Nematodes in Bulbs

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A number of parasitic nematodes—eelworms—may infect ornamental bulb crops.

Root knot nematodes (*Meloidogyne* species), lance nematode (*Hoplolaimus coronatus*), and meadow nematodes (*Pratylenchus* species) have occasionally caused severe damage to bulb crops, especially in the warmer sections of the United States.

In cooler sections where the hardier types of bulbous irises, Easter lilies, and narcissi are grown for sale to florists for greenhouse forcing rather than for immediate flower production the bulb and stem nematodes (*Ditylenchus* species) and the bud and leaf nematode (*Aphelenchoides olesistus*) are the most serious pests. This chapter concerns the latter two nematodes as pests in the bulb industry of the Pacific Northwest.

Bulb and stem nematodes usually attack the bulbs, crowns, and aboveground parts of plants. More than 350 kinds of plants have been reported as infected at some time or place. The type species, *Ditylenchus dipsaci*, was first discovered in 1857 causing a disease in the flower heads of fullers teasel, *Dipsacus fullonum*. These nematodes are less than one-sixteenth inch long.

Infected narcissus plants show characteristic discoloration and swellings in parts of leaves or stems and discoloration in bulbs.

Infected bulbous iris seldom show malformations of leaves, but spots or blotches often are present at the place the stem joins the bulb. Nematodes enter iris bulbs near the base. They produce a dark depression around the basal plate and cause the dry scales to fall away. In more advanced stages, dark streaks and blotches of lifeless tissue may be found in the fleshy scales from the base toward the bulb tip.

The nematodes on infected plant tissue appear under the microscope as tiny worms among the plant cells. Nematodes exist as males and females and reproduction is by means of eggs, from which hatch tiny larvalae, which are shaped like the adults and grow rapidly. They shed their cuticles (“skins”) and become second-stage larvae. The procedure is repeated to form third- and fourth-stage larvae and finally adult nematodes. The life cycle requires 25 to 30 days and is repeated as long as the plant grows.

When the narcissus plant dies, because of infection or final ripening, many nematodes leave the plant tissue and, if the soil is moist, migrate into the surrounding earth. Those that do not migrate become dried in plant debris and enter an inactive stage known as quiescence. In that condition they are able to withstand unfavorable conditions, such as extremely high temperatures, and have been revived, upon moistening, after remaining more than 5 years in dry plant tissue. The same thing happens if the soil becomes dried after the nematodes migrate from the hosts, but they remain active as long as there is enough moisture. Bulb and stem nematodes infecting narcissi have remained active in moist soil free of plant growth for 18 months. It took that much time for them to starve to death, as they can exist only on food stored in their bodies.

Control measures for nematodes in bulbous crops must be efficient enough to eradicate them entirely—regulatory measures allow no tolerance of nematode-infected bulbs in salable stocks.
Control measures must include sanitation, proper soil management, and the treatment of bulbs with hot-water-formalin.

The sanitary measures insure the destruction of infected plant materials and prevention of contamination by infested soil. Infected plants with adhering soil should be carefully removed from the field, placed in a deep, isolated trench, covered with quicklime, and buried with a layer of soil. Dry materials from fields and sheds may be burned. To prevent the spread of nematodes by scattering soil and debris from an infested field, adhering soil should be removed from tractors, trucks, diggers, shovels, and other tools. The implements should be washed thoroughly with water and then freely sprayed with formalin (1 part commercial formaldehyde solution U. S. P. to 9 parts of water). That solution may also be used to dip bulb trays and other equipment and to drench soil along paths to free them of the pests.

Proper management of infested soil must destroy the nematodes by an adequate starvation program or by the use of soil fumigants. The success of the starvation method is based upon the removal of all volunteer host plants from the field in question. Infested fields must be kept free of bulbs for at least 2 years following the eradication of host plants in order to starve the plant parasitic nematodes remaining in the soil. Because rapidly decaying plant material tends to lower the number of bulb and stem nematodes in the soil, the frequent use of fast-growing green-manure crops may be recommended during the starvation period. Corn, or most grains, when used as fast-growing annuals, may be used during the starvation period as cash crops.

