

Croptime: Scheduling Harvests & Timing Weed Management

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Cooperating farmers & seed companies



Oregon State
University



<https://smallfarms.oregonstate.edu/croptime>

OREGON STATE UNIVERSITY EXTENSION

EM 9305



Photos © Oregon State University

How long does it take broccoli to mature in your part of the state? A Croptime model can help you estimate more accurate maturity dates.

Vegetable Degree-day Models

An Introduction for Farmers and Gardeners

N. Andrews, L. Coop, H. Stoven, H. Noordijk and A. Heinrich

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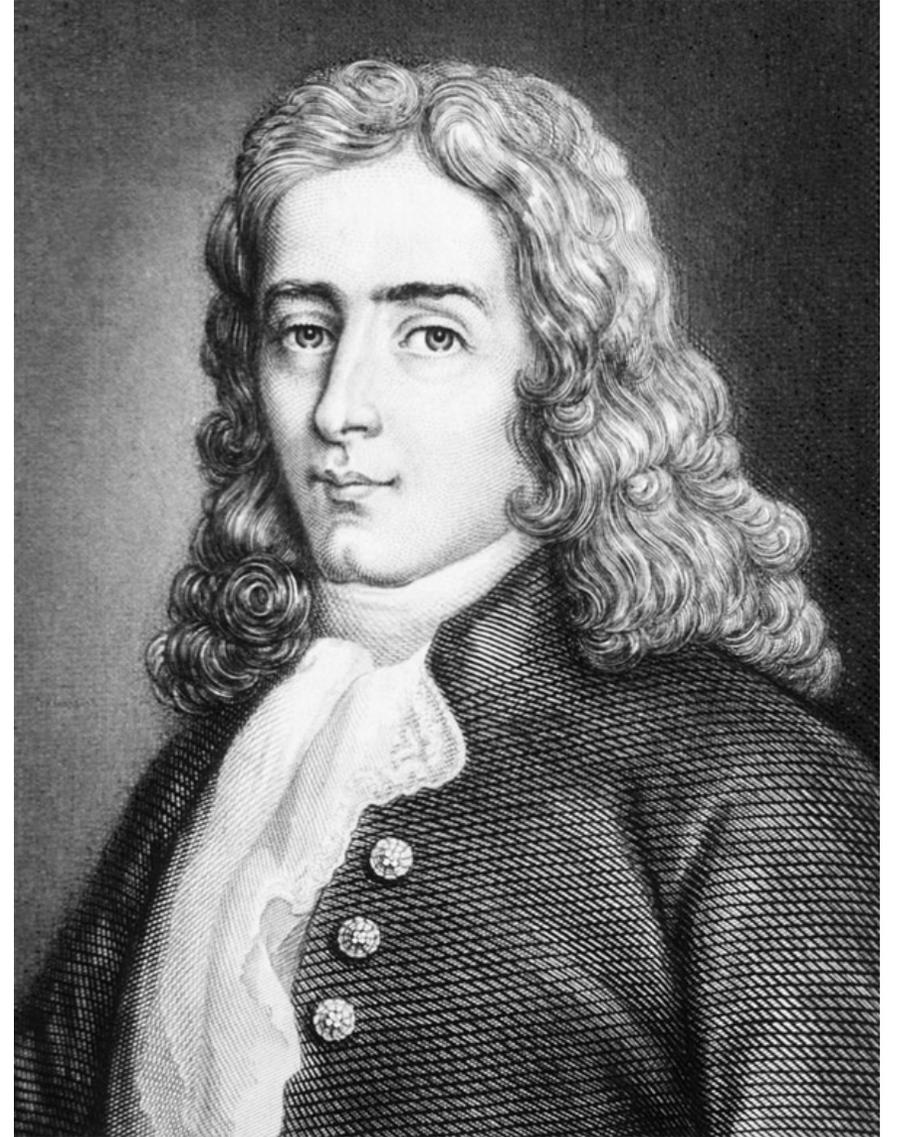
34 veg & weed degree-day models

