

# High Tunnel Winter Production

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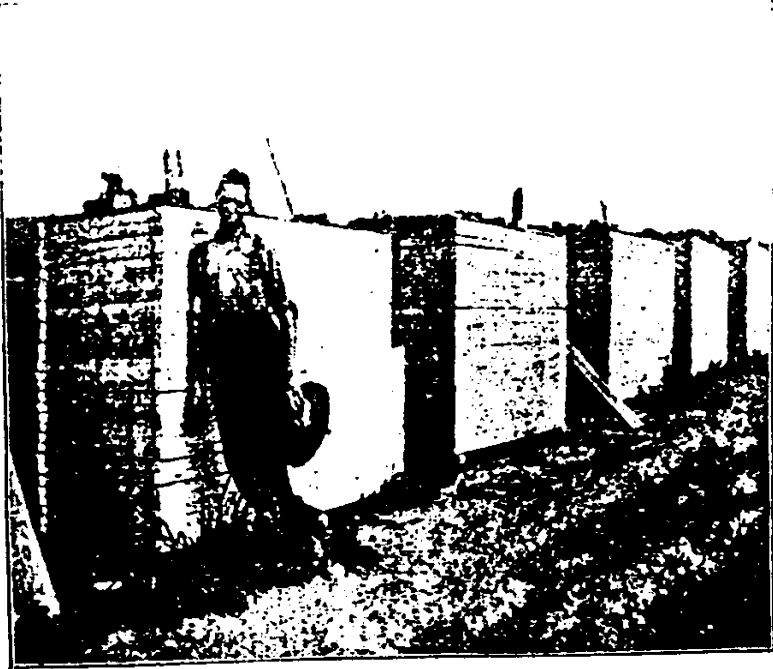
**Cell 919 218 4642**

# Fossil Fuel Heated Greenhouse

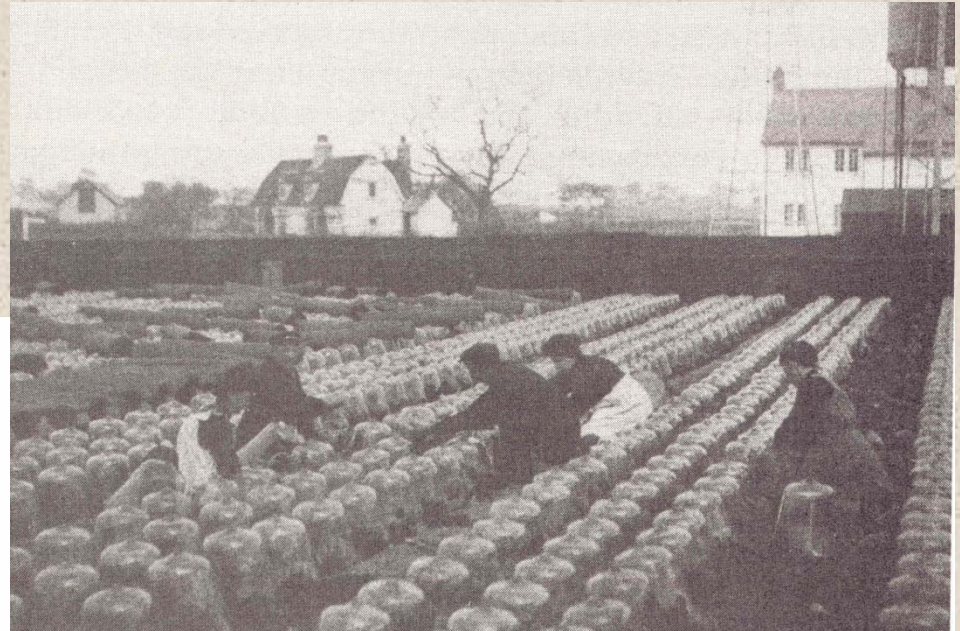




# Historic Uses of Season Extension



SUMMER STORAGE OF SASHES.



