

Crop Profile for Alfalfa in Virginia

Prepared: January, 2004



General Production Information

- In 2001, a total of 110,000 acres of alfalfa were harvested in Virginia. In 2002 and 2003, a total of 120,000 and 130,000 acres were harvested.
- Alfalfa production in Virginia yielded 3.10 tons/acre, and a total of 341,000 tons of alfalfa were produced in Virginia in 2001. In 2002 and 2003, production yielded 2.50 and 3.40 tons/acre and totaled 300,000 and 442,000 tons of alfalfa.

- Western Virginia
- Shenandoah Valley
- Southern Piedmont
- Northern Piedmont
- Eastern Virginia



- The 2001 crop was valued at \$38,874,000 or roughly \$114/ton. For 2002, the alfalfa crop was valued at \$34,200,000 or roughly \$114/ton, and in 2003 it was valued at \$47,294,000 or roughly \$107/ton.
- Virginia ranked 24th of 48 hay-producing* states, accounting for 1.8% of the national production in 2001.
* *Virginia Ag. Statistics Service combines alfalfa with all hay produced in the state in 2001.*

Cultural Practices

Alfalfa, *Medicago sativa*, is a perennial crop grown for hay, pasture, and silage in Virginia. It has a distinct deep, branched taproot that enables the plant to obtain water during dry periods, making it a good choice for drought-prone areas. The 2-3 foot tall stems have leaves that are smooth and arranged alternately on the stems. Each leaf has three leaflets with smooth edges on the lower two-thirds and small serrations on the upper one-third of each leaflet. Also, most varieties grown in Virginia have purple flowers.

There are several hundred varieties on the market, and many do well in Virginia. Variety selection often depends on several important factors such as resistance to diseases and persistence but also short-term yield, quality, and palatability. Consult your local Extension agent about varieties for a specific area or refer to the Virginia Cooperative Extension web site <http://www.ext.vt.edu/>.

Ideal planting dates are 30-60 days before the first killing frost in the fall or 10-30 days before the last killing frost in the spring. The seed is generally broadcast or planted in 6-8 inch rows. Also, alfalfa requires high levels of phosphorus (P) and potassium (K) in order to persist and yield to its potential. At seeding, use 0 lbs. of nitrogen (N), 110-140 lbs. P, and 110-140 lbs. K per acre at medium soil test levels. For top-dressing, use 70-90 lbs. P and 220-360 lbs. K per acre annually for medium soil test levels. Applications should be split: half in the fall and half in the spring. Lower levels of fertilizer

are required for pasture. Soil should be well drained, with sandy clay loam to clay subsoils. The pH should fall between 6.8 and 7.0.

Harvesting usually occurs at late bud to 1/4 bloom, except the first cutting. The first cutting should be made in (hay or silage) bud stage or when orchardgrass begins to head. Alfalfa may be cut 3-5 times/year at 30- to 40-day intervals, depending upon location in the state and average rainfall. Make the last cutting three to four weeks before average date of first killing frost in fall or in time to allow 6-8 inches of regrowth. Allow at least one harvest to reach 1/10 bloom to help persistence. Approximate yield is 3-6 tons of hay per acre per year.

During the growing season, worker activities in the field typically include such things as field preparation, planting (August-September and March-April), scouting or pest monitoring, spraying, and harvesting (May-September). The workers risk potential exposure to pesticides during these activities and should follow all safety procedures determined by the label, mostly by wearing proper personal protective equipment (PPE) and strictly following re-entry intervals (REIs) when returning to the field. Activities that bring workers in direct contact with the plants during the growing season are generally uncommon, as most work performed in the field is done mechanically. However, workers are sometimes required in the field for pest monitoring and also during harvest when square bales are loaded by hand.

Special Use Labels

Section 18 Emergency Use Exemption and Special Local Need 24(c) labels are used to supplement the chemical tools available to producers for pest control. Once the problem or gap in pest control has been identified, specialists submit the proper documentation for the emergency use/special local need label. Thus far, Extension specialists have been successful in obtaining these labels. Special Local Need (SLN) labels in Virginia are granted by the Virginia Department of Agriculture and Consumer Services (VDACS) and are usually only valid for limited time intervals. However, a fee must be paid annually by the registrant to keep the product registered for use in Virginia. Section 18 Emergency Use labels are evaluated and granted by the Environmental Protection Agency (EPA) and can be renewed annually. Without these temporary use labels, pest control might be extremely difficult for producers. However, in alfalfa there are no Section 18 Emergency Use or SLN labels needed at this time.

Insect Pests

Control recommendations found below were modified from information presented in the 2003 Virginia Cooperative Extension: Field Crops Pest Management Guide.

The most important insect pests of alfalfa in Virginia are alfalfa weevil and potato leafhopper. Aphids, armyworms, grasshoppers, and cutworms are considered minor pests. Consult your local county agent for help with identifying unknown insects or go to the Virginia Tech Insect Identification Laboratory web site, <http://www.ento.vt.edu/Facilities/OnCampus/IDInfo.html> for help.

Alfalfa Weevil, *Hypera postica*

The alfalfa weevil overwinters in field trash and surrounding brush as adults and as eggs in plant stems. In late winter or early spring, adults emerge and lay eggs in alfalfa stems. The larvae, pale green in color with a pale stripe down the center of the back and a black head, emerge and feed for three to four weeks before pupating. Injury mainly occurs to the first cutting in early spring when the larvae feed on the terminal buds and upper leaves, gradually moving down the plant and causing extensive skeletonization. Larvae are much more damaging than adults, and feeding by third and fourth instar larvae causes most (90%) of the damage. Generally, there is one generation per year. The risk of economic damage from alfalfa weevil is low in the ridge and valley portions of Virginia because natural populations of beneficial parasitic wasps often provide effective suppression. In a given year, most (80%) of the acres of alfalfa located in these areas do not need an insecticide spray for alfalfa weevil. However, the risk of economic damage in the Piedmont region is much higher (95-100%)

Monitoring: Once the alfalfa begins to grow in the spring, walk the field at least once a week to determine whether the field needs to be sprayed, harvested early, or if no pest management actions are needed. The decision to control should be based on the number of alfalfa weevil larvae and alfalfa stem length. Tools used to monitor alfalfa weevil include a 3-5

gal. bucket, clipboard, pencil, ruler, sampling form, and decision chart. Scouts should divide the field into six equal sections and walk to the approximate center of the first section.

