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Birdsfoot trefoil for grazing and harvested forage

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Birdsfoot trefoil (*Lotus corniculatus* L.) is a perennial legume that is well adapted to the north-central states. Individual plants can be long-lived in northern states, but typically live only two years in central and southern states. Stands may last much longer due to reseeding. It is primarily used for pasture but can also serve as a hay crop in areas where poorly drained, acidic soils make alfalfa production difficult. Trefoil tolerates poorly drained soils but will not survive in areas where standing water persists in summer or ice sheets form in winter. Its branched, relatively shallow taproot makes it less drought tolerant than alfalfa. Unlike most legumes, trefoil does not cause bloat in grazing animals. That factor, combined with high forage quality, excellent grazing tolerance, natural reseeding capability, and the potential for a long stand life, make it an ideal pasture legume.

Mature plant height varies from 12 to 30 inches depending on the variety and the degree of support provided by grasses or other more upright species included in the stand. Birdsfoot trefoil plants are fine-stemmed and tend to lodge easily. Each leaf has five leaf-like stipules, three attached at the end of the petiole and two attached at its base. Plants produce many bright yellow to orange-yellow flowers in clusters of two to eight. Each flower can produce a slender seedpod about 1-inch long which turns tan to dark-brown as the pod matures. The pods radiate away from the flower stalk like the toes on a bird's foot; hence the name. Birdsfoot trefoil requires a day length of about 16 hours to initiate flowering. Plants continue to flower over 3 to 8 weeks until fall. The ripened pods shatter, naturally dispersing the seed.

Variety selection

Birdsfoot trefoil varieties used in the north-central states can be categorized into three general groups: (1) the prostrate or grazing type represented by varieties such as AU-Dewey, Dawn, Empire, Fergus, and Leo; (2) the erect or hay type which includes the varieties Georgia-1, Maitland, and Viking; and (3) the semi-erect type with varieties such as Mackinaw and Norcen. The prostrate type of

trefoil is particularly suited for prolonged grazing because of its low profile. However, all the varieties listed here can be used for grazing. The erect types better suit hay, haylage, and green-chop production. They begin spring growth and flowering earlier than prostrate types, but are less winterhardy in northern states.

Empire and Viking, the first commercial varieties released in the United States, were developed in New York in the 1930s. While both varieties are still available, look for newer varieties with improved seedling vigor and resistance to diseases (see table 1 for variety characteristics). For example, Dawn was selected from Empire, but has improved resistance to root and crown diseases; Maitland and Mackinaw were selected for improved seedling vigor; Leo was developed with a high degree of winterhardiness; Norcen was developed with a diverse genetic background to broaden its adaption to conditions found in the north-central states; Georgia-1 was selected for tolerance to acid soils; and AU-Dewey and Fergus were

Table 1. Characteristics of selected birdsfoot trefoil varieties

Variety	Origin	Plant type[a]	Winterhardiness[b]	Performance
***AU-Dewey**	Auburn University	semi-erect	low to moderate	adapted to southeastern states
***Carroll**	Iowa State University	semi-erect to erect; matures earlier than Empire	high	excellent seedling vigor; yields are as good as or better than Empire
***Dawn**	Agricultural Research Service/USDA, University of Missouri	semi-erect; fine stemmed; late maturity	moderate to high	good yields; excellent fall growth; good grazing tolerance; adapted to southern Corn Belt
Empire	Cornell University	prostrate; fine stemmed; late maturity	high	good tolerance to grazing; adapted to wetter soils; harder to establish than Viking
***Fergus**	University of Kentucky	semi-erect; matures earlier than Empire	moderate	adapted to southeastern states; good grazing tolerance
***Georgia-1**	University of Georgia	semi-erect; early maturity	moderate	adapted to southeastern states
Leo	MacDonald College, Canada	semi-erect to erect; matures slightly earlier than Empire	moderate to high	very good seedling vigor; yields are as good as Viking
***Mackinaw**	Soil Conservation Service, USDA	semi-erect; fine stemmed; late maturity	high	slightly better seedling vigor than Empire; yields are better than Empire—similar to Norcen and Viking
Maitland	University of Guelph, Canada	erect; hay type	moderate to high	above-average seedling vigor; yields slightly less than Viking
Norcen	North Central States	semi-erect to erect; matures midway between Viking and Empire	high	good yields; best winterhardiness
Viking	Cornell University	erect; hay type; earliest maturity	moderate	excellent seedling vigor; good yields; good regrowth

*Proprietary variety

[a]This table compares variety maturity against Viking and Empire, the maturity extremes. Viking matures about 10 days earlier than Empire; all others mature somewhere in between.

[b]Moderate to high winterhardiness is adequate for northern states.

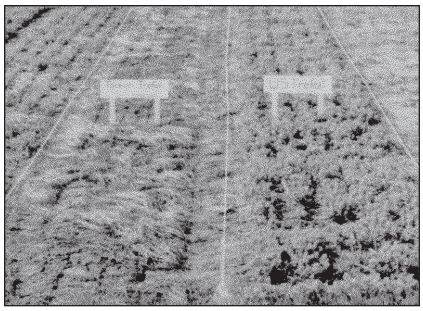


Figure 1. Trefoil from South America often has very poor winterhardiness.

Figure 2. Comparison of prostrate (left) and erect (right) varieties.

developed for persistence in humid pastures of the southern Corn Belt. New varieties being developed by plant breeders should improve establishment, disease resistance, and persistence.

Purchase certified seed to ensure that you are buying improved varieties. Imported trefoil seed has unpredictable performance. In particular, seed from South America often lacks winterhardiness. Use varieties recommended by your state Extension service for top persistence and yield.

