

Red Clover



Establishment, Management and Utilization

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Red clover (*Trifolium pratense L.*) is a short-lived perennial that is grown widely for silage, hay and pasture in Wisconsin. Diseases that attack red clover and weaken or kill it are largely responsible for its short life. However, newer, disease-resistant varieties extend stand life to four years under many conditions.

Red clover establishes rapidly. It can withstand more shading than most other legumes making it more compatible with grass sods in pastures. It tolerates lower soil pH, less fertility, and poorer drainage than alfalfa. Red clover is widely grown for hay on soils with poor internal drainage where alfalfa does not persist. Yield is higher than other forage legumes except alfalfa. Forage quality is similar to that of alfalfa but has the advantage of maintaining quality longer with advancing maturity.

The two major types of red clover are medium and mammoth. Medium types produce two to three cuttings per year and are recommended for Wisconsin because of higher yield. Mammoth red clover is late flowering and produces only one harvest per year. Most of the improved varieties are the medium types and have higher levels of disease resistance, longer stand life and greater yield than older medium or any mammoth types.

Variety Selection

When selecting a red clover variety, look for good disease resistance and proven persistence. Current varieties have been bred for better persistence and, with proper management, you can expect two to three good harvest years after the year of establishment. Varieties chosen should, at least, have resistance to the two important foliar diseases, northern anthracnose and powdery mildew. Severe infection of northern anthracnose can reduce yield and cause permanent damage to the stand. Powdery mildew usually does not affect forage yield because it occurs in late summer but it does hinder photosynthesis and the general health of the plant as it goes into fall and winter.

Public varieties, such as Arlington and Marathon, which have been developed and released in Wisconsin, have proven disease resistance and persistence. Excellent commercial varieties are also available. For current information on varietal performance in your area, contact your county extension agent.

Generally avoid seed labeled as "common," "common red clover," or "medium red clover." Such seed may be unlabeled varieties not adapted to the region and may have very little disease resistance and persistence.

Buy good quality seed. The seed label provides current information on source, germination, and purity. Purity is the percent (by weight) that is seed. Percent germination multiplied by percent purity gives the actual percentage of germinatable seed in the bag. This is called Pure Live Seed (PLS). Always compare price on a PLS basis.

Red clover can have a large amount of hard seed. Hard seeds are viable seeds with a seed coat that temporarily keeps moisture from entering the seed. Hard seeds are a natural survival mechanism spreading the time over which seeds

germinate. Long germination periods reduce the likelihood of all seedlings being killed by insects, drought, frost, diseases, soil crusting, or other hazards. Seed can be scarified to increase early germination of hard seeds. Approximately 10-15% hard seeds are preferred to spread out the germination period but avoid larger percentages of hard seeds. Seed lots with over 30% hard seeds should be seeded at higher rates to compensate for the large amount of hard seed.

Establishment and Seeding Year Management

Red clover grows on a wide range of soils but does best on medium-textured soils with a soil pH greater than 6.0. It tolerates some degree of poor drainage, more than alfalfa but less than ladino white clover. Red clover lacks drought tolerance and does not persist well on extremely sandy soils.

While most Wisconsin soils contain rhizobium effective on red clover, some fields may have either low levels that would reduce first year yields or no rhizobium so that nodulation and nitrogen fixation does not occur. Therefore, always buy pre-inoculated seed or inoculate red clover with the proper rhizobium prior to seeding. Other types of inoculum, e.g., for alfalfa, will not work.

Red clover can be established as a pure stand, with or without a companion crop, seeded with a grass to establish a clover-grass mixture, or sod-seeded into a grass sod for improved pasture. Each situation has special requirements that must be met for successful establishment.

Pure Stands

Pure stands of red clover are generally seeded during early spring with a small grain sown as a cover crop. This practice provides an early forage yield (of small grain) from the seeded field, reduces erosion potential, and decreases the need for herbicides to control weeds. Red clover should be seeded at the rate of 12-14 lbs/a. Best clover stands result from seeding the small grain at 50-75% of the usual rate (1-1.5 bu/a). To reduce competition to clover during establishment, harvest the small grain as silage at early heading. If the small grain is harvested for grain, remove straw so that it does not smother young clover seedlings.

Red clover may also be sown into winter wheat or barley seeded the previous fall. Under these conditions it should be seeded while the ground is still frozen but after most snow has melted, so that seed is worked into the ground by thawing and refreezing during the spring. Seed 12-14 lbs/a.

Red clover direct seeded in the spring without a companion crop will produce less total forage than when seeded with a companion crop (also harvested for forage). However, a larger amount of red clover is produced during the seeding year when red clover is seeded alone. Plant at the rate of 12-14 lb/a on a firm, well-prepared seedbed. Seed may either be drilled 1/4 to 1/2 inch deep or broadcast and rolled with a cultipacker. Use of a preplant or postemergence herbicide is recommended to

lessen weed competition which can reduce the stand and lower forage quality of the first cutting.

