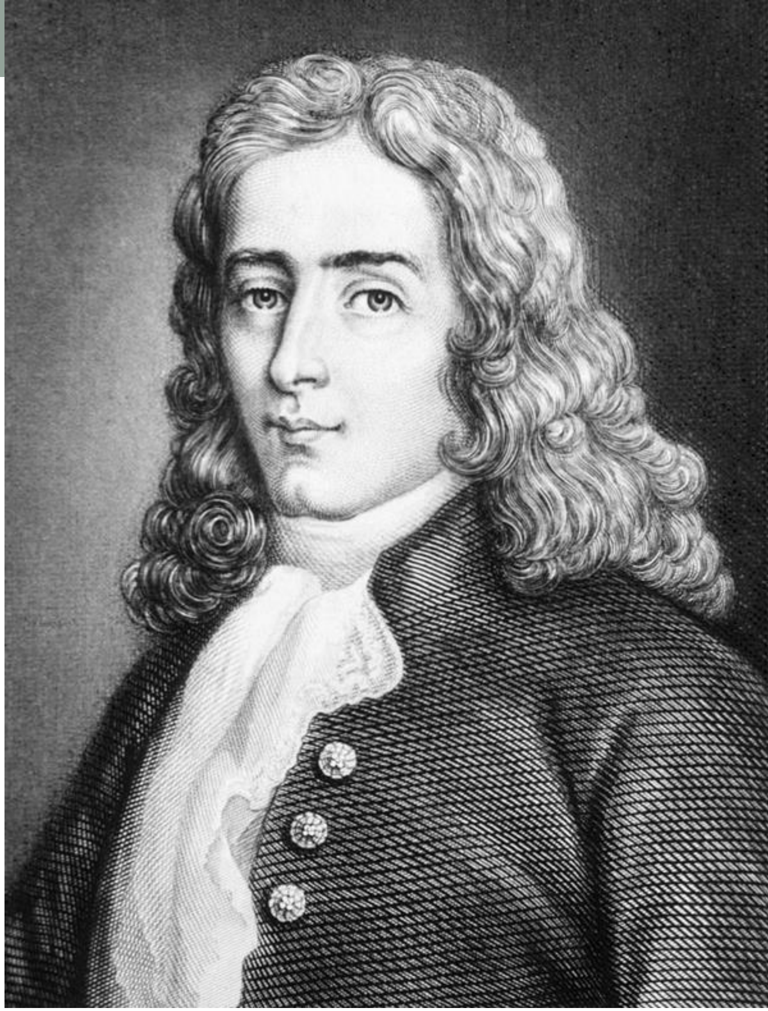
CROPTIME

ONLINE VEGETABLE SCHEDULING

HTTP://SMALLFARMS.OREGONSTATE.EDU/CROPTIME

Nick Andrews
Len Coop
Heidi Noordijk
Jim Myers
Ed Peachey
Aaron Heinrich
Dan Sullivan
Heather Stoven

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 (i.e. Arnold, 1959)
- Threshold temperatures are low or high temperatures that limit development and growth

