

## Removal of scapes

For hardneck garlic, scapes should be removed to encourage greater bulb growth. Research in Minnesota has shown that yields can be reduced by 20 percent to 30 percent if the scape is allowed to mature. Yields are most affected in poorly fertilized soil, and only minimally (< 5%) affected in high organic matter, well-fertilized soil. The time to remove the scape is just after the initiation of curling but may be removed any time after emergence (Figures 14 and 15). Scapes should be clipped right above the top leaf without damaging leaves. In some varieties and under wet conditions, the scape might rot after removal causing structural damage and risk of infection if water fills in.



Figure 14. Remove garlic scapes just after the initiation of curling.



Figure 15. Scapes should be clipped right above the top leaf without damaging leaves.



Figure 16. Immature scapes are edible and can be collected for sale.

The immature scapes are edible. They can be sold at farmers markets as a green and used in stir fries, salads, or steamed vegetables, and there is a growing market for processed scape products like pesto and pickled scapes. Therefore, after removal, they can be sold as there is a secondary market for them (Figure 16). In some situations, scapes can be left on if a market for the bulbils is available to offset the loss in bulb yield. More mature scapes are sometimes used in flower arrangements.

## Weed control

Garlic is a poor competitor with weeds. Unless weeds are controlled early, they can easily overtake young garlic plants, causing significant yield losses. Hand weeding and mechanical control are the most common weed control methods for MN growers. Before garlic is planted, use of a green manure, or cover crop, such as buckwheat plowed down before going to seed, will reduce annual weed competition. If perennial weeds are a problem, for conventional (nonorganic) garlic production, application of a broad spectrum, systemic herbicide such as glyphosate is recommended in late August or early September, before planting garlic in the fall. Tillage can reduce weed pressure, especially if done more than once before bed preparation. Be sure to use straw free of seed as mulch. If desired, a few soil-applied and post-emergence herbicides are registered for use on garlic. Always read and follow herbicide label instructions for use. For information on general management for garlic production and registered herbicides for use on garlic, see the Midwest Vegetable Production Guide: [https://mdc.itap.purdue.edu/item.asp?Item\\_Number=ID-56](https://mdc.itap.purdue.edu/item.asp?Item_Number=ID-56).

## Pests and diseases

### Pests

#### Garlic Bloat Nematode (GBN) (*Ditylenchus dipsaci*)

WHAT IT IS Parasitic nematode (Figure 17)

SYMPTOMS Stunting, twisted, and pale leaves, usually followed by rotting of the lower stem and base of the bulb. In severely infested fields, young plants become enlarged and deformed and frequently die (Figure 18). Symptoms can be subtle in early stages.

HOW TO IDENTIFY Laboratory test to confirm (<https://www.sfa-mn.org/garlic-bloat-nematode-testing/>).



Figure 17. Garlic bloat nematode.



Figure 18. Garlic infected with garlic bloat nematode.

CONTROL MEASURES GBN is usually introduced in infected seed and can be devastating if left uncontrolled. Do not use or sell garlic for seed if the garlic has tested positive for GBN. Keeping a careful record of where seed is obtained and planted in which field can be helpful if GBN is detected later. Control measures include planting clean seed stock, elimination of volunteer garlic and onions, and proper rotation. The nematodes are primarily located in infected tissue, so to control this pest, infected plants should be removed by digging and then burned. Do not plant garlic following garlic or any member of the onion family, or alternate hosts such as pea, parsley, celery, and salsify for a minimum of four years.

PREVALENCE IN MINNESOTA GBN is present in the Upper Midwest and has been devastating to some farms that focus on seed production. However, proactive and diligent testing and education programs have slowed the spread of this pathogen.

### Diseases

#### Aster Yellows (AYP)

WHAT IT IS A virus-like bacterial infection (phytoplasma) transmitted by leafhoppers (*Macrostelus quadrilineatus*).