Crops	Weeds
Broccoli (4)	Hairy nightshade
Cucumber (7)	Lambsquarter
Snap beans (3)	Redroot pigweed
Sweet pepper (4)	
Tomato (4)	



René A.F. de Réaumur (1683-1757)

- Used daily mean temperatures to predict plant development in mid 18th Century
- The importance of threshold temperatures was recognized by mid-20th Century (e.g. Arnold, 1959)
- Threshold temperatures are low or high temperatures that limit development and growth: used in degree-day models
- Measuring time & temperature is more accurate than time alone if you want to predict development of ectotherms (“cold blooded” organisms) like plants, insects, fungi, bacteria, etc.





Simple average degree-days

$$\frac{T_{\min} + T_{\max}}{2} - T_{\text{base}} = \text{degree-days}$$

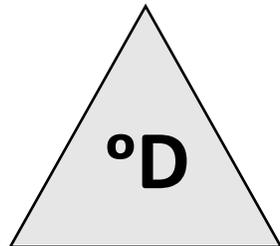
T_{\min} = minimum daily temperature

T_{\max} = maximum daily temperature

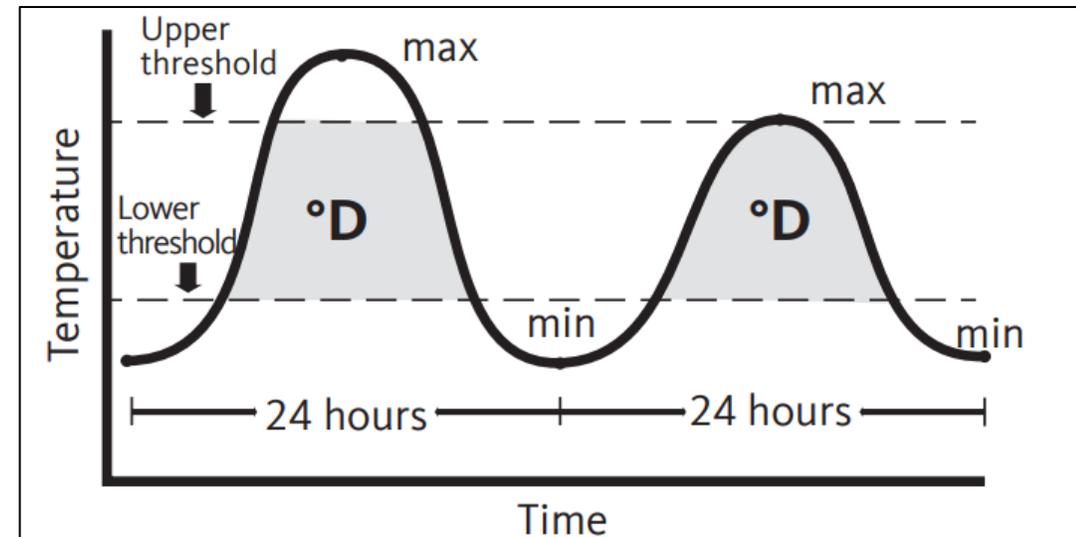
T_{base} = lower development threshold

- A crop with T_{base} of 50°F and no upper threshold
- A day with low of 40°F (T_{\min}) and a high of 90°F (T_{\max})

$$\frac{40 + 90}{2} - 50 = 15 \text{ degree-days}$$



DDs and sine curves



Graphic: University of California Statewide IPM Program

Figure 1. Accumulation of DDs within upper and lower development thresholds using the single sine method.

