APPENDIX IV

TEMPERATURE REGIME REQUIREMENTS OF CROP/LUTs

Notes:

Climates: B = Boreal; Te = Temperate; STR = Sub-tropics; WR = Winter Rainfall; SR = Summer Rainfall; Tr = Tropics

Growth cycle: L/Gc = Total; La = Pre-dormancy; Lb = Post-dormancy

Temperature profile interval symbols:

Temperature intervals (^{o}C)	<-5	-5-0	0-5	5-10	10-15	15-20	20-25	25-30	>30
Totals	L9	L8	L7	L6	L5	L4	L3	L2	L1
Increasing temperatures (winter to summer)	L9a	L8a	L7a	L6a	L5a	L4a	L3a	L2a	L1a
Decreasing temperatures (summer to winter)	L9b	L8b	L7b	L6b	L5b	L4b	L3b	L2b	L1b

Heat Units: TSgc = Temperature Sum during growth cycle

Temperature Growing Period: $LGP_{t=5}$ = Number of days with mean daily temperatures above 5°C

TEMPERATURE REGIME REQUIREMENTS OF CROP/LUTs

Crop	Sub-optimal Conditions	Optimal Conditions
Winter Wheat	*Climates: B, Te, STr (WR+SR)*	*Climates: B, Te, STr (WR+SR)*
(Wheat I)	*L6a < 0.667*Lb*	*L6a < 0.500*Lb*
Winter Barley	*L6a+L5a > 0.167*Lb*	*L6a+L5a > 0.084*Lb*
(Barley I)	*L2a+L2b < 0.333*Lb*	*L2a+L2b < 0.333*Lb*
Winter Rye	*L1a+L1b = 0*	*L1a+L1b = 0*
(Rye I)	*L2b+L3b+L4b+L5b < 0.500*Lb*	*L2b+L3b+L4b+L5b < 0.500*Lb*
L = 30 + 90	*L3b+L4b+L5b+L6b > La*	*L3b+L4b+NLb+L6b > La*
L = 35 + 105	*TSgc>1200 **	*TSgc> 1300 **
L = 40 + 120	*no permafrost*	*no permafrost*
L = 45 + 135	*LGP t=5 < 365*	*LGP t=5 < 365*
	dormancy required	*dormancy required*
Spring Wheat	*Climates: B, Te, STr (WR+SR)*	*Climates: B, Te, STr (WR+SR)*
(Wheat II)	*L6a < 0.333*L*	*L6a < 0.333*L*
L = 105/120/135/150	*L6a+L5a > 0.167*Lb*	*L6a+L5a > 0.167*Lb*
	L2a+L2b < 0.333*Lb	*L2a+L2b < 0.333*Lb*
	L1a+L1b = 0	*L1a+L1b = 0*
	L2b+L3b+L4b+L5b < 0.500*Lb	*L2b+L3b+L4b+L5b < 0.500*Lb*
	TSgc> 1400	*TSgc > 1800*
	no permafrost	*no permafrost*
	LGP t=5 < 365	*LGP t=5 < 365*
Spring Barley	*Climates: B, Te, STr (WR+SR)*	*Climates: B, Te, STr (WR+SR)*
(Barley II)	*L6a < 0.333*L*	*L6a < 0.333*L*
Spring Rye	*L6a+L5a > 0.167*Lb*	*L6a+L5a > 0.167*Lb*
(Rye II)	*L2a+L2b < 0.333*Lb*	*L2a+L2b < 0.333*Lb*
L = 90/105/120/135	*L1a+L1b = 0*	*L1a+L1b = 0*
	L2b+L3b+L4b+L5b < 0.500*Lb	*L2b+L3b+L4b+L5b < 0.500*Lb*
	TSgc> 1400	*TSgc > 1700*
	no permafrost	*no permafrost*
	LGP t=5 < 365	*LGP t=5 < 365*
Wheat (sub-tropics)	*Climates: STr (WR + SR)*	*Climates: STr (WR + SR)*
(Wheat III)	*L6a < 0.333*L*	*L6a < 0.167*L*
L = 105	*L6+L5+L4 > 0.167*Lb*	*L6+L5+L4 > 0.333*Lb*
L = 120	*L2a+L2b < 0.500*Lb*	*L2a+L2b < 0.500*Lb*
L = 135	*L1a+L1b = 0*	*L1a+L1b = 0*
L = 150	*TSgc> 1500*	*TSgc > 1800*
	LGP t=5 = 365	*LGP t=5 = 365*
Barley (sub-tropics)	*Climates: STr (WR + SR)*	*Climates: STr (WR + SR)*
(Barley III)	*L6a < 0.333*L*	*L6a < 0.167*L*
L = 90	*L6+L5+L4 > 0.167*Lb*	*L6+L5+L4 > 0.333*Lb*
L = 105	*L2a+L2b < 0.500*Lb*	*L2a+L2b < 0.500*Lb*
L = 120	*L1a+L1b = 0*	*L1a+L1b = 0*
L = 135	*TSgc> 1400*	*TSgc > 1700*
	LGP t=5 = 365	*LGP t=5 = 365*
Wheat (tropics)	*Climates: Tr*	*Climates: Tr*
(Wheat IV)	*L6a < 0.333*L*	*L6a < 0.167*L*
L = 100 at 20.0°C	*L6+L5+L4 > 0.167*Lb*	*L6+L5+L4 > 0.333*Lb*
L = 130 at 17.5°C	*L2a+L2b < 0.500*Lb*	*L2a+L2b < 0.500*Lb*
L = 160 at 15.0°C	*L1a+L1b = 0*	*L1a+L1b = 0*
L = 190 at 12.5°C	*TSgc> 1600*	*TSgc > 2000*
	LGP t=5 = 365	*LGP t=5 = 365*
Barley (tropics)	*Climates: Tr*	*Climates: Tr*
(Barley IV)	*L6a < 0.333*L*	*L6a < 0.167*L*
L = 100 at 20.0°C	*L6+L5+L4 > 0.167*Lb*	*L6+L5+L4 > 0.333*Lb*
L = 130 at 17.5°C	*L2a+L2b < 0.500*Lb*	*L2a+L2b < 0.500*Lb*
L = 160 at 15.0°C	*L1a+L1b = 0*	*L1a+L1b = 0*
L = 190 at 12.5°C	*TSgc> 1500*	*TSgc > 1900*
	LGP t=5 = 365	*LGP t=5 = 365*