SYMPTOMS At early stages of infection there may be no symptoms, but plants will later show:

- Premature yellowing and dieback of garlic plants, usually starting on the new growth first (Figure 19)
- Small, often soft bulbs

- Dark streaking or discoloration of wrapper (Figure 20 and 21)
- Blasting of flowers if scapes are left on (Figure 22)
- Unusual smell to bulb
- Very poor emergence of infected seed; plants that do emerge often eventually die.



Figure 19. Premature yellowing and dieback of garlic plants due to aster yellows.



Figure 20. Aster yellows causes dark streaking or discoloration of wrapper.



Figure 21. Aster yellows causes dark streaking or discoloration of wrapper.



Figure 22. Blasting of flowers occurs with aster yellows if scapes are left on.

**HOW TO IDENTIFY** Laboratory test to confirm.

**CONTROL MEASURES** Do not plant infected seed, reduce/eliminate perennial weeds, protect plants by spraying with pyrethroid insecticide when aster leafhoppers are present. Alternatively, use light colored or reflective mulches to disorient leafhoppers, or use floating row cover on seed crop from the beginning of the season.

**PREVALENCE IN MINNESOTA** AYP can be a major problem in Minnesota. The first severe outbreak was recorded in 2012. A moderate infestation occurred in 2021, and growers saw some crop losses. Leafhoppers appeared later in season in 2021 (June) and still caused crop losses, but not to the extremes as in 2012 when they arrived in April. There was some carryover in seed stock into 2022. There are few leafhoppers that overwinter in Minnesota. Most overwinter in southern states and then are carried to Minnesota by weather systems. Aster Yellows phytoplasma will survive and overwinter in the crown and roots of infected perennial plants, but not in plant debris.

### White rot (*Stromatina cepivorum*)

WHAT IT IS Fungal disease.

SYMPTOMS Premature yellowing and dying of older leaves, stunting and leaf tipburn, followed by destruction of the root system, shoot dieback, and rotting of the bulb.

HOW TO IDENTIFY Laboratory test to confirm (looks very similar to Garlic Bloat Nematode).

CONTROL MEASURES Rotating out of allium crops for many years (white rot has been known to persist in soil for ten years), destroying infected tissue, and planting disease-free seed stock.

PREVALENCE IN MINNESOTA Uncommon in Minnesota, but it is a major disease of commercial garlic grown in California and other areas of allium production. The organism is most active when the temperature is cool (less than 75°F). In northern climates it usually attacks in the spring.

### Fusarium - basal or bottom rot (*Fusarium spp.*)

WHAT IT IS A fungus present in most soils. Usually considered a secondary invader because it attacks plants already weakened by insects, mechanical damage, or other diseases.

SYMPTOMS Similar to white rot, except disease progression is much slower and death of the plant may not occur. Yellowing of older leaves first (Figure 23) and rotting of the basal plate (Figure 24). Bulbs infected with fusarium may decay further in storage.

HOW TO IDENTIFY Laboratory test to confirm.

CONTROL MEASURES This disease is controlled by proper crop rotation with non-susceptible crops for four years, removal of infected plants, and planting disease-free seed. Plant in well drained areas. Common but only occasionally causes significant reduction in yield or marketability.

PREVALENCE IN MINNESOTA Present in most soils.



Figure 23. Fusarium causes older leaves to yellow.



Figure 24. Fusarium affects the basal plate.

### **Pink Root (*Phoma terrestris*)**

WHAT IT IS Fungal infection.

SYMPTOMS Symptoms of this disease occur primarily in warm weather (>75°F F). The fungus infects the roots, causing them to turn pink, followed by root dieback. New roots are formed which also become infected. Aboveground symptoms include leaf tipburn.

HOW TO IDENTIFY Lab test to confirm

CONTROL MEASURES Three- to four-year rotation without alliums.

PREVALENCE IN MINNESOTA Not common.

### **Botrytis (*Botrytis* spp.)**

WHAT IT IS A fungus that attacks garlic leaves following periods of warm, wet weather, and bulbs in storage.

SYMPTOMS Water-soaked stems (which is why the disease is often called "neckrot".) In severe infections, the bulbs may rot. In mild infections, the disease may not be noticed during the season, but may attack the bulb during storage.

