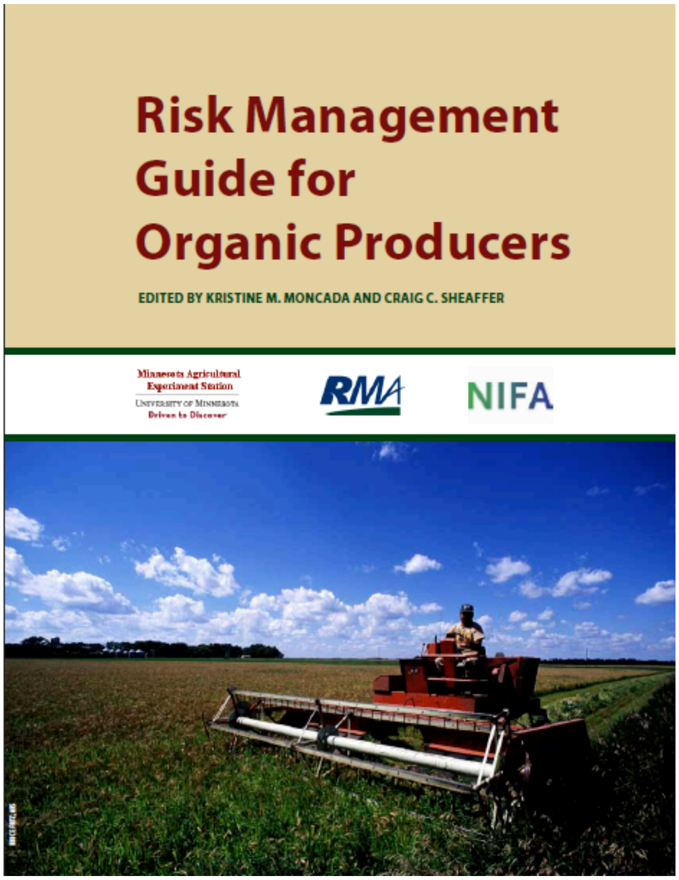
This chapter is an excerpt from the *Risk Management Guide for Organic Producers*, edited by Kristine Moncada and Craig Sheaffer.



For the entire publication, please visit one of the following websites:

Organic Ecology – http://swroc.cfans.umn.edu/OrganicEcology/
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CHAPTER 12

Forages

CRAIG SHEAFFER

There are several legumes and grasses that are used in organic cropping systems in the Midwest. The emphasis in this chapter is on small-seeded legume and grass use for hay or silage.

Choosing forages

Overall, grasses are longer-lived and more tolerant of adverse management and environmental conditions compared to legumes, but grasses require nitrogen fertilization to promote yield. Grasses and legumes also differ in composition that affects forage quality. For livestock feeding, legumes are valued for their protein content and digestibility.

LEGUME SELECTION

Selection of legumes for cropping systems is based on several factors. These include use as well as adaptability to climatic conditions and soil (Table 12-1).

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Figure 12-1. *A mixture of white clover, birdfoot trefoil and perennial grasses. Legumes and grasses are grown in mixture to reduce risk.*

Legume species

The following legumes are among the best suited for Upper Midwest. See Table 12-1 for a summary of traits for other legumes.

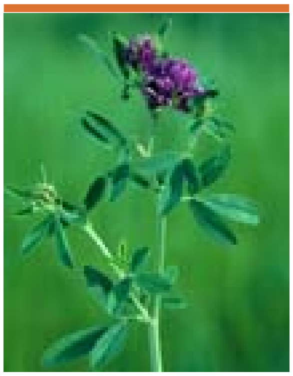

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Figure 12-2. ***Alfalfa.***

Alfalfa is the leading perennial forage legume in the Midwest. Stands typically last from three to five years with maximum yields in the first two years after seeding. Alfalfa can be harvested for hay, silage, or more frequently by grazing. Its herbage is high in protein and a good source of fiber for livestock rations. It has an extensive tap-root system that can extend to a depth of 20 feet. Alfalfa conducts biological nitrogen fixation and incorporation of herbage and roots can contribute nitrogen for following crops. Alfalfa is affected by several diseases and is damaged by the potato leafhopper. Disease resistant and potato leafhopper resistant varieties with appropriate levels of winter hardiness should be grown.

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Figure 12-3. ***Red clover.***

Red clover is a short-lived perennial that usually persists only two years. It is often used as a hay and pasture crop alternative to alfalfa especially on heavy soils with a low pH. Red clover herbage is succulent and harder to dry than alfalfa. There are two general types of red clover. "Medium" or multiple cut types are most widely grown in the north central region while "Mammoth" red clover produces only one crop of hay per season.

Table 12-1. Characteristics of various legumes for the Upper Midwest.

	TOLERANCE TO:							
LEGUME	Heat/ drought	Wet	Winter injury	Cutting/ grazing	Soil acidity	Low fertility	Seedling vigor	Bloat inducing
Alfalfa	E	P	G	F	P	P	G	Yes
Alsike clover	P	E	P	P	G	F	G	Yes
Birdsfoot trefoil	F	E	F	G	G	F	P	No
Cicer milkvetch	G	F	E	F	F	F	P	No
Crownvetch	G	P	F	P	G	F	P	No
Kura clover	F	G	E	E	F	G	P	Yes
Red clover	F	F	F	F	G	G	E	Yes
Sweetclover	E	P	E	P	P	F	G	Yes
White clover	P	G	F	E	G	G	G	Yes
Berseem clover	P	E	P	G	P	G	E	No

E = excellent, G = good, F = fair, P = poor

Figure 12-4. *White clover.*

White clover is a short-lived perennial legume most often used for pastures because it grows close to the ground. It spreads by horizontal aboveground stems called stolons. White clover is poorly rooted and grows best with adequate soil moisture. There are several types of white clover: tall, large-leafed types are more productive than smaller types (called white Dutch or wild white clovers). White clover is prone to winter injury but will persist in pastures through natural reseeding.

Figure 12-5. *Birdsfoot trefoil.*

Birdsfoot trefoil is a perennial legume that is noted for its tolerance of waterlogged soils and low soil pH. Its long-term stand persistence is related to its natural reseeding. Birdsfoot trefoil is a good pasture legume and will not cause bloat.

Figure 12-6. *Sweet clover.*

Sweet clover is a tall-growing biennial or annual legume. It is a traditional green manure crop and when unharvested it will contribute more N and biomass for incorporation than any other clover or alfalfa. However, sweet clover possesses several undesirable traits: 1) plants tend to be succulent and stemmy and are slow to dry if the forage is cut for hay; 2) plants contain coumarin, a chemical responsible for bleeding disease in cattle and horses that consumed spoiled hay; and 3) sweet clover is a prolific seed producer that can become a weed in cropping systems.

Legume adaptation

Several adaptive traits, including tolerance to soil pH, soil fertility, soil moisture, and winter hardiness will influence the success in growing forage legumes. Soil pH affects soil microbial activity and nutrient availability. Most legumes grow best at a soil pH of 6 to 7, but will tolerate soils below that range. While some like alfalfa grow poorly at a pH of less than 6; others like red clover and birdsfoot trefoil tolerate a lower soil pH.

Alfalfa can provide great benefits to organic farmers. One producer from Lac Qui Parle County has found that his operation truly began to turn around once he incorporated alfalfa into his rotation. He finds better soil, better yields, and greater weed control.

For good yields and persistence of all legumes, potassium, phosphorus, and sulfur need to be applied at recommended levels, based on soil testing, using approved organic fertilizers or manures.

Saturated or poorly drained soils inhibit root growth and nitrogen fixation of legumes and promote diseases. Alfalfa is not tolerant of wet soils; red clover has greater

Figure 12-7. Alfalfa winter injury. *Winter injury occurred in the low-lying areas of this field where ice formed during the winter.*

A producer from Faribault County prefers red clover over alfalfa for its consistency under his conditions. He plants at 8-10 pounds/acre and uses a medium red clover type.

tolerance, while birdsfoot trefoil has very good tolerance. No legume will tolerate flooding for more than a few days especially when air temperatures exceed 50° F. Poorly drained soils can also develop ice sheeting during winter. Legumes have poor tolerance to ice sheeting that continues for greater than a week (Figure 12-7).

All plants and sometimes varieties vary in winter hardiness. In the North Central Region, winter injury occurs due to a combination of low temperatures and lack of snow cover. Winter injury is also greater in poorly-drained soils than well-drained soils.

Reducing risk: legume adaptation. If soil pH is too low for alfalfa, grow red clover or birdsfoot trefoil instead. Test soil nutrients and apply amendments accordingly. Plant red clover or birdsfoot trefoil, instead of alfalfa, if soil lacks good drainage. Choose legume varieties with proper winter hardiness for your area. (edited)

Legume use

An essential component in choosing a forage legume will relate to the ultimate use. Factors to consider include frequency of cutting, hay quality, persistence, nitrogen contribution, and ease of establishment.

Frequent cutting stimulates regrowth and can deplete energy reserves. Producers should plant alfalfa if planning more than two cuts. Market is another important consideration.

When growing as a hay crop, forage quality will be vital. All legumes can produce hay of high nutritional value if harvested at immature stages. However, some legumes contain anti-quality components.

If planning to grow the crop for more than one year, long-term persistence will be important. Because of variability in winter hardiness and disease resistance, legumes vary in persistence. For example, red clover can provide good short term yields, but most varieties do not typically persist beyond the second year after seeding.

Contribution of nitrogen to subsequent crops in rotation will vary by species and the amount of herbage incorporated. Alfalfa and red clover are best for most organic rotations. Sweet clover is a traditional green manure crop for non-harvested systems.