* applicable to post-dormancy period only

Crop	Sub-optimal Conditions	Optimal Conditions
Indica Rice (wetland)	Climates: Tr, STr (SR+WR)	Climates: Tr, STr (SR+WR)
L = 105/120/135/150	L5=L6=0	L6=L5=L4 = 0
	L3 + L2+ L1 >0.833*L	L3+L2+L1 = 1.000*L
	L4a < 0.167*L	L1 < 0.667*L
	L4b < 0.167*L	TSgc >3000
	TSgc>2400	
Indica Rice (dryland)	Climates: Tr	Climates: Tr
L = 105/120/135	L5=L6=0	L6=L5=L4 = 0
	L3 + L2+ L1 >0.833*L	L3+L2+L1 = 1.000*L
	L4a < 0.167*L	L1 < 0.667*L (not implemented)r
	L4b < 0.167*L	TSgc >3000
	TSgc>2400	
Japonica Rice (wetland)	Climates: Tr, STR (SR+WR), Te	Climates: Tr, STR (SR+WR), Te
L = 105/120/135/150	L5a+L4a < 0.400*L	L5a+L4a < 0.400*L
	L4 >0	
	L2a+L2b < 0.667*L	L2a+L2b < 0.667*L
	L1a+L1b < 0.200*L	L1a+L1b < 0.200*L
	L4b+L5b < 0.250*L	L4b+L5b < 0.250*L
	L6=0	L6=0
	TSgc > 1800	TSgc> 2200
Lowland Maize and Sorghum	Climates: Tr	Climates: Tr
(Maize I)	L4a+L4b < 0.167*L	L4 = 0
(Sorghum I)	TSgc > 2200	TSgc > 2500
L = 90/105/120/135		
Highland Maize and Sorghum	Climates: Tr	Climates: Tr
(Maize II)	L1 = 0	L1 = 0
(Sorghum II)	L2 = 0	L2 = 0
L = 105 at 20.0°C	L5 < 0.500*L	L5 < 0.333*L
L = 180 at 17.5°C	L6=0	L6=0
L = 300 at 15.0°C	L3a+L3b < 0.333L	L3a+L3b < 0.333*L
	TSgc > 2200	TSgc > 2500
Maize (sub-tropics, grain)	Climates: STr (SR+WR), Te	Climates: STr (SR+WR), Te
(Maize III)	L5a+L5b < 0.200*L	L5 = <0.200*L
L = 105/120/135/150/165/180	L6=0	L6=0
	TSgc>1900	TSgc>2400
Maize (temperate, silage)	Climates: STr (SR+WR), Te	Climates: STr (SR+WR), Te
(Maize IV)	L5 < 0.667*L	L5 < 0.667*L
L = 105/120/135/150/165/180	L6=0	L6=0
	TSgc>1700	TSgc > 1900
	no permafrost	no permafrost
Irish Potato	Climates: B, Te, STr, Tr	Climates: B, Te, STr, Tr
L = 90/120/150/180	L6a < 0.333*L	L6a < 0.333*L
	L6b < 0.167*L	L6b < 0.167*L
	L2 < 0.333*L	L2 < 0.333*L
	L1 = 0	L1 = 0
	L6+L5+L4 > 0.400*L	L6+L5+L4 > 0.400*L
	TSgc >1200	TSgc>1500
	no permafrost	no permafrost
Pearl Millet	Climates: Tr	Climates: Tr
L = 70/90	L4a+L4b < 0.167*L	L4 = 0
	L5=L6=0	L5=L6=0
	TSgc > 1600	TSgc > 1800
Cowpea	Climates: Tr	Climates: Tr
L = 80/100/120	L4a+L4b < 0.167*L	L4 = 0
	L5=L6=0	L5=L6=0
	TSgc > 1800	TSgc > 2100
Cassava	Climates: Tr	Climates: Tr
L = 12 months	L4 < 0.333*L	L4 < 0.167*L
	L1 < 0.667 * L	L1 < 0.667 * L
	L5=L6=0	L5=L6=0
	TSgc> 6500	TSgc> 7500