Establishment and seeding year management

LIME AND FERTILIZER NEEDS

Fertility needs are best determined by soil testing. Apply lime and fertilizer according to soil test recommendations. Trefoil tolerates acid soils better than red clover or alfalfa, but benefits from liming the soil to a pH of at least 6.0. When lime is needed, apply 6 to 12 months before seeding and work it into the soil. If no-till seeding trefoil into sod, apply lime two years before seeding. Since this lime won't be incorporated, use the smallest particle size available—80 to 90 grade or finer. Select liming material based on the aglime neutralizing index.

Where soil nutrient levels are low, especially for phosphorus, apply fertilizer before seeding and incorporate the fertilizer with tillage. Research on trefoil fertility has not shown responses to broadcast or banded fertilizers at planting except for a small amount of nitrogen (about 30 lb/a) on soils with less than 2% organic matter.

Trefoil requires a specific strain of *Rhizobium* bacteria to fix nitrogen. To ensure the presence of the needed *Rhizobium*, purchase preinoculated seed or treat the seed using commercial inoculum available from seed dealers. Inoculum is critical on land where trefoil has never been grown before. If treating seed, use a sticker—an adhesive compound to attach the *Rhizobium* to the seed—and thoroughly mix inoculum and seed before seeding. If trefoil plants are yellow and lack vigor, check roots for small growths called nodules. The absence of nodules may indicate poor inoculation or excessively acid soils.

PURE STANDS

Pure trefoil stands can be grown for hay and used with pastures of other species to provide uniformly high-quality forage. Although pure stands offer high-quality forage and hay, they tend to thin out more rapidly than mixed stands, increasing weed problems.

The fall before planting a pure stand, control perennial weeds, such as quackgrass, using Roundup (glyphosate). In the spring, prepare a seedbed with appropriate tillage methods to provide a firm seedbed, free of weeds and clods. Then either apply a preplant-incorporated herbicide or seed without a herbicide and control weeds after trefoil emergence.

Plant when soil temperatures reach 50°F at a 4-inch depth. Seed at 8 lb/a into a conventionally tilled seedbed using a special forage-seeding drill, a broadcast seeder, or a grain drill equipped with a legume seeding attachment. If the seeding implement is not equipped with presswheels, use a cultipacker or roller after planting. When seed is sprayed or blown onto the surface of a prepared seedbed, cultipack to cover the seed and ensure good soil-seed contact to enhance germination and seedling growth.

Trefoil may be seeded with a small-grain companion crop (usually oats or barley) to prevent erosion and provide weed control. Use a relatively short small-grain variety and seed at 1 to 1.5 bu/a. The short-stature small grain and low seeding rate will reduce competition to the birdsfoot trefoil. Remove the companion crop by

grazing or machine harvesting when the small grain is in the boot stage. Control grazing carefully to minimize damage to the seedling trefoil plants. Monitor the stand for late-season weed growth (or regrowth of the oats) and clip if necessary.

On land where erosion is minimal, direct seeding with a preplant-incorporated herbicide is preferred. Seeding without a herbicide or companion crop should be limited to pastures or fields that have low weed pressure.

Several herbicide options are described below.

- *Balan (benefin)* is a preplant-incorporated herbicide that controls annual grasses and some annual broadleaf weeds. Balan must be incorporated to a depth of 2 to 3 inches. Incorporation may be delayed for up to eight hours, but prompt incorporation is best. Incorporate with a disk or other suitable implement and work in two different directions. Do not use Balan if planting forage grasses as they will be killed by Balan. Injury from Balan at recommended rates is generally not a problem.
- *Butyrac (2,4-DB)* is a post-emergence systemic herbicide that controls many annual broadleaf weeds but is weak on mustards and smartweed and will not control grasses. It partially suppresses perennial broadleaf weeds. Apply when seedling weeds are no more than 3 inches high. Correct timing is important as control is less effective on larger weeds. Check the label for specific rates according to weed species and size. Treated forage cannot be harvested or grazed for 60 days after application.
- *Eptam (EPTC)* is a preplant-incorporated herbicide that controls annual grasses and many broadleaf weeds. Eptam must be thoroughly incorporated to a depth of 2 to 3 inches. Incomplete incorporation may result in streaking which can cause trefoil injury or poor weed control. Incorporate with a disk or other suitable implement, working the field in two different directions. Do not use Eptam if planting forage grasses as they will be killed by Eptam.
- *Poast Plus (sethoxydim)* is a selective post-emergence systemic herbicide that controls most annual grasses present in trefoil. Apply when annual grasses are 3 to 8 inches tall. Grasses must be actively growing for best results. Poast Plus gives some suppression of quackgrass. It can also be used to kill an oat or barley cover crop once the crop is no longer needed for erosion control and weed displacement.

  Trefoil can be harvested 7 days after Poast Plus treatment if the forage is green chopped or ensiled and 20 days after treatment if harvested as dry hay. Use Poast Plus to control volunteer small-grain seedlings that emerge following wheat or oat harvest. Treat when cereals are 2 to 4 inches tall and before tillering has started.

  Poast Plus and 2,4-DB can be tank mixed and applied to newly seeded trefoil to treat a mixture of grass and broadleaf weeds. However, it is safer and more effective to apply 2,4-DB first and apply with Poast Plus 7 or more days later. With a tank mix, the possibility of crop injury increases because the oil concentrate increases 2,4-DB uptake. Use the rate of product as indicated for the weed species present. Do not use any additives other than the crop oil concentrate for this tank mix. Treated forage cannot be harvested or grazed for 60 days following the 2,4-DB application.

GRASS-TREFOIL AND LEGUME-TREFOIL MIXTURES

Birdsfoot trefoil is best seeded with a perennial companion grass which will use the nitrogen fixed by the trefoil and fill vacant areas in the stand where weeds would otherwise grow. Trefoil seedlings are small, slow to establish, and cannot tolerate much competition. Competition for light with the grass canopy is a major factor limiting successful birdsfoot trefoil establishment with grasses. Therefore, competition between trefoil and grasses or weeds must be controlled. Kentucky bluegrass and timothy are good companion crops because they grow more slowly than orchardgrass, smooth bromegrass, and tall fescue. The more aggressive grasses can result in uneven grazing and excessive competition but can be compatible with appropriate management. A small-grain companion crop (described in "Pure Stands") may be seeded with the grass-trefoil or legume-trefoil mixture to reduce the potential for erosion during establishment.

