Washington State Grape and Wine Research Program

DUE 5:00 p.m. June 30, 2020
by email to: ARCGrants@wsu.edu

PROJECT TITLE: Influence of climate variability on grapevine phenology

Project Duration: 3 Years
WRAC Project No:

Check:		
	☐ year 1 complete; year 2 proposal	☐ year 2 complete; year 3 proposal
Budget Request: $11,029		

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Please include a letter of acknowledgment from all Cooperators if there has been a change from the original Cooperator(s).

Cooperator Name:	**Dick Boushey**	**Cooperator Name:**	**Rick Hamman**
Organization	Boushey Vineyards	Organization	Hogue Ranches
Description of participation:	Advice, Access to the vineyards for data collection	Description of participation:	Advice, Historical data, Access to the vineyards for data collection

BUDGET AND OTHER FUNDING SOURCES

BUDGET

Approved By: Date:	**Year 1 FY**	**Year 2 FY**	**Year 3 FY**
	Jul 2017 – Jun 2018	Jul 2018 – Jun 2019	Jul 2019-Jun 2020
Item			
Salaries	27,216	27,355	7,022
Benefits	18,651	18,334	2,265
Wages		2,100	
Benefits			
Equipment	1,000		
Supplies	500	874	192
Travel	1,000	1,000	1,550
Miscellaneous			
Total	48,367	49,663	11,029

Project Summary:

There is an urgent need to identify Washington wine grape temperature thresholds from woolly buds through the first leaf. This information will be very valuable for climate variability, risk assessment, and frost control during the most sensitive periods. Knowledge of the critical temperatures and frost sensitivity of non-dormant tissue of grapevine cultivars for each of the development stages that reflect the decrease in hardiness level during budbreak and posterior development in spring can aid in vineyard design by helping growers to determine the most susceptible cultivars in the best sites. It will help guide appropriate crop management decisions especially for activating frost protection systems during the spring which should be started sooner on the more susceptible cultivars.

Phenological observations have been collected in a commercial vineyard and Roza (IAREC experimental plots) for Cabernet and Chardonnay and data was collected during four growing seasons. The duration of these stages was established in terms of thermal time (GDD), using the accumulation of the average daily temperature above the base temperature Tb, and estimated temperature thresholds. A simple thermal-time (TT) model based on historical observations of phenological stages for local conditions was developed using different thresholds. Based on this evaluation, the heat unit requirements for the beginning of the season, bloom, and veraison can be determined.

For critical temperature determination of non-dormant reproductive tissue, we have developed an automated freezing sampler from previous cold hardiness studies to perform controlled freezing tests on non-dormant reproductive tissue from samples collected in local vineyards at and around the Irrigated Agriculture Research and Extension Center (IAREC).

The goal was to develop an information delivery system and media tool in collaboration with stakeholders and the industry at large, to present the observed data on the web as a Decision Aid Tool. A preliminary web site was developed for grapevine phenology with information from previous projects.

Provide a guide (decision aid tool) for appropriate crop management, and especially for activating frost protection systems during the spring, which should be started sooner on the more susceptible cultivars. In addition, an early prediction of budbreak would be useful to assess the risk of spring frost damage and the potential for its mitigation for site-variety combinations.

Although degree-day accumulations have been related to the progression of phenological stages, no information is available on a variety of specific heat unit summations using different combinations of base temperatures and upper-temperature limits to predict those stages under WA conditions.

Justification and Importance of Research:

Temperature as a measure of heat is one of the most important climatic factors influencing the growth and developmental rate of grapevines (Jones and Davis 2000). Concepts as a heat summation and protocols such as growing degree days (GDD) have been developed to study thermal accumulation and regulation of plants or pest important for agricultural and biological systems; a certain amount of heat is required to develop from one point in their life cycles to another (Gu, 2015). This measure of accumulated heat is known as physiological time often expressed and approximated in units called degree-days. Theoretically, physiological time provides a common reference for the development of organisms. The amount of heat required to complete a given developmental stage does not vary the combination of temperature (between thresholds) will always be the same.

Until a prediction scheme is developed which will account for cultural and environmental differences to which most of the cultivars are responsive, simple heat unit accumulations will provide only a rough estimate of phenological stages. Additional research is underway to determine if improvement of the prediction accuracy is possible by incorporating thresholds variations into a prediction model, these additions may allow for a practical as well as a theoretically sound method for estimation of the phenological stages of grapevines under WA conditions. Utilizing different combinations of base temperatures and upper-temperature limits in degree-day calculations provide an improvement over the degree day summation system than using a 10°C base and no upper-temperature limit. With changes in the assumed lower an optimum cardinal temperature, effective heat units and degree days could produce more accurate results in prediction; it has been established that the use of actual calendar days is not appropriate for phenology prediction.

