NCR547 North Central Regional Extension Publication

Alfalfa management guide

Alfalfa management guide

Authors

Dan Undersander
Extension agronomist, forages
University of Wisconsin

Roger Becker
Extension agronomist, weed control
University of Minnesota

Dennis Cosgrove
Extension agronomist, forages
University of Wisconsin

Eileen Cullen
Extension entomologist
University of Wisconsin

Jerry Doll
Extension agronomist, weed control
University of Wisconsin

Craig Grau
Extension plant pathologist
University of Wisconsin

Keith Kelling
Extension soils scientist
University of Wisconsin

Marlin E. Rice
Extension entomologist
Iowa State University

Mike Schmitt
Extension soils scientist
University of Minnesota

Craig Sheaffer
Research agronomist
University of Minnesota

Glen Shewmaker
Extension agronomist
University of Idaho

Mark Sulc
Extension agronomist
The Ohio State University

ACKNOWLEDGMENTS

The authors wish to thank reviewers from industry and various universities for their suggestions and everyone who supplied photos, including those not specifically mentioned:

Steve Bicen, University of Wisconsin
anthracnose; aphanomyces, roots; Fusarium wilt, roots; Phytophthora, roots; root assessment; verticillium wilt, root

Dennis Cosgrove, University of Wisconsin
autotoxicity

Jim Ducy *title page photo*

Del Gates, Kansas State University
alfalfa weevils

Craig Grau, University of Wisconsin
aphanomyces, stunting; bacterial wilt, stunting; black stem, lesions; Fusarium wilt, field; Phytophthora, plant; sclerotinia; stand assessment; verticillium wilt, plants

B. Wolfgang Hoffmann, University of Wisconsin *alfalfa plant, page 1; alfalfa flowers*

Eric Holub, University of Wisconsin
aphanomyces, seedling

Jeffrey S. Jacobsen, Montana State University *nutrient deficiencies—all except boron leaf (from* Diagnosis of Nutrient Deficiencies in Alfalfa and Wheat*)*

Pioneer Hi-Bred International, Inc.
alfalfa closeups; cover photo ; cow; inside cover

Lanie Rhodes, Ohio State University
black stem, leaves; common leaf spot; lepto leaf spot

Marlin E. Rice, Iowa State University
alfalfa weevil, blister beetles; clover leaf weevils; grasshopper; pea aphids; plant bug, adults; potato leafhopper, adult; spittlebug; variegated cutworm

Judy A. Thies, USDA-ARS
root-lesion nematodes

John Wedberg, University of Wisconsin
alfalfa blotch leafminer; clover root curculio, damage

Thanks also to Bruce Gossen and Réal Michaud, research scientists at Agriculture and Agri-Food Canada, for their contributions to the disease maps.

This publication is a joint effort of:
University of Wisconsin-Extension, Cooperative Extension

Minnesota Extension Service, University of Minnesota

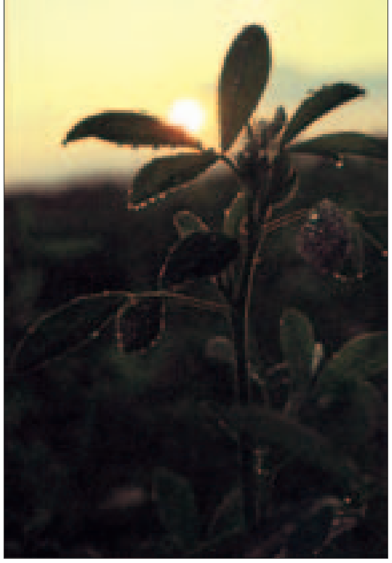
Iowa State University Cooperative Extension Service

Editor: Linda Deith
Designer: Susan Anderson

Published by:
American Society of Agronomy, Inc.
Crop Science Society of America, Inc.
Soil Science Society of America, Inc.

Library of Congress Catalog Card Number 00 135829

Printed in the U.S.A.



CONTENTS

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 the movement of soil oxygen to roots. Poor surface drainage can cause soil crusting 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.

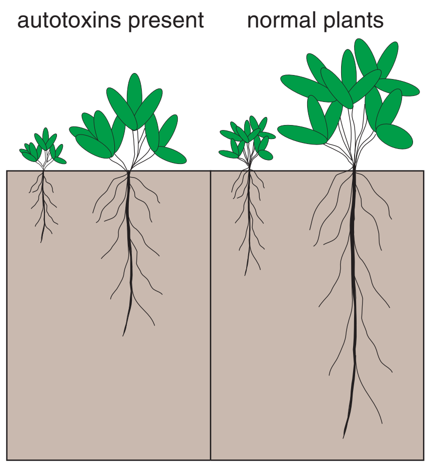
Fields should be free from herbicide carryover that may affect growth of the new alfalfa and/or companion crop. This is especially important after drought years and on fields where high herbicide application rates or late-season applications of long-lasting herbicides were used.