# Reasons for Season Extension

- Maintain important sales outlets and customers
- Spread out cash flow
- Spread labor more evenly over the year
- Sell products at higher (out of season) prices
- Provide customers with greater diversity of products
- Fresher and more nutritious produce
- Produce higher gross sales and higher income per unit of area
- Moderate climate change irregularities
- Contribute to a more sustaining food system by lowering energy demands, distance food travels, creating a more regional food system



# Heat Sources

- **Solar energy (light and heat)**
  - Insolation, regional and site
  - Greenhouse orientation
- **Ambient heat of the earth**
- **Thermal decay of a highly organic soil**

# Effects of Structure Design on Thermal Performance

- Gothic arch shape
- Relationship of perimeter to surface area
- Perimeter ground insolation
- Use of interior covers
- Types of films and coverings
- Interior layouts
- Gable end layout and ventilation

# Passive Solar Design

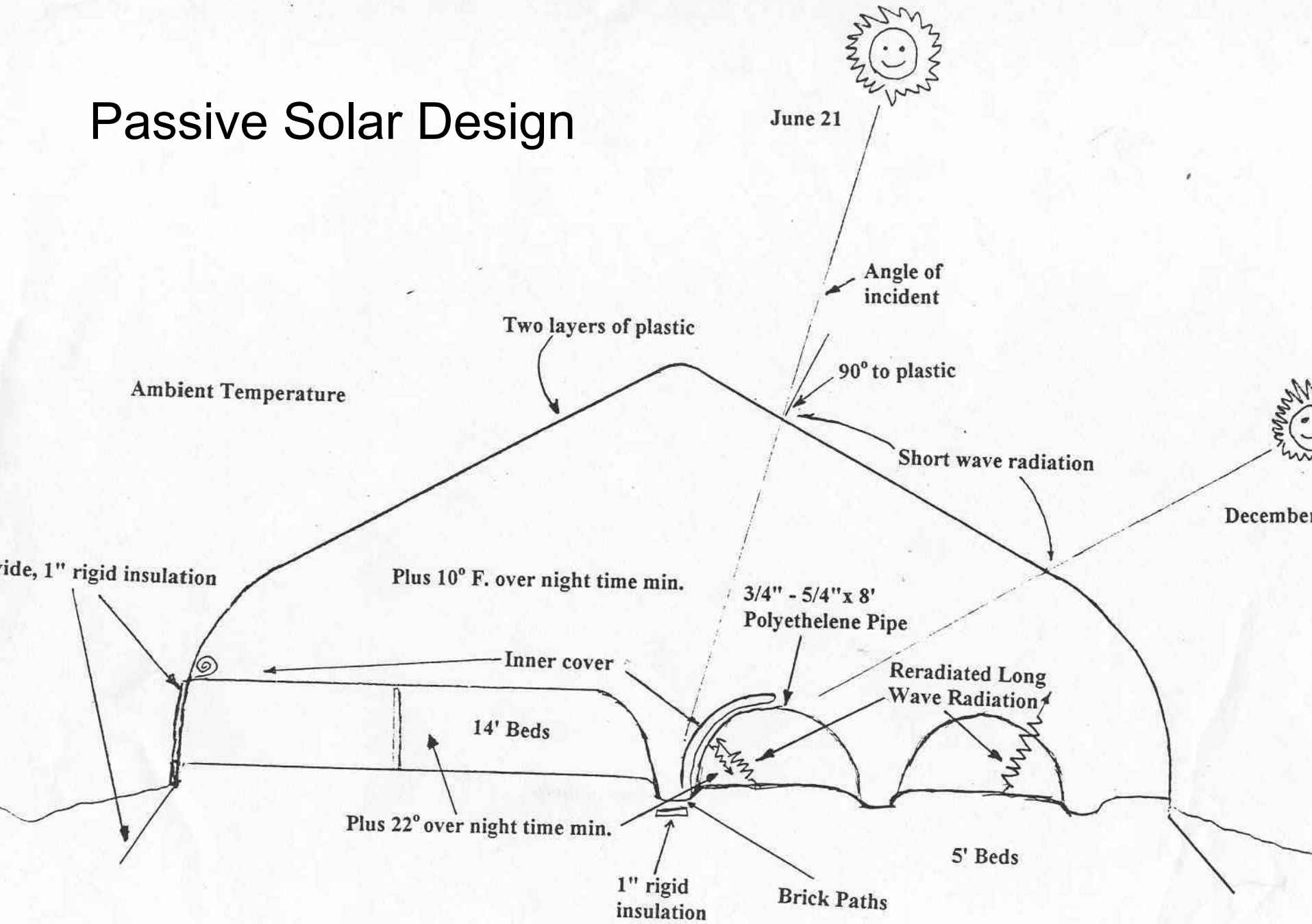
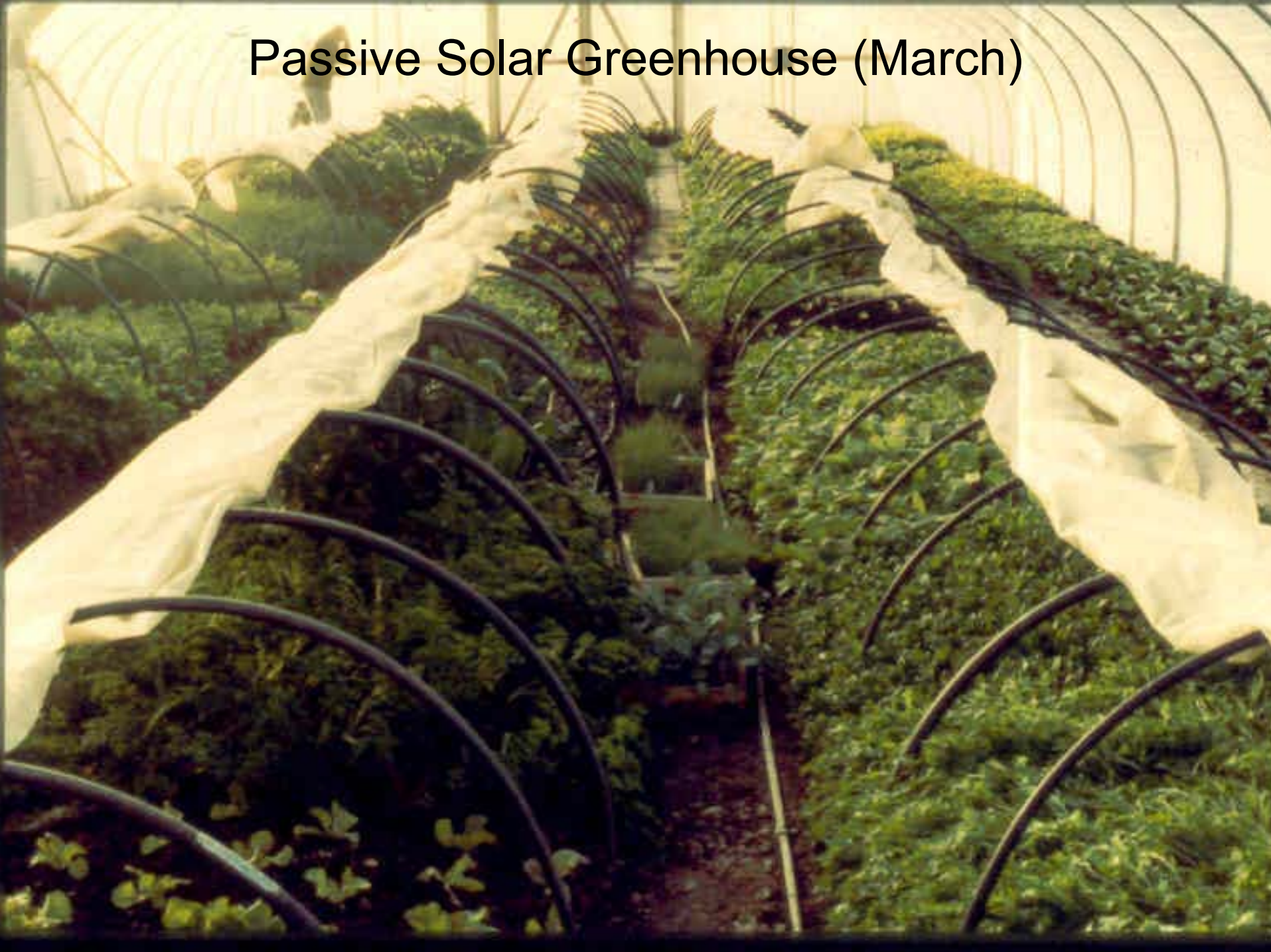


Figure 1.



