Cold Hardiness of fruit trees in Vermont

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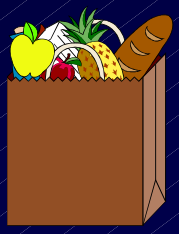
Fruit Trees

- Why?



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Cold Hardiness

"The ability or capacity of a plant to survive an unfavorable environmental temperature"

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Winter Hardiness

- The ability to remain dormant is important in areas of fluctuating temperatures
- Ability to withstand extreme low temperatures is important in colder climates

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Cold Hardiness is a complex phenomenon

Depends on:

- Genetics
- Temperature/Photoperiods
- Physiological status of the plant
  - Maturity
  - Water Content
  - Dormancy Status
  - Nutrition
  - Physiological Age

Plants are generally injured at two major stages:

1. Early/late frosts
   - Simply 'not ready'
   - Buds and greener tissue usually damaged
2. Mid-winter damage
   - Not properly readied
   - No mechanism to deal with freeze
   - Older tissues, xylem, and phloem

Early/late frost damage depends on acclimation status (physical and biochemical processes).

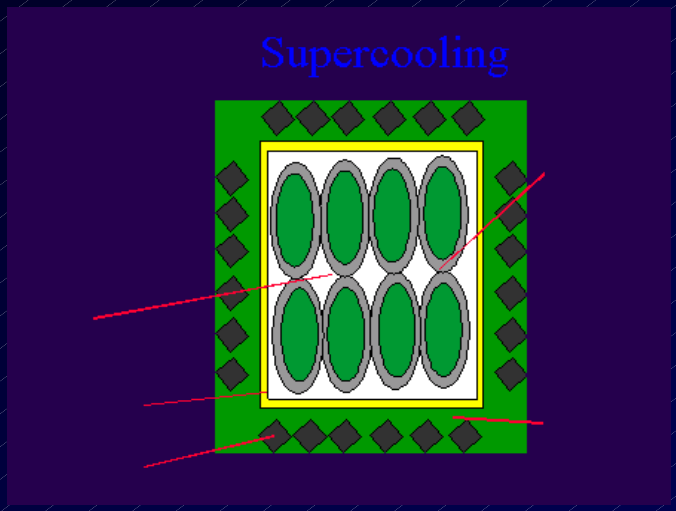
Acclimation ⟷ "Dormancy" ⟷ Deacclimation

- Acclimation and deacclimation are generally considered reversible biochemical processes of one another.
- Dormancy is not reversible

MID-WINTER: HOW TO HANDLE FREEZING STRESS?

- It's all about the water.
- Death is hypothesized to occur in many ways:
  - Ice crystal puncture sensitive tissues
  - Dehydration/mechanical stress

Diagram



Deep Supercooling

- Occurs in many fruit crops: peach, apple, and grapes (and other woody plants: oaks)
  - Depends on small cells and little to no intercellular space
  - Low water content
  - Barriers for nucleators/absence of nucleators/presence of anti-nucleators
  - Water leaves, freezes between cells

Freeze Damage

- Damage includes blind wood, root damage, bark cracking, crotch damage, blackheart injury
- Flower bud damage----difficult to tell
- In Burlington, VT, early and late frosts most frequently damage trees

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Winter Hardiness: Dehardening

- Loss of hardiness can be very rapid if tissues are exposed to warm temperatures
  - Cherry flower buds lost 10^0 F of hardiness when exposed to 4hr at 75^0 F
  - 'Haralson' apple lost as much as 57^0 F of hardiness during one day exposure to 70^0 F

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Vermont winters are cold…

Vermont winters

- Vermont's winter climate has been harsh on apple tree survival. The winter of 1933-34 illustrated this point. During this winter, freezing temperatures occurred frequently in November. Extreme temperatures (-30º C) were observed as early as December 29 and 30 (Cummings, 1935).

