F</td>
</tr>
<tr>
<td>Yellow rocket</td>
<td>P</td>
<td>F</td>
<td>N</td>
<td>G</td>
</tr>
</tbody>
</table>

Source: Adapted from Becker, University of Minnesota, 1994

\(^1\) G = good; F = fair; P = poor; N = no control.
**DISEASE MANAGEMENT**

Several diseases occur in alfalfa stands that can kill seedlings, limit yields, and shorten stand life. The occurrence and severity of diseases depend on environmental conditions, soil type, and crop management. Few economical control options are available for diseases once they’re present in a field, but knowing diseases are present can help you select resistant varieties for future plantings.

**Anthracnose**

Anthracnose occurs most often under warm, moist conditions and causes yield losses of up to 25%. On susceptible plants, stems have large, sunken, oval- to diamond-shaped lesions. Large lesions are straw colored with brown borders. Lesions can enlarge and join together to girdle and kill one to several stems on a plant. Girdled stems may wilt suddenly and exhibit a “shepherd’s hook.” This should not be confused with frost damage. Dead stems are often scattered in the field with straw-colored to pearly white dead shoots. Anthracnose is most important as a pathogen of crown tissue, turning it blue-black, resulting in fewer stems per plant and eventual plant death. Moderate or higher resistance is available in many varieties.

Poast Plus (sethoxydim) may be applied to established stands to suppress quackgrass or control annual grasses. Treat when quackgrass is 6 to 8 inches tall and when annual grasses are small and actively growing. Do not apply to grass-legume mixtures as forage grasses will be stunted or killed. Alfalfa may be harvested after 7 days as green chop or haylage and after 14 days for dry hay.

Velpar (hexazinone) controls a broad spectrum of annual and perennial weeds, including fair to good control of dandelion and quackgrass. Alfalfa should be established for 1 year or more prior to treatment. Apply Velpar in spring to dormant alfalfa or before new growth exceeds 1 to 2 inches. Treating taller alfalfa will severely injure plants. Rates vary according to weed types present and soil type. Consult the label for specific recommendations and rotational restrictions. Do not graze or feed treated hay for 30 days.

Fall-applied Velpar controls certain species (especially winter annuals) but is less effective on dandelion than spring applications. The uncertainty of winter survival of alfalfa also makes fall treatment a risky venture in most areas.

The diseased crown (right) shows blue-black coloring of anthracnose.

Straw-colored lesions on stems are indicative of anthracnose.
Aphanomyces root rot

Aphanomyces root rot is an important disease of wet soils. It stunts and kills seedlings and causes a chronic root disease in established plants. Infected seedlings develop yellow cotyledons followed by chlorosis of other leaflets. Roots and stems initially appear gray and water-soaked, then turn light to dark brown. Seedlings become stunted but remain upright. Aphanomyces reduces root mass on established plants. Nodules are frequently absent or in some stage of decay. Infected plants exhibit symptoms similar to nitrogen deficiency and are slow to regrow following winter dormancy or harvest. For best results, select varieties with high levels of resistance to both aphanomyces and Phytophthora root rot.
Bacterial wilt

Bacterial wilt symptoms begin to appear in the second and third year and may cause serious stand losses in 3- to 5-year-old stands. Affected plants turn yellow-green, are stunted and, in early stages, are scattered throughout the stand. Severely infected plants are stunted with many spindly stems and small, distorted leaves. Diseased plants are most evident in regrowth after clipping. Cross sections of the taproot show a ring of yellowish brown discoloration near the outer edge. Most varieties are now resistant to this disease.
Lepto leaf spot attacks young regrowth of alfalfa during spring and fall or midwinter in southern areas. Disease growth is particularly noticeable following cool, rainy periods. The lesions start as small, black spots and enlarge to 0.1 inch diameter with light brown or tan centers. The lesions are usually surrounded by a yellow, chlorotic area. Lesions often enlarge and grow together. Yield and quality is lost through loss of dead leaves by wind or during harvesting. Resistant cultivars are not available.

**Common leaf spot and lepto leaf spot**

Common leaf spot occurs primarily in first and second cuttings and in fall regrowth of most alfalfa stands. Disease severity depends on alfalfa conditions and varietal resistance. Symptoms appear as small, brown to black lesions—each less than 0.1 inch diameter—that rarely grow together. The lesions may have a small raised disc in the center of the lesion on upper leaf surface. Leaves turn yellow and fall off plant. The disease causes yield reductions and lowered forage quality through leaf loss. Severely infected fields should be harvested early. Some varieties are moderately resistant.

Lepto leaf spot lesions have tan centers and are surrounded by a yellow halo. Lesions often enlarge and grow together.

Common leaf spot lesions are small brown to black areas that rarely grow together.
Fusarium causes a characteristic reddish-brown discoloration that becomes more evident as the disease progresses (left to right).

Disease bleaches the leaves and stems on plants scattered throughout the field. Symptoms are similar to bacterial wilt but affected plants are not stunted.

**Distribution and severity**

*Fusarium wilt*

Fusarium wilt is a vascular disease that causes gradual stand thinning. Initially, plants wilt and appear to recover overnight. As the disease progresses, leaves turn yellow then become bleached, often with a reddish tint only on one side of a plant. After several months the entire plant dies. Symptoms are similar to bacterial wilt but plants are not stunted. To diagnose Fusarium, cut a cross section of the root. The outer ring (stele) of the root is initially streaked a characteristic reddish brown or brick red color. As the disease progresses the discoloration encircles the root and the plant dies. Practice good fertility and control pea aphids and potato leafhoppers to reduce the effects of this disease. Many varieties are resistant to Fusarium wilt.
Phytophthora root rot

Phytophthora root rot can kill seedlings and established plants in wet or slowly drained soils. The disease is especially prevalent among new seedlings in cool, wet soils. Infection occurs as plants emerge; they appear water-soaked and then collapse and wither. The disease appears on established plants in poorly drained soils and where water stands for 3 days or less. Plants wilt, then leaves, especially lower ones, turn yellow to reddish brown. Lesions develop on the roots. In severe cases, taproots may rot off at the depth of soil water saturation (frequently 1 to 6 inches below ground surface). Plants may die within one week of infection or linger on with reduced root mass and growth rate. Often Phytophthora root rot is not discovered until the soil dries and apparently healthy plants begin wilting because their rotted tap roots are unable to supply adequate water. Many highly resistant varieties are available for poorly drained soils.