# Passive Solar Greenhouse (March)





# Key bed Greenhouse Layout

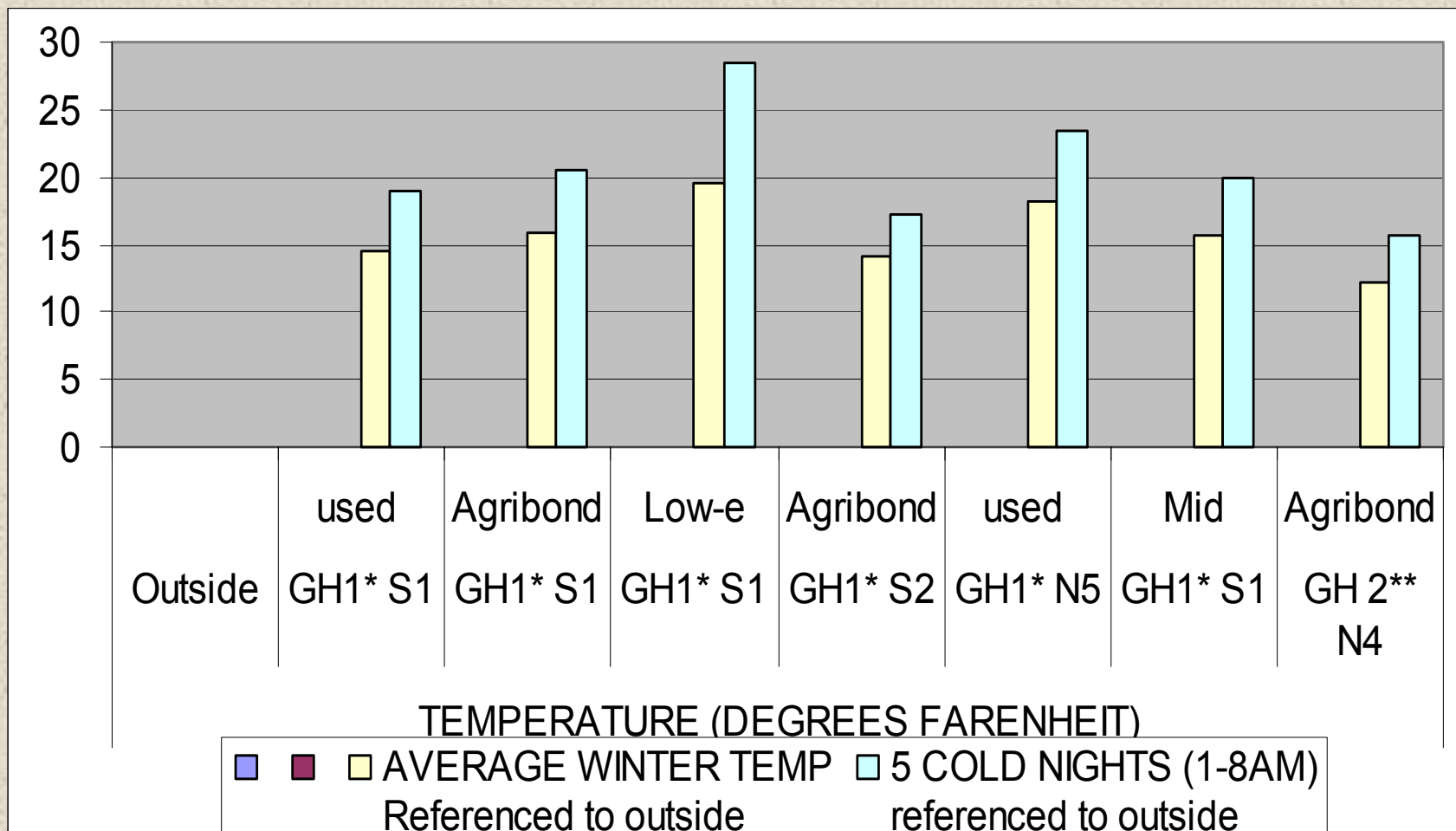




Inner Covers  
Closed for the Night



# 2003-2004 Thermal Performance of inner and outer covers in unheated Greenhouses standardized to outside for average temperatures mid December-mid February and for the average of five cold nights