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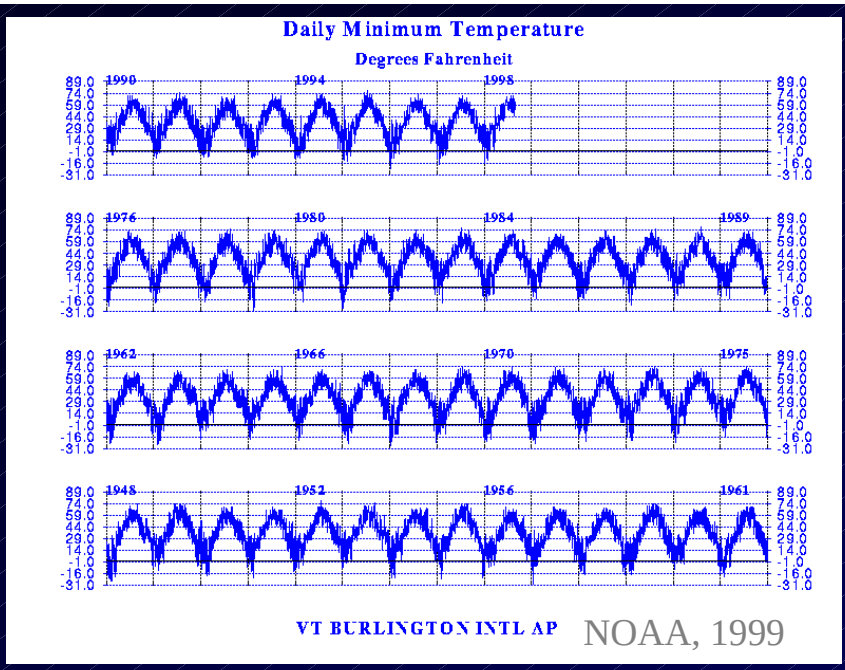

Vermont Hardiness Zones

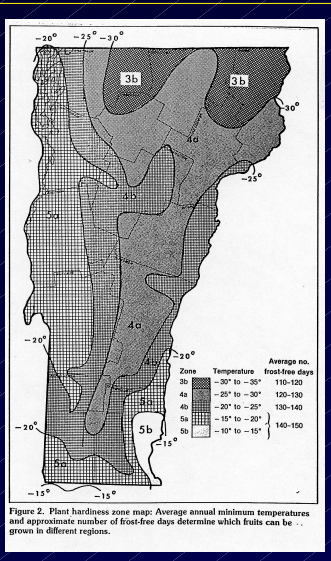

Figure 2. Plant hardiness zone map: Average annual minimum temperatures and approximate number of frost-free days determine which fruits can be . . grown in different regions.

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Depends on:

- Genetics
- Temperature/Photoperiods
- Physiological status of the plant
  - Maturity
  - Water Content
  - Dormancy Status
  - Nutrition
  - Physiological Age

Winter Hardiness

- Susceptibility of species to cold injury varies according to;
  - Species
  - Cultivars
  - Tissues

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Origin of Fruit Trees

- Temperate zone, deciduous trees
  - Origin in areas with cold winters
  - Mechanisms for winter dormancy and spring budbreak and flowering
- Generally adapted for animal dispersal
  - Colorful fruit
  - Often seeds are poisonous

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History and Origin

- Family: Rosaceae
  - Subfamily: Pomoideae (pomes)
  - Subfamily: Prunoideae (drupes)

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Origin: Pomes

- Subfamily: Pomoideae
- Pome fruits
  - *Malus* (apple)
  - *Pyrus* (pear)
  - *Cydonia* (quince)

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Origin: Drupes

- Subfamily Prunoideae
- Drupes or stone fruits
  - Prunus (peach, nectarine, cherry, apricot, plum, and almond)

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Origin: Malus

- Malus
  - Native to the Caucasian Mountains (Russia)
  - ~ 28 species, mostly European, some American (some crabapples)
  - Obligate cross-pollination
  - *Malus x domestica*- the domestic apple

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Geography

Geography

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Origin (Pyrus)

- Subfamily: Pomoideae
  - *Pyrus* (pear)
  - Native to most Europe, the Near East and temperate Asia

    One ornamental evergreen species in Japan
  - ~ 20 species

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Origin (Pear)

