The Dynamic Model Provides the Best Description of the Chill Process on 'Sirora' Pistachio Trees In Australia

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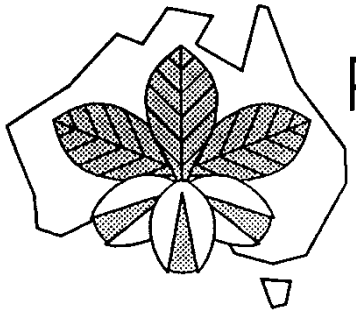

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HAL
Horticulture Australia

Project components and collaborators

Co-author – **Cathy Taylor, DPI,** Mildura, Victoria

Collaborator:-Graham Sanderson, Industry & investment (Dareton), NSW

Funding organisations:-

- Pistachio growers through voluntary levy contributions
- Pistachio R&D Committee
- Horticulture Australia Limited
- Australian Government.

What problems are being discovered?

- Winter 2005 was warm
- Many flowers opened in mid-November
- Some flowers opened in next February
- Crop reduced severely
- Problem of chill requirement was clear
- Study started in winter 2006

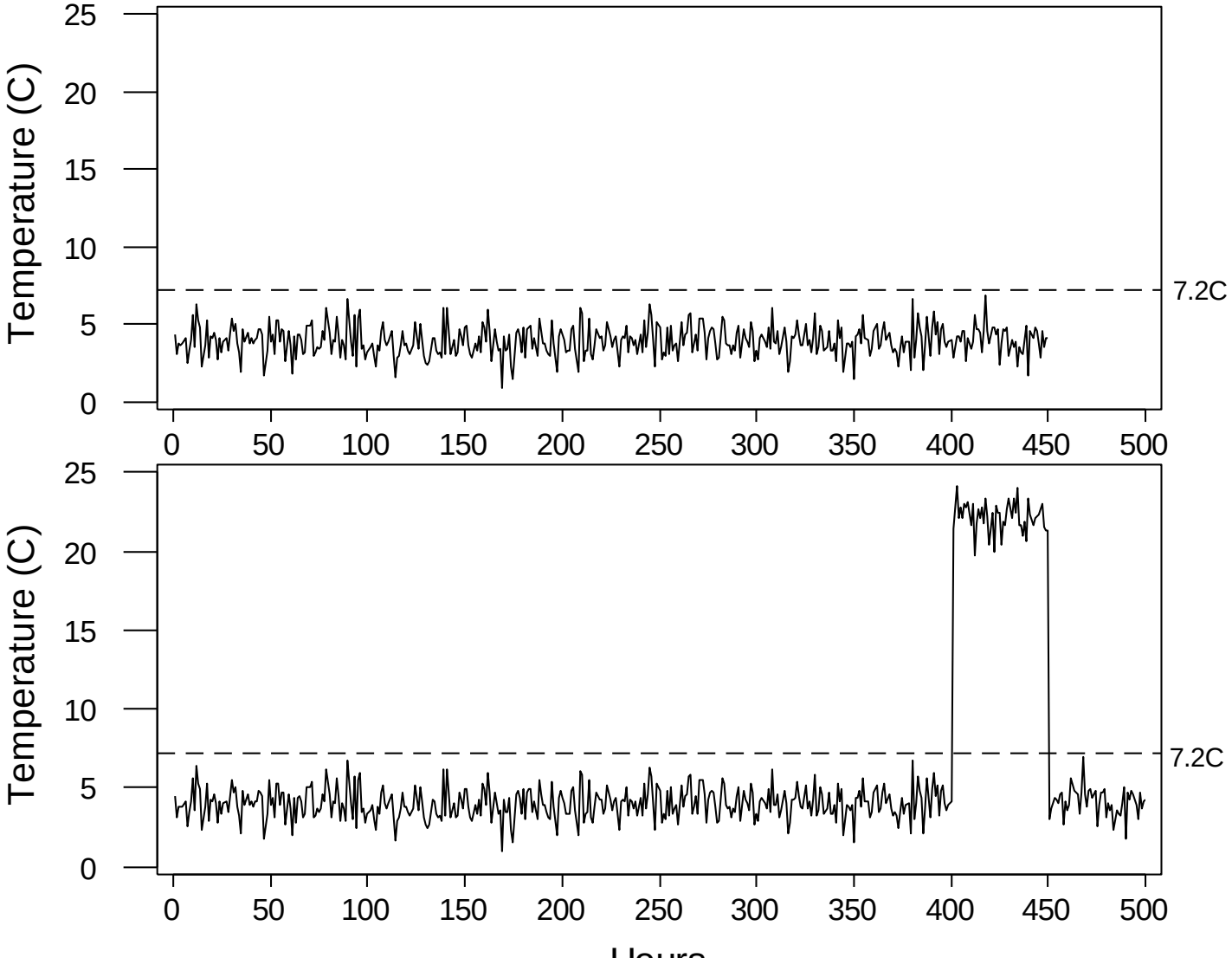
How are they being addressed?