Soil fumigants may be used to free the soil of plant parasitic nematodes after all volunteer host plants have been removed from an infested field. Fumigation probably is most economical when it is used to treat infested spots or parts of fields for eradication. The materials for fumigation may cost up to 100 dollars an acre. A grower who is thinking of fumigating soil will do well to consult local or regional horticultural officials about the source, cost, and choice of the various fumigants and applicators.

Proper hot-water-formalin treatment is the best method known at present for curing bulbs infected with nematodes. The use of heat for curing plants infected with nematodes was tried in Germany in 1909. Definite experiments with bulb crops were performed some 10 years later. As a result of those tests, Federal legislation in the 1920’s, designed to protect our new bulb industry from pests and diseases carried by imports from other countries, required that nematode-infected stock be treated with hot water. The imported bulbs usually arrived in late autumn after root development was well started and were severely injured by the hot-water treatment. The injury was overcome by a year’s growth, but treated bulbs could not be forced in greenhouses without being field-grown for a year. Many other methods of killing the nematodes in the bulbs were then tried, but none proved superior to hot water. It was found, however, that treatment with hot water at 110° to 111° F. for 3 to 4 hours, without the addition of formaldehyde solution U. S. P., did not kill all the nematodes.

When I was located at the Ornamentals Insect Research Laboratory at Sumner, Wash., in 1934, I added a presoak period of 2 hours in water at 75° F. in order to activate quiescent nematodes before the killing treatment. Commercial formaldehyde solution U. S. P. also was added to the treating water at the rate of 1 pint to each 25 gallons of water (0.5 percent) to kill the nematodes more rapidly and prevent the spread of rot organisms during treatment.

When the bulb industry was becoming established in the United States in the late 1920’s and early 1930’s, the small circular tanks used in England were found to be too
small to be practical on American farms and a substitute had to be found. Therefore, equipment for treating bulbs in hot-water formalin has been largely developed by the growers themselves. Using materials at hand, they constructed tanks of wood, metal, or concrete large enough to handle many bulbs in less time. Steam from a nearby boiler, liberated near a motor-driven propeller at the bottom and end of the tank, usually heated the water. A false bottom formed a channel under the load of bulbs through which the heated water was forced to the opposite end and eventually back to the propeller. Baffle plates helped distribute the heat uniformly through the tank. A thermometer was kept immersed near the manually operated steam valve, which was opened occasionally to keep the water between 110° and 111°. Bulbs in containers were lowered to the false bottom by hand or with hoists.

After 20 years of experience, growers have made several improvements. The false bottom is now a movable platform that may be raised to the top of the tank (which is at shed-floor level), quickly loaded by trucking stacks of trays filled with bulbs and covered with wire netting or empty trays secured in place, and again lowered into the treating bath. As several tons of bulbs may be treated at one time, the platform must be strong and sufficiently weighted to carry the bulbs into the bath. The hoist for raising and lowering the platform is geared to operate smoothly. Another improvement is a thermostat connected with an electromagnetic steam valve through a relay. When operated properly, it maintains the temperature more closely than manually operated valves. Some installations have alarm systems that give warning if the temperature drops below 110° or above 111° F.

One grower, unable to get a dependable steam boiler, substituted two propane-gas burners in two watertight flues, which looped along the bottom from the propeller end of the tank, down and back again and exhausted through a joint chamber. A fan in the chamber maintained a constant outward draft. Both burners are activated from a pilot light, but one is controlled by a thermostat and the other is manually operated as a booster heater. Because high temperatures harm bulbs and low temperatures do not control nematodes, great care is needed in the operation of the equipment. The growers who do custom treating for other growers have installed recording thermometers so that a permanent record is made of each lot.