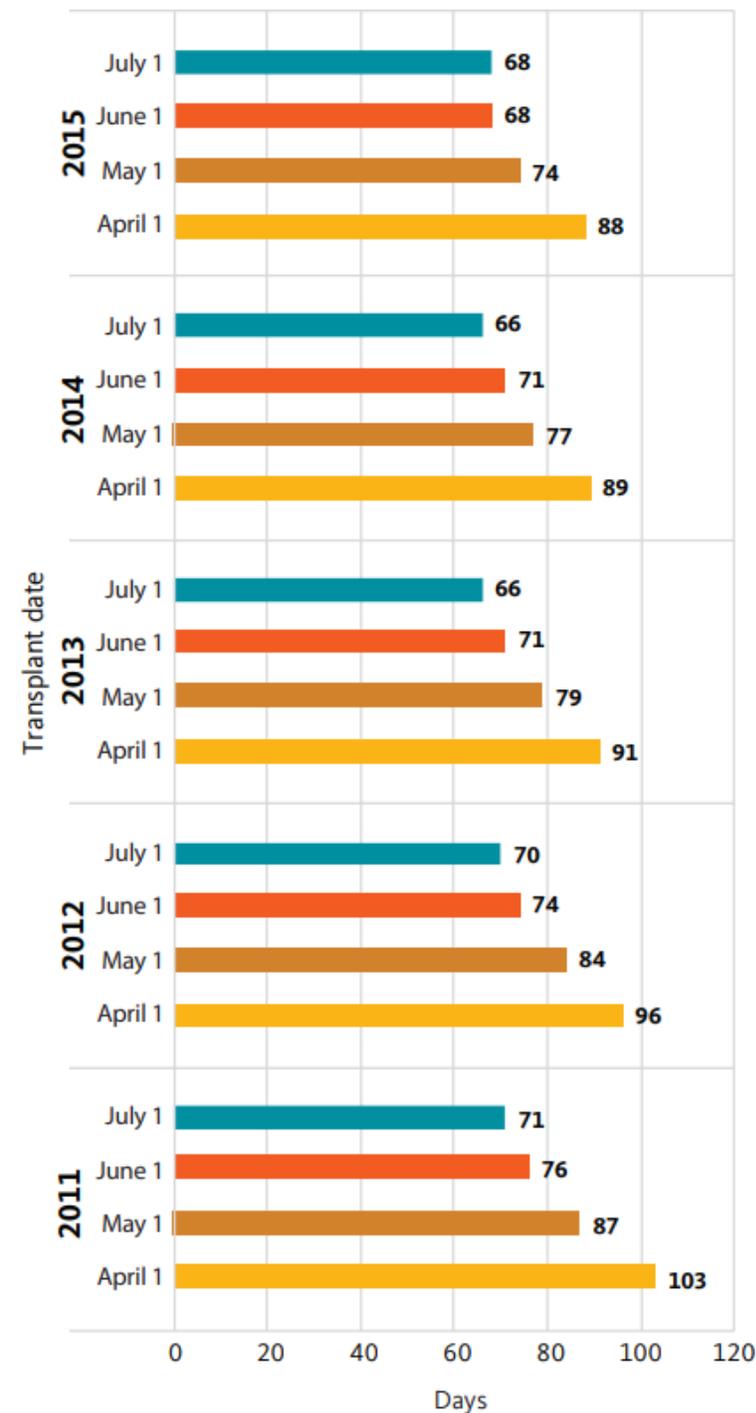


Using DD models to schedule planting & harvest

- More accurate than rough guidelines (e.g. days to maturity in seed catalogs)
- Schedule planting dates to ensure consistent supply during the harvest season with few gaps or gluts
- If you check the models during the season, the information can help communicate with buyers if crops are earlier or later than expected due to weather
- Early season predictions rely on long term forecasts
- Model predictions become more accurate during the season as actual weather data replaces weather data from long term forecasts
- Black plastic mulch increased pepper yield, but not development rate
- Separate models are used for transplanted vs. direct-seeded crops
- Crops grown in high tunnels, low tunnels or under row covers usually develop at different rates. Temperature data from modified environments can be used if available.