Autotoxicity

Alfalfa plants produce toxins that can reduce germination and growth of new alfalfa seedings. 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 compounds are water soluble and are concentrated mainly in the leaves. The compounds impair development of the seedling tap root by causing the root tips to swell and by reducing the number of root hairs (figure 1). This limits the ability of the seedling to take up water and nutrients and increases the plant's susceptibility to other stress factors.

Figure 1. Effect of autotoxicity on root development of alfalfa.



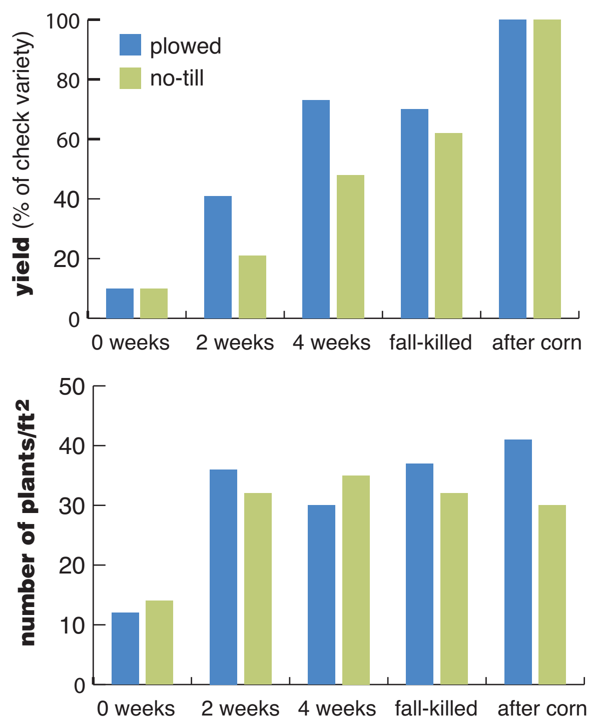
Source: Jennings, Nelson, and Coutts, Universities of Arkansas and Missouri, 1998

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

Surviving plants will be stunted and continue to yield less in subsequent years (figure 2). A waiting period after destroying the old stand is necessary to allow the toxic compounds 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. The autotoxic compounds are removed more rapidly from sandy than more heavy textured soils. However, while the compounds are present, the effect on root growth is much more severe in sandy soils.

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.

Figure 2. Effect of waiting periods when establishing alfalfa following alfalfa. Note that even though the number of plants is similar for all but fields planted with no waiting, yield increases dramatically.



Source: Cosgrove et al., University of Wisconsin-River Falls, 1996

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.

a

b

c

Effect of autotoxicity on alfalfa stands when alfalfa is seeded (a) immediately following alfalfa plowdown, (b) 4 weeks later, and (c) after 1 year.

Advanced techniques

Reseeding recommendations

Reseeding stands within 1 year carries a certain amount of risk of yield and stand failure due to autotoxicity. Use table 1 to calculate the risk. If reseeding, consider the following:

- 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 that is 2 years old or older. 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.
- In stands where the likelihood of successfully interseeding alfalfa is low, consider interseeding red clover or a grass species such as ryegrass or orchardgrass. These species will most likely establish well and provide good yield until new stands can be re-established.

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.

Table 1. Alfalfa autotoxicity reseeding risk assessment

	points	score
1. Amout of previous alfalfa topgrowth incorporated or left on soil surface		
Fall cut or grazed	1	
0 to 1 ton topgrowth	3	
More than 1 ton topgrowth	5	
2. Disease resistance of the variety to be seeded		
High disease resistance	1	
Moderate disease resistance	2	
Low disease resistance	3	
3. Irrigation or rainfall potential prior to reseeding		
High (greater than 2 inches)	1	
Medium (1 to 2 inches)	2	
Low (less than 1 inch)	3	
4. Soil type		
Sandy	1	
Loamy	2	
Clayey	3	
5. Tillage prior to reseeding		
Moldboard plow	1	
Chisel plow	2	
No-till	3	
6. Sum of points from questions 1–5		
7. Age of previous alfalfa stand		
Less than 1 year	0	
1 to 2 years	0.5	
More than 2 years	1	
8. Reseeding delay after alfalfa kill/plowdown		
12 months or more	0	
6 months	1	
2 to 4 weeks	2	
Less than 2 weeks	3	
Your total score (multiply points from 6, 7, and 8)		

Alfalfa reseeding risk

If you score:	The autotoxicity risk is:	Recommendation
0	low	Seed
4 to 8	moderate	Caution, potential yield loss
9 to 12	high	Warning, yield loss likely
> 13	very high	Avoid reseeding, likely stand & yield loss

Source: Craig Sheaffer, Dan Undersander, and Paul Peterson, Universities of Minnesota and Wisconsin, 2004.

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 3), and
- decreased manganese, iron, and aluminum toxicity (figure 3).

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 4).