The present methods for a complete control of nematodes in bulbs consist of the presoak bath and the treating bath. The presoak bath is water maintained at 75°F., with Vatsol O. S. added at the rate of 8 ounces to 100 gallons of water. Infected bulbs are soaked in this bath for 2 hours immediately before treatment. Its purpose is to revive dried or inactive nematodes, which are more difficult to kill than active ones. Vatsol O. S. is a wetting agent that assures the thorough wetting of all bulbs immersed in the treating bath by removing air pockets from parts of individual bulbs or from between the bulbs. Newer wetting agents have not been tested in bulb treatments and should be avoided until it is definitely known that they will cause no injury. Vatsol O. S. has been used with good results and no apparent injury to the treated bulbs.

The treating bath consists of water with 1 pint of commercial formaldehyde solution U. S. P. to each 25 gallons of water. The bath is maintained at 110°F. for different periods in the treatment of narcissi, bulbous irises, and Croft Easter lilies.

An efficient treating bath must meet several requirements. Agitation or circulation must be adequate to insure a rapid and constant flow of the bath to all parts of the tank. That is accomplished by electrically driven propellers and by properly placed baffle
plates in the tank, which assure an even temperature throughout the bath. It is necessary to have the correct amount of treating bath to maintain the ratio of 4 to 5 parts of liquid by weight to 1 part of bulbs. In order to maintain the correct amount of formaldehyde solution, the tank is calibrated to determine the number of gallons required to fill it to its working level and the amount of water necessary to raise this level of the bath 1 inch. With that information at hand, the operator can add the correct amount of commercial formaldehyde when the bath is first prepared and can also determine the correct number of gallons of water and amount of formaldehyde solution to add between runs. If steam is discharged into the bath as a heat source, the bath is measured before the valves are opened because it is necessary to know how much water is added by condensation of steam.

The concentration of 1 pint of commercial formaldehyde solution U. S. P. to 25 gallons of water must be maintained so as to complete the nematode kill and prevent the dispersal of rot organisms from one bulb to another during treatment. Exact amounts must be added to compensate for any water added to the bath, either by steam or other methods. The commercial formaldehyde solution should be clear and free of any waxy sediment or thickening. If it has been stored in a cool place such a condition may exist and is likely to result in an unreliable concentration. The bath solution should be replaced when it has an excess amount of discoloration, sediment, or both from the soil brought in with the bulbs, which usually occurs after 6 to 8 uses.

The proper temperature is 110°F for narcissi, bulbous irises, and Croft Easter lilies. The bath temperature must not fall below 110°F nor rise above 111°F for the entire treatment period, if results are to be satisfactory. In order to maintain this exact control, a reliable mercury-type thermometer, checked for variation with the one used by the State horticultural inspector, is a necessity. The cheap, spirit type of thermometer is not reliable enough to risk with a tank of bulbs which may be worth several hundred dollars. Growers doing custom treating should also use a recording thermometer and keep the records.

Duration of treatment is determined in hours after the bath has been stabilized at 110°F.

Bulbous irises are treated for 3 hours. Bulbs must be harvested early (about the same time as King Alfred narcissi) and treated within 3 to 4 weeks, or before any evidence of root development or basal swellings start.

Narcissi are treated for 4 hours. Bulbs should be harvested early, when about one-third of the foliage is yet greenish. Planting stock should be treated within 3 weeks after harvest.

Posttreatment care of irises and narcissi should consist of immediate cooling followed by planting or drying. Bulbs must be placed in shallow, sterilized containers and located where adequate air movement will dissipate the stored heat and excess moisture.

The bud and leaf nematode, *Aphelechoides olesistus*, was reported by me in 1945 as a serious pest of Croft Easter lilies in the Pacific Northwest. I later found that the infection can be controlled by a 1-hour treatment in the bath and temperature as used for irises and narcissi. Best results were obtained when bulbs were harvested 8 to 10 weeks following full bloom and their bulblets treated within 3 weeks. Only bulblets were treated, because we found that older stock may produce an excess of basal bulblets as a result of treatment, especially in late season. Treated bulblets are cooled immediately after treatment and planted in the field. If that is not feasible, they are kept moist and cool in well-ventilated storage.

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