'Arcadia' broccoli model runs

- Transplant dates = April 1, May 1, June 1 & July 1 (2011-2015)
- Different seed catalogs estimated 63-94 days to maturity (DTM)
- In the Willamette Valley we saw 66-103 DTM in model runs
- 20-32 days difference within a season depending on planting date
- 0-14 days difference at the same planting date in different seasons
- Average 7 days slower development in cooler years (2011-2012) than warmer years (2013-2015)
- Planting interval left variable production gaps that can be predicted with models, then adjust planting dates





Using Croptime

- **Choose** a local weather station:
- **Select** the crop and cultivar
- **Enter** up to four planting dates (only one in the mobile app)
- **Choose** your long term forecast type (optional) historical data or climate models, and output format (model events is default, daily output is optional)
- **“Click here to see full model output”**

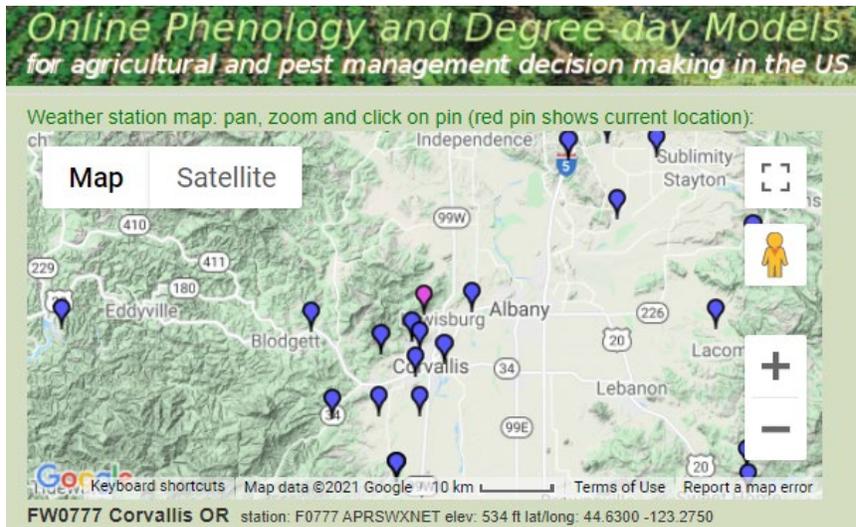


Using Croptime – computer or tablet

<https://smallfarms.oregonstate.edu/croptime>

CROPTIME CALCULATOR

Go to the calculator to use the DD models



- **Choose** a local weather station:
- **Select** the crop and cultivar
- **Enter** up to four planting dates (only one in the mobile app)
- **Choose** your long term forecast type: climate models (default) or historical data
- **“Click here to see full model output”**



Sample model output for 'Arcadia' broccoli, Kennewick, WA, 2021



MODEL OUTPUT

Weather station: 2021 D6561 APRSWXNET Kennewick DW6561 WA Lat:46.1706 Long:-119.1761 Elev:874 QA :

Month	Day	Max (F)	Min (F)	Precip(in)	DDs(F) Today	Day length (hr)	QA + Notes	Starting 4-1	
								Cumu. DDs(F)	Model Events
4	1	73.0	41.0	0.00	24.6	13.1		25	Transplanted - 2-4 leaves
5	1	74.0	54.0	0.02	31.2	14.7			
6	1	95.0	64.0	0.00	36.9	15.9			
6	2	99.0	64.0	0.00	36.9	15.9		1681	50% head initiation
6	21	94.0	64.0	0.00	36.8	16.2		2304	First harvest
6	24	96.0	65.0	0.00	37.1	16.2		2417	
7	1	94.0	69.0	0.00	37.9	16.1		2683	Early flowering

