Frost Protection Methods in Michigan – Costs and Considerations

Amy Irish-Brown
MSU Extension Educator
Commercial Tree Fruit Production
Frost Vs. Freeze

Frost is defined as the condition that exists when temperature falls below 32°F.

- Presence of ice crystals = hoar frost
- No ice crystals = black frost
  - Depends on humidity of the air – Dew Point
Types of Freeze

Advection Freeze
Radiation Freeze
Advection Freeze – Windy & Cold

• Occurs under windy conditions
• Associated with a large, dry, cold air mass, several thousand feet thick, moving into an area.
• High pressure cells with NW winds
• Air temperature is often colder than plant temperature.
• Not much can be done – even site has little effect.
Radiation Freeze – Clear & Calm

• Dry, cold air mass settles in with little or no wind.
• Little or No cloud cover overnight.
• Relatively warm during the day, heating soil and plants – this heat is released at night – no wind and an inversion layer forms – warm air (3 to 10°F) 30 to 50 feet about the ground.
• Cool, dense air is trapped beneath warm air; moving toward low areas.
• Dry air holds less heat – dew point.
Factors to Consider

- Coverage
- Power Options
- Unit Cost
- Fuel Consumption for One Hour
- Installation Cost
- Maintenance Costs
- Auto-Start Availability
- Enhancement of Other Frost Protection Methods
- Quiet Factor
- Special Weather Concerns
- Dual Usage Factors
- Years of Usefulness (?)
Systems/Types Included:

- Burning Organic Material
- Heaters
- Cold Air Drain
- Helicopters
- Wind Machines & Fans
- MicroSprinklers
- Sprayable Materials
### Frost Protection Methods in Michigan – Costs and Considerations

Amy Irish-Brown, Tree Fruit BPM Educator, Michigan State University Extension

November 3, 2012

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<th>Burning Organic Material</th>
<th>Heaters</th>
<th>Cold Air Blast</th>
<th>Helicopters</th>
<th>Wind Machines / Fans</th>
<th>Microsprinklers</th>
<th>Spray Boom Frost Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coverage</strong></td>
<td>Depends on all measurements</td>
<td>Drip, run water below freeze point</td>
<td>Approx. 20 acres</td>
<td>Approx. 20 to 30 acres</td>
<td>Approx. 20 to 30 acres</td>
<td>US federal</td>
</tr>
<tr>
<td><strong>Power Options</strong></td>
<td>NA</td>
<td>Gas, Electric, PTO</td>
<td>Yes</td>
<td>Yes, Electric, PTO</td>
<td>Yes, Electric</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Start Date</strong></td>
<td>Start of extreme low temperature, usually fall</td>
<td>On-Farm: Apples, 1500 hours, + 10,000 hours</td>
<td>Approx. 1000 hours</td>
<td>Approx. 1000 hours</td>
<td>Approx. 1000 hours</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Use Consumption for One Hour</strong></td>
<td>NA</td>
<td>Approx. 1 gpm/hr</td>
<td>Recirculated water</td>
<td>Approx. 15 gpm/hr</td>
<td>Electric</td>
<td>Full frost protection</td>
</tr>
<tr>
<td><strong>Installation Cost</strong></td>
<td>Installation costs for wet or dry system, usually minimal</td>
<td>Installation costs for wet system, usually minimal</td>
<td>Approx. 20,000 hours</td>
<td>Approx. 1000 hours + 10,000 hours</td>
<td>Approx. 1000 hours</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Maintenance Cost</strong></td>
<td>Seasonal, significant increase</td>
<td>Seasonal, significant increase</td>
<td>20-30 hours</td>
<td>20-30 hours</td>
<td>20-30 hours</td>
<td>NA</td>
</tr>
<tr>
<td><strong>State/State Standards</strong></td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td><strong>Enhance Other Frost Prevention</strong></td>
<td>Yes, Wind Machines</td>
<td>Yes, Wind Machines</td>
<td>Yes, Wind Machines</td>
<td>Yes, Wind Machines, Sammamish</td>
<td>Yes, Wind Machines</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Additional Features</strong></td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>Special Weather Conditions</strong></td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td><strong>Desalination Status</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td><strong>Years of use/installed</strong></td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>
Burning Hay Bales