$$\frac{Tmax + Tmin}{2} - Tbase = degree\ days$$

Simple average degree-days

$$\frac{Tmax + Tmin}{2} - Tbase = degree\ days$$

If high = 68°F & low = 45°F &

Base temp for sweet corn = 50°F, then

(68+45) / 2 = 56.5

56.5 – 50 = 6.5 degree-days

On a summer day >30 DDs can pass

Degree-days and sine curves

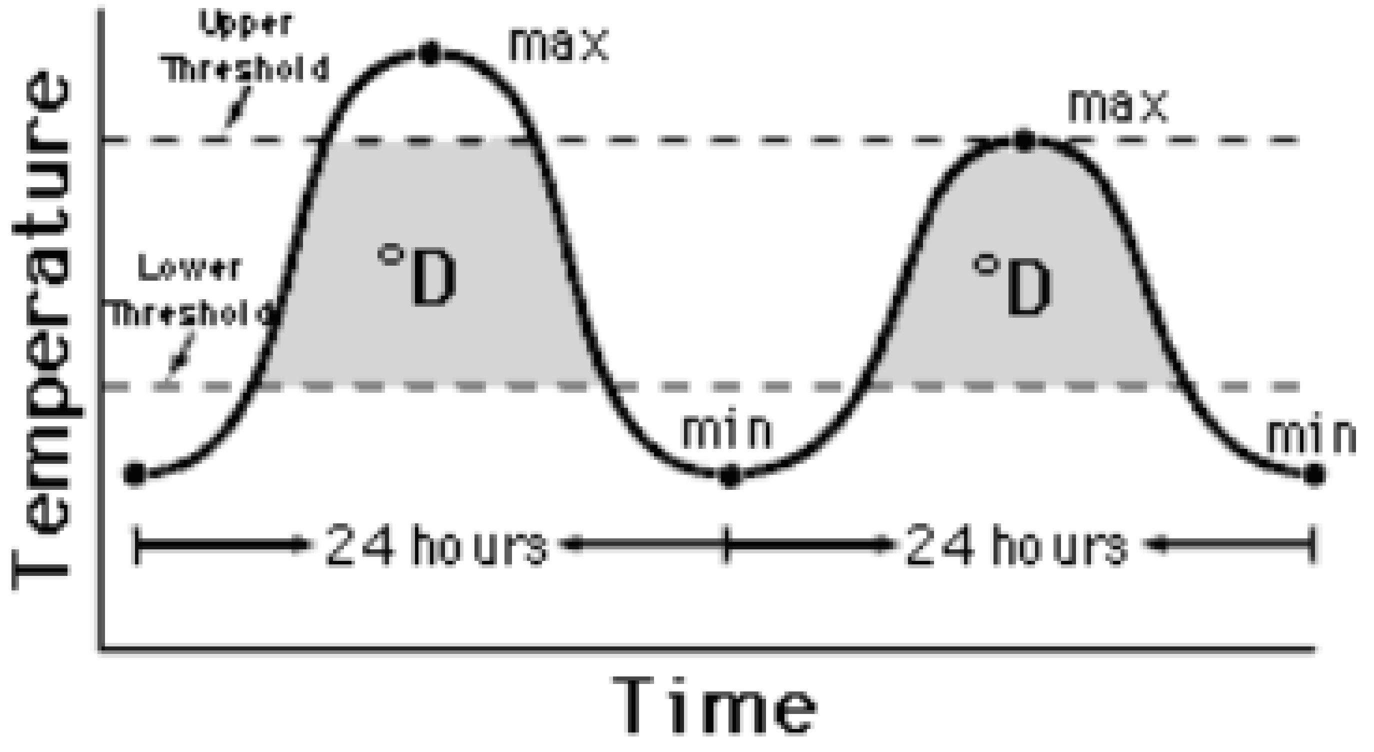


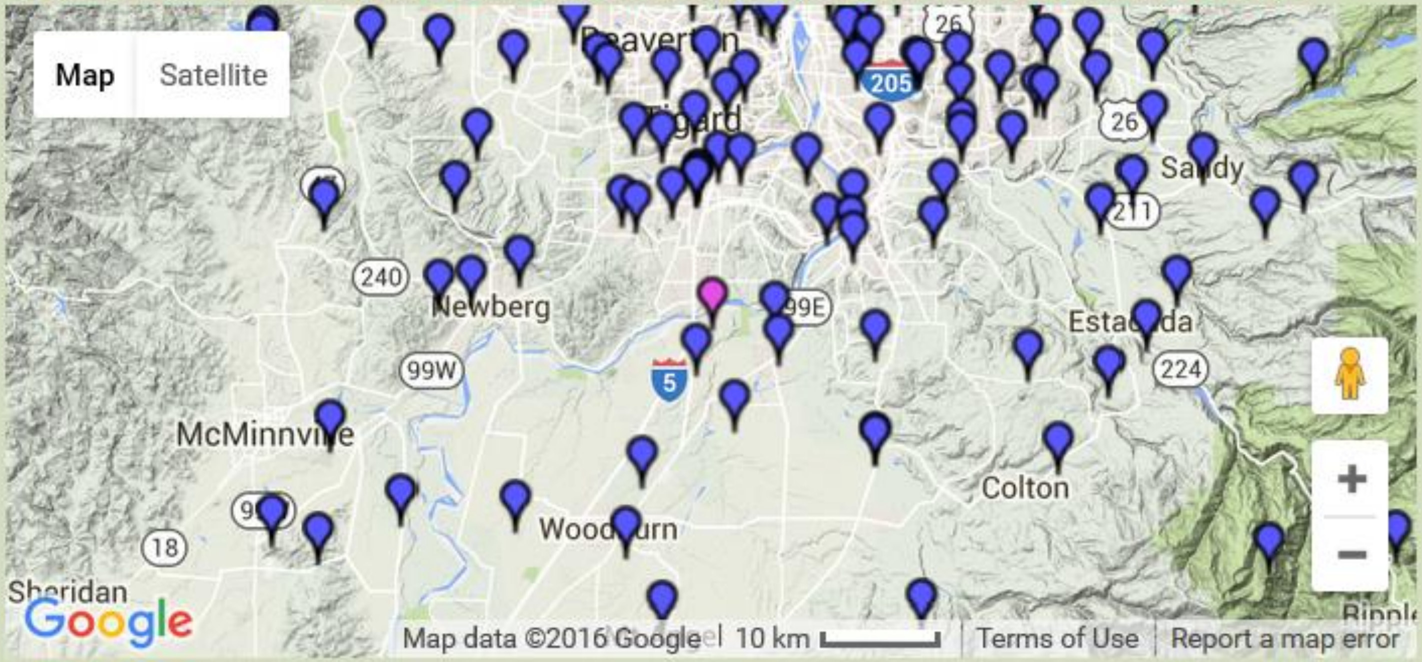
Figure 1. Thresholds and accumulated degree-days

http://www.ipm.ucdavis.edu/WEATHER/ddconcepts.html

Croptime components

- Vegetable degree-day models to predict harvest maturity of specific varieties
- Weed degree-day models to predict first germinable seed
- Nitrogen information explaining how temperature influences N release
- Croptime website to host this information so that models are accessible to growers as decision-tools

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



AURORA OR station: ARAO AGRIMET elev: 141 ft lat/long: 45.2817 -122.7503

broccoli-Arcadia
[Arcadia]
Andrews et al 2016



Model category: CROPTIME models ▾

see also "CROPTIME Home Page" for more info. on scheduling vegetable plantings

Model: broccoli-Arcadia [Arcadia] Andrews et al 2016 ▾ params

Start (up to 4 start dates - based on: date of transplant at 2-4 true leaves):

1. Apr ▾ 1 ▾ 2. May ▾ 1 ▾ 3. Jun ▾ 1 ▾ 4. Jul ▾ 1 ▾ 2015 ▾

End: Dec ▾ 1 ▾ same year ▾

Forecast type: after 7day use 30 year averages ▾

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

Click here to see full model output

Using degree-days
David Brown, Mustard Seed Farm

"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."

Frank Morton, Wild Garden Seed

Photo by Shawn Linehan

“The ‘days to maturity’ varietal information available in most seed catalogs is not useful to farmers, except in a vague relative sense.

If seed breeders and catalogs could provide degree-day information for their vegetable varieties, farmers would be able to more accurately model their crop delivery schedules in years of unusual weather patterns or extremes.”

Fruiting Crops

- Snap beans (3)
- Tomato (5)
- Summer squash (5)
- Cucumber (4)
- Sweet pepper (7)
- Winter squash (4)
- Sweet corn (6)







Root Crops

- Carrot (3)

- Parsnip (4)

Brassicas

- Broccoli (4)
- Cabbage (6)
- Cauliflower (3)
- Kale (2)

Leafy Crops

- Lettuce (4)
- Spinach (3)

Growth stages and descriptions

Monitoring

- Once per week
  - 2013
  - 2014
  - 2015
- Record growth stage
- Photos

Growth Stage
Direct Seed
Germination
Transplant
Number of true leaves
Cupping
Head initiation
Head development





Growth stage guide

Contents

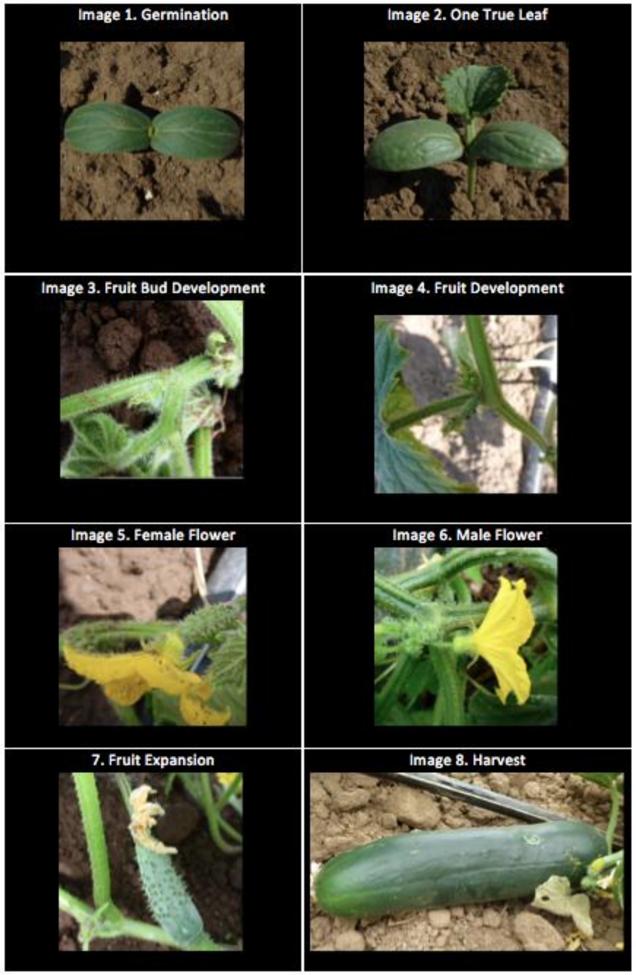
Growth stage guide

CUCURBITACEAE

CUCUMBER

Growth Stage	BBCH #	Description
Direct Seed	000	Note the seeding date if direct seeded in the field.
Germination	001 & 009	001 = seed can imbibe water due to soil moisture, irrigation or priming (this may be the same as direct seed date), 009 = cotyledons emerge from soil, estimate percent of crop emerged.
Transplant	101-103	Record the transplanting date and the number of fully unfolded true leaves at transplanting if appropriate. 101= 1 true leaf unfolded, 103 = 3 true leaves unfolded.
Number of true leaves	100-109	Count number of fully unfolded true leaves on main stem. 100 = cotyledons completely unfolded, 101 = first true leaf unfolded, 105 = 5 true leaves unfolded.
Flower bud development	501-509	Female flower buds are developing (elongated ovaries are visible on female flower buds). There are no open flowers. 501 = 1st female flower bud visible, 505 = 5th female flower buds visible.
Flowering	601-609	Female flowers open. 601 = 1st open female flower, 605 = 5th open female flower.
Fruit development	701-719	Measure developing fruit length when they start to expand. 702 = 2", 705 = 5" long fruit. Note any early fruit culling.
First harvest	745-747	Record the date and largest fruit length at first harvest. First harvest varies by variety. 745 = harvest with 5" fruit, 747 = harvest with 7" fruit.
Ongoing harvest	760	Harvest continues after first harvest and fruit length is no longer measured.
End of harvest	901	901 = Plants decline and fruit is no longer harvested.