If seedbed conditions tend to be poor at the time of forage establishment, seedling vigor will be something to consider. Seedling vigor affects the success of establishment especially during periods of less than ideal seedbed conditions. Red clover has greater seedling vigor than alfalfa and other legumes and is therefore more useful for frost seeding.

Reducing risk: legume use. Use only alfalfa if planning to cut forage more than three times or if planning to grow for more than two years. White clover and sweet clover are not good choices for hay. Red clover, berseem, and sweet clover are excellent green manures. See Table 12-2 for a summary of risk in forage legume production.

Table 12-2. Risk factors in the production of alfalfa, red clover, and white clover.

	Soil pH			Soil fertility			Soil moisture			
	5.5	6.5	6.5	low K	low P	low S	Dry	Wet	Cutting more than 3 times	Poor establishment
Alfalfa	high risk	very low risk	low risk	moderate risk	moderate risk	no effect or risk variable	low risk	moderate risk	very low risk	moderate risk
Red clover	no effect or risk variable	very low risk	low risk	moderate risk	moderate risk	no effect or risk variable	low risk	low risk	high risk	low risk
White clover	no effect or risk variable	very low risk	low risk	moderate risk	moderate risk	no effect or risk variable	low risk	low risk	high risk	no effect or risk variable

= very low risk
= low risk
= no effect or risk variable
= moderate risk
= high risk

GRASS SELECTION

Timothy, smooth bromegrass, reed canarygrass, and orchardgrass are most frequently grown in mixture with legumes or alone for hay or pasture. Kentucky bluegrass is a low-growing species that is used mostly in pastures.

Grass species

The following grasses are among the best suited for Upper Midwest. See Table 12-3 for a summary of traits.

JOHN CARDINA, OSU

Figure 12-8. *Smooth bromegrass.*

Smooth bromegrass is a long-lived, cool-season, tall-growing, sod forming perennial. It is frequently grown in mixture with alfalfa although in some regions pure stands exist. For haymaking, stands of smooth bromegrass are typically harvested three times per season with stems produced at all harvests. It has excellent winter hardiness and drought tolerance.

A producer from McLeod County uses a medium red clover type, which does better in his high magnesium and low calcium soils, but prefers alfalfa for feeding his livestock.

Table 12-3. Characteristics of various grasses for the Upper Midwest.

	TOLERANCE TO:						
GRASS	Heat/ drought	Wet	Winter injury	Frequent cutting/ grazing	Soil acidity	Seedling vigor	Maturity*
Kentucky bluegrass	P	G	E	E	F	F	Early
Orchardgrass	G	F	G	E	G	E	Early-medium
Perennial ryegrass	P	F	P	E	G	E	Early-medium
Reed canarygrass	E	E	E	E	E	P	Medium-late
Smooth bromegrass	E	F	E	P	F	E	Medium-late
Tall fescue	G	G	F	E	E	E	Medium-late
Timothy	P	P	E	P	G	G	Late

* Relative time of seed head appearance in spring. Will also depend on variety.

E = excellent, G = good, F = fair, P = poor

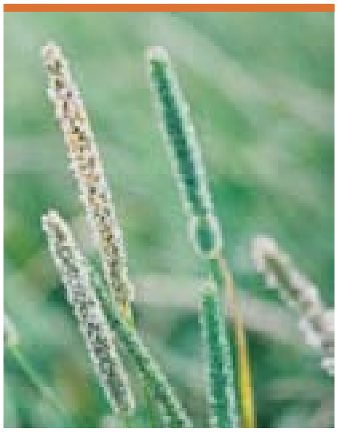

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Figure 12-9. ***Timothy.***

Timothy is a tall, long-lived, cool-season bunch grass. Timothy is used in mixture with alfalfa and other legumes. It grows best under cool and moist conditions and does not yield well in regions with hot, dry summers.

ROBERT H. MOHLENBROCK @ USDA-NRCS

Figure 12-10. ***Orchardgrass***

Orchardgrass is a cool-season, perennial bunch grass. Its growth habit results in an open sod. It is used in pastures or as a hay crop and often in mixture with alfalfa. Spring regrowth is stemmy but summer and fall growth is mostly leaves. Orchardgrass can suffer winter injury during years without snowcover. Some producers dislike orchardgrass because it matures early and its first growth is stemmy with low palatability. Also, it can be clumpy on the field.

Figure 12-11. ***Reed canarygrass.***

Reed canarygrass is a tall, cool-season, sod-forming perennial. It can be used in pastures or harvested for hay. It is known for its productivity in wetlands but also has good heat and drought tolerance. It has excellent forage yield potential. Reed canarygrass is slow to establish. The forage is very stemmy if allowed to mature and the spring regrowth must be harvested before flowering. It can become an invasive species if allowed to go to seed. Wild types of reed canarygrass can contain alkaloids that are undesirable chemicals that affect livestock performance. Growers should purchase only low-alkaloid varieties.

FORAGE INFORMATION SYSTEM, OREGON STATE UNIVERSITY

Figure 12-12. ***Perennial ryegrass.***

Perennial ryegrass is a short-lived, cool-season grass used for pasture and haymaking. It has excellent nutrition for livestock and is highly palatable. Its value is limited because of lack of winter hardiness and limited heat and drought tolerance. Perennial ryegrass is used alone and in mixtures with legumes.

ROBERT H. MOHLENBROCK @ USDA-NRCS

Figure 12-13. ***Kentucky bluegrass.***

Kentucky bluegrass is a low-growing species used for continuous or rotational grazing. However, its yields are lower than the tall growing grasses. It has poor heat and drought tolerance and undergoes a pronounced summer slump. Kentucky bluegrass is frequently found in mixture with white clover in perennial pastures.

FORAGE INFORMATION SYSTEM, OREGON STATE UNIVERSITY

Figure 12-14. *Tall fescue.*

Tall fescue is a perennial bunch grass that is best adapted to grazing. For the North Central Region, its use is limited by lack of winter hardiness except where reliable snow cover occurs.

Grass adaptation

As with forage legumes, soil pH, soil fertility, soil moisture, and winter hardiness will influence the success in growing forage grasses. For best establishment and production of grasses, a pH of 6.0 – 7.0 is recommended; however, grasses are much more tolerant of lower and higher pH than legumes and will grow well with the pH of most agricultural soils.

For good yields and persistence, N, K, P, and S need to be applied at recommended levels. Nitrogen is essential for grass growth and can be supplied by legumes growing in mixture or by fertilizers.

Grasses have a range of moisture tolerances. Only reed canarygrass can tolerate periods of prolonged flooding. Smooth bromegrass is the most drought-tolerant grass. Timothy lacks drought tolerance.

As described for legumes, winter hardiness is an important trait. Orchardgrass, perennial ryegrass, and tall fescue are among those grasses with lower levels of winter hardiness and may suffer winter injury.

Reducing risk: grass adaptation. Test soil nutrients and apply amendments accordingly. Choose grasses with proper drought tolerance, maturity, and winter hardiness for your area. Long-term yield and persistence of tall-growing grasses can be increased by cutting at three to four inches instead of one inch. Of course, Kentucky bluegrass can tolerate a one-inch cutting height.

Grass use

Factors to consider when growing forage grasses include frequency of cutting or grazing, as well as persistence. Frequent mechanical cutting can deplete the energy storage reserve of grasses, but grasses differ in the amount of energy storage. Reed canarygrass is most tolerant of frequent (three to four times per season) cutting, while timothy is less tolerant.

As with frequent cutting, continuous grazing by livestock can deplete grass energy reserves. Low-growing Kentucky bluegrass has greater tolerance of continuous grazing than tall growing grasses.

Because of variation in storage reserves and growth habit, grasses differ in persistence. Winter hardiness can also be a factor. Reed canarygrass and smooth bromegrass have greater long-term persistence (four+ years) than other grasses.

Reducing risk: grass use. Use reed canarygrass, orchardgrass or smooth bromegrass if planning to cut forage for hay more than three times. Choose Kentucky bluegrass under continuous grazing conditions. If planning to grow a grass for more than two

Figure 12-15. *An alfalfa and reed canarygrass mixture.*

years, reed canarygrass and smooth bromegrass are better choices.

GRASS AND LEGUME VARIETY SELECTION

For most grass and legume species, organically produced varieties are available. Varieties differ in traits and should be selected using the same criteria as discussed previously.

Reducing risk: variety selection. It is less risky to purchase a variety with known traits than a blend or a product with no variety identified. It is best to select varieties that reach your target maturity when you normally harvest.

GRASS-LEGUME MIXTURES

Mixtures of legumes and grasses are frequently used for forage (Figure 12-15). Growing a diversity of plants provides several risk reduction advantages compared to pure stands. Advantages are more pronounced when plants can be selected with diverse growth habits, competitiveness, and adaptation to environmental conditions.

Benefits of Mixtures

Mixtures enhance resource utilization. Grasses have fibrous root systems that remove nutrients and water mostly in the top foot of soil, while legumes typically have a tap root system that can penetrate deep in the soil profile and extract nutrients and water. Alfalfa with its deep tap root has greater drought tolerance than most grasses (Figure 12-16).

Legumes conduct biological nitrogen fixation; whereas grasses require nitrogen. Legumes can transfer nitrogen to grasses in mixture. However, legumes are generally more sensitive to low fertility compared to grasses. Mixtures of legumes with grasses are often more productive than either plant grown alone. This especially occurs as stands age and the stands of some species decline.

Mixtures promote survivability. Should winter injury or disease eliminate one species in the mixture, another will likely survive insuring stand persistence. Seeding grasses in mixture with alfalfa has been shown to reduce alfalfa winter injury by protecting the alfalfa crowns.