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 time for reaction with the soil. In addition, the accompanying tillage for rotation crops may result in two or three remixings of the lime with the soil. By the time alfalfa is replanted, the pH should be raised to the desired level.

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 disking may deposit the lime in a layer at the plow sole. For high rates of lime (more than 6 tons/acre), apply half before working the field; work the remaining half into the soil after plowing or other field preparation.

Lime effectiveness is determined by its chemical purity and the fineness to which it is ground. Figure 5 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).

Figure 3. Available nutrients in relation to pH.

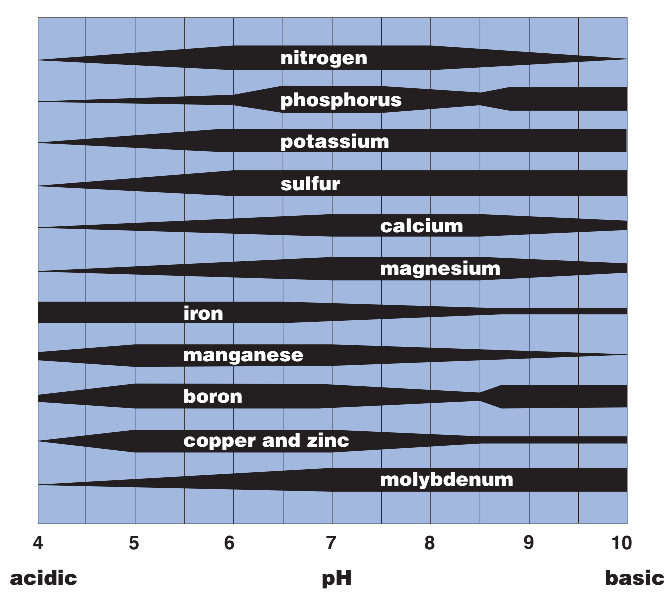
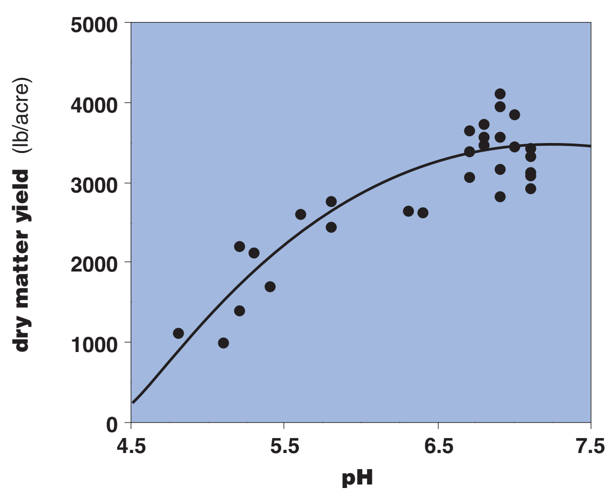


Figure 4. First-cutting alfalfa yield relative to soil pH.

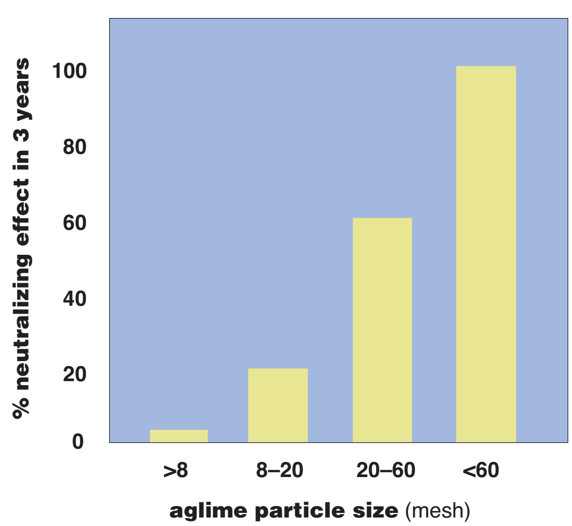


Source: Wollenhaupt and Undersander, University of Wisconsin, 1991

Liming materials come in several forms. Calcitic products contain calcium-based neutralizers while dolomitic sources contain both calcium and magnesium. Both are 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 to 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 5. 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. Despite the higher cost, sulfur is typically topdressed annually with fertilizer rather than incorporated at planting due to ease of application.

Nitrogen. Research has shown that small additions of nitrogen may enhance establishment and seeding year yields. Apply 25 to 30 lb/acre nitrogen when alfalfa is direct seeded on coarse-textured soils with low organic matter contents (less than 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 is a source of macronutrients and micronutrients and can be used to help meet the nutrient needs of alfalfa. Manure testing is recommended prior to application to any cropland.

For application before seeding, manure should be thoroughly mixed with the soil and limited to rates of not more than 7 tons/acre of solid dairy manure or 20,000 gal/acre of liquid dairy manure (environmental requirements may lower the recommended rates).

