

“There is no program that certifies garlic as nematode-free. Commercial suppliers of garlic bulbs are aware of this important problem, and may send a portion of their crop to a laboratory for nematode testing, but this does not certify a crop as nematode-free. Because the nematode and mite can survive for long periods on infected plant material, to prevent build-up of the nematode or mite populations in a field, you MUST rotate away from any Allium crops (garlic, onions, and leeks) and control nightshades for at least 4 years. DO NOT keep any bulbs or seed from an affected field no matter how clean it looks. You should start from fresh seed or bulbs. Rotation to areas of the farm that have not had garlic or onion plantings for many years with new garlic or onion seed is the best method of control, however, growers can use soil fumigants to reduce or eliminate the nematodes from infested areas of the field. Growers also can use bio-fumigant cover crops that can be planted after harvesting garlic. Mustard, sorghum-sudangrass have been shown to reduce nematode populations due to the bio-fumigant constituents they produce. Be sure to clean equipment and storage areas with meticulous sanitation techniques.” (Excerpt from: **Garlic Problems....Again** Author: Dr. Gerald Brust, IPM Vegetable Specialist at U of Maryland Extension, May 10, 2013)

This excerpt above summarizes what I consider to be a very good summary on bloat nematode in garlic. Questions that arise from this are as follows. Answers are my interpretation of current research from multiple university sources and conversations via phone and email with several nematologists.

1. What is a field? Nematodes spread from plant to plant via touching of leaves (typically NOT via roots. Research is consistent on this.). This is facilitated when leaves are wet due to rain or dew. Therefore a ‘field’ consists of any grouping of garlic that touch each other. In a planting with wide enough walking grows, it is possible the walking rows can isolate each strip and create multiple ‘fields’ if the mature garlic leaves don’t touch. For a grower planting densely, a single field might be many acres if the garlic are close together.
2. How long can nematodes (only 4th stage juveniles) survive in ‘infected plant material’? For dried plant material, the answer is many years or even decades. No research I’ve found has answered this definitively but everyone speaks confidently about it being a long time. Once the plant material is placed into soil and becomes moist thereby awaking the nematode, the answer is less clear but most research points to months or perhaps a year before the nematodes die if they cannot find a suitable host. There is proof they will survive over winter in the soil in a MN climate. I suspect having a suitable host plus climate and soil conditions have a lot to do with time variability. A nematode is an herbivore and once ‘awakened’ from its slumber in a piece of dried plant material, needs to feed to live and (more importantly) reproduce by moving from 4th stage juvenile to adult. Some university articles suggest nematodes can survive in soil ‘for years’ but this is contradicted by other research that says without a host it cannot survive for very long. Perhaps more accurately, it should probably be stated that with an acceptable host bloat nematodes can be found in a field indefinitely as they feed and move through their life cycle. All research agrees the bloat nematode lives in plants. It does not choose to live in the soil and the ambiguity in the research is how long can a bloat nematode survive in

soil before expiring without a host plant. Some nematologists speculate nematodes in soil might be eating fungi to stay alive but I can't find any actual research to support this.

3. Why does the article say 'nightshades'? As an herbivore, the nematode needs to eat plant material to live. It definitely munches Alliums and plants in the Nightshade family. Bad news is that more and more plants are getting identified as hosts including alfalfa, parsley, celery and Canadian thistle. I don't think there's a lot (if any) research going on with respect to host plants. My interpretation of the research is that you should keep all plant material out of an infected field for at least a year unless it is a bio-fumigant such as mustard. If a bloat nematode is hungry and has access to a plant, I don't think anyone knows exactly how broadly it will graze. Therefore via chemical or mechanical means, it is important to keep all green plant material out of any infected field (except bio-fumigants). And ideally, you keep all equipment and people off the infected field and, if not possible, carefully sanitize equipment and shoes after accessing an infected field. An unknown risk is transmission via an animal from one field to another. Having mulched garlic beds should reduce or even eliminate this vector since the animal will not access soil. And heavy mulch also reduces risk of people and equipment transmission if there is no bare soil.
4. What about soil transmission or root-to-root? The bloat nematode is microscopic and can be moved most easily via surface water transmission or physically by bringing infected garlic onto a site. It is not like an earthworm moving through the soil and it does not live in the soil by choice. Research says it is found 'rarely' in roots. That is not a preferred environment for the bloat nematode. It lives in plants and if a particular plant has a very bad infestation, it is possible for nematodes to be found in the soil at the location of that plant because literally there is no room at the inn and the plant is shedding them into the soil. In that circumstance, moving soil with nematodes can transport the infestation provided you give the nematodes a suitable host to feed on in the new location. Pulling a badly infected garlic plant can leave nematodes in the soil directly and in any pieces of the plant that remain behind. Leaving a small piece of an infected garlic behind in the field can provide a vector for spreading the nematode if that plant piece is moved to a new location. Running water via rain or irrigation can spread nematodes if they are on the soil surface due to recent harvesting or culling of heavily infected garlic which exposes soil with nematodes in it.
5. What about culling? Research says low infection rates in a plant will not have nematodes in the soil. Therefore, it pays to aggressively cull if you even suspect you might have bloat nematodes in a field. This is especially true when plants are young (and most likely not touching at all).
6. How does weather help or hurt? Research suggests cool, moist conditions are most favorable for transmission although I suspect moist is the most important condition since they move in and by water. Most often they enter a plant via stomata, cracks or leaf axils which is another way of saying almost anywhere above ground.
7. How to clean and sanitize equipment? Quaternary Ammonia is the preferred tool using recommended dilutions. It has the added side benefit of killing any AIDS viruses along with many other human diseases so if a person is worried about biological hazards in

- general, this is a great product. It's simple to use requiring only a sprayer: spray diluted product liberally on equipment/shoes, containers, etc., wait ten minutes and then rinse.
8. What about chemical soil fumigation? For most small-scale growers, even if they want to leave organic or sustainability practices behind and use a soil fumigant, that may not be a practical solution due to legal restrictions on fumigant use. And the solution may be worse than the disease given the damage done to the soil biome by these products.

My overall perspective is the biggest danger once a person has identified the disease on a farm comes from spreading the disease via infected plant material and from plant-to-plant transmission. Certainly soil transmission and moving water can spread the disease but that seems less likely unless the infection is particularly bad and you have bare soil in your field. Obviously, do NOT compost or in any way risk reintroducing the bloat nematode from infected plants that have been removed. And consider taking a shovel-full of soil from under each plant that is culled and removing that also. And then sanitize the shovel and your footwear.

My summary recommended approach for any grower that gets bad news from a testing lab on bloat nematode is to (1) isolate the field, (2) keep all living plants off the field for at least 6 months, (3) plant mustard or other bio-fumigant cover crop, (4) rotate on a 4 year basis and (5) clean all equipment and shoes that may have contacted the field.

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