Crop	Sub-optimal Conditions	Optimal Conditions
Sweet Potato	*Climates: Tr, STr (SR)*	*Climates: Tr, STr (SR)*
L = 150/180/210	*L4 < 0.333*L*	*L4 < 0.333 * L*
	L5 = L6= 0	*L5=L6=0*
	L1< 0.500 * L	*L1 < 0.500 * L*
	TSgc > 3500	*TSgc > 4000*
Foxtail Millet (Setaria)	*Climates: STr (SR+WR), Te*	*Climates: STr (SR+WR), Te*
L = 75/90/105/120	*L5a+L5b < 0.167*L*	*L5 = 0*
	L3>0	*L3>0*
	L6=0	*L6=0*
	TSgc > 1500	*TSgc > 1800*
Sugarcane	*Climates: Tr, STr (SR + WR)*	*Climates: Tr, STr (SR + WR)*
L = 12 months	*L4 + L5 < 0.667*L*	*L4 < 0.667*L*
	L5 + L4+L3 >0.084*L (n.a)	*L4 + L3 > 0.084*L*
	L6 = 0	*L5 + L6 = 0*
	TSgc> 6250	*TSgc > 6500*
Sugarbeet	*Climates: Te, STr (SR+WR)*	*Climates: Te, STr (SR+WR)*
L = 150/165/180/195/210	*L6a < 0.333 * L; L6b <0.167 * L*	*L6a < 0.333 * L; L6b <0.167 * L*
	L6+L5 > 0.167*L	*L6+L5 > 0.167*L*
	L2 < 0.400*L	*L2 < 0.400*L*
	L1 = 0	*L1 = 0*
	TSgc > 1600	*TSgc> 2000*
	no permafrost	*no permafrost*
Lowland Phaseolus Bean	*Climates: Tr*	*Climates: Tr*
L = 90/120/150	*L4a+L4b < 0.167*L*	*L4 = 0*
	L6+L5=0	*L6+L5=0*
	TSgc > 1800	*TSgc > 2400*
Highland Phaseolus Bean	*Climates: Tr*	*Climates: Tr*
L = 120 at 17.5°C	*L5a+L5b < 0.500*L*	*L5a+L5b < 0.500*L*
L = 150 at 15.0°C	*L3a+L3b < 0.050*L*	*L3a+L3b < 0.050*L*
L = 180 at 12.5°C	*L1+L2 = 0*	*L1+L2 = 0*
	L6=0	*L6=0*
	TSgc > 1500	*TSgc> 1800*
Phaseolus Bean (temperate)	*Climates: Te, STr (SR+WR)*	*Climates: Te, STr (SR+WR)*
L = 90/120/150	*L5< 0.667*L*	*L5 < 0.667*L*
	L5+L4+L3 > 0.500*L	*L5+L4+L3 > 0.500*L*
	L1 = 0	*L1 = 0*
	L6=0	*L6=0*
	TSgc > 1400	*TSgc > 1700*
Chickpea (cold tolerant)	*Climates: STr (WR)*	*Climates: STr (WR)*
L = 150/180	*L6a < 0.333*L*	*L6a < 0.333*L*
Winter sowing (cold resistant)	*L5b + L6b < 0.167*L*	*L5b + L6b < 0.167*L*
(data from ICARDA)	*L6a + L5a + L4a > 0.333*L*	*L6a + L5a + L4a > 0.333*L*
	L4b + L3b + L2b = 0	*L4b+L3b+L2b= 0*
	L1 < 0.167*L	*L1 < 0.167*L*
	L3a > 0	*L3a>0*
	TSgc > 1700	*TSgc > 2200*
Chickpea	*Climates:Tr, STr (SR+WR)*	*Climates:Tr, STr (SR+WR)*
L = 90/105/120	*L6a < 0.167*L*	*L6 = 0.167*
	L1 < 0.167*L	*L1 <0.167 * L*
	L6b+L5b+L4b+L3b+L2b = 0	*L5b+L4b+L3b+L2b = 0*
	L6a+L5a+L4a > 0.167*L	*L6a+L5a+L4a > 0.167*L*
	L3a>0	*L3a>0*
	TSgc > 1500	*TSgc > 2100*
Groundnut	*Climates: Tr, STr (SR+ WR), Te*	*Climates: Tr, STr (SR+ WR), Te*
L = 90/105/120	*L4a+L4b < 0.167*L*	*L4 = 0*
	L5=L6=0	*L5=L6=0*
	TSgc > 2200	*TSgc > 2500*
Soybean (tropics)	*Climates: Tr*	*Climates: Tr*
L = 90/105/120	*L4a+L4b < 0.500*L*	*L4 < 0.333*L*
	L5=L6=0	*L5=L6=0*
	TSgc > 2100	*TSgc > 2400*

