Scouting Horseradish for IPM

Instructions for Scouting

Always: To prevent the transport of *Verticillium* or other organisms from field to field, wear disposable plastic boot covers and change them before entering a new field, or wear rubber boots and scrub them in disinfectant solution before and after scouting fields.

Always: Note and record any problems that you see as you walk through fields. Do not limit your observations to selected sample sites or to just those pests or problems listed on the scouting form.

When plants are too small to sweep:

1. Map the field. Determine 5 to 10 sampling areas so that unique portions of the field are all represented (edges, nearness to woods, different varieties or soil types).

2. As you walk the field, within each sampling area, randomly choose a point to start examining plants. Examine 10 consecutive plants and note:

   - The number of plants damaged by flea beetles. Note whether damage is light (<10 percent defoliation), moderate (10 to 30 percent defoliation), or severe (>30 percent defoliation). Estimate defoliation based on amount of leaf area removed, not the number of leaves with feeding damage.

   - Which flea beetle species are present/most common.

   - The number of plants infested with diamondback moth larvae and the total number of diamondback moth larvae per 10 plants.

   - Any other pests that are present; describe their intensity in the most appropriate terms possible (number per 10 plants, number of infested plants, light to severe feeding damage, light to severe amount of disease infection, etc.).

3. Prepare a field report. Fill in the identifying information at the top of the scouting form. Note the time that you leave the field; an estimate of the temperature is adequate.

   Provide a map that shows locations of sampling sites by number, then list pest observations by site number. Scouts (unless trained to do so) should not be expected to make any recommendations regarding the need for pest control or selection of pesticides. Provide a copy of the scouting report to the producer; file a second copy at the office; retain a third copy in the vehicle.

When plants are large enough to sweep:

1. Map the field. Determine 10 to 20 sampling areas so that unique portions of the field are represented.

2. As you walk the field, within each sampling area, randomly choose a point to begin sweeping. Take 10 or more sweeps as you walk down the row. A single sweep is a one-way pass across one row. Sweep as deeply and strongly as the plants can withstand—your net may tear loose a little foliage, but it should not be full of leaves or wreak a path of destruction. Empty the contents of your net into

a clear plastic bag after sampling each site or after sampling a few sites when enough foliage has accumulated in the net to make it less effective for collecting insects. You can usually use 3 to 5 bags per field if samples are collected from 20 areas. You should take at least 200 individual sweeps from all sites combined.

– At 5 sites, count the pest species (see scouting form for list) that you capture before combining the sample with other samples in a plastic bag. If flea beetles are very numerous, estimates are satisfactory. (Note in the "Comments" section which flea beetles are present/most common.)

  If a set of sweeps captures more than 5 diamondback moth larvae, check 5 plants (continue down the row from the point where sweeps ended) to determine the range of stages present and to estimate the percent defoliation (percent leaf area removed).

– For samples from all other sites, check only for beet leafhopper. The reason for sampling so many sites is to increase the likelihood of detecting beet leafhopper as soon as possible after its arrival (if it arrives) each season. *The best way to examine samples for beet leafhopper is to kill all the insects in the plastic bags and then examine everything under a magnifying glass or binocular microscope*.

– At all sites, make a note on the scouting form if brittle root is observed.

** – From late May through late July, take additional sweeps for beet leafhopper while walking between sample sites. Take as many as 200 extra sweeps in this fashion, and add the insects collected from these sweeps to plastic bags for later examination.

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   Provide a map that shows locations of sampling sites by number, then list pest observations by site number. Scouts (unless trained to do so) should not be expected to make any recommendations regarding the need for pest control or selection of pesticides. Provide a copy of the scouting report to the producer; file a second copy at the office; retain a third copy in the vehicle.