Crop rotation is of little value for Phytophthora root rot control because the fungus can survive indefinitely in the soil. However, good management practices can prolong the productivity and life of infected plants that survive the initial infection.

1. Maintain high soil fertility to promote extensive lateral root development above the diseased region of the root and to extend the life of the plant.

2. Avoid un timel y cuttings that might stress the plants. Heavy rains immediately after cutting often result in severe infections. Do not cut, for example, between September 1 and October 15.

3. Control leaf-feeding insects, which can stress plants and make them more susceptible to Phytophthora.

4. Tilling and land-leveling, if practical, can reduce Phytophthora root rot by improving surface and subsurface drainage.

Stems and leaves are bleached by Phytophthora.

As the disease progresses (left to right), lesions develop and the taproot rots off.
Root-lesion nematodes

Root-lesion nematodes reduce yield and thin stands. The parasitic nematodes are microscopic worms that feed on root hairs, feeder roots, and nitrogen-fixing nodules of alfalfa. Root-lesion nematodes reduce the alfalfa plant's ability to take up soil nutrients and fix nitrogen. Plants appear unhealthy and stunted, usually in spotty areas within an otherwise healthy stand. Nematode populations can be reduced by rotating to row crops or fallowing for 2 months following incorporation of forage crop residue. Moderate resistance will soon be available in some varieties.
Sclerotinia

Sclerotinia crown and stem rot is most damaging to seedling stands, especially those seeded in late summer. The first symptoms appear in the fall as small, brown spots on leaves and stems. During the cool, wet weather of early spring, the crown or lower parts of individual stems soften, discolor, and disintegrate. As infected parts die, a white, fluffy mass grows over the area and hard, black bodies, known as sclerotia, form. These bodies remain on the surface of the stem or become imbedded in it. Infection will spread if cool, wet weather prevails during spring, rapidly thinning stands. Spring planting reduces incidence of the disease. Plowing buries sclerotia and reduces its ability to infect new plantings. No resistance is available yet.
Distribution and severity

Spring black stem

Spring black stem occurs in the northern United States during early spring and reduces forage yield and quality. Many small, dark brown spots develop on the lower leaves and stems. Leaves, especially lower ones, turn yellow, wither, and fall off. Lesions on stems enlarge and may blacken large areas near the base of the plant. Severe infestations girdle and kill the stem. The plant dies when infection spreads to the crown and roots. Cutting the stand at early stages of maturity will reduce leaf loss and disease prevalence. Currently available varieties have variable levels of resistance, but none are characterized for this disease.

Summer black stem

Summer black stem occurs during hot, humid weather, reducing forage yield and quality. The disease first affects the base of the plant and progresses up the stem, causing leaves to fall off. Leaf spots are brown with irregular margins and often surrounded by a diffuse yellow margin. Reddish to chocolate brown oval lesions form on the stems and merge to discolor most of it. Early harvest may reduce losses. Currently available varieties have little resistance.

Lesions may enlarge to girdle stems and kill the plant.

Leaf lesions (left) first appear on lower leaves.
**Verticillium wilt**

Verticillium wilt can reduce yields up to 50% beginning the second harvest year and severely shortens stand life. Early symptoms include v-shaped yellowing on leaflet tips, sometimes with leaflets rolling along their length. The disease progresses until all leaves are dead on a green stem. Initially, not all stems of a plant are affected. The disease slowly invades the crown and the plant dies over a period of months. Root vascular tissues may or may not show internal browning. Many varieties are resistant to this disease.

The following measures minimize the chances of introducing the fungus to an area and spreading the disease between and within fields.

1. Plant resistant varieties.
2. Practice crop rotation. Deep plow Verticillium-infested fields and do not plant alfalfa for 2 to 3 years, although a highly resistant variety could be planted immediately. Corn and small grains are important non-hosts. These crops should fit well into a rotation with alfalfa. Red clover is a questionable host, so don't grow red clover on Verticillium-infested land.
3. Harvest non-infested fields first. Then harvest infested fields at the hard-bud or early flower stage. Early harvest can limit some yield and quality losses caused by Verticillium wilt and can slow the spread of the wilt fungus in a field.
INSECT MANAGEMENT

**Alfalfa weevil**

Alfalfa weevil larvae chew and skeletonize leaves. Large larval populations may defoliate entire plants, giving the field a grayish color. Damage normally only occurs to the first harvest but both larvae and adults may damage regrowth when populations are high, resulting in both yield and stand loss.

Larvae are slate-colored when small, but bright green when full grown (% inch). They have a white stripe down the back and a black head. Although larvae are present from May well into the summer, peak feeding activity falls off by mid-June.

When full grown, the larvae spin silken cocoons on the plants, within the curl of fallen dead leaves, or within litter on the ground. They change into adults in 1 or 2 weeks. Adults are dark gray to brown snout beetles measuring 3/16 inch in length. There is a distinct dark shield-like mark on the back. After feeding a short time, most leave the field and enter a resting period that lasts until fall. In the fall, they return to the alfalfa field and lay a few eggs before the onset of cold temperatures. In northern states, fall egg laying is insignificant; most eggs are laid the following spring.

Begin checking alfalfa fields for signs of weevil feeding around mid-May in northern states and earlier farther south.