# Effects of various inner covers on Poc Choi (6mil plastic, typar, no cover)





# Winter Vegetables

- **Lettuce (head and mixes)**
- **Asian and other greens**
- **Spinach**
- **Parsley**
- **Spring onions**
- **Kale**
- **Collards**
- **Poc choi**
- **Radish**
- **Turnips**
- **Chard**
- **Celery**
- **Herbs**



# Management Considerations

- Soil salinization
- IPM
- Nitrate uptake in winter greens
- Variety selection and development
- Maximize yield within the structure



# Effects of Salinity in Greenhouse Pepper Production (2003)

High: 3.89 dS/m, Medium: 2.51 dS/m, Low: 0.85 dS/m





### Winter Seed to Harvest in a Passive Solar Greenhouse (in PA)

| CROP         | Cultivar        | Seeding | Transplant | Harvest (1) | Days in bed |
|--------------|-----------------|---------|------------|-------------|-------------|
| Asian Greens | Mizuna          | Jan. 3  |            | Jan. 30     | 27          |
|              | Tatsoi          | Jan. 3  |            | Feb. 1      | 29          |
| Beets        | Forono          | Jan. 16 |            | Mar. 12     | 55          |
| Cilantro     |                 | Jan. 10 |            | Feb. 23     | 44/18       |
| Kale         | Red Russian     | Jan. 14 |            | Feb. 26     | 35          |
| Lettuce      | Forellenschluss | Nov. 17 | Jan. 9     | Feb. 19     | 41          |
| Poc Choi     | Joi Choi        | Nov.14  | Jan. 9     | Feb. 2      | 24          |
|              | Joi Choi        | Dec. 24 | Jan. 15    | Feb. 21     | 37          |
|              | Ching Chiang    | Nov. 14 | Jan. 9     | Feb. 6      | 28          |
| Spinach      | Winter Giant    | Jan. 3  |            | Feb. 6      | 34          |
|              | Olympia         | Jan. 3  |            | Feb. 20     | 48          |
|              | Tyee            | Jan. 3  |            | Feb.23      | 51          |
|              | Space           | Jan. 14 |            | Mar. 12     | 57          |
|              | Spinner         | Jan. 14 |            | Mar. 12     | 57          |
|              | Perpetual       | Jan. 10 |            | Mar. 3      | 43          |
|              | Razzle Dazzel   | Jan. 10 |            | Feb. 12     | 40/21       |
| Turnip       | Hakurei         | Jan. 16 |            | Mar. 12     | 55          |
| Radish       | Easter Egg      | Jan. 28 |            | Mar. 7      | 38          |
|              | Cabernet        | Jan. 25 |            | Mar. 12     | 35          |