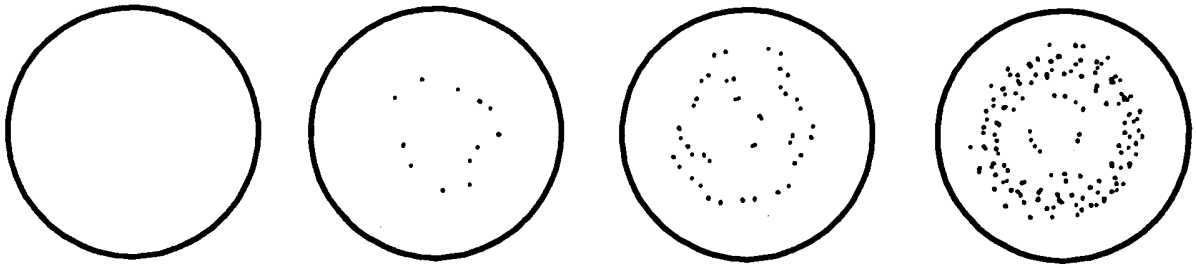
Special Sampling Trips:

For *Baris lepidii*, the imported crucifer weevil:
During early August, examine lower portions of foliage, crowns, and the upper portion of roots of 5 plants per site (approximately 10 feet of row) at 10 separate sites. Record the number of adult weevils at each site; report these counts on the scouting form along with the usual information.

For *Verticillium*:
In mid-July and again in mid-August, randomly select and dig one root at each of 20 sites. Rate the discoloration of each according to the PEPPER or PEG rating scales. Record your observations on the scouting form.

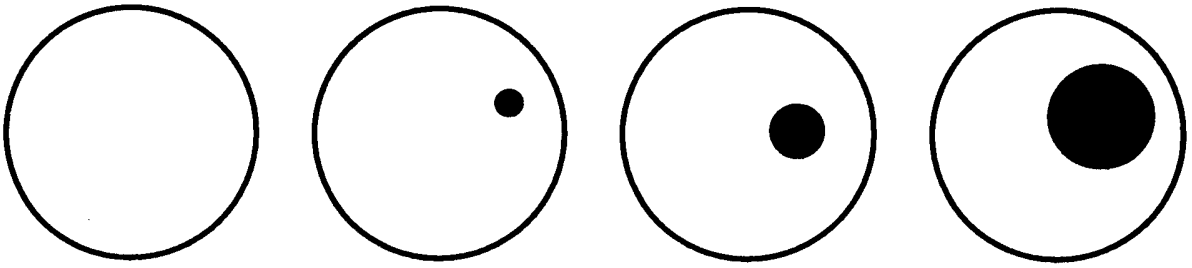
Weed Mapping:
In early June and again in early August, identify and rate weed infestations to produce a weed map for each field. Subjectively rate infestations in different areas as light, moderate, or severe.

PEPPER SYMPTOM RATING SCALE



0	1	2	3
CLEAN	LOW	MODERATE	HIGH
	0 TO 10%	10 TO 50%	> 50%

PEG and ROT SYMPTOM RATING SCALE



0	1	2	3
CLEAN	SMALL	MEDIUM	LARGE

Horseradish IPM

Grower _____ Date _____

Field _____ Time _____

Scout _____ Temperature _____

Site:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	AVR.
"Seedlings":																					
Flea Beetles:																					
Damaged plants/10 plants																					
Severity (L, M, S)																					
Diamondback Moth																					
Infested plants/10 plants																					
Total larvae/10 plants																					
Other _____																					
Insects/10 Sweeps:																					
Flea Beetles																					
Beet Leafhopper																					
Daimondback Moth																					
Cabbage Looper																					
Other Leps																					
False Chinch Bug																					
Others _____																					
_____																					
Baris/10 ft of row																					
Verticillium																					
_____																					
Weeds:																					
_____																					
_____																					
_____																					
_____																					

Field Map: Comments:

Horseradish IPM

Interpreting Scouting Results

The guidelines presented here are the best ideas available on thresholds and decision-making for the control of horseradish insects in Illinois. However, published data are not available to support all these guidelines.

1. Early-season defoliation by flea beetles and diamondback moth:

   Rarely is control warranted at this time for these insects, in part because sprouting plants can draw on root reserves and because plants seem to outgrow early attacks fairly rapidly. Flea beetles are not known to transmit any diseases in horseradish. Control is warranted only if feeding damage to the growing point prevents normal emergence and growth of new foliage.

2. Mid-season defoliators such as flea beetles and diamondback moth:

   Thresholds for mid-season defoliation are not based primarily on the number of insects present, but instead on degree of defoliation. Horseradish can withstand at least 30 percent defoliation without suffering loss in root yield (or apparent quality). Where defoliation approaches 30 percent and (1) young larvae of diamondback moth or cabbage looper are abundant, or (2) flea beetle counts are increasing over previous samples, control might be warranted. Rarely is control of defoliators necessary.

