Crop Profile for Alfalfa in Minnesota

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General Production Information

- Minnesota ranks 6th nationally in production of alfalfa hay; in 1997 the state contributed 5.4% to the total U. S. alfalfa hay production.[46]
- An average of 5,185,800 tons of hay is harvested from 1,505,000 acres annually.[28]
- Minnesota produces an average of 3.4 tons per acre per year; county averages range from 1.5–4.9 tons per acre.[28]
- 37.7% of Minnesota farms harvested alfalfa in 1997.[45]
- The price of alfalfa in the state is an average of $83.90/ton (range: $76-$98).[28]
- Alfalfa seed was harvested from 725 acres in 1997, yielding 36,870 pounds, an average of 50.9 lb./acre.[45]
- About two-thirds of growers use all the hay they produce on-farm. About one-third of alfalfa growers sell hay to end users such as dairies, cow/calf operations, or horse owners/operations.[17]
- Virtually all alfalfa in Minnesota is grown for hay; less than 0.5% of the total alfalfa acreage is harvested for seed.[45]

Production Regions

- Alfalfa is produced throughout most of Minnesota, but the heaviest production is in a band crossing the state from the northwest to the southeast.[45]
- The Central region leads the state in total alfalfa hay produced, followed closely by the Southeast region; these two regions combined usually account for almost 50% of Minnesota's total alfalfa hay production.The West Central and Northwest regions are the 3rd and 4th highest-producing regions, respectively;each of these regions contributes about 15% to the state's total

production.[28]

- The highest production per acre is found in Minnesota's southern and central regions, which average 3.8 tons per acre.[28]
- By geographic region, alfalfa production, in terms of average tons per acre, is as follows[28]: Southeast 3.9, South Central 3.8, Southwest 3.6, East Central 2.6, Central 3.5,West Central 3.2, Northeast 2.6, North Central 2.2, Northwest 2.5.
- Stearns County in the Central region and Otter Tail County in the West Central region lead the state in tons of alfalfa hay produced.The next highest ranked counties typically produce at about half of Stearns' or Otter Tail's level.[28,45]

Cultural Practices

Alfalfa (*Medicago sativa*)is grown on varying soil conditions, but a deep, well-drained soil is ideal, and is a critical factor in establishing a stand with optimum productivity.Well-drained soils promote a well-developed root system;they also reduce the conditions suitable for diseases, soil compaction, ice damage, and micronutrient toxicity.[12,44] Because alfalfa's root system can penetrate over 20 feet in good soils, it is very drought tolerant.[44] In Minnesota's soils, it is usually not necessary to irrigate[44] (although alfalfa responds well to irrigation due to the large water requirements of the crop[15]). Only 1.6 percent of Minnesota's alfalfa acreage is irrigated.[45] Once established, alfalfa stands remain in production for several years.About ¾ of alfalfa stands in Minnesota are 2-4 years old, and about 70% of growers reseed or plow under a stand when it is 3-5 years old.[41]

Alfalfa should be seeded on firm, smooth soil.Seed depth should be ¼ to ½ inch on clay and loam, and ½ to 1 inch on sandy soil.With good soils and equipment, seeding rates should be 12 – 15 lb./acre.[44] Alfalfa is usually seeded in the spring in Minnesota, ranging from April 15 in the extreme southern region to May 30 in the north.[44] A low percentage of acreage in Minnesota is seeded in late summer.[15] Reasons for seeding in late summer may include: more opportunities for perennial weed control, less annual weed pressure (especially grasses), more opportunity to prepare the proper seedbed, and a less busy time of year.[15] When late summer seeding is done, dates range from July 20 in northern areas through September 1 near the southern border.[44]

Alfalfa is commonly planted with a companion crop to help minimize erosion and weed pressure, provide additional forage, and provide additional income if grain is harvested.[44] Oats, flax, peas, and spring barley can be used, but oat is most commonly used.[20] In Minnesota, 80-85% of growers plant alfalfa with a companion crop; [38,41] in a 1995 survey, results indicate that 65% of these growers harvest the grain of the companion crop, and 26% chopped it during the vegetative stage.[41] In a 1992 survey, reasons cited for seeding with companion crops were production of silage, grain, or straw for livestock;

protection of alfalfa seedlings from weed encroachment; and reduction of wind or water borne soil erosion.[38] Of the portion of alfalfa not seeded with a companion crop, only a small portion is treated with herbicide.Preplant incorporated or postemergence herbicide options are available for alfalfa establishment if a companion crop is not seeded.The effects that companion crop plantings can have on alfalfa and weed density, and associated recommendations, are discussed in the Weed Pests section.

It is necessary to practice good soil fertility, including a liming program, for optimal alfalfa production. Test soil fertility prior to seeding and during the life of the stand, and apply appropriate rates of nutrients as needed.Soil tests are necessary because visual symptoms may not appear in the crop until nutrient deficiency has already caused significant yield loss.Fertilizer should be plowed down in the first year and topdressed in subsequent years.[12,44] Generally, nitrogen is added only at low levels (20-30 lb./ acre),[12,33,44] primarily in the year of seeding, and to coarse-textured soils.[33] Phosphate and potassium are both used heavily by alfalfa and are added as tests indicate.Potassium fertilization is more commonly needed in central, east central, and southern Minnesota.Sulfur may be applied at establishment, and in subsequent years of production on coarse soils, as soil tests indicate.Boron is the only micronutrient which may be needed in Minnesota soils; east-central and northeast Minnesota are the areas of the state which may be deficient in boron.When needed, boron may be applied every year.[33]

An adequate liming program is essential to alfalfa production.The pH level for optimum alfalfa stands is 6.7-6.9.If soil tests indicate a pH level below this range, the pH can be raised by adding lime to soils. Ideally, lime is added and plowed under at least 12 months prior to seeding; the best time is after a stand is plowed down.[12,44]

In stands which are in the first season of production (the seeding year), one fourth of growers take no cuttings, one quarter take one, one quarter take two, and one quarter take three cuttings.In established stands, a majority of Minnesota growers (about 70%) take three cuttings per year.About one-fourth take two cuttings per year, and a fourth cutting is taken by about 10% of growers.Most growers harvest alfalfa when the stand is at 10% bloom; if four cuttings are made, a greater percentage of growers harvest when the stand is at pre-bloom.Mid-August through mid-September is when almost all Minnesota growers take the last cutting of the season.[41]

Insect Pests

Alfalfa weevil, aphid, potato leafhopper, plant bug, spittlebug, and grasshopper are the most common pests of alfalfa in Minnesota.Blister beetle, clover leaf weevil, clover root curculio, and variegated cutworm are important but less common pests.Of these insects, alfalfa weevil, potato leafhopper, and clover root curculio periodically cause severe losses in Minnesota.The rest of the insects mentioned

cause losses, but they are less severe.[44] Additionally, alfalfa blotch leafminer is rapidly emerging as a pest in the state, but it's importance is stillbeing determined.[20]

There are some cultural controls used for insect control.In Minnesota, early cutting (first crop) is still used for alfalfa weevil control.[20] According to the National Alfalfa Assessment, in the North Central region of the U.S., 21.1% of acreage is burned (Missouri is one state which practices this), and resistant alfalfa varieties are used on 8.9% of acreage.[17] The primary target of resistant varieties is aphids; potato leafhopper is also the target of recent varietal selections.Resistant varieties are discussed in the aphids and potato leafhopper sections below.Cultural and biological controls specific to an insect pest are discussed in the following sections.Insecticide use is discussed in detail, following the insect pest section.

Alfalfa Weevil(Hypera postica [Gyllenhal])

Insect Description and Life Cycle:
Alfalfa weevil larvae emerge from eggs laid in the spring.Early instars are slate colored, and develop a bright green color and a white stripe down the middle of the back as they age.Larvae have a black head capsule.They will grow to about 3/8 inch in length.After feeding for 3-4 weeks, larvae spin loosely constructed cocoons on plants or in ground litter, and pupate into adults in 1-2 weeks.Adults are 1/4" long, have a long snout, and have a dark stripe down the back.They are light brown at emergence and darken in several days.Adults feed for a short time, then leave fields for grassy, brushy, weedy areas where they become inactive until fall. Weevil adults overwinter in these areas.In Minnesota, most eggs are laid in early May, and hatch in late May to early June. [12,23,44] Some larvae are present well into summer. [44] There is usually one generation per year.

Damage:
Most damage from Alfalfa Weevil is caused by the larval stage which feeds on leaves; damage ranges from pinholes to skeletonization of leaves.[12,23,44] Adults generally cause minor damage, mostly on the lower leaves and stems, although in severe cases adults can cause feathering of leaves.[12,44]

Occurrence:
Peak damage is usually just prior to the first cutting.[18,23,44] Serious damage can also occur shortly after the first cutting, as both larvae and adults feed on new growth;this can seriously reduce regrowth of the stand.[12,18,23,44] Peak feeding occurs from May through mid-June, although some larvae are present beyond this time.[44]

Also, cool, cloudy weather exacerbates damage done by the alfalfa weevil in two ways.Cool and cloudy weather conditions slow the regrowth rate of alfalfa, and also increase the daily feeding period of the weevil (both larvae and adults will hide under residue and will not actively feed during periods of strong

sunlight).[15,20]

Percentage of Acres Infested & Yield Loss:
Over one fourth of growers reported alfalfa weevil as a pest of their fields;about three-fourths of these growers estimated loss at 1-10%, about 10% estimated losses at 11-20%, and about 10% estimated severe losses of 41-80%.[41]

Critical Timing of Control Measures:
Weevil larvae can be found as early as May 1 in some years. Scouting typically begins in mid-May.It is critical to scout for live larvae and injured terminals on the first crop.Scout for larvae feeding on stubble of 2nd and 3rd crops.Sweep net sampling can detect insect presence;stem sampling should be used to establish accurate estimates.Post harvest, ground area sampling should be used on stubble.Fields should be treated when 35-40% (depending on the strength of the stand) of plant tips show signs of damage.[18,23,44]

Chemical Control:
In general, insecticides are recommended as a last resort and when losses will be significant, because cultural and biological controls can be very effective.Spraying is recommended if 40% tip feeding is found more than 7-10 days prior to planned harvest, or if infestations are severe and widespread enough that the grower cannot maintain control through cutting alone.Spraying may also be necessary if adults and larvae are found upon examination of stubble and debris 3-4 days after cutting, and 50% of stems have feeding injury.[23,44]

Carbofuran, chlorpyrifos, and permethrin are most commonly used, followed by methyl parathion, dimethoate, phosmet, malathion, and carbaryl.[17]

Biological Control:
There are several species of wasps that can be effective in maintaining weevil populations below economic threshold levels.Additionally, a fungal pathogen which attacks weevil larvae can control populations in several days.[13,23] These biological control agents are well-established in the state at self-sustaining populations; they are extremely effective control measures in all but major outbreak years.[15,20] The effectiveness of the fungal pathogen is highly dependent on high humidity. In Minnesota, weather conditions for the fungus are not always optimal.[13,23]

As growers become more aware of other insect pests (such as potato leafhopper), increased use of insecticides on the second and third crops may adversely affect populations of the natural enemies of alfalfa weevil, causing the weevil to become a much more important insect pest.[20]

Cultural Control:
Early harvest (first crop) is very effective in killing larvae, and is preferred to chemical control if the planned harvest is less than 7-10 days away.If harvesting is used to control alfalfa weevil, the stubble

and debris should be examined closely for adults and larvae, and stems should be examined for feeding signs.It may be necessary to spray stubble.[23,44] About 10% of Minnesota growers who responded to a survey cut their alfalfa early to control insects.[41]