**Treat fields when 40% of the plant tips of the first crop show obvious signs of damage. This does not mean 40% defoliation.** If damage occurs within 7 to 10 days of the suggested harvest date, harvest the hay as soon as possible; otherwise spray the field as soon as possible. Many weevil larvae are killed during harvesting.

An alternative approach for deciding when to treat involves comparing the control costs to the forage value. Use table 10 to find where these two values intersect for the number of alfalfa weevil larvae needed to justify chemical control.

If you’ve harvested early because of developing alfalfa weevil problems, or if substantial weevil damage has occurred, check the stubble carefully for signs of damage to new growth. Some fields may fail to green-up because adults and larvae consume new crown buds as fast as they are formed. Examine the stubble, the soil surface around alfalfa plants, and under leaf litter for larvae and adults. If they are present and if plants show no sign of regrowth within 3 or 4 days after harvest, spray the stubble as soon as possible.

Treat also if new growth has started and feeding damage is apparent on 50% of the growth and/or you find 6 to 8 weevils or more per square foot.

**Leaves skeletonized by alfalfa weevil larvae.**

**Severely damaged plants appear grayish-brown.**

---

**Table 10. Economic thresholds for alfalfa weevil larvae in early bud stage alfalfa.**

<table>
<thead>
<tr>
<th>control larva cost ($/acre)</th>
<th>forage value ($/ton)</th>
<th>average larvae/stem</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>45</td>
<td>55</td>
</tr>
<tr>
<td>7</td>
<td>4.0</td>
<td>3.3</td>
</tr>
<tr>
<td>8</td>
<td>4.6</td>
<td>3.6</td>
</tr>
<tr>
<td>9</td>
<td>5.2</td>
<td>4.2</td>
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<tr>
<td>10</td>
<td>5.8</td>
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<tr>
<td>11</td>
<td>6.3</td>
<td>5.2</td>
</tr>
<tr>
<td>12</td>
<td>6.9</td>
<td>5.6</td>
</tr>
<tr>
<td>13</td>
<td>7.4</td>
<td>6.1</td>
</tr>
</tbody>
</table>

*Source: Peterson, Danielson, and Higley, University of Nebraska, 1993*
**Aphids**

Aphids cause stunting and yellowing of alfalfa resulting in yield loss. Heavily infested plants wilt during the hottest parts of the days.

Green pea aphids or the spotted alfalfa aphids, which are yellow and faintly dark spotted, congregate on stems and leaves and suck plant juice. Spotted alfalfa aphids have been uncommon in the upper Midwest for many years. Parasites and disease keep the pea aphid in check most years, though population explosions periodically occur. Pea aphids are a major problem in the hot and dry western United States. Treat pea aphids when numbers exceed 100 per sweep, particularly during dry periods.

**Blister beetles**

Blister beetles in alfalfa hay can cause sickness and death in livestock, particularly horses. Blister beetles contain cantharidin, a chemical irritant that can blister internal and external body tissues. Although there are few documented cases of fatalities in cattle and sheep, cantharidin-contaminated hay is deadly to horses.

Blister beetles are a serious problem in southern and western states, and an occasional problem in the upper Midwest, particularly during drought years or the year following drought. The several species present in the Midwest vary in size and color, but are easily recognized by their elongated, narrow, cylindrical, soft bodies. The “neck” area is narrower than on most beetles. Sprays are generally not effective because cantharidin is a very stable compound and the dead beetles can be picked up in the hay. Because beetle populations tend to build throughout the season, especially in the south, horse owners should consider buying first-crop and early second-crop hay during high infestations of blister beetle.
**Clover leaf weevil**

Clover leaf weevil larvae eat alfalfa leaves, usually beginning with the foliage around the base of the plant. Crop injury occurs mostly before the first cutting, but it is usually insignificant compared with the injury caused by the alfalfa weevil. Clover leaf weevils are active at night and on cloudy days. During sunny days, they hide around the base of the plant.

Larvae are slate-colored when small, but bright green when full grown. They are similar in appearance to alfalfa weevil larvae except that the head is light brown and the white stripe down the center of the back is often edged with pink. Full-grown larvae are about ½ inch long.

Adult clover leaf weevils are two to three times larger than alfalfa weevils. They are ¾ inch long, dark brown flecked with black, and have a lighter colored stripe extending along each side of the wing covers. This insect normally leaves the fields shortly after the first cutting and returns in late summer to feed and lay eggs before winter. There is one generation per year and they overwinter mostly as partially grown larvae.

Treatment is rarely warranted for clover leaf weevil larvae. Management of alfalfa weevils will also control this insect. However, adult clover leaf weevils can cause damage by feeding on the green stems and regrowth after the first cutting. Large populations can cause extensive feeding damage, scarring the stems and rapidly consuming new foliage as it is produced. This type of injury is more common during dry springs when regrowth is slow and weevils are abundant. Treatment should be considered if the hay does not begin to regrow in 3 to 4 days after cutting and weevils are present in the field.
**Clover root curculio**

The clover root curculio is a potentially serious pest of alfalfa. Although this pest can be found in most alfalfa fields, high populations and serious damage have been localized and sporadic. However, even small populations may contribute to stand decline. At this time there is no reliable method of damage prediction or control.

Adults are black to dark brown, blunt-snouted weevils that are approximately \( \frac{1}{8} \) inch long and \( \frac{1}{16} \) inch wide. The surface of the beetle’s body is deeply “punctured.” Females lay eggs on the lower parts of stems, on lower leaves, or on the soil surface. Larvae hatch from these eggs and enter the soil through surface cracks.

There is only one generation per year. Adults lay eggs in fall or spring, and hibernate over the winter. Eggs hatch in the spring, and egg-laying is usually complete by mid-June. New adults emerge in June and July and live about a year.

Adult curculios injure plants by chewing the margins of leaves, creating crescent-shaped notches, or by chewing the stems and leaf buds of young seedlings. Feeding damage can weaken seedlings, causing poor growth or death. Mature plants are not at risk unless populations are exceedingly high.

