Olive Freeze Damage Review and Olive Knot Control

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1990 Freeze

2010 Freeze

Critical Temperatures

- Vary depending on climatic conditions
- At or below 20 degrees F are often critical

Factors Effecting Freeze Severity

- Cold temperatures and the duration of freezing
- Acclimatization
- Variety
- Tree age
- Irrigation
- Time of Pruning
- Previous Crop load

Low temperatures recorded in California olive producing regions, 1913-1990

Site	1990 lowest temperature			Previous record low temperature			Average yearly lowest temperature	
	°F	°C	*date*	°F	°C	*year*	°F	°C
Orland	15	-9.4	23 Dec	16	-8.9	1978	24.0	-4.4
Willows	11	-11.7	22 Dec	14	-10.0	1978	23.3	-4.8
Oroville	12	-11.1	23 Dec	13	-10.6	1932	24.6	-4.1
Davis	16	-8.9	23 Dec	12	-11.1	1932	23.8	-4.6
Visalia	21	-6.1	24 Dec	13	-10.6	1913	25.4	-3.7
Porterville	16	-8.9	24 Dec	18	-7.8	1913	24.7	-4.1

Site latitude, longitude, and elevation. Orland (Glenn Co.): 39° 45'N, 122° 12'W, 254 ft. (77.4 m); Willows (Glenn Co.): 39° 32'N, 122° 12'W, 140 ft. (42.7 m); Oroville (Butte Co.): 39° 30'N, 121° 33'W, 171 ft. (52.1 m); Davis 1WSW (Yolo Co.): 38° 32'N, 121° 45'W, 51 ft. (15.6 m); Visalia (Tulare Co.): 36° 20'N, 119° 18'W, 354 ft. (107.9 m); Porterville (Tulare Co.): 36° 04'N, 119° 01'W, 393 ft. (119.8 m).

Freezing event 2010

Dec. 6 through 10th

Lows low 20s to mid teens 3 of 4 nights

Moderate winds 3-4 mph

Dec 7- higher temperatures (mid 20s or higher) with higher winds (8-10 mph)

Minimum Temperatures Dec 6-10, 2010

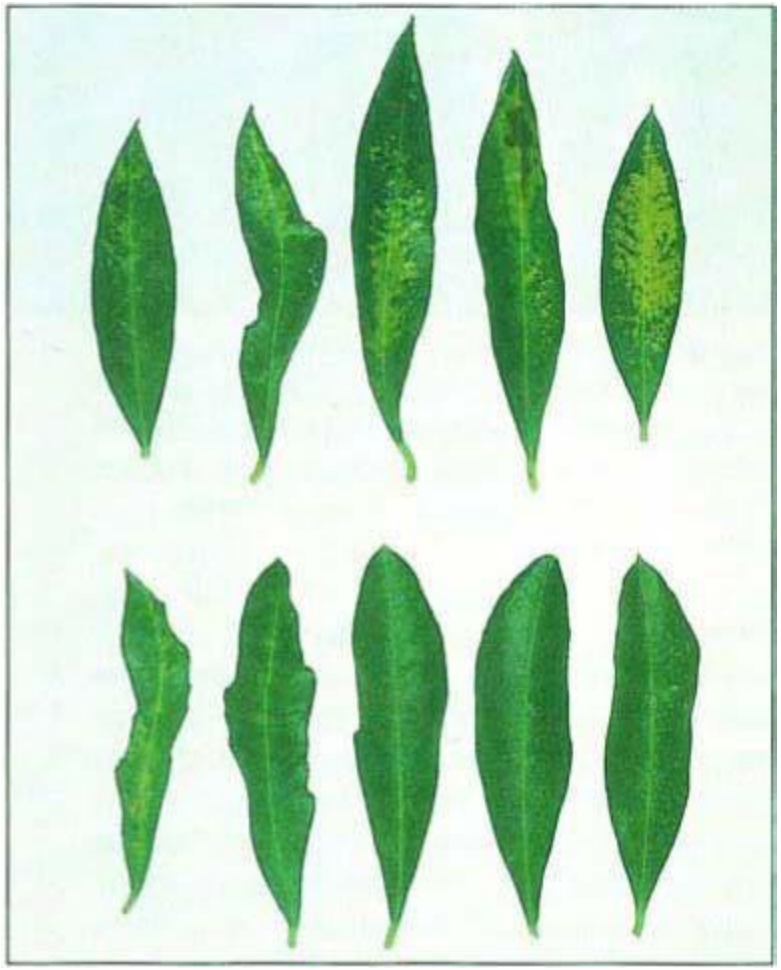
- Arbuckle, Nickels 23.6
- Willows-west 21.2
- Artois 16.8
- Orland East 17.5
- Orland Buttes 1 23
- Orland Buttes 2 17
- Orland CIMIS Rd 25 and N 18.6
- Durham CIMIS 18
- Chico CSU Farm 19.5
- Gerber CIMIS 18.4