Potato Leafhopper(Empoasca fabae [Harris])

Insect Description and Life Cycle:
Potato leafhopper adults are 1/8" long, wedge-shaped, winged, and green.Nymphs are similar in appearance, but are smaller, yellowish-green to fluorescent green, and wingless.[12,23,44] Potato leafhoppers migrate into Minnesota from southern states where they overwinter.[23,44] Timing of the first and subsequent arrivals to Minnesota is heavily dependent on weather patterns (i.e. winds and storm fronts from the south);the first typically arrive from May 1 to June 15.[18] Adults lay eggs in stems and leaf veins; eggs hatch in 6-9 days in mid-summer.[12] Each generation takes approximately 30-35 days to mature [23]; during summer, the life cycle can be significantly shortened.[15] We may experience 3-4 generations per year [23], and if weather conditions are favorable for migration, may also receive an influx of adults throughout the growing season.[20]

Damage:
Adults and nymphs both feed on alfalfa with piercing-sucking mouthparts, sucking plant sap and injecting a toxin into the plant.Damage is characteristic "hopper burn", which is a yellow wedge-shape area beginning at the tips of leaves.Leaves may eventually turn entirely yellow or reddish.Damage also appears as stunted plants.[12,23,44] Leafhoppers cause yield loss, reduced nutritional quality of alfalfa, and reduced plant vigor which results in increased winter kill and slower regrowth.[23]

Occurrence:
Potato leafhoppers can cause damage yearly throughout the state. The most consistent damage is done to solo seeded fields with or without the use of a herbicide for stand establishment.[15,20] In most years infestations are highest in July and August.[20]

Percentage of Acres Infested & Yield Loss:
About one third of growers reported potato leafhoppers as a pest of their fields;almost half of these growers estimated loss at 1-10%, about 30% estimated losses at 11-20%, about 20% estimated losses at 21-30%, and less than 10% estimated losses over 40%.One grower estimated losses of 71-80%. Growers estimated crop loss without controls is estimated at 10-80%.[41]

According to University of Minnesota experts, the potato leafhopper is the worst insect pest of alfalfa in the state, and can cause losses of 80% or more if not controlled.With control measures, losses are typically thought to be about 20%.Potato leafhoppers typically exceed economic thresholds in 8 of every 10 years in Minnesota. In 1999, Minnesota growers experienced the worst leafhopper outbreak in 20

years.[20]

Regional Differences:
Leafhoppers are a pest in the entire state. Any regional differences are initially only a function of gulf stream wind patterns in early spring, followed by local population establishment and redistribution.[15,20]

Critical Timing of Control Measures:
Leafhoppers are not generally a problem in the first crop in an established stand, but all subsequent crops will need to be monitored for infestation. The characteristic hopperburn will not appear until some yield and quality loss has occured [44], so it is important to scout for leafhoppers weekly on the second and subsequent crops.Scouting may be concluded 7-10 days prior to harvest.In spring planted seedling alfalfa, first growth is much more sensitive to leafhopper damage and should be closely monitored.[18]

Potato leafhopper economic thresholds are based on plant height. Scouting is accomplished by sweep net sampling.Control measures should be taken when these thresholds are reached: [18,20]

Average plant height	# adult leafhoppers/sweep
< 3 inches	0.3
3-7 inches	0.5
8-12 inches	1.0
> 12 inches	2.0

These potato leafhopper thresholds are based primarily on adult counts for two reasons: the sweep net is not the most accurate sampling method for nymphs, and much of the early research focused on adults. However, growers and consultants are also strongly encouraged to note the presence or absence of potato leafhopper nymphs; their presence is a good indication of an active local infestation.This information will alter the threshold recommendation for insecticide use.For example, if adult sweep counts are just below the threshold, and nymphs are present, an insecticide application is likely to be necessary.[20]

Chemical Control:
Chemical control of potato leafhopper is effective, but should not be used if harvest is within 7 days. Chemical control may also be necessary if, after cutting, sweeping regrowth results in counts above thresholds.[23]

Chlorpyrifos, carbofuran, dimethoate, and permethrin are commonly used, and provide good to very

good control.[17]

Biological Control:
Although a fungal pathogen and generalist insect predators attack the potato leafhopper, there are no natural enemies in Minnesota that consistently have a significant impact on population dynamics.[20]

Cultural Control:
Cutting will kill a large percentage nymphs, and will force adults out of the field.Cutting is the control of choice if thresholds are reached within 7 days of harvest.[23] Additionally, early harvest may be an alternative to insecticides when thresholds are reached in late August and thereafter;leafhopper numbers may begin to decline due to changing weather patterns and wind directions.[7]

Potato leafhopper is the target of recent varietal selections.Leafhopper-resistant (or "tolerant") varieties have focused on incorporating a morphological feature on alfalfa leaflets and stems (glandular hairs) that reduces the ability of the potato leafhopper to probe plant surfaces with its stylet, and also appears to increase nymph mortality.Small-plot field tests have shown significant reductions in plant injury and increased yields.However, more on-farm research is needed to ensure that these varieties perform well when leafhoppers do not have a choice to feed on standard, susceptible varieties.[20]

Aphids (Acyrthosiphon spp.)

Insect Description and Life Cycle:
Pea Aphids are soft-bodied insects of varying shades of green which are about 1/8" long.They may or may not be winged.In early spring, nymphs hatch from eggs which were laid in the fall; these aphids are all female.Females can reproduce without mating when conditions are favorable, and they do so in spring and summer.[12,23] The entire life cycle takes about 12 days.[12] Males appear in late summer, and mate with females to produce eggs capable of overwintering.[12,23]

Damage:
Aphids use piercing sucking mouthparts to remove plant sap, and prefer to feed on young growth.[12,23] Aphid feeding results in stunted and possibly wilting plants.[23,44] Damaged plants also turn yellow.[12]

New seedings more commonly experience damaging levels of aphid populations, since harvest is done less often than in established stands.[23]

Occurrence:
Pea aphid populations can increase rapidly when weather conditions are dry.[18] Additionally, aphid damage is more apparent in dry conditions, since they remove plant sap and cause wilting.[23,44] Aphids are typically a minor pest in Minnesota.[15,20]

Percentage of Acres Infested & Yield Loss:
Over one third of growers reported aphids as a pest of their fields;over three-fourths of these growers estimated loss at 1-10%, the rest estimated losses of 11-30%.[41]

Chemical Control:
Aphids are easily controlled with insecticides when they reach economic thresholds.[23] Most commonly used, and rated highly for efficacy are chlorpyrifos, dimethoate, and methyl parathion.[17]

Biological Control:
Pea aphids are a common pest of alfalfa, but in most years natural enemies keep aphid populations at levels which are not economically important.[18,23,44] Many natural enemies of pea aphids exist; common enemies in Minnesota are green lacewing larvae, damsel bugs, and parasitic wasps, both adult and larval states of lady beetles, and disease.It is useful to maintain natural populations of these species in the field.[23]

Cultural Control:
A frequent cutting schedule is very useful for preventing population explosions.If populations are at levels to warrant treatment and harvest is within 7 days, an early harvest is most appropriate control method.[23]

Some resistant varieties are used.[17]

Plant Bugs (Lygus spp. and Adelphocoris lineolatus)

Insect Description and Life Cycle:
Minnesota alfalfa is infested by three species of plant bugs: tarnished plant bug, alfalfa plant bug, and rapid plant bug; rapid plant bug is uncommon in the state.Currently all species are combined for purposes of scouting, thresholds, and control.[18]

Adult tarnished plant bugs are brown, winged, and ¼" long; nymphs are green, wingless, and third and subsequent instars have black spots.Adult alfalfa plant bugs are light green, winged, and 3/8" long; nymphs are green, wingless, and have red eyes.[23] Tarnished plant bug overwinters as adults; alfalfa plant bug overwinters as eggs in plant tissue.[23,44] Eggs are laid in plant tissue; during the growing season, the entire life cycle takes 21-49 days, depending on temperature.[12] There are two generations per year.

Damage:
Plant bugs suck sap from plants and leave toxic saliva in the plant.They cause leaves to crinkle, plants to be stunted, and flower buds to abort.[12,18,23]

Occurrence:
Plant bug populations do not usually reach significant levels until late May and early June.[18] Populations peak in late June to mid July and again in late August to early September.[23]

Percentage of Acres Infested & Yield Loss:
Plant bugs have typically been considered a pest of seed alfalfa; however, recent research from the University of Wisconsin indicates that plant bugs also contribute to forage yield reductions.[18]

Critical Timing of Control Measures:
Control measures are warranted when counts of plant bugs per sweep exceed 3 plant bugs on alfalfa less than 3 inches tall, and 5 plant bugs on larger alflafa.[23] If alfalfa plant bug is more common in the sweep nets, drop the threshold to 2-3/sweep.[18] Typically plant bugs are a pest of the second and third crops of the season.[20]

Chemical Control:

If thresholds are reached more than 7 days prior harvest, chemical control may be warranted.[23]

Carbofuran, chlorpyrifos, dimethoate, and methyl parathion are rated good to excellent for control of plant bugs.[17]

Cultural Control:
No varieties have resistance, and there are few natural enemies.Early harvest is an effective control measure if thresholds are reached within 7 days of harvest.[23]

<u>Meadow Spittlebug</u> (Philaenus spumarius [Linn])

Insect Description and Life Cycle:
Meadow Spittlebugs overwinter in masses of eggs in plant debris.[12] They hatch when weather becomes warm and humid, generally in early May.[12,23,44] Newly hatched nymphs are pale orange in color, are about 1 mm long, and as they mature they become yellow-green and then turn green.[12,23] The young nymphs need an immediate food source; when this is found, they form a white spittle mass in leaf axils and on new growth as they are feeding. Depending on conditions, the nymphal stage lasts from five to eight weeks.[12] Nymphs live in the moist environment of the spittle mass, and migrate little;they go through five instars before becoming winged adults.Adults are tan, brown, or grey in color, 3/8 inch long, and wedge-shaped.[12,23] There is one generation per year.[44]

Damage:

Spittlebug causes stunting in alfalfa, but not yellowing.[23,44] Nymphs suck sap from the plant;adults do not damage alfalfa.[12,23,44] Alfalfa can support very large populations of spittlebugs without incurring economically important yield reductions.[23,44] The heaviest damage is usually apparent in new stands and in stands established in small grain stubble.[12]

Occurrence:
Meadow Spittlebug is a common pest of alfalfa in Minnesota, but rarely reaches economically important levels.[44]

Percentage of Acres Infested & Yield Loss:
On average, a majority of the Minnesota acreage can be infested with meadow spittlebug.However, these populations rarely exceed economic thresholds.[20]

Chemical Control:
Treatment is not usually recommended until populations reach levels of one nymph per alfalfa stem, which is rare in the state.[23,44]

When treatment is justified, chlorpyrifos is rated most highly by experts for control.[17]

Grasshoppers (Melanoplus spp.)