Scroll right for other planting dates



Sample model output for 'Arcadia' broccoli, Kennewick, WA, 2021

2nd planting

3rd planting

4th planting

Month	Day	Starting 5-1		Starting 6-1		Starting 7-1			
		Cumu. DDs(F)	Model Events	Cumu. DDs(F)	Planting date	First harvest	Days to maturity	Early flowering	Production gap (days)
4	1								
5	1	31	Transplanted - 2-4 leaves		April 1, 2021	June 21	81	July 1	
6	1	935		37	May 1, 2021	July 10	70	July 20	9
6	2	971		74					
6	21	1595		697	June 1, 2021	Aug 3	63	Aug 13	14
6	24	1708	50% head initiation	810					
7	1	1974		1076	July 1, 2021	Sep 1	62	Sep 13	19
7	10	2311	First harvest	1413					
7	17	2572		1674	50% head initiation				
7	20	2685	Early flowering	1787					
8	3	3205		2308	First harvest				
8	13	3574		2676	Early flowering				
8	14	3612		2714				50% head initiation	
9	1	4219		3321				First harvest	
9	13	4635		3737				Early flowering	



Using Croptime: smart phone or tablet

https://uspest.org/dd/model_app



Online Phenology and Degree-day Models
for agricultural and pest management decision making in the US

Intro | Station | **Model** | Output | Graph

Weather Station

Currently selected: **CRVO CORVALLIS OR**

You can search for stations by city, other place name, ZIP code, or station code.

CRVO
search for stations OK

- Corvallis, OR 97330, USA lat: 44.5840 long: -123.2799
(MAP)

- E7764 EW7764 Corvallis (elev: 367 ft Quality 55%)
- C5709 Corvallis CW5709 (elev: 239 ft Quality 90%)
- AW100052 Corvallis.E (elev: 210 ft Quality 79%)
- OD150 OR34 EB at Peoria Rd M (elev: 220 ft Quality 96%)
- CRVO CORVALLIS (elev: 230 ft Quality 97%)**
- KCVO Corvallis Muni Apt (elev: 246 ft Quality 79%)
- E4613 EW4613 Philomath (elev: 308 ft Quality 97%)
- GEL03 GELLATLY (elev: 860 ft Quality 91%)

[About Quality Scores](#) [About Search Data](#)

Weather data is normally from a station, but you can upload your own if you prefer.

Weather station Upload file

Next

Select the "Model" tab to choose the model to use and related details.



Using Croptime – smart phone or tablet

Online Phenology and Degree-day Models for agricultural and pest management decision making in the US

Intro | Station | Model | Output | Graph

(no model selected) at CRVO, CORVALLIS OR, 2023

Species / Model

Select a model or species. (see list of models) To choose your own calculation method and threshold temperatures, chose "degree-day calculator".

Model category: CROPTIME models

Select Model:

Dates

Choose model before setting start date

Start: Jun 1 2023

End: Dec 31

Options

Forecast type: after 7 days, use CFSv2 extended seasonal forecast

Temperature scale: Fahrenheit

Next

That's all the necessary input. From here, you can study the model details below, or go to the "Output" and "Graph" tabs for your model output.

Select Model:

- degree-day calculator (general purpose)
- bean (snap)-5630 (Croptime project, Andrews et al. 2020)
- bean (snap)-Provider (Croptime project, Andrews et al. 2020)
- bean (snap)-Sahara (Croptime project, Andrews et al. 2020)
- broccoli-Arcadia (Croptime project, Andrews et al 2016)
- broccoli-Emerald Pride (Croptime project, Andrews et al 2016)
- broccoli-Green Magic (Croptime project, Andrews et al 2016)
- broccoli-Imperial (Croptime project, Andrews et al 2016)
- cucumber-Cobra (dir. seed) (Croptime project, Andrews et al 2021)
- cucumber-Dasher II (dir. seed) (Croptime project, Andrews et al 2016)
- cucumber-Extreme (dir. seed)

Online Phenology and Degree-day Models for agricultural and pest management decision making in the US

Intro | Station | Model | Output | Graph

bean at CRVO, CORVALLIS OR, 2023

Species / Model

Select a model or species. (see list of models) To choose your own calculation method and threshold temperatures, chose "degree-day calculator".