3. Miscellaneous summer pests:

   This group includes false chinch bug, aphids, mites, and thrips. Information on the impact of these pests on horseradish yield and root quality is lacking. Low to moderate infestations appear to cause no losses; these pests are not known to transmit any diseases.

4. Beet leafhopper:

   This insect is the vector of the brittle root pathogen (a spiroplasma). A control threshold unknown, but the detection of even a single beet leafhopper means that disease transmission is possible. All producers should be informed if/when beet leafhopper is detected. (Be sure that identification is confirmed.) Insecticide application is justified, if not certainly necessary, if more than a few beet leafhoppers are detected in the area by late July.

5. Imported crucifer weevil, *Baris lepidii*:

   Threshold for adults is not precisely known. An August observation of 1 or 2 adults per 10 plants might indicate the potential for detectable damage at harvest. Problems are likely to be spotty within fields. Grower history and field history are extremely important; sprays are most likely to be necessary if weevils are detected in fields with a history of a problem (in the field or in fields from which sets were taken).

6. Foliar diseases:

   Fungal diseases on horseradish foliage (for example, Cercospora leafspot) are not known to cause any reduction in horseradish yield or quality. Based on the reaction of horseradish to defoliation by insects, we do not recommend controlling these diseases except where they are severe and pose a threat to cause serious defoliation.

INSECTS THAT FEED ON HORSERADISH FOLIAGE

Several insects eat horseradish leaf tissue, but they rarely cause enough damage to warrant control. Flea beetles (Figure A), including (from left to right) the crucifer flea beetle, the horseradish flea beetle, and the striped flea beetle, are present and often numerous throughout the growing season. Flea beetles are very small; the largest of the three species in Figure A is less than ⅛ inch long.

Figure A. Flea beetles

Diamondback moth larvae (Figure B) are often most abundant on the variety "commons," but these small caterpillars (about ½ inch long when ready to pupate) generally are present on all horseradish varieties beginning in late spring. Outbreaks can occur where insecticides kill this pest's natural enemies and allow resistant strains of the diamondback moth to build up without predation or parasitism. Other common defoliators include (not pictured) the cabbage looper, the imported cabbage worm, and grasshoppers.

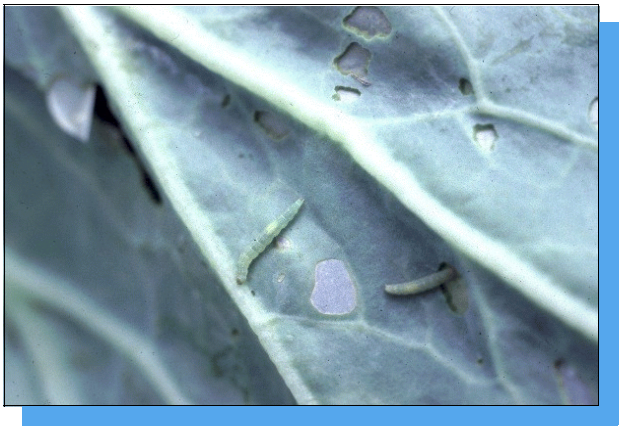


Figure B. Diamondback moth larvae

Controlling flea beetles, caterpillars, and other defoliators is rarely necessary, as horseradish generally tolerates at least 30 percent defoliation (30 percent of the leaf tissue removed by insect feeding) without yield loss.

The false chinch bug (Figure C) is one of several insects that use piercing mouthparts to suck plant fluids from horseradish. This pest can reach damaging levels in very dry seasons. Other sucking insects that feed on horseradish but rarely cause substantial damage include the green peach aphid and the mealy plum aphid. Onion thrips can damage horseradish, but as is true for other foliar insects of this crop, significant outbreaks are very uncommon.

Figure C. False chinch bugs

IMPORTED CRUCIFER WEEVIL

The imported crucifer weevil, *Baris lepidii*, was first discovered in Illinois in 1977. It is a direct pest of horseradish, as it feeds on the harvestable portion of the crop–the roots.

Figure A. Imported crucifer weevil, adult

Adult weevils (Figure A) overwinter in unharvested horseradish fields. Eggs overwinter in unharvested roots and in sets held in cold storage. Because most adults lack functional wings and are incapable of long-distance flight, dispersal is accomplished by the weevils "walking" from field to field and by the inadvertent transport of eggs and larvae in sets used in transplanting. Larvae (Figure B) are legless grubs that tunnel within roots. Infestations usually are seen in or adjacent to fields where unharvested roots or volunteer horseradish harbored this pest through the previous winter.