Figure 12-16. *Fibrous grass roots (left) and alfalfa taproots (right)—the nodules on alfalfa are the sites of nitrogen fixation.*

A producer from Lac Qui Parle County grows alfalfa in a mixture. He has problems with weeds when he grows alfalfa by itself.

Table 12-4. Growth habits of legumes and grasses.

CROWN-FORMERS	SPREADERS
Alfalfa	White clover
Red clover	Smooth bromegrass
Birdsfoot trefoil	Kentucky bluegrass
Orchardgrass	Reed canarygrass
Timothy	
Tall fescue	
Perennial ryegrass	

Legume forage tends to be more succulent than grass forage. Mixing grasses with legumes will increase the rate of drying of the total forage.

Legumes like alfalfa and red clover can cause bloat in ruminants like cows and sheep. Inclusion of a grass with the legume will reduce the incidence of bloat.

Mixtures can provide better weed control. Grasses have fibrous root systems and a spreading growth habit that covers the soil surface by filling in around crown-forming legumes like alfalfa and red clover. The combination of grasses and legumes can resist encroachment of weeds.

Mixture guidelines

One way to benefit from forage mixtures is to include species with diverse growth habits. Two types of growth habits are crown-forming versus spreading plants (Table 12-4).

Keep mixtures simple. Start with a legume and a grass that are most productive in your region. Shotgun mixtures that contain five or more species are typically not the most productive or persistent.

Forage mixture seeding rates

Here are some example forage mixtures with seeding rates for different uses.

Mixtures for plow down only (seeding year only):

Alfalfa (15 lb/acre) or Red clover (10 lb/acre)	*with*	Annual ryegrass (2 lb/acre)

Mixtures for hay or silage production:

Alfalfa (8 lb/acre) or Red clover (8 lb/acre)	*with*	Smooth bromegrass (8 lb/acre) or Timothy (4 lb/acre) or Orchardgrass (10 lb/acre)
Alfalfa (10 lb/acre)	*with*	Perennial ryegrass (6 lb/acre)

Mixtures for pasture:

Red clover (7 lb/acre) and Alsike clover (3 lb/acre) and White clover (1 lb/acre)	*with*	Orchardgrass (4 lb/acre) or Smooth bromegrass (6 lb/acre) or Perennial ryegrass (2 lb/acre)
Kura clover (6 lb/acre) and Birdsfoot trefoil (2 lb/acre)	*with*	Orchardgrass (4 lb/acre) or Reed canarygrass (4 lb/acre)

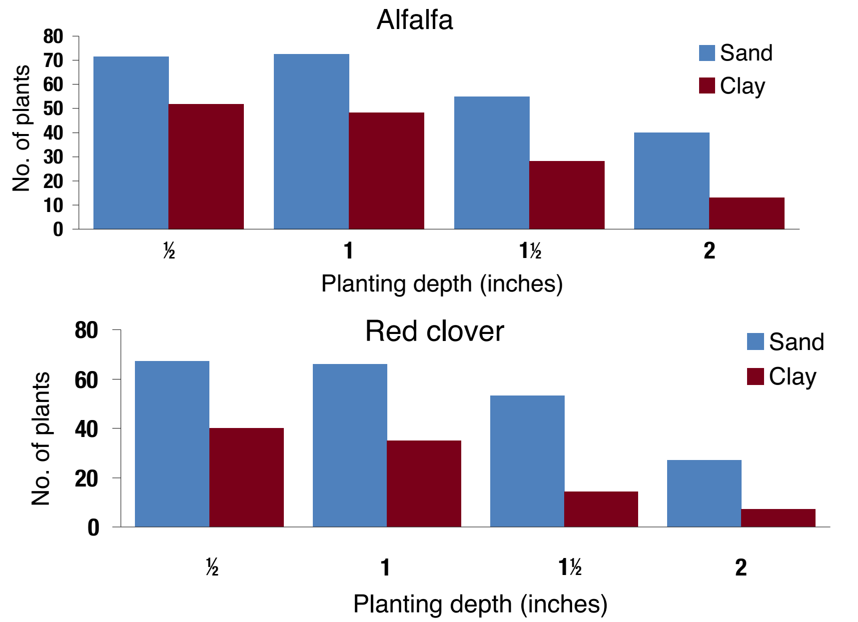

Figure 12-17. Alfalfa and red clover stands *produced by planting 100 seeds at four planting depths. Shallow seeding of alfalfa and red clover provides the greatest stands for sand and clay soils. At depths beyond 1/2 inch, seedling numbers decrease dramatically for the clay because of compaction. Adapted from Sund et al., 1966.*

Components of mixtures need to be selected for compatibility with mechanical harvesting versus pasture usage. Select species and varieties with similar maturity and palatability. This will provide mixed forage of uniform quality and insure that all portions will be consumed.

Reducing risk: forage mixtures. Choose mixtures with two or three species with diverse growth habits and adaptation to soil types. Species and varieties of grasses and legumes should have similar maturities to make harvest scheduling easier. For example, orchardgrass matures in mid-May, while alfalfa reaches target maturity at the beginning of June.

Forage establishment

SEEDBED PREPARATION

Small seeded grasses and legumes need fine yet firm seedbeds to insure good soil-seed contact. Ideally, the seedbed should be firm with some residue remaining as occurs with conservation tillage (>30 percent residue). This is usually achieved by disking or field cultivation followed by harrowing.

Rough uneven seedbeds reduce soil-seed contact and do not allow uniform planting depths. Excess crop residue can reduce seed contact with the soil and the seed will not germinate in a timely way. If rainfall occurs and the seed germinates on the residue, it will die if the root cannot reach the soil. Overworked seedbeds with no crop residue can result in soil crusting that prevents seedling emergence. This is particularly a problem on fine-textured (clay and silty) soils.

Reducing risk: seedbed. Prepare a firm seedbed with some residue. Ideally, your shoes should not sink greater than one inch into the seedbed.

PLANTING DEPTH

Small-seeded grasses and legumes are typically seeded 1/4 to 1/2 inch deep on most fine textured soils but somewhat deeper on drier, sandy soils (Figure 12-17). This provides moisture for germination of the seed and the seedling can reach the soil surface upon germination. Seed placed on the soil surface can absorb water following rainfall and begin to germinate but may die before the root can enter the soil. Seed planted too deep depletes its energy reserves before reaching the soil surface.

Table 12-5. Seeding rates for forage legumes and grasses alone and in mixtures.

	SEEDING RATE (BU/AC)	
	Pure stands	In mixtures
LEGUMES		
Alfalfa	13	5
Birdsfoot trefoil	8	6
White clover	4	2
Red clover	9	5
Sweet clover	10	3
GRASSES		
Bromegrass	16	5
Orchardgrass	10	3
Reed canarygrass	7	5
Tall fescue	15	5
Timothy	6	3
Perennial ryegrass	15	6
Kentucky bluegrass	10	5

Reducing risk: planting depth. **Seed needs to be planted 1/4 to 1/2 inch deep on most soils and up to one inch deep on sands. Calibrate your seeding equipment. Seed on the soil surface will be a greater risk.**

Figure 12-19. *Oat as a companion crop with alfalfa.*

PLANTING RATES

Planting rate recommendations are focused on establishing a target grass or legume population in the seeding year when all risks to establishment are considered. Target seeding year populations are from 25-50 plants/square foot. With a typical survival of about 60 percent, this provides adequate plant populations for the first production year. To achieve these populations, seeding rates are shown in Table 12-5.

Reducing risk: planting rates. **Exceeding the recommended seeding rates creates an economic risk because farmers bear the cost of applying more pounds of expensive seed. Inadequate seeding rates due to lack of seeder calibration results in seeding year populations that reduce yields and lower stand life.**

Legume and grass emergence

Legumes and grasses have different types of emergence (Figure 12-18). Legumes have epigeal emergence that results in the seed cotyledons being pulled from below the soil surface. Exposure of all the leaves and growing point can lead to defoliation and frost damage. Grasses have hypogeal emergence and the seed stays below ground protecting the growing point from damage.

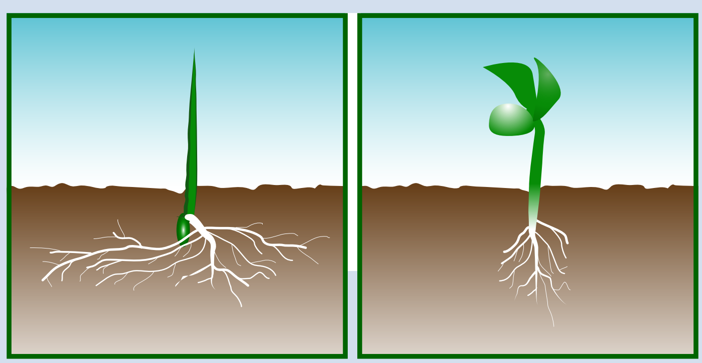

Figure 12-18. *Grasses have hypogeal emergence (left) while red clover and alfalfa have epigeal emergence (right).*

Figure 12-20. *Barley and oat companion crops used for alfalfa and red clover establishment.*

ESTABLISHMENT: COMPANION CROPS VS. SOLO SEEDING

Small-seeded legumes and grasses are established by two approaches: companion crops and solo seeding. Of these approaches, companion crops are most commonly used for spring seedings, whereas solo seeding is used for late summer plantings after small grain harvest.

Companion crops

Companion crops (also called nurse crops) are planted with small-seeded legumes and grasses and can be harvested for forage, straw, and grain (Figure 12-19). They are either small grains like spring oats, spring wheat, and spring barley or flax (Figure 12-20).