Instructions for Sampling, Measuring, and Decision Making to control alfalfa weevil:

Sampling weevil larvae: Randomly pull 10 stems and place them tip-end first into the bucket. Be careful not to lose any larvae that may fall off as you pull each stem. While holding the 10 stems by their base, vigorously shake the stems against the sides of the bucket for at least 5 seconds. Then carefully remove the plant material from the bucket and count the number of weevil larvae in the bucket. Record this number on the alfalfa weevil sampling form.

Measuring alfalfa stem lengths: Measure the length of two alfalfa stems (rounded to the nearest inch) from the ground to the topmost leaf bud and record the stem lengths on the alfalfa weevil sampling form. Repeat the sampling procedure for each of the remaining five sections of the field (for ease in calculating average stem length, only measure a total of 10 stem lengths).

Note: These thresholds are intended for alfalfa growing under adequate fertility and soil moisture conditions. Under drought stress conditions, the threshold should be lowered by about 0.5 weevil larvae per stem.

Alfalfa Weevil Decision-Making Chart



Alfalfa Weevil Sampling Form

Sample site	Weevil larvae	Stem lengths (inches)	
		1	2
1			
2			
3			
4			
5			
6			
Subtotal			
Total			
Avg. per stem			

Chemical Control: See *Chemical Insect Control* section.

Biological Control: Parasitic wasp, *Bathyplectes curculionis*, is one of several wasp species that aid in the biological control of alfalfa weevil in Virginia.

Cultural Control: In late fall remove the alfalfa for hay or by grazing. This removes the overwintering egg-laying sites for the adult weevils and will help reduce the number of alfalfa weevil larvae attacking the crop the following spring. Early harvest can sometimes be used in the spring instead of insecticide sprays if the crop has obtained sufficient growth before larval feeding damage becomes severe.

Potato Leafhopper (PLH), *Empoasca fabae*

Potato leafhopper (PLH) overwinters in the Gulf Coast states and migrates north in the spring. The wedge-shaped adult is about 1/8 inch long and is pale green with glassine wings. The nymphs are wingless, smaller than the adults, and appear pale green to yellow in color. The nymphs are also very quick when disturbed and usually move from one side of the leaf to the other. The life cycle generally takes about a month, allowing for several generations of PLH to occur in one growing season. Injury occurs when both PLH nymphs and adults feed by piercing the undersides of leaves and sucking out the plant sap. These pests also contain a toxin in their saliva that disrupts photosynthetic tissue and affects the plant's ability to produce food. This toxic effect causes a yellow, wedge-shaped area at the tips of the alfalfa typically known as "hopperburn." These symptoms should not be confused with disease and nutritional deficiencies, in which yellowing

of foliage typically begins at leaf margins. Initially, leafhopper feeding results in stippling of the leaf surface followed by rolling and yellowing of leaves and, in severe cases, leaf or plant death. Injury typically is worse in dry years. PLH feeding can cause more than 50% reduction in yield and up to 25% reduction in protein content (quality). During the first growing season, spring-planted alfalfa fields are particularly attractive to potato leafhopper adults, and young seedlings are very susceptible to leafhopper injury. Even new varieties with high levels of resistance to PLH often require chemical control during the seedling year.

Monitoring: Established alfalfa fields should first be sampled using a 15-inch sweep net one week after the first cutting. New seedlings of alfalfa should be sampled beginning in mid-May. Spring seedlings of alfalfa are not cut until late June or early July, when they often build up damaging leafhopper populations. Continue sampling every 7-10 days until potato leafhopper populations die back (usually late August to early September). Use a decision-making chart that uses alfalfa height and PLH numbers to determine whether to spray, harvest, or wait a week and sample again. Alfalfa fields can be sampled any time during the day as long as the foliage is not wet. Sweeping alfalfa when it is wet from dew or rain is difficult, and the samples are almost impossible to count. [6](#)

To sample potato leafhopper, use a 15-inch diameter sweep net, pencil, ruler, sampling form, and decision-making chart. Scouts should divide the field into six equal sections and walk to the approximate center of the first section.

Instructions for Sampling, Measuring, and Decision Making to control alfalfa weevil:

Sampling Potato Leafhoppers: A "sample" consists of 10 pendular sweeps, in which the net is swung like a pendulum in front of the scout as they walk at a brisk pace through the alfalfa. Adjust the depth of sweep into the foliage to consistently sweep about one-half of the net diameter. In alfalfa, shorter than 7 or 8 inches, sweep as close to the soil as possible without scraping the ground. After the 10th sweep, quickly grab the net near the ring to prevent the insects from escaping. Count leafhopper nymphs and adults in the rim area, then carefully and completely unfold the net, counting nymphs and adults. Because the adult leafhopper is an active flier, it is important to keep the net constricted as you unfold it. Record the number of nymphs and adults on the potato leafhopper sampling form.

Measuring alfalfa stem lengths: Measure the length of two alfalfa stems (rounded to the nearest inch) from the ground to the topmost leaf bud and record the stem lengths on the potato leafhopper sampling form.

Repeat this sampling procedure for each of the remaining five sections of the field (for ease in calculating average stem length, only measure a total of 10 stem lengths). Shake out the net before beginning each sample.

Decision Making: When finish with sampling the field, determine the average number of potato leafhoppers per sweep and the average alfalfa stem length, and plot the point on the potato leafhopper decision-making chart in order to determine what action to take. If the point falls on or above the economic threshold line (bold line on chart), either harvest (if alfalfa is taller than 14 inches) or treat the field with a recommended insecticide. If the point falls below the threshold line, no control measures are recommended; sample again in 7-10 days.

Potato Leafhopper Decision-Making Chart



Potato Leafhopper Sampling Form

Sample site	Potato Leafhoppers		Stem lengths (inches)	
	Nymphs	Adults	1	2
1				
2				
3				
4				
5				
6				
Subtotal				
Total				

Chemical Control: See *Chemical Insect Control* section.

Biological Control: Although several natural enemies of PLH occur, their impact on populations is minimal.

Cultural Control: Spring-planting alfalfa with a companion crop of spring oats will help prevent soil erosion, and it will also reduce potato leafhopper infestations in the first summer cutting of the alfalfa. It is important to reduce the oat seeding rate to one-fourth to one-half normal rate to reduce competition with alfalfa seedlings.