- *Pyrus* (pear)
  - Obligate cross-pollination
  - *Pyrus communis*- common or European pear
  - *Pyrus pyrifolia*- Chinese or sand pear

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Origin (Pear)

- *Pyrus pyrifolia*- Chinese or Sand pear
- Brought to California by Chinese immigrants

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Origin (Drupes)

- Subfamily *Prunoideae*
- Drupes or stone fruit
- *Prunus*
- ~ 150 species
- Most abundant in temperate zone, but a few species are found in tropical mountains

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Origin

- *Prunus*
- Subgenus: *Amygdalus*
  - *Prunus persica* (peach and nectarine)
    - Mostly self-fertile
    - Native to warm areas of China

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Geography (Peach)

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Origin (Almond)

- *Prunus amygdalus* - Almond
  - Obligate cross-pollination
  - Native to deserts of Western Asia
  - Not adapted for bird dispersal
  - Recessive gene for producing cyanide

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Origin
Prunophora

- Subgenus: *Prunophora*
- *Plums*
- Six species are grown
- *Prunus domestica* - European plum
- *Prunus saliciana* – Asian or Japanese plum
- *Prunus americana* - North American plum

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Origin (Plum)

- *Prunus domestica*- European plum
- Center of origin : Europe
  - Prunes
- *Prunus saliciana* – Asian or Japanese plum
  - Least winter hardy

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Origin (Plum)

- *Prunus americana*- North American plum
- *Prunus munsonisana*
- Both of these species can be as hardy as apples
  - Genes used to introduce winter hardiness into plums

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Origin (Apricot)

- *Prunus armeniaca*- Apricot
- Center of origin
- Manchuria, Siberia, and Korea
- Very winter hardy, low chilling requirements

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Origin (Cherry)

- Subgenus: *Ceraus*
- *Prunus avium*- sweet cherry
- *Prunus ceraus*-sour cherry

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Origin (Cherry)

- *Prunus avium*- sweet cherry
- Northwestern Europe to Russia
- Obligate cross pollinator

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Origin (Cherry)

- *Prunus ceraus*-sour cherry
- Origin- South Eastern Europe
- Some cultivars may be as hardy as apples

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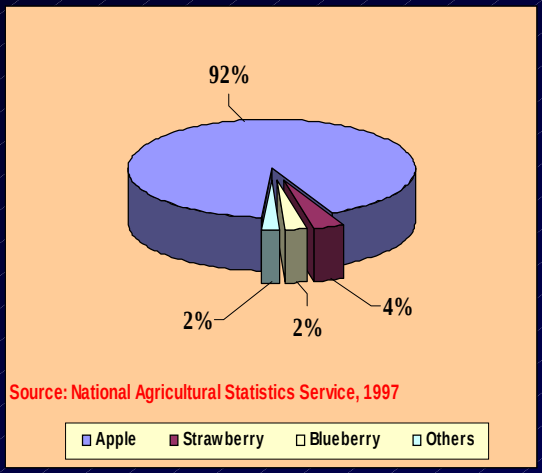
Production Statistics (Vermont)



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In Vermont

Freeze damage depends on:

- Species
- cultural practices (crop loads, N)
- winter temperatures
- light exposure
- cultivar-rootstock (genetics)
- physiological status

Fruit Tree Cold Hardiness

- Fruit trees are similar to many woody species
- Undergo acclimation/deacclimation
- Deep supercool in xylem
- Require dormant period (chilling requirement)
- Extraorgan freezing in buds (-196° C)

Chilling hour requirements

Approximately chilling hours (<7 C) to break winter rest for fruit tree species	
Apricot	300-600
Peach	400-700
Pear	500-1400
Apple	800-1700

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Winter Hardiness

- Suceptibilty of tissues to winter injury in apple:
- The order of acclimation and, consequently, the order of hardiness in fruit trees' organs is as follows: buds, young tissues, phloem and then the xylem
- However, during periods of acclimation and deacclimation, buds/ shoots become more vulnerable and at risk for damage .The older xylem and pith tissues are rarely damaged during this period

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Winter Injury

- Bud damage (vegetative and reproductive)
- 'Black heart'
- Sunscald
- Root injury
- Bark split