Larvae do the greatest damage, and such damage can be cumulative over the years that a field exists. Newly hatched larvae feed on nodules and small rootlets and chew out portions of the main root. Feeding on the main root leaves long brown furrows and may partially girdle the plant.

**Grasshoppers**

Grasshoppers can overwinter as eggs or adults, depending upon the species. Populations tend to build during the season, followed by movement of the grasshoppers into cultivated crops from grassy or weedy areas where they overwintered. It is important to detect infestations while the grasshoppers are small and concentrated in overwintering sites.

Several species can feed on alfalfa. Problems occur mainly in the western United States and during droughty years in the Midwest. Grasshoppers rarely cause economic damage in most areas of the Midwest and should be considered a minor pest.

Begin spot-checking overwintering sites during June. Estimate the number of grasshoppers per square yard while walking through these areas. Insecticide use is not suggested until populations reach 20 per square yard in field margins or 8 per square yard within an alfalfa field. If economically damaging infestations are detected while the grasshoppers are still concentrated, spot treat the area to protect alfalfa fields.
Plant bugs

Plant bugs extract plant sap with their tube-like mouths. High populations can stunt alfalfa growth or crinkle and pucker leaves. However, these symptoms may be caused by other factors so be sure to positively identify the problem before treating plants.

The two plant bugs that are particularly important to alfalfa production are the tarnished plant bug and the alfalfa plant bug. The adult tarnished plant bug is \( \frac{1}{4} \) inch long and brown. Nymphs are green with black spots on the back. Adult alfalfa plant bugs are \( \frac{3}{8} \) inch long and are light green. Nymphs are green with red eyes.

Treatment is suggested if there are three plant bug adults and/or nymphs per sweep on alfalfa less than 3 inches tall; treat when there are five or more adults and/or nymphs per sweep on taller alfalfa. If damage occurs within 7 to 10 days of the suggested harvest date, harvest the hay as soon as possible; otherwise spray the field as soon as possible.
**Potato leafhoppers**

Potato leafhoppers are mid- to late-season alfalfa pests that migrate to northern states from southern areas. First-crop alfalfa harvested at the proper time in the Midwest usually escapes damage. However, monitor subsequent crops as well as new seedlings for leafhoppers.

These small (1/8 inch), green, wedge-shaped insects suck sap from plants and inject a toxin into the leaves, creating a yellow wedge-shaped area on the tip of leaflets. Severely damaged plants will be stunted and chlorosis will appear on all leaves if leafhoppers are not controlled. Damage first appears on field perimeters.

Alfalfa stands suffer yield and quality losses before any yellowing is visible. To detect leafhoppers before symptoms appear, use an insect sweep net. Refer to table 11 to determine when to treat alfalfa fields.

### Table 11. Economic thresholds for control of potato leafhopper. (Treat when leafhopper densities reach these thresholds.)

<table>
<thead>
<tr>
<th>stem height (inches)</th>
<th>leafhoppers/net sweep (average)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>0.2 adult</td>
</tr>
<tr>
<td>6</td>
<td>0.5 adult</td>
</tr>
<tr>
<td>8-11</td>
<td>1.0 adult or nymph</td>
</tr>
<tr>
<td>12-14</td>
<td>2.0 adults or nymphs</td>
</tr>
</tbody>
</table>

Severely damaged plants are stunted and chlorotic. Leafhopper burn appears first as yellow wedge-shaped areas on the tips of leaflets.

![Adult leafhopper (actual size 1/8 inch)](image)
Spittlebugs

Spittlebug nymphs appear in early May. These soft, orange or green bugs can be found in white spittle masses in leaf axils, and later in the clumps of new growth at tips of stems. They suck plant juices and stunt but do not yellow the alfalfa. Alfalfa can support a tremendous population of spittlebugs without yield loss and they usually have no economic impact. Treatment is suggested if there is an average of one spittlebug per alfalfa stem.

Variegated cutworm

Variegated cutworm larvae feed on leaves and stems. Serious damage can occur on regrowth after the alfalfa is cut and larvae feed under the protection of drying windrows. They also can cut seedling plants in new stands. Larvae are variable in color, ranging from tan to greenish-yellow to almost black with a row of small yellow, dagger- or diamond-shaped spots down the center of the back. There are three to four generations a year.

Treatment should be considered if the hay does not begin to regrow in 4 to 7 days after cutting and larvae are present in the field.

Variegated cutworm larvae can cause serious damage on regrowth after alfalfa is cut.

When to rotate from alfalfa

To decide when to rotate from alfalfa, you’ll need to evaluate stand density and yield relative to your needs. You’ll also want to factor in rotation requirements, farm plan, total acreage of forage needed, and ability to reseed. Because most of these factors are farm specific, this section focuses on the relationship between stand density and yield.

Alfalfa has a tremendous ability to produce maximum yield over a wide range of stand densities. New seedings should have at least 25 to 30 plants per square foot the seeding year. Stands gradually thin and weeds may invade rapidly. Weedy stands force the choice of using herbicides, which increases production cost, or of harvesting much lower quality forage.

The decision to rotate from alfalfa should be based on yield potential of the stand. Plant density is a poor estimator of yield potential because an individual plant may have few shoots and contribute little to yield. Stem density is the best estimator of yield potential. However, you may need to base your decision on plant density if assessing the stand in spring before stem counts are available.
To determine season yield potential of a field, use the relationship in figure 13. Stem density can be counted any time after plants are 4 to 6 inches tall. Try to count only stems that would be cut by a mower. With experience, visual estimates are usually sufficiently accurate. Note that this calculates yield potential; actual yield will probably be less due to moisture, soil fertility, and other management practices that limit yield.