Aphids

Blue alfalfa aphid, *Acyrtosiphon kondoi*

Pea aphid, *Acyrtosiphon pisuma*

Pea aphids are long-legged and light to deep green in color with reddish eyes. The cornicles (a pair of tailpipe-like structures projecting from the abdomen) are characteristically long and slender. The eggs are light green initially and turn a shiny black before hatching. The adults are also wingless. Injury occurs when the aphids extract the sap from the terminal leaves and stem of the host plant. This kind of feeding can result in deformation, wilting, or death of the host depending on infestation levels. Injury can also reduce the alfalfa's feed value. A black fungus, commonly referred to as sooty mold, grows on the honeydew excreted by the aphid reducing palatability.

The blue alfalfa aphid is very similar in appearance to the pea aphid and is often confused with it. The distinguishing characteristic is the antennae. The antennae of the pea aphid show narrow dark bands at the tip of each segment, whereas those of the blue alfalfa aphid are uniformly brown.

Monitoring: Large aphid populations may be detected by the appearance of cast skins, sooty mold, or shiny honeydew accumulations on lower foliage.

Chemical Control: See *Chemical Insect Control* section.

Biological Control: Lady beetles, damsel bugs, and lacewing larvae strongly prefer to feed on aphids. Flower fly larvae are also effective aphid predators. In addition, there are numerous wasp species that parasitize aphids. Natural enemies will often keep aphid populations below damaging numbers and, therefore, should be considered before making an insecticide application. However, if the spread of virus is of concern, chemical treatment will be necessary.

Cultural Control: Always check surrounding weeds and other plants for aphids before planting. Avoid planting fields immediately downwind of a barrier such as hedgerows or wood lots, which reduce wind velocity and increase the number of dispersing aphids falling into fields. After harvest, always remove any crop residues left in the field as soon as possible.

Armyworms, *Pseudaletia unipuncta*

Armyworms are primarily a pest of new seedlings and are considered a minor pest in Virginia. The larvae are pale green in color when young, but as they mature they are yellow to brownish green in color with three dark, longitudinal stripes. The larvae prefer to feed on young foliage of new seedlings.

Monitoring: Armyworm larvae are active at night, so it can be difficult to detect their presence in the field. If you find five to seven small larvae per square foot or 10% damage to foliage, treatment may be needed.

Chemical Control: Apply when insects begin to cause injury. See *Chemical Insect Control* section.

Biological Control: Various diseases, parasites, insect predators, and birds.

Cultural Control: Harvest the alfalfa early if the time to harvest is close and damage levels are high.

Grasshoppers, *Melanoplus* spp.

Grasshoppers are occasional pests of minor importance in Virginia. They occasionally will move from uncultivated areas to cultivated fields. The grasshoppers feed on alfalfa leaves, causing minor damage.

Monitoring: Economically significant levels vary with the growth of the crop. Generally, populations of 15-20 per square yard or higher are considered severe. If grasshoppers are present in seedling stands, damage should be monitored closely to prevent stand failure.

Chemical Control: See *Chemical Insect Control* section.

Biological Control: No effective natural enemies are known at this time.

Cultural Control: It is critical that grasshoppers are controlled in adjacent fence-rows, pastures, and other areas before migration into alfalfa stands occurs.

Variegated Cutworm, *Peridroma saucia*

Considered a minor pest in Virginia, cutworms are usually springtime pests causing damage to alfalfa seedlings, but may also feed heavily on new growth on older stands of alfalfa, particularly under wind rows prior to baling. Newly planted fields are at greater risk, as they are more vulnerable to defoliation. Damage occurs when the larvae climb the plants and feed on new foliage. However, late instars may burrow in the soil and cut plants at or near the soil surface. The larvae are smooth-skinned and yellow to brown in color. The first four abdominal segments bear several yellow or orange spots. When disturbed, the larvae curl into a C-shaped ball. Variegated cutworm moths have pale gray or light brown wings with dark brown mottling.

Monitoring: Cutworm larvae are present in the spring, although they are not typically seen in the open during the day because they are most active at night. Digging in the soil around injured plants or under foliage may reveal their presence. Treatment is recommended if small larvae ($\leq 1/2$ inch) exceed an average of 3/sq. ft., or if large larvae ($> 1/2$ inch) exceed 2/sq. ft.

Chemical Control: Apply when insects begin to cause injury. See *Chemical Insect Control* section.

Biological Control: Often controlled by naturally occurring diseases and several parasitic wasps.

Cultural Control: Timely cutting and keeping the fields and field edges weed free are effective.

Chemical Insect Control

The list below contains products available to producers for insect control in alfalfa in Virginia along with recommended application rates. Always consult the label before making an application. **PHI** = Pre-Harvest Interval. **REI** = Re-Entry Interval.

- **azinphos-methyl** (*Guthion* 3F) - PHI - 14-21 days. Organophosphate. Apply at a rate of 0.25-0.75 lb. a.i./A for control of alfalfa weevil. Use a minimum of 10 gal. water/A by ground or 20 to 25 gal. water/A if growth is heavy. Restricted Use. REI- 48 hrs-4 days.
- **carbaryl** (*Sevin* 80S)(*Sevinmol*-4) - PHI - 7 days. Carbamate. Apply at a rate of 1.0 lb. a.i./A for control of potato leafhopper. For control of grasshoppers, apply at a rate of 0.5-1.5 lb. a.i./A. Use the lower rate for nymphs on small plants or sparse vegetation. Use the higher rate for adults or applications to dense vegetation. For control of armyworms and cutworms, apply at a rate of 1.0-1.5 lb. a.i./A. Carbaryl is highly toxic to bees; avoid spraying weeds in bloom or alfalfa beyond 10% bloom. Do **NOT** apply more than once per cutting. May cause temporary bleaching of tender alfalfa foliage. REI- 12 hours.
- **carbofuran** (*Furadan* 4F) - PHI - 7-28 days. Carbamate. Apply at a rate of 0.25-1.0 lb. a.i./A for control of alfalfa weevil and pea aphids. For control of potato leafhopper, apply at a rate of 0.5-1.0 lb. a.i./A. For control of grasshoppers, apply at a rate of 0.125-0.25 lb. a.i./A. Restricted Use. Do **NOT** make more than one application per season. Do **NOT** move bees to alfalfa fields within 7 days of application. REI- 48 hours.