Figure 12-21. *A comparison of flax (left) and barley (right) companion crops. Barley is a better competitor with weeds than is flax, as is evident from the weed canopy over-growing the flax crop.*

Using companion crops when establishing forages has several advantages. Companion crops cover and stabilize the soil and minimize seedling loss due to wind and water erosion. They are essential for hilly sites or sandy, wind-blown soils. Companion crops suppress weeds and seedling loss due to competition with weeds can be lessened (Figure 12-21).

Companion crops provide a product (e.g., forage, grain, and straw) for farm use and economic return during the seeding year when forage crop yields are normally low.

Companion crops can have disadvantages, too. They compete for light and water with small seedlings and can reduce establishment and yields. In addition, forage or straw from mature small grains can smother the legumes if left in rows on the field (Figure 12-22). Volunteer small grain can result from shattering of mature grain during harvest. The shattered grain can germinate with favorable moisture conditions and compete with and smother the forage seedlings.

Reducing risk: companion crops. Do not leave rows of straw or cut forage on longer than three days. Allowing small grains to grow to maturity will prolong competition with forage, leading to greater risk. Choose earlier maturing companion crops. Choose oats or flax, which will be less competitive with forages, instead of semi-dwarf varieties of wheat or barley. Do not apply N fertilizers to small grains with companion crops, as this may cause lodging. Lodged small grains can smother the forage seedlings.

Figure 12-22. *When companion crops are used for alfalfa and red clover establishment, it is important to promptly remove the straw following small grain harvest. After a week, the straw can kill the alfalfa seedlings.*

Alfalfa establishment with companion crops

Organic alfalfa establishment with companion crops was examined at three sites in Minnesota. The companion crops used were oats, wheat, barley, pea, and flax. It was found that small grains performed similarly with alfalfa, while peas were the most competitive with alfalfa (Table 12-6). Reducing small grain seeding rates is sometimes recommended to reduce competition with legume seedlings, but this research found no effect of small grain seeding rate on legume populations or stands (Table 12-7).

In the same experiment, alfalfa was seeded by August 15 after small grain harvest. This also can result in good establishment of the legume if moisture is adequate (Table 12-8).

Table 12-7. Effect of reducing seeding rates on companion crop grain and alfalfa yield.

GRAIN	SEEDING RATE (BU/AC)	GRAIN YIELD (BU/AC)	ALFALFA YIELD (TON/AC)
Oat	2.5	84	6.3
	1.3	78	5.7
Wheat	2.0	48	6.9
	1.0	33	6.7
Barley	1.8	78	5.9
	0.9	71	6.6
Pea	3.0	54	4.8
	1.5	38	5.1

Table 12-6. Alfalfa seeded with small grain: cover crop grain and alfalfa yield.

COVER CROP	GRAIN (BU/AC)	ALFALFA (TON/AC)	
	2006	2006	2007
Spring oat	84	0.4	6.3
Spring wheat	48	0.5	6.5
Spring barley	78	0.4	5.9
Field pea	54	0.2	4.8
Flax	19	0.4	6.7
No companion crop	--	--	6.1

Table 12-8. Alfalfa seeded after small grain harvest: cover crop grain and alfalfa yield.

COVER CROP	GRAIN (BU/AC)	ALFALFA (TON/AC)
	2006	2007
Spring oat	91	2.7
Spring wheat	42	4.7
Spring barley	66	3.4
Field pea	74	2.7
Flax	14	4.8
No companion crop	--	6.2


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Figure 12-23. *Oats.*


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Figure 12-24. *Six-row barley.*


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Figure 12-25. *Wheat.*

Small grains for spring forage establishment

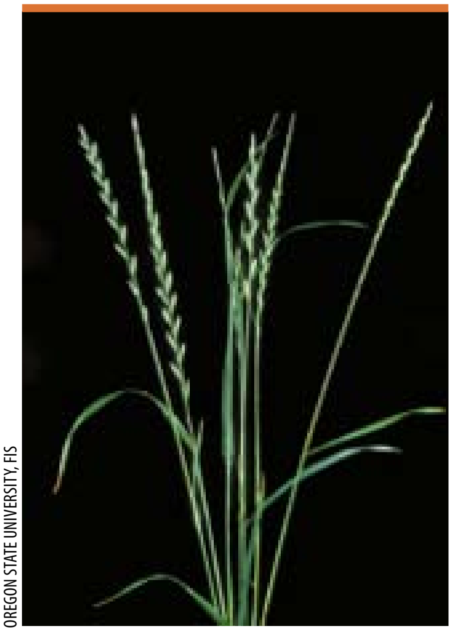
Oat is the most traditional companion crop in the Midwest. It is frequently grown for production of grain and straw for bedding. The grain is the least energy dense of the small grains, thereby reducing the risk of overfeeding of energy to horses. Oat is also the least competitive small grain and will have less impact on small forage seedlings. Only spring oats are grown in the Midwest.

Barley is primarily grown for production of grain for livestock feeding or, if high enough quality, for malting. Semi-dwarf varieties produce a high quality forage. Many barley varieties mature ahead of other small grains and that allows earlier harvest and reduces the period of competition. Semi-dwarf barley produces multiple tillers and can provide high levels of competition.

Wheat is valued for grain processed for food products. Spring varieties are used as companion crops. Semi-dwarf varieties can provide significant competition with small legume seedlings. Winter varieties of wheat are sown in the fall, but may winter-kill in northern latitudes. Frost seeding of legumes into winter wheat during winter is not recommended because of excess competition.

A producer from McLeod County finds it difficult to start alfalfa with solo seeding. He establishes alfalfa with an oat companion crop, grows the alfalfa for three years, fall plows the alfalfa, then plants corn. This practice provides nitrogen and reduces weed pressure on the corn.

Figure 12-26. *Winter rye.*



OREGON STATE UNIVERSITY, FIS

Figure 12-27. *Annual ryegrass.*

Winter rye is the only winter grain that reliably overwinters in the Midwest. It will not flower if planted in the spring. Therefore it is not useful as a spring-seeded small grain. Winter rye can be used as a spring-planted companion crop if a vegetative forage is desired. When planted in the spring, winter rye remains vegetative and can be harvested as forage. It will be killed by disease and summer temperatures. However, winter rye can compete with forages.

Annual (Italian) ryegrass is a forage-type rye that is spring seeded and used as a companion crop. It produces a very high quality forage and can enhance total forage yields. Annual rye can compete with alfalfa and red clover seedlings if seeding rates are greater than 10 pounds per acre.

Winter grains: Winter wheat and rye are seeded in the fall, overwinter, and vigorously grow in the spring. Frost seeding of legumes into winter grains is not recommended because of the excessive competition provided by these grains.

Solo seeding

Solo seeding is the direct seeding of small-seeded legumes or grasses in the spring or late summer without companion crops. Solo seeding provides the greatest opportunity to maximize seeding year yields if seeding occurs in the spring. Late summer solo seeding provides no yields in the seeding year but can result in vigorous stands the following year.

Reducing risk: solo seeding. Solo seeding is best in fields with low weed populations because weeds can provide significant competition with small-seeded legumes and grasses. Wind and water erosion can be greater when planting small-seeded grasses and legumes on sandy, windblown, or erodible soils.

Planting date

There are a number of options for time of establishing forages, including frost, spring, or summer seedings.

FROST SEEDING

Frost seeding takes advantage of the freezing and thawing action of the soil to bury small seeds. Typical times of frost seeding are late fall when average air temperatures are less than freezing, in midwinter, and in very early spring. Frost seeding is inexpensive and requires little equipment. Research in Minnesota has shown that frost seeding can be risky in Minnesota (Table 12-9 and Figure 12-28).

Figure 12-28. *Plants frost seeded in winter germinated only in the cracks of the soil (above) and led to an unsuccessful planting (top).*

Table 12-9. Alfalfa and red clover mix yields *in summer when frost seeded in early winter (December), late winter (March), and spring (April) at Rosemount and Lamberton. Frost seeding in winter often resulted in no plant establishment and no yield.*

		ROSEMOUNT		LAMBERTON	
Date of seeding	Forage	2007	2008	2007	2008
		YIELD IN TONS/ACRE			
Early winter	Alfalfa	0.2	0	0	1.9
	Red clover mix	0	0	0	1.7
Late winter	Alfalfa	0.3	0	0	1.4
	Red clover mix	0.2	0	0	1.4
Spring	Alfalfa	0.4	1.3	0.1	1.0
	Red clover mix	0.5	0.8	0.2	1.2

Reducing risk: frost seeding. Before committing to frost seeding, realize that this will be a risky practice in many areas. Winter temperatures on bare soils may reach levels to promote germination of seeds that are later killed. Late spring frosts that occur after seedling germination also can kill seedlings. Risk can be minimized by buying inexpensive seed.

SPRING SEEDING

Spring seeding provides the opportunity for seedlings to grow and produce forage in the first year. Generally, crops are sown at a time to take advantage of the seasonal patterns of precipitation, favorable moisture, and to capture the maximum amount of solar energy. For solo or companion crop seeding, see Figure 12-29 for the optimum times for seeding in the Upper Midwest. Recommended planting date shifts about one week later or earlier per 100 miles north or south.