Model category: CROPTIME models

Model: bean (snap)-Sahara (Croptime project, Andrews et al. 2020)

Dates

Set the start date to: date of planting (direct seed)

Start: May 1 2023

End: Dec 31

Temperatures (and degree-days) are in F; rain in inches.

date	max	min	rain	DDs today	DDs cumu	QA	events
5-1	59	44	0.00	11.6	12		* START *
5-27	73	50	0.00	21.5	541		First trifoliolate leaves
6-29	88	52	0.00	30.3	1273		First open flowers
7-18	88	58	0.00	32.7	1831		Ready for harvest

Online Phenology and Degree-day Models for agricultural and pest management decision making in the US

Intro | Station | Model | Output | Graph

bean at CRVO, CORVALLIS OR, 2023

Model Inputs

show model inputs table

Date Comparison

show Date Comparison table

Model Output

show full table

Temperatures (and degree-days) are in F; rain in inches.

date	max	min	rain	DDs today	DDs cumu	QA	events
5-1	59	44	0.00	11.6	12		* START *
5-27	73	50	0.00	21.5	541		First trifoliolate leaves
6-29	88	52	0.00	30.3	1273		First open flowers
7-18	88	58	0.00	32.7	1831		Ready for harvest

ipmPIPE Center

All data provided "as is" and users assume all risk in its use - see full disclaimer. All NWS derived data is not subject to copyright protection.

This app is produced by uspest.org at the Integrated Plant Protection Center at Oregon State University with support from the USDA National Plant Diagnostic Network. The OSU Agricultural Experiment Station



Using Croptime – if you have a good forgettory

- Sign up for “push” notification via email <https://uspest.org/push>

Create a New Account:

email:

password:

confirm password:

Create it

USPest.org [subscription email service](#) requires accounts to ensure that you control the emails we send to you.

Stations

- CORVALLIS, OR (CRVO) elev: 230 ft Quality 93%

Change Stations

Your Subscriptions

These are the models to which you are currently subscribed. You can edit them to unsubscribe, change when to receive notifications, and more for some models.

- **Broccoli-Arcadia**

Change subscribed for Tuesdays during July-October

- **Cucumber-Cobra (Dir. Seed)**

Change subscribed for Tuesdays, Thursdays during July-October

- **Pepper-Bell King**

Change subscribed for Tuesdays, Thursdays during July-October

- **Sweet Corn-Luscious-Dir. Seed**

Change subscribed for Tuesdays, Thursdays during July-October

- **Tomato-Big Beef**

Change subscribed for Tuesdays, Thursdays during July-October

Broccoli-Arcadia subscription details

Information about this crop and this model: [Andrews et al 2016](#), [Croptime project](#), [broccoli](#). This model, a degree-day model, is also available online through our [web app](#).

In which months do you want email with this model's output?

- January
- February
- March
- April
- May
- June
- July
- August
- September
- October
- November
- December

During those months, which days of the week do you want Broccoli-Arcadia model output?

- Sunday
- Monday
- Tuesday
- Wednesday
- Thursday
- Friday
- Saturday

Celsius or Fahrenheit:

Biofix event dates

When did the the biofix event "date of transplant at 2-4 true leaves" occur?

station	month	day
CORVALLIS (CRVO)	<input type="text" value="June"/>	<input type="text" value="15"/>



Using Crowthime – if you have a good forgettorry

Pest risk index report for Tuesday, October 31, 2023 :

Broccoli-Arcadia

Model source(s)

[Andrews et al 2016](#), [Crowthime project](#)

Calculation

single sine curve degree-days with thresholds 32°F, 70°F

Starts from biofix

date of transplant at 2-4 true leaves

Extended forecast type

After 7 days, use 7-month NMME based seasonal climate forecast

Broccoli-Arcadia for Station CORVALLIS OR (CRVO)

CRVO has 97% data quality score (average since March 1 (temperature only)).

[full model online](#)

Model starts Jun 15, 2023.