Select a good variety

Plant breeders have developed alfalfa varieties with greater yield potential, better disease resistance, and improved forage quality. But with over 250 varieties available, how does one decide? 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 2, yield has the largest effect on profitability, persistence next, and other factors have a lesser effect. Other factors such as fall dormancy and intended use may be important in certain circumstances.

Yield potential

Look for varieties with high yields in university trials. Compare new varieties against one you have grown. Comparing varieties to the same check, planted within the trial, also allows comparison across several trials. New varieties should perform better and result in higher yields. In Wisconsin and Minnesota variety trials performed between 1980 and 1998, the top varieties have yielded slightly over 1 ton more per acre than Vernal (a standard check variety) for each year of stand life (figure 6). For short-term stands, select varieties by yield from 2- to 3-year-old stands. For long-term stands, select by yield from 4- to 5-year-old stands.

Varieties will perform differently in various growing regions. Look for top yields of a variety grown in a site with as similar a soil type and climate to your farm as possible. Also, look for top yield over several sites. This indicates stability for high yield and is important because soils may vary on your farm and weather conditions change from year to year.

Persistence

Compare stand survival ratings or yields of 4- to 5-year-old stands to determine relative persistence of varieties. Persistence in northern locations depends primarily on winterhardiness because of the severity of winter temperatures; farther south persistence is more dependent on disease resistance. If stand survival ratings or yields of 4- to 5-year-old stands are not available, use winterhardiness and disease resistance to estimate persistence.

When evaluating varieties, remember that long-term stands are not necessarily the most profitable. Many farmers are finding that a 4-year rotation with 3 years of alfalfa may be more profitable than trying to keep one stand of alfalfa for 5 or 6 years in a 7- or 8-year rotation. This occurs for the following reasons:

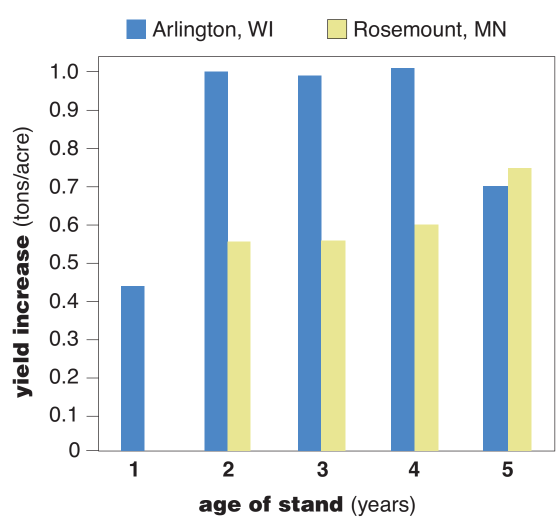
- younger stands of alfalfa yield more than older stands,
- with a 4-year rotation, nitrogen credits from plowdown alfalfa are available twice in 8 years,

Table 2. Factors influencing dollar return per acre for alfalfa from milk production.

factors	return per acre
standard yield (18% CP, 33% ADF, 45% NDF) assuming 5 ton/acre yield and $10/cwt milk	$778
yield potential 0.2 ton/acre lower yield	–$50
persistence shorter stand life (3 vs 4 yr)	–$24
forage quality higher quality forage (+1% CP, –1% ADF, –1% NDF)	+$15
seed cost $1/lb higher at 15 lb/acre seed	–$4

Source: Undersander, University of Wisconsin, 1991
Abbreviations: ADF = acid detergent fiber; CP = crude protein; NDF = neutral detergent fiber.

Figure 6. Yield increase over Vernal of top five varieties in Wisconsin and Minnesota from 1980 to 1998.



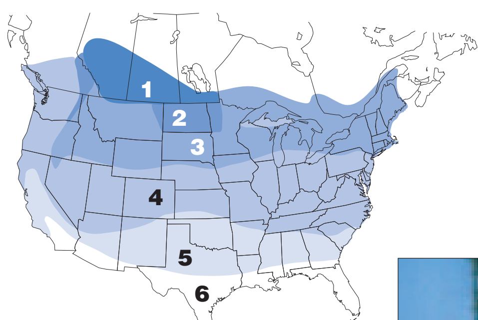
Source: Undersander and Martin, Universities of Wisconsin and Minnesota, 1998

- corn following alfalfa yields approximately 10% more than corn following corn, and
- corn rootworm is less of a problem in the first year following alfalfa than in corn following corn.

Winterhardiness

Winterhardiness is a measure of the alfalfa plant's ability to survive the winter without injury. It is measured on a scale of 1 to 6 with 1 being the most hardy and 6 being the least hardy (see figure 7). Winter-injured plants may survive the winter, but the buds formed in the fall for spring regrowth may be killed. Such plants have fewer shoots for first cutting and produce a lower yield.

Figure 7. Winterhardiness needed. Varieties grown north of primary region of adaptation will suffer winterkill and injury. Western mountain valleys may grow less winterhardy varieties than indicated.



