

# Crop Profile for Carrots in Michigan

Prepared: August, 1999

## General Production Information



Over 100,000 acres of carrots are planted annually in the United States. California produces over half of the fresh market carrots in the United States. Washington is the main producer of processing carrots in the United States.

With approximately 7,000 acres planted and harvested annually, Michigan ranks among the top carrot producers of the nation, in both the processing and fresh produce markets. (6)(14)

- Michigan ranks third nationally in the production of fresh market carrots, producing 3.9% of the total U.S. commodity (1998) (5)
- Michigan ranks fifth nationally in the production of processing carrots, producing 6.9% of the total U.S. production (1998) (5)
- The five-year average for Michigan fresh-market carrot production is 1,300,000 cwt.
- Processing carrots can, on good fields, yield 35-40 tons per acre, and fresh market production may exceed 15 tons per acre.
- The area planted and harvested is showing major declines in recent years.

	Carrots (Processed)	Carrots (Fresh)
<b>Michigan Ranking</b>	5	3
<b>Percent of U.S. Production</b>	6.9	3.9
<b>Area Planted (5 year average) (ac)</b>	1,780	5,840
<b>Area Harvested (5 year avg.) (ac)</b>	1,680	5,440
<b>Value of Production (thousands) (5 year average) (\$)</b>	2,195	20,476

(10)

- Carrot production is localized primarily in the West central region of Michigan in the Muskegon, Newaygo, and Oceana counties.
- Montcalm County, in the Central region, produces fresh market carrots.
- Lapeer County, in the Southeast, also produces carrot for fresh market.



(7)

	<b>Counties</b>	<b>Acres Planted</b>	<b>Yield (lb/acre)</b>	<b>Production</b>
<b>Fresh Market Carrots</b> (from 1995-96 MASS, MRS statistics)	<b>Muskegon</b>	420	38,000	15,960,000
	<b>Newaygo</b>	1,250	38,000	47,500,000
	<b>Oceana</b>	180	38,000	6,840,000
	<b>Montcalm</b>	850	31,000	26,350,000
	<b>Lapeer</b>	1,050	34,000	35,700,000
<b>Carrots for Processing ('95-96)</b>	<b>Oceana</b>	350	40,000	14,000,000
<b>TOTAL 1996 Acres:</b>				<b>7,700</b>

(6)

References: (10)

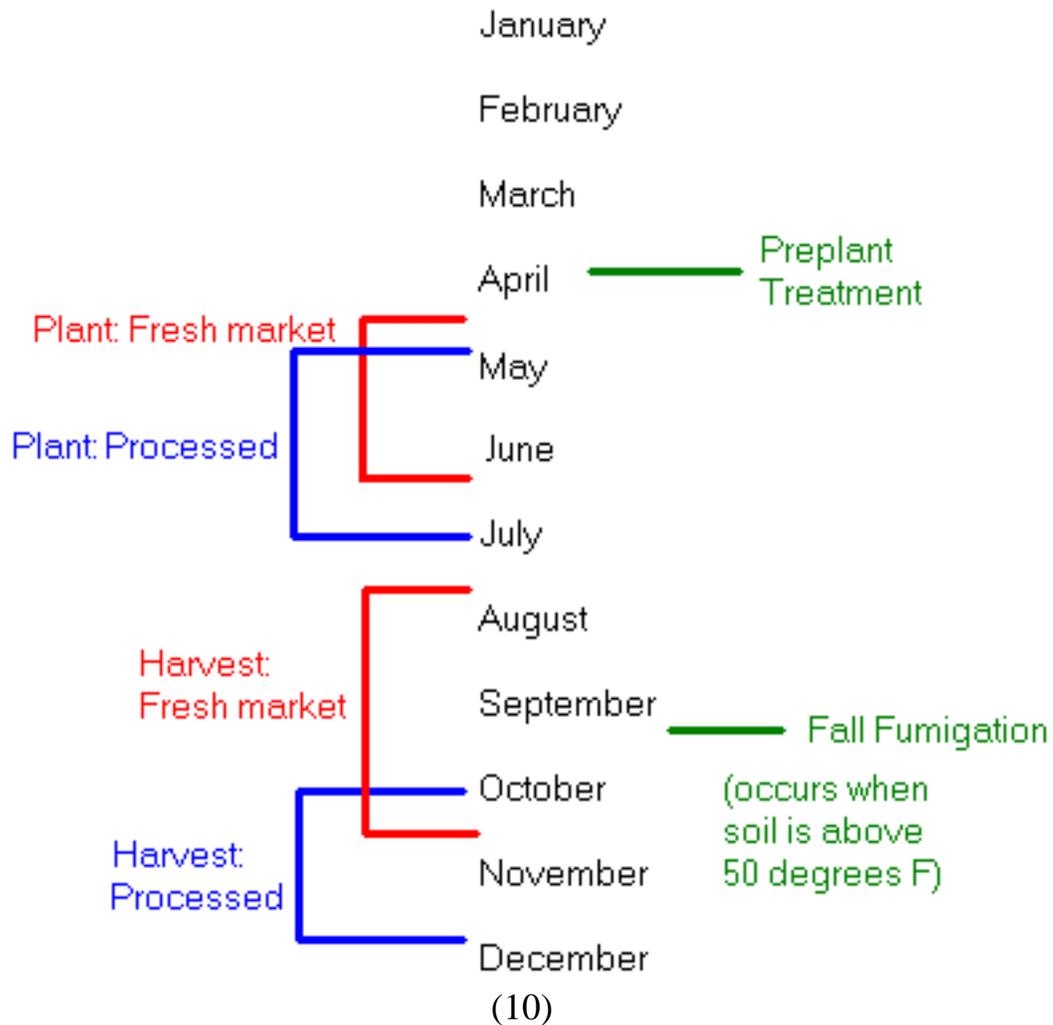
## Cultural Practices

Carrots are grown in Michigan for processing and fresh market use. They are primarily grown in deep, well-drained muck and mineral soils. Carrots are extremely sensitive to environmental conditions such as heat, soil compaction, and particularly water stress and saturation. Michigan farmers often intercrop carrots with rye and barley to protect the young seedlings from wind damage, and rotate with lettuce and onions.(14)

Carrots are a cool season crop; young seedlings can withstand mild frosts, but can be significantly damaged by high temperatures. Thus, planting usually begins in mid-April to mid-June and is often scheduled to allow for continuous harvesting. The plants then take approximately 120 to 180 days to mature.