Crop	Sub-optimal Conditions	Optimal Conditions
Soybean (sub-tropics)	*Climates:STr(SR+WR), Te*	*Climates:STr(SR+WR), Te*
L = 105/120/135	*L5 =0*	*L5 =0*
	*L3+L4 > 0.333*L*	*L6=0*
	*L1 < 0.333*L*	*L3+L4 > 0.333*L*
	TSgc > 1700	*L1 <0.333*L*
		TSgc > 2000
Sunflower (tropics)	*Climates:Tr*	*Climates:Tr*
L= 135/150/165	*L5 + L4 + L3 > 0.500* L*	*L5 + L4 + L3 > 0.500* L*
	*L3 < 0.500*L*	*L3 < 0.500*L*
	*L4 > 0.167 * L*	*L4 > 0.167 * L*
	L1 = L2 = L6 = 0	*L1 = L2 = L6 = 0*
	TSgc > 2200	*TSgc > 2500*
Sunflower (sub-tropics)	*Climates:STr (SR+WR), Te*	*Climates:STr (SR+WR), Te*
L = 135/150/165	*L5 < 0.300*L*	*L5 < 0.200*L*
	*L5+L4 + L3 > 0.400*L (n.a.)*	*L5+L4+L3 > 0.400*L (n.a.)*
	*L1 < 0.333*L*	*L1 < 0.333*L*
	L6 = 0	*L6 = 0*
	TSgc > 2000	*TSgc > 2400*
Winter Rape	*Climates: Te, STr (SR+TR)*	*Climates: Te, STr (SR+TR)*
L = 35 + 105	*L6a < 0.667*Lb*	*L6a < 0.500*Lb*
L = 45 + 120	*L2a+L2b < 0.400*Lb*	*L2a+L2b < 0.400*Lb*
	L1a+L1b = 0	*L1a+L1b = 0*
	*L2b+L3b+L4b+L5b < 0.500*Lb*	*L2b+L3b+L4b+L5b < 0.500*Lb*
	N4b+N5b +N6b > La	*N4b+N5b +N6b > La*
	*TSgc > 1200 **	*TSgc > 1400 **
	LGP $_{t=5}$ < 365	*LGP $_{t=5}$ < 365*
	dormancy required	*dormancy required*
	no permafrost	*no permafrost*
Spring Rape	*Climates: Te, STr (SR+WR)*	*Climates: Te, STr (SR+WR)*
L = 135/150/165	*L6a < 0.333*L*	*L6a < 0.333*L*
	*L2a+L2b < 0.400*L*	*L2a+L2b < 0.400*L*
	L1a+L1b = 0	*L1a+L1b = 0*
	*L2b+L3b+L4b+L5b < 0.500*L*	*L2b+L3b+L4b+L5b < 0.500*L*
	TSgc > 1400	*TSgc > 1800*
	LGP $_{t=5}$ < 365	*LGP $_{t=5}$ < 365*
	no permafrost	*no permafrost*
Rape (rabi)	*Climates: Tr, STr (SR + WR)*	*Climates: Tr, STr (SR + WR)*
L = 135/150/165	*L6a < 0.333*L*	*L6a < 0.333*L*
	*L2a+L2b < 0.500*L*	*L2a+L2b < 0.500*L*
	L1a+L1b = 0	*L1a+L1b = 0*
	*L6+L5+L4 > 0.167*L*	*L6+L5+L4 > 0.167*L*
	TSgc > 1400	*TSgc > 1800*
	LGP $_{t=5}$ = 365	*LGP $_{t=5}$ = 365*
Cotton (tropics)	*Climates: Tr*	*Climates: Tr*
L = 135/150/165/180	*L4a+L4b < 0.250*L*	*L4 = 0*
	TSgc > 3000	*TSgc > 3400*
Cotton (sub-tropics)	*Climates:STr (SR+WR), Te*	*Climates:STr(SR+WR), Te*
L = 135/150/165	*L4a+L4b < 0.333*L*	*L4a+L4b < 0.167*L*
	TSgc > 2700	*TSgc > 3000*
Banana/Plantain	*Climate: Tr, STr (SR+WR)*	*Climate: Tr, STr (SR+WR)*
L = 12 months	*L5< 0.667*L*	*L5< 0.500*L*
	*L2+L3 >0.333*L*	*L2+L3 >0.400*L*
	*L1 < 0.667 * L*	*L1 < 0.500 * L*
	TSgc > 6000	*TSgc > 7000*
Oil Palm	*Climate: Tr, STr (SR)*	*Climate: Tr, STr (SR)*
L = 12 months	*L4a+L4b< 0.333*L*	*L4 < 0.167*L*
	TSgc > 7500	*TSgc > 8000*