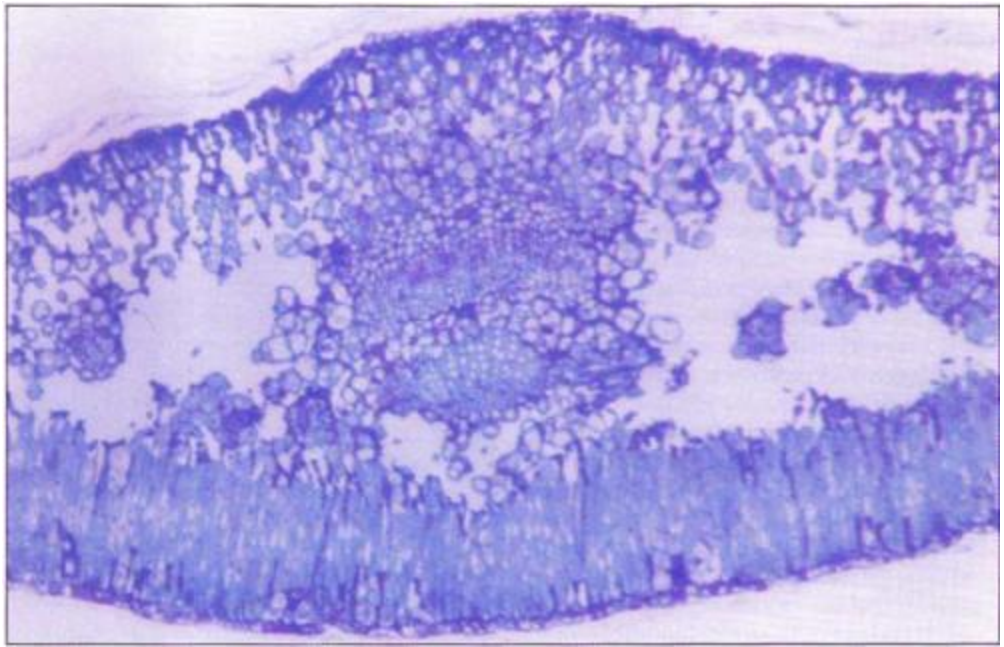
Number and frequency (%) of years reporting at least one occurrence of minimum temperatures below given temperatures thresholds in olive producing areas in California 1913-1990

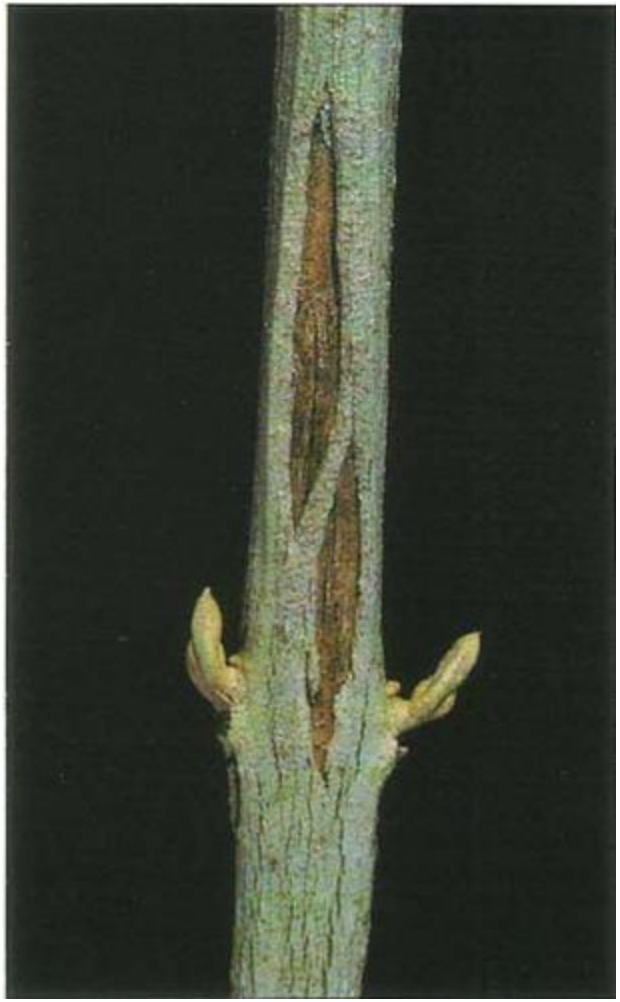
	≤20°F (-6.7°C)		≤17°F (-8.3°C)		≤14°F (-10°C)		≤11°F (-11.7°C)	
Site	Yrs.	f	Yrs.	f	Yrs.	f	Yrs.	f
		%		%		%		%
Orland	12	15	3	4	0		0	
Willows	15	19	7	9	2	3	1	1
Oroville	9	12	3	4	2	3	0	
Davis	11	14	3	4	1	1	0	
Visalia	5	6	2	3	1	1	0	
Porterville	7	9	1	1	0		0	