The best time to make stand decisions is in the fall. During the last growth period record stem density. Then dig a random sampling of plants and assess root health (see related advanced technique). Typically, stands that fall below 40 stems per square foot or three to four healthy plants per square foot are no longer profitable, although the critical yield range will vary with individual farming operations. Marginal stands that are healthy may be kept while fields with high levels of crown rot will decline rapidly and should be considered for rotation along with low yield potential fields.

**Figure 13.** Alfalfa stem count and yield potential.

![Dry Matter Yield vs Stems Per Square Foot](source: Undersander and Cosgrove, University of Wisconsin, 1992)

\[
yield = (0.10 \times \text{stems}) + 0.38
\]

**ADVANCED TECHNIQUES**

**Stand evaluation**

To evaluate stands dig several alfalfa plants and look at the condition of the root. This will give an idea of stand vigor and future life span. Some crown rot will be visible in most older stands. Look for the number of crowns and roots with rot and the degree of infection. Compare to photo. Individual plants with severe injury (greater than 50% rot) are not likely to survive another year. Stands with a high percentage of these plants should be considered for replacement.

Varying degrees of crown rot. From the left: the first two are healthy, the next three show moderate injury, and the remaining five show severe crown rot. Plants with severe rot are unlikely to survive another year.
The final step to profitable alfalfa production is to set goals for forage quality and use the appropriate harvest techniques to minimize field losses and maximize tonnage of high quality forage. This recognizes that high quality forage is profitable to animals that can use the quality but that tradeoffs exist between forage quality, yield, and stand life.
FORAGE QUALITY

Alfalfa is superior to other forage crops because it is high in crude protein and energy, reducing the need for both types of supplements in rations. The superior intake potential allows for greater use in rations of high-producing dairy cows.

What quality forage is needed?

The nutrient need of an animal depends primarily on its age, sex, and production status (figure 14). Maximum profit results from matching forage quality to animal needs. Lower-than-optimum quality results either in reduced animal performance or increased supplement costs. Conversely, feeding animals higher quality forage than they need wastes unused nutrients that were expensive to produce and may result in animal health problems.

Quality standards are presented in table 12. (Forage quality terms are defined at the end of the Harvest section.) Use the RFV index to allocate the proper forage to the proper livestock class (figure 14). Performance of high-producing dairy cows is most limited by intake of digestible dry matter and prime hay or haylage is recommended. Grade 1 is recommended for dairy cows after the first trimester, heifers, and stocker cattle.

Table 12. Quality standards for legume, grass, and grass-legume mixture.

<table>
<thead>
<tr>
<th>quality standard</th>
<th>RFV$^1$</th>
<th>ADF</th>
<th>NDF</th>
<th>% dry matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>prime</td>
<td>&gt;151</td>
<td>&lt;35</td>
<td>&lt;40</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>151-125</td>
<td>35-40</td>
<td>40-60</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>124-103</td>
<td>40-45</td>
<td>47-53</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>102-87</td>
<td>41-42</td>
<td>54-60</td>
<td></td>
</tr>
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<td>4</td>
<td>86-75</td>
<td>43-45</td>
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</tr>
<tr>
<td>5</td>
<td>&lt;75</td>
<td>&gt;45</td>
<td>&gt;65</td>
<td></td>
</tr>
</tbody>
</table>

$^1$RFV = relative feed value; ADF = acid detergent fiber; NDF = neutral detergent fiber.

Figure 14. Forage quality needs of cattle and horses.
Forage quality is also influenced by the time of day alfalfa is cut. Plants convert sugars and starches to energy in a process called respiration. Respiration after cutting lowers forage quality and is stopped only by drying the forage. Therefore, the best time to cut alfalfa is in the morning to speed drying and capture sugars and starch for higher quality hay and haylage.

**HARVEST MANAGEMENT**

Forage yield, quality, and stand persistence are all major considerations in the development of a profitable harvest management program. Increased awareness of the nutritional value of high quality alfalfa in terms of potential savings of energy and protein supplements has caused many to re-evaluate current harvest strategies.

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**Figure 15.** Carbohydrate content of alfalfa roots.

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**Figure 16.** Forage yield relative to quality at different growth stages.
Cutting schedule

Selection of a harvest schedule begins with the decision on quality of forage desired. Growers desiring all high quality alfalfa will shorten stand persistence and decrease yield. Harvest schedule decisions include number of cuts per season, date of cut, stage of maturity, interval between cuts, and cutting height. The link between the stage of maturity and yield, quality, and persistence makes it apparent why growth stage is frequently used to decide when to harvest alfalfa. Keying harvests to specific stages of development also takes into account the varying effects of changing environments and variety maturity rates. A shortened growing season in northern states dictates combining calendar dates and stage of development into harvest strategies.

Maximum persistence. If harvesting for maximum persistence, cut alfalfa between first flower and 25% flower. This is approximately 35 to 40 days between cuttings (figure 17). The system has a slightly wider harvest window and longer cutting interval than when cutting for high quality because the emphasis is on high yield.

High quality. When harvesting for high quality the first cutting should be taken by an early calendar date appropriate for the region. The remainder of cuttings should be taken at midbud, generally 28- to 33-day intervals early in the season and longer near the end of the season (figure 17). Cutting for high quality forage means that forage must be harvested within a 3- to 4-day period. No late-fall cutting should be taken in northern states, although it should be taken in regions where needed to decrease insect overwintering. Yield of the late fall cutting is generally low and removal of this forage will increase winterkill and first cutting yield the next spring.

