

Tomato, *Solanum lycopersicum*
Vegetable Phenology (Degree-Day) Model Documentation
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Introduction: The CROPTIME project of OSU is intended to aid vegetable producers in timing the planting and harvest dates for major vegetable varieties, serving Western Oregon and Washington, and perhaps other regions with similar climate and soil conditions. Heat units in the form of degree-days can be used to provide closer guidance than simple average days development. We have determined the thresholds and degree-day requirements for four tomato varieties. Using the range of forecasts available at uspest.org, one may reasonably predict events such as flowering and harvest dates for these and similar (related) varieties.

Methods: Using events monitored in the field, the lowest error (C.V. or coefficient of variation) was used to determine lower and upper threshold temperature values for four transplanted tomato varieties. We used between 6 and 11 site-years for each variety. All site years were from the Willamette Valley of Western Oregon from 2013-2015 except one variety from Western Washington in 2015. Varieties included: “Big Beef”, “Indigo Rose”, “Monica”, and “New Girl”. Standard sites included the OSU vegetable farm (near Corvallis, OR), the OSU NWREC research farm (near Aurora, OR), Tabor farm (near Scio, OR), with other farms depending on variety and year. Degree-day values were calculated using the Baskerville-Emin single sine formula with the online calculator at uspest.org.

The main model interval used to determine thresholds for most varieties was from transplant date (usually with 3 to 5 true leaves) to first ripe harvest (when the median plant has 4 mature fruit). Other event degree-day requirements included approximate first flower date (the majority of plants with at least one open inflorescence) and 2nd week of fruit expansion (or approximately 2” fruit diameter) for majority of plants, depending on variety.

Results: All tomato phenology models (Tables 1-4) were determined by a combination of the lowest C.V. method, and consideration of published results from the literature. They were assigned a lower thresholds of 45°F (11.11°C), and upper threshold of 92°F (33.3°C) and single-sine degree-day calculations using the horizontal upper cutoff method. Degree-day models for the 4 transplant varieties had C.V. values between 4.2 and 7.6, in three cases better than, and in one case worse than, using average number of days to harvest, which had C.V. values between 3.3 and 7.7. The mean absolute deviations (MAD) to predict harvest date using average DDs ranged from 2.0 to 3.4 days.

Using the Models: These models are available at the OSU Integrated Plant Protection (IPPC) websites <https://uspest.org/dd/model> and https://uspest.org/dd/model_app (the latter also available as a cell phone app; search for “uspest.org” at your app store starting Feb. 2019 for Android and April 2019 for Apple). To use the website, select the nearest weather station code by entering a nearby city, zipcode, or weather station code, or clicking in the Google map. Then select “CROPTIME models” at “Model Category” and select any of the listed tomato models using the “Model:” pulldown menu. Enter up to 4 start dates (not available for model_app version), end date (any date after expected last harvest date), and forecast type. Click on button (or tab) for model output. New charting output compares up to six forecast types showing a range of expected harvest dates. For more information, see the CROPTIME website at: <https://extension.oregonstate.edu/croptime>.

Quick links to the four tomato variety models:

Big beef: <https://uspest.org/dd/model?spp=tbb>

Indigo rose: <https://uspest.org/dd/model?spp=tir>

Monica: <https://uspest.org/dd/model?spp=tmo>

New girl: <https://uspest.org/dd/model?spp=tng>

Suggested applications for the models: The model may be run to test whether a particular variety will likely reach maturity in your region, or determine an optimal planting time for a variety to reach maturity by a given date. Using the multiple start date version of the calculator, you can simultaneously check up to four different planting dates. With data from past years, you can determine the probability that later plantings will have sufficient heat units to reach maturity in your region. You may

want to warm the seedlings or plantings under glass or plastic, or use plastic mulch to warm the soil to artificially extend the growing season in marginal regions and years. For successive plantings, you can determine the approximate optimal dates to plant in order to produce longer and more even harvests.

Table 1. Summary for Big Beef tomato – lower threshold 45°F, upper threshold 92°F, single sine horizontal cutoff method, begin date usually at 3-5 leaves present at transplant. Data from Western Oregon, 2013-2015.