Table 2. Recommended seeding rates for grass-trefoil mixtures

Seeding mixtures	Rate (lb/a) of pure live seed[a]	
	Grass	Trefoil
Birdsfoot trefoil (pure stand)	—	8
Kentucky bluegrass	2	6
Orchardgrass	2	6
Smooth bromegrass	5	6
Tall fescue	4	6
Timothy	3.5	6

[a]Pure live seed = % germination x % purity

Seeding trefoil with other legumes is generally less desirable than mixing with grasses. Red clover and alfalfa are very competitive but could be used at low seeding rates. White and alsike clover might be desirable in a wildlife mix.

Keep the seeding mixtures simple. Table 2 suggests recommended seeding rates for various grass-trefoil mixtures. Plant seeds in a firm soil with good seed-soil contact as described above.

SEEDING METHOD FOR PASTURE IMPROVEMENT

No-till seeding into sod. For pasture renovation or for new seedings on sloping land subject to erosion, no-till techniques are generally used. Test soil and apply lime, if necessary, one to two years before seeding (apply lime earlier on heavier soils). Check the field for biennial and perennial broadleaf weeds, such as thistles, and control them with herbicides for at least two years before seeding. Productive stands can be no-till established by any of four methods:

- *Roundup (glyphosate)* is a non-selective herbicide that can be used to control existing vegetation. Treat fields in the fall prior to no-till seeding. Roundup is recommended where the sod is primarily highly competitive perennials such as quackgrass or smooth bromegrass. If applied in the spring, treat when grasses are 6 to 8 inches tall and wait at least three days after spraying Roundup before planting. Do not graze pastures treated with Roundup for 8 weeks after application.
- *Gramoxone Extra (paraquat)* is a contact herbicide and can be used on early season growth for temporary burn down. Treat only closely grazed or mowed pastures that are no more than 2 to 3 inches tall when sprayed. Bluegrass and other perennial species will recover in 3 to 5 weeks. Plant within 1 to 2 days after herbicide application using a no-till drill or grain drill heavy enough to place the seed ¼ to ½ inch deep. If grain drills are used, press wheels are recommended. Do not graze pastures treated with Gramoxone Extra for 6 weeks after herbicide application.
- *Overgraze or mow* in the late summer and fall prior to seeding to reduce competition from sod growth. In the spring, seed early and suppress sod growth by grazing after seeding but before trefoil emergence. Grazing must be intensive so that grass is as short as possible at seedling emergence.
- *Do a controlled burn of winter-killed residue* in late winter or early spring to effectively reduce early grass competition in established grass-trefoil in southern states of the north-central region. Prescribed burning temporarily injures and slows spring growth of the grass. Burning also reduces thatch and residue, encouraging the germination and establishment of new trefoil seedlings.

Frost seeding. This seeding method relies on repeated freezing and thawing to incorporate the seed into the soil. This low-cost method is less reliable than seeding with a drill. Research has shown that grass sod suppression is vital to successful frost seeding. This can be accomplished with several clippings or intensive rotational grazing the prior season. Seed in early spring when the ground is still frozen. Fall or overwinter seeding is often less effective than spring seeding due to the amount of seed eaten by wildlife and lost with runoff during thaws. Broadcast seed by any method including mixing seed with fertil-

izer. For improved trefoil stands, suppress grass growth after seeding using the methods described above for no-till seeding.

MANAGING GRASS COMPETITION

Managing competition from aggressive grasses by grazing or haying practices is key to successful establishment and retention of birdsfoot trefoil in mixed stands. These practices include early haying, early and close grazing, or intensive, rotational grazing. Graze birdsfoot trefoil stands in the seeding year whenever companion crops or regrowth of grasses in sod seedings reaches a height of 8 to 10 inches to prevent excessive competition. As table 3 indicates, cutting during establishment year or using a herbicide to control grass growth increased the trefoil yield in succeeding years. Not cutting, as many farmers do to "go easy on the new seeding" actually reduced trefoil in the stand due to competition from the grasses.

Grazing during the establishment year should be done quickly and intensively, being carefully controlled to prevent damage to the small trefoil seedlings.

Alternatively, mow or greenchop the companion crop or competitive grasses for forage if field conditions permit. Do not graze or clip after August 15 in the seeding year. Grazing after this date greatly reduces the stand's ability to overwinter.

Production management

FERTILIZER NEEDS

Research shows that soil test phosphorus of about 15 ppm (parts per million) and potassium of about 90 ppm appear adequate for average yield levels (2 to 3 t/a dry matter). These levels are lower than recommended for alfalfa but are similar to those for red clover. Where soil tests are below these levels annual broadcast application with phosphate and/or potash is recommended.

Harvested trefoil forage usually contains about 0.20 to 0.40% phosphorus and 1.50 to 3.20% potassium. Each ton of dry matter harvested removes about 15 pounds of phosphate (P_2O_5) and 55 to 60 pounds of potash (K_2O). These rates are similar to those for alfalfa.

Trefoil has a high requirement for sulfur, perhaps due to its ability to produce high protein levels. It also has a high requirement for boron, often showing deficiency symptoms when alfalfa does not.

Trefoil is apparently able to exclude some potentially toxic micronutrients. In acid soils (pH<6.0), trefoil has tissue concentrations of manganese, iron, and aluminum that are 50 to 60% less than the levels found in alfalfa grown under the same conditions.