High yield and high quality. For harvest schedules to provide the highest yield of high quality forage, the first two cuttings must be timely. During this time forage quality changes most rapidly and short delays mean low quality forage (figure 18). Take the first cutting at bud stage or between May 15 and 25 in Minnesota and Wisconsin, and earlier farther south. Take the second cutting 28 to 33 days after the first cut or midbud, whichever is earlier, and take subsequent cuttings at 38- to 55-day intervals or at 10 to 25% bloom. An early first harvest followed by a short cutting interval gives a high yield of quality forage (figure 17) while letting...
one cutting mature to early flower will increase root reserves and stand persistence. The forage quality of alfalfa does not change as rapidly in later cuttings as in earlier cuttings so later cuttings maintain quality to later maturity stages (figure 18). This slower quality change allows a harvest window of 7 to 10 days. Additional cuttings may be taken if time permits before the required 6- to 8-week rest period prior to the first killing frost. In northern regions, delaying the third cut often results in alfalfa flowering during the 6 weeks before the first killing frost (between September 1 and October 15 in northern states). To prevent loss of persistence, delay harvest until mid- to late October, regardless of the stage of maturity. However, this late-fall cutting will shorten stand life and decrease yield the next spring, so should be cut high (at 6 inches) or not harvested if adequate forage is available. Minnesota researchers found that highest yields came from three cuttings during the growing season with a late-fall cutting. Using this cutting schedule, the percentage of total yield cut at “prime standard” (>150 RFV index) ranged from 32 to 75%.

**FALL MANAGEMENT**

Fall management of alfalfa involves assessing the risk of winter injury and the need for additional forage. The risk of winter injury to alfalfa depends on uncontrollable environmental factors (snow cover, temperature, and soil moisture) and controllable factors (variety, soil fertility, seasonal cutting strategy, stand age, and cutting height).

**Uncontrollable environmental factors**

- Periods of cool temperatures are required in the fall for alfalfa to develop resistance to cold temperatures. Sudden changes from warm to cold reduce hardening.
- A snow cover of 6 inches or more protects alfalfa plants from severe cold. During winters without snow cover, soil temperatures can fall below 15°F, injuring or killing plants.
- Even hardy varieties can be injured or killed by 2 weeks or more of temperatures below 5° to 15°F.
- Warm fall weather (40°F or higher) and midwinter thaws cause alfalfa to break dormancy and have less resistance to freezing.
- Excessively moist soil in the fall reduces hardening and predisposes alfalfa to winter injury. Excess surface and soil moisture can lead to the formation of ice sheets. Ice sheets smother plants by freezing the soil before the plant has hardened. Ice sheets also allow high concentrations of toxic substances—such as carbon dioxide, ethanol, and methanol—to accumulate. Ice sheeting frequently occurs in conjunction with midwinter thawing and is more prevalent in poorly drained soils.

**Controllable factors**

- Select alfalfa varieties with good winterhardiness and moderate resistance to several diseases. These varieties will better tolerate late-fall cuttings.
- Soil fertility management is vitally important for maintaining productive alfalfa stands. Potassium (potash) is particularly important for developing plants that have good winter survival.
- Greater harvest frequency and stand age at harvest increases the potential for winter injury when fall cuttings are taken. When the interval between previous cuttings has been 35 days or less, avoid harvesting during the critical fall period 6 weeks before the first killing frost (between September 1 and October 15 in northern states, later in southern states). This allows plants to enter winter with higher root carbohydrates (figure 15).
- Young alfalfa stands survive winters better than older stands due to lower disease infestation and less physical damage.
- Stem and leaf stubble remaining in the late fall catch snow and insulate the soil. Alfalfa harvested in October should have a 6-inch stubble left and uncut strips to reduce risk of winter damage.

Making the decision to cut in the fall requires using the above factors to estimate the risk of winter injury to alfalfa and weighing it against the need for forage. Use the questions and scoring system shown in table 13 to assess risk of winter injury. Then assess risk potential with demand for hay from a fall harvest.
Harvesting the late fall cutting will increase tonnage for the season and may be more profitable where risk potential is low (see Table 13) and good snow cover or less severe winters occur. Minnesota research shows that taking a fourth cutting after October 15 is more profitable than three cuts by September 1 (6 weeks before killing frost) or four cuts by September 15 with no fall cutting for a 4-year-old alfalfa stand. In five-cut systems, the first cutting yield the next spring was lowered by approximately the same amount as the yield from the fall cutting. Root rot was increased and, therefore, stand life was also shortened.

### Table 13. Calculate your risk of alfalfa winter injury.

<table>
<thead>
<tr>
<th>points</th>
<th>score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What is your stand age?</td>
<td></td>
</tr>
<tr>
<td>&gt; 3 years</td>
<td>4</td>
</tr>
<tr>
<td>2–3 years</td>
<td>2</td>
</tr>
<tr>
<td>≤ 1 year</td>
<td>1</td>
</tr>
</tbody>
</table>

2. Describe your alfalfa variety:
   a. What is the winterhardiness (fall growth score)?
      - Moderately winterhardy: 3
      - Winterhardy: 2
      - Very winterhardy: 1
      - a. total __
   b. What is the disease resistance?
      - Moderate resistance to only bacterial wilt: 4
      - Moderate resistance to bacterial wilt plus either anthracnose, Fusarium wilt, Phytophthora root rot, or Verticillium wilt: 3
      - Moderate resistance to all above-mentioned diseases: 1
      - b. total __
   - Alfalfa variety total score (multiply a x b)

3. What is your soil pH?
   - ≤ 6.0: 4
   - 6.1–6.5: 2
   - ≥ 6.6: 0

4. What is your soil exchangeable K level?
   - Low (<80 ppm): 4
   - Medium (80–120 ppm): 3
   - Optimum (120–160 ppm): 1
   - High (≥ 160 ppm): 0

5. What is your soil drainage?
   - Poor (somewhat poorly drained): 3
   - Medium (well to moderately well drained): 2
   - Excellent (sandy soils): 1

6. What is your soil moisture during fall/winter?
   - Wet: 5
   - Medium to dry: 0

7. Describe your harvest frequency:
   - Cut interval | Last cutting
   | < 30 days | Sept. 1–Oct. 15 | 5 |
   | After Oct. 15 | 4 |
   | Before Sept. 1 | 3 |
   | 30–35 days | Sept. 1–Oct. 15 | 4 |
   | After Oct. 15 | 2 |
   | Before Sept. 1 | 0 |
   | > 35 days | Sept. 1–Oct. 15 | 2 |
   | After Oct. 15 | 0 |
   | Before Sept. 1 | 0 |