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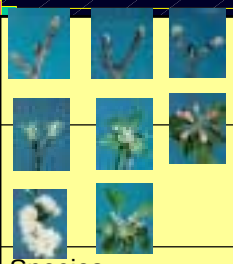

	Critical temperatures in degree F at which 90% of the flower buds are killed at various stages of development							
	Bud developmental stages * Indicates full bloom							
Species	1	2	3	4	5	6	7	8
Apple(Red Del)	2	10	15	24	25	26	27*	25
Apple (McIntosh)	2	10	15	21	25	25	25*	25
Pear	-0.4	6.8	15	19	23	23	23*	24
Apricot	-0.4	8	14	19	22	24*	25	32
Cherry	5	9	14	17	21	24	25	25*
Peaches	1.4	5	9	15	21	24*		

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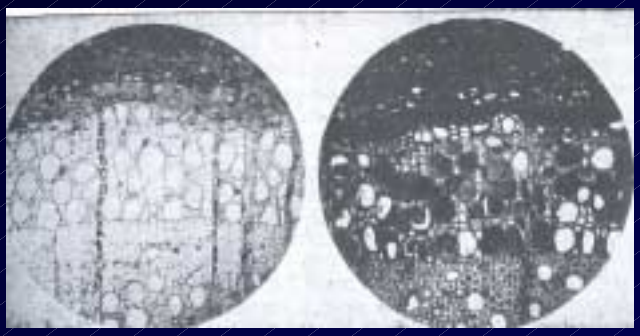
BLACKHEART INJURY



Childers, 1995

BARK CRACKING AND SPLITTING (SW exposure)

Childers, 1995

Vermont winters

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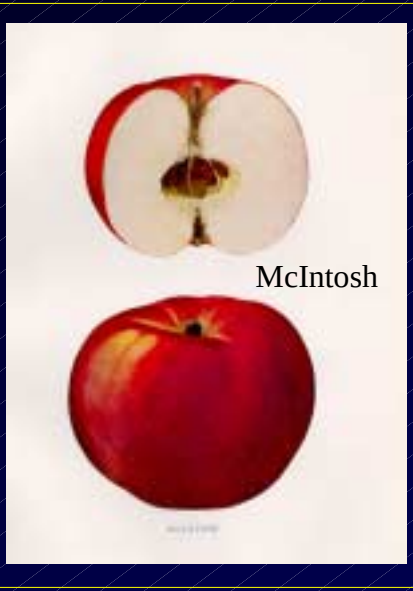
McIntosh



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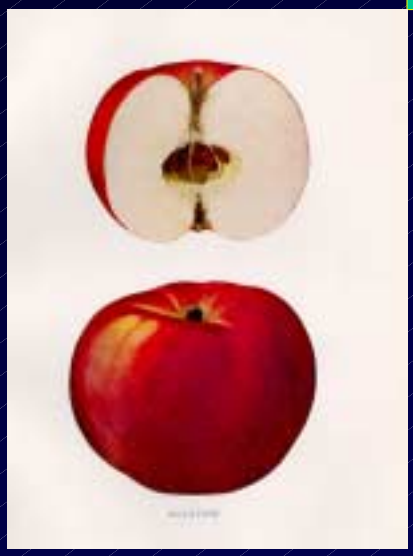
McIntosh

- Ontario farm (1811)
- Brought to Newport VT in 1868



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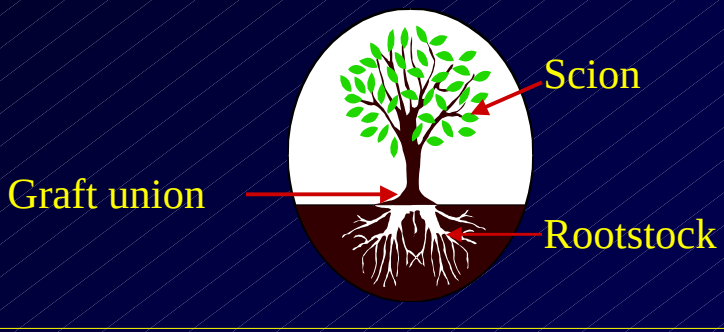
Cultivars and Rootstocks (Tree fruits)