Fresh market carrots are harvested from late July through September or October, while processing carrots are harvested from early October through late November. Carrots are mechanically harvested in Michigan. The roots are undercut and then they are lifted out of the soil by grasping the leaves. If foliar diseases are left uncontrolled it is difficult to harvest the carrots because the foliage is too weak to lift the carrots out of the ground. Healthy leaves are important for effective harvesting. Weeds and foliar diseases can interfere with harvesting. Carrots are loaded onto machinery, washed, cooled and packaged and then they are placed in storage. Great care is taken with post-harvest handling to ensure good quality. (14)

## Carrot Timeline

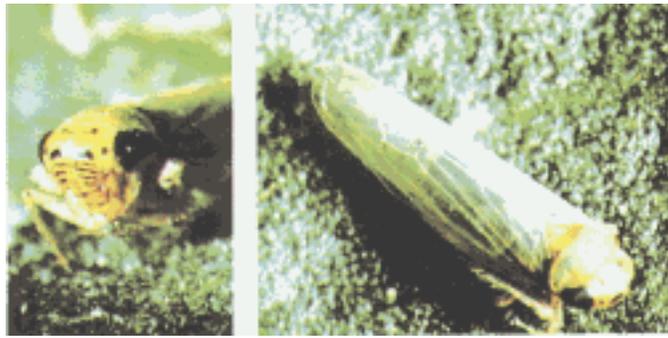


### **Chemical Controls: Critical Use Issues**

- Oxamyl (Vydate) is the only material available to control carrot weevil in the North West Region.
- There has been some instances of 1-3D failure on carrot.

## **Insect Pests**

### Aster Leafhopper



### ***Biology***

The aster leafhopper (*Macrostelus fascifrons*) is a key pest of carrots, as well as many other vegetable crops. The aster leafhopper does not seriously damage carrots; however, it transmits a phytoplasma that causes aster yellows. The adult and nymph aster leafhoppers have piercing mouthparts that they use to enter into vascular tissues of plants to extract sap. When they penetrate the tissue, they release pathogen-transmitting saliva. Aster yellow diseases dwarf the carrots, causing them to be abnormally shaped and have poor flavor, often reduces the size leading to losses in both quality and quantity of carrot yields. The phytoplasma also pre-disposes plants to other diseases such as soft rot.(3)

Control of aster yellow disease in Michigan is dependent on controlling the population of aster leafhoppers. Both overwintering and migratory aster leafhoppers have become key pests, but the migratory leafhoppers are considered to be less of a problem than the local population.(14)

The migratory population is dependent on conditions in the southern states where it overwinters. When these states have cold winters, the population decreases. They first arrive in Michigan with warm southerly winds, allowing temperature and wind patterns to be used to predict levels of migratory leafhoppers.(14)

### ***Cultural Controls***

Removal of infected plants.

**Weed control** is an essential part of controlling aster leafhopper. Removing weeds and winter grasses near carrot fields can decrease the local population significantly. Linuron (Lorox) has been used for weed control; however, **some resistance is developing**.(14)

**Early seeding** helps the crop to mature before the disease becomes well established. Because fresh market growers use early-harvest varieties of carrots while processed carrots are late-harvest varieties, processed carrots get significantly more exposure to the disease than do fresh market carrots.

### ***Chemical Controls***

Some common chemical controls are:

- **Carbaryl** (Sevin)
- **Malathion** (Cythion)

## *Alternative Controls*

Alternatives to Malathion and Carbaryl include:

- **Endosulfan** (Thiodan)
- **Esfenvalerate** (Asana)
- **Methomyl** (Lannate)
- **Methyl parathion** (Penncap-M)
- **Oxamyl** (Vydate)

## Carrot Weevil



## *Biology*

Carrot weevil (*Listronotus oregonensis*) infestation has caused serious economic damage to carrot producers in Michigan. Initial damage is evidenced by small circular feeding holes left by adult insects on the underside of leaf petioles. Later damage will appear as larval tunneling on the outer surface of the carrot root, rendering the crop unacceptable for fresh or processing markets. Early season damage usually occurs to plants in border rows or row ends, near field margins.

Adult weevils overwinter in fields, field margins, and ditchbanks in the upper 2-3" of soil, before emerging in mid-April to late May to begin feeding and egg laying on the petioles or crown of the carrot. Larvae usually hatch within a week and bore down to the roots. There they spend two to four weeks feeding and maturing before leaving to pupate in the surrounding soil. Adults emerge from these pupae as early as mid-June, and begin laying eggs within two weeks. Since a female may continue to lay eggs until mid-late August, all stages of development may be present at any one time.(4)

## *Cultural Controls*

**Sound cultural practices** to minimize spread of infestations, and

In fields that consistently have problems, the most economical solution may be to **rotate** to a crop other than carrots or celery and maintain good control of weed hosts for one or two years until the infestation has been reduced or eliminated. Late planting (e.g. mid-June) will also reduce damage.(14)

To prevent spread of the infestation, good sanitation is important. Proper disposal of culls and trimmings from infested fields is important. Also, extra care should be taken to prevent infestation on greenhouses or seedbeds where carrot weevils may multiply and be spread throughout the fields with the transplants. Pull any dead or dying plants and examine the roots and surrounding soil for larvae or pupae. This is especially important in greenhouses and seedbeds. Proper soil sterilization will greatly minimize problems in the greenhouse.

### ***Chemical Controls***

Proper timing of sprays is critical for good control while minimizing costs. Sprays for carrot weevils should be applied in the spring or early summer, as soon as adults become active. Some common sprays used to control carrot weevils are:

- Methyl parathion
- Oxamyl (Vydate)

### ***Alternatives Chemical Controls***

- Esfenvalerate
- Baythroid

### **Green Peach Aphid**



### ***Biology***

Green Peach aphids are key pests of celery, but are not generally a big problem in carrots because of the effectiveness of common controls. They cause damage by transmitting mosaic viruses through sucking, causing twisting and distortion of the new growth.

Green peach aphids are yellow-green, except for winged adults, which have black markings on their bodies. They may overwinter as eggs on an overwintering host or in greenhouses, or migrate into Michigan from southern locations. On the overwintering host, the eggs hatch in the spring and – after several generations – produce winged aphids. These adults migrate to several different weeds and crops. Winged forms are especially common when the host plant is dying or aphids are becoming crowded.(14)

Aphids have extremely high reproductive rates – each aphid can give birth to 50-100 young, and there

may be five to ten generations per year. Usually population numbers are held in check by natural enemies (lady beetles, hover fly larvae, lacewing larvae, fungal diseases, and tiny wasps), **but insecticide or fungicide sprays sometimes disrupt this natural control and result in aphid outbreaks**. Spraying with the wrong insecticide only increases aphid problems by killing natural enemies.(14)

Aphids can be monitored by direct visual observation of plant foliage. Traps can also be used, but identification is difficult because many harmless aphids and other insects may also be trapped. Green peach aphids can rapidly build up resistance to insecticides because females reproduce without mating, and offspring are genetically identical to the mother.

### ***Cultural Controls***

Maintain natural enemy populations.

### ***Chemical Controls***

- Diazinon
- Endosulfan
- Malathion
- Methyl parathion

### ***Alternatives***

No information available

## **Insecticide Profiles**

### **Carbaryl (carbamate)**

Formulations: Sevin

Pests Controlled: aster leafhopper

Percent of Crop Treated: used by 22% of Michigan carrot farmers on 100% of the acreage. Carbaryl was applied to 14% of acreage in carrot production in Michigan; 10% of farmers in the Northwest region, 33% of farmers in the West Central region

Types of Applications: foliar spray

Application Rates: 0.77 pounds per acre

Number of Applications: 2.9 applications annually

Timing: applied as a foliar spray in response to sweep net scouting

Pre-Harvest Interval: 30 day

REI: 12 hours

Use in IPM Programs: no information available

IPM concerns: Kills beneficial insects. Excessive use leads to aphid outbreak  
Use in Resistance Management Programs: Used as part of a resistance management program

Efficacy Issues: inexpensive yet effective

Advantages: Product can also be used on other crops such as onions. It is an inexpensive yet effective product. At least one processor allows its use

Disadvantages: At least two processors do not allow the use of Carbaryl on carrots, so many growers who do not know where their crop will be marketed do not use the pesticide.