Insect Description and Life Cycle:
There are 75-100 species of grasshoppers in this area;however, only five species are considered economic pests.[26] Grasshoppers overwinter in grassy and weedy areas as eggs or adults;[12,26,44] the economically important grasshoppers overwinter as eggs.Populations migrate into cultivated fields as their populations build through the season.Most egg laying occurs in late summer and fall in production areas;most species prefer uncultivated, grassy or weedy areas, and lay eggs ½-2½ inches below the soil surface.[26]

Damage:
Grasshoppers rarely cause economic damage in the state [12,44], and are considered a minor pest. Grasshopper nymphs and adults damage alfalfa by chewing on leaves from the margin inward in an irregular pattern.Attacks are often on new growth, but will occur on any stage.[12]

Occurrence:
Grasshopper infestations are more severe in warm and dry years.[26,44] Warm, dry weather immediately following egg hatch favor survival of nymphs, since nymphs are more susceptible to adverse conditions and cool, wet weather.[12,26] Long warm autumns prolong the egg-laying season, and result in heavier populations in the next growing season.It can take 3-5 years for populations to build to economically

important levels.[26]

Percentage of Acres Infested & Yield Loss:
One third of growers reported grasshoppers as a pest of their fields;most of these growers estimated loss at 1-10%, 13% estimated losses at 11-20%, and less than 10% estimated losses over 20%.[41]

Regional Differences:
The western and southwestern portions of the state are more likely to experience grasshopper problems, due to the lower average annual precipitation these regions receive.[15,20]

Critical Timing of Control Measures:
Scouting should begin in early May and continue through late June or early July.[26] Also, in the fall closely monitor areas where adults are congregating.In spring these areas should be scouted shortly after the spring egg hatch to detect overwintering areas with concentrated, high populations.These areas can then be treated when populations reach the thresholds outlined above to prevent migration.[12,44,45]

Chemical Control:
Insecticides are not recommended until grasshopper populations reach 8 per square yard within an alfalfa field, or 20 per square yard in field margins.[44]

Most used, and rated good to very good for efficacy, are (most used first) carbaryl, carbofuran, chlorpyrifos, methyl parathion, and malathion.[17]

Biological Control:
Nosema locusta, a sporazoan, is a disease-causing organism which occurs naturally but usually does not control grasshopper populations. When *N. locusta* is applied to bran baits and targeted against early occurring nymphs, the rates of infection can be dramatically increased. Higher infection rates are the results of grasshoppers cannibalizing when populations are high.*N. locusta* can also be transmitted through the egg to nymphs, impacting next year's population.*Beauveria bassiana* is another naturally occurring disease-causing organism and is available as a commercial product. It can be applied to baits to increase efficacy.Both are slow to act, expensive, and require specific conditions to become established.Thus, crop protection is non-existent until a sufficient percentage of the grasshoppers have become infected. Other species of fungi have been researched but none have been successfully released as commercial products.[26]

Nematodes and parasitic flies are both parasites of grasshoppers;[26] However, these are not available commercially for grasshopper control and are not used in the state for control.[15] Population control from natural rates of these parasites is extremely rare.[26]

Grasshoppers also are preyed upon by insects, birds and mammals.This is not effective in controlling population explosions, however, because these enemies are a natural part of the grasshopper's life

cycle.[26]

Cultural Control:
A vigorous, weed-free stand is helpful in keeping grasshopper populations low.[12] Production sites should be disturbed with tilling if possible, since grasshoppers prefer untilled, hard ground for egg laying.Tilling must be done prior to egg laying to be effective.Weeds should also be controlled in these areas to increase control.If nearby CRP land is cut for hay, leave 10-20 yard strips in the CRP uncut to prevent grasshoppers from moving into the alfalfa field.[26]

For More information:
http://www.ext.nodak.edu/extpubs/plantsci/pests/e272-1.htm

http://www.nwes.umn.edu/ent/gh98/hopper1.html

Blister Beetles (Epicauta spp.)

Insect Description and Life Cycle:
There are several species of blister beetles in the state which vary widely in size and color.The most common species in Minnesota during the 1980s was the black blister beetle (*E. pensylvanica*), which is black and about ¾ to 1 inch long.Other species are ashgray blister beetle, margined blister beetle, and striped blister beetle.[21] All blister beetles are recognized by the shape of their body, which is elongated, narrow, cylindrical, and soft.The area between the head and wings is distinctly narrower than the wings, and is usually narrower than the head.Most species have one generation per year, although some have two.Blister beetles overwinter as larvae.[12] The adults begin to emerge in late May, and populations peak in mid-August.[21]

Damage:
Blister beetles, in very high numbers, can sometimes cause stunting and ragged leaves.[12] However, the main concern is that their presence in alfalfa hay used for feed can cause sickness in cattle and sheep, and death in horses. Blister beetles contain cantharidin, which is a very stable, oily irritant that can blister internal and external body tissue.[21,44] Counts of 0.5–1 per sweep are high enough that the hay should not be sold for horse feed.[19]

Occurrence:
Blister Beetles are an occasional problem in Minnesota, and are most severe in dry years or the year following drought.Blister Beetle populations can become high where grasshopper infestations are high, because larvae feed on grasshopper eggs.[21,44] Populations also rise if alfalfa is allowed to mature beyond early bud to first flower stages, because adults feed on pollen and nectar.[19,21]

Percentage of Acres Infested & Yield Loss:
Yield losses due to blister beetle in Minnesota are insignificant. Although they rarely cause significant yield or other loss in alfalfa itself, they are a serious problem to animals, especially horses, when beetles (live or dead) are present in alfalfa hay.[12,21,44]

Chemical Control:
Sprays are effective in a closely monitored field in the sense that they can help prevent the population from reaching hazardous levels.While insecticides will control the population, some dead beetles may still be picked up with the alfalfa hay.[21,44] However, most beetles dying from insecticide treatment will usually fall, or crawl to the ground, and not get caught in harvested hay.[19,21]

If insecticide is used, alfalfa should be harvested as soon as possible after the pre-harvest interval expires, to get hay out of the field before it is re-infested.[19,21]

Carbaryl and malathion are most commonly used; their efficacy is rated by experts as very good.[17,21] Methyl parathion is also used, and is rated excellent.[17]

Alternatives to Controls:
When alfalfa hay is purchased for horses, it is recommended that during times of high infestation only first-crop and early second-crop hay is used.This will effectively limit the level of cantharidin in the hay.[21,44]

Cultural Control:
Fall plowing and cultivation may help blister beetle populations by disrupting the sites for grasshopper egg laying.Do not allow alfalfa to go beyond early bud and first flower bloom stages.Practice good weed management, as blister beetles are attracted to flowering plants of all types.During harvest, some species will swarm ahead of the harvester; allow beetles to disperse prior to continuing.Crimping and conditioning, as well as wheel traffic over cut hay, will kill more beetles; consider modified harvest methods to reduce these practices.[21]

Post harvest control:
Hay should be monitored for the presence of any number of blister beetles.However, there are no adequate sampling techniques to ensure hay is free of blister beetles.[21]

<u>Clover Root Curculio</u> (Sitona hispidula [Fabricius])

Insect Description and Life Cycle:
Eggs are laid in fall or spring, prior to mid-June, on the soil surface and lower parts of plants.Eggs hatch in the spring.White larvae, about ¼" long, move into the soil and feed on roots until they pupate.[12,23]

Pupae are found just below the soil surface.Adults emerge in June and July and live about one year.[23] Clover root curculios overwinter as mainly adults, but also as eggs.The adult is a brown or black blunt-snouted weevil about 1/8" long.[12,23] There is one generation per year. Adults migrate by crawling, and thus infest new areas.[23]

Damage:
The clover root curculio adults feed on alfalfa leaf margins, leaving crescent-shaped notches,[12,23] and chew on stems and leaf buds of seedlings.Seedlings may be stunted or die due to adult feeding;mature plants are less susceptible.[23] Most damage is done by the larvae.First larval instars feed on root nodules and lateral roots;later instars feed on the taproot,[12,23] leaving furrows on the surface.Feeding on the taproot can girdle the plant.[12,23]

Clover root curculio damage is believed to weaken the overall vigor of a stand; damage contributes to winter kill and increases the plant's susceptibility to disease.Even the low populations which are usually present contribute to stand decline.[23]

Occurrence:
Clover root curculio is usually present in small numbers.Severe damage occurs when populations reach high levels;these outbreaks are usually localized andsporadic.[23]

Percentage of Acres Infested & Yield Loss:
It is estimated that most alfalfa fields in the area harbor small populations of clover root curculio.High populations are sporadic and local.[23]

Critical Timing of Control Measures:
Currently there is no reliable chemical or biological method to control clover root curculio or to predict outbreaks.[23]

Cultural Control:
Do not plant alfalfa into a field which has previously been infested; clover root curculio is known to infest soybeans, clover, and bluegrass.Do not seed alfalfa next to established stands.[23]

Clover Leaf Weevil (Hypera punctata [Fabricius])

Insect Description and Life Cycle:
Adult clover leaf weevils are 5/8" long, dark brown with black flecks and tan stripes on the sides of wing covers.Young larvae are grey, and when full grown they are ½" long and bright green with a white stripe (sometimes edged in pink/red) down the back.Clover leaf weevil larvae have a brown head capsule and are slightly larger than alfalfa weevil larvae.[12,44]

Eggs are laid in late summer and fall and usually hatch in the fall.Most clover leaf weevil overwinter as larvae,[44] but they can overwinter as eggs or adults.[12] Larvae feed on alfalfa leaves through spring, then pupate in cocoons;adults emerge in early summer.[12,44] Both adults and larvae are active at night and on cloudy days, and hide in debris during sunny days.UP>Adults leave the field after the first cutting, then return in late summer to mate and lay eggs.There is one generation per year.[44]

Damage:
Damage is done by larvae, and, to a lesser extent, adults.Both feed on leaves, resulting in holes and skeletonization.Damage is similar to alfalfa weevil, but is usually much less severe.[12,44] Adults can cause significant damage just after the first cutting when populations are high.They will feed on and scar stems, and will destroy foliage as it emerges.Most damage is done prior to and just after the first cutting.[44]

Occurrence:
Clover leaf weevil larvae cause the most damage prior to the first cutting.Damage is more severe in dry springs when regrowth is slow.[44]

Percentage of Acres Infested & Yield Loss:
Less than 5% of growers reported clover leaf weevil as a pest of their fields;all reported estimated losses of less than 10%.[41]

Critical Timing of Control Measures:
Management of alfalfa weevil also controls clover leaf weevil;treatment is rarely recommended for larvae.[44]

Chemical Control:
If weevils are present, treatment should be considered if alfalfa does not begin to regrow 3-4 days after cutting.[44]

Variegated Cutworm (Peridroma saucia [Hűbner])

Insect Description and Life Cycle:
Larvae range in color from greenish-yellow to brownish-black, and have a row of yellow diamond-shaped spots down the back.Larvae are 1.5 to 2 inches long at maturity. The adult is a moth with grey or tan wings with dark mottling.[12,30,44] Pupae are ½-¾ inch long and are reddish-brown in color.[30] There are three to four generations per year.[12,44] Variegated cutworms overwinter in the pupal stage.[12]

Damage:

Variegated cutworm larvae feed on stems and leaves of plants, and can limit regrowth after harvest. Larvae will also cut the stems of seedlings.[12,30,44]

Occurrence:
Infestations are sporadic.[15,20]

Percentage of Acres Infested & Yield Loss:
About 5% of growers reported cutworms as a pest in their alfalfa fields.Of these growers, most estimated losses of 1-10% due to this pest.The maximum loss reported was in the range of 11-20%.[41]

Regional Differences:
Variegated cutworm is more common in the southern half of Minnesota.[20]

Critical Timing of Control Measures:
Treatment should be considered when alfalfa does not begin to regrow after 4-7 days and larvae are present.[23]