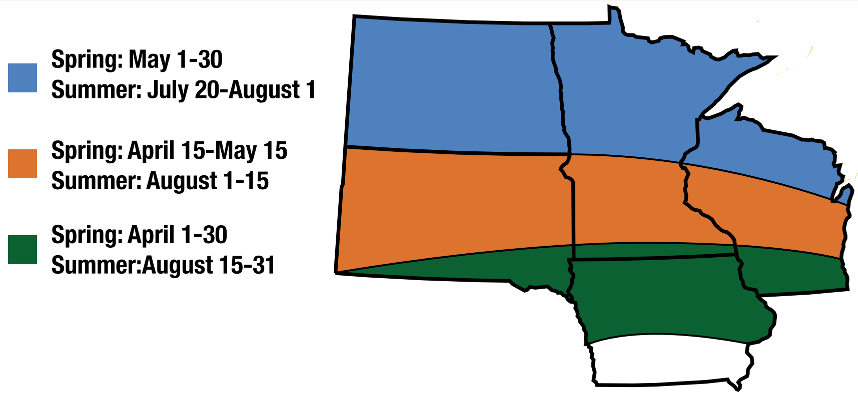


Figure 12-29. *Optimum times for spring or summer seeding of forages.*

Reducing risk: spring seeding. Plant at the recommended time for your region. Planting before the recommended date will lead to an increased risk of frost damage. Planting after will increase risk of moisture deficit, high temperatures and competition with annual weeds.

SUMMER SEEDING

Late summer seedings are typically sown after harvesting a spring-seeded crop such as a small grain. Successful summer seeding depends on adequate soil moisture, as well as adequate heat units for plants to develop more than three leaves and a crown before the onset of freezing temperatures. This typically takes from six to eight weeks. Therefore, the decision is influenced by the climate in a region. For most of the North Central region, the optimum time to summer seed forages is August 1 – 15 (Figure 12-29).

Reducing risk: summer seeding. The least risky time to summer seed in Minnesota is at the beginning of August, unless significant weed pressure is anticipated. Planting at the end of August may leave plants an inadequate time to develop. After the beginning of September, there is a great risk of winter kill to seedlings and yield reduction the following year. For winter survival, legumes and grasses must develop a crown and have three to five leaves formed. Snow cover of six inches during the winter can protect summer seedings from winter injury.

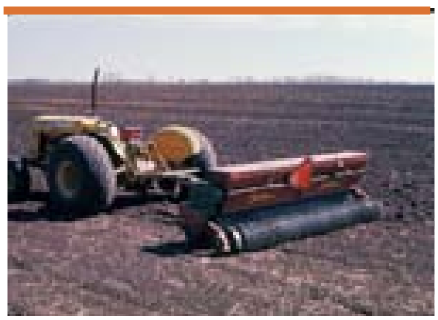


Figure 12-30. *A cultipacker consists of two rollers.*

Seeding equipment

Broadcast seeding and drill seeding are two approaches to seeding of small-seeded legumes and grasses. Each can result in successful seeding if proper seeding depth and soil seed contact occur.

BROADCAST SEEDING

Broadcast seeding can be achieved by aerial, manual or mechanical sowing or by using a cultipacker seeder (Figures 12-30 and 12-31). With broadcasting of seed, distribution and coverage are risk factors. Excessive residue from the previous crop on the soil surface can prevent the seed from reaching the soil.

Producers sometimes incorporate legume seed by light harrowing. Dragging can incorporate seed but carries a high risk of burying seed too deep.

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Figure 12-31. *Frost seeding can be done using a ATV on frozen ground. Frost seeding depends on the freezing and thawing of soil to cover seed.*

A couple from Stevens County successfully establishes alfalfa by broadcast seeding and harrowing it after they have drilled wheat. They have livestock and usually have 100 acres of alfalfa.

Reducing risk: broadcast seeding. Consider drilling if there is excessive residue. Dragging can be risky, depending on conditions. Cultipacker seeders can compact clay soils if the soil is moist. Cultipacker seeders pack the soil and cover the seed ensuring shallow seed placement into a firm seedbed.

Alfalfa autotoxicity

Autotoxicity is a risk when trying to establish alfalfa after alfalfa. The result of autotoxicity is poor establishment of new seedlings. Autotoxicity is likely related to the presence of chemicals that are produced by decaying herbage. Growers should plant corn or other crops requiring N fertilization to utilize nitrogen, but sometimes alfalfa is planted after alfalfa. Take the **Alfalfa Autotoxicity Quiz** at the end of the chapter to assess your autotoxicity risk.

Figure 12-32. *For successful seeding of small-seeded legumes and grasses with a grain drill, risks are reduced if the drill has a small-seeded legume box, tubes which deliver the seed behind the coulters and press wheels that increase soil-seed contact.*

DRILL SEEDING

Seeding with a grain drill or specialized seeder places in rows that are typically six to seven inches apart (Figure 12-32). With drills, coulters open the soil and deposit the seed (Figure 12-33). This can occur with small grain drills equipped with legume seed attachments or with specialized drills designed to insert seed into untilled seedbeds.

Reducing risk: drill seeding. Reduce risk of improper planting depths by adjustment of drop tubes from legume seed boxes to insure shallow seed placement. Visually inspect the depth of seeding. Use drills with depth control bands. Use press wheels that follow the coulters to increase soil-to-seed contact.

Figure 12-33. *A grassland drill can be used for seeding legumes and grasses into grass sods or small grain stubble. Note that it has a coulter for slicing the soil, openers to make a place to deposit the seed and press wheels for getting soil-seed contact.*

Weed control in forages

Annual and perennial weeds can affect forage crop establishment, forage persistence, and forage quality. Forage production is an effective way to reduce weed populations. Many annual weeds can be controlled by routine harvesting or grazing that coincides with harvesting of the forage crop. Likewise, even weeds like Canada thistle can be controlled by forage harvest.

Producers need to be aware that weeds may provide yield and have good levels of forage quality (Tables 12-10 & 12-11). Therefore, their control may be unnecessary unless weeds compete with the crops for resources and reduce their yield.

Figure 12-34. *Forage harvest.*

Reducing risk: weed control. Poor weed control in annual crops will increase risk in forages because of buildup of weed seed banks and increasing perennial weeds. Increase diversity in crop rotation; rotating different crops will reduce weed populations.

Table 12-10. Forage quality of alfalfa and annual weeds. *Adapted from Maten and Anderson, 1975.*

SPECIES	DIGESTIBILITY	ACID DETERGENT FIBER	CRUDE PROTEIN
Alfalfa	72	24	27
Redroot pigweed	73	21	25
Lambsquarters	68	22	25
Common ragweed	73	25	25
Pennsylvania smartweed	51	22	24
Yellow foxtail	69	30	20
Giant foxtail	62	33	18
Barnyardgrass	70	33	18

Table 12-11. Palatability of oats and weeds for sheep. *Adapted from Maten and Anderson, 1975.*

CATEGORY	SPECIES	% OF FORAGE CONSUMED
Crop	Oats	73
Palatable grasses	Yellow foxtail	90
	Barnyardgrass	83
	Green foxtail	60
Palatable forbs	Redroot pigweed	80
	Pennsylvania smartweed	75
	Lambsquarters	72
Unpalatable grass	Giant foxtail	35
Unpalatable forbs	Wild mustard	3
	Giant ragweed	0
	Cocklebur	0

Successful harvests of forages

HARVEST DECISIONS

For both legumes and grasses, crop development influences the forage yield and forage quality. For any given harvest, forage yield increases with crop maturity and forage quality declines (Figure 12-35). These changes are related to changes in the leaf/stem proportion as the crop matures. Therefore, growers should harvest at a maturity to reach a specific forage yield or quality goal. Harvest of forages at vegetative stages will provide a high quality, leafy forage but will sacrifice yield and persistence. Harvest at flowering or later stages will prove high yield of stemmy, low quality forage.

On a seasonal basis, producers typically harvest forage crops from two to four times (Figure 12-36). A seasonal cutting schedule considers the forage yield and quality relationships at an individual harvest as well as the growing conditions within a region. Some sample harvest schedules for southern Minnesota are shown in Figure 12-37.

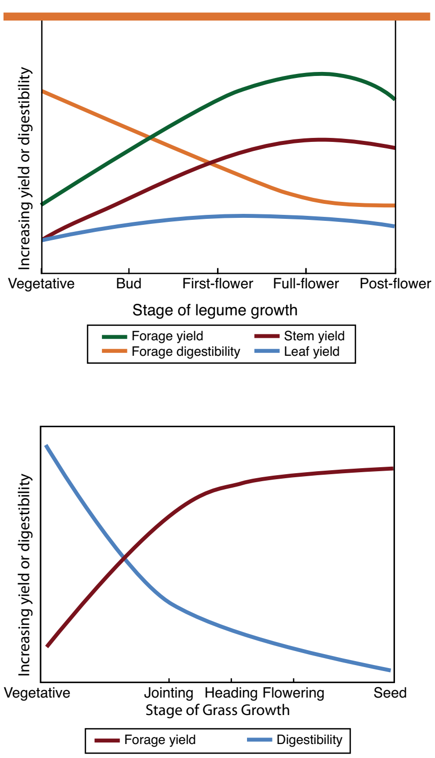

Figure 12-35. ***With increased maturity, yield increases as digestibility decreases in both legumes (top) and grasses (bottom).***

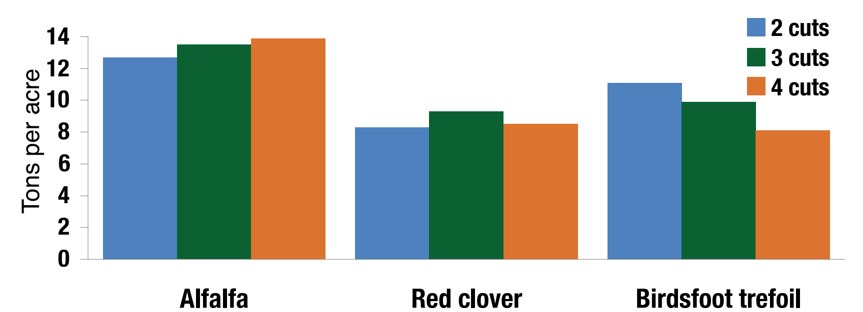

Figure 12-36. ***Effect of cutting schedules on alfalfa, red clover and birdsfoot trefoil at Lamberton, MN, in 1987-1989.***