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## **Malathion (Organophosphate)**

Formulations: Cythion

Pests Controlled: is used to control a broad spectrum of insects control including aster leafhopper and aphids

Percent of Crop Treated: Malathion was applied to 15% of the acreage. It is used by approximately 10% of Michigan carrot farmers on approximately 100% of the acreage. About 20% of West Central regional farms use Malathion, while only about 1% of Northwest regional farms use the chemical.

Types of Applications: foliar spray

Application Rates: 1.23 pounds per acre

Number of Applications: 3.2 applications annually

Timing: The foliar spray is applied, in the West Central region, at the three or four leaf stage; in the North Central region, at any stage necessary in response to sweep net scouting.

Pre-Harvest Interval: 30 days

REI: 12 hours

Use in IPM Programs: no information available

IPM concerns: This is a broad-spectrum insecticide that kills beneficial insects.

Use in Resistance Management Programs: The product is part of a resistance management program. In the West Central region, growers report that the product is losing its effectiveness. In the Northwest region, growers report a need for Organophosphate or Carbamate insecticides to rotate with synthetic pyrethroids to avert the development of resistance to synthetic pyrethroids.

Efficacy Issues: In West Central region, Malathion has only medium efficacy.

Advantages: Processors accept carrots treated with this product.

Disadvantages: expensive

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## **Methyl parathion (Organophosphate)**

Formulations: Penncap-M

Pests Controlled: carrot weevils, aster leafhopper, aphids

Percent of Crop Treated: used by approximately 20% of Michigan carrot farmers

Types of Applications: spray

Application Rates: (suggested) 3/4 to 1 pt (2)

Number of Applications: repeat as necessary (2)

Timing: sprayed only after the carrots have reached the six-leaf stage and only on fields on which weevils have been monitored

Pre-Harvest Interval: 30 days

REI: 48 hours

Use in IPM Programs: no information available

IPM concerns: This is a broad-spectrum insecticide and may also target beneficial insects.

Use in Resistance Management Programs: used as part of a resistance management program in the West Central region

Efficacy Issues: good (2)

Advantages: Inexpensive. Encapsulated insecticide has a slower release rate and therefore allows a larger window of opportunity to target adults.

Disadvantages: Toxic to applicator. Risk of honeybee and other non-target loss.

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## **Oxamyl (Carbamate)**

Formulations: Vydate

Pests Controlled: insecticide/nematicide, carrot weevil, aster leafhopper

Percent of Crop Treated: is used by approximately 60% of Michigan carrot farmers, on approximately 75% of the acreage.

Types of Applications: banded over the row, foliar spray

Application Rates: 4 pts Vydate L (2)

Number of Applications: maximum 3 treatments (2)

Timing: banded over the row after the plants have reached 6 inches

Pre-Harvest Interval: 14 days (2)

REI: 48 hours

Use in IPM Programs: no information available

Use in Resistance Management Programs: used as part of a resistance management program in the West Central region.

Efficacy Issues: Moderate efficacy

Advantages: Systemic insecticide. Translocates downward when applied as foliar spray. Ease of application because material can be applied at planting time, unlike fumigation. In the Northwest region, it is the only material that is available for control of carrot weevil.

Disadvantages: Growers in the West Center region report that there may be groundwater concern.

Resistance Management Concerns: May become a resistance management issue in the West Central region.

Comments: Special Michigan SLN label(2)

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## **Esfenvalerate (Synthetic Pyrethroid)**

Formulations: Asana, Conquer

Pests Controlled: aster leafhopper, carrot weevils

Percent of Crop Treated: Applied to 18% of the acreage (8)

Types of Applications: foliar treatment

Application Rates: 0.03 pounds per acre(8)

Number of Applications: 2.8 applications annually(8)

Timing: begin early in spring (2)

Pre-Harvest Interval: 7 days

REI: 12 hours

Use in IPM Programs: no information available

Use in Resistance Management Programs: is used as part of a resistance management program in the West Central region

Efficacy Issues: High efficacy rate for controlling aster leafhopper

Advantages: In the Northwest region, most growers prefer this product because processors are more likely to allow use of this product

Disadvantages: Kills predators of mites, which could lead to a mite outbreak.

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### **Methomyl (Carbamate)**

Formulations: Lannate SP, Lannate LV

Pests Controlled: aster leafhopper and cutworms

Percent of Crop Treated: no information available

Types of Applications: foliar treatment

Application Rates: (suggested) Lannate SP, 1/2 to 1 lb or Lannate LV 1 1/2 to 3 pt (2)

Number of Applications: no information available

Timing: post plant

Pre-Harvest Interval: 1 day (2)

REI: 48 hours

Use in IPM Programs: no information available

Use in Resistance Management Programs: It is used as part of a resistance management program in the West Central region.

Efficacy Issues: Moderate efficacy

Advantages: compatible with other pesticides, rapid knockdown (19)

Disadvantages: toxic to bees, fish and birds (19)

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### **Endosulfan (Organochlorine)**

Formulations: Phaser, Thiodan

Pests Controlled: aster leafhopper, aphids

Percent of Crop Treated: no information available

Types of Applications: foliar spray

Application Rates: (suggested) 3 EC, 2/3 to 1 1/3 qt or 50 WP 1 to 2 lb (2)

Number of Applications: Currently limited to one application a year

Timing: apply when insects first appear (19)

Pre-Harvest Interval: 7 days (2)

REI: 24 hours(2)

Use in IPM Programs: no information available

Use in Resistance Management Programs: no information available

Efficacy Issues: Moderate efficacy

Advantages: compatible with most pesticides, relatively non-toxic to bees (19)

Disadvantages: highly toxic to fish, corrosive to iron (19)

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## **Baythroid**

Formulations: Baythroid 2 E, cyfluthrin

Pests Controlled: carrot weevils, cutworms, leafhoppers

Percent of Crop Treated: no information available

Types of Applications: foliar treatment

Application Rates: (suggested) 1.6 fl oz (2)

Number of Applications: no information available

Timing: no information available

Pre-Harvest Interval: 0 days (2)

REI: 12 hours

Use in IPM Programs: no information available

Use in Resistance Management Programs: no information available

Efficacy Issues: good

Advantages: very effective against chewing insects, fast-acting (19)

Disadvantages: toxic to fish, not effective against sub-surface soil insects (19)

## **Diazinon**

Formulations: Diazinon 500-AG, Diazinon 14G

Pests Controlled: wireworms, aphids

Percent of Crop Treated: no information available

Types of Applications: Diazinon 14G post-plant soil treatment; Diazinon 500-AG, foliar treatments

Application Rates: 4 pt muck soil (2), 1 pt. (2)

Number of Applications: no information available

Timing: no information available

Pre-Harvest Interval: 10 days (2)

REI: 12-24 hours

Use in IPM Programs: no information available

Use in Resistance Management Programs: no information available

Efficacy Issues: good (2)

Advantages: compatible with other pesticides (19)

Disadvantages: bird and bee toxicity (19)

Comments: Long residual time (19)

(8)(10)(11)

## **Diseases**

### **Aster Yellows**

#### ***Biology***

Aster yellows are caused by a mycoplasma-like organism that causes the carrot plant to yellow and dwarf, and to acquire an unpleasant taste. Leaves of infected plants become twisted, stunted, and yellow, and most develop a dense cluster of dwarfed and chlorotic adventitious shoots. This increased lateral rootlet development makes harvesting difficult to impossible, and predisposes roots to diseases. Carrots infected at early stages are not likely to survive. Losses of 10-25% are not uncommon.(1)

The mycoplasma for aster yellows overwinters in weeds and is transmitted to plants by aster leafhoppers, a key pest for carrots and other commodities in Michigan. The aster leafhopper infects the plant by penetrating the vascular tissues while feeding, and injecting the pathogen through its saliva. Once an aster leafhopper has been infected with the pathogen, it incubates for three weeks before becoming infectious. It takes 24 to 30 days for an infected plant to express symptoms.

