MP-356

Plant Nematodes

THEIR IDENTIFICATION AND CONTROL

TEXAS AGRICULTURAL EXTENSION SERVICE
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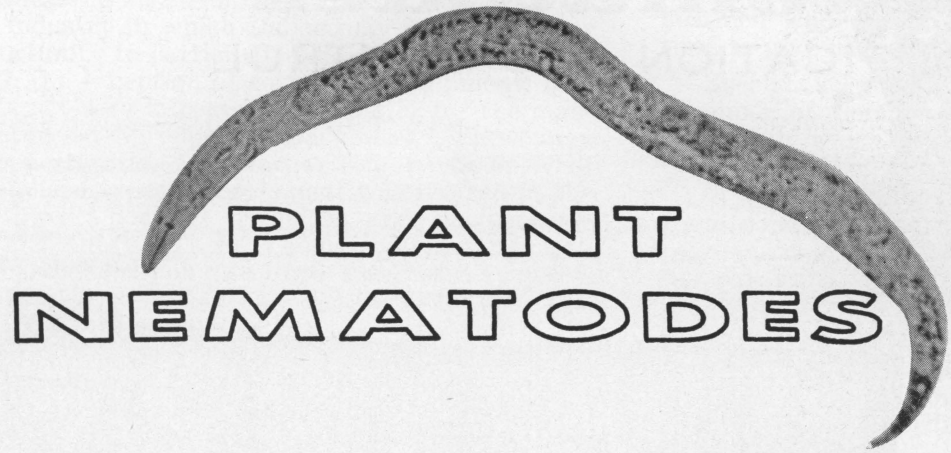

PLANT NEMATODES

Their Identification and Control

HARLAN E. SMITH AND DON C. NORTON*

NEMATODES CAUSE an estimated yearly loss of at least one-tenth of the farmers' gross income in the United States. Nematode loss estimates are unavailable for Texas; the damage, however, is considerable. On susceptible crops, the loss may exceed 50 percent or in extreme cases may cause total destruction. Mere presence of parasitic nematodes does not necessarily indicate economic damage to plants. Loss will be governed by the nematode species, population buildup and environmental conditions. In some cases the care the crop itself receives, such as fertilizing and watering, plays a large part in limiting or promoting nematode damage. High populations of some species appear to have little, if any, detrimental effect on some hosts.

Many different species of parasitic nematodes are associated with plants in Texas. No field, garden, lawn or flower bed is entirely free of these pests. These plant parasites feed on roots, stems, bulbs, tubers and to a lesser extent on leaves and flowers.

What Are Nematodes?

A plant-parasitic nematode is a worm-shaped, almost microscopic animal. In some instances, the adults become pear to flask shaped. Both the male and female nematodes contain a complete digestive system, a well-developed nervous system and a type of excretory system. No circulatory or respiratory system is known. Most plant-parasitic nematodes are from 1/50 to 1/10 inch long.

Feeding by these tiny animals usually is accomplished with the help of a pointed structure called a spear or stylet. These spears punch holes in plant cells and suck plant juices into their digestive tracts.

Nematodes usually feed and reproduce on the roots of many kinds of plants and may survive in the soil from one year to the next. The seriousness of their damage has been recognized only in recent years. Their small size, the habit of many species of feeding from outside the roots and the lack of clear-cut symptoms has caused their importance to be overlooked.

There are two general types of nematodes, classified according to their feeding habits: endoparasitic; and ectoparasitic. Endoparasites actually burrow into plant tissue and feed inside. Ectoparasites feed on the roots without completely entering the plants.

The pin nematode is one of the smallest of the parasitic forms. It measures about 1/70 of an inch in length.

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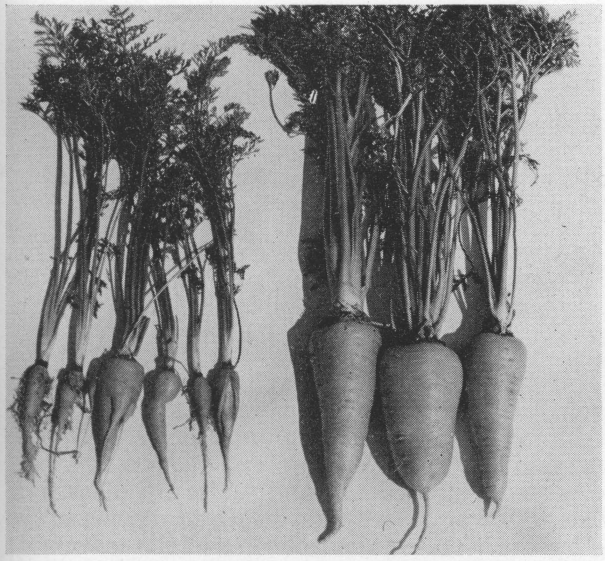


Carrots grown in nematode infested soil, left; grown in 1,2-Dibromo-3-chloropropane treated soil, right.