Fall dormancy

Fall dormancy is measured by determining how tall alfalfa grows in the month following a September 1 cutting. More dormant types, such as Vernal, will remain short and low yielding through the fall period no matter how good the growing conditions are. Less-dormant varieties typically yield more in the fall, green up earlier in the spring, and recover more quickly between cuttings.

Plant breeders have finally broken the relationship between winterhardiness and fall dormancy. Until recently, obtaining higher yields meant selecting a variety with less dormancy and lower winterhardiness. The strategy now should be to choose less-dormant varieties that meet your winter survival requirement. These plants will green up earlier in the spring and recover more quickly between cuttings to give higher total season yields.

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

Disease resistance

Diseases may kill seedlings, 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 2 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.

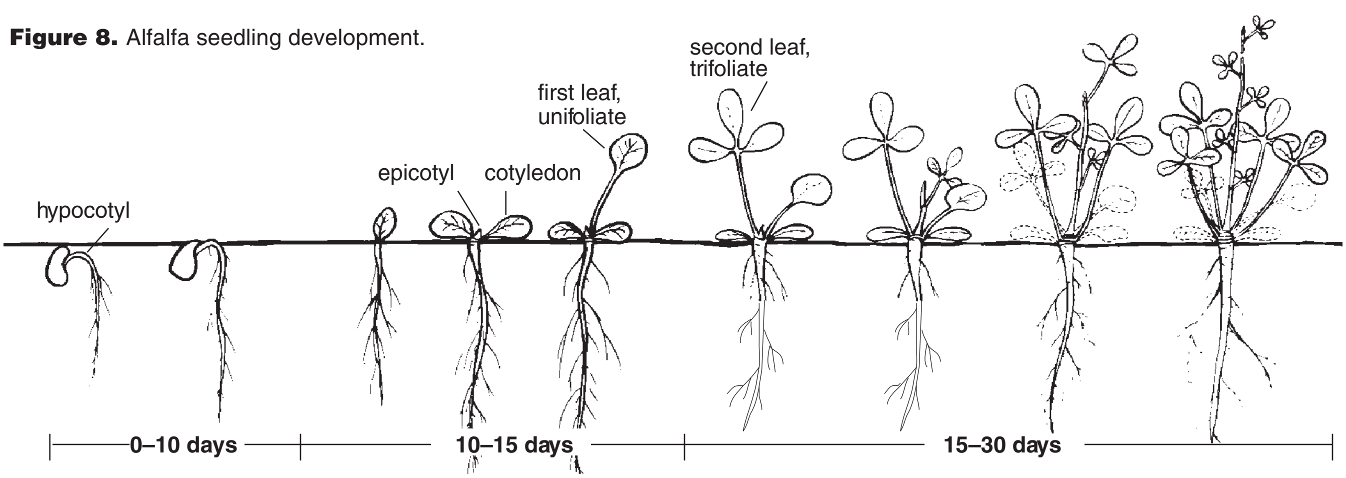
Spring seeding of alfalfa can begin as soon as the potential for damage from spring frosts has passed. At emergence, alfalfa is extremely cold tolerant. At the second trifoliate leaf stage (figure 8), seedlings become more susceptible to cold injury and may be killed by 4 or more hours at 26°F or lower 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 fields are tilled and ready to seed. Spring seedings have less weed competition and less moisture stress during germination than do late-summer seedings because of cooler temperatures.

The spring seeding dates shown on the map (figure 9) 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. Although successful stand establishment can be made outside the recommended dates, the likelihood of consistent success is low.

Successful late-summer seeding depends on soil moisture during the establishment period and sufficient plant growth before a killing frost (figure 9). Do not seed unless good soil moisture is present. A preplant herbicide is usually not needed for light weed infestations because annual weeds will be killed by frost. Postemergence herbicides can be used if severe weed pressure or volunteer grain problems develop. Use of a companion crop is not recommended, especially if seeding before August 15, because it will compete 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 if it develops a crown before a killing frost. The crown 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. Alfalfa seedling development.



Source: Dodds and Meyer, North Dakota State University, 1984

Figure 9. Spring and late-summer seeding dates.