Manure can be used to fertilize trefoil and will reduce the need for adding commercial fertilizer. It may be advantageous to harrow a pasture immediately following a grazing period to break up and spread the manure droppings. This also will reduce the uneven grazing that often occurs when animals avoid grazing lush plants growing near the manure. Harrowing is more beneficial at lower animal stocking rates (e.g., less than 30,000 lb animal weight per acre in paddock of rotation). Manure applied to supply phosphorus and potassium also contains nitrogen which is used by both the grasses and trefoil. Manure applications also will stimulate grasses in the stand and may introduce weeds.

ANIMAL PERFORMANCE

Birdsfoot trefoil is an ideal pasture species. Inclusion of trefoil improves both average daily gain and gain per acre (figure 3) compared to pure grass pastures. It has excellent feeding value, withstands grazing better than any other legume except white clover and annual lespedeza, can be very productive, and has the potential for a long stand life. Trefoil's excellent quality and the absence of

Table 3. Yield of frost-seeded red clover and birdsfoot trefoil during the second and third years of growth in Michigan[a]

	Hay yield (t/a)			
	Red clover		Birdsfoot trefoil	
Treatments	2nd year	3rd year	2nd year	3rd year
0 cuts	0.5	1.1	0.3	1.9
2 cuts	2.7	1.0	1.4	2.8
4 cuts	3.7	0.9	1.6	2.8
Herbicide	3.8	1.4	1.9	3.3

[a]Seeded into three grass swards that were suppressed with a herbicide or by cutting. Data averaged over three grass sods (smooth bromegrass, reed canarygrass and orchardgrass).

Source: Tesar, 1983

bloat potential, probably due to the presence of tannin compounds, make it a valuable legume for all animals, including grazing milk cows. Farmers occasionally report that livestock must first become accustomed to the taste of the plants before they will graze it readily, but consumption problems are not common.

Digestibility of trefoil is similar to alfalfa at comparable stages of maturity except that trefoil maintains high quality into later stages of flowering (figure 4). The levels of nitrogen, phosphorus, potassium, calcium, and other nutrient elements in birdsfoot trefoil forage are very similar to those in red clover and alfalfa. Early or mid-

Figure 3. Animal performance in Iowa and Wisconsin on birdsfoot trefoil pastures.

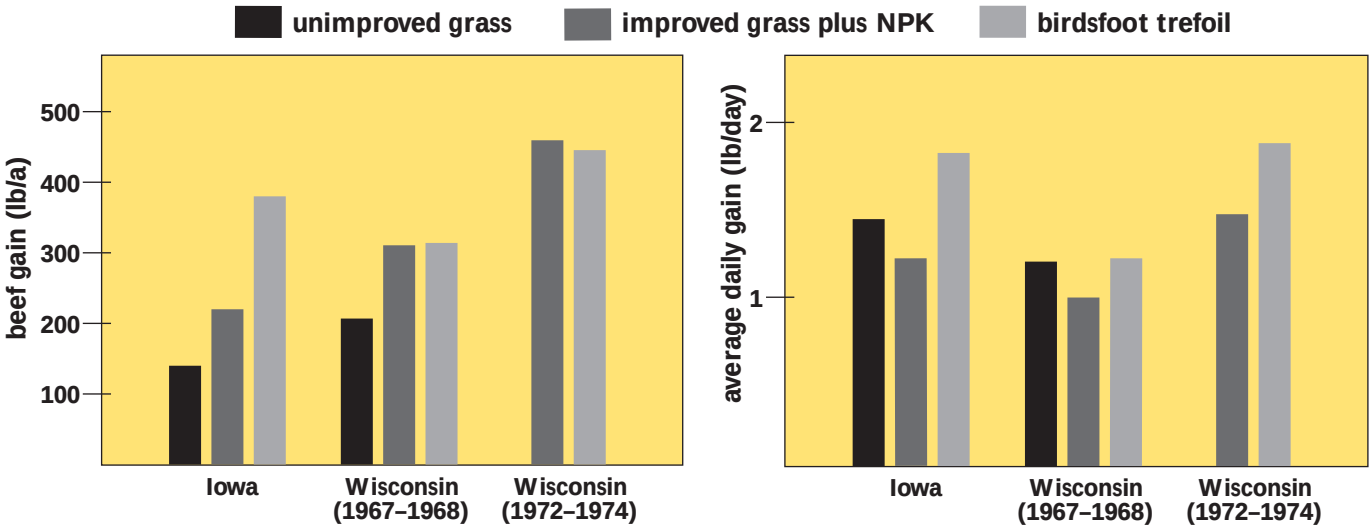


Figure 4. Comparison of *in vitro* digestibility of Viking birdsfoot trefoil and alfalfa during early and late season growth periods. *Source: Buxton, Hornstein, Wedin, and Marten, 1985.*