CUCUMBER



Growth stages - Broccoli

- Transplant
- Cupping
- Head Initiation
- Mature
- Early Flowering

Diversity in Horticultural Systems

Priority crops ID'd by growers

Fruiting Crops (34)

- Snap beans (3)
- Tomato (5)
- Summer squash (5)
- Cucumber (4)
- Sweet pepper (7)
- Winter squash (4)
- Sweet corn (6)

Root Crops (7)

- Carrot (3)
- Parsnip (4)

Brassicas (15)

- Broccoli (4)
- Cabbage (6)
- Cauliflower (3)
- Kale (2)

Leafy crops (7)

- Spinach (4)
- Lettuce (3)

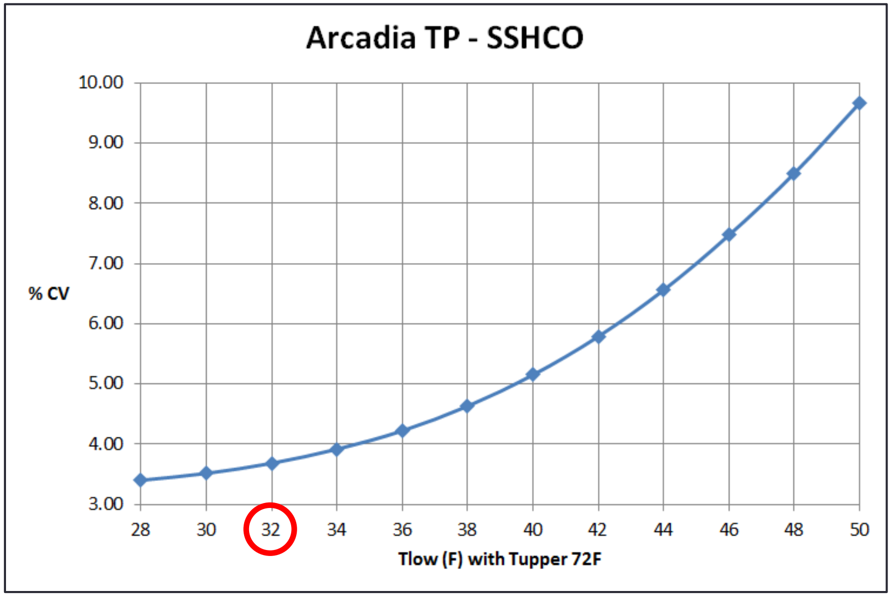
- ➢ 20 crop models by Apr 2016
- ➢ 50 crop models by Mar 2017

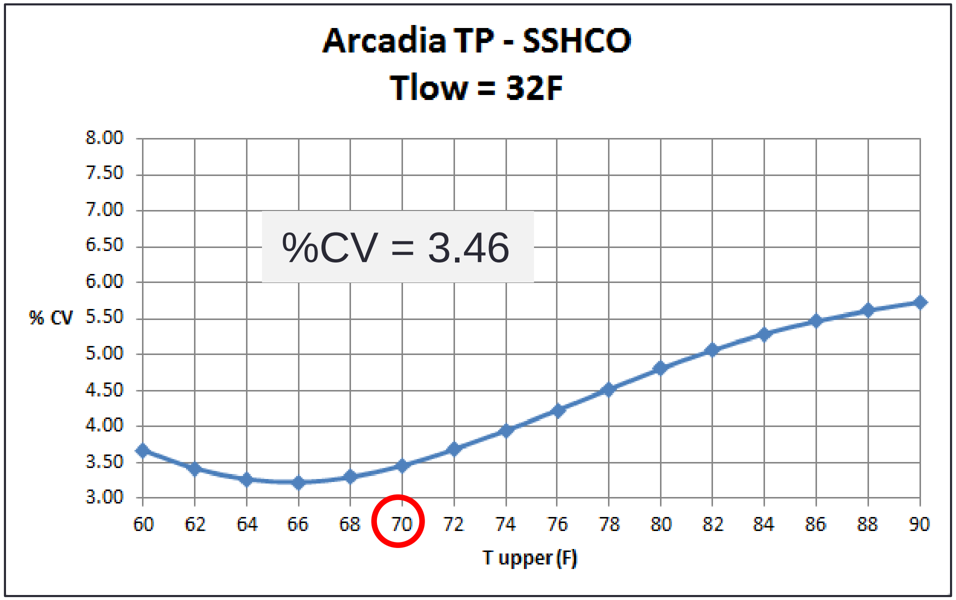
Data collection & model development

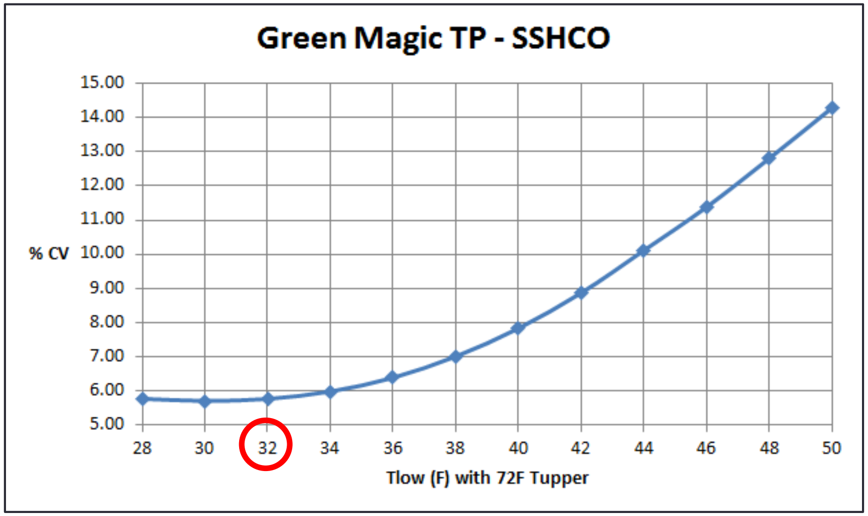
Data sets: 1 data set = crop development observations paired with daily max/min temperature records:

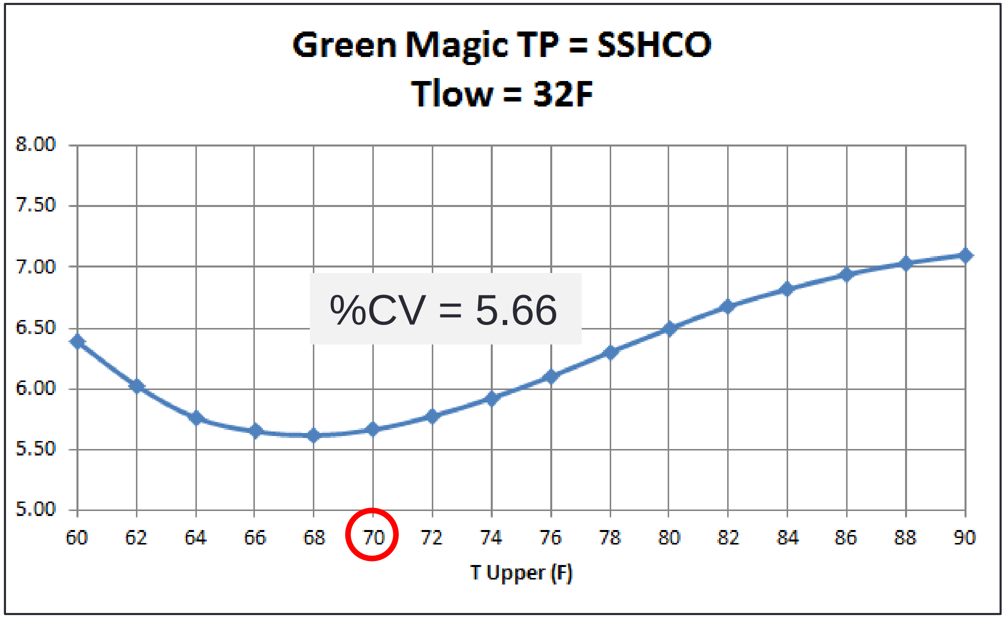
- 8-10 data sets to verify thresholds for a crop
- 4-6 data sets to verify thermal time to maturity for a variety

Supports broccoli thresholds 32/70F









Thermal time to maturity

Transplanted broccoli 32/70F, SSHCO	**50% head initiation**	**First harvest**	**Early flowering**	**Accuracy (± days)**
Arcadia (TP)	1674	2281	2672	2.5
Green Magic (TP)	1458	2103	2456	4.1
Emerald Pride (TP)	1565	2151	2518	6.4
Imperial (TP)	1753	2383	2688	4.6