Continuing defoliation of Manzanillo

Leaf symptoms from the 1990 freeze, spotty mottled roughened and chlorotic leaves
Internal empty spaces caused by splitting apart of cells in the area of the vascular bundles





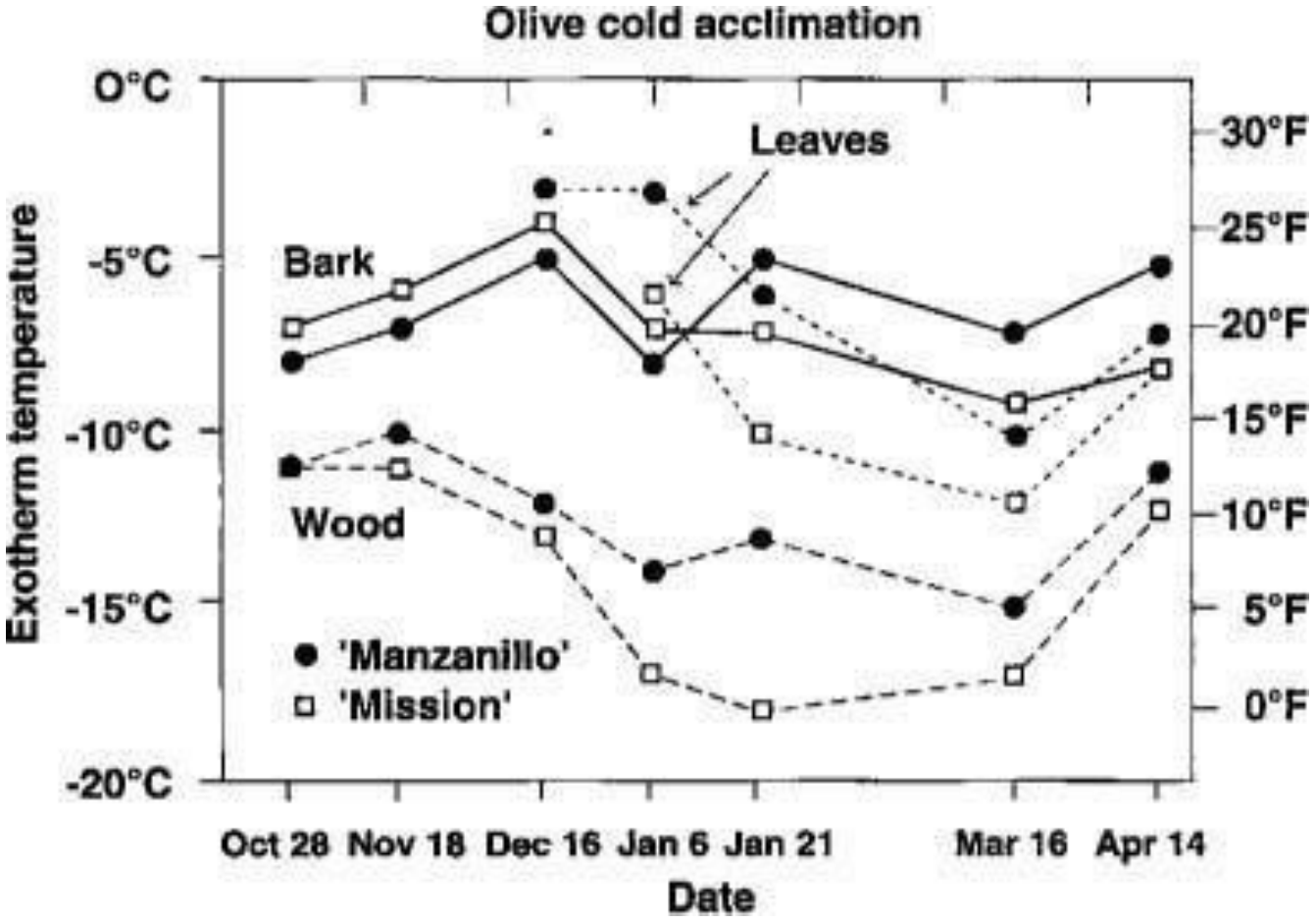


Bark split in Manzanillo

Cross section of healed over bark split

Acclimatization

- Hardiness increases when trees are exposed to cold temperatures as autumn proceeds into winter
- 1985 Manzanillo block in Artois
  - 22 degrees in Nov.
  - Defoliation, bark split, olive knot
  - Cut back within 2 ft of the ground


Olive cold acclimation
0°C
-5°C
-10°C
-15°C
-20°C
30°F
25°F
20°F
15°F
10°F
5°F
0°F
Exotherm temperature
Leaves
Bark
Wood
'Manzanillo'
'Mission'
Oct 28
Nov 18
Dec 16
Jan 6
Jan 21
Mar 16
Apr 14
Date

Timing of lowest yearly minimum of 20 degrees or less, 1913-1990

Periods	Orland	Willows	Oroville	Davis	Visalia	Porterville
Dec. 1-10	1	0	0	0	0	0
Dec. 11-20	1	2	3	1	0	0
Dec. 21-31	6	6	2	4	0	2
Jan. 1-10	3	6	3	6	2	3
Jan. 11-20	0	0	0	0	2	1
Jan. 21-31	1	1	1	0	1	1
Total	**12**	**15**	**9**	**11**	**5**	**7**

Variety Cold Hardiness

- Hardy
  - Arbequina, Aglandau, Acolano, Bouteillan, Coratina, Hojiblanca, Leccino, Maurino, Mission, Pendolino, Picudo, Picual,
- Moderate
  - Sevillano,Kalamata, Picholine,
- Sensitive
  - Manzanillo, Koroneiki, Empeltre, Frantoio, Moraiolo, Taggiasca, Arbosana?

Response to grower survey estimating damage by variety from 1990 freeze

Cultivar	Orchards				Damage rating*,†
	no.	*ac*	*ha*	%	*mean ± std. dev.*
'Manzanillo'	255	8,151	3,299	69.2	1.7 ± 0.8a
'Mission'	26	307	124	2.6	1.3 ± 0.9b
'Barouni'	9	99	40	0.8	1.2 ± 0.7b
'Sevillano'	152	2,783	1,126	23.6	1.1 ± 0.8b
'Ascolano'	32	432	175	3.7	0.9 ± 0.8b
All	474	11,772	4,764	100.0	1.3 ± 0.3

*Means followed by the same letter are not significantly different at the 5% level using ranked ANOVA Duncan's multiple range test and Tukey's studentized range test.

†Damage rating: 0 (none), 1 (light), 2 (moderate), 3 (heavy).