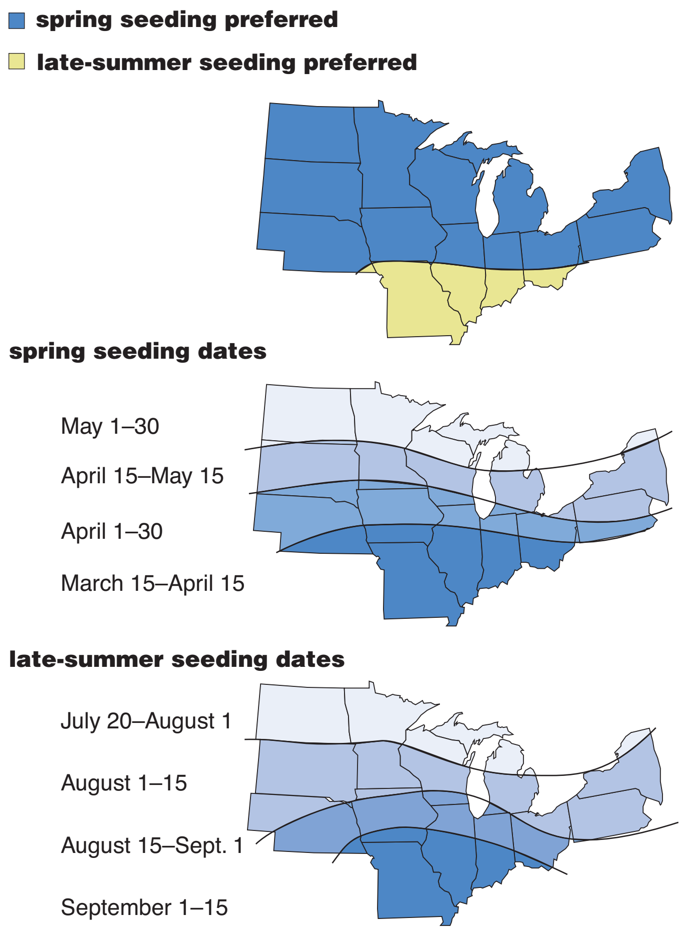
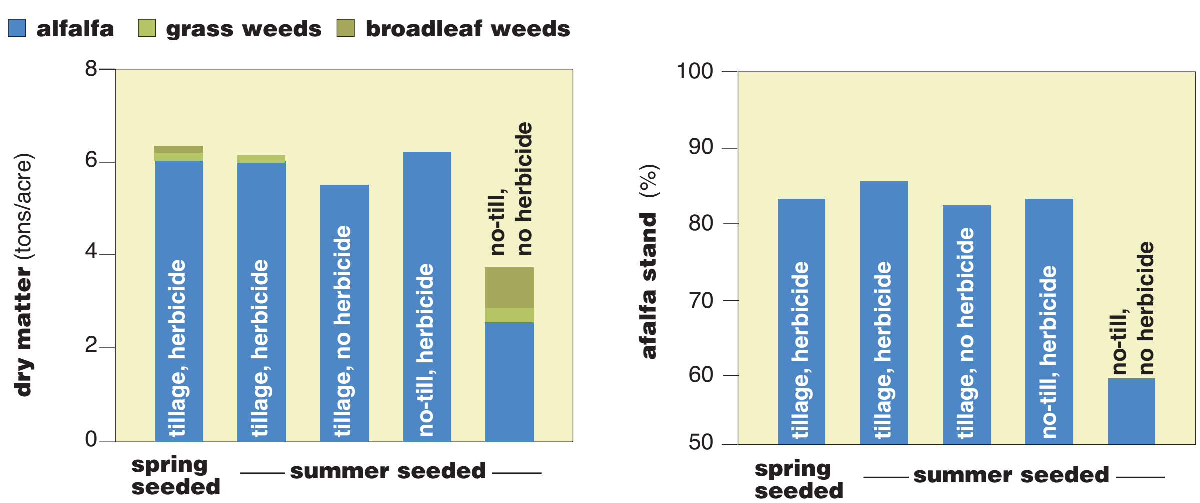


Figure 10. Effect of weed management systems for late-summer seedings on yield and stand the year following establishment.



Source: Becker, 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. Failure to do so cuts seedling establishment and lowers yields (figure 10), particularly in no-till fields.

Field preparation

Field preparation should begin the year before seeding. Perennial weeds can be particularly competitive both during the seeding year and in subsequent years. Controlling weeds before seeding will help ensure a long-lasting, productive stand. 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 pretillage application of glyphosate or a postemergence application of Accent or Beacon. Cultivate when corn is 14 to 18 inches tall. Similarly, control Canada thistle, yellow nutsedge, dandelion, and other perennial weeds with an effective management program before seeding alfalfa. Be sure to follow herbicide replant restriction time intervals before seeding alfalfa to prevent herbicide carryover injury.

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 controls weed regrowth, 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 up clods. It also reduces field operations in the 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.

Soil should be firm enough at planting for a footprint to sink no deeper than ⅜ inch.

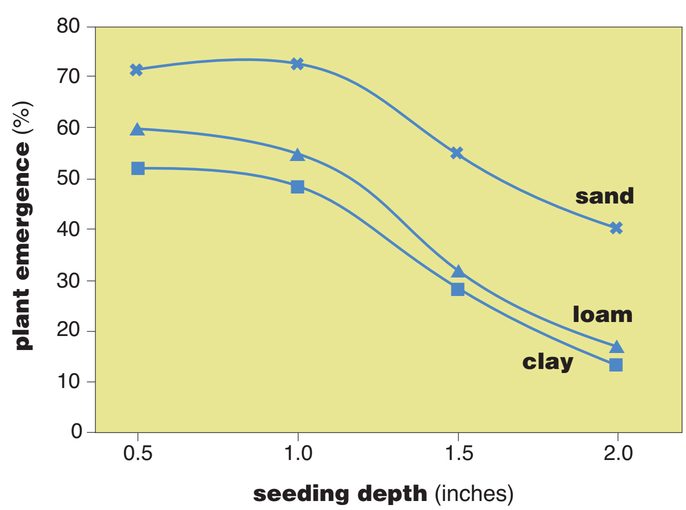
Seed inoculation

Rhizobium bacteria create nodules on alfalfa roots, allowing the bacteria to fix nitrogen where it becomes 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, make sure the inoculant was stored in a cool place before and after purchase; apply with a sticker—an adhesive compound to attach the *Rhizobia* to the seed—and thoroughly mix inoculum and seed before planting.