* applicable to post-dormancy period only

Crop	Sub-optimal Conditions	Optimal Conditions
Olive	*Climates: STr (SR+WR), Te*	*Climates: STr (SR+WR), Te*
L = 12 months	*L8 = L9 = 0*	*L8 = L9 = 0*
	L7 + L6 + L5 + L4 > 0.400*L	*L7 + L6 + L5 + L4 > 0.400*L*
	L4 + L3+ L2+ L1 > 0.333*L	*L4 + L3+ L2+ L1 > 0.333*L*
	TSgc > 4000	*TSgc > 5000*
Alfalfa (Lucerne)	*Climates: Te, STR (SR+WR)*	*Climates: Te, STR (SR+WR)*
L = LGP $_{t=5}$	*Gc (L) = (LGP $_{t=5}$) > 120 days .*	*Gc (L) = (LGP $_{t=5}$) > 150 days .*
	L6 < 0.500*L	*L6 < 0.500*L*
	L1 < 0.333*L	*L1 < 0.333*L*
	TSgc > 1800	*TSgc > 2250*
Grasses	*Climates: Tr, STR (SR+WR), Te*	*Climates: Tr, STR (SR+WR), Te*
L= LGP $_{t=5}$	*TSgc > 750*	*TSgc > 1000*
	Gc (L) = (LGP $_{t=5}$) >90 days	*Gc (L) = (LGP $_{t=5}$) >120 days*
Grasses	*Climates:Te, B*	*Climates:Te*
L= LGP $_{t=5}$	*TSgc > 750*	*TSgc > 1000*
	Gc (L) = (LGP $_{t=5}$) >90 days	*Gc (L) = (LGP $_{t=5}$) >120 days*