#### ***Cultural Controls***

Weed control is essential in controlling aster yellows. Weed and grass hosts near the target crop can harbor the pathogen – as well as aster leafhopper eggs – over the winter. While some carrot varieties are more resistant to the disease than others, none are totally resistant.(14)

Early planting allows plants to become well established prior to possible infection. Removal of infected plants will help to prevent spread of an existing infection, although this is not feasible for commercial production.

#### ***Chemical Controls***

Chemical control of leafhoppers

## ***Alternative Controls***

No information available

## **Alternaria**

### ***Biology***

Alternaria leaf spot is a fungal disease caused by conidia borne on conidiophores. It can cause severe damage in carrot crops in Michigan. Damage is evidenced through dark brown or black spots appearing on older leaves, increasing in severity with the maturity of the plant. The spots are easily recognizable as they have dark centers with yellow margins. The leaves may begin to curl at the edges.(14)

Outbreaks first occur as isolated patches, quickly spreading throughout the rest of the field. Alternaria leaf spot can weaken foliage and/or defoliate, making harvest impossible. The disease can also cause damping off of seedlings, and often occurs concurrent with Cercospora leaf spot.(1)

Alternaria leaf spot overwinters in soil and plant debris, and can also be present in volunteer carrots. Pathogens are blown in by the wind, carried by water or equipment, or introduced within the seeds. Favorable conditions such as overhead irrigation and rainy, windy weather increase the rate of the spread of this disease. If left untreated entire acreage could become infected.(1)

### ***Cultural Controls***

Post-harvest tilling is useful in controlling the disease because the pathogen overwinters in plant debris. Turning under carrot residue will hasten decomposition.

Using two to four year crop rotations with non-host crops will deter infection; avoidance of continuous carrot cropping is essential. New fields should not be planted near infected fields. Growers in Michigan frequently rotate a minimum of 2 years, but this does not deter the disease.(14)

The use of clean or resistant seeds is helpful in disease control. Soaking seeds in hot water (122° F, 50° C) for twenty-five minutes also reduces potential for infection. The process must be done with a stir plate and be extremely precise or germination is affected. This process is risky, and since most inoculum is wind borne it is not effective in controlling the disease.

### ***Chemical Controls***

Regular application of one of the following chemical fungicides will guarantee control of Alternaria Leaf Spot:

- Iprodione (Rovral) (B2 carcinogen) every 7 to 10 days after emergence at a rate of Rovral 4 F, 1 to 2 pt or
- Rovral 50 W or WG, 1 to 2 lb. This chemical is also used to control Rhizoctonia.( growers apply after canopy closure at the earliest)

- Chlorothalonil (Bravo) (B2 carcinogen) can be applied through irrigation equipment. (PHI 0 days)
- Bravo 500, 2¼ or 2¾ pt
- Bravo Ultrex 82.5 WDG, 1.4 to 1.8 lb
- Bravo Weather Stik or Bravo 720 or Supanil 720 or Terranil 6L, 1½ to 2 pt
- Copper hydroxide (Kocide 2000) applied at a rate of 1.5lb/acre. (Does not provide commercially acceptable control when the disease is significant)
- Copper sulfate
- Copper ammonium carbonate

### ***Alternative Controls***

No information available

## **Cercospora Leaf Spot (*Cercospora carotae*)**

### ***Biology***

Cercospora leaf spot disease can cause severe problems in carrots crops in Michigan. It commonly occurs in association with alternaria. The first signs of Cercospora leaf spot appear as small circular brown spots, commonly on the margins, accompanied by yellow or red discolorations on leaves. The fungus produces a photosensitizing agent that causes cells to die when exposed to light. The Leaf Spot affects younger leaves first, enlarging rapidly. Lesions can encircle petioles, causing defoliation. Lesions can occur as soon as 3 days after infection, whereupon the plant becomes infectious. Cercospora occurs beginning in August, and it does not affect the root.

Cercospora spores overwinter in or on seeds and infected foliage, including wild hosts such as weeds. They are transmitted by wind and water to new plants, infecting leaves only when wet. The fungus grows best in warm moist conditions.

### ***Cultural Controls***

Use disease-free seed

Disease tolerant cultivars

Crop rotation is done on a 2 year basis.

Turning under carrot residue to hasten decomposition (the fungus dies after debris decomposes).

### ***Chemical Controls***

The chemicals used to control Cercospora Leaf Spot are applied after canopy closure:

Iprodione (Rovral) (B2 carcinogen)

Chlorothalonil (Bravo, Terranil)(B2 carcinogen) can be applied through irrigation equipment

Copper hydroxide (Kocide) applied at a rate of 1.5 lb/acre – typically is not commercially effective control under significant disease pressure.

### ***Alternative Controls***

No information available

## **Bacterial Blight (*Xanthomonas carotae*)**

### ***Biology***

Bacterial Blight, caused by the bacteria *Xanthomonas*, is evidenced by yellow-ringed dark spots on leaves and roots first appearing on the lower side of the leaf.

Bacteria moves from the lesions into the vascular tissue and on to the stem. Dark streaks may form on the petioles, accompanied by a sticky, yellow exudate. The seed-borne pathogen can survive in plant residue, and is spread by splashing and running water and through soil from wind and implements. Leaves are infected primarily during extended periods of high humidity. Bacterial blight is not a problem in all years.(1)

### ***Cultural Controls***

Planting only *Xanthomonas*-indexed seed to avoid introduction of the disease

Turning under carrot residue to hasten decomposition

Avoiding continuous carrot crops

Crop rotations are helpful in controlling Bacterial blight on carrots. A 2 or 3 year rotation scheme is suggested, although this does not assist with seed-borne pathogens.

### ***Chemical Controls***

Copper hydroxide (Kocide) and Champ2 (copper 37.5%) are suggested for use once the bacterial blight appears. The suggested application rate for Kocide (50W) is 2 lb and Champ2 is 2 2/3 pt every seven to ten days after the disease is spotted.(8)

### ***Alternative Controls***

No information available

## **Storage Rots, Crater rot (*Rhizoctonia carotae*)**

### ***Biology***

Storage and Crater rots are caused by bacteria and fungi. *Rhizoctonia* is a key pathogen for crater rot in carrots, sometimes resulting in 100% crop loss. Once *Rhizoctonia* is present in a soil culture, it remains there indefinitely, overwintering as mycelium in the soil or in infected plant material. The pathogen can then be spread through transfer of contaminated soil. Therefore, sanitation measures are of utmost

importance in limiting the spread of the disease. Soil moisture conditions, rate of cooling after harvest, and harvest injury also affect the rate of loss due to storage and crater rot in carrots.