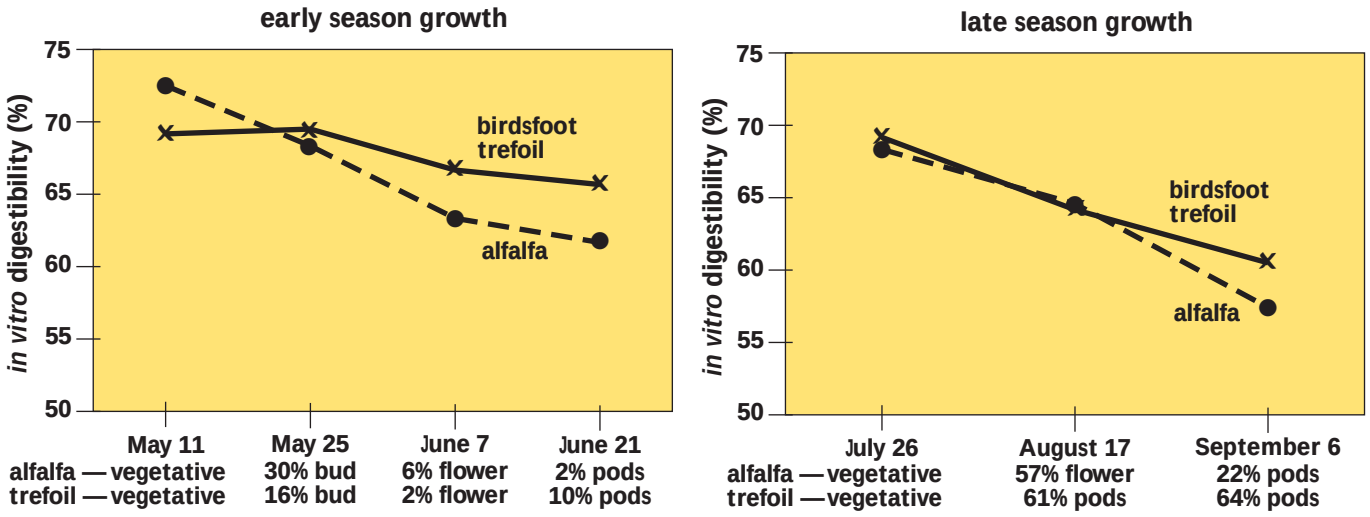


Figure 5. Dry matter yield and *in vitro* digestibility of trefoil harvested at different intervals at Griffin, Ga. *Source: Hoveland et al., 1990.*

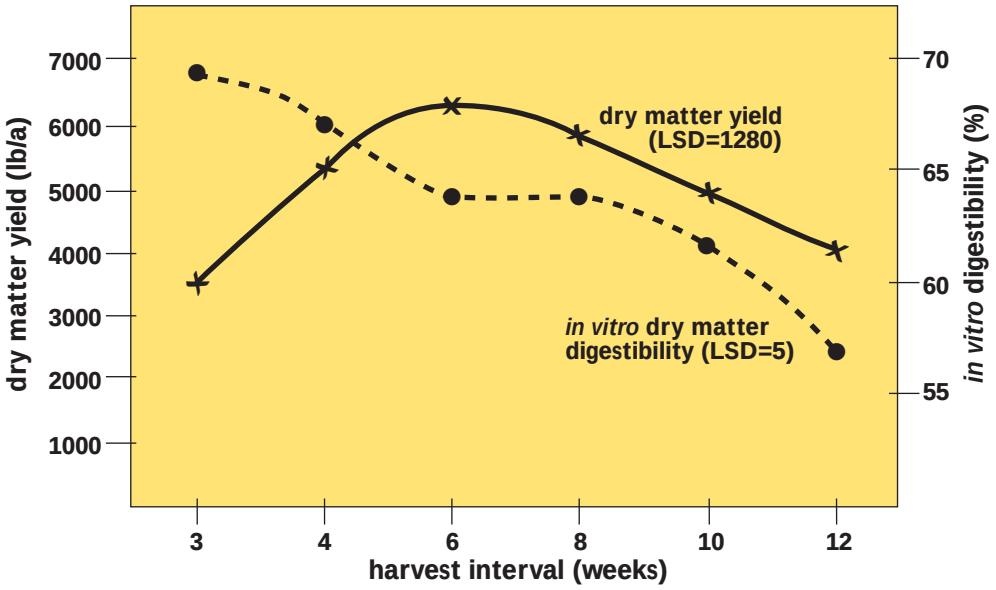
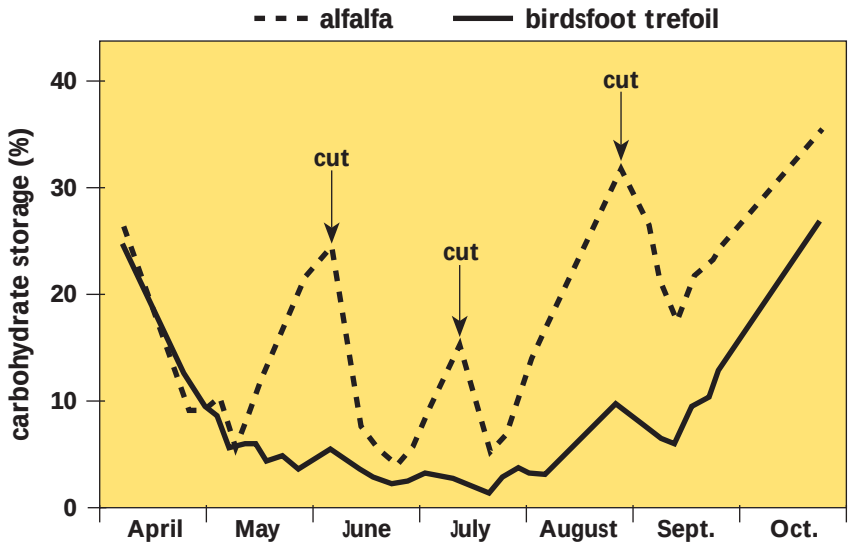


Figure 6. Comparison of carbohydrate storage in Empire birdsfoot trefoil and Vernal alfalfa in Iowa. *Source: Greub and Wedin, 1971.*



season trefoil stockpiled for late-summer grazing maintains a higher quality than most other species used for such a purpose. However, forage stockpiled for over 6 to 8 weeks may have greatly reduced yields and lower forage quality (figure 5).

GRAZING FOR STAND PERSISTENCE

Established trefoil, especially the semi-erect type, begins growth later in the spring than most alfalfa and clover varieties. Allow animals to graze pure stands when first flowers appear. Earlier grazing of pure stands reduces trefoil's growth potential for the remainder of the season. Graze mixed stands containing faster growing and earlier maturing grasses (such as Kentucky bluegrass or orchardgrass) first to maximize forage quality and control competition from the grasses. In fact, mixed stands may need to be grazed very early (through mid-May) to reduce rhizoctonia in birdsfoot trefoil and then allowed to flower and produce seed for reseeding.