Farm	Nearby weather station code	Date begin	First Flower Date	2" Fruit Growth		Harvest 4 ripe fruit per plant		Predicted Harvest based on 1969 DD	Diff-erence Days	Ab-solute Diff. Days				
				Days	DDs 45/92	Days	DDs 45/92				Days	DDs 45/92		
OSU VEG	CRVO	06/10/13	07/02/13	22	418.8	07/29/13	49	1049.4	9/3/2013	85	1888.5	09/07/13	4	4
SIO TABOR	ODT95	05/19/14	06/12/14	24	448.5	07/03/14	NA	NA	08/08/14	81	1859.7	08/12/14	4	4
OSU VEG	CRVO	05/27/14	06/24/14	28	427.1	07/16/14	50	960.4	08/21/14	86	1871.3	08/25/14	4	4
NWREC	ARAO	06/05/13	07/02/13	27	558.8	07/26/13	51	1145	08/30/13	86	1992.2	08/30/13	0	0
NWREC	ARAO	06/02/14	06/25/14	23	411.7	07/17/14	45	899.1	08/22/14	81	1914.4	08/25/14	3	3
NWREC	ARAO	05/27/15	06/22/15	26	585.3	07/11/15	45	1139.9	08/18/15	83	2084.5	08/13/15	-5	5
NWREC	ARAO	07/01/15	07/22/15	21	598.1	08/12/15	42	1141.3	09/27/15	88	2084.9	09/20/15	-7	7
OSU VEG	CRVO	06/05/15	06/27/15	22	503.5	07/17/15	42	1014.9	08/25/15	81	1980.2	08/25/15	0	0
mean:				24.4	504.7		45.8	1050.1		83.7	1969.6		-0.1	3.3
SD:				2.6	77.9		3.7	97.9		2.7	90.8		4.3	2.4
CV (sd/mean*100):				10.6	15.4		8.1	9.3		3.3	4.6			

Table 2. Summary for Indigo Rose tomato – lower threshold 45°F, upper threshold 92°F, single sine horizontal cutoff method, begin date usually at 3-5 leaves present at transplant. Data from Western Oregon, 2013-2015.

Farm	Nearby weather station code	Date begin	First Flower Date	2 nd week fruit expansion		Harvest 4 ripe fruit per plant		Predicted Harvest based on 2010 DD	Diff-erence Days	Ab-solute Diff. Days				
				Days	DDs 45/92	Days	DDs 45/92				Days	DDs 45/92		
OSU VEG	CRVO	06/10/13	07/09/13	29	572.4	07/29/13	49	1049.4	09/12/13	94	2105.2	09/09/13	-3	3
OSU VEG	CRVO	05/27/14	07/01/14	35	576.1	07/16/14	50	960.4	08/26/14	91	2003.1	08/27/14	1	1
NWREC	ARAO	06/05/13	07/04/13	29	605.9	07/25/13	50	1117.3	08/30/13	86	1992.2	08/31/13	1	1
NWREC	ARAO	06/02/14	07/02/14	30	574.5	07/18/14	46	1009.8	08/25/14	84	1991.9	08/26/14	1	1
NWREC	ARAO	05/27/15	06/24/15	28	633.5	07/15/15	49	1242.2	08/19/15	84	2147.4	08/14/15	-5	5
OSU VEG	CRVO	06/05/15	06/29/15	24	558	07/22/15	47	1141	08/22/15	78	1915.8	08/27/15	5	5
mean:				29.2	589.6		48.4	1094.1		84.6	2010.1		0.6	2.6
SD:				3.5	27.7		1.6	101.3		5.7	84.8		3.5	2.0
CV (sd/mean*100):				12.1	4.7		3.4	9.3		6.7	4.2			

Table 3. Summary for Monica tomato – lower threshold 45°F, upper threshold 92°F, single sine horizontal cutoff method, begin date usually at 3-5 leaves present at transplant. Data from Western Oregon, 2013-2015.

