Season Extension

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Introduction

- Plant growth
- High tunnel
- Low tunnel
- Deep winter greenhouse

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Plant growth

- Plant growth
  - Water
  - Temperature
  - Light
  - Plant available nutrients
  - Stress
- Plant growth takes time

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Plant growth

- How does a high tunnel, low tunnel, and deep winter greenhouse optimize plant growth?
  - Temperature
  - Time
  - Reduce stress
  - Water and plant available nutrients can be applied when needed
  - Light

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High tunnel

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High tunnel

- What is a high tunnel?
  - Structure that resembles a greenhouses
  - Use no artificial heat (except for emergencies)
  - Use no artificial ventilation such as fans, tubes, or forced air
  - Plants are grown in the ground
- Many shapes and sizes
  - 14-30 feet wide, 12-14 feet high, 24-96 feet long

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High tunnel

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High tunnel

- Planting dates in Northern Minnesota
  - March 25- April 7
    - Onion , radish, lettuce
  - April 7-15
    - Cabbage and broccoli
  - April 25 – May 10
    - Tomato and pepper

Slide source: Terrance T. Nennich, Extension Professor Vegetable and Small Fruit Production, University of Minnesota Extension

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High tunnel

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High tunnel

- Yields in a high tunnel can be 3 to 4 times the yield obtained in the field

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Low tunnel

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Low tunnel

- Built high enough to cover plant canopy
- Wire or pipe frame
- Frame covered with clear plastic
- Temperature increase on sunny day
  - 5 - 15 ^{O}F
- Need ventilation to avoid high temperature stress

Maughan et. al. 2014

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Low tunnel

- U of M researching day-neutral strawberry production in low tunnel
- Increased yield when grown under low tunnel compared to no low tunnel

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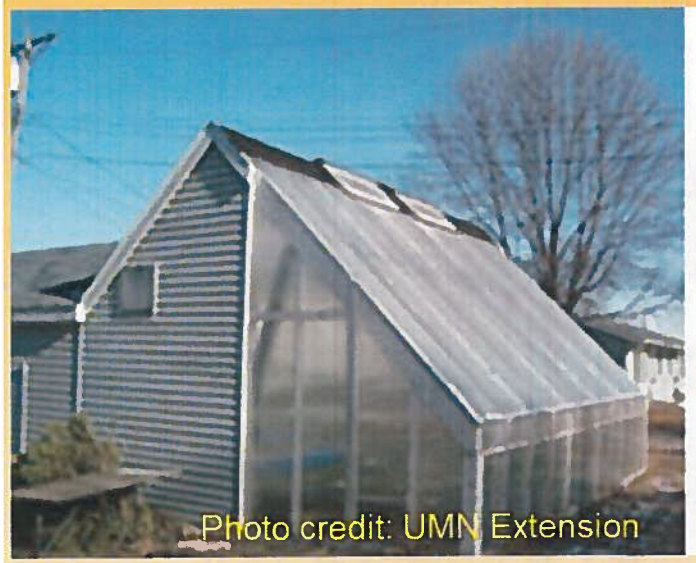
Deep winter greenhouse



- Passive solar greenhouse designed to limit amount of fossil fuel needed for heat
- Oriented east-west with south facing front angled to maximize solar energy on the shortest day of the year

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Deep winter greenhouse

- Foundation
  - Four feet or more below grade
  - Masonry or cast-in-place stem wall with a poured reinforced concrete strip footing
  - Insulated foundation helps keep soil warm during winter

Rader et al., 2013

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Deep winter greenhouse

- Solar energy is stored in thermal mass materials above ground
  - Concrete, ceramic tile, water, soil
  - Heat radiates from thermal mass materials
- Subterranean heating
  - Hot air captured from ridge of greenhouse structure and directed below ground into an insulated rock bed
  - Rocks store heat and radiate to soil above

Rader et al., 2013

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Deep winter greenhouse

- Generally used for growing cold hardy crops that need minimal light throughout the middle of winter
- Crops suited for deep winter greenhouse
  - Greens
  - Broccoli
  - Kale
  - Collards
  - Chinese cabbage

RSDP, 2016

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