Birdsfoot trefoil does not undergo a cyclic utilization and storage of root and crown carbohydrates as do alfalfa and clovers (figure 6) in northern states (though cyclic variation has been reported in Georgia). Trefoil stands benefit from leaving some stubble and residual leaf area after cutting, rotational grazing, or continuous grazing. Stands regrow significantly better from 3-inch stubble than from 1.5-inch stubble because regrowth comes only from axillary buds on the stems (table 4). Trefoil harvested at 3 inches has leaf area equal to approximately 40% of the ground area. That leaf area provides energy for faster regrowth than closer clipping or grazing. However, as shown in table 4, leaving a 4.5-inch stubble height did not increase the useable dry matter yield. Prostrate varieties may be grazed shorter, to 1.5- to 2-inch stubble height, because more stem length remains uneaten compared with the upright types.

While trefoil can be defoliated more frequently than alfalfa, studies show that trefoil yield decreases the more frequently it is harvested. Increasing the harvest interval from three weeks to six weeks increases forage yields, root weights, and the next season's growth potential. A fall rest period is critical to trefoil's ability to overwinter. Dry matter availability and forage quality must be balanced against the plant's need for food reserves stored in the fall. Trefoil may be even more sensitive than alfalfa to fall grazing because trefoil stores fewer carbohydrates, making it more vulnerable to severe winter injury. If you must graze after a killing frost or after the onset of plant dormancy, be sure to leave several inches of stubble for overwintering protection, especially in areas of little snow cover.

Various grazing systems allow trefoil to regrow and reseed. These range from frequent, incomplete defoliation under continuous grazing with low stocking rates, to intensive, carefully managed rotational grazing. Rotational grazing makes the most efficient use of the forage. Productive management systems carefully match stocking rate and grazing duration to the availability of forage which varies during the season due to rainfall, temperature, and sunlight conditions. Overgrazed trefoil will be unproductive for the remainder of the season and may be more susceptible to winter injury. When trefoil is severely defoliated during the warmer part of the summer it is more susceptible to root and crown rot diseases which can take a heavy toll on the stand.

To maintain a long-lived and productive stand, allow birdsfoot trefoil to flower and set seed at some point during the growing season. Reseeding is particularly important in years when the stand

Table 4. Regrowth yield of Empire birdsfoot trefoil defoliated to three stubble heights

Stubble height (inches)	Residual LAI[a]	Net dry matter yield (t/a) after 7 weeks regrowth	
		Early June	Mid-July
4.5	1.1	2.11*	0.83*
3.0	0.4	2.05*	0.78*
1.5	0.1	1.76	0.53

*Values within a column followed by an asterisk are not significantly different at P=.05.

[a]Residual LAI = leaf area index after cutting. LAI is expressed as units of leaf area per unit of land area.

Source: Greub and Wedin, 1971

needs to be thickened. The need is more frequent in the south where stands thin faster due to increased disease pressure.

In summary, graze pure birdsfoot trefoil stands two to three times annually with the first cycle beginning at first flower (or later if reseeding is desired) and with succeeding grazing cycles following in approximately 35 to 40 days. The last grazing should end in mid-August to rebuild root reserves for overwintering. Recommendations are the same for grass-legume mixtures except that an early, additional grazing (when grass is 6 to 8 inches tall) may be desirable to reduce early season competition and rhizoctonia prevalence.

HARVESTING FOR HAY

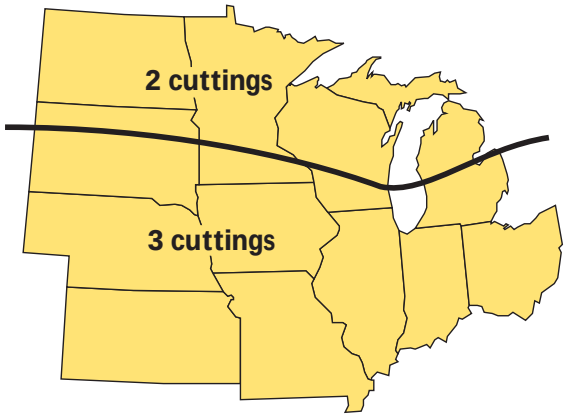
Trefoil can be harvested for hay or haylage. However, because trefoil yields less than alfalfa, it is grown for hay primarily on soils where alfalfa is poorly adapted. The management principles discussed earlier for grazing trefoil also apply to using it for hay. Harvest trefoil at early flower for optimum yield and quality. The main disadvantage for hay harvesting is the difficulty in getting it sufficiently dry to bale without excessive leaf shatter. Trefoil has small, thin leaflets which dry more rapidly than the stems, making timing of the baling even more critical than for other legumes to minimize shattering losses. Two cuttings should be possible north of the line shown in figure 7 and three cuttings elsewhere. Leave a 2- to 4-inch stubble height to enhance regrowth from the lower stems.

Weed management

Maintain a weed-free stand through proper grazing or harvesting management and through adequate fertilization and liming. However, even under good management, thistles, mullein, or other biennial or perennial broadleaf weeds may appear in pastures. Clip when the weeds are in the bud or early bloom stage. More than one clipping per season may be required.

Herbicide use in established stands is generally limited to spot treatment to control serious perennial weeds such as Canada thistle or brush. If quackgrass or annual grasses are a problem, use Poast Plus (sethoxydim) to suppress them. This treatment may be beneficial if the trefoil has been weakened by overgrazing, winter injury, or other stresses that allow grass weeds to encroach. Consult Extension publications in your state for specific weed management suggestions and grazing restriction information of herbicides.

Figure 7. Number of birdsfoot trefoil hay cuttings for the north central states.