Vigorous plants are better able to resist *Rhizoctonia* infection. Early planting with quality seed encourages plants to germinate early and be healthy and more resistant. The control of insects, nematodes and other disease also helps to protect against *Rhizoctonia* infection. Storage and crater rots can be a problem in some years.(1)(14)

### ***Cultural Controls***

Crop rotation.

Allowing plant residue to decompose for 30 days

Preparing land so that a minimum amount of old plant debris is on the soil surface

Planting when the soil temperature is suitable for rapid germination

Use of only healthy disease-free seed. Seeds can be treated with a fungicide for protection against infection from *Rhizoctonia* and other fungal pathogens in the soil. The fungicides are nonsystemic in the plant, and are labeled for use on numerous plant species. The control of soil insects and nematodes is important for disease control because these organisms weaken the plant, thereby predisposing the plant to infection.(2)

### ***Chemical Controls***

Thiram is used for seed treatment against a variety of diseases in vegetables, fruit and turf. It is a broad-spectrum pesticide. Thiram is used on 15% of the farms (25% of the acres) in the West Central Region and on 75% of the farms (100% of the acres) in the North West Region. Most growers treat the carrot seeds themselves.

Iprodione (Rovral) (B2 carcinogen) is used in the West Central Region of Michigan, with Captan used as a seed treatment.

### ***Alternative Controls***

Mulching and composting soils can help to reduce the disease. Thiram is less expensive than alternatives, Captan and Iprodione.

## **Damping off (*Pythium*)**

### ***Biology***

Damping off can be a problem. It is a seed disease caused by several fungi, most commonly *Pythium*, a

key cause of pre-emergence and post-emergence damping off. Infection rates can be high, particularly during the periods of cool, wet weather, and can lead to germination failure. Infected seedlings wilt, turn brown, and die, resulting in poor stands. Seedlings that are attacked at the ground level develop a water-soaked, discolored stem and topple over. Infected plants seldom recover. Yield loss due to pythium damping off can be as severe as 100%.<sup>(2)</sup>

Pythium develops as white mycelium, branching off and forming reproductive structures. The spores move through water to the host, surviving best on dead plant and animal matter, but able to survive on living plants in particularly wet soils. The fungus enters plant cells, consumes cellular material, and kills the cells. If the initial infection of a plant occurs at a more mature stage of the plant's development, the host is able to resist the fungal growth. However, at more immature stages -- such as seeds and young seedlings -- the fungus is able to grow readily into the plant tissues and kill the plant. Young roots can be attacked by fungus at any stage of plant growth.<sup>(2)</sup>

### ***Cultural Controls***

Regulation of soil moisture is essential in controlling damping off disease

Seedlings must not be overwatered – although this is not always in the growers control

Good drainage is important in limiting disease development

Planting at times conducive to rapid plant growth minimizes the opportunity for infection

Compost and other soil amendments are able to improve drainage and air circulation and thereby decrease infection.

Crop rotation helps to decrease the incidence of damping off.

### ***Chemical Controls***

Chemical controls are sometimes recommended for difficult cases:

Oxadixyl (Anchor) is a commonly used seed treatment. The suggested rate is 1½ lb per 100-lb seeds.

Thiram is used for seed treatment against a variety of diseases in vegetables, fruit and turf. It is a broad-spectrum pesticide and less expensive than alternatives, Captan and Iprodione. Thiram is used on 15% of the farms (25% of the acres) in the West Central Region. It is used on 75% of the farms (100% of the acres) in the North West Region. In the West Central Region Thiram is used only when a problem is suspected. The suggested rate is 8 oz per 100 lb of seed for seed treatment.

Iprodione (Rovral) (B2 carcinogen) is the preferred application in the West Central Region of Michigan, with Captan used as a seed treatment.

Metalaxyl (Ridomil) (B2 carcinogen) is a new product used in the West Central Region. It is usually applied in a 7-inch band among the rows at planting. The suggested rate is Ridomil Gold EC, 1 to 2 pt, and Ridomil Gold WSP, 1 to 2 lb. There are concerns regarding resistance in the use of Metalaxyl.(8)

### ***Alternative Controls***

Thiram is less expensive than alternatives, Captan and Iprodione (Rovral). Mefenoxam, oxadixyl, fludioxonil are also alternatives to Thiram.

## **Powdery Mildew (*Erysiphe polygoni*)**

### ***Biology***

Powdery mildew is very common to a variety of crops and plants, it is an occasional problem in carrot production in Michigan. It generally occurs in August. Powdery mildew rarely kills the plant, but significantly reduces its yield. White fungal mycelium and powdery spores appear on the lower leaves first, then spread to the terminal growth. This fungal covering of the surface of leaves interferes with photosynthesis, considerably weakening the plant. This weakening of the foliage makes it difficult or impossible to harvest the carrots. At mature stages of the disease, Mycelium send feeding structures, called haustoria, into plant tissues and extract nutrients, thereby weakening the plant. Lesions occur on the leaves, sometimes becoming necrotic. Severe infection results in low yield.(1)

The fungus overwinters both as mycelium in the soil and as reproduction structures. It can also reside in carrot seed.

Spores are carried by the wind to new hosts, and under proper conditions, can germinate and infect the host plant.

### ***Cultural Controls***

New carrot fields should be isolated from established fields infected with powdery mildew. The use of two-year old seeds may also reduce instances of the disease.(2)

### ***Chemical Controls***

Sulfur (microthiol special) may be applied at early leaf stage, with two-week repeat intervals at a rate of 3-10 lb/acre. Thiram has been suggested as a viable alternative, applied at a rate of 0.5 tsp/lb of seed.

### ***Alternative Controls***

Biological control of powdery mildew has been proposed as a possible alternative to chemical treatment. *Ampelomyces quisqualis*, a common parasite that preys on live powdery mildew, could be introduced as a means of reducing the strength of the disease. These spores stop the development of powdery mildew by parasitizing and killing the fungal organisms that cause it.

## **White Mold (*Sclerotinia sclerotiorum*)**

### ***Biology***

White mold can be a problem in carrots in Michigan. White mold is caused by a fungi called *Sclerotinia sclerotiorum*. An initial symptom of the disease is the appearance of white mycelium. These form dark sclerotia, which send out mycelium infestation. Carrots develop white cottony growth on their surfaces when infected: this occurs both in the ground and in storage. Infected tissues become dark, soft and watery. When in storage, infected carrots can spread the disease to non-infected carrots.(1)(2)

*Sclerotinia* overwinters as sclerotia on infected tissues and in the soil. In spring they germinate and produce ascospores that are released into the air. Spores are carried by the wind to new host plants. Under favorable conditions, such as ample moisture and cool temperatures, the spore germinates and infects the host. White mold can persist in the soil as black sclerotial bodies for many years

### ***Cultural Controls***

Planting in well drained soil using proper spacing to prevent crowding

Avoiding areas with poor air circulation

Watering early in the day and deeply; avoid frequent light watering.