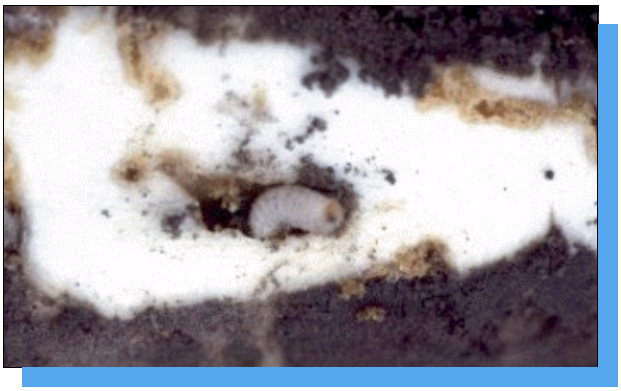


Figure B. Imported crucifer weevil, larva

Surveys done by Eastman and Sherrod in the 1980s indicated that the imported crucifer weevil is present throughout the commercial horseradish production area of southwestern Illinois but that the incidence of eggs and larvae in sets is generally very low.

Rotating crops, controlling volunteer horseradish, and planting uninfested sets help to prevent infestations of the imported crucifer weevil. Locating horseradish plantings as far as possible from known infestations of this pest also minimizes its impact. Dipping infested sets in a permethrin suspension before planting (according to label directions) kills weevil eggs and prevents the introduction of this pest into new fields during transplanting. Foliar insecticide sprays can be used to kill adult weevils on plants in late summer.

BRITTLE ROOT

Brittle root disease is caused by the pathogen *Spiroplasma citri* and vectored by the beet leafhopper (Figure A). Symptoms include an inward curling and yellowing of the leaves (Figure B), stunting of new growth, and discoloration of the vascular tissues in the root (Figure C). Symptoms usually appear about 40 days after leafhopper transmission of the disease causing organism. The pathogen belongs to a specialized group of bacteria called the spiroplasmas, and is restricted to the phloem, the tissue that transports the sugars made in the leaves to the rest of the plant. Infections result in reductions in root yield and quality. The disease gets its name from the brittle texture that the roots develop following infection. Root discoloration is initially tan but darkens to brown or black. Infected roots are smaller than normal, and infected plants usually die within a few weeks of the onset of symptoms.

The beet leafhopper does not overwinter in Illinois, but in some seasons substantial numbers of these insects immigrate from states to the southwest. Disease outbreaks are most severe when migrations occur early in the season (May or June). Drought conditions and strong southwesterly wind patterns seem to favor leafhopper buildup and disease outbreaks. Horseradish isolates of *Spiroplasma citri* are also known to infect other members of the crucifer family, including shepherd's purse, wild mustard, turnip, and radish, as well as a few non-cruciferous ornamentals such as periwinkle, China aster, and phlox. This disease can be managed by controlling the leafhopper vector. The application of an insecticide is advised when sweep net samples reveal the presence of beet leafhoppers, especially if they appear before late July or August.

Figure A. Beet leafhopper

Figure B. Leaf yellowing and stunting

Figure C. Vascular discoloration of roots

CERCOSPORA AND BACTERIAL LEAF SPOTS

Cercospora leaf spot is one of the most common foliar diseases of horseradish in Illinois. The pathogen causing this disease is the fungus *Cercospora armoraciae*. Symptoms first appear as small, light colored circular areas on the leaves. These areas enlarge to become 1/2 to 3/4 inch in diameter and light brown to grey in color. As the fungus sporulates, the spots may appear almost black. Sometimes the fungus forms dark concentric rings giving the lesions a bulls-eye or target appearance. The spots can coalesce, killing large areas of the leaf. We have observed that plants subjected to moisture stress are more susceptible to this disease. The fungus probably overwinters in infested leaf debris, so crop rotation is the suggested strategy for managing this disease. Little if any testing has been done to evaluate the efficacy of fungicides for controlling Cercospora leaf spot.