Chemical Control:
Chlorpyrifos, permethrin, and carbaryl are most commonly used and provide good early- to mid-season control. For mid- to late-season control, chlorpyrifos and carbaryl are used most commonly and provide very good control.[17]

Biological Control:
There are no options that we are aware of.[20]

Cultural Control:
There are no options that we are aware of.[20]

For More Information:
http://ipmwww.ncsu.edu/AG271/forages/variegated_cutworm.html

http://axp.ipm.ucdavis.edu/PMG/r1300911.html

Alfalfa Blotch Leafminer (Agromyza frontella)

Insect Description and Life Cycle:
The alfalfa blotch leafminer adult is a black fly about 1/8-inch long; it emerges from the pupal stage in which it overwinters in ground litter.Females pierce holes in the undersides of leaves, creating a conspicuous pinhole on leaflets.Males and females feed on fluids which seep from these pinholes, and

females deposit eggs via pinholes under the lower epidermis.[23,40,44] Yellowish maggots emerge in 5-10 days.These maggots feed within the leaf as they develop through three instars, forming a mine which develops into a characteristic comma-shaped blotch as the larvae mature.After feeding, the third instar exits the leaf and drops to the ground to pupate.[20,23,40,44] There are two to four generations per year in Minnesota.[47]

Alfalfa blotch leafminer is a new pest to Minnesota, but has rapidly invaded the state.The first infestation was reported in 1994, which is believed to have originated from Thunder Bay, Ontario, Canada.Since that time it has become established statewide, spreading at a rate of 58 miles (93 km) per year.[22,47]

Damage:
Damage includes pinholing, leaf mines, and leaf drop.[23] Wounded leaves may be more susceptible to diseases, especially spring black stem.[47]

Occurrence:
Because the pest is relatively new to the state and is still invading this area, typical occurrence patterns have not yet been established.Additionally, natural enemies of the alfalfa blotch leafminer are invading the area less rapidly, and will likely affect leafminer population dynamics as they become established.[47]

Percentage of Acres Infested & Yield Losses Attributed:
Damage, in terms of leaflets showing damage, in the state is currently about 20%. In Minnesota, pinholing may occur on about 50% of leaves; one adult female creates an average of 3,769 pinholes during her lifetime.In heavy infestations, 70% or more of leaflets may be affected by both larvae and adults.[47] Heavy infestations may lead to leaf drop, which would reduce forage quality, palatability, and yield.[23]

Actual yield loss attributable to alfalfa blotch leafminer in Minnesota is not yet clear, but is potentially significant.States with established infestations of this pest have an estimated 7% yield loss, and this may increase to 20%.A 7% yield loss would result in a statewide loss $36.3 million (based on production of 5,185,800 tons @ $100/ton).Additionally, protein content may be reduced 10-20%.[47]

Regional Differences:
Severe infestations seem to follow the invasion front by about 1 year.[47] There may be increased loss from this insect in southern Minnesota, where there is the possibility that alfalfa blotch leafminer may complete 3-5 generations per year, and cause economic damage on each cutting.[22]

Critical Timing of Control Measures:
If insecticides are used, they must be applied during the adult pinhole feeding stage.[23] Insecticides can significantly reduce adult populations for about 7 days.However, pinholing and larval mining activity will resume after the 7-day period.Furthermore, none of the insecticides currently labeled will prevent

larvae from feeding.Once larvae have hatched within the leaf, they appear to be protected from organophosphate and pyrethroid insecticides.[20]

Chemical Control:
Warrior is the only insecticide recommended for use against alfalfa blotch leafminer, because it is the only one which, in Minnesota trials, impacted yield significantly.At a rate of .03 lb. per acre, Warrior increased yield about 12% over untreated plots.[47] Typical grower usage of insecticides against this pest in the state is not yet established.

Biological Control:
The parasite *Dacnusa dryas* is effectively suppressing populations of alfalfa blotch leafminer below economic levels in Canada and the eastern U.S.[47] *D. dryas* is not yet established in Minnesota. The first releases were made in 1999.[20] Other parasites native to Minnesota have not been effective in controlling alfalfa blotch leafminer.[22]

Control via *D. dryas* appears to have the most potential for effective long-term control;[47,22] control is usually complete within 5 years of successful release.[22]

Cultural Control:
Harvest may reduce damage in the first crop; subsequent cuttings will likely not correspond with larval damage, thus cutting may not be effective in reducing damage in these crops.[23] There are no varieties evaluated thus far, that show a high level of resistance to alfalfa blotch leafminer damage.[20,47]

For More Information:
http://www.ag.uiuc.edu/cespubs/pest/articles/199904f.html

http://www.ipmworld.umn.edu/chapters/venette.html

Chemical Control for Insect Pests

According to the 1995 survey of Minnesota alfalfa growers, less than 2% of the acreage in Minnesota is typically treated with insecticides.[41] A Minnesota crop consultant estimated that the acres treated with insecticides may be 3-7% of total Minnesota alfalfa acreage.[15] According to the National Alfalfa Assessment, 13.7% of alfalfa hay acreage is treated with insecticides in the United State's North Central region in a typical year.[17] Because the national assessment is based on a 3-year average and included both high and low infestation years, we elected to use these data for the following section on insecticide use.

A majority of insecticide applications are applied via ground application, with the grower applying to

40.8% of acreage and 35.1% applied via ground by a custom applicator.In the early 1990s, the cost of application ranged from $7.29-$8.94 per acre, in addition to the cost of the insecticide.[17]

Since there are many beneficial insect species in alfalfa, use of chemical control is only recommended when economically justified, or when cultural and biological controls are ineffective.[44] Due to potential hazards to bees, appropriate measures should always be taken to protect bees when using insecticides.

Carbaryl

- Trade Names: Sevin 4F, Sevin 80WSP, Sevin XLR Plus
- Carbamate.
- Typical target insects: potato leafhopper, grasshoppers, and plant bugs.[20]
- Labeled for use on blister beetles, alfalfa caterpillar, potato leafhopper, alfalfa blotch leafminer, armyworm, plant bugs, alfalfa weevil larvae, and other.
- Percent of acres treated:0.7% [17]
- Average rate and frequency:1.1 lb. AI per acre per yearaverage.[17]
- Maximum rate of 0.75 lb. AI per acre. May be applied only once per cutting.
- Do not harvest or graze for 7 days (Sevin 4F and 80WSP) or 14 days (XLR Plus), REI 12 hours.
- The higher labeled rates are necessary for control of all pests except blister beetles.
- Recommended for use against blister beetles.[19]
- There are insecticides for most insects on carbaryl's label which are better choices (due to higher efficacy, better persistence, etc.).[15,20] However, it is still preferred by some growers because of its non-restricted use status.[20]

Carbofuran

- Trade Name: Furadan 4 F
- Carbamate. Restricted Use Pesticide.
- Typical target insects:alfalfa weevil, potato leafhopper, plant bugs [20]
- Labeled for use on: grasshoppers, alfalfa blotch leafminer, blue alfalfa aphid, alfalfa weevil adults and larvae, pea aphids, plant bugs, and other.
- Percent of acres treated:2.7% [17]
- Average rate and frequency:0.59 lb. AI per acre per year [17]
- Labeled for application at rates of 0.25-1.0 lb. AI per acre. May only be used once per season.
- REI of 48 hours, PHIs are: 7 days at 0.25 lb. AI per acre, 14 days at 0.5 lb. AI per acre, 28 days at 1.0 lb. AI per acre.
- May only be used on fields of pure alfalfa (no companion crop plantings).
- The higher label rates are necessary for control of weevils, aphids, alfalfa blotch leafminer, and potato leafhopper.Highest label rate necessary for control of plant bugs.

Chlorpyrifos

- Trade Names: Chlorpyrifos 4E AG, Lorsban-4E
- Organophosphate.
- Typical target insects: alfalfa weevil, potato leafhopper, grasshoppers, and plant bugs.[15,20]
- Labeled for use on: aphids, grasshoppers, alfalfa blotch leafminer, alfalfa weevil larvae and adults, armyworms, cutworms, plant bugs, leafhoppers, spittlebugs.
- Percent of acres treated: 3.9% [17]
- Average rate and frequency: 0.57 lb. AI per acre per year average.[17]
- Labeled for application at rates of 0.25 to 1.0 lb. AI per acre. May be used only once per cutting and a maximum of 4 times per season.
- Label PHIs:7 day PHI at 0.25lb. AI per acre, 14 day PHI at 0.5 lb. AI per acre, 21 day PHI at rates above 0.5 lb. AI per acre. 24 hour REI.
- The lower label rates are effective only on grasshoppers and leafhoppers.The higher label rates are necessary for the other pests, including aphids, alfalfa blotch leafminer, alfalfa weevil, armyworms, cutworms, plant bugs, and spittlebugs.

Cyfluthrin

- Trade Name: Baythroid 2
- Synthetic pyrethroid. Restricted Use Pesticide.
- Typical target insects: alfalfa blotch leafminer, alfalfa weevil, potato leafhopper, cutworms, and plant bugs.[15,20]
- Labeled for use on: cutworms, spittlebug, potato leafhopper, plant bugs (alfalfa and tarnished) alfalfa weevil, alfalfa caterpillar, aphids (pea and blue), alfalfa blotch leafminer, grasshoppers, and other.
- Percent of acres treated: no data
- Labeled rates are from 0.0125 to .044 lb. AI per acre. May be applied once per cutting, and a total of 0.175 lb. AI per acre per season.
- Label PHI is 7 days, REI 12 hours.
- The higher label rates are necessary for control of alfalfa blotch leafminer, grasshoppers, and moderate or heavy insect pressure of all other species.

Dimethoate

- Trade Names: Dimethoate 400, Dimethoate 4EC, Dimethoate, 5 lb.
- Organophosphate.
- Typical target insects:potato leafhopper, aphids, plant bugs.[20]
- Labeled for use on: pea and blue alfalfa aphids (suppression of other aphids), grasshoppers, leafhoppers, plant bugs, reduction of alfalfa weevil larvae.
- Percent of acres treated:2.0% [17]
- Average rate and frequency:0.37 lb. AI per acre per year average.[17]
- May be applied at rates of 0.25-0.5 lb. AI per acre. May be applied only once per cutting.

- Label PHI of 10 days, REI 48 hours.
- This is the most popular choice of growers to control potato leaf hopper, because of effectiveness and low cost.[20]

lambda-cyhalothrin

- Trade Name: Warrior T
- Pyrethroid. Restricted Use Pesticide.
- Typical target insects: alfalfa blotch leafminer, potato leafhopper, plant bugs, and cutworms.[15,20]
- Labeled for use on:All alfalfa insect pests important in Minnesota, and others.
- Percent of acres treated:too early to estimate [20]
- Labeled rates of 0.015 to 0.03 lb. AI per acre. Do not apply more than 0.03 lb. AI per acre per cutting and 0.12 lb. AI per acre per year.
- 1 day PHI for forage, 7 days for hay, REI 24 hours.
- Although other products are also labeled, Warrior T is the only insecticide with acceptable efficacy against alfalfa blotch leafminer.[47]
- The highest label rate is necessary for control of alfalfa blotch leafminer.