- Most commercially sold fruit trees consist of two parts



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Cultivar and Rootstock

- What to look for in a cultivar
  - Type of fruit
  - Disease resistance
  - Type of tree
  - Cold hardiness
  - Pollination

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Cultivars and rootstocks

- What to look for in a rootstock
  - Hardiness
  - Soil type adaptability
  - Pest resistance
  - Overall tree size
    - standard
    - semidwarf
    - dwarf

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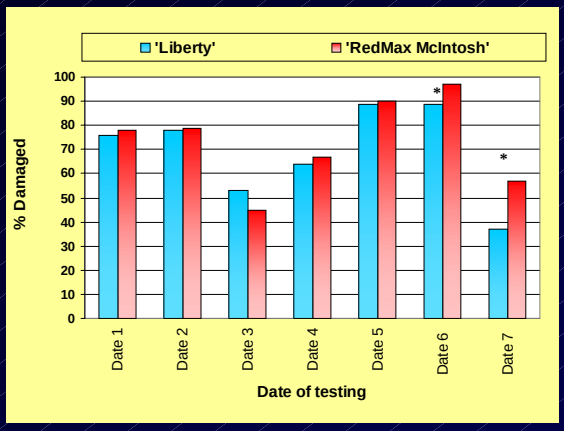

Study I. Responses of both cultivars, 'Liberty' and 'RedMax McIntosh', on seven dates of collection. Temperatures and method of evaluation (callus or TTC) did not affect these results. Date 1= 3 November 1999; Date 2= 2 December 1999; date 3= 30 December 1999; date 4= 11 February 2000; date 5= 5 March 2000; date 6= 12 March 2000; date 7 = 26 April 2000

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Winter Hardiness Study: Results

Results of this study indicated significant cultivar differences: 'Honeycrisp' and 'Pristine' were hardier than the other cultivars.

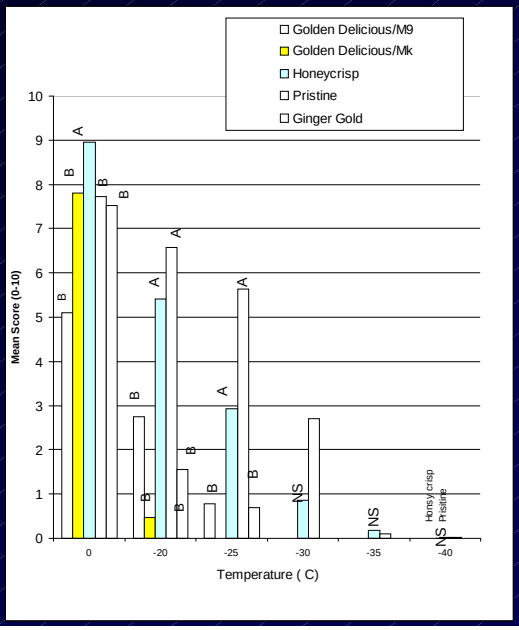

Fig. 3.1. Mean score for the five apple cultivars at the six temperatures tested on the first date of collection, 10 March 2000. There is a significant difference between the cultivars (P=0.0001; PROC GLM). Data from both evaluation methods, callus and TTC, are pooled. 0= no callus regrowth and no reduction; 10=full regrowth and full reduction.

Winter Hardiness Study:Results

Cultivar	n	Mean Score[z,y,x]	
'Honeycrisp'	**40**	**5.4**	**A**
'Pristine'	**50**	**4.1**	**AB**
'Ginger Gold'	**50**	**4.1**	**AB**
'Golden Delicious/Mk'	**50**	**2.3**	**BC**
'Golden Delicious/M9'	**48**	**1.4**	**C**

[z] Means not sharing the same letter are significantly different (*P*=0.0003) according to the SNK test
[y] Both methods of evaluation, callus regrowth and TTC, and all temperatures (0, -5, -10, -15, -20 ºC) are pooled.
[x] 0= no callus regrowth and reduction; 10=full regrowth and reduction.