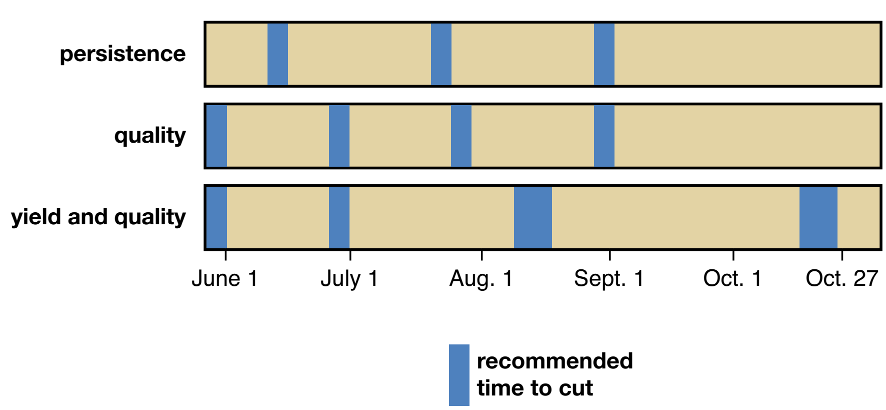

Figure 12-37. ***Cutting schedules can be selected for providing persistence, forage yield, and forage quality. These dates of alfalfa cutting apply for southern Minnesota and much of Wisconsin. For more northern sites, cutting will be delayed with fewer harvests per season. Adapted from Undersander et al., 2004.***

Figure 12-38. *Organic alfalfa at two stages of maturity. Alfalfa on left is flowering and lower quality than the vegetative alfalfa on the left.*

Reducing risk: harvest decisions. Seasonal schedules must be timed to allow the maximum number of harvests during the growing season to reach harvest and quality goals.

FALL CUTTING OF LEGUMES

Complicating harvest schedules for legumes are the risks associated with fall cutting. Generally this refers to harvest anytime after early September. Cutting after early September has the potential to lead to winter injury of legumes. Removing legume herbage stimulates regrowth from the crown. Such regrowth depletes carbohydrate reserves required for overwintering of the crop. Fall cutting removes herbage that catches snow and insulates the soil over winter.

Reducing risk: fall cutting. Take the Fall Cutting quiz at the end of the chapter to determine the risk of fall cutting.

HARVESTING OF FORAGES FOR HAY OR SILAGE

Forages are harvested for storage as hay or silage (Figure 12-39). Hay is stored in the air (aerobically) at a moisture level of 20 percent or less. In silage making, the forage is stored at moisture levels greater than 40 percent in structures or packages that exclude air (anaerobically). Both hay and silage making can lead to losses in forage yield and quality. In haymaking, losses as high as 30 percent occur due to weather exposure and to mechanical handling (Figure 12-40). Field losses are less for silage making because of shorter field exposure and because silage is handled at higher moisture content than hay. However, storage losses are higher because of biochemical reactions during storage.

Standing forage contains about 80 percent moisture. For successful storage, moisture levels must be decreased by field drying (Figure 12-41). This process is dependent on solar energy to drive moisture from plant herbage. Other climatic factors such as air temperature, wind speed, and relative humidly influence the drying rate. In the Midwest, one to three days are typically required for drying to safe storage moistures.

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Figure 12-39. *Large square hay bales are being loaded for transport.*

Forage quality: what is it?

Forage quality describes the potential feeding value of a forage. Ultimately, livestock convert potential feeding value into products humans use such as meat, milk, wool, or work. Nutritive value, intake, and antiquality factors are the three components of forage quality.

Nutritive value describes the nutrient content of the forage. Nutrients include crude protein, energy, and minerals are important for growth and sustenance of animals (Table 12-12).

Table 12-12. Average composition of forages *(on a dry matter basis). Legumes and grasses differ in their nutrient composition, which results in differences in forage quality. For livestock feeding, legumes are valued for their protein content, high intake potential, and digestibility. For both legumes and grasses, maturity affects forage quality. Adapted from Sheaffer, 1996.*

SPECIES / GROWTH STAGE	CRUDE PROTEIN	NEUTRAL DETERGENT FIBER*	ACID DETERGENT FIBER**	DIGEST-IBILITY
Alfalfa				
- pre-bloom	22	41	31	65
- early bloom	18	48	38	58
- mid-bloom	16	50	40	56
- full bloom	15	52	42	54
Alfalfa-Grass mixture	17	52	36	55
Bromegrass (boot)	11	68	40	56
Red Clover (full bloom)	15	56	41	59
Orchardgrass (boot)	15	61	34	62
Timothy (boot)	9	61	32	59

* A predictor of forage intake potential; greater concentrations mean lower intake.
** A predictor of digestibility; higher concentrations mean lower digestibility.

Intake describes how much of a forage an animal will eat. Two forage factors affecting forage intake are its palatability and its fiber content.

Palatability describes the relative preference of a animal for one forage versus another. For example, grazing livestock will typically select immature ryegrass compared to thistle. Palatability is somewhat of an adaptive trait; i.e. animals can learn to eat a forage they initially reject.

Fiber in forages is made up of cell walls that are composed mostly of cellulose, hemicelluloses, and lignin. Compared to high energy feeds like corn, the bulky nature of forage fiber lowers the rate of digestion and passage of forage. Fiber is typically measured as neutral detergent fiber (NDF) that is a measure of the cell wall concentration.

Antiquality factors include chemical compounds that reduce intake or cause detrimental affects to animal health or performance. For example, the soluble protein in alfalfa can cause bloating. Nitrates in sudangrass, sorghum, and some weeds can damage the hemoglobin and kill livestock. Alkaloids in reed canarygrass are bitter and reduce palatability, and if ingested cause digestive system disorders.

Two terms that you may encounter when evaluating overall forage quality are Relative Feed Value (RFV) and Relative Forage Quality (RFQ). The Relative Feed Value index ranks forage quality based on potential digestible dry matter of forages and the intake potential. RFV is used to establish a grade for selling and buying hay (Table 12-13). Relative Forage Quality is an index like RFV except that it ranks forages by potential digestible dry matter intake calculated by NDF and NDF digestibility.

Table 12-13. The effect of hay grade on medium square bale prices per ton (conventional). *Adapted from Martens, 2009.*

RFV	2007	2008
176-200	$ 123	$ 210
151-175	$ 111	$ 194
126-150	$ 97	$ 164
101-125	$ 81	$ 142

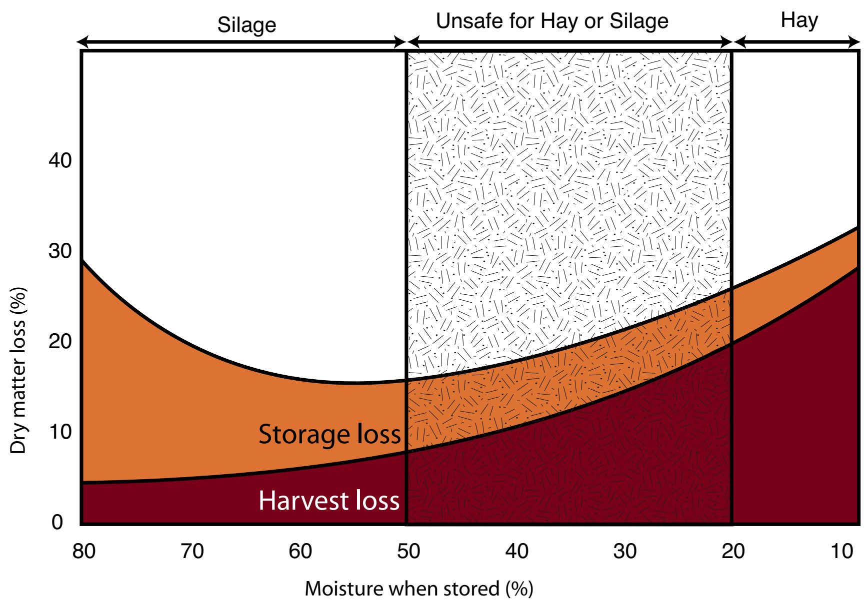

Figure 12-40. *Losses in dry matter with making of hay or silage. In the unsafe moisture range, forage is too wet for hay and too dry for silage. Adapted from Sheaffer and Moncada, 2008.*

Figure 12-41. *Mold growing on hay that was packaged too wet.*

Table 12-14. Changes in alfalfa quality with rain damage.
Adapted from Pitt, 1990.

	CP	DIGESTIBILITY	NDF	DM YIELD
	-------------- % --------------			TONS/ACRE
Standing crop	23	70	43	2
Hay	20	64	46	1.7
Rain-damaged hay	20	57	54	1.5

CP = Crude protein, NDF = Neutral detergent fiber, and DM = Dry matter

Heavy dew and rainfall during curing can cause significant losses in forage yield and quality by shattering leaves and leaching of nutrients (Table 12-14 & Figures 12-42 and 43). Legumes, especially the clovers, are wetter and dry slower than the grasses. Therefore, it takes longer to dry cut legume forage than grass forage. Planting grasses in mixtures with legumes will increase forage drying rate.