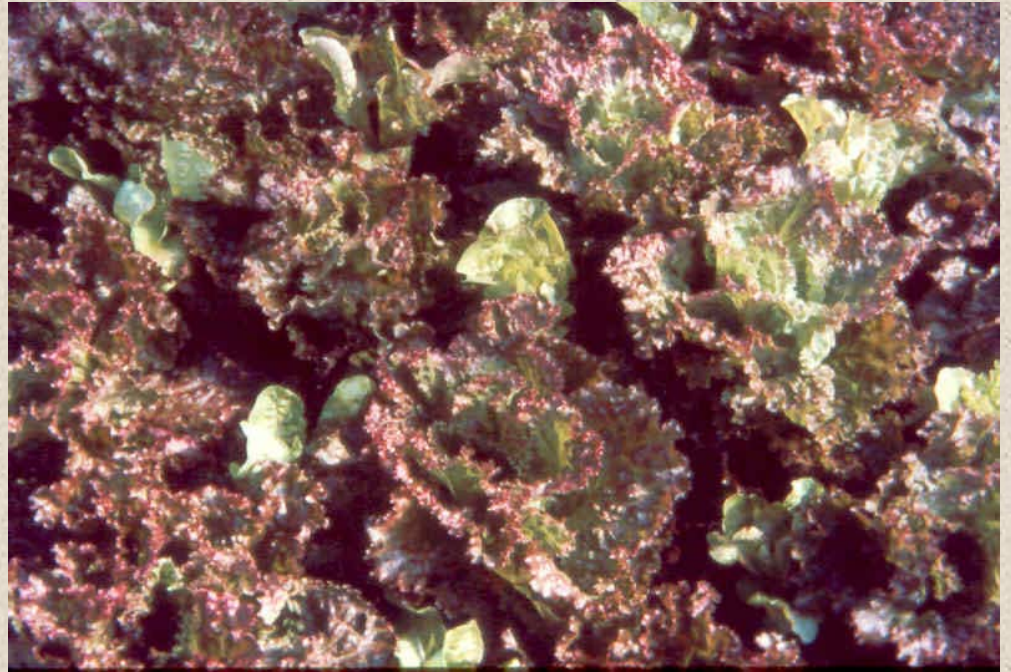


# Maximizing Production

- Use well started transplants in open flats
- Close Plant spacings
  - 6” spacings give 621 plants/100 sq. ft., 8”-320 plants, 10”-201 plants, 12”-159 plants
- Interplanting
- Multilayer using troughs
- 4 Square plantings
- Utilize pathways for flat production



# Maximizing Production







Early Summer (99)



# Importance of Variety Selection

Cold growth difference between Outredgious (L) and  
Oscarde (R)





Winter Greenhouse (harvest)







Jan. '97 (weekly min. -7 degrees F.)