Cultivar ('Honeycrisp', 'Pristine', 'Ginger Gold', 'Golden Delicious/M9', 'Golden Delicious/Mk') differences in hardiness for the second collection date, 28 March 2000. Both methods of evaluation, callus and TTC were pooled.

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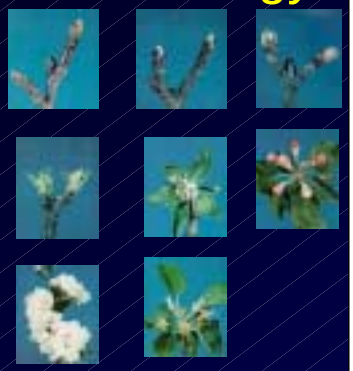
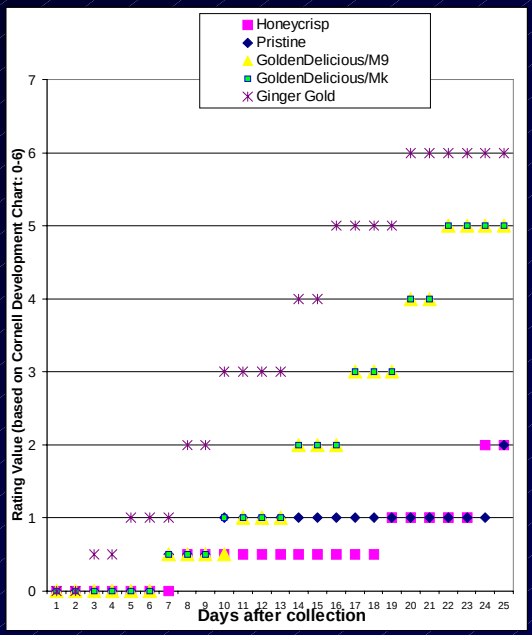
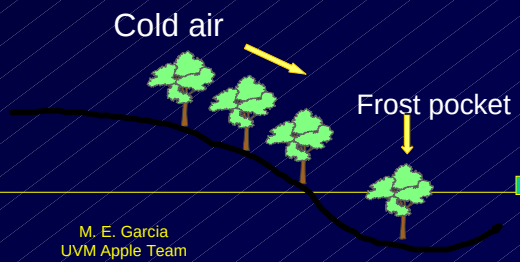
Winter Hardiness Study: Phenology





Cultural Practices: Planting Site

- Slope
  - A 4 to 8% slope is ideal.
  - A steeper than 10% slope may make it difficult to operate machinery.
  - Avoid areas at the bottom of the hill where cold air settles and frost pockets form.



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Insulating Value of Snow

TABLE 2–4 INSULATING VALUE OF 9 in. (23 cm) OF SNOW[a]

	TEMPERATURE [°F (°C)]	
Air	−14	(−26)
Snow surface	−1	(−18)
3-in. (7.6-cm) depth	16	(−9)
6-in. (15-cm) depth	22	(−6)
9-in. (23-cm) depth (soil surface)	28	(−2)

Source: Rutgers Cooperative Extension.
[a]Measurements were conducted in January in New Jersey.

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Floor Management Practices

TABLE 2-7 COMPARISON OF MINIMUM TEMPERATURES OF SOIL SURFACES UNDER VARIOUS TYPES OF FLOOR MANAGEMENT PRACTICES.[a]

Bare, firm moist ground	Warmest
Shredded cover crop, moist ground	½°F colder
Low cover crop, moist ground	1–3°F colder
Dry, firm ground	2°F colder
Freshly disked ground	2°F colder
Higher cover crop	2–4°F colder
In some instances where high cover crop restricts air drainage	6–8°F colder

[a]Listed in order of increasing hazard.

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Cultural Practices

Any practice that extends growth into the fall decreases hardiness

- Nutrition
  - Avoid late nitrogen fertilization
- Pruning
  - Pruning prior to low-temperature injury tends to increase injury
- Have ‘healthy’ trees :Photosynthesis
  - Reduce pest damage
- Paint tree trunk

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