Forage should be harvested during the seeding year as the plants begin to bloom but prior to September 1. Preventing the plants from heading will increase tillering but cutting too early may reduce stand vigor and cutting after September 1 will decrease winter survival. A second harvest may be taken in southern Wisconsin before September 1 most years. Late fall (after a killing frost) cuttings are *not* recommended, unless you need the forage, because it may reduce winter survival. The late cutting should be made at a 4- to 6-inch height.

Grass-Clover Mixtures

Grass-clover mixtures are advantageous because of reduced bloat potential when grazing and more rapid drying when harvested for hay or haylage harvest. A disadvantage of grass-clover mixtures is the higher fiber and lower crude protein content of the forage. The most common mix is 8-10 lbs of red clover with 3-5 lbs of timothy per acre. To ensure uniformly mixed planting, use separate seedboxes for the two species. Even carefully mixed seed will separate during seeding, resulting in more clover in some parts of the field and more timothy in other parts. Seed 1/4 to 1/2 inch deep into a smooth, firm seedbed. Do not use a preplant herbicide as this will kill the grass seeded with the mixture. Such mixtures can be seeded directly but most often they are seeded with a companion crop.

Sod Seeding

Sod seeding is used to improve production and forage quality of pastures. The keys to successful establishment are to seed as early in the spring as possible and to reduce grass competition during establishment. Therefore, apply needed lime and fertilizer but do not add nitrogen as it will increase competition of grass to new clover seedlings. Also, graze or clip the pasture to a 1-inch stubble height prior to seeding. Cattle may continue grazing the pasture after seeding but remove cattle when legume seedlings emerge. Grazing immediately prior to seedling emergence will reduce competition of the grass sod to clover seedlings. Use a no-till drill with openers cutting into the sod to the proper depth (1/2 inch) for good seed-soil contact. Improper opener depth is a major cause of stand failure. Seed at a rate of 8-10 lbs/a. Graze again during the establishment year when clover begins to bloom. Keeping the clover in the vegetative stage will encourage tillering.

Management for Production

Hay, Haylage and Silage

Hay yields of red clover average about 3-5 tons dry matter/a, being highest the year after seeding and declining thereafter. Stands tend to thin over summer from disease and drought rather than from winter kill. The forage quality of red clover is comparable to that of alfalfa. An important advantage is that the forage quality of red clover does not decline as rapidly with advancing maturity as alfalfa (see figure 1). This gives the

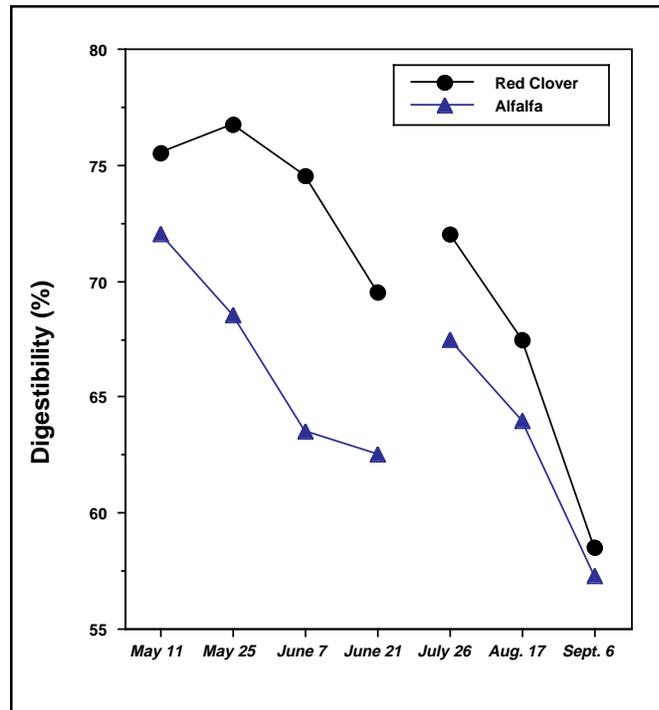


Figure 1. Digestibility of red clover and alfalfa as plants mature (From Buxton et al., 1985)

producer a longer time over which high quality forage can be harvested. For maximum nutrient or milk per acre production, red clover should be harvested at early flower.

A major disadvantage of red clover is that it does not dry as rapidly as alfalfa after being cut. Early season cuttings may be especially difficult to dry for hay because of unfavorable weather. Use for haylage where possible. Red clover should always be cut with a mower-conditioner to decrease drying time. Use of a dessicant may be helpful. A dessicant is a product, usually potassium or sodium carbonate, sprayed on the forage when cut to disturb the waxy cuticle and speed drying.

The first cutting of the season is the highest yielding. It should be cut at a 2-inch stubble height between when the first flowers are seen and when 20% of the clover stems have flowers. You can make one or two additional cuttings at 5- to 7-week intervals or whenever the clover begins to bloom again.