Symptoms and Effects of Common Nematodes

General above-ground symptoms of nematode injury consist of stunted growth, loss of yield and plant nutrient deficiency symptoms. Seldom does a nematode suddenly kill a plant. Decline often is slow. Other symptoms of nematode damage are yellowing of foliage; forked, crooked or brushy appearance of fleshy tap roots such as carrot; stubby, small root systems of plants with excessively branching roots; small roots larger near the tip end; wilting of apparently healthy (but sometimes not vigorous) plants in summer heat, reviving overnight; and abnormal brown or black spots on roots. Often one or more of the above symptoms are absent. When examining for symptoms, dig roots and soil with a shovel; carefully shake the soil from the roots; wash the roots and allow them to dry. Compare normal plant roots with those suspected. In some cases nematodes occur as part of a fungus or bacterial root-crown rot complex.

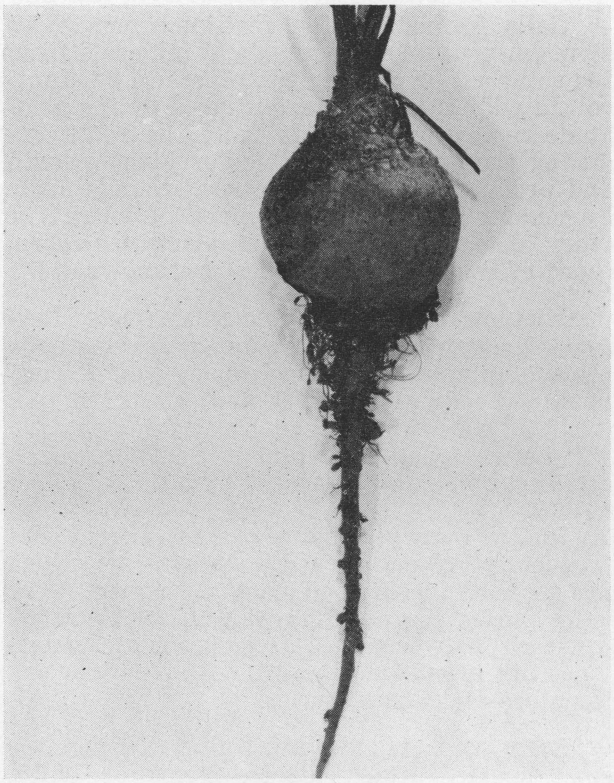
Root symptoms, in connection with high populations of parasitic nematodes and one or more above-ground symptoms usually are the best indications of nematode disease. Several general types of plant diseases are caused by nematodes.

ROOT-KNOT, *Meloidogyne spp.* is the most common nematode disease; it is found on nearly 2,000 kinds of plants. The appearance of root-knot-diseased plants varies with different crops and with the severity to which each crop is affected. Usually the trouble is first noticed when the plants begin to show lack of vigor. Stunting, wilting and yellowing of the leaves often become apparent. Defoliation frequently follows. In severe cases the plant ultimately dies. In plants such as tomatoes, fruits usually are small and unprofitable for harvest. In root knot, the above-ground symptoms are produced by the defective root system.

When a diseased root-knot plant is removed from the soil, the roots are a gnarled, distorted mass of uneven swellings. These are not to be confused with the small bead-like nodules on legumes which are caused by beneficial nitrogen-fixing bacteria.

The root-knot nematode is very small and only the female, when filled with eggs, can be seen with the naked eye as a tiny pearl-like speck in the gnarled root tissues. When the eggs hatch the young nematodes move about in the soil for short distances and invade new roots. Several generations may be produced in one year.

Under their own power, most nematodes do not move more than a few inches from where they were hatched. However, movement from place to place in the same field or from field to field is principally brought about by (1) setting out infected transplants; (2) movement of diseased plant debris; (3) movement of contaminated soils by tractors or by the



Root knot of table beet.

Root knot of vetch. The plant on the right is healthy.

mud on shoes and animals' hooves; (4) irrigation water and drainage.