7.2°C model

- Human beings do not understand the chill requirement process exactly, we have to use models to solve our current production problem
- Since 1930s', simple calculation was conducted for chill requirement
- 0-7.2°C model (Bennett, 1949, Calif. Agri.)
- ≤ 7.2°C model (Weinberger, 1950, Proc. ASHS)
- It was called Weinberger model
- Until 2009, a paper by Luedeling et al. pointed that <0°C was not useful for chill requirements
- clearly there was a need to stop using this model

How are they being addressed?

7.2°C model



How are they being addressed?
Utah model

- High temperature have a negative chill-contribution

Table 1. Conversion of selected temperatures to Chill Units (Richardson et al., 1974)

Temperature (°C)	<1.4	1.5-2.4	2.5-9.1	9.2-12.4	12.5-15.9	16-18	>18
Chill units	0	0.5	1	0.5	0	-0.5	-1

How are they being addressed?

Peach tests up to 1150 hours in 4-6°C with different cold-hot rhythms (Erez et al, 1979)

4-6°C	20-24°C	Redskin	Redhaven
16 hours	8 hours		
48 hours	24 hours		
96 hours	48 hours		
144 hours	72 hours		

24 plants per treatment

How are they being addressed?

Peach tests up to 1150 hours in 4-6°C with different cold-hot rhythms (Erez et al, 1979)

4-6°C	20-24°C	Redskin	Redhaven
16 hours	8 hours	No bud break	No bud break
48 hours	24 hours	Low break	Good break
96 hours	48 hours	Good break	Good break
144 hours	72 hours	Good break	Good break

24 plants per treatment

How are they being addressed? Dynamic model

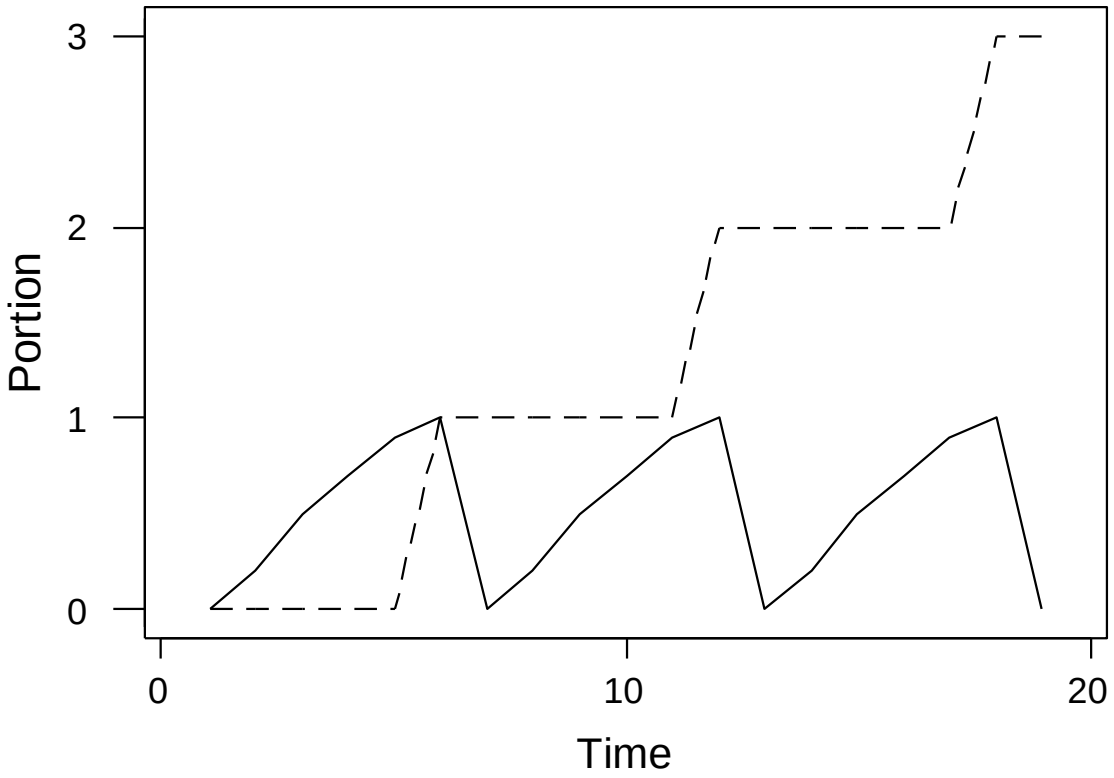
- Other models treated each hour independently
- non-stationary and time-inhomogeneous processes should be introduced to chilling models.
- In Fortran language at beginning
- Fishman created a calculation in excel “DYNAMICS.xlsx”