Malathion

- Trade Name: Malathion 57 EC
- Organophosphate.
- Typical target insects: potato leafhopper, grasshoppers, and plant bugs.[15,20]
- Labeled for use on: alfalfa weevil larvae, leafhoppers, plant bugs, pea and spotted alfalfa aphids, grasshoppers, armyworms.
- Percent of acres treated:0.4% [17]
- Average rate and frequency:0.98 lb. AI per acre per yearaverage.[17]
- Labeled rates of 0.94 to 1.41 lb. AI per acre.
- No PHI.REI of 12 hours.

Methyl parathion

- Trade Names: Declare, Penncap-M
- Organophosphate. Restricted Use Pesticide.
- Typical target insects: potato leafhopper, alfalfa weevil, and plant bugs.[20]
- Labeled for use on alfalfa blotch leafminer, alfalfa weevil larvae and adults, grasshoppers, green clover worm, aphids (blue and pea), spittlebug, plant bugs (alfalfa and tarnished), potato leafhopper.
- Percent of acres treated: no data
- Rates: Labeled rates are 0.25-1.0 lb. AI per acre.
- 48 hour REI, do not graze or harvest for 15 days.

Permethrin

- Trade Names: Ambush, Ambush 25W WP, Ambush 25W WSP, Pounce 25 WP, Pounce 3.2 EC, Pounce WSB
- Pyrethroid. Restricted Use Pesticide.
- Typical target insects: potato leafhopper, plant bugs, and cutworms.[15,20]
- Labeled for use on: alfalfa caterpillar, armyworms, cutworms, aphids (blue, green peach, and spotted alfalfa), alfalfa weevil, spittlebug, plant bugs, potato leafhopper, and other.
- Percent of acres treated:1.1% [17]
- Average rate and frequency:0.12 lb. AI per acre per year.[17]
- May be applied at rates of 0.05 to 0.2 lb. AI per acre. Use no more than 0.2 lb. AI per acre per cutting.
- Label PHIs of 0 days at 0.1 lb. AI per acre and 14 days at rates greater that 0.1 lb. AI per acre. REI of 12 hours.
- The high label rates are necessary for weevils, plant bugs, potato leafhopper, spittlebug, and increased pressure from other insect pests.

Critically Needed Insecticides

Warrior T (lambda-Cyhalothrin) is currently the only insecticide effective against alfalfa blotch leafminer, and will be necessary for control of this pest at least until biological controls are established in the state, and possibly thereafter.[20]

Dimithoate is important to Minnesota alfalfa growers due to its low cost of application.[15,20]

Pyrethroids (permethrin (Ambush and Pounce) and cyfluthrin (Baythroid 2)) are critically needed due to their superior persistence to provide residual control, which is especially important in controlling migrating populations of insects such as potato leafhopper.[15,20]

Diseases

Generally, alfalfa diseases are favored by cool, wet, late springs with frequent rains and heavy dew. Blights, seed rots, and damping off are favored by poorly-drained acidic soils with high levels of organic matter or prolonged, wet weather after planting.Viruses may weaken a plant, making it more susceptible to root and crown rots, insects, drought, and lead to an unproductive stand.High stubble and weeds

around alfalfa promote disease development by prolonging moist conditions.[12]

One of the most important measures for disease control is to be aware of diseases present in a field and select resistant varieties accordingly.There are few economic controls available once a disease is present in a field.[44]

Bacterial wilt, Common leaf spot, Lepto leaf spot, Fusarium wilt, Phytophthora root rot, and Spring blackstem are severe diseases in the entire state.Summer blackstem is severe in southern Minnesota, and moderate in rest of state.Verticillium wilt is severe in the southeast portion of the state and mild elsewhere.Anthracnose exerts moderate disease pressure in the southern half of the state and is mild in the rest of state.Aphanomyces root rot is a moderate disease in the entire state except in the northwestern corner, where it exerts mild disease pressure.Sclerotinia is moderate in the southeastern portion of the state and mild elsewhere.[44]

Bacterial Wilt - caused by the bacterium *Corynebacterium insidiosum* (McCulloch) Jensen = *Clavibacter michiganensis* subsp. *insidiosus* (McCulloch) Davis et al.

Disease Description and Damage:
The first symptoms of bacterial wilt appear on scattered plants throughout a stand, beginning in the second or third years of production.Plants turn yellow-green, are stunted, and growth may be distorted.A yellow-brown ring will be evident near the outer edge of infected taproots.Diseased plants are more visible after cutting.[44]

Cultural and Biological Control:
Many resistant varieties are available.[44]

Common Leaf Spot - caused by the fungus *Pseudopeziza medicaginis*

Disease Description and Damage:
Common leaf spot is a severe disease in the entire state.This disease occurs in most stands, primarily on the first and second cuttings and fall regrowth.Symptoms are brown to black circular lesions 1-3 mm in diameter, which may have a raised disc in the center on the upperside of the leaf.Lesions of common leaf spot rarely grow together.Leaflets will turn yellow and fall off the plant; leaf loss results in reduced yield and forage quality.[44]

Cultural and Biological Control:
There are no adequate controls for this disease.[3] It is recommended to harvest severely infected fields

early, cut the plants as close as possible to the ground,and remove the hay quickly from the field to minimize the inoculum source for the next crop.[15] Some varieties are moderately resistant.[44]

Lepto Leaf Spot – caused by the fungus *Leptosphaerulina briosiana*

Disease Description and Damage:
This is a severe disease in the entire state, typically attacking regrowth in spring or fall, especially after cool, rainy periods.Lesions are small black spots which enlarge to 1-3 mm in diameter, and develop a tan center.Lesions are usually surrounded by a chlorotic area, and often grow together.Loss of leaves by wind or harvest results in reduced yield and forage quality.[44]

Cultural and Biological Control:
There are no resistant cultivars.[44] There are no adequate controls for this disease.[3]

Fusarium Wilt – caused by the fungus *Fusarium oxysporum f. sp. medicaginis*

Disease Description and Damage:
Fusarium wilt is a severe vascular disease, affecting the entire state.Diseased plants have yellow leaves that become bleached; sometimes a reddish tint is present on only one side of the plant.Infected plants die in several months.The outer ring of infected roots has characteristic reddish brown streaking which develops into a ring.[44]

Cultural and Biological Control:
Control aphids and leafhoppers to reduce effects.Practice good soil fertility.[44] Many resistant varieties are available.[34]

Phytophthora Root Rot – caused by the fungus *Phytophthora medicaginis*

Disease Description and Damage:
This disease is severe in the entire state, and is particularly severe in wet soils.In new seedings, the disease occurs as plants emerge, causing a water-soaked appearance.Seedlings then collapse and die.In established stands, plants wilt, then leaves (typically lower leaves) turn yellow to reddish brown.Roots of infected established plants develop dark lesions on the surface, and eventually rot completely.[44] Severity of the disease is heavily dependent on location and soils which are excessively wet for the first several weeks after sowing.Losses in individual fields may range from 0-100%;average losses annually,

statewide, are difficult to estimate.[3]

Cultural and Biological Control:
There are many varieties that provide high resistance.Maintain high fertility to promote lateral root development.Control plant stress by not cutting when heavy rains are expected, and control leaf-feeding insects which stress plants.Tillage and land-leveling can improve drainage conditions.[44] Maintain soil structure and preserve pore spaces and aeration by minimizing harvest equipment compaction.[15]

Spring Blackstem – caused by the fungus *Phoma medicaginis*

Disease Description and Damage:
Spring blackstem occurs in early spring, and is severe in entire state.Infected plants develop many tiny black spots on lower leaves and stems.Leaves may turn yellow, wither, and fall off.In severe cases, lesions will girdle the stem. Plants will die when the fungus spreads to the crown and roots. [44]

Cultural and Biological Control:
Cutting early will reduce leaf loss and disease prevalence. [44]

Summer Blackstem – caused by the fungus *Cercospora medicaginis*

Disease Description and Damage:
Summer blackstem is a severe disease in the southernmost part of the state, and is moderate in rest of state.It occurs during hot, humid weather, causing brown, irregularly-shaped lesions to form on leaves. Stem lesions are reddish to dark brown, oval, and will grow together to cover most of the stem.The disease affects lower parts of the plant first, and will progress up the plant and also cause leaf loss. Forage quality and yield are reduced. [44]

Cultural and Biological Control:
Early cutting may reduce losses.There are no varieties with sufficient resistance. [44]

Verticillium Wilt – caused by *Verticillium albo-atrum*

Disease Description and Damage:
Verticillium wilt is a severe disease of alfalfa in southeastern Minnesota, and is mild in the rest of state. Initially, it causes v-shaped lesions to form on the tips of leaflets, and sometimes causes leaflets roll

lengthwise.As the disease progresses, all leaves on a stem will die, leaving a green stem.Typically, stems of a plant are not infected at the same time; rather, the disease invades other stems until the plant dies. Roots may or may not show vascular discoloration.Verticillium wilt severely shortens the life of a stand, and can reduce yield as much as 50% beginning in the second year. [44]

Cultural and Biological Control:
There are many resistant varieties.Rotate infected fields with non-host crops such as corn and small grains.Do not plant infected fields to alfalfa for two to three years.Do not rotate with red clover. Harvest at hard-bud or early flower stage to prevent some yield loss and slow disease spread within a field. Reduce the chances of infecting clean fields by harvesting clean fields before infected fields. [44]

Anthracnose – caused by the fungus *Colletotrichum trifolii*

Disease Description and Damage:
Anthracnose is believed to produce moderate disease pressure in the southern half of Minnesota, and is considered mild in the rest of state.On susceptible plants, the fungus produces large, sunken oval- or diamond-shaped straw colored lesions with brown borders on plant stems.Lesions may merge, girdle the stem, and cause sudden wilting.Dead stems with white or straw-colored dead shoots may be scattered within a field.Anthracnose is considered a pathogen of crown tissue, causing it to turn blue-black. Diseased plants produce fewer stems and eventually die.The disease is more severe under warm, moist conditions, and can cause up to a 25% loss in yield. [44]

Cultural and Biological Control:
There are many varieties which exhibit moderate to high resistance. [44]

Aphanomyces Root Rot – caused by the fungus *Aphanomyces euteiches*

Disease Description and Damage:
Aphanomyces root rot exerts moderate disease pressure in entire state except the northwest corner, where it's effect is generally mild.Wet soils promote outbreaks of this disease.Diseased seedlings develop yellow cotyledons and chlorotic leaflets; their roots and stems look grey and water-soaked, then turn brown.Seedlings are stunted, but remain upright.In established plants, root mass is reduced, nodules are decaying or absent, and regrowth is slow.Plants may also exhibit symptoms of nitrogen deficiency. [44]

Cultural and Biological Control:
Plant varieties which exhibit high resistance to both Aphanomyces root rot and Phytophthora root rot. [44]

Sclerotinia – caused by the fungus *Sclerotinia trifoliorum*

Disease Description and Damage:
Sclerotinia is an important disease only in the southeast corner of Minnesota, where it exerts moderate disease pressure.It is more severe in seedling stands, especially fall-seedings.Initially, small dark lesions appear on leaves and stems during the fall.In the following spring, the crown or lower parts of the stems soften and decay.A white fluffy mass grows over the decaying or dead tissue.The fungus forms sclerotia under the white masses; sclerotia remain on or become embedded in the stem.Sclerotinia spreads rapidly in cool, wet weather and can quickly thin a stand. [44]

Cultural and Biological Control:
Plow residue to bury sclerotia, which will reduce the disease's ability to infect new plantings.Spring planting will reduce disease incidence.No resistant varieties are available. [44]

Chemical Control of Diseases

Currently, the only significant use of fungicides is seed treatment to control Phytophthora and Pythium. Use of metalaxyl has increased dramatically in the past decade. In the late 80's and early 90's, experts estimated that about 5% of alfalfa seed used in Minnesota is treated with metalaxyl.[3] Currently, experts estimate that most of the alfalfa seed in the state is treated with metalaxyl.[15,34] There are several seed treatments available, current usage of these chemicals is not known.