Diseases

Fungal diseases appear to impose the most important limitations to birdsfoot trefoil adaptation and persistence. It can behave as a long-lived perennial in the northern north-central states, but can act more like a biennial when grown in the southern states. The lack of persistence appears to be mainly due to a disease complex commonly referred to as a root and crown rot.

Foliar and stem diseases. Many fungal pathogens can affect the foliage and stems of trefoil. These pathogens include species of *Stemphylium*, *Rhizoctonia*, *Phomopsis*, *Uromyces*, *Curvularia,* and *Diaporthe*. Of these, *Stemphylium loti* and *Rhizoctonia solani* can cause extensive losses of foliage and entire shoots, particularly in warm and humid regions. Symptoms of infection by *S. loti* consist of reddish-brown lesions on leaflets and cankers on stems. Infected leaflets commonly drop from the plant prematurely. Plants infected by *R. solani* have blighted leaflets and stems. No chemical controls are available for these diseases, however, losses can be minimized by grazing or harvesting before severe defoliation occurs. Additionally, because lower leaves are affected most severely by these pathogens, time grazing and harvesting carefully to maximize the amount of healthy foliage remaining on stubble which will contribute to plant regrowth.

Root and crown rot. The first symptom of root rot infection is the failure of plants to resume growth after harvest. Root decay usually begins within an inch of the soil line, with the color of the infected tissue varying from tan to reddish brown or black. Tissues are usually infected by combinations of plant pathogenic fungi including species of *Fusarium, Mycoleptodiscus, Pyrenochaeta, Rhizoctonia,* or others. Environmental factors affect the incidence and severity of root and crown rot. These factors include soil moisture, drainage, air and soil temperature, nutrients, stand density, crop rotation, frequency and height of cutting, insect injury, and previous invasion by viruses and nematodes. The effects of these diseases can be reduced by management practices that allow for reseeding.

Root-lesion nematode (*Pratylenchus penetrans*). This parasitic nematode is a microscopic worm that feeds on root hairs, feeder roots, and nitrogen-fixing nodules on legumes. It is a severe pest of trefoil, especially on lighter soils. Root-lesion nematodes reduce the plant's ability to take up soil nutrients and fix nitrogen. Nematodes can cause stand establishment failures. When root-lesion nematodes and Fusarium are both present, they reduce yield and can cause stand loss.

Seedling diseases. *Pythium* species cause seedling diseases that can result in poor establishment of stands. Metalaxyl, formulated as Apron and applied as a seed treatment, is an effective fungicide for Pythium control.

Insects

FORAGE-PRODUCTION PESTS

Potato leafhopper is a potential pest of trefoil. Potato leafhoppers are mid- to late season pests that migrate north from southern areas. The small (⅛ inch), green, wedge-shaped insects move rapidly and are nearly impossible to see without first catching them in a sweep net. Leafhoppers suck sap from plants. Severely damaged plants may be stunted. Information regarding the effects of leafhopper feeding on the yield and quality of trefoil are limited. In a 1989 University of Wisconsin study, birdsfoot trefoil leaves did not show the classic "hopperburn" symptoms that were present on the leaves of alfalfa in adjacent plots. Adult potato leafhopper populations peaked approximately two weeks later in trefoil than in alfalfa, indicating slower development of leafhoppers feeding on trefoil. Populations were also higher in the alfalfa plots than in the trefoil plots.

Plant bugs. Plant bugs are sucking insects that feed on plant sap from various plant parts, including stems, buds, flowers, and developing seeds. Plant bug populations decline naturally between generations towards the end of July so the crop can often recover.

Adult alfalfa plant bugs are ⅜-inch long, light green, and have relatively long antennae which become wider and reddish-brown at the tip as the adult matures (figure 8). Nymphs are green with red eyes. Alfalfa plant bugs overwinter as eggs in trefoil and other plant stems. Nymphs appear around mid-May and adults are common by early July. There are two generations per year in the upper Midwest. The second cycle begins in mid-July, with adults laying eggs in September.

Tarnished plant bug (also called lygus bug) adults are ¼-inch long, brown to yellowish-brown, with a V-shaped marking in the middle of the back (figure 9). Nymphs are green with four to five black spots on the back. Tarnished plant bugs overwinter as adults in and around trefoil fields. There are two generations per year in the upper Midwest with the first generation of adults appearing in early May and the second in July. These plant bugs are most abundant in late July and early August.

Forage losses from plant bugs are seldom large enough to justify pesticide application.

Spittlebug nymphs are soft, orange or green bugs that can be found in white spittle masses in leaf axils and stems. Spittlebugs suck plant sap and excrete frothy and sticky masses. Spittlebug feeding can stunt plants, but seldom warrants control.

Grasshoppers feed on trefoil but seldom cause economic damage.

Figure 8. Alfalfa plant bug.

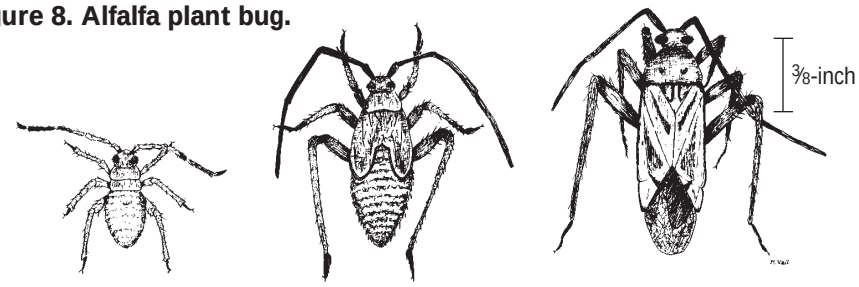
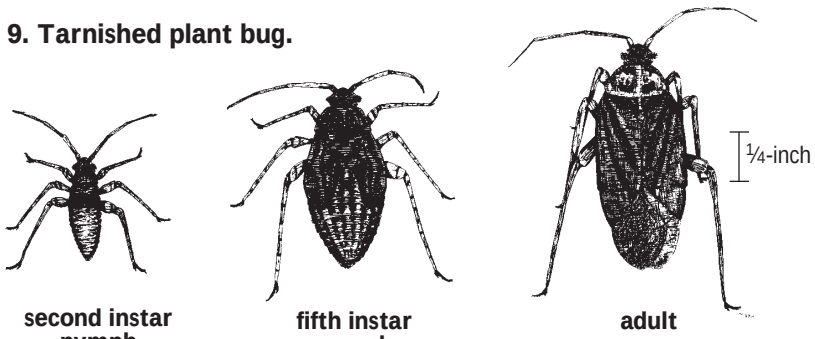


Figure 9. Tarnished plant bug.



