Beans, *Phaseolus vulgaris L.*

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 to development. We have determined the thresholds and degree-day requirements for three bean varieties, known as “bush”, “green” or “snap” beans; as opposed to “climbing” or “pole” beans, which are not considered here. Using the several forecasts available at uspest.org, one may reasonably predict events such as first trifoliate leaf, first 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 temperature threshold values for three direct seeded bean varieties. We used between 4 and 9 site-years for each variety. All site years were from the Willamette Valley in western Oregon, from 2013-2015. Standard sites included the OSU vegetable farm (near Corvallis, OR) and the OSU NWREC research farm (near Aurora, OR), with other farms depending on variety and year. Varieties included: “Provider”, “Sahara”, and “5630”. Degree-day values were calculated online at uspest.org using the single sine degree-day (DD) calculation formula.

The model interval used to determine thresholds was from the direct seeding date to first harvest, determined by the method of lining up 10 center seeds tip to tip from each of 10 bean pods. When the length measures 3.5 to 4.0 inches then the variety is ready to harvest. Other stages for which degree-day requirements were estimated included the first trifoliate leaves unfolded and first flowers opened.

Results: All bean phenology models (Table 1) were determined by a combination of the lowest C.V. method, consideration of published results from the literature, and the goal of using best overall thresholds in common, when possible. All three varieties were determined to have a 40ºF (4.44ºC) lower developmental threshold, and a 90ºF (32.2ºC) upper threshold. Degree-day models for the three varieties had C.V. values between 3.4 and 6.4. The mean absolute deviations (MAD) to predict harvest date using the models ranged from 1.8 to 4.0 days. In comparison, the MAD for days to harvest ranged from 1.5 to 5.1 days, and was at a lower value (1.5 days) than using DDs (4.0 days) for the "Provider" variety. This supports long-standing belief that average days from planting to harvest may be nearly equal or sometimes better than using a DD model for snap beans. We maintain the assumption that a DD model will provide a more robust prediction system across diverse seasons and climates. The intervals from planting to harvest ranged from 1630 DD and 58 days for "5630", to 1681 DD and 60.5 days for "Provider", and to 1805 DD and 63.5 days for "Sahara".

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 mobile device app; search for "uspest.org" at your app store starting Feb. 2019 for Android, available soon for Apple). To use the website, select the nearest weather station code by entering a nearby city, zipcode, or weather station code, or clicking on a weather station pin in the Google map. Then select "CROPTIME models" at "Model Category" and select any of the listed bean 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 (for table output). Click on button (or tab) for model output. The new charts compare 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 bean variety models:
5630: https://uspest.org/dd/model?spp=bnfs
Provider: https://uspest.org/dd/model?spp=bnpr
Sahara: https://uspest.org/dd/model?spp=bnsa

Suggested applications for the models: The models can be used in a variety of ways:

- Predict harvest dates using planting date and local temperature
- Time crop planting dates to achieve a specific harvest date

- Plan for successive harvests during the growing season
- Predict whether late plantings will mature
- Use long-term forecasts and climate models to predict time to harvest

Table 1. Degree-day (DD) modeling summary for bean varieties. For all varieties: lower threshold 40ºF, upper threshold 90ºF, using the single sine DD calculation method, begin date at time of seeding. Data from western Oregon, 2013-2015.

Variety	Abb-rev.	1st tri-foliate leaf DDs	% CV (seed - 1st trifol)	1st open flowers DDs	% CV (seed - 1st flower)	Harv-est DDs	% CV (seed-harv-est)	Mean abs. dev. (DD)	Days to Har-vest	Mean abs. dev. (days)	# data sets
5630	bnfs	601	12.3	1148	11.9	1630	6.37	3.33	58	5.11	9
Provider	bnpr	608	6.51	1094	6.51	1681	8.45	4.0	60.5	1.5	4
Sahara	bnsa	526	12.46	1248	8.76	1805	3.46	1.75	63.5	2.0	4