Figure A. Cercospora leaf spot

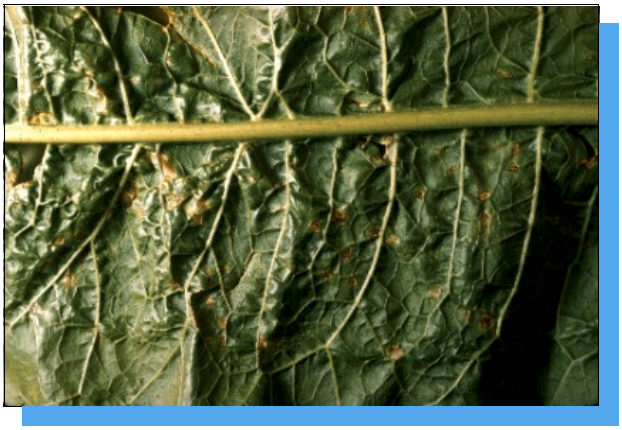


Figure B. Bacterial Spot

Bacterial leaf spot also can be a very destructive foliar disease, especially during wet seasons. The disease is caused by the bacterium *Xanthomonas campestris* var. *armoraciae*, which is closely related to the bacterium which causes black rot of cabbage and other crucifers. However, the pathogen on horseradish causes a localized leaf spot which does not spread through the plant's vascular system, as does black rot. Symptoms first appear as small dark green, translucent spots that later enlarge and turn black. Spots are usually scattered over the entire surface of the leaf, in the areas between veins, and are most conspicuous on the underside of the leaf. Spots can be circular to angular in shape and remain fairly small, rarely exceeding 1/4 inch in diameter. Heavy infection can cause an entire leaf to quickly curl and dry up. Because this disease is favored by wet conditions, plantings should be located on high ground away from windbreaks to promote drying of the leaves. If infected plants have been found workers and equipment should stay out of fields that are wet from rain or dew until the foliage is dry. Crop rotation and the removal or incorporation of infested crop debris should reduce chances of infection in future crops. Several applications of copper-based bactericides when symptoms first appear should reduce the spread of bacterial leaf spot in the field.

TURNIP MOSAIC VIRUS

Turnip mosaic virus (TuMV) is probably the most common pathogen of horseradish. Some researchers have stated that almost all horseradish plants appear to be infected. The most characteristic symptoms of infection by TuMV are ring spots (Figure A) and chlorotic mottling (Figure B) on the leaves. Other symptoms include black streaks on the petioles and, occasionally, a clearing of the leaf veins. Symptoms are most pronounced when plants are growing at temperatures below 60 F, and may not form at all at temperatures above 80 F. TuMV is transmitted from plant to plant by several species of aphids, and may also be transmitted when planting stock is handled. Virus free plants can be generated by the use of tissue culture, but most plants become infected within one growing season once placed in the field. With nearly all horseradish plants in commercial plantings infected with the virus, it is not clear what effect the presence of the virus has on the size or quality of the roots.