How are they being addressed? Dynamic model

- 2-step scheme

$$REST \underset{\nu}{\overset{k_0}{\rightleftarrows}} IRCF \rightarrow RCF$$

rest completion factor (RCF).
intermediate rest completion factor (IRCF)



How are they being addressed?
Lab work

- Twigs from Dareton station, DPI, NSW
- 10 times of sampling from 6 July to 7 Sep 2006
- 2 shoots each sampling from 5 trees
- Lab at DPI, Victoria (Mildura)
- Temperature 23±1°C

How are they being addressed?

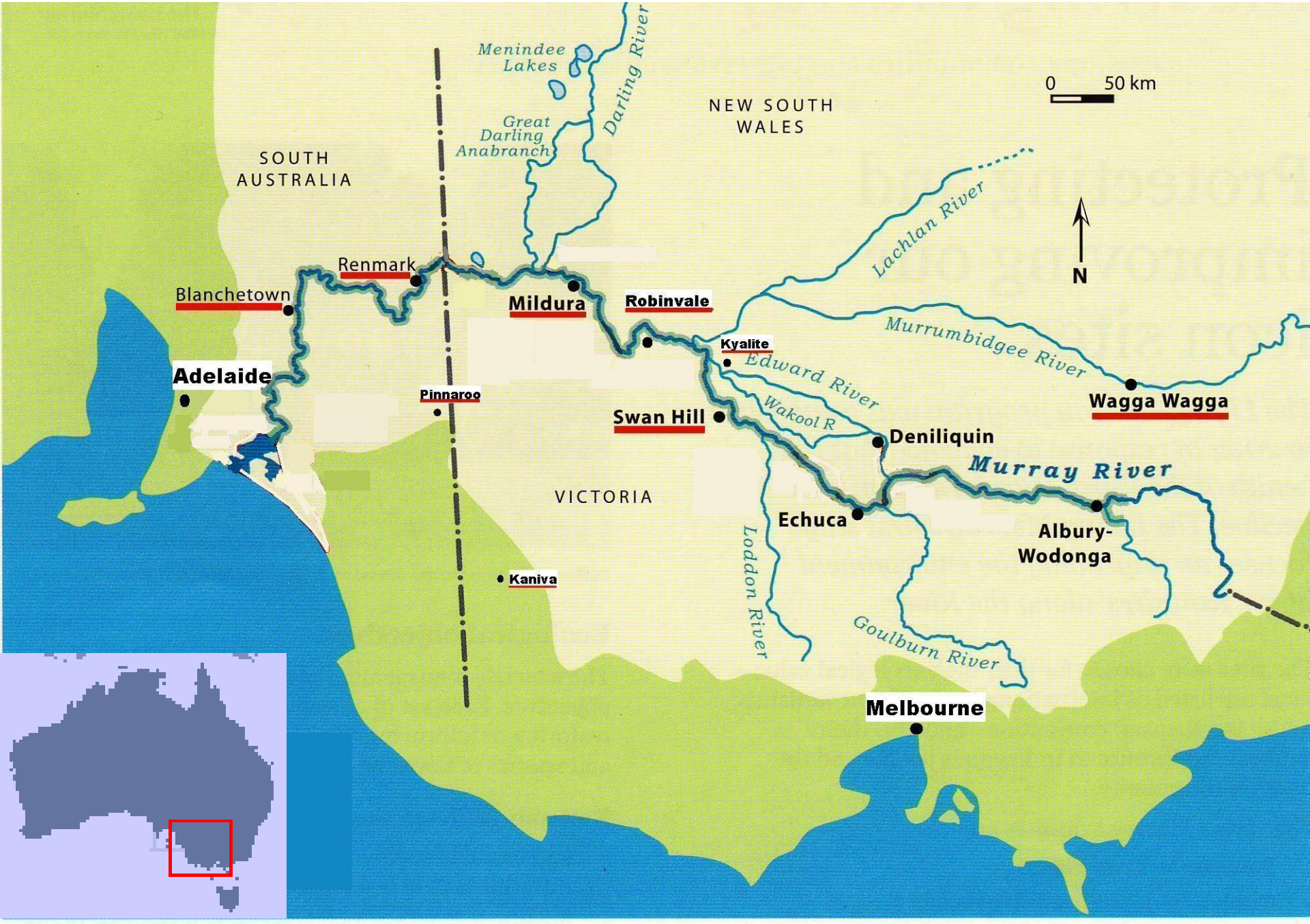
Flower stages recorded

-50% Cluster appearing stage within 3 weeks

				
Loose scale	Cluster appearing	Cluster extension	Tight cluster	Loose cluster

How are they being addressed? Results for trial trees

Winter	Chilling fulfillment date	Chilling hours	Chill units	Chill portions
2006	10 Aug.	645	990	59
2007	13 Sept.	677	919	58
2008	3 Sept.	569	1,078	62
2009	9 Sept.	412	752	60
2010	25 Aug.	535	1,123	61


Menindee Lakes
Darling River
NEW SOUTH WALES
0 50 km
Great Darling Anabranch
SOUTH AUSTRALIA
Lachlan River
N
Renmark
Blanchetown
Mildura
Robinvale
Kyalite
Murrumbidgee River
Edward River
Adelaide
Pinnaroo
Swan Hill
Wakool R
Wagga Wagga
Deniliquin
Murray River
VICTORIA
Echuca
Albury-Wodonga
Loddon River
Kaniva
Goulburn River
Melbourne

How are they being addressed? Results for historical records

Winter	Evenness of bud break		Chilling hours 645[z]		Chill units 990[z]		Chill portions 59[z]	
	Renmark	Mildura	Renmark	Mildura	Renmark	Mildura	Renmark	Mildura
1999	Even	Even	[y]602	[y]600	[y]818	1,028	59	66
2000	Even	Even	706	715	1,097	1,291	70	75
2001	Even	Even	645	[y]635	[y]955	1,062	64	63