~10 days diff. between varieties

± 3-6 days with DDs

± 15 days in catalogs for Arcadia

Thermal time to maturity

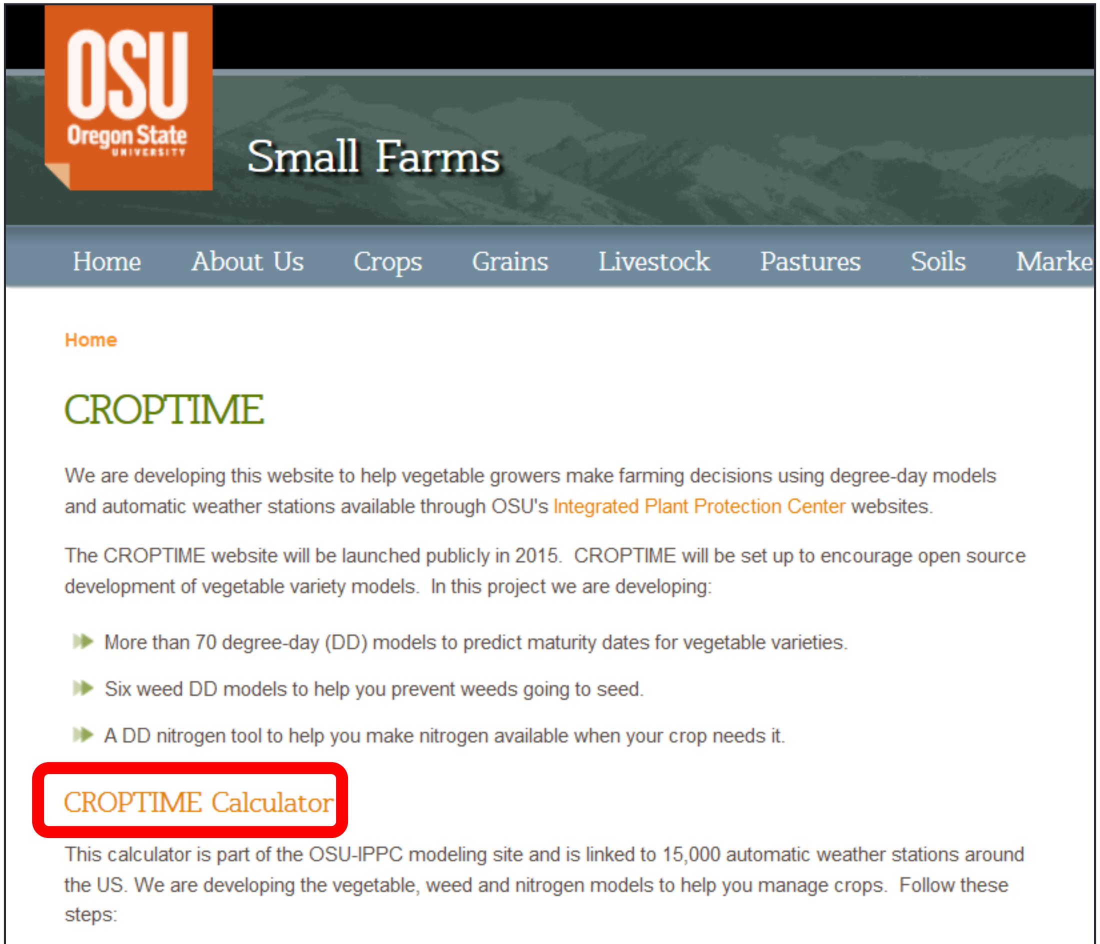
Cucumber 50/90F, SSHCO	Type	2 true leaves	Early flowering	First harvest	Accuracy (± days)
Cobra (DS)	Slicing	339	665	964	2.5
Marketmore-76 (DS)	Slicing	364	784	1211	1.1
Marketmore-76 (TP)	Slicing	-	344	805	1.9
Dasher II (DS)	Slicing	365	731	1060	1.8
Zapata (DS)	Pickling	380	688	984	2.7
Extreme (DS)	Pickling	366	692	946	1.2
Supremo (DS)	Pickling	366	677	981	0.8

~12 days diff. between varieties

± 1-3 days accuracy

Using Croptime

1. Search for Croptime
   http://smallfarms.oregonstate.edu/croptime




Weather station map: pan, zoom and click on pin (red pin shows current location):
Map
Satellite
Select weather station (Google maps)
Beaverton
Tigard
Sandy
Estacada
McMinnville
Colton
Woodburn
Sheridan
Map data ©2016 Google
10 km
Terms of Use
Report a map error
AURORA OR station: ARAO AGRIMET elev: 141 ft lat/long: 45.2817 -122.7503
broccoli-Arcadia [Arcadia]
Andrews et al 2016
Select crop & variety
Model category: CROPTIME models
see also "CROPTIME Home Page" for more info. on scheduling vegetable plantings
broccoli-Arcadia [Arcadia] Andrews et al 2016
params
4 start dates - based on: date of transplant at 2-4 true leaves):
Jul 1 2015
Enter planting dates
Select forecast type
Output & Daylength
End:
same year
Forecast type:
7day use 30 year averages
Output: Condensed: yes Show Daylength: yes Critical Daylength: 12.0
Click here to see full model output
Click here

MODEL INPUTS

Model species/general links	broccoli-Arcadia [Arcadia]
Type	crop
Model source/other links	Andrews etal 2015
Calculation method	
Lower threshold	32 degrees Fahrenheit
Upper threshold	72 degrees Fahrenheit
Directions for starting/BIOFIX	date of transplant at 2-4 true leaves
Starting date(s)	4-1,5-1,6-1,7-1 2015
Ending date	12-1
Model validation status	new model-not yet validated
Region of known use	W. Oregon
Short day critical day length (hr)	12.0
Day length < critical value indicator:	**

EVENTS TABLE

DDs after transplant:	Model Event
5	transplanted - 2-4 leaves
1762	50% head initiation
2344	first harvest
2734	early flowering

Date

Temp/Precip

DD

Day length

Cum DD

Crop events

								Starting 4-1	
Month	Day	Max	Min	Precip	DDs Today	Day length (hr)	QA + Notes	Cumu. DDs	Model Events
4	1	53.0	40.1	0.10	14.6	13.1		15	transplanted - 2-4 leaves
5	1	73.8	45.6	0.00	27.5	14.6		612	
6	1	62.5	53.9	0.21	26.2	15.8		1458	
6	11	81.4	49.9	0.00	31.4	16.0		1780	50% head initiation
6	28	83.6	66.3	0.00	38.6	16.0		2351	first harvest
7	1	95.4	57.9	0.00	36.2	16.0		2461	
7	9	85.2	59.8	0.00	36.2	15.9		2751	early flowering
7	14	83.4	57.6	0.00	35.1	15.8		2930	
7	22	72.1	53.1	0.00	30.6	15.5		3205	
7	26	72.7	55.6	0.03	32.1				
8	8	79.7	56.2	0.00	34.0				
8	19	97.6	59.7	0.00	36.9				
8	20	81.1	58.4	0.00	35.2	14.3		4214	
9	7	74.5	52.2	0.00	31.0	13.3		4787	
9	20	77.7	52.6	0.00	32.0	12.7		5190	

Scroll right for other planting dates

2nd planting

3rd planting

4th planting

Month	Day	Starting 5-1		Starting 6-1		Starting 7-1	
		Cumu. DDs	Model Events	Cumu. DDs	Model Events	Cumu. DDs	Model Events
			transplanted - 2-4 le[illegible]				
[illegible]	[illegible]	[illegible]					
			[illegible]nitiation	919			
7	1	1877		[illegible]			
7	9	2166		[illegible]			
			[illegible]vest	[illegible]			
				[illegible]			
7	26	2753	early flowering	[illegible]			
				[illegible]			
				[illegible]			
[illegible]	[illegible]	[illegible]		[illegible]			
				3355		2362	first harvest
[illegible]	[illegible]	[illegible]		3758		2765	early flowering