Galls formed by the root-knot nematodes slow down uptake of water and minerals from the soil thereby causing the plants to be stunted. In addition, plants are injured by the nematode removing nutrients from the roots, reducing the amount available for plant growth and production. In some cases, wounds made by nematodes serve as avenues of entry for other disease-producing organisms. Several types of root-knot nematodes are known.

MEADOW OR ROOT-LESION NEMATODES, *Pratylenchus spp.*, feed mostly on the inside of the roots of plants and do not form galls. They puncture cells of the root and enter the root itself. There they develop, lay eggs and feed. These nematodes feed on many kinds of plants and occur in many areas of Texas.

Plants damaged by root-lesion nematodes frequently have browned root systems which are reduced in size and partially rotted. The outer part of the root may slip off easily when squeezed between the fingers. These nematodes are prevalent on corn, sorghum, grasses, tomatoes and strawberries.

STEM AND BULB NEMATODES, *Ditylenchus spp.*, usually attack leaves, stems or bulbs. Garlic is known to be damaged by them in Texas. Other susceptible plants are narcissus, hyacinth, bulbous iris, onions, Irish potatoes, sugar beets, clover, alfalfa, rye, strawberry and sweet potatoes. Larger populations are more apt to be found in heavier soils than in sand. Leaves become yellow or brownish and galls or swellings may or may not develop. Plants are stunted.

Garlic seedlings when attacked often emerge white. In older plants, leaves lodge and bulbs split. The inside of bulbs appears mealy at first and then rots.

BUD AND LEAF NEMATODES, *Aphlenchoides spp.*, may damage strawberry, rice, chrysanthemum, orchid, delphinium and phlox. The nematodes cause spring and summer dwarf disease of strawberry and white tip disease of rice. Lower leaves first begin to die when the chrysanthemum is attacked, and the leaves die progressively toward the top of the plant.

STYLET NEMATODES, *Tylenchorhynchus spp.*, attack corn, cotton, sorghum, rice, strawberry, alfalfa, peanut, bean, ornamentals and grasses. These nematodes are among the most common parasitic forms in Texas. The damage often noted is varying degrees of plant stunting but often no decline is noted even though high populations exist.

STUBBY ROOT NEMATODES, *Trichodorus, spp.*, often may be detected by decay at the root ends. Roots have a stubby, sawed-off appearance. Corn, sorghum and grasses may often be attacked. St. Augustinegrass is a common host. The nematodes stay outside of the root to feed. Relatively few nematodes can cause severe damage.

CITRUS NEMATODES, *Tylenchulus semipenetrans*, are common in most areas where citrus grows. They are known to attack grape and

Peach killed by root knot nematodes.

Peanuts damaged by root-lesion nematodes.

persimmon. Affected trees may or may not show a general lack of vigor when nematodes damage the roots.

STING NEMATODES, *Belonolaimus spp.*, are not widespread in Texas but appear damaging wherever they occur. They are known to be associated with decline of roses, strawberries and corn in Texas but also attack many other plants.

Other nematodes that attack plants in Texas include RENIFORM NEMATODES, *Rotylenchulus spp.*, in the Lower Rio Grande Valley, which attack roots of different kinds of plants. DAGGER NEMATODES, *Xiphinema spp.*, feed on the outside of roots of many plants including iris, alfalfa, corn, grasses, rose, ligustrum, nandina, grape and cantaloupe. SPIRAL NEMATODES, *Rotylenchus spp.*, and *Helicotylenchus spp.*, are common parasites on many different plant roots. Hosts include grasses, ligustrum, strawberry, rose and chrysanthemum. CYST-FORMING NEMATODES, *Heterodera spp.*, exist in Texas but do not appear to be common. LANCE NEMATODES, *Hoplolaimus spp.*, are believed to damage the roots of plants such as iris, St. Augustinegrass and vetch.

Soil and Plant Analysis for Nematodes

Where plants, crops, shrubs or trees show slow decline, loss of vigor, unthriftiness, failure to respond properly to fertilizer or water or slower than normal growth, and for no apparent reason, nematode damage may be suspected. If this is the case collect a *special soil and root* sample for analysis at the Plant Disease Diagnostic Laboratory, College Station, Texas.

1. Collect sample after soil has been moist for 2 to 3 weeks.

2. Try to collect when disease symptoms of the plant are most severe and when the soil is moist, not wet.

3. Select soil and roots from unthrifty or diseased plants that are still partly alive.

4. Collect at least ½ pint of soil, including a few short pieces of roots.

5. Place soil and roots in a plastic freezer bag. Tie the bag securely.

6. Place the bag or bags of soil and roots in a sturdy pasteboard box.

7. Obtain a D-418 form from your extension agent and fill out the section entitled, "Plant Disease Specimen Record;" and include with the shipment.