8. For a mid- to late October cut, do you leave more than 6 inches of stubble?
   - No: 1
   - Yes: 0

Determine your total score (sum of points from questions 1–8) total

Fall cutting risk

<table>
<thead>
<tr>
<th>If you score:</th>
<th>Your risk is:</th>
</tr>
</thead>
<tbody>
<tr>
<td>3–7</td>
<td>low/below average</td>
</tr>
<tr>
<td>8–16</td>
<td>moderate/average</td>
</tr>
<tr>
<td>17–27</td>
<td>high/above average</td>
</tr>
<tr>
<td>28 or more points</td>
<td>very high/dangerous</td>
</tr>
</tbody>
</table>

Source: Adapted from C.S. Shaeffer, University of Minnesota, 1990

1 Dates listed are for northernmost states; states south of that area should use later dates.
HAY AND SILAGE MANAGEMENT

Hay-making and silage-making differ in how the moisture content of alfalfa is employed as a strategy in preservation. Fresh alfalfa contains about 80% moisture. Soluble sugars and proteins are dissolved in the forage liquid. When concentrated through wilting, this “juice” provides an ideal medium for the growth of yeasts, molds, and bacteria and for rapid activity of plant enzymes. Appropriate bacterial growth can result in fermentation that produces lactic acid and preserves the material as silage. When forage is dried to hay before harvest, water in the forage evaporates, resulting in a higher concentration of nutrients in the remaining liquid where cell growth and enzyme activity are restricted.

Losses. Each step in the preservation process—mowing, raking, chopping, baling, storing, and unloading—causes a loss of forage dry matter (figure 19). Some losses result from mechanical action; others are biological processes. Total losses from cutting to feeding are 20% to 30% of the standing crop dry matter in typical hay and silage systems. In hay-making, most of the losses result from mechanical handling and weather damage in the field. In silage-making, most losses occur during storage and feed out.

Quality changes. Most of the dry matter lost from forage during harvest and storage has high nutritional value. More leaves than stems are lost during hay-making, and most protein- and energy-rich nutrients are concentrated in the leaves. Biological processes in silage-making use the most readily available nutrients, such as plant sugars. Thus, in both hay and silage systems, the changes that occur are often detrimental to the quality of the final product.

Table 14. Summary of good hay-making practices.

<table>
<thead>
<tr>
<th>practice</th>
<th>reason</th>
<th>benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>mow forage early in day</td>
<td>allow full day’s drying</td>
<td>faster drop in moisture, less respiration loss, less likelihood of rain damage</td>
</tr>
<tr>
<td>form into wide swath</td>
<td>increase drying rate</td>
<td>faster drop in moisture, less respiration loss, less likelihood of rain damage</td>
</tr>
<tr>
<td>rote at 40-50% moisture content</td>
<td>increase drying rate</td>
<td>faster drop in moisture, less respiration loss, less likelihood of rain damage</td>
</tr>
<tr>
<td>bale hay at 18-20% moisture content</td>
<td>optimize preservation</td>
<td>less leaf shatter, inhibits molds and browning, low chance of fire, higher quantity and quality</td>
</tr>
<tr>
<td>store hay under cover</td>
<td>protect from rain, sun</td>
<td>inhibits molds and browning, less loss from rain damage, higher quantity and quality</td>
</tr>
</tbody>
</table>

Source: Pitt, Cornell University, 1991

Figure 19. Dry matter losses during harvest and storage relative to forage moisture content at harvest.

Source: Hoglund, Michigan State University, 1964
Minimizing losses. Dry matter losses and quality changes cannot be eliminated in hay preservation, but they can be minimized by using good management practices. The practices for good hay-making are summarized in table 14.

Quality losses during hay-making
- Respiration uses plant sugars, a process which increases NDF and ADF and decreases digestibility.
- Rain damage on hay before baling leaches soluble nutrients (protein and carbohydrates). NDF and ADF increase; digestibility and crude protein decrease. Additional quality is lost from leaf shattering.
- Rainy weather causes delays in harvest. NDF and ADF increase; digestibility and crude protein decrease.

Good hay preservation depends primarily on handling and harvest management. The drying rate, mechanical handling of the forage, and the moisture content at baling all impact the quality of the hay. With proper management, little or no deterioration takes place in the hay during storage.

Quality losses during silage-making
- Dry matter loss increases ADF and NDF; lowers digestibility and dry matter intake by animals.
- Loss of leaves decreases crude protein.
- Soluble protein can increase in silage during fermentation. Animals on high-performance diets (dairy or growing beef) need insoluble protein, so performance is adversely affected.

Figure 20. Conditions for profitable use of inoculant on silage. Shaded areas indicate profitable conditions.

Source: Adapted from Muck, USDA, 1993

ADVANCED TECHNIQUES

Drying agents, preservatives, and silage inoculants

To speed drying, use a chemical conditioner in addition to mechanical conditioning. These products, either sodium or potassium carbonate, are applied to alfalfa as it is cut and increase drying rate by 5 to 24 hours. Drying agents do not work on grasses. The disadvantages of these products are the cost, $2 to $6 per acre, and the need to carry large volumes of water for application.

Preservatives allow hay to be baled at moisture contents greater than the 20% that can normally be stored. These products are only cost effective if their use prevents rain damage. So apply only when rain is imminent.

