Bacterial blight

*Xanthomonas hortorum* pv. *carotae*
Alternaria leaf blight

*Alternaria dauci*
Black rot
*Alternaria radicina*
Cercospora leaf spot

*Cercospora carotae*
Survival & spread

• *Xanthomonas campestris pv. carotae*
  - seed (internal & external)
  - infested residues in soil (1 year)
  - splashing water, insects, seed

• *Alternaria dauci*
  - seed (internal & external)
  - infested crop residues, Umbelliferous weed hosts
  - wind, splashing water, farm machinery, workers, seed

• *Alternaria radicina*
  - seed (internal & external)
  - soil (>8 years), infested residues on soil surface
  - movement of soil, roots, seed; splashing water

• *Cercospora carotae*
  - seed (internal & external)?
  - infested residues, wild carrot, other *Daucus* species
  - wind, splashing water, farm machinery, workers, seed
Conditions favoring disease

- **Xanthomonas campestris pv. carotae**
  - warm, wet conditions
  - 77-86°F optimal (55-100°F, killed at 120°F)
  - 10-12 day disease cycle

- **Alternaria dauci**
  - moderate-warm, wet conditions
  - 84°F optimal (57-95°F)
  - 8-16 day disease cycle

- **Alternaria radicina**
  - cool to warm, wet
  - 84°F optimal (31-93°F)
  - storage >92% RH
  - “monocyclic” root infection; “polycyclic” foliar infection

- **Cercospora carotae**
  - cool to warm, wet conditions
  - 68-86°F optimal, >12 hours leaf wetness
  - ~10 day disease cycle
Management of bacterial blight

- Pathogen-free or hot-water treated seed (122°F, 25 min)
- 2–3 year crop rotation
- Incorporate infested residues
- Resistance? e.g., Danvers
- Bactericide applications:
  - Coppers, ManKocide
  - Preventative only
  - Thorough coverage
Management of Alternaria leaf blight

- Pathogen-free or treated seed
- 2-3 year crop rotation
- Incorporate infested carrot residues in fall
- Avoid excessive nitrogen fertility
- Partially resistant cultivars
- **Fungicides:**
  - coppers
  - chlorothalonil
  - strobilurins, fludioxonil, etc.
  - timing applications, coverage
- **Gibberellic acid** (Santos et al. 2000)
- **Seed treatments:**
  - Maxim, Rovral, Quadris, hot water
Management of black rot

- Pathogen-free or treated seed, stecklings
- 8+ year crop rotation
- Incorporate infested carrot residues
- Irrigate so carrots dry by nightfall
- Discard infected roots before storage
- Storage: 32°F & 92% RH if infested
- Resistant cultivars?

**Fungicides:**
- Coppers, strobilurins, iprodione (Rovral), …

**Seed treatments:**
- fungicides, e.g., Rovral, Maxim, Quadris, …
- hot water @ 122°F for 30 min
- hot sodium chloride (0.1-1.0%, 122°F 30 m)
Management of Cercospora leaf spot

- 2–3 year crop rotation
- Fall incorporation of residues
- Irrigate so carrots are dry at night
- Spartan cultivars resistant, e.g., Delite, Delux, Fancy, Bonus, Classic, Winner, Premium

- Fungicides:
  - coppers, Bravo, strobilurins, ...
  - prediction for sprays (Canada)
  - thorough coverage
Carrot powdery mildew
Erysiphe heraclei, Leveillula taurica

E. heraclei (Braun, 1995)
Management of powdery mildew

- Crop rotation
- Incorporate infested residues in fall
- Overhead irrigation
- Plant spacing/row orientation
- Avoid excessive nitrogen fertilization
- Avoid crop stress
- Resistance
- Fungicides: many choices, thorough coverage, resistance management
White mold
*Sclerotinia sclerotiorum*
asci with ascospores

ascospores
White mold

- Broad host range, persistent sclerotia
- Sclerotial germination: apothecia or mycelium
- Apothecia release ascospores aerially - foliar infections
- Favorable conditions: extended moisture, humidity

**Management:**
- rotation (non-host crops, e.g., cereals)
- row orientation
- trim canopy (increase air circulation)
- irrigation management (keep top of bed dry)
- flooding
- broccoli, green manure crops

**Fungicides:**
- Contans (sclerotia)
- foliar applications (boscalid, fluazinam, iprodione, thiophanate-methyl, ...)
- timing, coverage, resistance management
Pythium diseases
Cavity spot

Heated + Peeled
Pythium diseases
Root tip dieback
Damping-off

*Pythium, Rhizoctonia, Fusarium*
Management of carrot damping-off

Cultural practices

• Testing soils for damping-off risk
  - Measuring total *Pythium* or particular species **did NOT work** (Howard et al., 1975; Liddell et al., 1989)
  - Soil grow-out for *R. solani* **predicted incidence in fields** (Shlevin & Katan, 1975) - avoid fungicides in 'clean' fields

• Soil flooding, e.g., Strandberg (1985):
  - Florida for *Pythium*, short-term benefit
  - More effective at 25-30°C than 15-20°C

• **Crop rotation**
  - Green manure/biofumigant crops
  - Cash crops - broad host range of pathogens

  Davis & Nunez (1999), CA: alfalfa exacerbated, barley/cotton increased forking/stubbing some years, small grains reduced damping-off, **interval** between cover crop & carrot
Management of carrot damping-off

Chemical practices

• Conventional fungicides
  • *Pythium*-specific: e.g., metalaxyl or mefenoxam, fenamidone (Reason), cyazofamid (Ranman), fluopicolide (Presidio)
    - Seed treatments, drenches
    - Biodegradation in sandy soils, resistance
  • *Rhizoctonia*-specific: e.g., PCNB, strobilurins
    - Less effective as seed treatment vs. drenches or banded/incorporated
  • *Fusarium*-specific: e.g., fludioxonil, thiabendazole

• Soil fumigation: e.g., metam sodium

• Biological fungicides: Efficacy? Diverse environments
Phytoplasmas/spiroplasmas
Aster yellows, BLTVA, purple leaf
Phytoplasmas & spiroplasmas

• Broad host range
• Vectors: aster & beet leafhoppers, etc.
• Causal agents:
  - aster yellows phytoplasma (16SrI)
  - clover proliferation (16SrVI) = BLTVA
  - *Spiroplasma citri*
• Management:
  - remove infected weeds/carrots
  - avoid planting near symptomatic crops
  - leafhopper control, e.g., Admire, Provado, Lannate, Actara, Mustang, ...
  - resistant cultivars
  - “Aster Yellows Index” (Midwest)
    - leafhopper testing + carrot cv. susceptibility
Root knot nematode

Meloidogyne hapla,
other species
Root knot nematode

- Infects other crops
- Worse on sandy soils, optimum development at 60-77°F
- 1-3 generations/season,
- Low tolerance: 2 juveniles of *M. hapla*/100 cm³ soil in WA

Management:
- test soil before planting (fall), roots + soil
- early planting (cool soils)
- rotate with non-host crops (corn, cereals)
- avoid irrigating from ponds that drain infected fields
- resistant cultivars being developed
- soil fumigation:
  - Vapam pre-plant
  - Vydate in-furrow at planting or chemigated post-planting/pre-emergence + subsequent applications
Play With Your Food