- **chlorpyrifos** (*Lorsban* 4E) - PHI - 7-21 days. Organophosphate. Apply at a rate of 0.5-1.0 lb. a.i./A for control of alfalfa weevil. For control of potato leafhopper, apply at a rate of 0.25-0.50 lb. a.i./A. Some temporary yellowing may occur after application, but this will disappear within a week and not cause yield loss. Do **NOT** apply more than 4 times/year or more than once/cutting. Highly toxic to bees. REI- 24 hours.
- **cyfluthrin** (*Baythroid* 2E) - PHI - 7 days. Pyrethroid. Apply at a rate of 0.025-0.044 lb. a.i./A for control of alfalfa weevil. For control of potato leafhopper, apply at a rate of 0.0125-0.025 lb. a.i./A. Do **NOT** exceed 0.175 lbs. a.i./A/season, and only one application per cutting may be made. Only four applications allowed per season. Restricted Use. REI- 12 hours.
- **dimethoate** (*Dimethoate* 4EC)(*Cygon* 400) - PHI - 10 days. Organophosphate. Apply at a rate of 0.25-0.50 lb. a.i./A for control of potato leafhopper and pea aphids. Make **ONLY** one application/cutting. Do **NOT** apply if crops and weeds are blooming to avoid killing bees. REI- 48 hours.
- **indoxicarb** (*Steward SC* 1.25) - PHI - 7 days. Carbamate. For control of alfalfa weevil, apply at a rate of 0.065-0.110 lb. a.i./A. Do **NOT** apply more than once per cutting. A total of 0.44 lbs. a.i./A may be applied per season. REI - 12 hours.
- **lambda-cyhalothrin** (*Warrior T* 1EC) - PHI - 1-7 days. Pyrethroid. Apply at a rate of 0.02-0.03 lb. a.i./A for control of alfalfa weevil, armyworms, grasshoppers, and pea aphids. For control of cutworms and potato leafhopper, apply at a rate of 0.015-0.025 lb. a.i./A. Do **NOT** apply more than 0.03 lbs. a.i./A/cutting. Do **NOT** apply more than 0.12 lbs. a.i. /A/season. Restricted Use. REI- 24 hours.
- **malathion** (*Malathion* 8EC) - PHI - 0 days. Organophosphate. Apply at a rate of 1.0-1.5 lb. a.i./A for control of grasshoppers and pea aphids. Restricted Use. REI- 12 hours.
- **methomyl** (*Lannate LV* 2.4) - PHI - 7 days. Carbamate. Apply at a rate of 0.9 lb. a.i./A for control of alfalfa weevil. REI- 48 hours.
(*Lannate* 1.8L)(*Lannate* 90WSP) - PHI - 7 days. Carbamate. Apply at a rate of 0.225-0.90 lb. a.i./A for control of armyworms and cutworms. For control of pea aphids, apply at a rate of 0.45-0.90 lb. a.i./A. REI- 48 hours.
The following applies to all methomyl formulations: Wait 7 days after application before grazing or feeding livestock. Do **NOT** apply to dormant or semi-dormant alfalfa when minimum daily temp. is 50°F or lower. Do **NOT** apply more than 3.6 lbs. a.i./A/crop. Do **NOT** make more than 10 applications/crop. Classified as a Restricted Use Pesticide (RUP) by the EPA.
- **permethrin** (*Pounce* 3.2EC)(*Ambush* 2E) - PHI - 0-14 days. Pyrethroid. Apply at a rate of 0.1-0.2 lb. a.i./A for control of alfalfa weevil. For control of potato leafhopper, apply at a rate of 0.1-0.2 lb. a.i./A for *Pounce* and 0.05-0.2 lb. a.i./A for *Ambush*. For control of armyworms and cutworms, apply at a rate of 0.05-0.20 lb. a.i./A. Do **NOT** apply more than 0.2 lb. a.i./A per cutting. When honeybees are foraging, apply during early morning or evening. Restricted Use. REI- 12 hours.
- **phosmet** (*Imidan* 50WP) - PHI - 7 days. Organophosphate. Apply at a rate of 1.0 lb. a.i./A for control of alfalfa weevil. For control of potato leafhopper, apply at a rate of 1.0 lb. a.i./A. Do **NOT** apply more than once/cutting. Do **NOT** apply during bloom. Restricted Use. REI- 24 hours.

Pesticide Use Data - %Acres Treated				
	1992	1997	2003*	Growers Needs
azinphos-methyl	n/a	n/a		
carbaryl	n/a	n/a		
carbofuran	6.0	19.0		
chlorpyrifos	6.0	21.0		
cyfluthrin	n/a	n/a	5.0 - 25.0	<i>critical</i>
dimethoate	9.0	16.0	7.0	<i>critical</i>
indoxicarb	n/a	n/a		
lambda-cyhalothrin	n/a	n/a	20.0	<i>critical</i>
malathion	0	2.0		
methomyl	n/a	n/a		
permethrin	0	1.0		
phosmet	0	1.0		

*Limited data from counties. No state-wide data available.

Weeds

Control recommendations found below were modified from information presented in the 2003 Virginia Cooperative Extension: Field Crops Pest Management Guide.

A number of weeds are commonly found invading alfalfa in Virginia. These include annual grasses such as: barnyardgrass, crabgrass, foxtail spp., goosegrass, and fall panicum. Perennial grasses commonly found include: bermudagrass, cheat, johnsongrass, orchardgrass, quackgrass, tall fescue, and yellow nutsedge, a perennial sedge. Also, broadleaf weeds such as: spiny amaranth, common chickweed, dandelion, dock spp., hemp dogbane, henbit, horsenettle, horseweed, knawal, common lambsquarters, prickly lettuce, milkweed spp., mustard spp., nightshade, pennycress spp., pepperweed spp., pigweed spp., plantain spp., common ragweed, sheperdspurse, smartweed spp., speedwell, bull thistle, Canada thistle, plumeless thistle, musk thistle, and yellowrocket are all problems in alfalfa.

Legume seedlings are relatively slow growing, whereas weeds often have a rapid initial growth period. Thus, in new seedlings, weeds compete strongly with the legume seedlings for light, moisture, and nutrients. Severe reduction or loss of stands may result. Several preplant-incorporated treatments are available that offer good annual grass control and some broadleaf weed control. Once a stand is established, weeds may continue to reduce yields and impair quality of forage. Residual herbicides and postemergence herbicides are both available for use in established forage stands. Most are recommended for fall or spring dormant application. Applicators should pick the treatment that best suits the specific weed infestation and carefully follow label directions in terms of timing and rates of application.

Monitoring: Proper weed identification is an important part of effective weed control. Weeds observed in previous crops within a given field should be noted to aid in future herbicide decisions. It is also important to monitor the effectiveness of preplant-incorporated and preemergent herbicides once the crop emerges.