# New Style Hot Bed





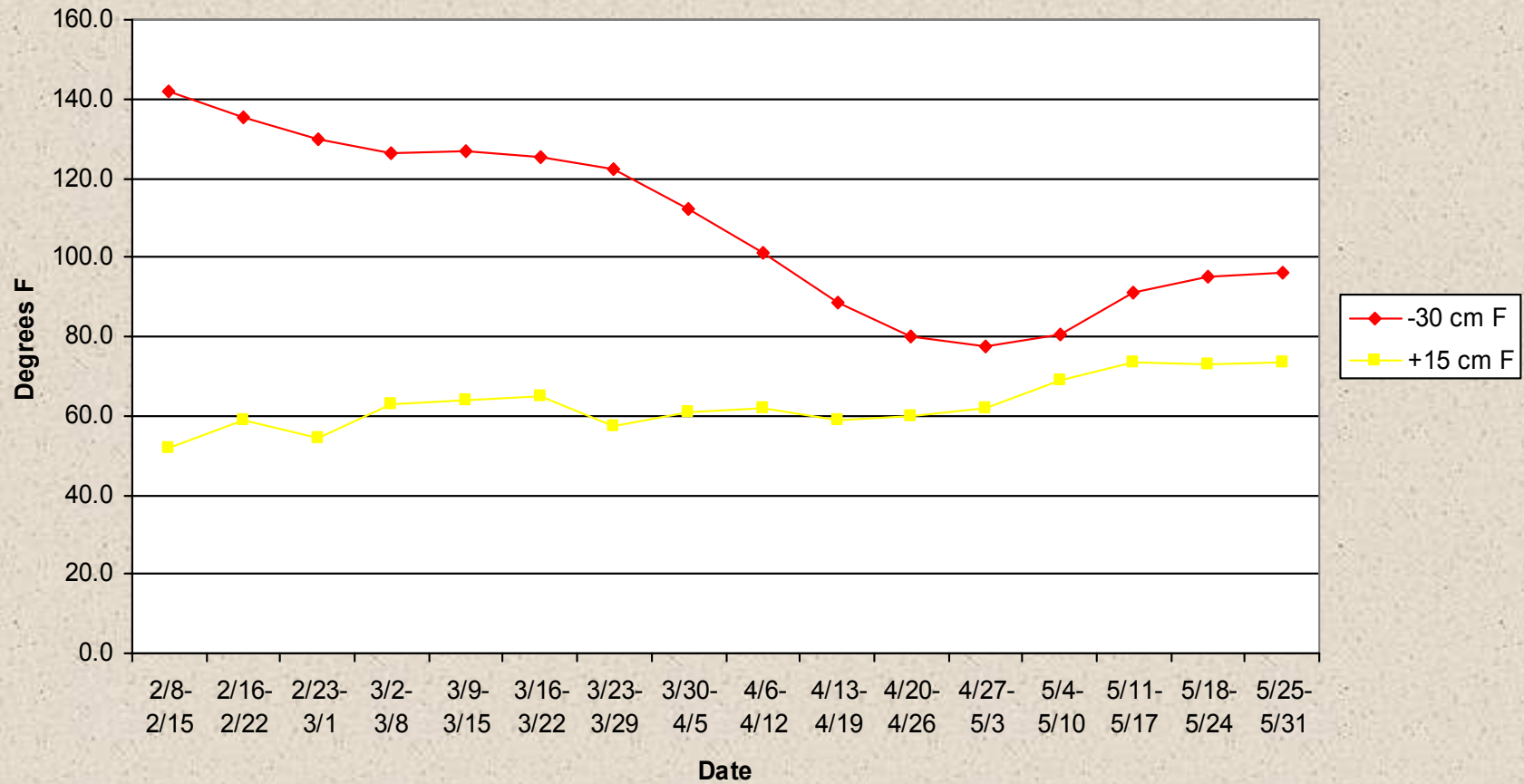


## Old Style Hot Bed





# Plant Starter Temperatures 1999







Cherry Tomatoes (in cages)

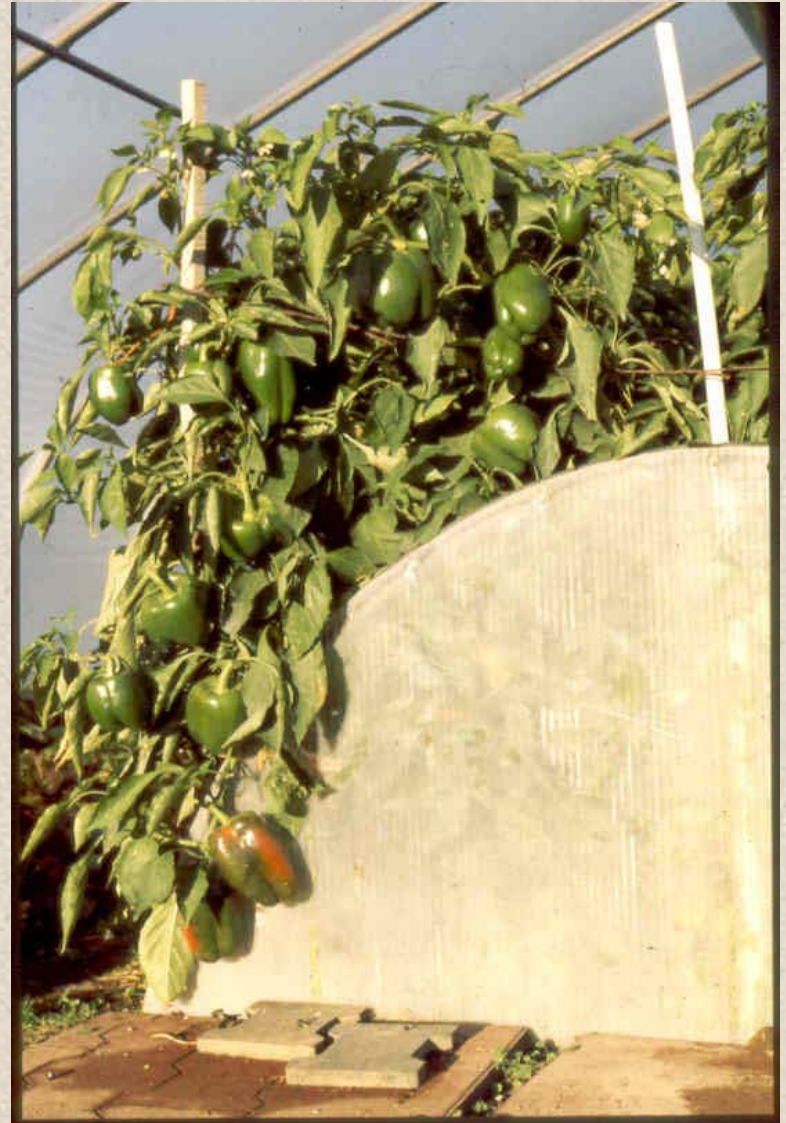


European single Leaders  
Tomatoes (on Strings)