Allow 6 weeks for regrowth before killing frost in the fall so that plants can build up root carbohydrates to better survive the winter. Cutting after a killing frost weakens the stand because red clover does not die back like alfalfa but continues to grow when cut. The growth and lack of insulation from plant residue weaken the stand.

Seed production is an alternative to hay production. Allow first crop to mature and harvest the seed. If time also permits a forage harvest before frost, remove residue from seed production to allow clover to grow back faster.

Pasture

Good management increases yield and stand longevity when red clover is used in a pasture. Grass-legume pastures require rotational grazing to maintain the legume portion of the stand. Rotational grazing improves both yield, by allowing growth during a rest period, and utilization of forage, by encouraging cattle to eat both legume and grass. Under continual grazing, cattle will preferentially graze the legume in the stand until it dies out leaving a grass pasture.

Begin grazing established stands in the spring when plants are about 6 inches tall. Use a rotational or intensive grazing system to rest pastures. Harvest pastures for hay if 10% of the tillers are blooming and the pastures cannot be stocked with animals. This will keep pastures from getting overly mature for good animal performance while providing forage reserves for periods of low pasture growth.

Lime and Soil Fertility Needs

Fertilizer needs can be best determined by soil testing. Soil testing predicts in advance of growing the crop whether more nutrients are needed. Other diagnostic methods, such as observation of deficiency symptoms or plant tissue analysis, are useful for problem solving, but often result in loss of yield and quality before the fertilizer need is determined.

Responses to Lime

Several north-central Wisconsin experiments have shown that red clover out-performs alfalfa markedly under very acid conditions (pH <5.5). Red clover also responds to lime to at least pH 6.3 as shown in figure 2 where both alfalfa and red clover were grown at the Marshfield Research Station for two hay years at different soil pH's. Both species tended to produce higher yields at soil pH levels above 6.0, but increases were greater for alfalfa. Similar increases were also seen in protein content. Red clover stand counts from these and other experiments have shown that stand vigor and persistence are improved by liming to raise soil pH to 5.8 or above.

Some northern Wisconsin farmers substitute red clover for alfalfa in crop rotations instead of following the suggested liming program for alfalfa. However, it is clearly profitable to lime red clover fields to a pH of 6.0 to 6.3.

Phosphorus and Potassium Requirements

Red clover uses soil or topdressed phosphorus or potassium more efficiently than alfalfa. This is due to red clover's more extensive surface rooting system. Minimum recommended soil test levels for red clover (see table 1 on the following page) are generally lower than those recommended for alfalfa. When soil test levels are below these values, fertilizer will increase yield and stand persistence. Yield responses are less likely if soil test levels are above the values in table 1, and less fertilizer is recommended. However where stand persistence is of primary importance, apply some topdressed potassium (about 60 lbs/a K_2O) unless soil test values for potassium exceed 150 ppm.

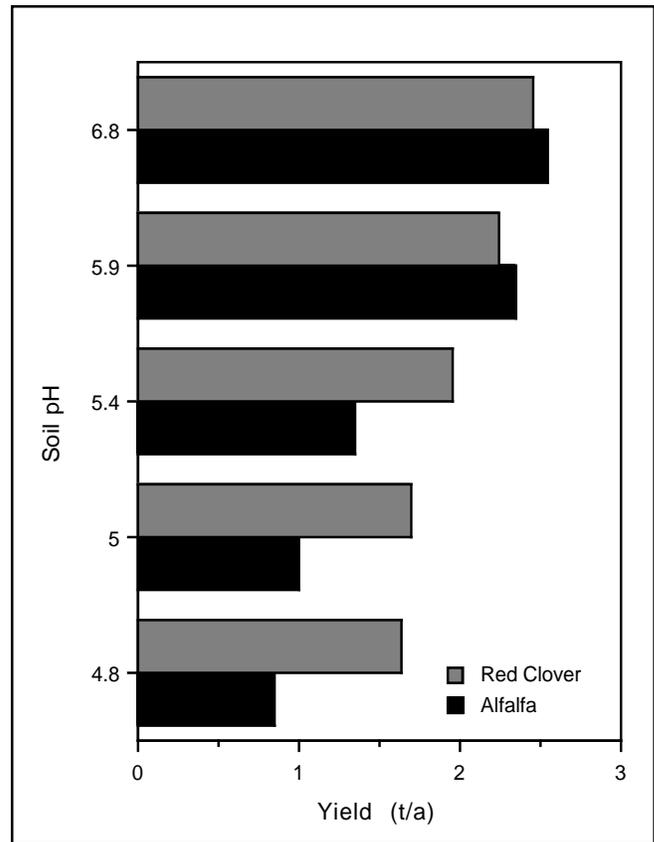


Figure 2. Effect of soil pH on alfalfa and red clover yields, Marshfield, WI 1980-1981.