TP dates

Apr 1 = 88 DTM

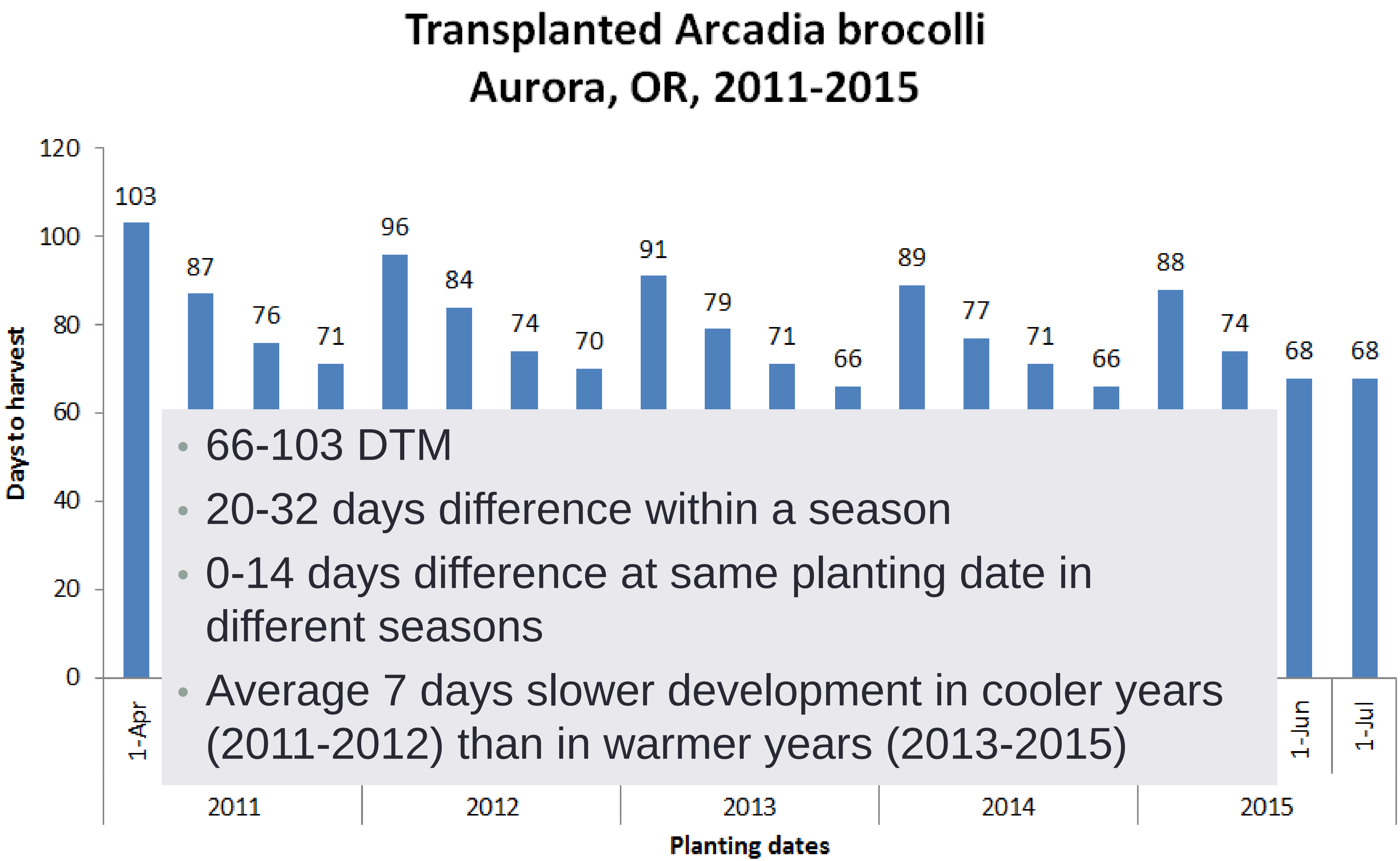
May 1 = 74 DTM

Jun 1 = 68 DTM

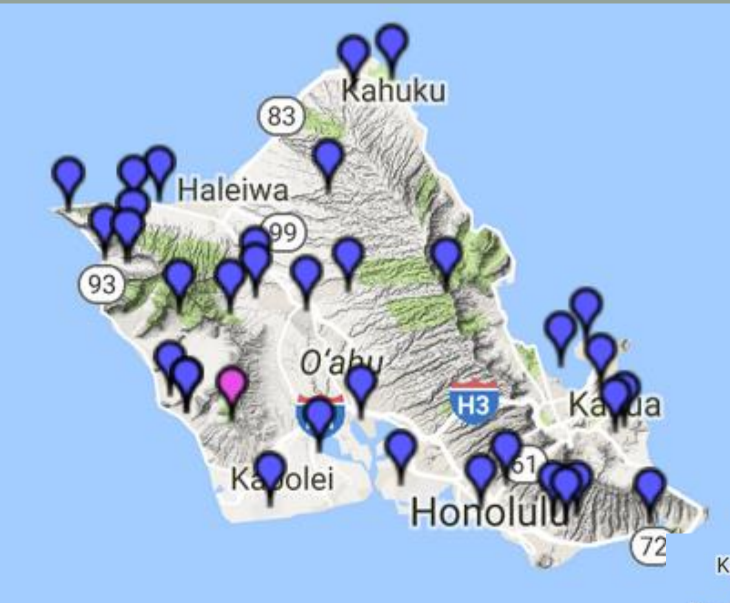
Jul 1 = 68 DTM

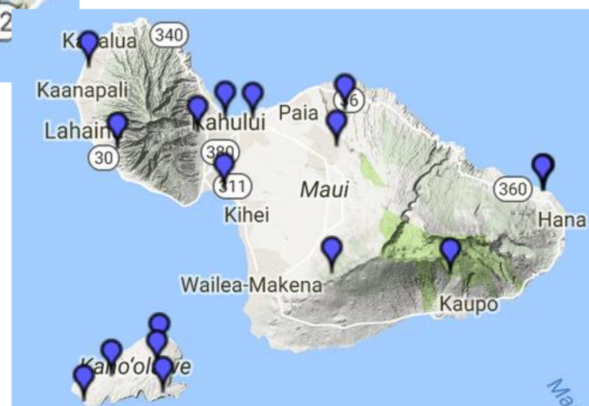
Seed catalogs estimate 63-94 DTM
In W OR we saw 66-103 DTM

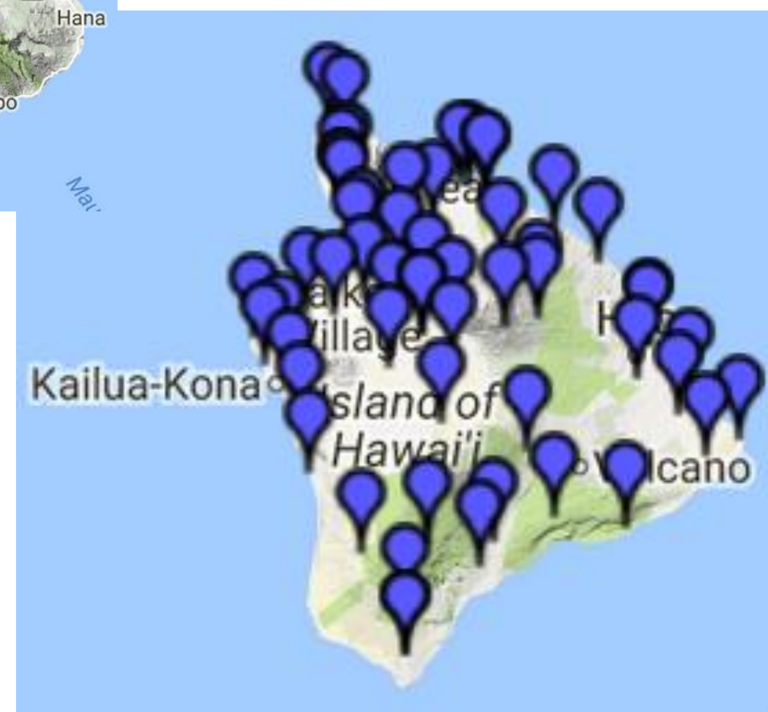
Degree-day models use local temperature data, forecasts or historical averages to predict harvest within a few days



- 66-103 DTM
- 20-32 days difference within a season
- 0-14 days difference at same planting date in different seasons
- Average 7 days slower development in cooler years (2011-2012) than in warmer years (2013-2015)


Kahuku
83
Haleiwa
99
93
O'ahu
H3
Honolulu
72


340
Kaanapali
Paia
30
Maui
360
Kihei
Hana
Wailea-Makena
Kaupo


Kailua-Kona

Croptime weed models

Weed models can help farmers answer the following questions:

- **When can I stop cultivating?**
- **Do I need to send in a crew to hand weed before harvest to prevent seed set?**
- **Should I remove weeds from field?**
- **Can the harvest crew just focus on specific weeds?**



Farmer’s choice

Lambsquarter

Hairy

Crabgrass

Pigweed

Croptime weed models reduce uncertainty

Do you think the seeds in this flower head are viable?