HOW TO IDENTIFY Lab tests to confirm

CONTROL MEASURES Promoting air movement by controlling weeds and proper plant spacing throughout the field so that foliage does not remain wet. Rapid drying during harvest, followed by good aeration during storage will also minimize the problem. Use planting stock free of the disease.

PREVALENCE IN MINNESOTA While the fungus itself is common, this is not usually a serious issue. More of a concern in wet years.

### **Skin Blotch (*Embellisia allii*)**

WHAT IT IS Fungal infection.

SYMPTOMS Normally superficial and feeds on dead tissue, but can penetrate into bulbs and cause more significant damage if left unchecked.

HOW TO IDENTIFY Characteristic black or gray blotches on bulb or stem after harvest (Figure 25).

CONTROL MEASURES Increase air flow and reduce humidity during curing and storage. Removal of outer skins after drying can reduce or eliminate blotches.

PREVALENCE IN MINNESOTA Common, especially in wet years and when stored under humid conditions.



Figure 25. Fungal infections can cause black or gray blotches on bulb or stem.

### **Penicillium molds (*Penicillium spp.*)**

WHAT IT IS Fungus.

SYMPTOMS Plants from infected cloves planted in the fall will often emerge in the spring, turn yellow, and then die. A blue-green color is observed on cloves in soil and in storage (Figure 26).

HOW TO IDENTIFY Symptoms on leaves look similar to fusarium, use laboratory tests to confirm and look for blue-green color on cloves. Can be confirmed by a lab test.

CONTROL MEASURES If a bulb is infected, do not use the cloves for planting stock. Wash hands after touching the bulb and avoid bruising or wounding stored bulbs. Prevent the disease by planting clean stock.

PREVALENCE IN MINNESOTA Present in most soils.

### **Anthracnose (*Colletotrichum fioriniae*)**

WHAT IT IS Fungal disease that affects garlic scapes.

SYMPTOMS Tan or orange colored lesions located on the scape that lead to twisting, girdling and collapse of scape (Figures 27 and 28).



Figure 26. Penicillium molds cause a blue-green color on garlic.



Figure 27. Anthracnose causes tan or orange colored lesions located on the scape



Figure 28. Anthracnose can lead to collapse of scape.

HOW TO IDENTIFY Symptoms and lab test to confirm.

CONTROL MEASURES Difficult to control in wet weather. Do not over irrigate.

PREVALENCE IN MINNESOTA The fungus is most prevalent during wet years and incidence is greatest following scape removal, but still may occur with scape still on the plant.

## Rust (*Puccinia allii*)

WHAT IT IS Fungal infection.

SYMPTOMS Initial symptoms occur on the foliage and stem as small, white flecks that develop into orange spots (spores) or pustules. The bulbs become shrunk and deformed. Heavily infected plants may turn yellow and die.

HOW TO IDENTIFY Red/orange pustules on leaves and stem (Figure 29).

CONTROL MEASURES Conditions favorable for disease development include high humidity and low rainfall and a temperature between 45 and 55 degrees Fahrenheit. Disease incidence is highest in stressed plants. To reduce infection potential, use healthy seed in well-drained soil. Rotate with non-allium crops. Registered preventive fungicides may be the only method of control in situations where the disease potential/incidence is high. Varietal resistance has not been reported.

PREVALENCE IN MINNESOTA Until recently, this fungus was considered to be of minor importance in garlic production. However, outbreaks in California have reduced crop yields by up to 75 percent in some fields. The disease has been reported in Minnesota but damage has been minor.

## Virus - Potyvirus, Mosaic virus

WHAT IT IS Virus, Transmitted by aphids.

SYMPTOMS Usually none, but can cause severe leaf mosaic when in combination with other viruses (Figure 30).

HOW TO IDENTIFY Virus can be identified in the lab using molecular and serological tests.