Red clover removes 12-15 lbs of P_2O_5 and 50-60 lbs of K_2O per ton of dry matter harvested (see table 2). These amounts are similar to the nutrient removal of alfalfa. Fertilization at rates about equal to nutrient removal is recommended when soil tests are near those in table 1. Rates slightly above nutrient removal are profitable when soil tests are in the low and very low ranges. Table 3 shows the recommended nutrient applications for the various soil test level categories. Remember, these categories as shown for red clover are somewhat lower than they would be for alfalfa.

Critical levels of phosphorus and potassium in red clover tissue are slightly lower than those established for alfalfa (0.20-0.25% P and 1.75-2.25% K).

Sulfur and Micronutrients

Red clover has needs similar to alfalfa for sulfur and micronutrients except that its boron requirement is lower (manganese—low; copper—medium; zinc—low; boron—medium; molybdenum—medium). Red clover can also tolerate higher levels of manganese than alfalfa, permitting red clover to grow in north central Wisconsin's acid soils which are naturally high in manganese. Some studies have shown lower levels of sulfur in clover tissue as compared to alfalfa. Responses to a molybdenum seed treatment (2-4 oz/a) may be obtained where red clover is grown on very acid soils without lime additions.

Table 1. Minimum recommended Wisconsin soil test levels for red clover.

	Sands	Medium textured soils		
		Southern and western soils	Eastern red soils	Northern soils
Soil pH	6.2	6.2	6.2	6.2
Available phosphorus ^a , ppm	23-30	16-20	18-23	13-18
Exchangeable potassium ^a , ppm	56-70	61-80	56-70	71-90
Boron, ppm	1.0	1.5	1.5	1.5
Sulfur, soil index	40	40	40	40
Calcium, ppm	250	1,500	1,500	1,500
Magnesium, ppm	50	100	100	100

^a At these soil test levels, topdressed fertilizer should be applied at rates equal to anticipated nutrient removal.

Table 2. Nutrient removal by red clover at several yield levels.

Yield	Nutrient removal				
	P ₂ O ₅	K ₂ O	S	Ca	Mg
Tons/a dry matter	----- lb/a -----				
1.5-2.5	20	100	8	48	16
2.6-3.5	30	150	12	72	24
3.6-4.5	40	200	16	96	32
4.6-5.5	50	250	20	120	40

Table 3. Recommended fertilizer rates for red clover based on soil test categories and yield goals.

Yield goal	Soil test category ^a					
	VL ^b	L ^b	Optimum	H	VH	EH
Ton/a	----- Recommended nutrient applications (lb/a) -----					
	Phosphate (P ₂ O ₅)					
1.5-2.5	35-50	25-40	20	10	0	0
2.6-3.5	45-60	35-50	30	15	0	0
3.6-4.5	55-70	45-60	40	20	0	0
4.6-5.5	65-80	55-70	50	25	0	0
	Potash (K ₂ O)					
1.5-2.5	115-140	110-130	100	50	0	0
2.6-3.5	165-190	160-180	150	75	40	0
3.6-4.5	215-240	210-230	200	100	50	0
4.6-5.5	265-290	260-280	250	125	60	0

^a VL = very low; L = low; H = high; VH = very high; EH = excessively high.

^b Recommended rate varies according to soil buffering capacity with the higher amounts recommended on soils with high buffering capacities.

Weed Management

The best defense against weeds is a vigorously growing forage. Proper production and management practices will do most of what is needed to maintain a relatively weed free stand of red clover.

Before seeding a field you must kill quackgrass infestations. A fall application of Ranger or Roundup (glyphosate) prior to seeding the next spring works best. Fall applications to quackgrass 6 inches or more in height are preferred over spring treatments because they kill the quackgrass more effectively and allow earlier spring planting. To kill quackgrass in the spring, wait until early or mid-May when the quackgrass is growing and has significant leaf area to apply Ranger or Roundup.

Weeds are of special concern in the seeding year because they can out-compete the young seedlings and cause a thin stand. Weeds can be controlled by using companion crop, herbicides, and/or cutting management.

Use of a companion crop, such as oats, is the most common red clover establishment method in Wisconsin. The small grain usually displaces annual broadleaf weeds, such as common lambsquarters and pigweed, and grassy weeds like foxtail and barnyardgrass. If weeds become a problem in a companion crop seeding, harvesting the oats as silage removes both oat and weed competition to the red clover.

When solo-seeding red clover you may need herbicides to control weeds. However, very few products are registered for use in red clover. Table 4 summarizes the options available and describes the weeds controlled and relative crop safety.

Balan has been available for many years. It is very effective on annual grasses and safe to red clover. It does not control ragweed or velvetleaf. Use a disk or other suitable implement to thoroughly incorporate Balan into the soil surface before seeding.