Grower #1 - **35-50%**

Grower #2 - **None**

Lab results – **~50% viable**

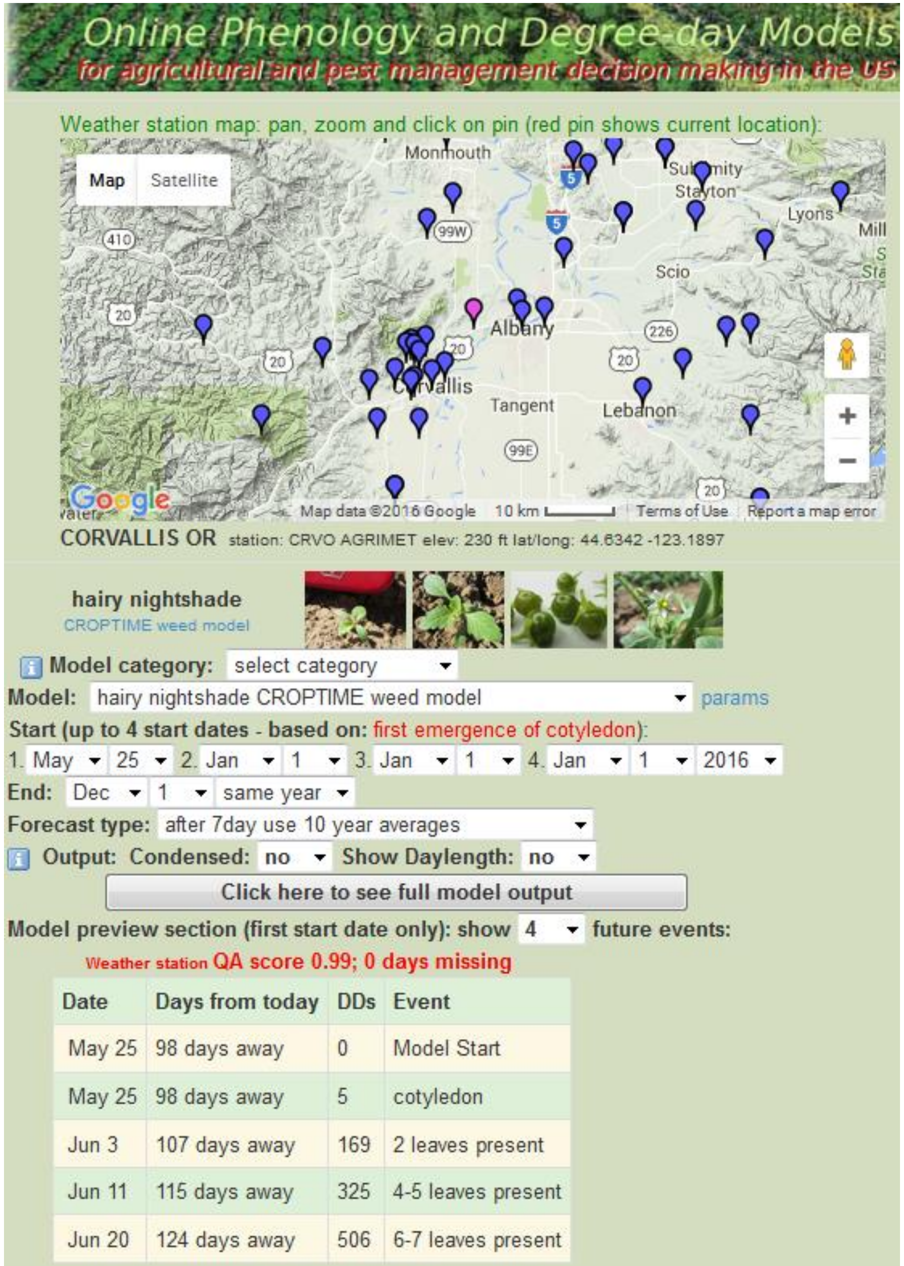
Is the GDD model better than days alone?

Hairy Nightshade				
	Cotyledon to First Flower (Days)	Cotyledon to First Flower (DD)		
	32 (22-44)	766		
CV (%)	**25**	**20**	**12**	**9**

How to use weed models

Identify weed & emergence date → Input into model → **Estimate of first germinable seed**

The model



- Model 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

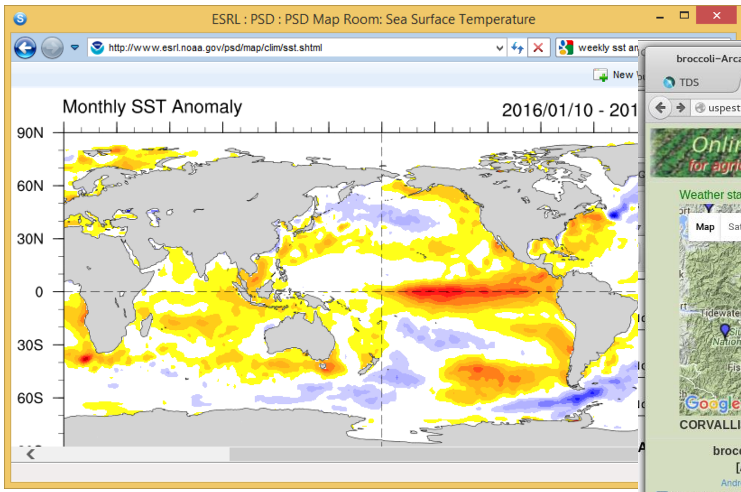
Output

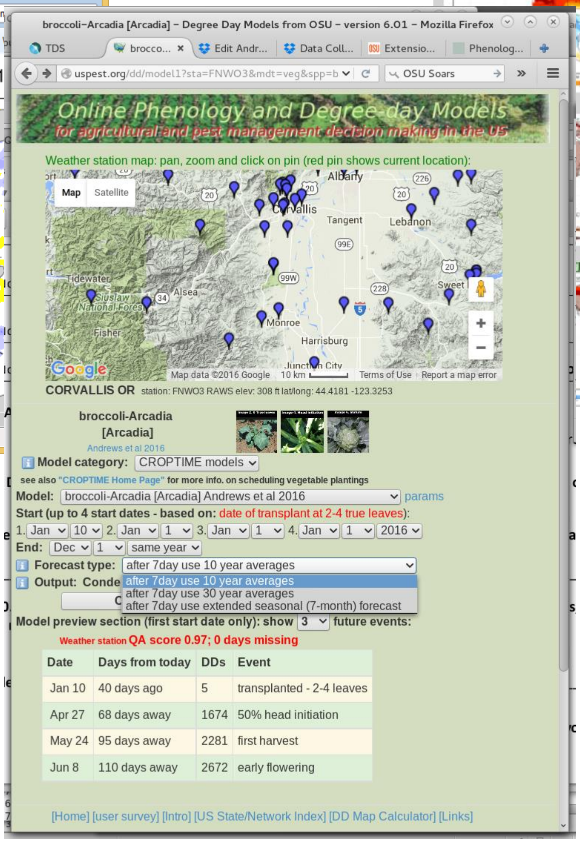
Month	Day	Starting 6-1 Model Events	
6	1	cotyledon present	
6	7	2 leaves present	
6	13	4-5 leaves present	
6	20	6-7 leaves present	
6	28	first flowering	
7	26	lower 95% CI first viable seed	Low risk
7	31	average first viable seed	Moderate
8	4	upper 95% CI first viable seed	High risk