CONTROL MEASURES Tissue culture has been shown to be effective in producing "virus-free" garlic and is now used extensively for commercial plantings in California. Any plants exhibiting severe mosaic symptoms should be rogued out. Most of the garlic purchased from seed catalogs and other garlic growers contains some virus.

PREVALENCE IN MINNESOTA Because garlic is clonally propagated, almost all planting stock is infected with some type of virus. The viruses are usually mild and do not seriously affect yield, and may even impart desirable characteristics in some varieties. One exception is onion yellow dwarf virus, which can cause severe mosaic in combination with other viruses.



Figure 29. Red/orange pustules on leaves and stem are caused by rust fungal infection.



Figure 30. Garlic leaf mosaic.

## Mites

### Garlic Mites (*Rhizoglyphus* spp. or *Aceria* spp.)

[https://www.sfa-mn.org/wp-content/uploads/2020/02/bulb\\_mites\\_garlic.pdf](https://www.sfa-mn.org/wp-content/uploads/2020/02/bulb_mites_garlic.pdf)

**WHAT IT IS** Tiny arachnids that are not visible to the unaided eye. Often referred to as either “dry bulb mites” if in the *Aceria* genus or simply the standard “bulb mite” in the *Rhizoglyphus* genus.

**SYMPTOMS** Failure to germinate or lack of vigor with stunted, deformed leaves. Feeding on the basal plate (Figure 31) can cause wounding and infection with *Fusarium* or *Penicillium*. It is possible that plants survive and outgrow damage. Mites will continue to feed on bulbs in storage. In storage, look for sunken tan to brown spots on cloves (Figure 32). Dry bulb mites can transmit allelopathic compounds.



Figure 31. A garlic bulb wounded by mite feeding in the field.



Figure 32. A garlic bulb wounded by mite feeding in storage.

**HOW TO IDENTIFY** Mites have 4 pairs of legs and are about 0.5-1 mm in length. Bodies are whitish to yellow. A hand lens or microscope is helpful for identification.

**CONTROL MEASURES** Do not plant infected seed; rotate alliums out for at least four years and control wild allium species in each field. Mites can survive on crop residue. Avoid planting garlic following brassicas, corn, grain, or grass cover crops; Treat seed before planting by:

- Soaking for 24 hours in 2% soap (not detergent) and 2% mineral oil
- Dusting bulbs with sulfur
- Hot water treatment is effective but may reduce germination (130°F 10-20 minutes, or 140°F for 10-15 minutes)

**PREVALENCE IN MINNESOTA** Incidence of mite damage has been recorded in Minnesota garlic. Some years appear to be more damaging than others and may be related to an infected seed source.

## Insects

### Allium Leaf Miner - (*Phytomyza gymnostoma*)

**WHAT IT IS** Insect-fly Symptoms: Larvae are the most destructive phase of the insect, eating soft tissue of plants as they mine down toward the bulb. This weakens plants and leaves them susceptible to secondary fungal infections and bacterial rot.



**HOW TO IDENTIFY** The adult allium leaf miner fly is  $\frac{1}{8}$  inch long and mostly black with distinctive orange patches on the head. Can be identified on the garlic plant by looking for slits in leaves from where the female deposits eggs which look like white dots.

**CONTROL MEASURES** There is no treatment available after infection, so preventative measures are important. Rotate garlic to a field without alliums for at least one year. Cover cropping with collards, mustard, cabbage, rapeseed, or daikon. Avoid high nitrogen fertilizer. Row cover (fine-mesh) is one of the most effective ways of preventing infection.

**PREVALENCE IN MINNESOTA** Leafminers have not been reported in Minnesota, but have been found in the eastern US and are moving west.

### **Wireworms (several genera)**

**WHAT IT IS** Beetle larvae.

**SYMPTOMS** Damage to roots and bulbs. Usually one or two holes bored into bulbs.

**HOW TO IDENTIFY** Yellow/brown beetle larvae  $\frac{1}{2}$ " to  $1\frac{1}{2}$ " long.

**CONTROL MEASURES** Wireworms are more common if garlic is planted into fields following sod, so the best control is to avoid planting garlic following sod. Allow at least one year after sod is turned under before planting garlic.