Nematodes

Root-lesion nematodes are the only significant nematode pest of alfalfa in the state.

Root-lesion nematodes (Pratylenchus penetrans)

Description and Life Cycle:
Root-lesion nematodes are parasitic, unsegmented roundworms that attack alfalfa. They feed on roots and nitrogen-fixing nodules of alfalfa.[12,23,44] This nematode has a wide host range which includes row crop and weed species.[12,14,31] Adults and larvae enter roots and move through root issue while

feeding.[31] They use a stylet to puncture plant root cells, removing liquid contents and injecting enzymes.[12]

Damage:
Dark lesions may form on older roots, and fine fibrous roots may be absent.[34] Feeding can cause inferior root growth, stunting, yellowing, and reduced nitrogen fixation.Feeding may also cause increased susceptibility to winter injury, root and crown rots, and other fungal and bacterial infections.[12,31] Root-lesion nematode damage usually is not evenly distributed in a stand, but instead appears as patches of unhealthy plants in an otherwise healthy stand.[12,23,44] In new stands, seedlings may not be able to compete with weeds and grasses, resulting in a thin stand.[31]

This pest is a greater problem in soils which are sandy and granular.[14] Root-lesion nematode is a moderate problem in all areas of the state except the extreme Northwest, where it is a mild problem.[44] Frequency of occurrence, percentage of acres infested, and typical yield loss are difficult to know; only minimal sampling has been done for the nematode.[20]

Biological Control:
There are no biological controls used.

Cultural Control:
Cultural controls are the only realistic methods available. There are some varieties which show moderate resistance to root-lesion nematodes in university trials from the University of Minnesota, Wisconsin, and South Dakota.[14] Crop rotation to row crops can be effective in reducing populations [23,31,44] but may not be effective because of the wide host range of the root-lesion nematode.[14]

Chemical Control:
The only option for chemical control is the use of Furadan when establishing new stands in fields known to have nematode problems.[20] However, chemical control for nematodes is rarely used in the state. Chemical controls are cost prohibitive.[14,15]

For More information:
http://geertsonseed.com/monument.htm

http://www.forages.css.orst.edu/Topics/Pests/Nematodes/Root-Lesion.html

Weeds

Weeds affect alfalfa production by competing with alfalfa plants for nutrients, moisture, and light.Weed

infestations can reduce alfalfa yield, reduce alfalfa stand density, and may alter forage quality.

Forage Quality

Weeds can lower forage value by lowering forage quality.Depending on the species, weeds may not be palatable, may reduce forage intake potential, and/or may be toxic, thereby degrading forage quality. However, weeds can be forage, and can contribute to yield (although as noted in the next section, they also reduce stand density).The species and its effect on forage quality will help determine how important it is to control the weed.

Both annual and perennial grass weeds are the weeds of most economic importance in alfalfa because they reduce alfalfa quality by increasing Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF).That is why grass weeds consistently lower forage intake potential.[27,42] If quackgrass is managed appropriately, often the most serious economic weed pests based on forage quality in Minnesota during the seeding year are annual grasses such as giant, yellow, or green foxtail.[1]

Common weeds in alfalfa in Minnesota that can be toxic to livestock are Eastern black nightshade, the buttercups, and for horses, hoary alyssum.Some broadleaf weeds have quality similar to that of alfalfa.[27]

Removing weeds with herbicide during alfalfa establishment has not always resulted in forage of higher quality.[4,36] Also, forage with weeds in solo seeded alfalfa may have higher forage quality than companion crop forage.[4,36,42]

Research on forage quality of some perennial weeds can be summarized as follows: [11]

- Similar to alfalfa:dandelion and white cockle (Common dandelion seldom lowers forage quality. Dandelion may significantly increase the time required to dry alfalfa to appropriate moisture for storage, but should not be detrimental in grazed situations.[1])
- Lower than alfalfa: quackgrass and yellow rocket
- Much lower than alfalfa: quackgrass curly dock, Canada thistle, hoary alyssum, swamp smartweed, and Jerusalem artichoke

Forage quality of some annual weeds can be characterized as follows: [27,42]

- Similar to alfalfa: redroot pigweed, common lambsquarters, and common ragweed
- Lower than alfalfa: giant and yellow foxtail, shepherds purse, and Pennsylvania smartweed

Palatability studies conducted by Marten and Andersen (1975) showed that yellow foxtail, barnyardgrass and green foxtail were palatable annual grasses, while giant foxtail was unpalatable to livestock in grazing studies.Redroot pigweed, Pennsylvania smartweed, and common lambsquarters where palatable while wild mustard, giant ragweed, and common cocklebur were unpalatable in livestock grazing studies.

Common ragweed and velvetleaf were termed "interactors" in that they were not palatable to livestock in certain situations.[27]

Density and Yield

In addition to their effect on forage quality, weeds and their population density can affect alfalfa yield and population density during establishment [8,25,32] This, also, is a major consideration in weed management decisions.

Established alfalfa stands will not fill into an area; if weeds are removed, it is likely that the area will be reinfested unless the density of the stand is high enough to fill in the gaps left by weed removal.As discussed above, weeds do add volume to yield.Thus, when weeds are removed, the yield may decrease, and the quality of forage may or may not increase significantly, depending on the weed species involved.[44]

Companion crops also affect alfalfa density.Small grains may suppress growth of seedling weeds, but they also compete with alfalfa for light, moisture, and nutrients.[2,5,6,8,32] This competition occasionally reduced alfalfa yields and stands compared with seeding without a companion crop.[25,32,35,36] Bula et al. (1954) found that weed infestations increased as oat (a common companion crop) seeding rate decreased, thereby limiting the benefits of reduced companion crop competition with seedling legumes.[6] Recommendations to reduce competition with alfalfa seedlings include removing small grain before maturity [5], reduced small grain seeding rates, [25,39] and using a less competitive companion crop such as oat.[36] Unfortunately, even with the best small grain management practices, lodged small grains and windrows of straw and forage left in the field for prolonged periods may dramatically reduce alfalfa population density.[1]

Solo seeding alfalfa with herbicide is the primary alternative to companion crop seeding.Sheaffer et al. (1988) reported higher seeding year alfalfa yields and population density when alfalfa was solo seeded with herbicide compared to seeding with a companion crop, [36] while Brink and Marten (1986) and Buxton and Wedin (1970) also found increased alfalfa yield, but population densities were often similar.[5,8]

Weed Control

Most critical to weed control is to establish and maintain a vigorous stand.Poor alfalfa stands result in severe weed problems.Weed management in alfalfa starts with good agronomic practices; it begins prior to seeding the field and continues throughout the life of the stand. This includes controlling perennial weeds before seeding, selecting the appropriate alfalfa variety, establishing optimal soil fertility and pH, planting at the optimal time, and preparing a good seedbed.

Stand Establishment and Seeding Year Stand Management

Seeding year weed management issues are much different than in established alfalfa.It is critical to begin weed control prior to seeding, and to establish a vigorous stand in the seeding year.Fields should be tilled as close to planting time as possible; this can be useful in preventing the early establishment of perennial weeds.Also, knowing which weeds are present in a stand, how severely weeds will affect forage quality and stand density, and the intended use of the hay is important in deciding when it is economically sound to apply herbicides.[44]

Troublesome perennial weeds must be managed prior to establishing. Quackgrass is a perennial of particular concern.Left unmanaged, quackgrass grows vigorously, reproducing by both seeds and rhizomes, and can be allopathic.Quackgrass can severely degrade an alfalfa stand.[24] It can be the most serious weed pest in a seeding year if farmers seed alfalfa into fields where there is an existing problem which was not controlled prior to planting.However, if quackgrass is managed appropriately, often the most serious economic weed pests based on forage quality in Minnesota the seeding year are annual grasses such as giant, yellow, or green foxtail. Canada thistle and dandelion are also of particular concern, and must be controlled in first year stands. Chickweed is a problem in the Grand Rapids area of the state, but isn't a notorious problem in alfalfa seedings elsewhere. If managed before seeding alfalfa, perennial weeds generally are not a significant problem in the seeding year, and they typically do not encroach as long as alfalfa plant population densities are maintained at appropriate levels. However, they will encroach as the stand thins with age.

The most effective management system for quackgrass is use of a glyphosate product in the fall prior to seeding alfalfa.Two other important perennial weeds, Canada thistle and common dandelion, should be treated with herbicides that do not have the potential to carryover and damage alfalfa seedlings the following spring (such as glyphosate, or low rates of 2,4-D tank mixed with glyphosate).[1]

Annual weeds most common in spring seeded alfalfa in Minnesota are:giant, yellow, and green foxtail, pigweed species, common lambsquarters, common ragweed, and wild mustard.Other weeds which can be of economic importance are Ladysthumb or Pennsylvania smartweed, wild buckwheat, giant ragweed, velvetleaf, common cocklebur, eastern black nightshade, large and smooth crabgrass, shepherds purse, and field pennycress.Annual grasses often survive clipping from forage harvest during the seeding year, and contribute to forage yield in more than one cutting.As mentioned above, annual grasses such as giant, green, and yellow foxtail can be the most serious weeds in the seeding year.Many annual broadleaf weeds establish with the alfalfa seedlings but often do not persist beyond the first cutting because buds for regrowth often are removed by harvesting. [1]

Producer surveys show that 80-85% of the alfalfa in Minnesota is established with a small grain companion crop.[38,41] Reasons cited for seeding with companion crops were production of silage, grain,

or straw for livestock, protection of alfalfa seedlings from weed encroachment, and reduction of wind or water borne soil erosion.[38] Of the portion of alfalfa not seeded with a companion crop, only a small portion is treated with herbicide.Preplant incorporated or postemergence herbicide options are available for alfalfa establishment if a companion crop is not seeded.[1]

Development of postemergence herbicides for alfalfa has increased management options for establishment,[10,43] including a companion crop oat mulch system.[2,9] Direct seeding or using the oat mulch system to establish alfalfa can increase forage quality and net profits and reduce weed presence in forage the seeding year compared to using the companion crop seeding method.[2]

Established Stand Management

In established alfalfa, annual weeds generally are not a significant problem if the alfalfa stand was established successfully the preceding year with adequate alfalfa plant densities to suppress annual weed invasions.However, as alfalfa stands start to thin out with age, perennial weeds often encroach; usually, common dandelion and quackgrass are the first to encroach.(Quackgrass is the most serious weed pest in established stands in the Great Lakes region.)Secondarily, Canada thistle, yellow nutsedge, curly dock and yellow rocket may be present in the field, but generally not at populations densities as high as that of quackgrass or dandelion.Some winter annual mustards such as pennycress and shepherds purse, and biennials such as white cockle can be a problem in established alfalfa as well.Site-specific weed problems are perennial hoary alyssum, common on drought-prone soils or in drought years, and perennial tall buttercup or the biennial small-flowered buttercup, common in wet years.[1]

Once a stand is established, weed management is typically accomplished via herbicide applications. Weed management decisions in established stands are dependent on the weed species involved, its effect on forage quality, the severity of infestation, and the density of the stand.