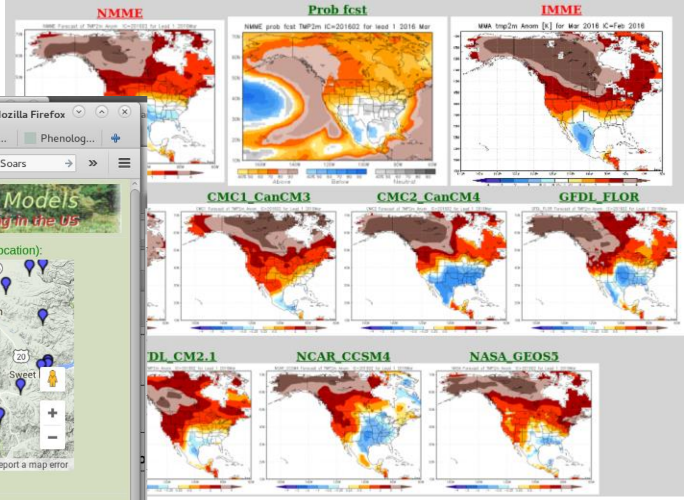
Avoid this! Reduce future weed pressure by using weed models in conjunction with crop models to minimize the risk of seed set occurring before harvest

Forecast Options for DD Models

Len Coop, OSU
Integrated Plant Protection Center





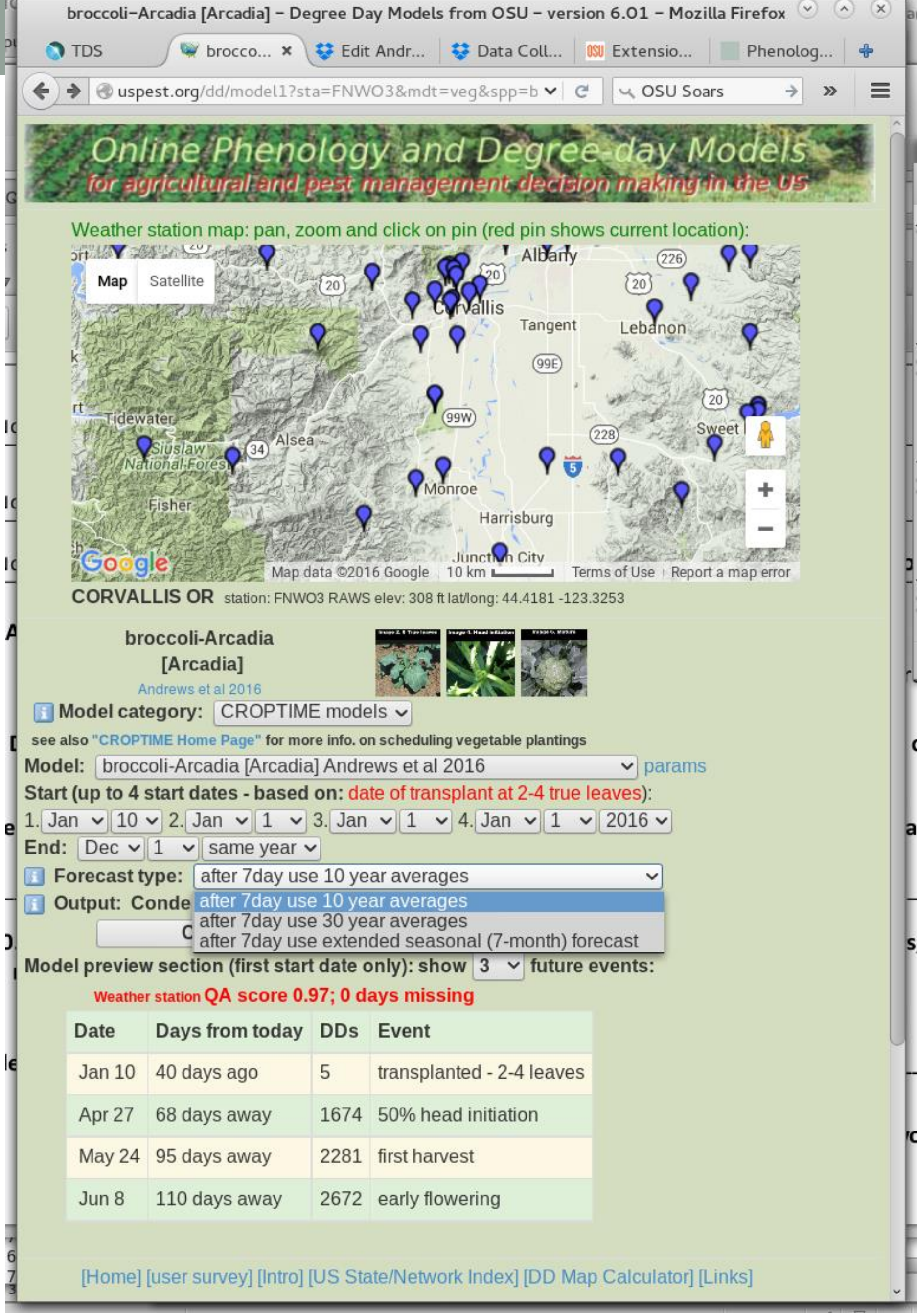


Oregon State University
Extension Service

Western SARE
Sustainable Agriculture Research & Education

Forecast Options

- Uses recorded temps up to the day before a model is run
- Uses 7-day forecasts
- Long-term forecast options:
  - NEW 7-month seasonal climate forecast
  - 10-year average
  - 30-year average



broccoli-Arcadia [Arcadia]
crop model of Andrews et al 2016

Output from uspest.org/wea insect degree-day/phenology model program:
Heat Units and predictions of key events from daily weather data