Chemical Control: Herbicides are applied either preplant or postemergence. Incorporation of some herbicides to a depth of 2 to 4 inches is required for activation. See *Chemical Weed Control* section below.

Biological Control: No commercially effective controls are available.

Cultural Control: Crop rotation is also important to prevent domination of any one weed species year after year. Also, avoiding fields with a history of severe weed infestations may be an appropriate action.

Chemical Weed Control

The list below contains all of the fully labeled products available to producers for weed control in alfalfa. Always consult the label before making an application. **PHI** = Pre-Harvest Interval. **REI** = Re-Entry Interval.

Preplant:

- **benefin** (*Balan 60DF*) - PHI - N/A. Dinitroanilines. Apply to clean, dry soil surface no more than 10 weeks before planting for control of annual grasses and broadleaf weeds at 1.2-1.5 lb. a.i./A. Incorporate within 4 to 8 hours with a disk set to cut 4 to 6 inches and operate in two different directions at 4 to 6 mph or with power takeoff-driven equipment set to cut 2 to 3 inches deep once over. See label, and adjust rate to soil texture. REI - 12 hours.
- **EPTC** (*Eptam 7E*) - PHI - N/A. Thiocarbamates. Spray on the surface of freshly prepared soil at a rate of 3.0-4.0 lbs. a.i./A. Incorporate into the soil to a depth of 2-3 inches immediately after application. Follow label suggestions for proper incorporation procedures. Plant alfalfa seed immediately after incorporation. Perennial grass rhizomes must be chopped up thoroughly (2-inch sections or less) before treatment. Temporary stunting and sealing of first leaves may occur. Do **NOT** use if more than 1.2 lbs. active ingredient of atrazine were applied within the previous 12 months. REI - 12 hours.
- **glyphosate** (*Roundup Ultra Max*)- PHI - 56 days*. Phosphono Amino Acids. Apply no more than 2.0 lbs. a.i./A/application for the control of emerged vegetation before the establishment of alfalfa in conventional systems or when overseeding into a cover crop. When overseeding alfalfa, glyphosate must be applied before planting a labeled cover crop. Avoid contact of spray with foliage, green stems, or fruit of desirable crops, plants, trees, or other vegetation because severe damage or destruction may result. Repeated treatments may be necessary to control weed regeneration from underground parts or seed. Repeat treatments must be made before the crop emerges. REI - 4 hours.
(*Touchdown*)- PHI - 56 days*. Phosphono Amino Acids. Apply 0.75-2.0 lbs. a.i./A. for control of emerged vegetation before the establishment of alfalfa in conventional systems, or when overseeding **36 hours** before the crop is harvested and fed to livestock. If spot treating alfalfa, remove livestock before application and wait **14 days** after application before

grazing livestock or harvesting.

- **paraquat** (*Gramoxone Max*) - PHI - 42 days. Bipyridyliums. For no-till establishment of alfalfa into perennial grass sods, apply treatment before the emergence of the crop. Apply 0.6-1.0 lbs. a.i./A. Additional herbicide treatments or alternate methods of establishment may be required if perennial broadleaf weeds are present. Apply as a broadcast application in 10 gal. of water/A using ground equipment. Use a higher rate for kill or suppression of harder-to-control weeds and grasses, such as the perennial and smooth brome species. Crop plants that emerge at time of application will be killed. Seeding should be done with a minimum amount of soil disturbance. REI - 12 hours.

Seedling Stand & Fall/Spring Dormant:

- **bromoxynil** (*Buctril 4EC*) - PHI - 30 days. Nitriles. Apply 0.25-0.38 lbs. a.i./A when weed seedlings are actively growing but do **NOT** exceed 4 leaf stage or 2 inches in height. Do **NOT** apply to seedling alfalfa with less than 2 trifoliolate leaves. Leaf burn can occur following application and warm, humid conditions may even enhance leaf burn. New growth, however, will not be affected. REI - 24 hours.
- **2,4-DB** (*Butyrac 200*) - PHI - 60 days. Phenoxys. Apply 0.5-1.5 lbs. a.i./A when weeds are actively growing and no more than 3 inches high, or rosettes are less than 3 inches across. May be applied either to seedling legumes (when seedling plants have 2-4 trifoliolate leaves) or to established stands (in late fall or early winter for best control) at a rate of 0.5-1.5 lbs. a.i./A. Do **NOT** apply if temperature is expected above 90°F during or shortly after treatment. Fields should **NOT** be grazed within 30 days on established stands after application. REI - 48 hours.
- **pronamide** (*Kerb 50DF*) - PHI - 120 days. Amides. Use on established plantings or on new plantings after legume has reached trifoliolate stage. Apply 0.5-1.5 lbs. a.i./A during fall or early winter and before winter freeze-up. Apply when soil temperature is 50°F or less. Remove or disperse trash or crop residue before treatment. Rainfall is necessary to move it into the root zone where it is absorbed. Avoid drift to nontarget areas. Do **NOT** graze within 120 days of treatment. REI - 24 hours.

Postemergence/Postcutting/Fall & Spring Dormant:

- **Clethodim** (*Select 2EC*) - PHI - 15 or 60 days. Cyclohexanediones. May be applied to seedling or established alfalfa using 0.09-0.25 lbs. a.i./A for control of annual and perennial grasses. Do **NOT** plant rotational crops until 30 days after application. Can be tank mixed with 2,4-DB, but a 60-day feeding, grazing, and harvesting restriction must be observed. REI - 24 hours.
- **diuron** (*Karmex 80DF*) - PHI - N/A. Ureas. Apply 1.20-2.40 lbs. a.i./A in March or early April when alfalfa is dormant and before it begins growth in the spring. Treat only stands established for one year or more. Do **NOT** apply to alfalfa/grass mixtures or to alfalfa with unusually shallow root penetration (such as shallow hard pans) or on sandy soils with less than 1% organic matter. Do **NOT** replant treated areas to any crop within two years, unless otherwise directed. REI - 12 hours.
- **hexazinone** (*Velpar 90W*) - PHI - 30 days. Triazinones. Apply 0.45-1.35 lbs. a.i./A as a postemergence treatment to established stands of alfalfa in the fall or winter after alfalfa becomes dormant or in the spring before new growth begins or after cutting following hay removal. Use the lower rate on coarse-textured soils and higher rate on fine-textured soils. Apply in a minimum of 20 gal/A when weeds are 2 inches high or less for best results. Corn may be planted 12 months after application. Do **NOT** graze or feed treated forage to livestock within 30 days following application. REI - 24 hours.
- **imazethapyr** (*Pursuit 70DG*) - PHI - 30 days. Imidazolinones. Apply 0.047-0.095 lbs. a.i./A postemergence to seedling alfalfa, in the fall to dormant alfalfa, in the spring to dormant alfalfa or before spring regrowth reaches 3 inches, or between cuttings. Make applications when weeds are no larger than 1-3 inches or when rosettes are less than 3 inches in diameter. Apply in 10 or more gal. of water/A in combination with an approved nonionic surfactant or crop oil concentrate. Do **NOT** apply to seedling alfalfa before the crop has two fully expanded trifoliolate leaves. Consult the label and adjust rate for the specific weed infestation. Rates of 0.063-0.095 lbs. a.i./A are generally used for broad-spectrum weed control. May be applied to alfalfa/grass mixtures except in the establishment year or in the last year due to rotational restrictions. REI - 12 hours.
- **metribuzin** (*Lexon 4L*)(*Sencor 4F*) - PHI - 28 days. Triazinones. Make a single application of 0.25-1.00 lbs. a.i./A in the fall after alfalfa becomes dormant or in the spring before new growth starts. Stands planted in the spring that are less than one year old at the time of application may be treated with a maximum of 2/3 lb. of *Sencor DF/A* after alfalfa growth ceases in the fall. Do **NOT** graze within 28 days after application. May be used in alfalfa/grass mixtures. REI - 12 hours.
- **paraquat** (*Gramoxone Max*) - PHI - 30 and 60 days. Bipyridyliums. For control of annual grasses, broadleaf weeds, and suppression of perennial plants, apply 0.28 lbs. a.i./A between cuttings. Do **NOT** treat more than five days after cutting. Foliage present at application will be burned. Make one to three applications per year as required. May be used as a salvage treatment on alfalfa less than one year old where weeds threaten the stand. First-year alfalfa lands and yields may be reduced if alfalfa is allowed to regrow more than 2 inches. For first-year alfalfa, do **NOT** apply more than twice during

the growing season. Do **NOT** cut, or harvest within 30 days of application.

For use during the dormant season on established alfalfa, apply 0.56-0.75 lbs. a.i./A. Use higher rate for kill or suppression of harder-to-control weeds and grasses, such as the perennial and smooth brome species. Do **NOT** apply if fall regrowth following the last fall cutting is more than 6 inches high or if spring regrowth is more than 2 inches. Apply to well-established stands (at least one year old) after the last fall cutting when the crop is dormant or before spring growth reaches 2 inches. Alfalfa foliage present at the time of application will be burned, which may reduce the yield of the first cutting. Weeds and grasses should be succulent and growing at the time of application. Do **NOT** graze, cut, or harvest within 60 days of application. REI - 24 hours.

- **sethoxydim** (*Poast Plus*) - PHI - 7-14 days. Cyclohexanediones. Apply to actively growing grasses at the size and rate indicated on the label for the individual grass species. Use 0.09 lbs. a.i./A for annual grass less than 4 inches in height, or 0.125 lbs. a.i./A for annual grasses 4-8 inches in height, as directed by the label. Use 0.30 lbs. a.i./A for control of johnsongrass, quackgrass, and bermudagrass. Always add crop oil concentrate to the spray solution. A second application is required for complete control of perennial grass species. Do **NOT** apply sethoxydim within 7 days of feeding, grazing, or harvesting forage or within 14 days of feeding or harvesting hay. Do **NOT** exceed 0.47 lbs. a.i./A per application or 1.22 lbs. a.i./A per season. REI - 12 hours.
- **terbacil** (*Sinbar 80W*) - PHI -N/A. Uracils. Treat only stands established one year or more. Make a single application of 0.4-1.2 lbs. a.i./A in the fall after plants become dormant or in the spring before new growth exceeds 2 inches or after cutting following hay removal. For semidormant and nondormant varieties, apply in the fall after last cutting or in the spring before new growth exceeds 2 inches in height. Common chickweed and henbit may be selectively controlled in alfalfa as well. Do **NOT** use on seedling alfalfa or on alfalfa grass mixtures or other mixed stands. Do **NOT** apply on snow-covered or frozen ground because injury to the crop may result. Do **NOT** replant to any crop within two years after last application. Do **NOT** apply to established stands after new growth begins in the spring as injury to the crop may result. Do **NOT** apply to stands lacking good crop vigor due to winter-kill, insect or disease injury, or other causes. REI - 12 hours.

Pesticide Use Data - %Acres Treated				
	1992	1997	2003	Growers Needs
2,4 - DB	10.0	5.0	2.0	
clethodim*	n/a	n/a	4.0	<i>critical</i>
EPTC	2.0	0	2.0	
glyphosate	n/a	n/a	5.0	<i>critical</i>
hexazinone	3.0	0	0	
imazethapyr	n/a	n/a	10.0	
metribuzin	3.0	1.0	15.0	<i>critical</i>
paraquat	2.0	3.0	20.0	<i>critical</i>
pronamide	0	2.0	0	
sethoxydim*	1.0	7.0	3.0	<i>critical</i>
terbacil	0	4.0	15.0	<i>critical</i>

*At least one or both are needed to growers

Diseases

Control recommendations found below were modified from information presented in the 2003 Virginia Cooperative Extension: Field Crops Pest Management Guide.

Disease control in field crops is optimized through the development of a long-term management program. Prevention and risk reduction through the integration of various cultural practices including crop rotation, plowing under old plant material, fertilizer management, and pesticides are the goals of an effective and economical disease-management program. Stand establishment of forage legumes may benefit from the use of seed-protectant fungicides, particularly in spring seeding, no-till seeding, or in other situations that may slow germination. Also, planting locally adapted, disease-resistant cultivars will help reduce losses from diseases.

Damping-off and Seed Decay, *Pythium spp.*

These diseases can reduce the stand, especially when alfalfa is grown in poorly drained, acidic soils with a high content of organic matter, or when prolonged wet weather follows planting. In general, cool, wet soil conditions favor seed decay and damping-off diseases. Several types of injury can occur. With preemergence damping-off, seed may decay or seedlings may become blighted and be killed before they emerge. With postemergence damping-off, infection commonly occurs as the seedling emerges, causing wilting, collapse, and death. Also, young roots and stems may decay, causing varying degrees of stunting, but the infected plants survive the early seedling stage. Some of those plants later will turn yellow, wither, and die while the remaining recover.