Weed control is important in controlling white mold because many weeds act as hosts to the white mold fungus

Careful removal and destruction of infected plant material

3-4 year rotations with non-host crops is suggested to minimize occurrence. Avoid beans, cucurbits, celery, and cabbage.

### ***Chemical Controls***

Benomyl (Benlate) (carbamate) at a rate of 0.25-1 lb

### ***Alternatives***

No information available

## **Fungicide Profiles**

### **Chlorothalonil (Nitrile Compound)**

Formulations: Bravo 500, Bravo 720, Bravo Ultrex, Bravo Weather Stik, Echo, Daconil

Diseases Controlled: Alternaria Leaf Spot and Cercospora Leaf Spot

Percent of Crop Treated: 59% of the acreage  
Types of Applications: foliar  
Application Rates: 1.08 pounds per acre  
Number of Applications: 4.2 applications annually  
Timing: 7-14 day intervals suggested (2)  
Pre-Harvest Interval: 0 days(2)  
REI: 48 hours(2)  
Use in IPM Programs: no information available  
Use in Resistance Management Programs: no information available  
Efficacy Issues: no information available  
Advantages: broad-spectrum foliage protectant fungicide  
Disadvantages: B2 carcinogen  
(1)(8)(11)

### **Copper hydroxide** (Inorganic Compound)

Formulations: Kocide, Champ  
Diseases Controlled: Alternaria Leaf Spot, Cercospora Leaf Spot and Bacterial Leaf blight  
Percent of Crop Treated: 26% of the acreage  
Types of Applications: foliar treatment  
Application Rates: 0.51 pounds per acre  
Number of Applications: 4.1 applications  
Timing: begin when disease is likely  
Pre-Harvest Interval: 0 days (2)  
REI: 24-48 hours (2)  
Use in IPM Programs: no information available  
Use in Resistance Management Programs: no information available  
Efficacy Issues: no information available  
Advantages: a protectant for vegetables, compatible with most other pesticides (21)  
Disadvantages: toxic to fish  
(1)(8)(11)

### **Iprodione** (Dicarboximide)(used in the West Central Region of Michigan)

Formulations: Rovral 4 F, 50 W or WG  
Diseases Controlled: Damping off, Alternaria Leaf Spot and Cercospora Leaf Spot, crater and storage rots  
Percent of Crop Treated: no information available  
Types of Applications: seed treatment  
Application Rates: Rovral 4 F 1 to 2 pts, Rovral 50 W or WG 1 to 2 lb (2)  
Number of Applications: maximum 4 applications per year  
Timing: apply after canopy closure  
Pre-Harvest Interval: 0 days (2)

REI: 12 hours (2)

Use in IPM Programs: no information available

Use in Resistance Management Programs: no information available

Efficacy Issues: no information available

Advantages: no information available

Disadvantages: B2 carcinogen

(1)(8)(11)

## **Sulfur** (Inorganic Compounds)

Formulations: microthiol special

Diseases Controlled: Powdery mildew

Percent of Crop Treated: no information available

Types of Applications: foliar treatment

Application Rates: 3-10 lb/acre

Number of Applications: no information available

Timing: applied at early leaf stage

Pre-Harvest Interval: 0 days (2)

REI: 24 hours (2)

Use in IPM Programs: no information available

Use in Resistance Management Programs: no information available

Efficacy Issues: effectiveness is related to the fineness of the sulfur particles (21)

Advantages: very safe chemical(21)

Disadvantages: do not apply when temperatures exceed 90° F(21)

(1)(8)(11)

## **Metalaxyl** (Phenylamides) (used in the West Central Region)

Formulations: Ridomil Gold EC, Ridomil Gold WSP, Ridomil Gold GR

Diseases Controlled: Damping off

Percent of Crop Treated: no information available

Types of Applications: post plant treatment, foliar treatment

Application Rates: Ridomil Gold EC 1 to 2 pt, Ridomil Gold WSP 1 to 2 lb (2)

Number of Applications: no information available

Timing: applied in a 7-inch band among the rows at planting, 14 day intervals

Pre-Harvest Interval: 7 days (2)

REI: 48 hours (2)

Use in IPM Programs: no information available

Use in Resistance Management Programs: no information available

Efficacy Issues: no information available

Advantages: long lasting activity (21)

Disadvantages: B2 carcinogen, resistance concerns, corrosive

(1)(8)(11)

## **Benomyl** (carbamate)

Formulations: Benlate 50 W or SP

Diseases Controlled: White mold

Percent of Crop Treated: no information available

Types of Applications: foliar treatment

Application Rates: 0.25-1 lb

Number of Applications: no information available

Timing: when disease first appears (21)

Pre-Harvest Interval: 4 days (2)

REI: 24 hours (2)

Use in IPM Programs: no information available

Use in Resistance Management Programs: no information available

Efficacy Issues: depends on roots being in treated areas (21)

Advantages: both preventative and eradicating, excellent residual activity, can control some nematodes (21)

Disadvantages: some resistance has been reported (21)  
(1)(8)(11)

## **Oxadixyl** (Phenylamides)

Formulations: Anchor

Diseases Controlled: Damping off

Percent of Crop Treated: no information available

Types of Applications: seed treatment

Application Rates: 1 1/2 oz / 100 lb seed

Number of Applications: 1

Timing: NA

Pre-Harvest Interval: not applicable

REI: not applicable

Use in IPM Programs: no information available

Use in Resistance Management Programs: used in combination with other fungicides to reduce risk of resistance (21)

Efficacy Issues: no information available

Advantages: curative and eradicant (21)

Disadvantages: no information available

Comments: available in combination with fungicides to broaden spectrum of effect (21)  
(1)(8)(11)

## **Captan** (Carboximide, Sulfenimide)

Formulations: Captan 50 WP, Captan 30-DD or 300, Captan 400 or 400-DD

Diseases Controlled: Damping off, crater and storage rots

Percent of Crop Treated: used in the West Central Region of Michigan

Types of Applications: seed treatment

Application Rates:

Number of Applications: 1

Timing: Planting

Pre-Harvest interval: not applicable

REI: not applicable

Use in IPM programs: no information available

Use in Resistance Management Programs: no information available

Efficacy Issues: no information available

Advantages: no information available

Disadvantages: Captan is a B2 carcinogen

(1)(8)(11)

### **Thiram (Dithiocarbamates)**

Formulations: Thiram 50 WP dyed, 42-S Thiram

Diseases Controlled: Powdery mildew, crater and storage rots

Percent of Crop Treated: on 15% of the farms (25% of the acres) in the West Central Region and on 75% of the farms (100% of the acres) in the North West

Region. In the West Central Region Thiram is used only when a problem is suspected

Types of Applications: seed treatment

Application Rates: 0.5 tsp/lb of seed

Number of Applications: 1

Timing: for seed treatment

Pre-Harvest Interval: not applicable

REI: not applicable

Use in IPM Programs: no information available

Use in Resistance Management Programs: no information available

Efficacy Issues: no information available

Advantages: It is a broad-spectrum pesticide and less expensive than alternatives, compatible with common pesticides

Disadvantages: no information available

(1)(8)(11)

## **Nematodes**

## General Biology

Nematodes do substantial damage to carrot crops in Michigan. Root lesion, root knot, carrot cyst and pin nematodes are the most significant, with the root knot and carrot cyst being the biggest problems in Michigan.(18) Nematode infestation causes decreased yield and damage to carrots. The infected carrots are disfigured and stunted, and are predisposed to other diseases. Necrotic cells, chlorosis, wilting and stunting are also common symptoms. It can be difficult to diagnose nematodes because many of the above ground symptoms are similar to a variety of unrelated diseases and abiotic factors. Nematode feeding causes wounds through which microorganisms can enter roots and cause disease. The diagnosis of nematodes requires soil and plant tissue samples and submission to a nematode diagnostic laboratory for analysis.