Date	DDs cumu	Events
Jun 15	25	Transplanted - 2-4 leaves
Aug 7	1696	50% head initiation
Aug 25	2305	First harvest
Sept 6	2684	Early flowering
Oct 31	4077	* NOW *



Vegetable Degree-day Models

An Introduction for Farmers and Gardeners

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EM 9305, 2021 - Appendix

Table 4. Model parameters for three transplanted and five direct-seeded sweet corn cultivars

Variety	Direct-seeded or transplanted	5 true leaves (DDs)	5-inch tassel (DDs)	95% silk (DDs)	Fresh harvest (DDs)	Process harvest (DDs)	DD model accuracy ¹ (days)	Observed days to harvest ²	Calendar-days accuracy ¹ (days)	Number of data sets ³
4001	DS	390	794	1075	1441	1644	±1.8	105	±22	4
Jubilee	DS	308	883	1145	1539	1597	N/A	N/A	N/A	N/A
Kokanee	DS	300	845	1130	1498	1650	±3.1	96	±8	8
Luscious	DS	442	1084	1414	1854	N/A	±1.9	78	±6	7
Luscious	TP	451	1123	1516	1934	N/A	±0.3	81	±4	3
Sugar Pearl + Temptation	DS	446	982	1342	1883	N/A	±1.5	75	±1.5	4
Sugar Pearl + Temptation	TP	409	1099	1555	2014	N/A	±2.6	81	±4	5



Five true leaves



5-inch tassel



95% silk



Fresh market harvest



Are models useful outside the Willamette Valley?

- Primarily developed with Willamette Valley data
- Local weather patterns and other factors might influence crop development rates in the Columbia Basin
 - Higher summer temperatures
 - Different light intensity
 - Different precipitation or humidity
 - Day length, etc.
- Check models:
 - Record your planting date and harvest date (refer to Growth Stage Guide on Croptime website)
 - Compare to Croptime model after harvest (using actual weather data)



David Brown, Mustard Seed Farms



“I have used degree days for over 20 years to schedule successive plantings of vegetables.”

“I have made some educated guesses... but having more information, based on some research, would be helpful in refining my schedules and maybe even using the information for more crops.”

Ben Torres-Cortez from Simplot has been using degree-days to schedule pea planting and harvest dates. In 2022 he said:

“Even though we had a cool spring that delayed our harvest by 2 weeks we were still able to harvest most of our crop with 80% of it being A Grade. Your program is a great tool for a pea planting schedule and I will keep using it.”

We don't have any pea models in Croptime, Ben used the degree-day calculator to create his own models.



Summer annual weed models

When can I stop cultivating weeds without
risking weeds going to seed?