8. Ship to Plant Disease Diagnostic Laboratory, College Station, Texas.

9. It is impossible for the laboratory to test dry soil and roots for nematodes. *The soil and root test can be no better than the quality of the sample shipped to the laboratory.*

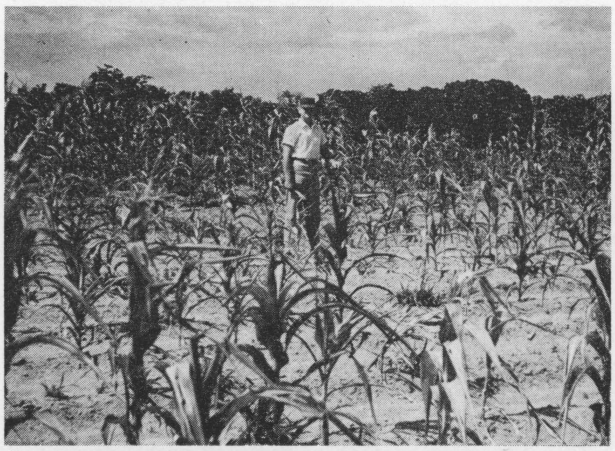
10. A report of the laboratory findings will be returned to you as soon as possible. Should nematodes appear to be the cause of the problem, control measures will be recommended whenever possible.

Control Measures

No control measures that will completely destroy all nematodes are known. In many cases control measures are practical, however, and can give satisfactory results.

Crop rotation. Information is lacking concerning exact rotations to use to control all nematodes. In general, avoid growing the same crops or plants continuously in the same soil and, if possible, avoid growing all fibrous-rooted plants or all tap-rooted plants in the same rotation.

Resistant crops or varieties. Grow resistant or immune crops where adapted. Plants



Corn damaged by sting and root-lesion nematodes.

resistant or immune to the most common species of root knot follow:

Field crops. Resistant or tolerant—barley, corn, Plains and Auburn cotton, crotalaria, grasses, kafir, milo, oats, peanut, redtop, sorghum, timothy, velvet bean and wheat.

(Susceptible—alfalfa, clover, most cotton varieties, most cowpeas, field peas, flax, vetch.)

Fruits and nuts. Resistant or tolerant—apple, avocado, pear on resistant root stock, plum on Marianna root stock, peach on S-37 root stock.

(Susceptible — blackberry, cherry, grape (old world), fig, strawberry, pecan, walnut.)

Trees and Ornamentals. Resistant or immune — camellia, cosmos, dogwood, evening primrose, gaillardia, geranium, lantana, lysine, marigold, narcissus, nasturtium, zinnia.

(Susceptible — begonia, clematis, coleus, dahlia, European elm, fig, hollyhock, peony, rose, sweet pea, violet, weeping willow.)

Vegetables. Resistant or immune—Fordhook 242, Nemagreen, and Bixby lima bean, Alabama No. 1 and No. 2 pole bean, California Blackeye 5, Dixie Lee and Texas Cream 12 southern pea; Nemagold sweet potato; Manalucie tomato.

(Susceptible—asparagus, bean, beet, cabbage, cantaloupe, carrot, celery, southern pea, cucumber, eggplant, lettuce, okra, onion, garden pea, pepper, potato, pumpkin, spinach, squash, sweet potato, tomato, watermelon.)

Clean summer fallow. Most nematodes die in dry soil. Plow three or four times to lift successively deeper layers of soil during a 3-week period of hot, dry weather. Crotalaria may be grown in the place of summer fallow.

Fumigated area of cotton field, background, shows cotton almost waist high. Untreated area, foreground, shows spotty growth and low-growing plants.

Selection of planting site. When planting susceptible crops, avoid sites which have been infested with nematodes within recent years. Inspect susceptible weeds for root knot. Select sites to avoid drainage water which often carries nematodes from infested land to noninfested land.

Selection of transplants. Use transplants that have been grown in soil free of nematodes. Produce transplants in soil that has been fumigated with a nematocide or in sterilized soil.

Cultivation and fertilization. Providing plants with conditions for rapid root growth sometimes helps reduce losses from some nematode species. This is especially true with large trees and shrubs. Although infected, a vigorous root growth may partially offset the detrimental effects of nematodes.