### Key Nematode Pests

**The Root knot nematode**, a form of endoparasite, is a key pest of Michigan carrots. They can cause galls, forked roots, and bunching of the roots. The adult female root knot nematode feeds on carrot roots and swells, then produces an egg mass at the root surface. The first stage larva develops in the egg, while the second stage larva exits the egg. The second stage larva is worm-like in shape and motile, moving through the soil until it finds a suitable root. The larva then enters the root and becomes sedentary. Nematode juveniles enter plant root tips, migrate through the tissue to feeding sites near the center of the root, and stop movement to feed. Crop rotation is usually not effective for control of root knot nematodes because of their wide host range.(2)

**Root lesion nematodes** are migratory endoparasites, and are also key pests of carrots in Michigan. The nematodes burrow into the cortex of the carrot to feed, causing necrosis and discoloration, stunting and disfiguration. Root Lesion nematodes repeatedly enter and exit roots, causing tissue damage and making the roots susceptible to secondary pathogens. They overwinter in soil or roots as eggs, while larva and adults are migratory. The eggs hatch in the roots of the plant, or, if root tissue decomposes, are released into the soil. The first larva stage occurs in the egg; the second larval stage is motile and relocates through the soil into the roots.(15)

**Carrot cyst nematodes** instigate the formation of cysts on the root, causing the root to become shallow and disfigured, severely reducing yield. The above ground growth is irregular: stunting, chlorosis and wilting often occur. Foliage can be reddish in color, and is often dry. Males are thread-like in appearance, and females form lemon-shaped cysts after fertilization. Their stylets pierce vascular tissue, extracting nutrients and injecting toxins --killing the cells. The second stage juveniles are motile and infective. They migrate toward food-conducting tissues where they become sedentary and mature. Carrot cyst nematodes are limited to carrots and multiply rapidly when a suitable host is present.(15)

**Pin nematodes** are important to carrots in Michigan. It retards the root growth and effects the orange pigment later. It is not as readily recognized a concern but can cause problems in isolated areas in Michigan. In crop rotation, the pin nematode does well on barley and corn and other small grains and is a non-host for the root knot nematode.(18)

## Cultural Controls

Several different means are recommended for controlling nematode problems, including cultural controls, chemical controls, and alternative control methods.(14)

Proper sanitation is helpful in controlling nematodes. The use of clean, uninfected plantings and seeds is important. To avoid infesting new fields, it is important to clean machinery and equipment with water to prevent movement of infested soil and water into fields.

Crop rotations with non-host crops are helpful in controlling some nematodes. Corn, rye, onions and many other crops are resistant to root knot nematodes; rotating with these crops can decrease occurrence of the problem. Rotations can be very successful with cyst nematodes due to their host specificity. In the West Central Region of Michigan, crop rotation has been highly effective in the control of lesion and root knot nematodes, particularly on muck soils.(2)

The planting time can also help control many nematodes by establishing plants in cooler soil temperatures when nematodes are not yet active. When temperatures are warmer the roots will be established before nematodes cause forking. This is not helpful with the root knot nematode of carrots (*meloidogyne hapla*) which is active at lower temperatures. Under hot, dry conditions, summer fallows can help control lesion nematodes. Resistant cultivars are not available.(2)

## Chemical Controls

Some recommended chemical controls are:

- Soil fumigants such as Methyl bromide, Dichloropropene, and Metham
- Nematicides such as Oxamyl (Vydate)

Soil fumigants have been applied in the fall at a depth of 8 inches followed by sealing the soil. Methyl bromide has been used as a soil fumigant to control nematodes.

## Alternative Controls

Some alternative control strategies are:

Nematicidal plants such as Marigolds can decrease nematode levels significantly, although they can be phytotoxic to crops. Bacterial nematicides such as Bt can reduce root knot nematodes significantly. Soil amendments can be used for nematode control as well; Crab meal and other chitinous materials are nematode suppressing. Organic substances including sewage sludge, certain green manures, sawdust and bonemeal are useful in suppressing nematodes as well.

There are no resistant varieties such as genetic resistance. There is DENY, which is *Pseudomonas cepacia*, used on root knot. This does well in the lab but has not proven itself in the field. (18)

There is some instances of 1-3D failure on carrots.(18)

Reference: (11)

## Nematicide Profiles

### Dichloropropene

Formulations: 1,3-D, Telone II

Pests Controlled: nematodes

Percent of Crop Treated: no information available

Types of Applications: fumigant

Application Rates: 26 gal on muck soil and 15 gal on mineral soil are suggested

Number of Applications: 1

Timing: a pre-plant and fall fumigant; injected into the soil a few days before planting to kill nematode eggs

Pre-Harvest Interval: no information available

REI: 5 days

Use in IPM Programs: no information available

Use in Resistance Management Programs: no information available

Efficacy Issues: particular effective against cyst forming nematodes and meadow nematodes.(20)

Advantages: also helps control weeds and diseases(20)

Disadvantages: cannot use on heavy soils(20)

(2)(14)(15)

### Metham

Formulations: Busan 1020 or Vapam

Pests Controlled: general-purpose fumigant for nematodes, fungicide and herbicide

Percent of Crop Treated: no information available

Types of Applications: fumigant

Application Rates: 75 to 100 gal

Number of Applications: 1

Timing: fall fumigant or pre-planting fumigant in the spring

Pre-Harvest Interval: no information available

REI: 48 hours

Use in IPM Programs: no information available

Use in Resistance Management Programs: no information available

Efficacy Issues: highly efficient

Advantages: controls bacteria, fungi, weeds and soil insects.(20)

Disadvantages: very expensive

This is the nematicide of choice in Michigan.(18)

(2)(14)(15)

## Oxamyl (carbamate)

Formulations: Vydate 3.7L, 2L

Pests Controlled: nematodes and insects

Percent of Crop Treated: In Michigan 60% of carrot farms use Oxamyl on 75% of their acreage.

In the West Central Region Oxamyl is used by 100% of the farms

Types of Applications: pre-treat seeds, pre-planting and planting treatment. Vydate can be applied at a rate of 1-2 gal. per 20 gal. of water in the seed furrow during planting. Treatment must be incorporated into the topsoil. The 3.7L is used as a foliar spray.

Application Rates: 2-4 gal. per 20 gal. water

Number of Applications: maximum 3 treatments per year (2)

Timing: Oxamyl is used when a problem is revealed through soil tests for nematodes and assessment of the field history.