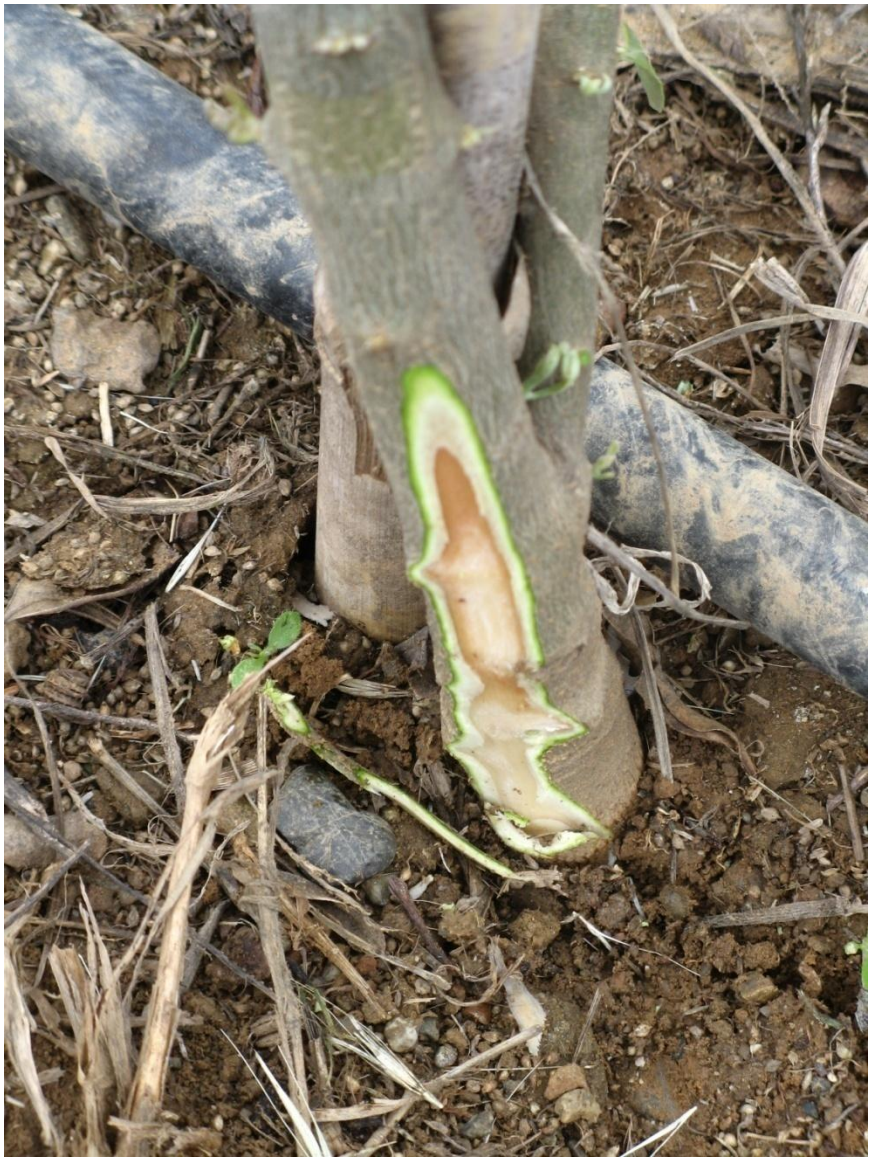
Freeze Damage to Koroneiki Arbuckle 2010

Low temperature 23 degrees

Damage by age of tree 1990

Years of age	Average damage level*		
	'Manzanillo'	'Sevillano'	All cultivars
1-5	2.0	—	1.8
6-15	1.9	1.7	1.8
16-30	1.6	0.9	1.4
31-50	1.5	1.2	1.3
51+	1.5	1.1	1.2

*Damage levels: 0 (none), 1 (light), 2 (moderate), 3 (heavy).



Effect of Irrigation

- Madera County Irrigation study 1990
  - Different levels of irrigation to establish crop coefficient
  - Trees receiving more water (especially post harvest) were more damaged – greater initial defoliation
  - Well watered trees recovered more quickly in the spring
  - Recovery less vigorous on low watered trees and defoliation throughout the season was greater

Time of Pruning

- Pruning prior to freeze in 1990 and in 2010 resulted in more damage than where pruning was delayed until after the freeze occurred.

- Damage to Fruiting buds 1990

- Fewer inflorescenses that developed slower
- Some persisted to harvest but were smaller
- 1991 crop light in San Joaquin good in Sacramento Valley
    - Probably related to previous crop and variety compositon
- 2011 crop will be reduced where damage is significant