The National Alfalfa Assessment cited the following information for the 13-state North Central Region of the U.S.:Clipping is used on 24.5% of spring seedings for weed management, and 1.8% of established stands; overall, it is used on 6.2% of acreage.Flash grazing and burning are both used on about 1.2% of established stands (1% of total acreage), and cultivation is used on less than 1% of established stands; flash grazing, burning, and cultivation are not used on an appreciable acreage of spring seedings.[17]

Chemical Control of Weeds

According to the National Alfalfa Assessment, in spring seedings, clipping and companion crop plantings are used more widely than herbicides, but herbicides are necessary for their efficacy.In

established stands, there are no cultural practices that are used more widely than herbicides.In both first-year and established stands, herbicides are more effective than non-chemical alternatives. An average of 8.1% of North Central Region alfalfa hay acreage is treated with herbicides, at a cost which ranges from $2.19 per acre for grower application to $4.48 per acre for custom application, in addition to the cost of the herbicide, which will significantly increase the total cost of herbicide applications.[1,17]

Herbicide selection is based on many factors, including but not limited to weed species involved and age of the stand.Despite the total number of herbicides available, for a given need, there may be only a couple that provide acceptable control.[17]

2,4-DB

A postemergence broadleaf herbicide used primarily on seedling and established alfalfa.

- Trade Names: Butyrac 200, Butoxone 175, Butoxone 200, Butoxone 7500
- Target Weed: primarily annual broadleaves in spring seedings [17]
- Percent first year seeding acreage treated: 3.8% [17]
- Percent established alfalfa acreage treated: 0.6% [17]
- Percent of acres total treated: 1.1% [17]
- Typical rates: 0.95 lb. AI per acre in spring seedings, 1.0 lb. AI per acre in established stands. [17]
- No pre-harvest restrictions, but the following restrictions apply: do not graze or feed hay for 30 days on established alfalfa or 60 days on seedling alfalfa.
- Apply as a postemergent spray when alfalfa has reached the 1 to 2 trifoliate leaf stage and growing conditions are good, or in established alfalfa apply in late fall or early winter for best control of weeds emerging in fall and winter.
- May cause stem twisting and leaf malformation, which is usually outgrown, in established alfalfa. Rainfall or irrigation within 7-10 days of application will wash chemical into the rootzone and cause crop injury. Do not apply to drought-stressed crops.
- Effective on small summer annual broadleaf weeds, slightly less effective on small winter annual broadleaf weeds (apply when weeds are less than 2" tall or rosettes are less than 2" in diamater for best results). No control of grasses. Poor to fair control of perennial broadleaf weeds; [17] may stunt perennial broadleaves such as Canadian thistle, thereby reducing Canada thistle effect on forage, but will not reduce the population density of Canada thistle. Good product for high populations of pigweed species; it has a broader window of application than Buctril, and may be cheaper than Pursuit for pigweed.[1]
- Butyrac 200 is much safer to the alfalfa for use on spring seedings for broadleaf weed control than MCPA.[1,15]

Benefin

A selective herbicide used primarily on direct-seeded plantings, preplant incorporated.[44] Will not control

established weeds.

- Trade Names: Balan DF
- Target Weed: primarily annual grasses; [17] also some annual broadleaves.
- Percent first year seeding acreage treated: 2.3% [17]
- Percent established alfalfa acreage treated: none [17]
- Percent of acres total treated: 0.4% [17]
- Typical rate is 1.18 lb. AI per acre in spring seedings.[17] Label rates range from 2.0-2.5 lb. AI per acre, based on soil texture.
- REI 12 hours. PHI not specified since the product is preplant incorporated.
- Highly effective against summer annual grasses, good control of winter annual grasses and summer annual broadleaves, fair control of winter annual broadleaves, poor control of perennials.[17] Good control of barnyardgrass, foxtails, kochia, night-flowering catch-fly, pigweed spp.; fair control of lambsquarters.[44]
- Cannot be used when planting with a forage grass crop.[44]
- Must be applied prior to seeding and must be incorporated.
- May cause crop damage if not fully incorporated or if sub-optimal growing conditions are present following seeding.

Bromoxynil

A selective postemergence herbicide, used primarily on broadleaf weeds in seedling alfalfa.

- Trade Names: Buctril, Buctril 4EC
- Useful on seedling stands (direct-seeded plantings and companion-crop seeded plantings).[44]
- Percent first year seeding acreage treated: 0.6% [17]
- Percent established alfalfa acreage treated: none [17]
- Percent of acres total treated (only spring seedings considered): 0.1% [17]
- Typical rate of 0.25 lb. AI per acre [17]
- Label rates of 0.25-0.38 lb. AI per acre, up to 0.5 lb. AI per acre only if chemigating; rates of 0.13-0.25 lb. AI per acre if tank mixed with approved products. One application per year.
- Do not harvest for feed or graze for 30 days. Label REI 12 hours.
- This is the only postemergence herbicide recommended for use on companion-crop seeded plantings as well as direct-seeded plantings which will not destroy the companion crop.[44]
- Provides good to very good control of many annual broadleaf weeds, but only fair to poor control of perennial broadleaves.[17,44] Provides fair control of hoary alyssum.[44] Can be weak on larger pigweed species if plants are beyond two- to four-inch stage of growth.[1] Offers better control of some mustards such as wild mustard (common in alfalfa seedings in Minnesota) compared to 2-4, D, and provides an advantage over 2,4-DB for smartweed species such as wild buckwheat, and Pennsylvania or Ladysthumb smartweed.[1] Pursuit will control all of these but may cost more and has its own unique injury, persistence, and weed resistance issues.[1]

- Registered only on seedling stands. Maximum rate of 0.5 lb. AI per acre per season. Treat when alfalfa has at least four trifoliate leaves and weeds are 2 inches or less tall with four or less leaves. Alfalfa injury may occur when temp is >70F within 3 days of application. Do not treat alfalfa stressed by insect damage, excess moisture, moisture shortage, etc.

Clethodim

A systemic postemergence herbicide for control of annual and perennial grasses.

- Trade Name: Select 2EC
- Target Weed: annual and perennial grasses
- Percent of acres treated: no data
- Rates:label rates of 0.125-0.25 lb. AI per acre
- REI 24 hours, PHI 15 days, do not graze or feed for 15 days.
- Quackgrass may be managed with repeat applications.[1] Sethoxydim and clethodim are the only products labeled for postemergence grass control in new seedings and reduction of quackgrass in established stands. They are also useful on alfalfa seeded with companion crops, when the desired result is to kill the companion crop as a planned approach to stand establishment.[15]

EPTC

A selective herbicide used primarily on direct-seeded plantings, preplant incorporated.[44]

- Trade Names: Eptam 20-G (preplant incorporated) Eptam 7-E (preplant incorporated and post emergence via irrigation (very rare in Minnesota, very few alfalfa acres are irrigated.)
- Target Weed: primarily annual grasses,[17] some broadleaves, prior to germination.[44] Will not control established weeds.
- Percent first year seeding acreage treated: 2.2% [17]
- Percent established alfalfa acreage treated: none [17]
- Percent of acres total treated: 0.4% [17]
- Typical rate of 3.07 lb. AI per acre in spring seedings.[17]
- Eptam 7-E label rates are 3.0–4.0 lb. AI per acre incorporated. If controlling only annual grasses growing from seed, a reduced rate of 2.0 lb. AI per acre may be incorporated just before planting. Cannot be used when planting a forage grass crop. Established perennial weeds must be turned and very thoroughly chopped. On established stands, the 7-E formulation may be chemigated at 2.0–3.0 lb. AI per acre prior to weed emergence; observe a 14 day interval prior to harvest or grazing.
- Must be incorporated completely or will cause alfalfa injury or loss of product. Can stunt alfalfa in sub-optimal growing conditions (if there are prolonged periods of hot and dry or cool and wet conditions, or if there is pressure from other pests, soil conditions, or some insecticide use).[44]
- Label information: Eptam 20G must be incorporated to control weeds as they geminate. Labeled only for use on new seedings, not for established stands in Minnesota. For annual grasses,

broadleaves, and nutsedge, incorporate 3.0 lb. AI just before planting. Cannot be used when planting a forage grass crop. Established perennial weeds must be turned and very thoroughly chopped. For quackgrass suppression and control of above weeds in finely textured soils use 4.0 lb. AI per acre. The rate of 4 lb. AI per acre may not be used on coarse soils. Cannot be used if atrazine was used in the previous 12 months or crop damage may occur.

- Provides very good control of summer annual grasses; good control of winter annual grasses, and fair control of perennial grasses. Fair to good control of annual broadleaves, poor control of perennial broadleaves. Not used on established stands in Minnesota.[17] Good control of barnyard grass, foxtails, and pigweed spp.; fair control of velvetleaf, kochia, wild oats, and lambsquarters.[1,44] EPTC can reduce the stand density of hoary alyssum seedlings during alfalfa establishment, but has no activity on established perennial plants.[1]

Glyphosate

A non-selective herbicide, for control of all actively growing plants. Used primarily on primarily seedings, also as a spot treatment in established stands.[17]

- Trade Names: Roundup Custom, Roundup EZ Dry, Roundup Original, Roundup Original RT, Roundup Solugran, Roundup Ultra, Roundup Ultra RT, Ranger, Rattler
- Target Weed: quackgrass, Canada thistle, and dandelion are the most serious targets; also controls all actively growing weeds.[15]
- Percent first year seeding acreage treated: 8.6% [17]
- Percent established alfalfa acreage treated: 0.48% [17]
- Percent of total acres treated: 1.58% [17]
- Typical application rates of 0.75 lb. AI per acre in spring seedings, 1.03 lb. AI per acre in established stands [17]
- In established stands, glyphosate is used as a spot treatment; acreage reported may be in terms of field acreage, therefore actual acres treated may be overestimated.[17]
- The primary use is site preparation prior to spring planting; glyphosate is commonly applied in the fall prior to seeding alfalfa for quackgrass and other weed control.[44] May also be used as a spot treatment.
- Glyphosate is nonselective and therefore can only be used as a spot treatment in the crop.[1]
- Provides very good to excellent control of summer and winter annual grasses and broadleaves, as well as perennial broadleaves.[1]
- Glyphosate has activity on the broadest spectrum of weeds and is the best herbicide to effectively control quackgrass before seeding alfalfa.[1]

Hexazinone

A general herbicide, provides both contact and residual control, used primarily on established alfalfa.

- Trade Names: Velpar, Velpar DF, Velpar L
- Target Weed: many annuals [44]
- Percent first year seeding acreage treated: none [17]
- Percent established alfalfa acreage treated: 1.5% [17]
- Percent of acres total treated: 1.2% [17]
- Typical rate of 0.28 lb. AI per acre in established stands [17]
- Do not graze or feed forage or hay to livestock for 30 days. REI 24 hours.
- Ranks very highly for control of winter annual grasses and broadleaves; provides fair to good control of summer annuals and perennials.[17] Provides good control of hoary alyssum and yellow rocket, fair to good control of dandelion and quackgrass.[44]
- Alfalfa should be at least one year old. Apply in spring to dormant alfalfa or before new growth is greater that 1-2 inches. Fall applications control winter annuals and other species, but dandelion is better controlled with spring application.[44]
- Label information: For Velpar and Velpar L: Do not use on alfalfa grown for seed. Application rates are dependent on soil texture and percent organic matter, and range from 0.5–1.5 lb. AI per acre for Velpar and Velpar L, and 0.67–2.0 lb. AI per acre for Velpar DF. For use only in stands at least one year old. On non- and semi-dormant varieties, apply once per year in spring or after cutting and hay removal, in all situations, apply when new alfalfa growth does not exceed 2 inches. On dormant varieties, apply once per year after dormancy begins and prior to any new growth in spring. Most effective when temperature is above 80 degrees F, humidity is high, and soil moisture is good. After application after cutting, crop damage can occur if temperatures exceed 90 degrees F. Do not use on companion crop plantings.