Pre-Harvest Interval: 14 days

REI: 48 hours

Use in IPM Programs: no information available

Use in Resistance Management Programs: Vydate is used in the West Central Region of Michigan as part of a rotation program for resistance management

Efficacy Issues: moderate

Advantages: A systemic insecticide, primarily by growers on muck soils. Oxamyl (Vydate) is the only material available to control carrot weevil in the North West Region.

Disadvantages: possible concerns in resistance management in the West Central Region, possible ground water concerns in the North West Region.

(2)(14)(15)

## Weeds

### General

#### Biology

Annual grasses and broadleaf weeds are common weed pests for carrot crops in Michigan. Weeds compete with carrots for nutrients, sunlight and water, thereupon reducing their size and quality. Serious cases often cause carrots to be deformed and unmarketable. Many weeds act as hosts to insects and diseases that may then do further damage. At harvest, weeds cause mechanical problems with machinery.

(13)

Weed control is an important aspect of insect and disease control. The aster leafhopper overwinters in weeds and grasses on the edge of fields; removing weeds reduces the population of aster leafhoppers, thus decreasing incidences of aster yellows disease. White mold is a fungal disease of carrots that also infects weeds, which can serve as a source inoculum for the carrot crop. Pre-emergence as well as post-emergence herbicides are used to control weeds, though some resistance is developing to commonly used herbicides.(13)

Growers can do several things to avoid weed resistance. First, rotate crops often and change cultural practices. Plowing, cultivating, and harvesting earlier or later, will interrupt the life cycle of weeds and help to maintain the genetic diversity. Second, rotate herbicides as much as possible. If two or more herbicides are labeled for a crop, use them alternately whenever possible. Third, use the lowest labeled rate while maintaining good control. It has recently confirmed common purslane resistance to Lorox and atrazine in Michigan carrot fields. As we use fewer, more effective herbicides, the incidence of weed resistance will probably increase.(13)

### *Cultural Controls*

Cultivation is important in removing weeds. When rye or grasses have been planted as windbreaks, the cultivation and removal of these plants also removes many weeds.

Crop rotation is also useful in controlling weeds. Other practices such as mulching and composting can help to reduce the development of weeds as well.

### *Chemical Controls*

Preplanting (Glyphosate) apply either prior to planting in the spring or after harvest in the fall to control emerged perennial weeds. Rate of 2-3 pounds per acre.

Preemergence (Linuron and Trifluralin) apply after seeding but before carrots emerge. Use low rate on light soils, and increase rate on soil containing more clay and organics.

Postemergence

Emerged broadleaves (Linuron and Metribuzin)

Emerged grasses (Fusilade and Poast)

## **Herbicide Profiles**

### **Glyphosate (Phosphono Amino Acid)**

Formulations: Roundup Ultra

Weeds Controlled: wide spectrum weed control

Percent of Crop Treated: No information available

Types of Applications: No information available

Application Rates: 2 lb. AI/acre

Number of Applications: No information available

Timing: . It is applied to emerged perennials before planting in the spring or after harvest in the fall

Pre-Harvest Interval: not applicable

REI: 12 hours (13 )

Use in IPM Programs: No information available

Use in Resistance Management Programs: No information available

Efficacy Issues: Excellent

Advantages: non-residual, used to control dense stands of perennials which can not be controlled by other herbicides (22)

Disadvantages: can injure spears

(8)(11)(13)

### **Linuron (Phenylureas)**

Formulations: Lorox 50 DF, Linex 50 DF

Weeds Controlled: pre- and post-emergence weed treatment for controlling annual broadleaf weeds and some grasses

Percent of Crop Treated: 74% of the area

Types of Applications: Broadcast after carrots are 3 inches high

Application Rates: of 0.62 pounds per acre

Number of Applications: 1.9 applications

Timing: applied after planting but before emergence

Pre-Harvest Interval: not applicable

REI: 24 hours (13)

Use in IPM Programs: No information available

Use in Resistance Management Programs: No information available

Efficacy Issues: not effective on perennial weeds (18)

Advantages: It is very effective on muck soils

Disadvantages: Some resistance has been reported, some weeds in the Compositae family have begun to show resistance. Cannot be applied at

temperatures above 85° F, at high pressures (above 40 psi) or with other pesticides; it can be harmful to young seedlings

(8)(11)(13)

### **Trifluralin (Nitroanilines)**

Formulations: Treflan 4E, Trilin 4E

Weeds Controlled: to control broadleaves and annual grasses

Percent of Crop Treated: 4% of the acres

Types of Applications: incorporated into soils for pre-planting weed control

Application Rates: 0.75 pounds per acre

Number of Applications: 1.0 applications

Timing: before planting

Pre-Harvest Interval: not applicable

REI: 12 hours (13)

Use in IPM Programs: No information available

Use in Resistance Management Programs: No information available

Efficacy Issues: soil incorporation within 24 hours gives greatest effectiveness, good grass control (13)

Advantages: kills weed seeds as they germinate, rainfall is not required (22)

Disadvantages: not very effective on muck soils  
(8)(11)(13)

### **Fluazifop-P-butyl (Oxyphenoxy Acid Esters)**

Formulations: Fusilade DX 2E

Weeds Controlled: for control of grass

Percent of Crop Treated: 62% of the area

Types of Applications: No information available

Application Rates: 0.11 pounds per acre, recommended rate 0.16-0.19 ai.A (13)

Number of Applications: 1.3 applications

Timing: Apply to actively growing grasses

Pre-Harvest Interval: 45 days (13)

REI: 12 hours (13)

Use in IPM Programs: No information available

Use in Resistance Management Programs: No information available

Efficacy Issues: use a high rate on quackgrass (22)

Advantages: broadleaf crops are tolerant (22)

Disadvantages: No information available  
(8)(11)(13)

### **Sethoxydim (Cyclohexenone)**

Formulations: Poast 1.5E

Weeds Controlled: post-emergence control of grasses

Percent of Crop Treated: No information available

Types of Applications: foliar spray to actively growing grasses

Application Rates: 0.19 to 0.28 lb AI/ac, 5 pt

Number of Applications: No information available

Timing: Apply to actively growing grasses

Pre-Harvest Interval: 30 days (13)

REI: 12 hours (13)

Use in IPM Programs: No information available

Use in Resistance Management Programs: No information available

Efficacy Issues: not effective at temperatures below 60° F(22)

Advantages: selective for emerged grasses (22)

Disadvantages: established grasses may require two applications (22)  
(8)(11)(13)

## Metribuzin (Triazines)

Formulations: Sencor 75DF, Lexone 75DF

Weeds Controlled: controls a wide spectrum of weeds

Percent of Crop Treated: No information available

Types of Applications: No information available

Application Rates: 0.25 lb AI/ac

Number of Applications: No information available

Timing: it is broadcast when carrots have 5-6 leaves

Pre-Harvest Interval: 60 days (13)

REI: 12 hours (13)

Use in IPM Programs: No information available

Use in Resistance Management Programs: No information available

Efficacy Issues: good

Advantages: control lasts 3-4 months (22)

Disadvantages: higher rates are necessary on soils with high organic matter (22)  
(8)(11)(13)

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