Reducing risk: harvesting of forages. **Avoid exposure to rain during drying by timing harvest during dry weather. Grasses dry quicker and are less of a risk of losses due to moisture.**

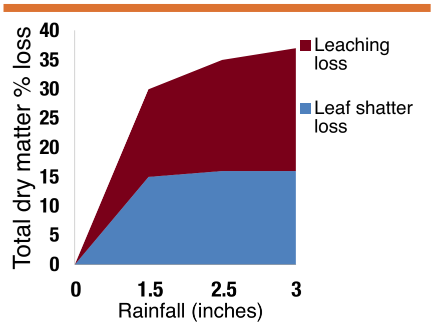

Figure 12-42. *Dry matter losses from leaching of nutrients and from leaf shatter during rainfall of varying amounts. Adapted from Pitt, 1990.*

Figure 12-43. *Alfalfa hay with rain damage. It was re-raked to facilitate drying. Note regrowth before harvest.*

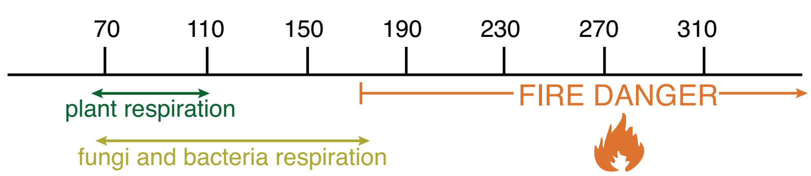

Figure 12-44. ***Plant respiration and microorganisms are responsible for the heating of hay that leads to spontaneous combustion.***

Hay

Heating and spontaneous combustion are major risks in hay making (Figure 12-44). For safe long-term storage of all hays a target moisture content should be less than 20 percent for small square bales (about 50 pounds) and less than 17 percent for larger bales (greater than 500 pounds). While heating and "sweating" occurs to some extent in all forage baled at above 15 percent moisture, the extent of heating is highly correlated to the moisture content at baling. Heat generated by plant respiration, molds, and chemical reactions can lead to losses in dry matter and forage quality, and if high enough, spontaneous combustion and barn fires can occur. In addition to changes in feeding value, handling of dusty, moldy hay can affect human and animal respiratory systems and cause health problems such as farmers' lung disease.

Reducing risk: hay.
See Table 12-15.

Silage

Successful silage making involves two important steps. The first is excluding oxygen from the forage. Oxygen exclusion occurs by using air-tight containers that can be plastic bags or wrappings, structures, or piles (Figure 12-45). Each ensiling system has advantages and disadvantages based on economic, environmental, and logistic concerns.

The second step is to rapidly develop a fermentation that reduces the pH and preserves the forage. During fermentation sugars in the forage are converted to lactic acid by bacteria normally present on the forage. Lactic acid reduces the pH to about 4.0-5.0 and pickles the forage inhibiting further microbial growth.

Reducing risk: silage.
See Table 12-16.

Figure 12-45. ***Silage can be successfully made in disposable plastic containers. The key to successful silage making is to exclude air.***

Table 12-15. Recommended hay-making practices to reduce risk. *Adapted from Pitt, 1990.*

PRACTICE	BENEFITS
Monitor weather forecast	Avoid rain damage
Mow forage early in day	Allows full day's drying. Less likelihood of rain damage.
Form mowed forage into wide swath	Increase drying rate. Faster drop in moisture. Less likelihood of rain damage.
Rake at 40 to 50 percent moisture content	Increased drying rate. Faster drop in moisture. Less likelihood of rain damage. Less leaf shatter.
Bale at 18 to 20 percent moisture	Optimum preservation. Less leaf shatter. Inhibition of molds. Low chance of fire.
Store under cover	Protection from rain, sun. Inhibition of molds. Less loss from rain damage.
Monitor new hay for heating	Indicates fire damage risk

Table 12-16. Recommended practices to reduce risk for hay crop grass-legume silage.
Adapted from Pitt, 1990.

PRACTICE	BENEFITS
Minimize drying time	Reduced nutrient and energy losses. More sugar to prolong fermentation.
Chop at correct length (3/8 inch). Fill silo quickly. Compact. Seal silo carefully.	Minimal exposure to oxygen. Reduced nutrient and energy losses. Reduced silo temperature and heat damage. Faster pH decline and lower pH.
Ensile at 60 percent dry matter content.	Optimum fermentation. Reduced nutrient and energy losses. Prevents leaching of water from silage.
Leave silo sealed for at least 14 days	Allows complete fermentation. Lower silage pH
Unload 2 to 6 inches per day. Keep smooth surface	Minimal spoilage
Discard deteriorated silage	Avoids animal health problems


COURTESY OF JOHN DEERE

Figure 12-46. *Baling hay.*

MEASURING FORAGE MOISTURE CONTENT

The ability to determine forage moisture will reduce risks in hay and silage production. There are three ways to measure moisture content—by hand, with a moisture tester, or using the microwave technique.

The hand method estimates forage moisture by compressing forage by hand to gauge its status. See Table 12-17. This method is very subjective and therefore most risky.

Table 12-17. Hand method for estimating forage moisture concentration.

CHARACTERISTIC OF FORAGE SQUEEZED IN HAND	MOISTURE (%)
Water is easily squeezed out and forage holds shape	> 80
Water can just be squeezed out and forage holds shape	75 - 80
Little or no water can be squeezed out but forage holds shape	70 - 75
No water can be squeezed out and forage falls apart slowly	60 - 70
No water can be squeezed out and forage falls apart rapidly	< 60

The second method is to use a moisture tester. The two types of moisture testers are heat and electronic conductance. The electronic testers are faster, but less accurate when compared to the heat moisture tester. The last method is the microwave technique. See **http://pubs.ext.vt.edu/442/442-106/442-106.html** for more information on this method. This method will give a good approximation of moisture and will be more accurate than electronic testers.

Regardless of the method used, it is important to obtain a sample that is representative of the forage to be tested.

Figure 12-47. *Cutting forages.*

MECHANICAL OPERATIONS

Mechanical operations of hay and silage making typically include baling or chopping (Figure 12-46). Leaves, which make up about half of forage mass, are fragile and are often the fraction that is lost (Table 12-18). Unfortunately, because leaves contain more nutrients and less fiber than stems, their loss leads to a significant change in forage quality.

Reducing risk: mechanical operations. **Minimize field operations and excessive handling of forages, especially when the forage is dry.**

Table 12-18. Mechanical operations and dry matter and leaves lost. *Adapted from Pitt, 1990.*

OPERATION	% DRY MATTER LOST	% OF LEAVES LOST
Mowing	1	2
Mowing/conditioning:		
- reciprocating mower, fluted rolls	2	3
- disc mower, flail conditioner	4	5
Raking:		
- at 70% moisture	2	2
- at 50% moisture	3	5
- at 20% moisture	12	21
Baling, pickup + chamber:		
- at 20% moisture	4	6
- at 12% moisture	6	8
Baling at 18% moisture:		
- conventional square baler/ejector	5	8
- round, variable chamber	6	10

Alfalfa Autotoxicity Quiz

Adapted from Undersander, et al, 2004.

	Points	Score
1. Amount of previous alfalfa topgrowth incorporated or left on soil surface		
Fall cut or grazed	1	
0 to 1 ton	3	
More than 1 ton	5	
2. 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	
3. Soil type		
Sandy	1	
Loamy	2	
Clayey	3	
4. Tillage prior to reseeding		
Moldboard plow	1	
Chisel plow	2	
No-till	3	
5. Age of previous alfalfa stand		
Less than 1 year	0	
1 to 2 years	1	
More than 2 years	2	
6. Reseeding delay after alfalfa kill/plowdown		
12 months or more	0	
6 months	1	
2 to 4 weeks	2	
Less than 2 weeks	3	
TOTAL		

ALFALFA RESEEDING RISK

If you score:	The autotoxicity risk is:
4 to 7	low
8 to 11	moderate
> 12	high

Alfalfa Fall Cutting Quiz

Adapted from Undersander, et al, 2004.

	Points	Score
1. What is your stand age?		
> 3 years	4	
2-3 years	2	
1 year or less	1	
2. Describe your alfalfa variety:		
a. What is its winter hardiness?		
Higher than recommended for region	3	
Recommended for region	2	
Lower than recommended for region	1	
A. TOTAL		
b. What is the resistance to important diseases in your region?		
No resistance	4	
Moderate or low resistance	3	
High level of resistance	1	
B. TOTAL		
Alfalfa variety total score (multiply a and b)		
3. What is your soil exchangeable K level?		
Low (80 or less)	4	
Medium (81-120)	3	
Optimum (121 - 160)	1	
High (161 or more)	0	
4. What is your soil drainage?		
Poor (somewhat poorly drained)	3	
Medium (well to moderately drained)	2	
Excellent (sandy soils)	1	

		Points	Score
5. Describe your harvest frequency:			
Cut interval	Last cutting		
< 30 days	Sept. 1-Oct. 15	5	
	After Oct. 15	4	
	Before Sept. 1	2	
30-35 days	Sept. 1-Oct. 15	4	
	After Oct. 15	2	
	Before Sept. 1	0	
6. For a mid-September or late October cut, do you leave more than 6 inches of stubble?			
	No	1	
	Yes	0	
YOUR TOTAL SCORE (sum of points from questions 1-6)			

WINTER INJURY RISK

If you score:	Your risk is:
3 to 7	low
8 to 11	moderate
12 to 17	high
> 17	very high