Photo: Phil Schwallier
Burning Hay Bales

• Cost
  – bales, time to set out and tend
• Effect – little
• Annoying to neighbors
• Not to be used in dry conditions
Heaters/Smudge Pots

Photo: Phil Schwallier
Heaters/Smudge Pots

Photo: Phil Schwallier
Heaters or Smudge Pots

• Costs –
  – time to set out, fill and tend
  – $50 each if you can find them ($100 for propane heaters??)
  – Cost of fuel = 1 gal/hour/heater

• Effect – little to some

• Perhaps some benefit when used with fans
Frost Fans/Wind Machines

Photo: Phil Schwallier
Frost Fan Types
Cold Air Drain Fan

Photo: Phil Schwallier
How the Cold Air Drain® Works

Cold Air Drain Fan

• Costs
  – Unit cost = $13,500
  – Fuel use – 1 gal/hour (gas)
    • Units can run on gas, electric, PTO

• Installation – can be moved easily

• Could enhance other frost protection methods

• Where does the cold air go???

• Coverage area - variable
Frost Fans

Photo: Phil Schwallier
Frost Fans/Wind Machines

• Costs
  – $16,000 to $35,000 installed
    • Some require a cement pad and fuel tank plus path to refill
    • Portable units are less costly overall
  – 12 to 13 gallons per hour/unit

• Benefits
  – Covers 10 to 13 acres (less if really cold)
  – Auto start
  – Improving fruit finish?

• Limited by number of units in the area/location
Helicopters

Photo: Phil Schwallier
Helicopters

Photo: Phil Schwallier
Helicopters

• Costs
  – $700 to $1600 per bird per hour (4 to 7 hours/night)
    (+travel time & fueling time)

• Benefits
  – Large area coverage:
    • Large = 40 to 60 acres
    • Smaller = 25 to 40 acres
  – Can move vertically to find thermal layers using infrared cameras
  – Can move from site to site

• Limited by number of units in the area
MicroSprinklers

Photo: Amy Irish-Brown
MicroSprinklers

Photo: Amy Irish-Brown
MicroSprinklers

• Costs
  – Well, irrigation system PLUS $1000 to $1200/acre for microsprinkler heads
  – Electricity to run
  – Maintenance is higher than drip irrigation systems

• Benefits
  – Covers as many acres as your well can cover
  – Dual usage as irrigation & possibly evaporative cooling??

• Water Source Capacity
  – Have to run until all ice is water again.
  – 35 GPM for 10+ hours
Sprayable Materials

• Commercial Materials
  (cryoprotectants, antitranspirants, nutrients)
  – Glacier, KDL, Mega-Fol plus K-Leaf tank mix

• Experimental Materials (delay bud break):
  – Promalin, Kaolin Clay, Latex Paint

• Evaporative Cooling

*work still needed on all these before recommendations can be made*
Other Protective Measures:

• Proper site selection
• Cultural measures in and around the site
  – Avoid planting in low spots.
  – Plant rows parallel to cold air drainage.
  – Prune trees and vines properly to avoid blocking air movement.
  – Prune out the lower portions of windbreaks
  – Keep air drainage pathways open.
• Nutrition & Orchard Floor Management
Handout in the Back