Eptam has been more widely used than Balan. Even though it may cause early season injury, Eptam controls more broadleaf weeds than Balan. Do not use Eptam if atrazine residues are present. There is a synergistic reaction between Eptam and atrazine that may cause serious crop injury. Balan is a better choice where atrazine carryover may be a problem. Thoroughly incorporate the herbicide into the soil surface for adequate weed control.

The herbicide 2,4-DB has effectively controlled broadleaf weeds for many years. Until recently, there were several brands of 2,4-DB on the market; now only **Butyrac** remains. It is available as an amine or ester formulation. The amine is preferred in most situations. The biggest limitation with 2,4-DB use is the 60-day interval between spraying and harvest. Red clover seeded in early or mid-April and treated in early to mid-May can not legally be harvested until 60 days later, i.e., early to mid-July. Most red clover stands will be well into the flowering stage by this time and forage quality will be reduced. There are no indications that the harvest interval will be shortened.

MCPA has been available for over 25 years but has never been widely used because of potentially serious crop injury. MCPA may be appropriate for emergency or "rescue" treatments, but is not normally a first choice for broadleaf weed control in underseeded cereals. The weeds and small grain must form a protective canopy over the red clover and even then there is a significant risk of crop injury.

As the stand ages and thins, perennial weeds like quackgrass, yellow rocket, white cockle and dandelions will appear. No herbicides are registered for use in established red clover for perennial weed control. The best option is to rotate to another crop for one or more seasons and then re-establish red clover once the perennial weeds have been adequately suppressed.

Table 4. Characteristics of herbicides available for direct (solo) seeded and companion crop red clover establishment.

Herbicide	Seeding method ^a	Application time ^b	RATINGS ^c			
			Annual broadleaf weeds	Annual grasses	Perennial grasses	Crop safety
Balan	Solo	PPI	F-G	G-E	P	G
Eptam	Solo	PPI	F-G	G-E	F	F-G
Butyrac	Solo	Post	F-E	N	N	G
MCPA	Comp. Crop	Post	F-G	N	N	P-F

^a Comp. Crop = companion crop; Solo = red clover seeded alone

^b PPI = preplant incorporated; Post = postemergence

^c Ratings: N = none; P = poor; F = fair; G = good; E = excellent



Figure 3. Brown leaf blotches caused by anthracnose



Figure 4. "Shepherd's crook," dead shoot tops caused by severe anthracnose



Figure 5. Gray to white powdery layer typical of powdery mildew

Diseases

While numerous diseases may be present in red clover stands, northern anthracnose and powdery mildew are the two diseases most commonly responsible for stand and yield loss. The best defense against both diseases is use of resistant cultivars.

Northern Anthracnose

Northern anthracnose is one of the most important clover diseases in Wisconsin and can be very damaging during cool wet seasons, unless resistant varieties are grown. The first harvest is most severely affected. The disease first appears just before flowering in June and is noticeable all season. Both the stems and foliage may be attacked. Primary symptoms include brown sunken blotches and spots on stems and leaf petioles (figure 3). Cracking of stem tissue is common. On severely attacked plants, shoots and flower head often wilt and lop over, creating a "shepherd's crook" appearance (figure 4).

This disease is caused by a fungus called *Kabatella caulivora* (*Aureobasidium caulivorum*), which overwinters in diseased clover tissue. Fungal spores are produced in the spring and spread by rain.

Northern anthracnose of red clover should not be confused with alfalfa anthracnose. The two are different diseases caused by different organisms. Red clover is the only crop that is very susceptible to northern anthracnose. Several resistant cultivars are available. The level of resistance varies considerably among varieties. Rotations will reduce fungal inoculum and initially slow the disease.

Powdery Mildew

Plant leaves infected with powdery mildew show a gray to white powdery layer over the surface (figure 5), which is composed of the fungus, *Erysiphe polygoni*. Severely attacked foliage becomes yellow or brown, and often die. If plants are attacked while small, growth is reduced substantially.

Powdery mildew is favored by moderately dry weather, in contrast with most other diseases, and therefore occurs most frequently in late summer and early fall. Wind can move the fungal spores rapidly. With favorable conditions and susceptible varieties, powdery mildew can become epidemic and substantially reduce stand life, quality of forage, and, possibly, yield. Resistant cultivars are available.

Fusarium Root and Crown Rot

Root and crown disorders are also limiting factors in clover production, especially in older stands. Fungal attacks by soil-borne organisms are probably major contributors to stand losses that are associated with winter-damaged crops. *Fusarium* spp. are the primary organisms usually involved.

Roots may become completely rotted before the tops show symptoms (figure 6). Plants may become weakened through partial loss of the crowns or tap roots. Symptoms are somewhat variable, but the crown is usually more severely damaged than roots. Wounds caused by winter injury and mechanical damage probably contribute significantly to root and crown rot.

Control is limited. However, good cultural practices that encourage vigorous growth, e.g., proper fertilizing and harvesting practices, are beneficial.