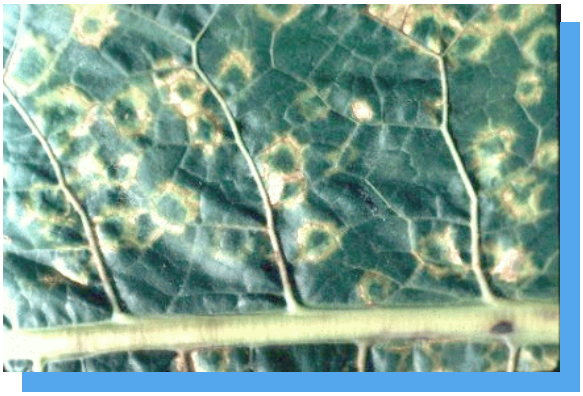


Figure A. Ring spot symptom

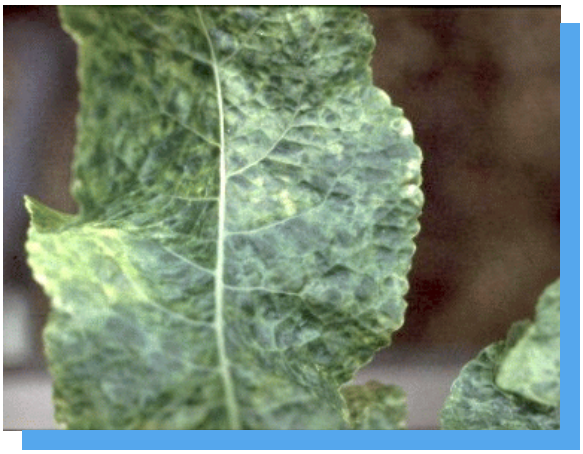


Figure B. Mosaic or mottling symptom

VERTICILLIUM ROOT DISCOLORATION

The soilborne fungus, *Verticillium dahliae*, infects the vascular tissue of the horseradish plant, resulting in a discoloration of the root. The discoloration often appears as black specks in cross-section (Figure A) or as streaks along the root when the root is sectioned length-wise (Figure B). Sometimes infected roots develop a diffuse, light-brown discoloration of the entire vascular ring, instead of the more distinct specks. Leaf symptoms may also develop, starting as a yellowing near a leaf vein, usually near the leaf margin. The yellowing expands out from the vein and back towards the midrib of the leaf, resulting in the formation of a V-shaped lesion (Figure C). With time the yellowed tissue dies and turns light brown. In addition to discoloring the roots, infection by *Verticillium dahliae* makes the roots more susceptible to attack by other microorganisms that rot root tissues.

This fungus overwinters in the soil in the form of small black resting structures called microsclerotia. These microsclerotia can survive in the soil for many years. This pathogen also can infect many different species of plants, including several crops and weeds. So once a field is infested it is difficult to get rid of the pathogen. *Verticillium dahliae* can be introduced into fields by the movement of infested soil, for example soil on equipment, or in infected planting material.

Fumigating soil with methyl bromide and/or chloropicrin has been shown to reduce populations of *Verticillium dahliae* in the soil. Long term rotation to non-host species, such as corn, wheat, and other grass species may eventually reduce populations of this pathogen in the soil. Horseradish cultivars vary in their susceptibility to Verticillium root discoloration.

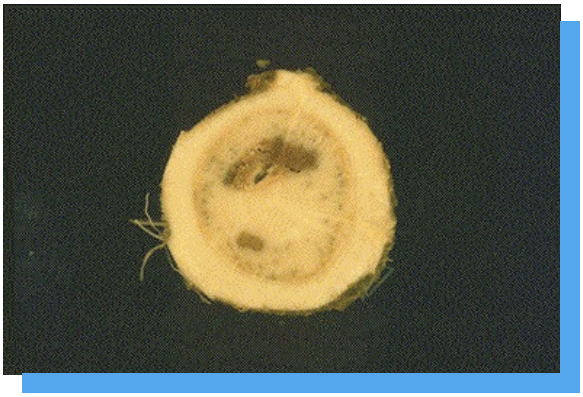


Figure A. Cross-section of a root showing vascular discoloration and rotting

Figure B. Longitudinal section of root showing vascular discoloration

Figure C. Leaf symptoms

WHITE RUST

White rust is a very damaging foliar disease of horseradish which is caused by the fungus *Albugo candida*. Extensive leaf damage prevents normal root growth and can result in significant reductions in yield. White rust can be identified by the characteristic white pustules or sori which appear on leaves (Figure A). Symptoms first appear as small chlorotic areas which are visible on both the upper and lower leaf surfaces (Figure B). The white pustules then appear within the chlorotic areas, almost always on the lower leaf surface. These pustules are grayish- to creamy-white and vary in shape from oval to irregular. The expanding pustule eventually ruptures the epidermis of the leaf, exposing the powdery white spores beneath. The pathogen may also become systemic in the crown of the plant, and can occasionally infect the root.

Figure A. White rust pustules or sori on lower leaf surface

Albugo candida survives in living, infected plant tissues and is usually introduced on infected sets, or spreads from infected plants growing in nearby horseradish cull piles. Pustules form on these systemically infected plants and produce spores that spread the disease within the field. Spores produced in the pustules can be dispersed by wind, rain, or insects to neighboring plants. Epidemics occur during or following periods of cool, moist weather. Temperatures in the 60 to 70 F range are most favorable for infection.

Figure B. Chlorotic areas on upper leaf surface

Management strategies for white rust depend on using only disease-free planting stock, a two to three year crop rotation away from horseradish, and the destruction of cull piles near commercial fields. Sets for next year's planting should be taken only from the terminal end of the root. Sets located near the crown should be avoided. Sets showing discolored, cracked or swollen areas should be destroyed.