**PREVALENCE IN MINNESOTA** Common, but only occasionally cause significant reduction in yield or marketability; infestations often limited to a few larval aggregations in a given field.

### **Onion Thrips (*Thrips tabaci*)**

**WHAT IT IS** Small, sucking insects that are most prevalent during warm, dry weather.

**SYMPTOMS** whitish specks on the leaves, which become blotchy or scarred in severe cases.

**HOW TO IDENTIFY** most thrips are about 1 mm in length.

**CONTROL MEASURES** Use of insecticidal soaps will help to control the pest and a few chemical insecticides, such as the organic-certified pyrethrins (e.g, Pyganic), are also available for control.

**PREVALENCE IN MINNESOTA** Common, however the small, sucking insects are most prevalent during warm, dry weather.

### **Onion maggot (*Delia antiqua*)**

**WHAT IT IS** White larvae of the onion fly.

**SYMPTOMS** Young garlic plants yellow and wilt; base of the plant may rot due to feeding damage; includes direct feeding damage on the bulb.

**HOW TO IDENTIFY** White larvae, about one millimeter in length soon after hatching, usually found at the base of the plant. They grow to about five millimeters after about 15 to 20 days.

**CONTROL MEASURES** Yellowed plants should be removed immediately and discarded. Control this pest through proper rotation. Do not plant garlic after onions or other alliums.

**PREVALENCE IN MINNESOTA** Although the maggot can complete two to three generations per year in the Midwest, maggot pressure and damage is highest in the spring. Onion maggots are present but not common.

## Armyworms

**WHAT IT IS** The two most common species in Minnesota include the True and Fall armyworms. True armyworm (*Pseudaletia unipuncta*) caterpillars will often have yellow to cream, or orange stripes down the side, with orange heads. Fall armyworms (*Spodoptera frugiperda*) range from brown to gray, green, or yellow-green in color with a whitish inverted Y shape between the eyes and three whitish stripes behind the head.

**SYMPTOMS** Defoliation of leaves can occur quickly following a high influx of moths and egg-lay

**HOW TO IDENTIFY** Eggs are laid in large, fuzzy masses, and many larvae can feed on a given plant, often on the upper leaves.

**CONTROL MEASURES** If high populations exist and damage occurs, the insect can be controlled by using Bt (*Bacillus thuringiensis*) sprays; however, only the young (early instar) larvae are most susceptible to Bt (e.g., larvae < ¼" length). Another insecticide registered for leaf-eating caterpillars on garlic includes spinosad (Entrust SC), certified for organic growers.

**PREVALENCE IN MINNESOTA** Both the true and fall armyworm are common in the upper Midwest. True armyworm is active in June, while fall armyworm migrates from southern states in July and August. Once a plant is defoliated, larvae will move in mass to the next available plant. Not generally a major problem in Minnesota garlic.

## Other

### Waxy Breakdown

**WHAT IT IS** Physiological condition not due to infection by microorganisms.

**SYMPTOMS** Cloves shrink and turn yellow and waxy inside the bulb. Bulbs sometimes become pasty or gelatinous or sometimes turn hard.

**HOW TO IDENTIFY** Symptoms.

**CONTROL MEASURES** Cause is unknown, but it has been suggested that it may be due to high temperatures during growth and/or after harvest or poor ventilation and low oxygen levels during storage.

**PREVALENCE IN MINNESOTA** Not highly prevalent but present.

## Harvesting and curing

Knowing when to harvest has always been tricky. In general, garlic harvest in Minnesota usually extends from the second week of July through the first week in August. Different varieties will often mature at different times. Harvesting too early will result in small bulbs that do not store well. Harvesting too late will force the cloves to pop out of the skins, making them susceptible to disease and resulting in unmarketable bulbs. There are a couple of methods that can be used to determine when to harvest:

1) by early July the lower leaves will start to brown, and harvest is usually optimum when half or slightly more than half of the leaves remain green; or when a third of the leaves at the bottom have gone brown or yellow.