Virus Diseases

A number of viruses can cause distinct mottling, distortion and mosaic patterns of clover foliage. These include bean yellow mosaic, alfalfa mosaic, red clover vein mosaic virus, and pea streak mosaic, among others.

Symptoms vary through the season. Sometimes they are "masked" or present in the plants but not causing symptoms, while at other times they cause typical virus symptoms including stunting. Considerable reduction in yield by viruses can occur.

Many viruses are seed-borne. Thus seed can serve as the primary source of virus. Several species of aphids also carry the viruses. Once infected, plants remain so, and serve as continuing sources of inoculum to infect other plants. A number of other crops, especially legumes, several vegetable crops, and some ornamentals, are attacked by one or more of these important viruses. Controls include selecting varieties resistant to viral diseases whenever possible and planting virus-free seed.

Sclerotinia Crown and Stem Rot

The fungus *Sclerotinia trifoliorum* attacks a number of legume crops, including clover and alfalfa (figure 7). This fungus, or a closely related species, also attacks many non-legume hosts. It is usually not serious on clover, but has caused considerable stand loss in some years, especially during 1988 and 1989.

On other crops it is often referred to as "white mold" disease because of a conspicuous, fluffy growth that sometimes occurs over infected tissue. Plants are infected in late summer and early fall. They survive the first harvest of the following season and then die. In Wisconsin, the crown and lower stems of red clover are usually attacked. Infected stems and leaves lose turgidity, and often collapse quickly. Usually individual plants are attacked, while patches of infected plants are evident in other instances. The best identifying feature of the disease is the hard, black sclerotia (dormant fungal mass) about the size and shape of a bean seed that is usually associated with the damaged tissue. Look for them embedded in the crowns or stems.



Figure 6. Brown root discoloration caused by fusarium



Figure 7. Dead plants in stand killed by sclerotinia

Resistance is not available to this disease. Control measures include plowing deeply to bury sclerotia, and maintaining a 3- to 4-year rotation with non-legume crops should help.

Blackpatch

This foliage and stem disease is usually not very visible in the field, but can cause a cattle feeding disorder called “slobbers.” Sheep, goats and other animals can be affected, too. Blackpatch is caused by the fungus *Rhizoctonia leguminicola*. The disease typically occurs in patches in the field during wet or humid weather combined with rather cool temperatures. Several other legumes, including alfalfa, are susceptible, but the “slobber factor” has not been reported from feeding the latter.

Infected foliage shows dark brown spots or lesions that have concentric rings. Look for a dark, coarse, aerial fungal growth (mycelium) adhering and growing over the surface of the affected plants. Seed losses of up to 50% have been reported in other states by this condition. It can cause flower heads to turn brown and shrivel, often resembling early maturity. Seedlings can be killed by the fungus.

The fungus produces no spores, but spreads from plant to plant via the fungal threads, and can be spread some distance mechanically. It is also seed transmitted.

Resistance is not available to this disease and no control measures are known.

Other Foliage and Stem Diseases

A number of fungi cause leaf and stem diseases that are common, but often not serious on red clover. These include target spot (*Stemphylium sarcinaeforme*), which causes irregular dark brown, sunken lesions that frequently show concentric rings. When abundant, target spot causes significant leaf drop, reducing protein levels considerably. Gray leaf spot (*Leptosphaeria pratensis*) causes spots with dark margins and lighter centers, often with dark fungal bodies embedded. Spring black stem (*Phoma trifolii*) and summer black stem (*Cercospora davisii*) may also occur. Few, if any of these diseases affect alfalfa, although the causal organisms are closely related and behave similarly to alfalfa foliage diseases.

Seedling Blights

Germinating seeds that fail to emerge, or young seedlings that collapse or have a rot of the lower stem and root tissue, may be caused by common soil-borne pathogens such as *Pythium*, *Rhizoctonia*, or *Fusarium*. Fortunately, red clover appears not to be susceptible to either *Aphanomyces* or *Phytophthora*, two water-mold fungi that are common in Wisconsin’s heavier soils, and which are often damaging to alfalfa stands. Resistance by red clover to these organisms is one reason for its usefulness in wetter soil sites. Red clover becomes resistant to the common damping-off causing organisms after the 4- or 5-leaf stage is reached.

Crop rotation is the only practical control measure.

Insects

Many insects will feed on red clover but few cause economic damage. The clover root curculio and clover root borer are the two major insect pests causing economic damage to red clover stands in Wisconsin.

For control suggestions, see extension bulletin A1981, *Forage and Small Grain Pest Management in Wisconsin*.

Clover Root Curculio

The adult is black to dark brown, has a blunt snout, and is approximately 1/8 inch long (figure 8). The eggs are laid on stems, the undersides of lower leaves, or on the soil surface. Larvae are small, white, fleshy, legless, slightly tapered grubs with a light-brown head. They are approximately 1/4 inch long when fully grown.