Weed models (Peachey & Heinrich) – farmer's choice



Lambsquarter



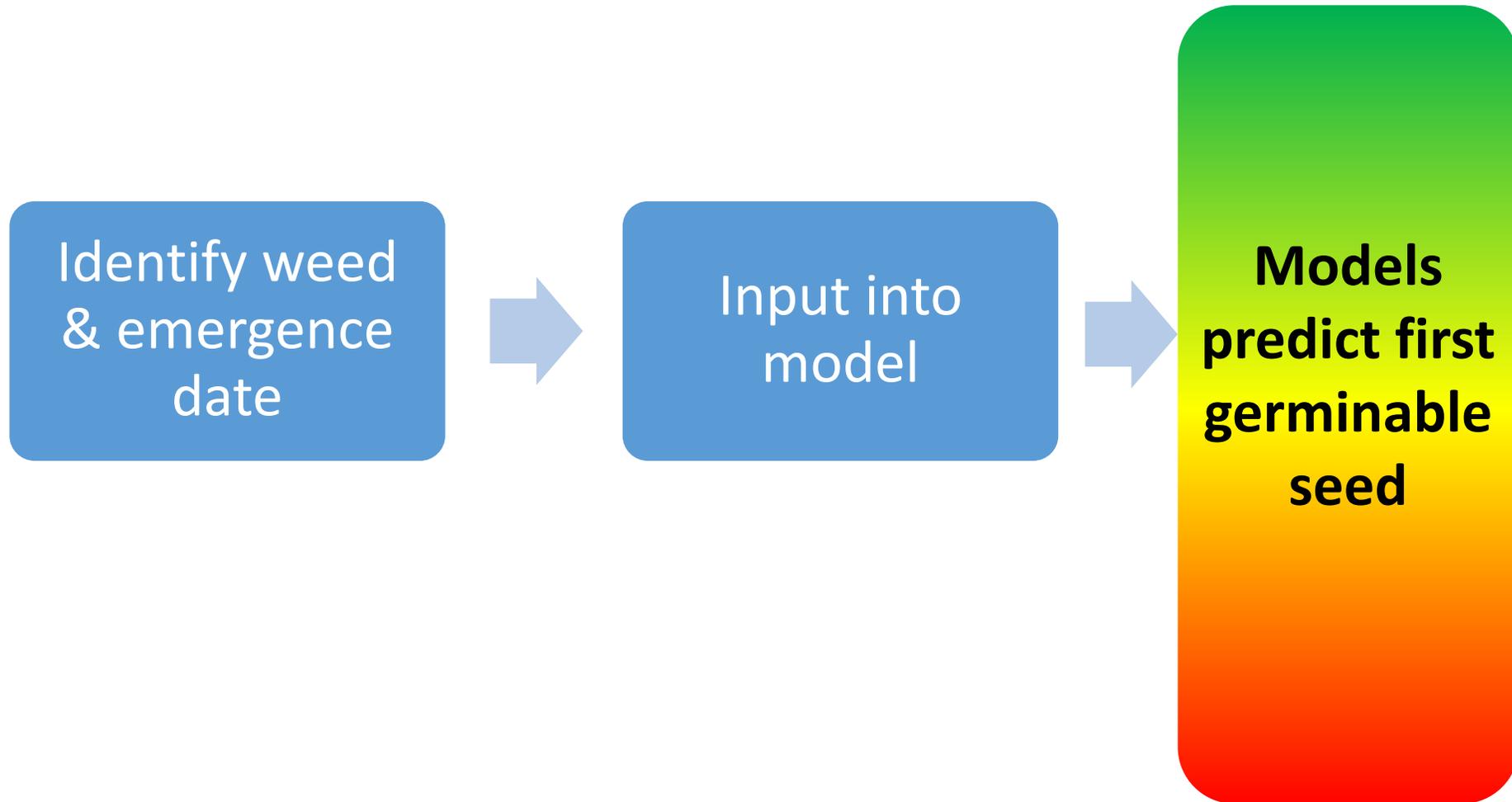
Hairy nightshade



Pigweed



Using Crowthtime weed models





Using Croptime weed models

- Models are most appropriate for late April through early July plantings
 - Influence of photoperiod on growth not considered
- Start date = cotyledon
 - Hard to identify some weeds at cotyledon stage
 - Use first flush of weeds after cultivation as start date?
- Combine with in-field observations

Weather station map: pan, zoom and click on pin (red pin shows current location):

Map Satellite

Kennewick DW6561 WA station: D6561 APRSWXNET elev: 874 ft lat/long: 46.1706 -119.1761

lambsquarter
Croptime project, CROPTIME weed model

Model category: CROPTIME models
see also "CROPTIME Home Page" for more info. on scheduling vegetable plantings

Model: lambsquarter Croptime project

Start (up to 4 start dates - based on: first emergence of cotyledon):
1. Jun 1 2. Jan 1 3. Jan 1 4. Jan 1 2021

End: Dec 1 same year

Forecast type: after 7day use CFSv2 extended seasonal forecast

Output: Condensed: yes Show Daylength: yes Critical Daylength: 12.0

[Click here to see full model output](#)

Month	Day	Starting 6-1
		Model Events
6	1	Cotyledon present
6	2	2 leaves present
6	6	4 leaves present
6	11	6 leaves present
6	22	First infloresc.
7	10	Lower 95% CI first viable seed
7	13	Average first viable seed
7	15	Upper 95% CI first viable seed

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