Posted at: apples.msu.edu

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November 5, 2012

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</thead>
<tbody>
<tr>
<td>Coverage</td>
<td>Depends on area</td>
<td>On-site: 4500 btu/h</td>
<td>Assumed: 30 acres</td>
<td>Hopper: 25 to 30 acres</td>
<td>Approx. 15 acres</td>
<td>Hopper: 25 to 30 acres</td>
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<tr>
<td>Power Options</td>
<td>NA</td>
<td>Gas, Electric, PTO</td>
<td>Gas, Electric</td>
<td>Gas, Electric, PTO</td>
<td>Gas, Electric</td>
<td>Gas, Electric, PTO</td>
</tr>
<tr>
<td>Cost</td>
<td>Cost of air handling or burner plus is usually minimal</td>
<td>Cost: 390 h, 1000 kwh</td>
<td>Cost: 250 h, 5000 kwh</td>
<td>Cost: 150 h, 3000 kwh</td>
<td>Cost: 150 h, 3000 kwh</td>
<td>Cost: 150 h, 3000 kwh</td>
</tr>
<tr>
<td>Fuel Consumption for Hour</td>
<td>NA</td>
<td>Approx. 3.5 gph/hr</td>
<td>Fuel cost</td>
<td>Method: Cost</td>
<td>Method: Cost</td>
<td>Method: Cost</td>
</tr>
<tr>
<td>Installation Cost</td>
<td>Cost of installation, labor, and materials</td>
<td>Cost: 1250</td>
<td>Cost: 2500</td>
<td>Cost: 1500</td>
<td>Cost: 1500</td>
<td>Cost: 1500</td>
</tr>
<tr>
<td>Maintenance Cost</td>
<td>Depends on system</td>
<td>Significant: inventory stored before 30-30 h of cold</td>
<td>Cost: 1500</td>
<td>Cost: 1500</td>
<td>Cost: 1500</td>
<td>Cost: 1500</td>
</tr>
<tr>
<td>Start-Up &amp; Installation</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Calculation</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
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<td>Initial Cost</td>
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<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>References</td>
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<td>NA</td>
<td>NA</td>
<td>NA</td>
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</tbody>
</table>

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- **Spray / Frost Materials**
  - Can be applied under certain conditions
  - May need to be applied more than once
  - Can be effective in certain situations
  - Can be used to supplement other methods

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Other relevant notes:

- **Benefits**:
  - Protection against frost
  - Can be used in a variety of climates
  - Can be applied to different types of trees
  - Can be used in both large and small areas

- **Hazards**:
  - May cause damage to trees
  - Requires a lot of labor
  - Can be expensive

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**References**

What happened in 2012 – 6 strikes

1. Lake Michigan was warmer than normal with almost no ice cover.

2. Mild Fall and Mild Winter.

3. There was little frost in the ground last winter, and little snow cover.

4. The string of warm days in Mid-March was a very unusual, rare event (unprecedented by most climatologic measures).

5. In the timeframe between late-March and the average end of spring frosts (mid-May), there is an average of 6 to 8 frost/freeze events for Kent County - for 2012, there were 22.

6. The final two freeze events were extreme and really the deciding factor(s) in the extreme crop loss. Had we not had that early warm March weather, these events in late April would still have caused some damage to tree fruits (perhaps 30 to 50% losses).
Thank You
Other Methods – not used in MI

- from Agrofrost nv [agrofrost.eu]
- FrostBuster
- FrostGuard
- Amarillo Wind Machines
Other Methods

- FrostBuster
- FrostGuard
## Technical Data - FrostGuard

<table>
<thead>
<tr>
<th>Model</th>
<th>Type GC20</th>
<th>Type GC30</th>
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<tbody>
<tr>
<td>Dimensions L x W x H (mm)</td>
<td>1700 x 775 x 1200</td>
<td>1700 x 1010 x 1770</td>
</tr>
<tr>
<td>Weight without gas cylinders</td>
<td>490 Kg</td>
<td>490 Kg</td>
</tr>
<tr>
<td>Average capacity</td>
<td>oval of 50/70 by 90/110 meters</td>
<td>circle of 80 to 120 meters diameter</td>
</tr>
<tr>
<td>Drive of fan</td>
<td>Motor Briggs &amp; Stratton, Vanguard, twin-cylinder 16 HP, electrical starter</td>
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<tr>
<td>Gas installation</td>
<td>Equipped for 5 or 10 cylinders</td>
<td>Equipped for 5 or 10 cylinders</td>
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<tr>
<td>Average gas consumption</td>
<td>13 to 15 kilograms/hour</td>
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