# Yields (1999)

- Peppers
  - *New Ace*, 561 lbs/100 sq.ft.
  - *Vidi*, 513 lbs/100 sq.ft.
- Eggplant
  - *Orient Express*, 396 lbs/100 sq.ft.
  - *Neon*, 288 lbs/100 sq.ft.



# Peppers Harvest (late December)





# Zone 3 (Northern Vermont)





# Cost of Season Extension

| TYPE OF PROTECTION  | LIGHT TRANSMISSION (%) | DURABILITY  | AMOUNT OF PROTECTION | COST                     | COST PER YEAR          |
|---|------------------------|-------------|----------------------|--------------------------|------------------------|
| <b>INDIVIDUAL PLANT PROTECTORS</b>                        |                        |             |                      |                          |                        |
| water filled protectors                                   |                        | 5-10 years  | up to 16             | \$3 each                 | \$.30-\$.60 each       |
| Individual covers   |                        | 5-10 years  |                      | \$2-20 each              | \$.20-\$4.00 each      |
| <b>FABRIC ROW COVERS</b>                                  |                        |             |                      |                          |                        |
| Tufbel  | 92-95%                 | 2-5 years   | 5-10 degrees         | \$.23/ sq.ft.            | \$.046-\$.125/sq. ft.  |
| Typar T-518   | 70%                    | 3 years     | 6 degrees            | \$.039/sq. ft.           | \$0.013/sq. ft.        |
| Agribon 19  | 85%                    | 1 year      | 2-4 degrees          | \$.01/sq. ft.            | \$0.01/sq. ft.         |
| Agribon 30  | 70%                    | 1-2 years   | 4-6 degrees          | \$.02/sq. ft.            | \$.01-\$.02/sq. ft.    |
| Agribon 50  | 50%                    | 1-3 years   | 6-8 degrees          | \$.04/sq. ft.            | \$.013-\$.04/sq. ft.   |
| Agribon 70  | 30%                    | 2-5 years   | 8 plus degrees       | \$.05/sq. ft.            | \$.01-\$.025/sq. ft.   |
| <b>PLASTIC ROW COVERS</b>                                 |                        |             |                      |                          |                        |
| Zip House (501)   | 90%                    | 2 years     |                      | \$.29/ lineal ft.        | \$0.145/lineal ft.     |
| Plastic (6mil, 4 yr, greenhouse)                          | 92%                    | 4 years     |                      | \$.08/sq. ft.            | \$.02/sq. ft.          |
| Slited row cover (.5 mil)                                 | 95%                    | 1-2 years   | 1-4 night, 10-30 day | \$.008/sq. ft.           | \$.004-\$.008/sq. ft.  |
| Polycarbonate   | 83%                    | 25-30 years |                      | \$1.60/sq. ft.           | \$.05-\$.06/sq. ft.    |
| <b>LARGE STRUCTURES (own construction labor)</b>          |                        |             |                      |                          |                        |
| Hoophouse (12'x96')(single layer 6 mill plastic)          |                        | 25 years    |                      | \$2.60 (est.)/sq. ft.    | \$.13/sq. ft.          |
| Unheated passive solar greenhouse (30'x96')(2 layers, 6 m | 83%                    | 25 years    | 34 (plus) degrees    | \$2.08 (est.)/sq. ft.    | \$.18/sq. ft.          |
| Heated greenhouse (30'x96')                               | 83%                    | 25 years    |                      | \$4.17 (est.)/sq. ft.    | \$.35/sq. ft.          |
|   |                        |             |                      | \$2000-\$4000/yr to heat | Total/yr \$1.04-\$1.74 |





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