Seeding depth and rate

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 11). 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 seedings may be used when moisture is adequate while deeper seedings should be used in drier soils.

Figure 11. Alfalfa emergence from various seeding depths.



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

Table 3. Effect of seeding rate on first-year alfalfa dry matter yields.

seeding rate (lb/acre)	dry matter yield (tons/acre)
12	3.4
15	3.6
18	3.6

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

Seeding rates should be between 12 and 15 lb/acre with good soil conditions and seeding equipment (table 3). 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 conditions and environmental conditions experienced at seeding make this necessary to obtain consistently good stands. For example, extended periods of cool, wet weather can cause high seedling mortality (this can be reduced by planting Apron-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 12).

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.

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 alfalfa seeded with a companion crop. However, total forage tonnage may be less than that of companion-crop seedings. Some important management considerations are listed below:

- Select level fields with low erosion potential for direct seedings; use companion seedings where the erosion potential is greater. Erosive soils can be direct seeded using reduced-till 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 60 days after germination, regardless of maturity stage. This eliminates many annual weeds and allows the second cutting to reach 10% bloom by September 1 in areas with short growing seasons.

Companion crops such as annual (Italian) ryegrass, 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 grain. Straw produced by the companion crop is also valued as livestock bedding.

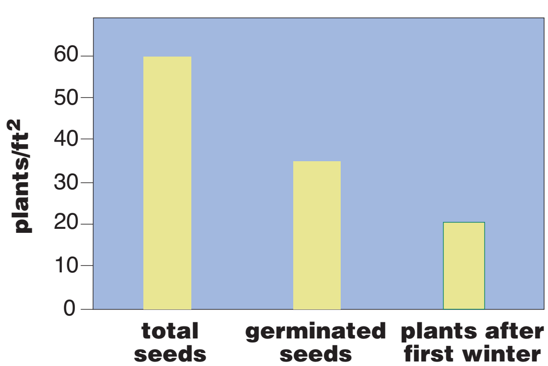
Annual ryegrass provides a higher-quality first harvest and greater yield potential in the seeding year than small grain companion crops. Plant late-maturing annual ryegrass varieties, which remain vegetative in the seeding year (early-maturing types flower in the seeding year). Seed at 4 to 6 lb/acre.

For small grains, when companion crop growth is dense and grown 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.

Following removal of spring-seeded companion crops, alfalfa regrowth and yield will be largely dependent on moisture availability. One or more harvests may be possible before the fall critical period. Usually, alfalfa regrowth competes well against summer annual weeds; however, herbicide use may be beneficial if weed populations are high and regrowth is slow.

In most of the alfalfa growing regions, companion crops are used only with spring seedings. With summer and

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



Source: Undersander, University of Wisconsin, 1995 fall seedings, moisture is often limiting and competition from the companion crop may limit alfalfa seedling development. If companion crops are needed with summer and fall seeding, the best strategy is to use the advanced technique described at right.

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 follow:

- Select companion crop varieties that are short, stiff strawed, and early maturing to avoid lodging and smothering the alfalfa.
- Seed companion oats or barley at 1 to 1½ 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.
- If you plan to harvest the companion crop for grain, consider seeding an early variety in the spring and no-till seeding alfalfa into the grain stubble after harvest.

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. However, they do not work as well as drills on very hard ground or on very sandy soil.

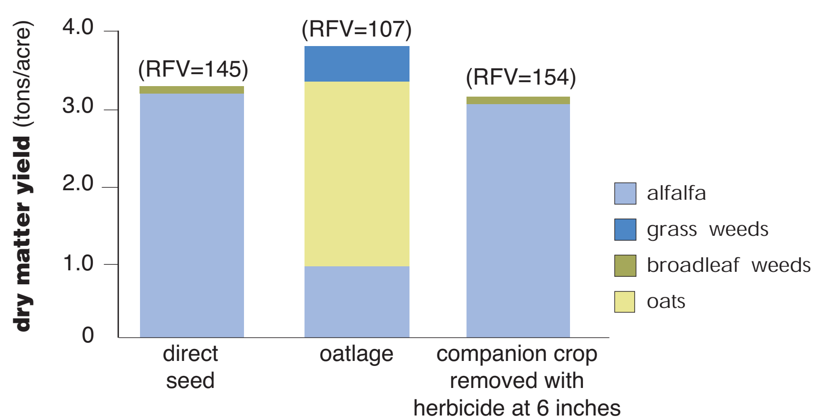
Drills place the seed in rows, usually with 7- to 9-inch spacings, and can