Forage Establishment Quiz

	Points	Score
1. What is the status of your seedbed?		
Firm	1	
Soft	2	
2. How much crop residue is on your seedbed?		
20-30% residue	1	
>30% crop residue	2	
no crop residue	3	
3. At what depth do you plant forages?		
1/4-1-/2 inch	1	
1/2-1 inch	2	
1 inch or more	3	
4. When do you plant forages?		
Spring seeding	0	
Summer seeding	1	
Frost seeding	5	
5. If you plant in spring, at which date do you plant?		
15 April-15 May	0	
15 May-1 June	2	
1 June-15 june	3	
Not Applicable - go to next question		
6. If you plant in summer, at which date do you plant?		
1-15 August	0	
15 August-1 September	1	
After 1 September	3	
Not Applicable - go to next question		
7. If you frost seed, at which date do you plant?		
December to January	3	
February to March	3	
March to April 15	1	
Not Applicable - go to next question		

	Points	Score
8. Do you use a companion crop?		
Yes	0	
No	5	
9. Which companion crop do you use?		
Flax	0	
Oat	0	
Barley	1	
Wheat	1	
Not Applicable - go to next question		
10. Do you fertilize the small grain companion crop with nitrogen fertilizer?		
Yes	1	
No	0	
Not Applicable - go to next question		
11. When do you remove the small grain companion crop?		
Vegetative stage	0	
Boot stage	0	
Soft dough	1	
Mature-seed	2	
Not Applicable		
TOTAL		

FORAGE ESTABLISHMENT RISK

If you score:	Your risk is:
15-23	High risk
9-14	Moderate risk
3-8	Low risk

Harvesting Forages Quiz

		Points	Score
1. At what stage do you harvest forage when your goal is to maximize forage quality?			
	bud stage	0	
	early bud	1	
	first flower	3	
	full flowering	4	
2. At what stage do you harvest forage when your goal is to maximize forage persistence?			
	bud stage	3	
	early bud	2	
	first flower	1	
	full flowering	0	
3. At what moisture do you rake forage?			
	50% + moisture	0	
	25-50% moisture	1	
	>20% moisture	3	
4. How many raking operations do you do?			
	Swathing only	0	
	Raking once	1	
	Raking twice	2	
	Raking 3 times or more	3	
5. How do you gauge hay moisture content before baling?			
	Microwave a subsample	0	
	Portable moisture tester	1	
	Feel and visual	2	
	Do not gauge moisture	3	
6. What is the moisture content at hay baling?			
	<17%	0	
	<20%	1	
	20-25	3	
	>30%	4	
7. How is hay stored?			
	Inside, off the soil	0	
	Outside, plastic covered, off the ground	1	
	Outside, on the ground	2	
	YOUR TOTAL SCORE (sum of points from questions 1-7)		

HARVESTING RISK

If you score:	Your risk is:
15-22	High risk
9-14	Moderate risk
0-8	Low risk

Test Your Knowlege: Forage Grasses

	Points	Score
1. Which grass has the most winterhardiness and least risk of winterkill?		
Smooth bromegrass	a	
Kentucky bluegrass	b	
Reed canarygrass	b	
Timothy	c	
Orchardgrass	d	
Tall fescue	e	
Perennial ryegrass	f	
2. Which grass has the greatest persistence and least risk when cut frequently for hay?		
Reed canarygrass	a	
Tall fescue	b	
Orchardgrass	b	
Perennial ryegrass	c	
Smooth bromegrass	e	
Timothy	f	
3. Which grass has the most drought tolerance and least risk of yield reduction and death?		
Smooth bromegrass	a	
Reed canarygrass	b	
Tall fescue	c	
Orchardgrass	d	
Timothy	e	
Kentucky bluegrass	e	
Perennial ryegrass	f	
4. Which grass has the most tolerance to excess moisture and flooding and least risk of injury?		
Reed canarygrass	a	
Smooth bromegrass	b	
Kentuckybluegrass	c	
Timothy	c	
Orchardgrass	c	
Tall fescue	c	
Perennial ryegrass	d	
5. Which grass has the greatest seedling vigor and least risk of establishment failure?		
Perennial ryegrass	a	
Tall fescue	b	
Orchardgrass	b	
Smooth bromegrass	b	
Kentucky bluegrass	c	
Timothy	c	
Reed canarygrass	e	
YOUR TOTAL SCORE (sum of points from questions 1-5)		

Score 0 for each "a"

Score 1 for each "b"

Score 2 for each "c"

Score 3 for each "d"

Score 4 for each "e"

Score 5 for each "f"

If you score:	Your grass knowledge is:
0 - 7	High
8 - 14	Moderate
15 - 22	Low

Test Your Knowlege: Forage Legumes

	Points	Score
1. For a low soil pH, 5.0-6.0, the best adapted legume for hay is:		
Birdsfoot trefoil	a	
Alsike clover	b	
White clover	b	
Red clover	b	
Alfalfa	c	
Sweet clover	d	
2. For long-term persistence for hay, which legume has the least risk?		
Alfalfa	a	
Birdsfoot trefoil	b	
White clover	c	
Alsike clover	d	
Red clover	d	
3. For general ease of establishment, which legume has the least risk?		
Red clover	a	
Alfalfa	b	
White clover	c	
Alsike clover	c	
Birdsfoot trefoil	d	
4. For tolerance of excess soil moisture, which legume has the least risk?		
Birdsfoot trefoil	a	
Alsike clover	b	
White clover	b	
Alfalfa	c	
Red clover	c	
5. For tolerance to low fertility (K, P), which legume has the least risk?		
Red clover	a	
Alsike clover	b	
Birdsfoot trefoil	b	
White clover	b	
Alfalfa	c	
6. For fast drying rate and least potential for hay molding, the legume with the least risk is:		
Alfalfa	a	
Birdsfoot trefoil	b	
Alsike clover	c	
White clover	c	
Red clover	d	
YOUR TOTAL SCORE (sum of points from questions 1-6)		

Score 0 for each "a"

Score 1 for each "b"

Score 2 for each "c"

Score 3 for each "d"

Score 4 for each "e"

Score 5 for each "f"

If you score:	Your forage legume knowledge is:
0 - 7	High
8 - 14	Moderate
15 - 22	Low

FOR MORE INFORMATION

University of Minnesota Extension Forages. http://www.extension.umn.edu/forages/

University of Wisconsin - Extension Forage Resources. http://www.uwex.edu/ces/crops/uwforage/uwforage.htm

Midwest Forage Association. http://www.midwestforage.org/

REFERENCES

Ball, D.M., M. Collins, G.D. Lacefield, N.P. Martin, D.A. Mertens, K.E. Olson, D.H. Putnam, D.J. Undersander, and M.W. Wolf. 2001. Understanding forage quality. Am. Farm Bureau Fed. Pub. 1-01. Park Ridge, IL.

Barnett, K. 2009. UW-Extension. Weekly Hay Market Demand and Price Report for the Upper Midwest. http://www.uwex.edu/

Decker, A.M., G.A. Jung, J.B. Washko, D.D. Wolf, and M.J. Wright. 1967. Management and productivity of perennial grasses in the Northeast: Reed Canarygrass. Bulletin 550T, West Virginia University Agricultural Experiment Station.

Gay, S.W., R. Grisso, and R. Smith. 2003. Determining Forage Moisture Concentration. 442-106. Virginia Cooperative Extension, Virginia Polytechnic Institute and State University, Blacksburg, VA.

Jeranyama, P. and A.D. Garcian. 2004. Understanding Relative Feed Value (RFV) and Relative Forage Quality (RFQ). SDSU Cooperative Extension Service. Extension Extra #8149.

Martens, D. 2009. History Selected Lots 2008 - 2009. Quality Tested Hay Auction. www.extension.umn.edu/cropenews

Maten and Anderson, 1975. Forage nutritive value and palatability of 12 common annual weeds. *Crop Science* 15:821-827.

Pitt, R.E. 1997. Silage: Field to feedbunk. North east regional Agricultural Engineering service NRAES-99. Cooperative Extension, Ithaca, NY.

Pitt, R.E. 1990. Silage and Hay Preservation. Northeast Regional Agricultural Engineering Service, Publication NRAES-5, Ithaca, NY.

Sheaffer, C.C. 1996. Harvesting hay and silage. Minnesota Conservation Reserve Program Information Series. Minnesota Department of Agriculture.


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Sheaffer, C.C., D.K. Barnes, and G.H. Heichel. 1989. "Annual" Alfalfa in Crop Rotation. University of Minnesota Agricultural Experiment Station Bulletin 588-1989 (Item No. AD-SB-3680).

Sheaffer, C.C., N.J. Ehlke, K.A. Albrecht, and P.R. Peterson. 2003. Forage Legumes: Clovers, Birdsfoot Trefoil, Cicer Milkvetch, Crownvetch and Alfalfa. 2nd edition. Minnesota Agricultural Experiment Station, University of Minnesota. Station Bulletin 608-2003.

Sheaffer, C.C. and N.P. Martin. 1979. Hay Preservation. Agricultural Extension Service, University of Minnesota, Extension Folder 489-1979.

Sheaffer, C.C. and K.M. Moncada. 2009. Introduction to Agronomy: Food, Crops, and Environment. Delmar Cengage Learning: NY.

Smith, D., R. Bula, and R.P. Walgenbach. 1986. *Forage Management*, 5th edition. Kendall Hunt Publishing Company, Dubuque, IA.

Sund, J. M., G.P. Barrington, and J.M. Scholl. 1966. Depths of sowing forage grasses and legumes. *Proceedings 10th International Grassland Congress,* Helsinki, Finland. Sec1:319–322.

Undersander, D., R. Becker, D. Cosgrove, E. Cullen, J. Doll, C. Grau, K. Kelling, M.E. Rice, M. Schmitt, C. Sheaffer, G. Shewmaker, and M. Sulc. 2004. Alfalfa Management Guide. North Central Regional Extension Publication. NCR547.

Undersander, D. and J.E. Moore. 2002. Relative forage quality. UW Extention. Focus on Forage. Vol. 4., No. 5.