Monitoring: No monitoring necessary.

Chemical Control: A seed treatment may help control seed root and damping-off where the soils are wet and poorly drained or where stands fail consistently. Seed companies offer pre-inoculated fungicide-treated seed with a protective seed coating. See *Chemical Disease Control* section.

Biological Control: No commercially effective controls are available.

Cultural Control: Plant high-quality, certified seed whenever possible in a fertile, well-prepared seedbed where soil drainage is good. Acid soils should be limed to get a pH of 6.5 to 7.0.

Root Rot, *Phytophthora spp.*

This soilborne disease can be one of the most devastating diseases in alfalfa. Young stands of alfalfa can be greatly affected and can also cause yield loss in older stands. Infected plants become stunted, and leaves may wilt and die. The infection can spread up the taproot to the crown, and the root may rot off. Infected taproots show brown to black lesions an inch or two below the soil surface. Plants suddenly turn yellow or red, wilt, and then die. Cool, wet weather favors this disease, and an outbreak can occur if the soil becomes saturated for three or more days. It occurs primarily in low-lying and poorly drained soils. It is recommended that an alternative crop should be planted in traditionally wet and poorly drained sites.

Monitoring: No monitoring necessary.

Chemical Control: Effective control measures against root rot at seeding are mefenoxam (*Apron*) for seed treatment or mefenoxam (*Ridomil*) to treat soil. There are no effective chemical controls for mature stands. See *Chemical Disease Control* section.

Biological Control: No commercially effective controls are available.

Cultural Control: Using alfalfa varieties with high levels of resistance and using cultural practices like good field leveling, avoidance of heavy soils, and crop rotation can control *Phytophthora* root rot.

Sclerotinia Crown and Stem Rot

Sclerotinia can cause seedling stand losses or failures with fall plantings. It is most common during cool, wet falls and on fields where alfalfa and/or clover have been grown during the preceding three to four years. The only guaranteed way to avoid *Sclerotinia* damage is to plant in the spring, but late summer plantings (mid-August) with adequate moisture often allow sufficient plant size to tolerate *Sclerotinia* damage.

Monitoring: No monitoring necessary.

Chemical Control: No commercially effective controls are available.

Biological Control: No commercially effective controls are available.

Cultural Control: There are no commercially available alfalfa cultivars that have high levels of resistance to Sclerotinia crown and stem rot.

Chemical Disease Control

The list below contains all of the products available for disease control in alfalfa along with the recommended application rates for these chemicals. Always consult the label before making an application. **PHI** = Pre-Harvest Interval. **REI** = Re-Entry Interval.

- **captan** (*Captan* 30-DD, 300, 400, and 400-DD) - PHI - N/A. Phthalimides. Apply as a slurry to control seed decay and damping-off at a rate of 6.5 fl. oz./100 lbs. REI - 12 hours.
- **mefenoxam** (*Apron* XL LS) - PHI - N/A. Phenylamides. For control of damping-off and early season rot, apply as a seed treatment at the rate of 0.64 fl oz/100 lbs. of seed. REI - 48 hours.
- **metalaxyl** (*Apron* 50W) - PHI - N/A. Phenylamides. For control of damping-off and early season rot, apply as a seed treatment at the rate of 1.0 oz/100 lbs. of seed. REI - 48 hours.
- **metalaxyl-mefenoxam** (*Ridomil Gold EC*) (*Ridomil Gold WSP*) - PHI - N/A. Phenylamides. For control of damping-off and root rots caused by *Phytophthora* spp., apply 0.125-0.25 lbs. a.i./A as a broadcast spray at planting in a minimum of 20 gal. water. If alfalfa seed is already treated with metalaxyl or mefenoxam as a seed dressing, use only 0.125 lbs. a.i./A spray. Alfalfa may be planted immediately following last application. To avoid possible illegal residues, do **NOT** feed green forage or cut hay for 60 days following application. REI - 48 hours.
- **thiram** (*Thiram*-50WP Dyed) - PHI - N/A. Dithiocarbamates. Apply as a slurry to control seed decay and damping-off. REI - 24 hours.

Nematodes

Control recommendations found below were modified from information presented in the 2003 Virginia Cooperative Extension: Field Crops Pest Management Guide.

The alfalfa stem nematode (*Ditylenchus dipsaci*), the lesion nematode (*Pratylenchus* spp.), and the root-knot nematode (*Meloidogyne* spp.) are the most important species of nematodes affecting alfalfa in Virginia. Plant-parasitic nematodes are microscopic roundworms that live in soil and plant tissues and feed on plants by puncturing and sucking the cell contents with a needlelike mouthpart called a stylet. The alfalfa stem nematode feeds in the crowns, stems, and buds of the alfalfa plant, while the other nematodes listed above feed on roots. Root-feeding nematodes are most damaging to crops grown in sandy soils. Nematodes cause reduced growth and yield, and a decline in vigor and stand. Symptoms and damage can mimic other diseases and pests, making identification nearly impossible to determine on site. Many new alfalfa varieties have moderate to high resistance to the alfalfa stem nematode and root-knot nematode. If nematode damage is a concern, check variety specifications before purchasing seed.

In addition, several ectoparasitic species may also be important, including *Xiphinema* spp., *Criconebella* spp., *Paratrichodorus* spp., and *Tylenchorhynchus* spp. *Paratrichodorus* spp. is also responsible for transmitting several important alfalfa viruses. Soil and root samples should be collected and analyzed by an expert for determination.

Monitoring: Both diagnostic and predictive nematode assay programs in Virginia provide data to producers on the numbers and kinds of nematodes in soil along with recommendations for control. Soil samples for diagnostic assays are processed without charge to determine the cause of production problems during the growing season. Predictive nematode assays are done on samples collected after harvest. These samples must be collected in the fall no later than November 20.

Chemical Control: When using soil fumigation, it is important that the fields be sufficiently prepared for planting. All crop debris and clods should be removed, and soil moisture should be adequate. Otherwise, soil fumigation will not be effective due to lack of penetration of all soil particles by the gaseous fumigant. It is also necessary to allow an aeration period between fumigant applications and planting, otherwise crop injury will occur. For recommendations, see the *Chemical Nematode Control* section below.

Biological Control: No commercially effective controls are available.