SEED-PRODUCTION PESTS

Trefoil will normally produce more than adequate seed for natural reseeding. However, two kinds of insect pests reduce yield for commercial birdsfoot trefoil seed producers: plant bugs that feed on buds and developing seeds and the seed chalcid, a seed-feeding wasp.

Plant bugs. In addition to the alfalfa plant bug and the tarnished plant bug described above, the *Plagiognathus* plant bug can also cause seed losses. These adults are ⅛-inch long and light green. *Plagiognathus* (figure 10) is similar to the alfalfa plant bug, but smaller. The alfalfa plant bug and *Plagiognathus* overwinter in the egg stage in trefoil and other plant stems. Nymphs appear on trefoil around mid-May and adults are common by early July. Unlike the alfalfa plant bug, which has two generations per year, the *Plagiognathus* has only one generation per year. Adults usually lay eggs and die by August. Alfalfa and *Plagiognathus* plant bugs overwinter in trefoil stems and because of this they are often abundant during bud development.

Feeding by plant bugs causes buds and flowers to drop and seeds to shrivel. Bud blasting is the most serious type of injury produced. High populations can delay blossoming. However, because trefoil produces buds throughout the season, bud blasting early in the season does not necessarily reduce seed yield.

Scouting. Scout fields for plant bugs when trefoil is in the early bud stage. Use a standard 15-inch-diameter sweep net and take 5 groups of 20 sweeps for each 40 acres. Place the swept material in plastic bags and freeze them to kill insects. Too many bugs escape when counting takes place in the field. Calculate the plant bug equivalent (PBE) using the chart above and treat if the PBE exceeds 100 per 20 sweeps.

Control. Early spring burning substantially reduces levels of plant bugs. Burn stubble as soon as the snow melts and soil begins to dry. Be sure to obtain a burning permit and follow all safety guidelines. Spray when fields have more than 100 PBE per 20 sweeps. A single application during the bud stage will provide adequate plant bug control. Multiple applications do not provide additional protection and will harm natural enemies of plant bugs. Do not apply insecticides to blossoming fields to avoid killing honey bees.

Figure 10. *Plagiognathus* plant bug.

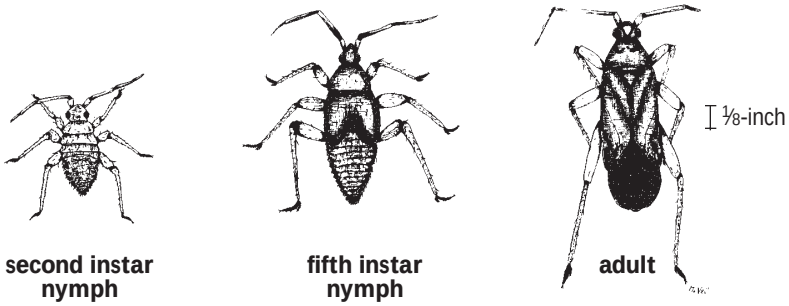


Table 5. Determining plant bug equivalents

Plant bugs	Count per 20 sweeps		Plant bug equivalents
1. Alfalfa plant bug nymphs	_____	x .75 =	_____
2. Tarnished plant bug nymphs	_____	x .75 =	_____
3. *Plagiognathus* nymphs	_____	x .50 =	_____
4. Alfalfa plant bug adults	_____	x .50 =	_____
5. Tarnished plant bug adults	_____	x .50 =	_____
6. *Plagiognathus* adults	_____	x .50 =	_____
Total plant bug equivalents (PBE) (add lines 1–6)			_____

Seed chalcid. The adult trefoil seed chalcid is a tiny black wasp, approximately 1/16 inch in length with a hump-backed appearance. The female lays eggs in developing seeds and one larva develops inside one seed. Larvae are white, legless grubs hidden inside trefoil seeds. Adults appear when trefoil pods become abundant, usually in mid-July. There are usually two generations of seed chalcids each year. The insect overwinters as a mature larva inside a hollowed-out trefoil seed.

Tiny holes in seed pods indicate that seed chalcids have emerged from seeds within the pod. The seed chalcid destroys the seed it uses as a host. Damage from this insect ranges from 1% to 40%. Seed fields that have been in production for many years are more likely to have higher seed chalcid levels than newer fields.

Control. Insecticides and spring burning are largely ineffective against seed chalcids. The following practices will minimize damage from this insect:

- Harvest as early as possible to avoid pod shattering and spread of infested seed.
- Harvest seed fields regardless of yield. Seed left in the field will result in higher levels of seed chalcid the next year.
- Burn or bury chaff and light seed.
- Destroy or clip roadside trefoil near seed fields.
- Apply insecticides for plant bugs when trefoil is in the early bud stage to avoid killing natural enemies of the seed chalcid.
- Make an early hay cutting to delay pod set. This practice will lessen the amount of infested seed, but it also may reduce seed yield.
- If seed chalcid damage is likely to be high because of several years of seed production, harvest hay for the entire growing season. Not allowing seed to set will break the cycle of the insects.

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NCR 474, Birdsfoot trefoil for grazing and harvested forage

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