2002	Uneven	Even	591	[y]640	764	[y]940	56	59
2003	Even	Even	[y]620	[y]629	[y]953	1,037	63	64
2004	Even	Even	652	[y]625	[y]971	1,100	63	65
2005	Very uneven	Very uneven	604	574	829	894	55	57

How are they being addressed? Results for model validation

Winter	Evenness of bud break		Chilling hours 645[z]		Chill units 990[z]		Chill portions 59[z]	
	Renmark	Mildura	Renmark	Mildura	Renmark	Mildura	Renmark	Mildura
2006	Even	Even	727	773	[y]974	1,137	68	72
2007	Uneven	Even	573	688	837	[y]970	55	59
2008	Even	Even	657	662	1,122	1,152	65	68
2009	Very uneven	Very uneven	445	488	678	823	55	58
2010	Even	Even	645	[y]644	1030	1,198	65	69
2011	Even	Even	604	646	914	1116	59[x]	67
2012			701	754	1078	1152	68	73

Impacts of the project

- Clarified difference between normal winter and low chilling winter for ‘Sirora’ pistachio production
- During global waring period, it is especially important for future fruit production

Importance of the project/research to the industry

- Industry makes decisions according to the results

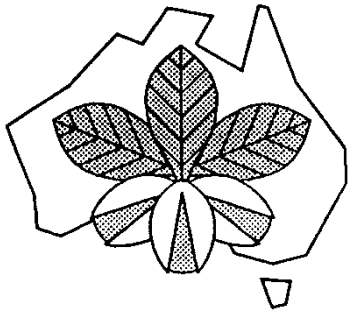
How are nut growers/others going to find out about the project?

- Zhang, J. and C. Taylor. 2011. The dynamic model provides the best description of the chill process on ‘Sirora’ pistachio trees in Australia. *HortScience* 46(3):420-425.
- Zhang, J.; Taylor, C. 2011. Chill calculation: the Dynamic model provides the best description of the chill process on 'Sirora' pistachio trees in the Murray-Darling area. *Australian Nutgrower* 25(2):26-28

What other nuts could benefit from your project/results?