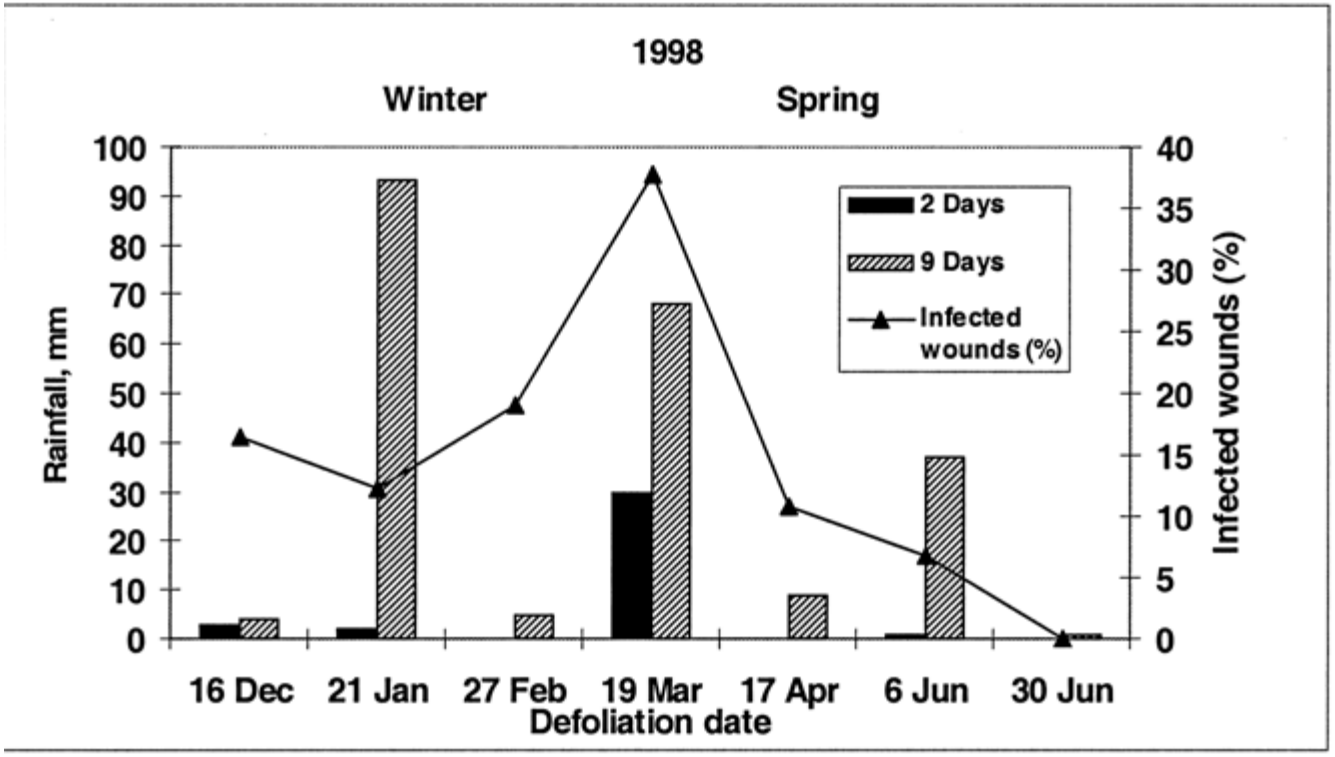
Developing Olive Knot

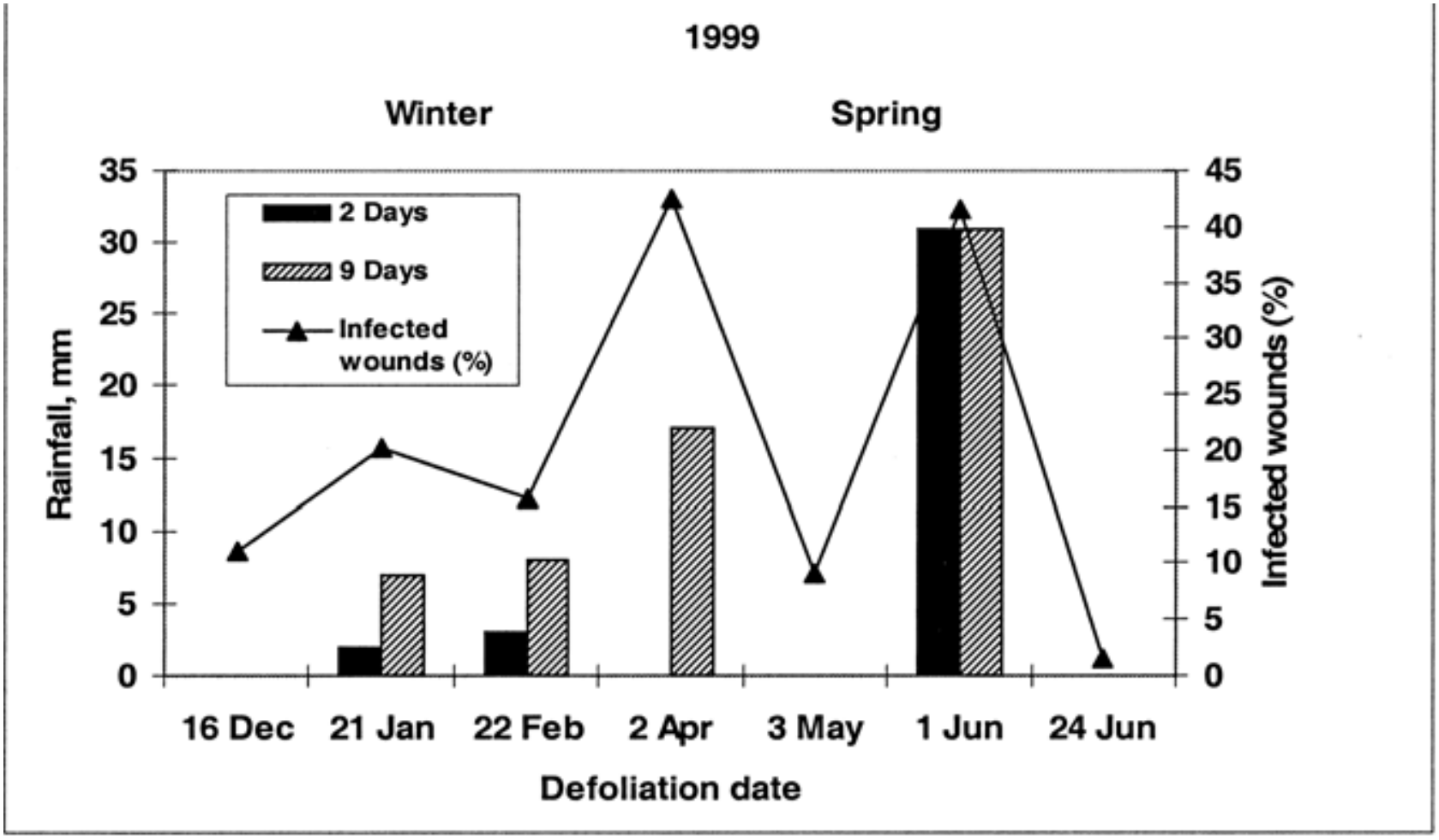
Life Cycle