Imazethapyr

A postemergence selective herbicide used primarily on first year seedings [17]

- Trade Names: Pursuit, Pursuit DG, Pursuit W, Pursuit W DG
- Target Weed: primarily annual broadleaves in spring seedings [17]
- Percent first year seeding acreage treated: 4.8% [17]
- Percent established alfalfa acreage treated: 0.5% [17]
- Percent of acres total treated: 1.3% [17]
- Typical rates are 0.06 lb. AI per acre in both spring seedings and established stands.[17]
- Label rates range from 0.047-0.094 lb. AI per acre, for a maximum of 0.094 lb. AI per acre per season. May not be applied at rates higher than 0.047 lb. AI per acre north of Highway 210.
- Label information: Only Pursuit and Pursuit DG may be applied during the last year of a stand, at a maximum rate of 0.06 lb. AI per acre. Adequate soil moisture is necessary for optimal results. Pursuit W and W DG may not be used during the last year of a stand. Must be applied postemergence for seedling alfalfa. In established fields may be applied in the fall after the last cutting, in spring to dormant fields or fields with less than 3 inches of growth, or during the season immediately after hay is cut and removed.
- In both spring seedings and established stands, good to very good efficacy against summer and

winter annual broadleaves (annual weed seedlings must be relatively small when treated for good results), good control of annual grasses. Fair to no control of perennial grasses and perennial broadleaves.[1,17]
- Imazethapyr has the widest spectrum of weeds controlled, and is a good bargain for the money invested. This product is the best choice for producers demanding pure stands of alfalfa to harvest during the seeding year.[15]

MCPA

A selective herbicide used primarily on first year of spring seeded stands for broadleaf control.

- Trade Names: Riverdale MCPA-4 Amine, Riverdale Dri-MCPA Amine, Class MCPA Phenoxy Herbicide, Weed-Rhap A4-MCPA Herbicide, Clean Crop MCP Amine 4, MCPA Amine 4, Dow MCP Amine, MCPA NA Salt
- Target Weed: annual and perennial broadleaf weeds [17]
- Percent first year seeding acreage treated: 1.9% acreage treated in spring seedings; not used on fall seedings[17]
- Percent established alfalfa acreage treated: none [17]
- Percent of acres total treated: 0.4% [17]
- Typical rate is 0.24 lb. AI per acre in spring seedings [17]
- Used only when alfalfa is grown with a tolerant companion crop which physically shields alfalfa seedlings from the herbicide.
- Good to very good control of summer and winter annual and perennial broadleaf weeds. This is one of the most effective controls of broadleaf weeds.[17]
- MPCA is generally labeled for use in small grains when a legume companion crops is present. However, the University of Minnesota does not recommend this use of MPCA because of the potential to severely damage the alfalfa stand even when a companion crop or a weed canopy is present to protect the underseeded legume from spray contact. The University of Minnesota does not recommend the use of MCPA on alfalfa because of an unacceptably high risk for significant alfalfa injury and potential loss of stand. Butyrac 200 is much safer to the alfalfa for use on spring seedings broadleaf weed control than MCPA.[1,15]

Metribuzin

Used primarily on established stands.[44]

- Trade Names: Sencor DF/Solupak, Sencor 4, Lexone DF
- Target Weed: non-selective, not clear what weeds drive application,[17] possibly seedling dandelion and winter annuals [15]
- Percent first year seeding acreage treated: none [17]
- Percent established alfalfa acreage treated: 4.8% [17]

- Percent of acres total treated: 3.8% [17]
- Typical rate of 0.54 lb. AI per acre in established stands [17]
- Do not harvest or graze for 28 days. REI 12 hours.
- Label information: May be used on established stands only. Label rates range from 0.25-1.0 lb. AI per acre. Lowest label rate effective only on a couple species; controlling the more severe weed pests in Minnesota requires using the higher label rates. For best results apply before weeds are more than two inches tall or foliage is more than 2 inches in diameter.
- Good control of all weed classes in established stands.[17] Good control of many annuals, fair to good control of dandelion, hoary alyssum, and quackgrass.[44] Apply in spring when alfalfa is dormant or impregnate on fertilizer and apply to alfalfa less than 3 tall with dry foliage.[17]

Paraquat

A contact herbicide used primarily on seedings prior to emergence, as a dormant season herbicide, and during the season immediately after a cutting.

- Trade Names: Gramoxone Extra. Restricted Use Pesticide
- Target Weed: non-selective, controls most emerged annual broadleaf weeds and grasses, suppresses perennials but will not kill them.
- Percent first year seeding acreage treated: 2.3% [17]
- Percent established alfalfa acreage treated: 2.4% [17]
- Percent of acres total treated: 2.4% [17]
- Typical rates are 0.5 lb. AI per acre in spring seedings, and 0.62 lb. AI per acre in established stands.[17]
- Label rates: When used as a dormant season application, rates may range from 0.47-0.78 lb. AI per acre. When used as a preemergence herbicide, rates range from .625-.938 lb. AI per acre. On fall-seeded stands less than one year old rates range from .25-.47 lb. AI per acre. When used between cuttings (within 5 days after a cutting) rate is .25 lb. AI per acre for a maximum of 2 times in first year stands or 3 times during the growing season in established stands.
- 42 day PHI when used as a dormant season application, 30 days when used between cuttings.
- Must be applied to actively growing plant tissue thoroughly. Not as effective on drought-stressed weeds.
- Primarily used for site preparation or as spot treatments. Also used as a dormant spray; paraquat has to be applied between cuttings or when dormant to avoid spray contact with alfalfa plants to avoid injury.[1]
- When applied between cuttings, the target weed is stressed and most of the vegetation is removed, resulting in poor coverage of the target weed. Weeds with the ability to regrow from buds below the cutting height often will do so.[1]
- Provides fair to good control of annual grasses, and poor to fair control of perennial grasses.[1] In field conditions, provides poor control of most broadleaf perennials [17]; may control broadleaf weeds that have a low, prostate habit with a lot of vegetation exposed to the herbicide.[1]

Sethoxydim

A selective, broad spectrum postemergence herbicide for control of annual and perennial grasses, used primarily on direct-seeded plantings and established stands, postemergence.[44]

- Trade Names: Poast, Poast Plus
- Target Weed: primarily annual grasses in spring seedings, [17] reduction of quackgrass in established stands [15]
- Percent first year seeding acreage treated: 2.5% [17]
- Percent established alfalfa acreage treated: 3.6% [17]
- Percent of acres total treated: 3.4% [17]
- Typical rates of 0.22 lb. AI per acre in spring seedings, 0.23 lb. AI per acre in established stands.[17]
- Maximum labeled rate is 1.2 lb. AI per acre per season.
- 12 hour REI, do not graze, feed, or cut for undried forage for 7 days; do not harvest for 14 days if harvesting for dry hay.
- In both spring seedings and established stands, provides very good control of summer annual grasses, also provides control of winter annual grasses and perennial grasses.[17] No control of broadleaves, [17] good control of most annual grasses, will suppress quackgrass.[44]
- Sethoxydim and clethodim are the only products labeled for postemergence grass control in new seedings and reduction of quackgrass in established stands. They are also useful on alfalfa seeded with companion crops, when the desired result is to kill the companion crop as a planned approach to stand establishment.[15]
- Treat when quackgrass is 6-8" tall and annual grasses are actively growing; on cereals treat when 2-4 inches high and not yet tillering. Not for use on grass-legume mixtures. Use on companion-crop seeded plantings to control cereals only after grain is harvested.[44]

Trifluralin

A selective preemergence for control of annual grasses and broadleaf weeds, primarily in established alfalfa; a few individual products are labeled for use in new seedings.

- Trade Names: Treflan HFP, Treflan TR-10, Tri-4 HF, Trifluralin 480, Trifluralin 4EC, Trilin, Trilin 10G
- Target Weed: primarily annual grasses in spring seedings, [17] used on both seedings and established alfalfa.
- Percent first year seeding acreage treated: 1.1% [17]
- Percent established alfalfa acreage treated: 0.6% [17]
- Percent of acres total treated: 0.25% [17]
- Typical rates of 0.76 lb. AI per acre in spring seedings, 0.97 lb. AI per acre in established stands [17]

- Label rates ranging from 0.75-1.0 lb. AI per acre for incorporation, and 2.0 lb. AI per acre when chemigated or irrigated; labeled application methods vary per product. Maximum per season of 2.0 lb. AI per acre.
- Absorbed by emerging shoots, killing seed/weed.
- In both spring seedings and established stands, ranks very highly for control of summer annual grasses, and also provides fair to good control of some annual broadleaves [17] (for example, some small seeded broadleaf weeds such as redroot pigweed and common lambsquarter [1]). Not effective on winter annual grasses.[17] Does not control perennial grasses or broadleaves.[17]

Weed Control Issues

In Minnesota, agriculture production demographics are shifting to larger, more consolidated livestock production facilities, and vertical integration of livestock is occurring.Forage quality is becoming much more important.As this trend continues, demand will increase for weed-free alfalfa feed, and there will be more commercial alfalfa growers that market hay based on forage quality.There may be a premium for quality forage achieved only through the use of herbicides.Then, herbicide use will be extremely important and essential to the production of high quality alfalfa without weeds which have anti-quality factors.Herbicide use will be especially critical the seeding year.This is the primary reason for continued support of the currently labeled products for use in alfalfa.[1,15]

A second issue which is important in the evaluation of herbicide importance in alfalfa is the effect herbicides have on forage quality.The value of improved forage quality attributable to controlling weeds has been characterized in terms of increased milk production[11], or assigning value to forage with estimated discount values based on percent dry weight and presence of weeds[29]. However, because alfalfa is often produced and used on-farm, the economic benefit of improved forage quality from weed control is difficult to assess.[17]

Critically Needed Herbicides

The loss of one herbicide which provides good control of both broadleaf and grass weeds will likely require replacement by two or more herbicides, which may increase the herbicide and application cost to the grower.[17] In addition to this, the following products are critical for the reasons noted.

Buctril- This offers better control of some mustards such as wild mustard (common in alfalfa seedings in Minnesota) compared to 2-4,D, and provides an advantage over 2,4-DB for smartweed species such as wild buckwheat, and Pennsylvania or Ladysthumb smartweed.Pursuit will control all of these but may cost more and has its own unique injury, persistence, and weed resistance issues.[1]

Glyphosate – This is the most effective herbicide against quackgrass.It can be used as a spot treatment in established stands and is also necessary for site preparation.[1]

Imazethapyr – This has the widest spectrum of weeds controlled, and is a good bargain for the money invested. This product is the best choice for producers demanding pure stands of alfalfa to harvest during the seeding year.[15]

Sethoxydim and clethodim – These are the only products labeled for postemergence grass control in new seedings and reduction of quackgrass in established stands. They are also useful on alfalfa seeded with companion crops, when the desired result is to kill the companion crop as a planned approach to stand establishment.[15]

2-4,DB – This is a good product for high populations of pigweed species; it has a broader window of application than Buctril, and may be cheaper than Pursuit for pigweed.[1]

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