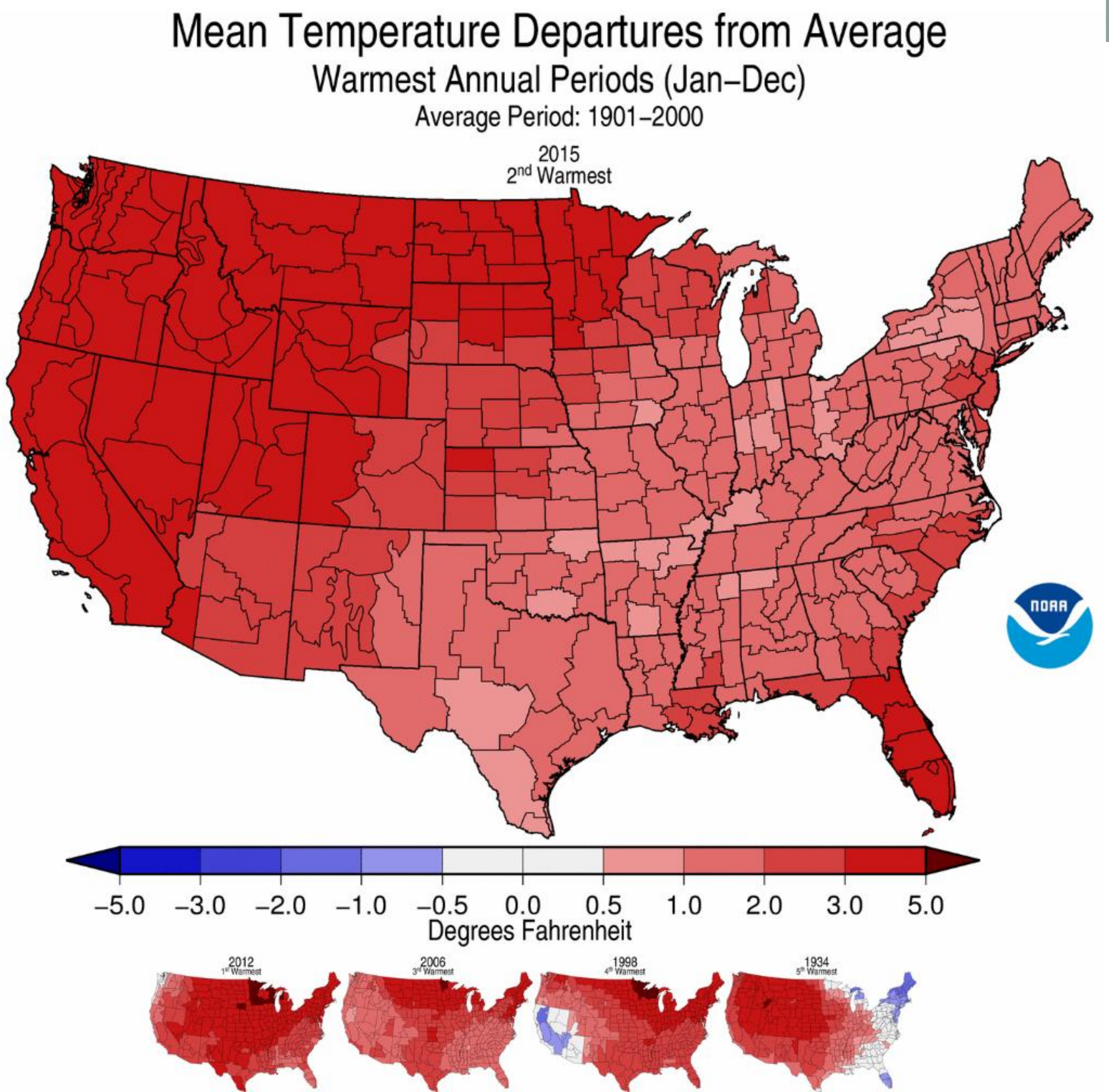
MODEL INPUTS

Model species/general links	broccoli-Arcadia [Arcadia]
Type	crop
Model source/other links	Andrews et al 2016
Calculation method	single sine curve
Lower threshold	32 degrees Fahrenheit
Upper threshold	70 degrees Fahrenheit
Directions for starting/BIOFIX	date of transplant at 2-4 true leaves
Starting date(s)	1-10 2016
Ending date	12-1
Model validation status	new model-not yet fully validated
Region of known use	W. Oregon
Extended forecast type	After 7 days, use 7-month NMME based seasonal climate forecast

MODEL OUTPUT
w/ NMME:

Month	Day	Max	Min	Precip	DDs Today	QA + Notes	Cumu. DDs
					13.0		500
					21.0		521
					23.5		544
					18.5		563
2	17	63.0	46.0	0.04	22.5		585
2	18	51.0	43.0	0.39	15.0		600
2	19	49.7	43.3	0.246	14.5	Fx Fn forecast	615
2	20	53.9	34.5	0.042	12.2	Fx Fn	627
2	21	49.7	31.8	0.095	8.8	Fx Fn	636
2	22	52.1	31.7	0.006	9.9	Fx Fn	646
2	23	62.7	33.2	0.00	15.9	Fx Fn	662
2	24	55.4	38.6	0.165	15.0	NMME	677
2	25	55.6	38.7	0.163	15.2	NMME	692
2	26	55.8	38.8	0.162	15.3	NMME	707
2	27	56.0	38.9	0.16	15.4	NMME	723
2	28	56.2	39.0	0.158	15.6	NMME	738
2	29	56.2	39.1	0.158	15.7	NMME	754

Is recent climate well-predicted by 30-year Normals?



OSU/WSU/Fox Weather have a grant to add NOAA extended weather/climate forecasts into models at uspest.org

Many studies linking sea surface temperatures to future climate = one form of “teleconnection” or statistical correlation of climate anomalies at large distances

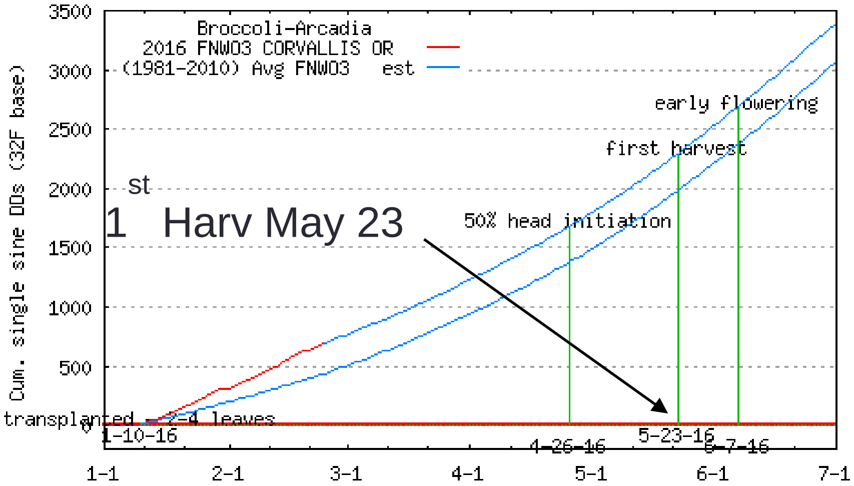
Our Project is using NOAA ensemble extended weather/climate forecasts (NMME) (e.g. March 2016)

Current & Forecast El Nino is a major part of the forecast

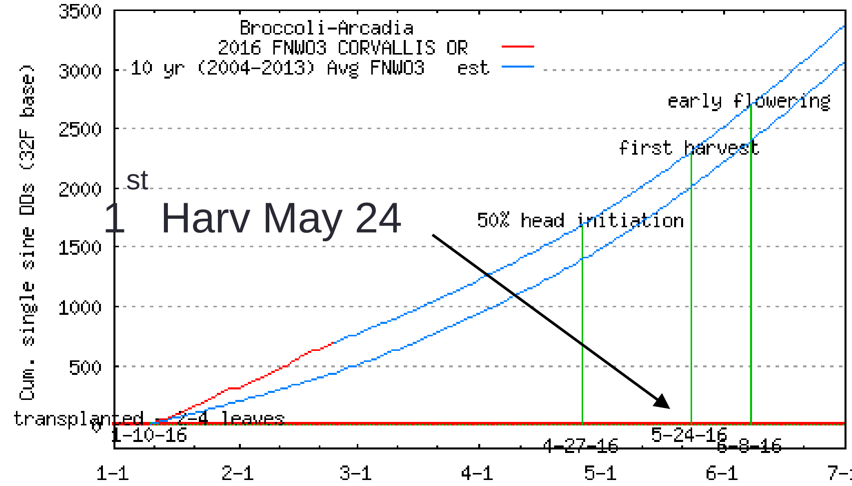
FORECAST COMPARISONS

Broccoli-Arcadia transplanted Jan 1, 2016 ☺

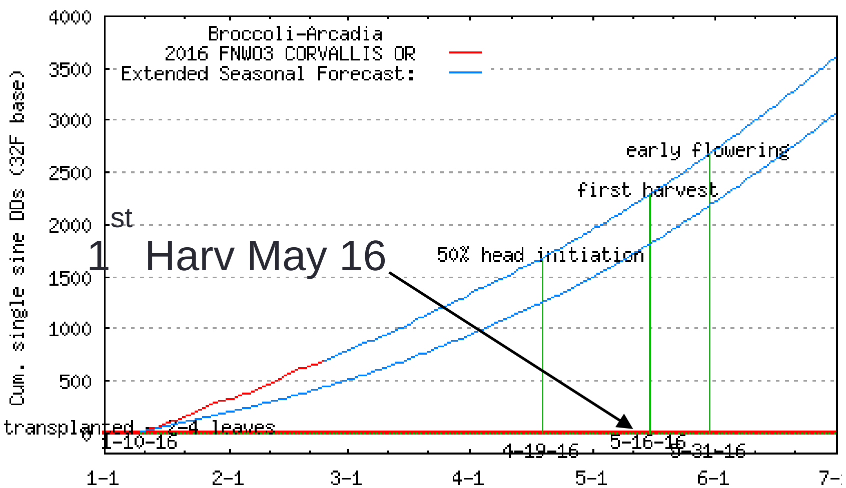
30 yr avg (Normals) Forecast



10 yr avg Forecast



New 7-month Seasonal Forecast



2015