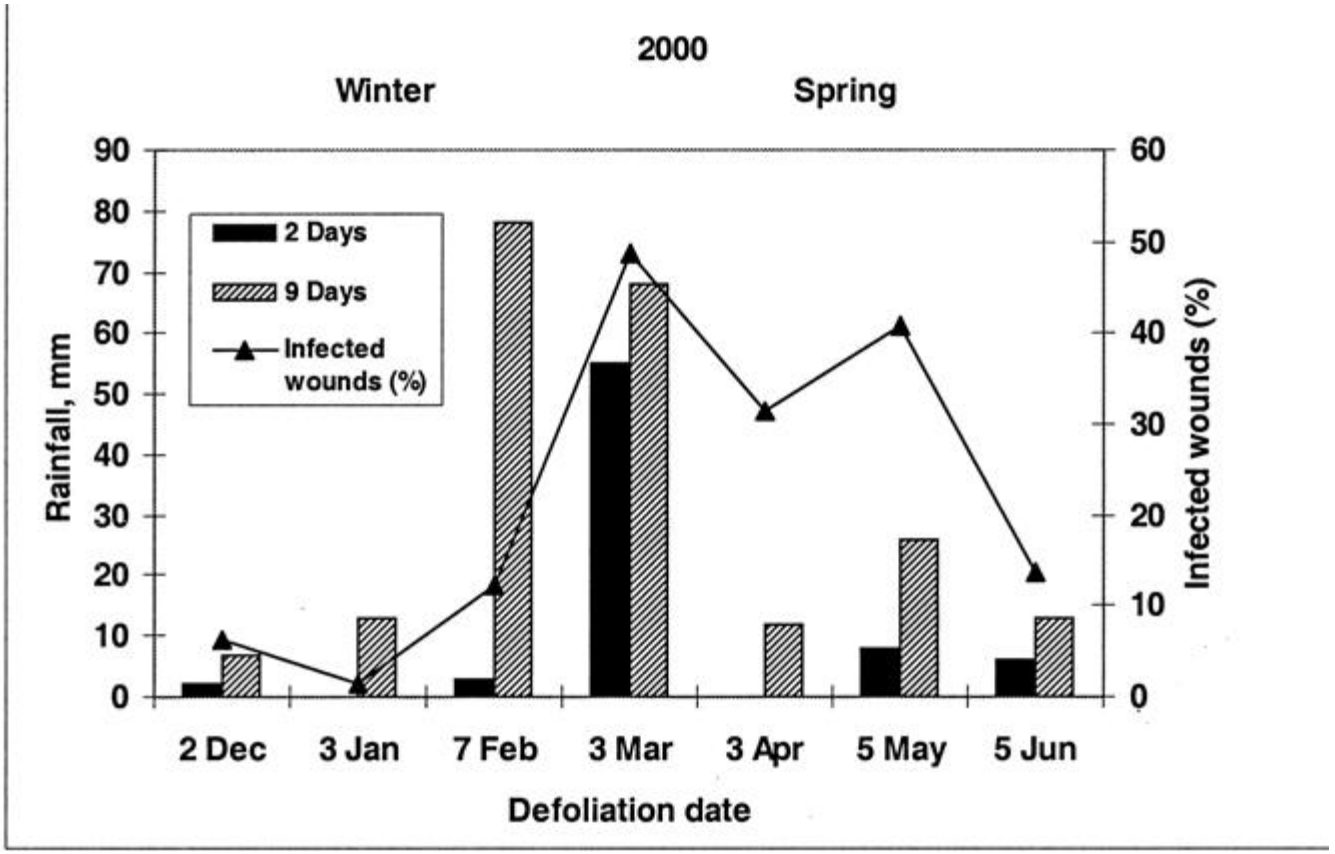
- Bacteria survive in galls
- Spread by wind and rain
- Infect openings in tree
  - **Leaf scars**, pruning wounds, freeze cracks
- Infection-fall, winter,spring
- Symptoms-late spring, summer