There is only one generation per year. The adult is probably the primary overwintering stage in Wisconsin, and survives under plant debris in alfalfa and clover fields, pastures and non-cropland areas. Young are born in the spring. Upon hatching, larvae move through soil cracks and other openings, to feed on plant roots (figure 9). Newly emerged larvae first feed on small rootlets and nodules, but move to the main root as they mature. Pupation and emergence of new adults occurs during July.

Adults chew small crescent-shaped notches in the edges of clover leaves. Unless adults are numerous, this damage is unimportant. The larvae feed on the roots, causing a pitting and scarring of the surface. This damage may contribute to general decline of the stand. No control suggestions have been established.



Figure 8. Adult clover root curculio



Figure 9. Pitted and scarred root surface caused by root curculio feeding



Figure 10. Clover leaf weevil larva



Figure 11. Adult clover leaf weevil

Clover Root Borer

Adults are dull black to dark brown, cylindrical, hard-bodied beetles that are about 1/10 inch long. The larvae are also 1/10 inch long, but are legless and white with a brown head capsule.

This pest overwinters in the roots of the infested plant, primarily in the adult stage, but also as a larva. In the spring the females deposit eggs in cavities chewed in the crown of the plant, in the sides of roots, or in tunnels already existing within the roots.

Larval feeding damages the roots, hindering nutrient and moisture transport and eventually causing death. Infested plants turn brown, wilt and die. Larvae chew grooves on the root surface and numerous tunnels within.

No control suggestions are available.

Clover Leaf Weevil

Clover leaf weevil larvae (figure 10) closely resemble alfalfa weevil larvae, except for being almost twice as large (about 1/2 inch long). The larva is a light green worm with a light yellow to white pinstripe down the middle of the back. Pupae are found in lace-like oval cocoons in plant debris on the soil surface. Adults are brown robust snout-beetles and are approximately 1/4 inch long (figure 11).

Adults can be found from July through late September in Wisconsin and eggs are laid in stems of clover plants. The egg is the overwintering stage, although a few protected larvae may be able to overwinter. The small, green larvae which hatch in the spring, feed on red clover leaves and mature in late May and June. There is one generation per year in Wisconsin.

Clover leaf weevil populations are low enough in Wisconsin that there are no recorded instances of damage progressing to the point that control has been warranted. In most years, a fungal disease kills the larvae. The feeding damage by larvae gives the leaves a ragged appearance, similar to alfalfa weevil damage to alfalfa. In regions of the United States where the clover leaf weevil is common, it is possible to find totally defoliated plants, particularly during cool springs that slow the rate of red clover development.

Potato Leafhopper

Potato leafhoppers are small, yellow-green, wedge-shaped insects that are approximately 1/8 inch long (figure 12). Nymphs closely resemble adults except for being wingless and smaller in size. Females lay eggs by inserting them into plant tissue.

Immigration of adults into Wisconsin from southern states normally begins in mid- to late-May. The adults lay eggs in fields of alfalfa, clover, potatoes, succulent beans, and numerous other cultivated and uncultivated crops. Depending on temperatures, the time of immigration, and other environmental factors, up to five overlapping generations may occur in Wisconsin.

Leafhoppers damage plants by sucking plant sap and injecting a plant toxin during feeding. There is also disruption of the plant's vascular tissues. Red clover shows less yellowing and stunting than infested alfalfa plants. Treatment thresholds have not been developed for red clover.



Figure 12. Potato leafhopper



Figure 13. Adult tarnished plant bug



Figure 14. Adult alfalfa plant bug

Plant Bugs (Tarnished and Alfalfa Plant Bugs)

Adult plant bugs range from 1/4 to 3/8 inch long (figures 13 and 14). They have flattened, oval bodies and may vary in color from plain yellow or green to tan or brown. Nymphs closely resemble the adults, except that they are smaller and lack wings. When first hatched they are pale green but become darker in color once feeding begins.

Two generations are known to occur per year in Wisconsin. The alfalfa plant bug overwinters in the egg stage, while tarnished plant bugs overwinter as adults. Eggs are inserted into plant tissue and take 7-10 days to hatch at normal summer temperatures. The entire life cycle takes from three to seven weeks, depending on temperatures.

Although plant bugs can stunt plants and distort leaf tissue by feeding on plant tissue with their piercing-sucking mouthparts, this injury is not believed to be significant in red clover. Plant bugs probably are of greater importance in seed production where feeding can cause blasting of flowers or seeds. Although no treatment thresholds are available for this crop, research on other crops suggests that approximately 5 plant bugs per sweep of an insect sampling net will cause economic injury in red clover seed production.

Clover Seed Chalcid

The adult is an active shiny black wasp-like insect that is only 1/15 of an inch long. Because of this small size they are often overlooked during routine sweep sampling of red clover fields.

The clover seed chalcid spends the winter as a full-grown larva in infested clover seeds on the soil surface. Adults emerge in late May and June in southern Wisconsin, later in the north. Adults of the first generation can be numerous.