Advanced techniques

Getting direct seeding benefits while controlling erosion

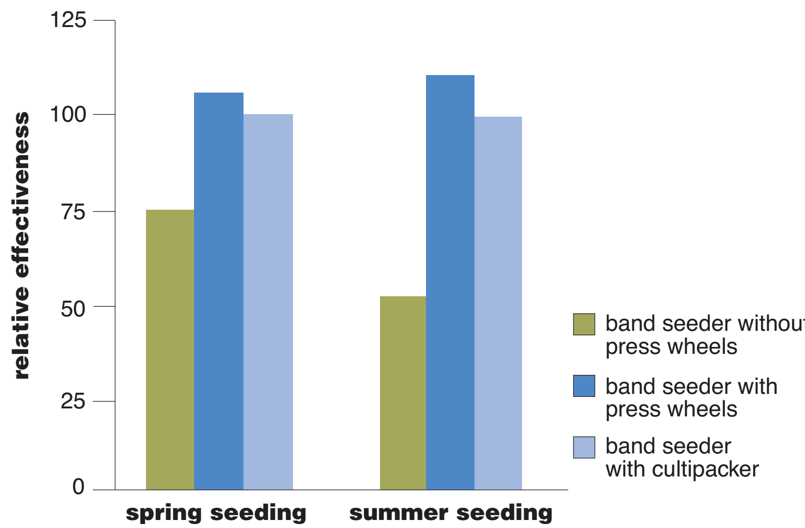
Where the benefits of direct seeding are desired, yet the need for erosion control suggests a companion crop, it may be practical to seed oats as a companion crop and kill it with Poast Plus or Select herbicide when 4 to 6 inches tall. The oats will control weeds early, provide erosion control, and protect seedlings from wind damage. When the oats have been killed, alfalfa will perform about the same as in a direct seeding (figure 13). Thus, the erosion control benefits of a cover crop are achieved while still getting the higher alfalfa yield of a direct seeding. The practice may be particularly beneficial for fields with steep slopes or long gradients.

Figure 13. First-season yield and relative feed value (RFV) of alfalfa using different establishment methods.



Source: Becker, University of Minnesota, 1989 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 14). The most common drills for forage establishment are grain drills that can seed a companion crop simultaneously with the alfalfa. Grain drills have poor depth control for seed placement. Drills 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 14. Importance of packing soil after seeding.



Source: Tesar, Michigan State University, 1984

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 (a) and place the drop tube for the cover crop between coulters (b).

Reduced tillage and no-till planting

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 (figure 15).

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. 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. Oats can still be used as a companion crop.

Additional considerations in no-till alfalfa establishment are 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 before 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 paper-mill lime sludge or cement plant kiln dust can also be used.

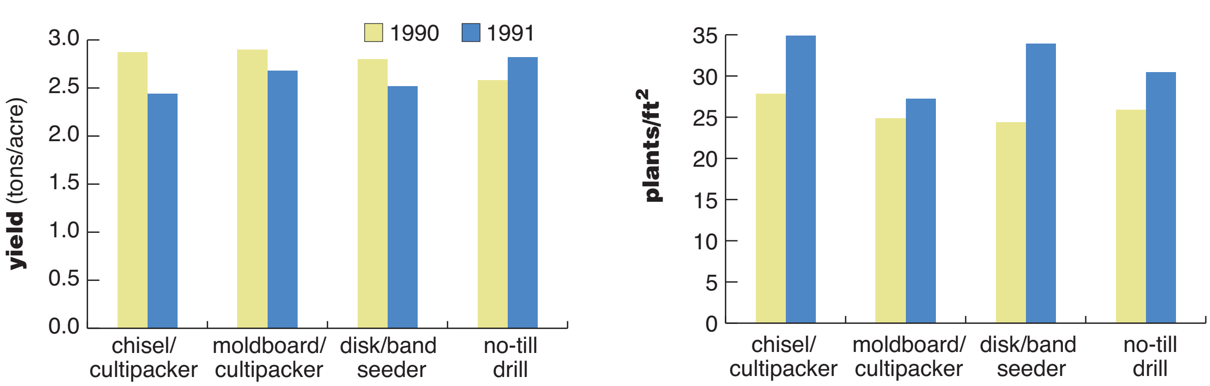
Many implement companies produce specialized no-till seeders for alfalfa and other crops. The design of these seeders differs among companies but should have the following features to ensure success:

- 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 USDA Natural Resources Conservation Service, or local fertilizer dealers and elevators.

Figure 15. Effect of seeding equipment on yield and stand in seedling year.



Source: Undersander and Mueller, University of Wisconsin, 1992