Cultural Control: Sanitation and good cultural practices are the best preventive measures against nematodes. Examples include obtaining nematode-free roots and washing soil from machinery and tools before using them at different locations. Crop rotation with nonhost crops, such as cereals, cotton, corn, and grasses, for two to three years may lower the population size and is highly recommended in the event of nematode activity. Use certified seed to control stem nematodes and use resistant varieties when available.

Chemical Nematode Control

Typically, chemical controls are used only when cultural practices are unable to provide adequate control. However, these chemicals are still important tools when other methods of control have failed.

Contacts

Developed and Written by:

Therese N. Schooley

Project Manager
Virginia Polytechnic Institute and State University
Department of Entomology
Virginia Tech Pesticide Programs (0409)
34 Agnew Hall
Blacksburg, VA 24061
Ph: (540) 231-2086
Fax: (540) 231-3057
E-mail: tschooley@vt.edu

Contributing Authors:

Diseases:

Erik L. Stromberg

Professor and Extension Plant Pathologist
Department of Plant Pathology, Physiology, and Weed Science
Virginia Polytechnic Institute and State University
410 Price Hall
Blacksburg, VA 24061-0331
Ph: (540) 231-7871
Fax: (540) 231-7477
E-mail: elstrom@vt.edu

Insects:

Curt A. Laub

Research Associate
Department of Entomology
Virginia Polytechnic Institute and State University
308 Price Hall
Blacksburg, VA 24061-0319
Ph: (540) 231-7311
Fax: (540) 231-9131
E-mail: claub@vt.edu

Roger R. Youngman

Professor and Extension Specialist
Department of Entomology
Virginia Polytechnic Institute and State University
312 Price Hall

Blacksburg, VA 24061-0319
Ph: (540) 231-9118
Fax: (540) 231-9131
E-mail: youngman@vt.edu

Pesticides:

Michael J. Weaver

Professor and Extension Pesticide Coordinator
Virginia Polytechnic Institute and State University
Department of Entomology
Virginia Tech Pesticide Programs
34 Agnew Hall
Blacksburg, VA 24061-0409
Ph: (540) 231-6543
Fax: (540) 231-3057
E-mail: mweaver@vt.edu

Weeds:

E. Scott Hagood

Professor
Department of Plant Pathology, Physiology, and Weed Science
Virginia Polytechnic Institute and State University
418-A Price Hall
Blacksburg, VA 24061-0331
Ph: (540) 231-6762
Fax: (540) 231-7477
E-mail: shagood@vt.edu

Reviewed by:

Eric R. Day

Manager, Insect ID Laboratory
Department of Entomology
Virginia Polytechnic Institute and State University
215 Price Hall
Blacksburg, VA 24061-0319
Ph: (540) 231-4899
Fax: (540) 231-9131
E-mail: idl@vt.edu

S. Ray Smith

Associate Professor
Department of Crop & Soil Environmental Science
Virginia Polytechnic Institute and State University
425-B Smyth Hall
Blacksburg, VA 24061-0403
Ph:(540) 231-9590
Fax:(540) 231-3431
E-mail:sasmith8@vt.edu

Edited by:

Susan E. Nessler

Project Coordinator
Virginia Polytechnic Institute and State University
Department of Entomology

Virginia Tech Pesticide Programs (0409)
34 Agnew Hall
Blacksburg, VA 24061
Ph:(540) 231-8956
Fax:(540) 231-3057
E-mail: snessler@vt.edu

On-Line Resources

C&P Press Online Crop Protection Reference
<http://www.greenbook.net/free.asp>

Crop Data Management Systems - Pesticide Labels
<http://www.cdms.net/pfa/LupdateMsg.asp>

Insects and Related Pests of Field Crops
<http://ipm.ncsu.edu/AG271/contents.html>

Virginia Cooperative Extension: Field Crops Pest Management Guide
<http://www.ext.vt.edu/pubs/pmg/>

Virginia Tech Pesticide Programs
<http://www.vtpp.ext.vt.edu/>

Virginia Tech Weed Identification Guide
<http://www.ppws.vt.edu/weedindex.htm>

References

1. Virginia Agricultural Statistics Bulletin and Resource Directory, 2002. Virginia Agricultural Statistics Service; Richmond, Virginia, Bulletin #77, pg. 29, _
<http://www.nass.usda.gov/va/>
Virginia Agricultural Statistics Service Bulletin, August 2003. Supplied by Ray Smith.
2. Virginia Agricultural Statistics Bulletin and Resource Directory, 2002. Virginia Agricultural Statistics Service; Richmond, Virginia, Bulletin #77, pg. 42, _
<http://www.nass.usda.gov/va/>
3. Virginia Cooperative Extension Agronomy Handbook, 2001. _
<http://www.ext.vt.edu/pubs/agronomy/>
4. Peterson, P.R., Starnes, D.E., Wilkinson, W.B., Dixon, D.R., Hutton, S.J., Benson, G.B., and White, H.E.; The Virginia Alfalfa Variety Report: A 5-Year Summary (1995-1999), 2000. Virginia Cooperative Extension (Publication 418-201).
5. Youngman, R.R., INSECTS (Grain Crops, Soybeans, Forages). The Pest Management Guide (PMG)-Field Crops, 2003. Virginia Cooperative Extension (Publication 456-016).
6. Townsend, L., Field Crop Insects. University of Kentucky Entomology, June 1, 2003. _
<http://www.uky.edu/Agriculture/Entomology/entfacts/fldcrops/ef115.htm>
7. Stromberg, E.L., Phipps, P.M., Grybauskas, A.P., and Mulrooney, R.P., DISEASES and NEMATODES (Grain Crops, Soybeans, Forages). The Pest Management Guide (PMG)-Field Crops, 2003. Virginia Cooperative Extension (Publication 456-016).
8. Stromberg, E.L., Phipps, P.M., Grybauskas, A.P., and Mulrooney, R.P., DISEASES and NEMATODES (Grain Crops, Soybeans, Forages). The Pest Management Guide (PMG)-Field Crops, 2003. Virginia Cooperative Extension (Publication 456-016).
9. Eisenback, J.D., Professor. Virginia Tech Department of Plant Pathology, Physiology, and Weed Science. Communications via email May 16, 2003.
10. Hagood, E.S., Swann, C.W, Wilson, H.P., Ritter, R.L., Majek, B.A., Curran, W.S., Chandran, R., WEEDS (Grain Crops, Soybeans, Forages). The Pest Management Guide (PMG)-Field Crops, 2003. Virginia Cooperative