The female pushes her eggs into the soft, immature seeds of clover. These eggs hatch into white maggot-like larvae that feed within the seed. Larvae will complete their growth in two weeks or more, depending on the weather. Because the overwintered adults emerge over a long period, first-generation larvae also occur over a long period. Upon becoming full-grown they pupate inside the seed either in the red clover flower head or in seed dropped to the ground. The adults emerge during midsummer and lay eggs for the second generation. These generations probably overlap.

The seed chalcid is a threat only to seed production. It can be significant in some years. Damage usually goes unnoticed until poor yields are noted at seed harvest. Seeds will be broken or cracked open, and threshed seed will contain many empty seeds, or parts of seed coats.

Control is difficult. Insecticides seldom control most seed chalcids and overuse of insecticides can kill the insects that are parasites on chalcids, leading to increased seed damage. Manipulation of clover growth by hay harvest to allow blossoming during periods of low adult chalcid activity may be the most reliable technique.

Meadow Spittlebug

Adults are wedge-shaped, usually mottled brown to cream, and approximately 1/4 inch long. The eggs are small, light yellow to white, and laid in rows on plant stubble. Nymphs (immatures) are soft-bodied, yellow-orange to green, and usually enclosed in a frothy mass.

There is one generation per year in Wisconsin, and overwintering takes place in the egg stage. Upon hatching, the young nymphs immediately secrete a frothy mass to surround themselves and the portion of the plant upon which they are feeding. One to several nymphs can be found within each mass. Adults begin to appear in late June to early July. Egg laying takes place during late summer and early fall.

When abundant, nymphs stunt the plant by sucking plant sap. Chemical control is not profitable at populations of less than one nymph per stem.

Grasshoppers

Several species of grasshoppers are frequently found in red clover. Adults are generally 1 to 1-1/2 inches long and have yellow, brown, black to reddish brown markings, depending upon the species. Except for being wingless, the nymphs resemble the adults. Eggs are laid in masses shaped like a pod, in the soil of uncultivated areas.

Depending upon the species, eggs hatch from late June through July, and nymphs and adults may be found throughout most of the summer. Egg laying takes place during September and October.

Grasshoppers typically feed from the outer edge of red clover leaves, and may result in substantial defoliation during years when large numbers occur. Dry weather favors grasshopper population booms. Treatment is not suggested unless populations reach 20/yard² in field margins or 8/yard² within clover fields.

Utilization

Red clover can be harvested and used as dry hay or low moisture silage for dairy, beef, and sheep production. Due to its relatively slow drying rate, most red clover is harvested as low moisture silage. Ensiling techniques are similar to those used for other legumes with optimum fermentation and preservation occurring when red clover is ensiled at 50-60% moisture.

Research and observation at the University of Wisconsin Marshfield and Ashland Agricultural Research Stations indicate excellent animal performance when dairy cattle are fed red clover as the sole forage. Dairy cattle research trials directly comparing red clover and alfalfa silage, found no appreciable differences in milk, fat, and protein production. These studies confirm laboratory analyses that red clover and alfalfa have about the same nutritional qualities.

Because of the comparable forage quality to alfalfa, the recommended mineral, vitamin, and protein supplementation programs are similar. For dairy cattle, mineral supplementation with a high quality 1:1 Ca:P mineral is generally recommended. Protein fractions in red clover are somewhat less degradable in the rumen than comparable alfalfa, therefore emphasis on supplemental by-pass protein may be less critical. However, all dairy cattle diets should be evaluated for quantity and quality of protein regardless of forage source.

Red clover also performs similar to alfalfa in dry cow rations. Dry cows should not receive 100% red clover due to its relatively high (>1.0%) calcium levels. Excessive calcium in the dry cow diet (>100 grams/day) increases the incidence of milk fever and related metabolic problems. Both high and poor quality red clover can serve as roughage sources for replacement heifers. Forage quality should be analyzed and appropriate diets should be formulated to support average daily gains of 1.6-1.8 lbs/day. There appears to be no age limitations associated with properly harvested and stored red clover in replacement heifer diets.

Red clover infected with black patch disease has been found to occasionally contain the toxic alkaloid, slaframine. Symptoms of slaframine poisoning in cattle include excessive salivation, bloat, frequent urination and diarrhea. Clinical cases of slaframine poisoning are extremely rare in Wisconsin and proper harvesting and storage techniques have virtually eliminated potential problems. The disease has been reported less than 10 times in Wisconsin during the last 20 years (all from hay).

Cattle consuming large amounts of red clover may exhibit darker fecal output. While exact causes are not fully understood, this change does not alter animal performance or influence animal health.

As with all forages, livestock species respond favorably to increasing forage quality in red clover. Proper harvest and storage management are critical to the efficient utilization of red clover and in obtaining the highest profit per acre.

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