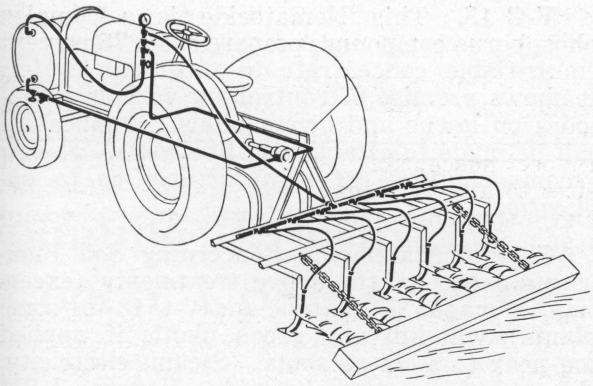
Flooding. Flooding land for about a month will drown most nematodes, but in most areas this procedure is impractical.

Fumigation or sterilization of soil. In many cases, soil sterilization or fumigation is necessary to control certain soil-borne and root diseases as well as nematodes.

Steam. Steam is one of the most effective methods of sterilizing small quantities of soil; however, the necessary equipment may not be available. Live steam from a boiler is conducted into an inverted box which is moved about over the loosened soil. Drain tile or iron pipe buried in the soil may also be used to distribute the steam. Heat soil by steam until a medium-sized potato, buried several inches in the soil, is thoroughly cooked.

Electricity. Electricity may be used for sterilizing small quantities (about 1 cubic yard) of soil in boxes in which heating cables have been installed. The soil is heated at about 160 degrees F. for 3 or 4 hours. This procedure kills the disease-producing organisms without impairing the condition of the average soil. Electrical soil-sterilizing units can be purchased. Small quantities of soil used in flower pots may be sterilized by placing in an oven, at the temperature and time previously described.

Chloropicrin. Chloropicrin is a liquid form of tear gas which has specific uses for sterilizing soil, especially against nematodes and diseases such as verticillium wilt. It is used at the rate of about 1 pound to 140 square feet of soil surface and is placed 6 to 8 inches deep in the soil in holes about 15 inches apart. Close holes immediately and keep the surface wet by occasional sprinkling for a few days to a



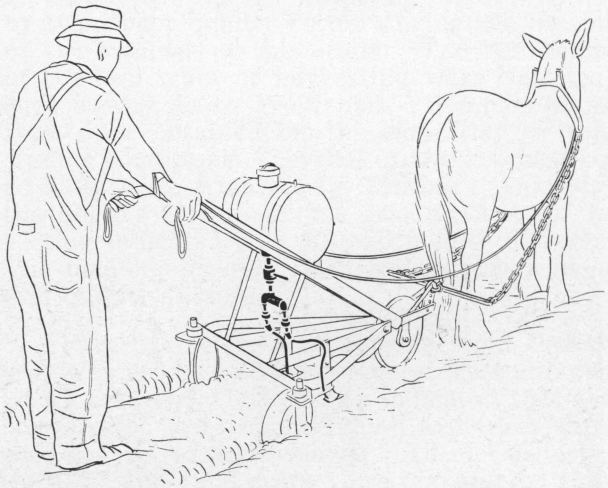
Tractor injecting equipment for soil fumigant. Note the extremely efficient pump mounted directly on the power takeoff of the tractor. Also note the convenient position of the quick shutoff valve and pressure gauge with respect to the driver. Photo courtesy of Shell Chemical Corporation.

depth of 1 to 2 inches. Chloropicrin has been used for control of verticillium wilt on chrysanthemum and strawberry in other states.

The method used is as follows: plow, disc or rototill the soil to a depth of at least 9 inches as soon as the land can be worked after rain or irrigation. This insures adequate moisture up to the soil surface. Break up clods. Should the surface soil be dry, before the fumigant is applied, work the soil to bring moisture to the surface. Apply the fumigant. If a hand gun is used inject 3 ml. or approximately ¾ teaspoon at 1-foot staggered spacings, 6 inches deep. Hand application necessitates prior marking of the soil into 1-foot squares. If the application is by machine, apply 480 pounds (34.5 gal.) to the acre, distributed so that no square foot of land receives less than 3 ml. After injection of the chemical, smooth and roll the soil. A light sprinkling provides an excellent seal. If water for sprinkling is not available, and if the soil was moist to the surface when fumigated, the initial dragging and rolling will suffice. Land should not be used for seeding or planting until 2 weeks after the fumigation. The amount of disease control achieved by fumigation depends upon the condition and tilth of the soil. Dry, cloddy, shallowly worked soil should not be fumigated. A poor job of fumigation or too low a dosage of fumigant may actually cause the verticillium wilt disease to increase. *Chloropicrin is a very active material. Persons applying it should study and strictly follow the warning on the package label furnished by the manufacturer.* Some of the chloropicrin trade names are Larvacide and Picfume.