Olive Knot Variety Susceptibility

- Very susceptible – Manzanillo, Arbequina
- Susceptible – Empeltre, Sevillano, Hojiblanca, Koroneiki, Moraiolo, Penedolino, Picual
- Resistant – Ascolano, Blanqueta, Frantoio, Leccino, Mission, Arbosana?


1998
Winter
Spring
Rainfall, mm
Infected wounds (%)
2 Days
9 Days
Infected wounds (%)
100
90
80
70
60
50
40
30
20
10
0
40
35
30
25
20
15
10
5
0
16 Dec
21 Jan
27 Feb
19 Mar
17 Apr
6 Jun
30 Jun
Defoliation date


1999
Winter
Spring
2 Days
9 Days
Infected wounds (%)
Rainfall, mm
Infected wounds (%)
0
5
10
15
20
25
30
35
40
45
16 Dec
21 Jan
22 Feb
2 Apr
3 May
1 Jun
24 Jun
Defoliation date


2000
Winter
Spring
2 Days
9 Days
Infected wounds (%)
Rainfall, mm
Infected wounds (%)
90
80
70
60
50
40
30
20
10
0
60
50
40
30
20
10
0
2 Dec
3 Jan
7 Feb
3 Mar
3 Apr
5 May
5 Jun
Defoliation date

Effects of Copper Application Timing and Defoliation Date on Natural Incidences of Olive Knot Disease – Manzanillo cv - Corning 2000

Number and dates of applications[x]					Infected wounds (%) by defoliation date[y]					
2 Dec	7 Feb	3 Mar	3 Apr	5 May	2 Dec	7 Feb	3 Mar	3 Apr	5 May	Means[z]
One application										
X	...	...	...	...	0.6 bcd	2.6 abcd	19.4 b	21.6 b	19.6 bcd	12.8 b
...	X	...	...	...	9.6 a	0.6 cd	16.4 bc	16.8 b	35.0 ab	15.7 b
...	...	X	...	...	6.8 a	8.4 a	2.0 d	7.4 cd	20.8 bc	9.1 bc
...	...	...	X	...	4.4 ab	5.9 ab	35.4 a	3.2 de	15.8 cd	13.0 b
Two applications										
X	X	...	...	...	0.6 bcd	0.2 d	5.8 cd	10.2 c	12.6 cd	5.9 cde
X	...	X	...	...	3.2 abc	4.4 abcd	1.3 de	9.0 cd	18.2 c	7.2 cd
X	...	...	X	...	0.0 d	5.5 abc	14.9 bc	0.6 e	4.8 de	5.2 def
Three applications										
X	X	...	X	...	0.6 bcd	0.4 cd	11.8 bc	0.0 e	2.4 e	3.0 ef
X	...	X	...	X	0.2 cd	1.2 bcd	1.3 de	5.6 cd	0.8 e	1.8 f
Nontreated control	...	...	...	...	6.2 a	12.2 a	48.6 a	31.4 a	40.8 a	27.9 a
Means, defoliation date	...	...	...	...	3.2 e	4.1 de	15.7 a	10.6 b	17.1 a	...

Olive Knot Conclusions

- More olive knot develops from spring infections than fall and winter
- Copper fungicides will redistribute to protect wounds that occur after the spray is applied
- Multiple spray improve contro.

Recommendations for freeze damaged trees

- Spray to prevent olive knot
- Delay pruning until the extent of the damage can be see
- Irrigate adequately but not excessively
- Fertilize as needed