- This should benefit all deciduous tree

Thank you



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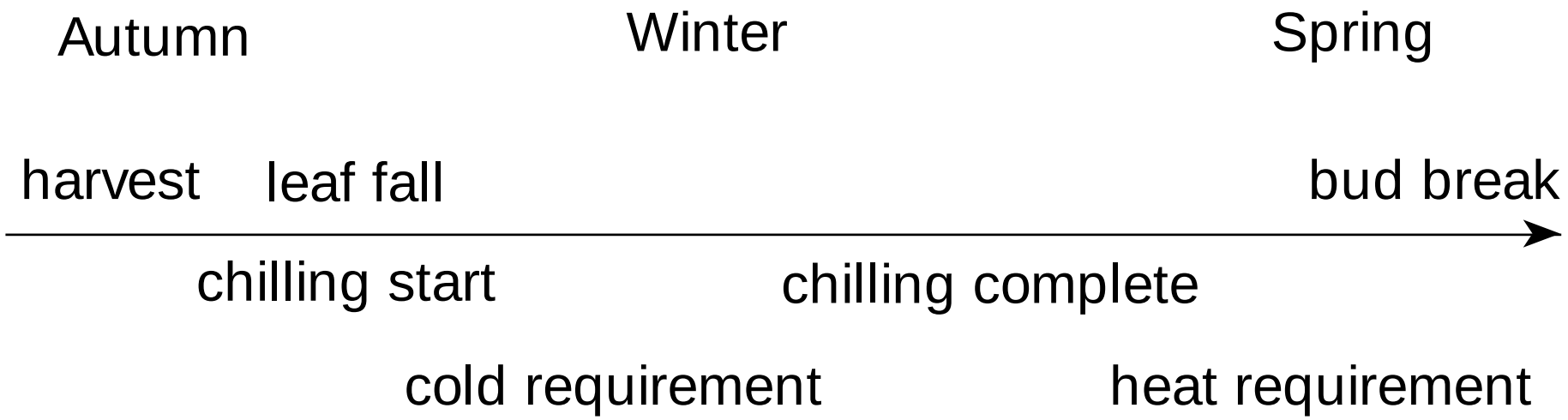
Modelling on chilling requirement



Dynamic model

- The temperature leading to a maximal chilling effect is 7°C
- Zero effect at -2°C and 13°C
- For 1 portion, under best temperature, it needs about 28 hours.
- >18 °C have negative effects
- 13-16 °C in a short period may speed up the process

Calculation process of Dynamic model

$$x_i = \frac{e^{slp \cdot tetmlt \cdot (T_k - tetmlt)/T_k}}{1 + e^{slp \cdot tetm\,lt \cdot (T_k - tetmlt)/T_k}}$$

$$x_s = \frac{a_0}{a_1} \cdot e^{\frac{e_1 - e_0}{T_k}}$$

$$ak_1 = a_1 \cdot e^{-(e_1/T_k)}$$

$$inter_E = X_s - (X_s - inter_s) \cdot e^{-ak_1}$$

$$inter_s = \begin{cases} t = t_0 & : 0 \\ t > t_0 \wedge inter_{E_{t-1}} < 1 & : inter_{E_{t-1}} \\ t > t_0 \wedge inter_{E_{t-1}} \geq 1 & : inter_{E_{t-1}} \cdot (1 - X_i) \end{cases}$$

$$delt = \begin{cases} t = t_0 & : 0 \\ t > t_0 \wedge inter_E < 1 & : 0 \\ t > t_0 \wedge inter_E \geq 1 & : x_i \cdot inter_E \end{cases}$$

$$chill\ portions_t = \begin{cases} t = t_0 & : delt \\ t \geq t_0 & : delt + chill\ portions_{t-1} \end{cases}$$

Calculation in excel

e0	3.52E+03									
e1	1.15E+04		DYNAMIC MODEL CHILLING PORTIONS - EREZ, A. and FISHMAN, S.							
a0	1.41E+14			References)						
a1	1.88E+16			(Look for papers titles under"						
slp	1.6		Add hourly data in column B from row 13 down. **Do not erase rows 11, 12.**							
tetmlt	277		copy data from row12 colums C to L till the last entry in column B.							
aa=a0/a1	7.49E-03		total cumulative chiling portions will appear in column L.							
ee=e1-e0	8.01E+03									
Temp(C)	Temp (K)	ftmprt	sr	xi	xs	ak1	Inter-S	Inter-E	delt	**Portions**
15	288.00	16.93	22471935.51	1.00	###	0.08	0.00	######	0.00	0
12	285.00	12.44	252887.94	1.00	###	0.05	30.020934	######	601085995.72	601085996

Winter temperatures at Mildura and Renmark