Ethylene Dibromide and Dichloropropene-Dichloropropane Mixture. Ethylene Dibromide is a colorless, volatile liquid used as a soil fumigant for control of nematodes and soil insects. Various amounts from 2 to 30 gallons per acre are used, depending upon the method of treatment and concentration of product. Some commercial products, based mainly on ethylene dibromide, are Dowfume W-85, Garden Dowfume, Soilfume, Bromofume-40, Bromofume-85, Nemex-42 and Nemex-85. Dichloropropene-dichloropropane mixture is a volatile liquid used as a soil fumigant for control of nematodes and certain soil-borne insects. A commercial product containing a mixture of dichloropropene-dichloropropane is D-D. Ethylene Dibromide and dichloropropene-dichloropropane has been used to a limited extent in cotton, commercial vegetable production, flower gardens and ornamentals. These chemicals have been used more widely than other soil fumigants. Tractor-drawn applicators have been used in treatment of large areas at a reasonable cost. *Follow directions of manufacturer in applying ethylene dibromide or D-D.* Telone is a soil fumigant containing dichloropropene. Dorlene is a soil fumigant containing a mixture of ethylene dibromide and dichloropropene.

Methyl Bromide. This chemical is colorless, highly volatile and is liquid below 43 degrees F. but quickly vaporizes at higher temperatures. *This material is highly poisonous and should be handled carefully.* It is best to use a commercial product containing a small percentage of chloropicrin as a warning agent. It is used for soil fumigation to control nematodes, fungi, bacteria, weed seeds, insects and



Row applicator, gravity feed type, mule-drawn, for treating soil. Two shanks in the row are spaced 12 inches apart. Disc hillers following the shanks mark a raised bed for planting. Tank is equipped with a constant pressure device to insure uniform flow of soil fumigant. Note quick shutoff valve and orifice unions. Photo courtesy of Shell Chemical Corporation.

other organisms. It generally is used on seedbeds, lawns or other relatively small areas. Polyethylene sheets confine the gas in the soil. *Follow recommendations of the manufacturer.* Commercial products containing methyl bromide are Dowfume MC-2, Bromex Soil Fumigant 1, Picride and Pest Master.

Sodium N-methyl Dithiocarbamate (Anhydrous.) This chemical is a water-soluble soil fumigant that is used in damp soil to control weeds and grasses, nematodes and some soil fungi. It is sold under the commercial names Vapam and VPM. *Use according to directions of manufacturer.*

1,2-Dibromo-3-Chloropropane. This is one of the newest soil fumigants. It is injected into the soil with the same equipment used to apply other liquid soil fumigants. It differs from others in that applications may be made after the root systems of plants have been established as well as prior to planting. This chemical is more stable and has a longer residual action than most soil fumigants. It is used for the control of root knot nematodes and certain other plant parasitic nematodes. It can be used on large acreages. *Use this chemical with care because some plants are highly sensitive to it.* Commercial preparations of this chemical are Fumazone and Nemagon. *Follow the recommendations of the manufacturer as to application.*

V-C 13. This Nematocide is a complex phosphorus compound, prepared as a 75 percent emulsifiable concentrate to mix with water. It shows promise of controlling various nematodes on lawns and ornamentals. Application can be made to established, live roots. *Follow recommendations of manufacturer as to application.*

General Statements Concerning Soil Fumigants. Any of the above treatments (exception, Nemagon, Fumazone and V-C 13 for some plants) will kill any green plants if applied too near to stem or roots. Steam, electricity, chloropicrin methyl bromide, Vapam, VPM and V-C 13 generally are restricted in their use to smaller soil areas. This is because they are more hazardous and difficult to use, prohibitive in cost or less efficient. Fumigation is most effective in sandy and light loam soils. These methods of soil sterilization or fumigation sometimes are difficult. Whenever possible, obtain fresh, disease-free soil from uncultivated areas to use for growing plants indoors or for replacing infested garden soil. Likewise, when soil-borne diseases are discovered in the field, change the location of the affected crop if possible and plant some nonsusceptible crop in the infested area. Preliminary information indicates that the use of soil fumigants for nematode control will increase in the future.

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