Farm	Nearby weather station code	Date begin	First Flower Date	2 nd week fruit expansion				Harvest 4 ripe fruit per plant				Predicted Harvest based on 1975 DD	Difference Days	Absolute Diff. Days
				Days	DDs 45/92	Date	Days	DDs 45/92	Date	Days	DDs 45/92			
47 th LUS	ARAO	05/20/14	06/15/14	26	450.2	07/09/14	50	976.7	08/15/14	87	1945	08/17/14	2	2
OSU VEG	CRVO	05/27/14	06/30/14	34	544.1	07/16/14	50	960.4	08/26/14	91	2003.1	08/26/14	0	0
NWREC	ARAO	06/05/13	07/08/13	33	689.4	07/25/13	50	1117.3	08/30/13	86	1992.2	08/30/13	0	0
NWREC	ARAO	06/02/14	06/30/14	28	513	07/18/14	46	1009.8	08/18/14	77	1818.8	08/20/14	2	2
NWREC	ARAO	05/27/15	06/24/15	28	633.5	07/15/15	49	1242.2	08/19/15	84	2147.4	08/13/15	-6	6
OSU VEG	CRVO	06/05/15	07/01/15	26	619.5	07/21/15	46	1123.8	08/22/15	78	1915.8	08/25/15	3	3
mean:				29.8	599.9		48.2	1090.7		83.2	1975.5		-0.2	2.2
SD:				3.5	88.2		2.0	108.7		5.4	109.1		3.3	2.2
CV (sd/mean*100):				11.7	14.7		4.1	10.0		6.5	5.5			

Table 4. Summary for New Girl tomato – lower threshold 45°F, upper threshold 92°F, single sine horizontal cutoff method, begin date usually at 3-5 leaves present at transplant. Data primarily from Western Oregon, 2013-2015.

Farm	Nearby weather station code	Date begin	First Flower Date	2" Fruit Growth				Harvest 4 ripe fruit per plant				Predicted Harvest based on 1844 DD	Difference Days	Absolute Diff. Days
				Days	DDs 45/92	Date	Days	DDs 45/92	Date	Days	DDs 45/92			
OSU VEG	CRVO	06/10/13	07/02/13	22	418.8	07/25/13	45	964	08/24/13	75	1650.9	09/02/13	9	9
NWREC	ARAO	06/05/13	07/02/13	27	558.8	07/25/13	50	1117.3	08/25/13	81	1863	08/24/13	-1	1
SIO G	CRVO	05/24/13	06/21/13	28	410.6	07/15/13	52	961.5	08/22/13	90	1866.3	08/22/13	0	0
SIO T	ODT95	05/19/14				07/03/14	45	868.6	07/31/14	73	1629.4	08/08/14	8	8
OSU VEG	CRVO	05/27/14	06/24/14	28	427.1	07/16/14	50	960.4	08/19/14	84	1830.2	08/20/14	1	1
NWREC	ARAO	06/05/13	07/02/13	27	558.8	07/25/13	50	1117.3	08/30/13	86	1992.2	08/24/13	-6	6
NWREC	ARAO	06/02/14	06/25/14	23	411.7	07/08/14	36	734.5	08/12/14	71	1659.6	08/19/14	7	7
NWREC	ARAO	05/27/15	06/18/15	22	499.7	07/09/15	43	1093.7	08/12/15	77	1963.7	08/08/15	-4	4
NWREC	ARAO	07/01/15	07/23/15	22	621.4	08/15/15	45	1213.1	09/20/15	81	1981.9	09/12/15	-8	8
OSU VEG	CRVO	06/05/15	06/27/15	22	503.5	07/20/15	45	1103	08/19/15	75	1849.2	08/19/15	0	0
Deerpk WA	D6242	05/21/15	06/19/15	29	564.6	07/12/15	52	1182.7	08/15/15	86	1992.8	08/10/15	-5	5
mean:				25.0	497.5		46.6	1028.7		79.9	1843.6		0.1	4.5
SD:				3.0	77.1		4.8	144.5		6.2	140.0		5.8	3.4
CV (sd/mean*100):				12.1	15.5		10.3	14.0		7.7	7.6			