Good haylage or silage fermentation requires lactic acid forming bacteria. These bacteria occur naturally on alfalfa. Silage inoculants (either microbial or enzyme products) are beneficial when naturally occurring populations of lactic acid forming bacteria are low and plant carbohydrate levels high. In the northern United States, these conditions occur on all early- and late-season cuttings when the drying time has been less than 2 days (figure 20). Bacterial inoculants must be stored in cool places and contain $10^6$ Lactobacillus plantarum colony forming units (cfu) per gram. In order to be effective the inoculant must be uniformly mixed throughout the forage. A dry applicator on the chopper or a liquid applicator on the blowor are preferred methods of application.
- Acid detergent fiber: crude protein is protein made insoluble through the heating during fermentation. Up to 14% is beneficial; more than 14% reduces protein availability to the animal.

Unavoidable losses include those due to field losses, plant respiration, and primary fermentation. Avoidable losses occur from effluent, anaerobic fermentation, and aerobic deterioration in storage structure. Estimates of unavoidable dry matter losses range from 8% to 30%; avoidable losses from 2% to 40% or higher. The importance of quickly achieving and maintaining oxygen-free conditions has led to improved equipment and techniques for precision chopping, better compaction, rapid filling, and complete sealing.

Alfalfa is more difficult than corn to ferment properly because alfalfa contains fewer soluble carbohydrates relative to protein. For an outline of good silage management practices see Table 15.

**Feeding considerations of hay and haylage**

A widely used rule of thumb in formulating rations for lactating dairy cattle is that one-third of the diet be forage, one-third concentrate, and the remaining one-third either forage or grain, depending upon the quality of the forage fed. By feeding high quality alfalfa in place of lower quality forages, dairy producers can decrease the amount of concentrates that must be fed and can increase the utilization of forage. The lactation study in Table 16 shows concentrates cannot supply the energy required at high production levels when the quality of the forage is too low.

How alfalfa is harvested and preserved has been the focus of many research studies, but no clear advantage in animal performance has been demonstrated for harvesting and storing alfalfa either as hay or haylage. Harvesting alfalfa at higher moisture contents will decrease field losses but will increase storage losses unless forage is kept in airtight silos or silage tubes.

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**Table 15. Summary of good alfalfa silage practices.**

<table>
<thead>
<tr>
<th>practice</th>
<th>reason</th>
<th>benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>minimize drying time</td>
<td>reduce respiration</td>
<td>reduced nutrient, energy losses, more sugar for fermentation, lower silage pH</td>
</tr>
<tr>
<td>chop at correct TLC, fill silo quickly, enhance compaction, seal silo carefully</td>
<td>minimize exposure to oxygen</td>
<td>reduced nutrient, energy losses, more sugar for fermentation, reduced silo temperatures, less heat damage (browning), faster pH decline, better aerobic stability, less chance of listeria, less protein solubilization</td>
</tr>
<tr>
<td>ensile at 30–50% dry matter content</td>
<td>optimize fermentation</td>
<td>reduced nutrient, energy losses, proper silo temperatures, less heat damage (browning), control clostridia, prevent effluent flow</td>
</tr>
<tr>
<td>leave silo sealed for at least 14 days</td>
<td>allow complete fermentation</td>
<td>lower silage pH, more fermentation acids, better aerobic stability, less chance of listeria</td>
</tr>
<tr>
<td>unload 2–6 inches/day</td>
<td>stay ahead of spoilage</td>
<td>limit aerobic deterioration</td>
</tr>
<tr>
<td>keep surface smooth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>discard deteriorated silage</td>
<td>avoid animal health problems</td>
<td>prevent toxic poisoning, mycotic infections, prevent listeriosis, clostridial toxins</td>
</tr>
</tbody>
</table>

Source: Pitt, R.E., Cornell University, 1990

1 TLC = theoretical length of cut. Chop alfalfa silage at ½-inch TLC.
Table 16. Fat-corrected milk (FCM) yield as influenced by change in alfalfa maturity and concentrate level.

<table>
<thead>
<tr>
<th>Concentrate in ration (% dry matter)</th>
<th>Alfalfa maturity (bloom)</th>
<th>lb 4% FCM/cow per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>79.6</td>
<td>68.0</td>
</tr>
<tr>
<td>37</td>
<td>83.2</td>
<td>69.1</td>
</tr>
<tr>
<td>54</td>
<td>87.1</td>
<td>77.2</td>
</tr>
<tr>
<td>71</td>
<td>86.0</td>
<td>77.2</td>
</tr>
</tbody>
</table>

Source: Adapted from Jorgensen, University of Wisconsin, 1987.

### FORAGE QUALITY TERMS

**Acid detergent fiber (ADF)** is the percentage of highly indigestible and slowly digestible material in a feed or forage. This fraction includes cellulose, lignin, pectin, and ash. Lower ADF indicates a more digestible forage and is more desirable.

**Neutral detergent fiber (NDF)** is the percentage of cell walls or fiber in a feed. It includes acid detergent fiber (except pectin) and hemicellulose. NDF is inversely related to animal intake potential; lower NDF percentages indicate greater animal consumption. Thus, a low percentage is desirable as long as a certain minimum fiber level in the ration is met.

**Relative feed value (RFV)** is an index used to rank forages by potential intake of digestible dry matter. The index ranks forages relative to the digestible dry matter intake of full bloom alfalfa (assuming 41% ADF and 53% NDF at full bloom).

Relative feed value (RFV) calculations:

1. Calculate digestible dry matter of forage (% of dry matter)
   \[ \text{DDM} = 88.9 - (0.779 \times \text{ADF}) \]

2. Calculate dry matter intake of forage (% of body weight)
   \[ \text{DMI} = 120 - \text{NDF} \]

3. Calculate relative feed value
   \[ \text{RFV} = \left( \frac{\text{DDM}}{\text{DMI}} \right) = 1.29 \]

**Crude protein (CP)** is a mixture of true protein and nonprotein nitrogen. It is determined by measuring total nitrogen and multiplying this number by 6.25. Crude protein content indicates the capacity of the feed to meet an animal’s protein needs. Generally, moderate to high CP is desirable since this reduces the need for supplemental protein. Forage, cut early or with a high percentage of leaves has a high CP content.
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