Dormancy is part of the life cycle in grapevines that correspond to a period of inactivity during the fall and winter in which buds suspend temporally their growth. A change in temperature is one of the main factors driving dormancy through the reduction in the biochemical activity of plants (Wake and Fennell, 2000). Understanding the environmental factors involved in the induction, progress, and release of dormancy in grapevine is important, as it is related to the cold hardiness process occurring at the same time (Ferguson et al., 2011). Cold hardiness allows plants to survive under low temperatures during the winter and to avoid cold damage that can affect bud development next year (Howell, 2001). Irregular and patchy year to year budbreak due to seasonal temperatures experienced during the dormancy affect vineyard management and influence production and harvest dates (Lavee, S. and May, P. 1997) (Ashenfelter and Storchmann, 2016).

The timing of budbreak is crucial, and there is a need to identify temperature thresholds and the effects of extreme temperature on crop production. Identification of critical temperatures will provide a starting point for assessing extreme temperature-related risks and this will provide a pathway toward exploring adaptation options.

Knowledge of the critical temperatures and frost sensitivity of non-dormant tissue of grapevine cultivars for each of the development stages that reflect the decrease in hardiness level during budbreak and posterior development in spring can aid in vineyard design by placing the most susceptible cultivars in the best sites, it is also very important as a guide for appropriate crop management, and especially for activating frost protection systems during the spring which should be started sooner on the more susceptible cultivars.

Project Major Accomplishments:

Objective 1. *To determine and adjust the duration of the key phenological stages using thresholds for GDD estimation.*

Long-term historical data including budbreak, full bloom and veraison were collected at Roza IAREC for three consecutive seasons 2016-2017, 2017-2018, 2018-2019 (by Lynn Mills) Table 1, and weather data obtained from AWN were used to adjust the duration of the phenological stages based on thresholds temperatures most suited for the season.

Table 1. Phenological stages for years 2016, 2017, 2018 and 2019 for Cabernet Sauvignon and Chardonnay, collected at Roza (IAREC experimental plots)

Phenological Stage	Cabernet Sauvignon				Chardonnay			
	2016	2017	2018	2019	2016	2017	2018	2019
Full Swell	101	115	120	116	96	106	113	110
Bud break	104	122	122	120	99	110	117	113
First bloom	145	160	151	154	138	155	146	150
Full Bloom	150	163	156	160	140	159	151	153
Start Veraison	208	222	215	217	203	219	216	215
Veraison (50%)	222	234	227	229	207	229	222	225

Base temperatures determined in our previous projects were adjusted to predict key stages for two different grapevine cultivars Cabernet Sauvignon, and Chardonnay. The estimated base temperatures varied between phenological stages with an increasing trend toward veraison, for Cabernet Sauvignon the base temperature for Bud break was 46.9, for Bud break to Full bloom 50.7 and Full bloom to Veraison 54.5 in contrast to Chardonnay that Bud break temperature was 43.7, from Bud break to Full bloom 46.9 and from Full Bloom to Veraison 49.5. The average day of the year (Table 2) was used to calculate the thermal time in terms of Growing Degree Days.

Minimum, Average, and Maximum (DDmin), (DDAve), and (DDmax) respectively for three key phenological stages, using estimated Based temperature per stage (Tb), is presented in Table 3.

Table 2. Minimum, Average, and Maximum day of the year of the occurrence for each stage.

Phenological Stage	Cabernet Sauvignon			Chardonnay		
	Min	Ave	Max	Min	Ave	Max
Full Swell	101	113	120	96	106	113
Bud break	104	117	122	99	110	117
First bloom	145	153	160	138	147	155
Full Bloom	150	157	163	140	151	159
Start Veraison	208	216	222	203	213	219
Veraison (50%)	222	228	234	207	221	229

Table 3. Thermal time in terms of Growing Degree Days (DDmin), (DDAve), and (DDmax) for three key phenological stages, using estimated Based temperature per stage (Tb) and Tb=50. The accumulation started on 1 of April for each stage.

Cabernet Sauvignon										Chardonnay									
Bud break																			
Year	Tb	DDmin	DDAve	DDmax	Year	Tb	DDmin	DDAve	DDmax	Year	Tb	DDmin	DDAve	DDmax	Year	Tb	DDmin	DDAve	DDmax
2016	46.9	136	284	340	2016	50	99	209	248	2016	43.7	93	253	364	2016	50	49	141	209
2017	46.9	30	94	120	2017	50	12	41	54	2017	43.7	39	109	165	2017	50	11	28	41
2018	46.9	51	141	183	2018	50	24	80	106	2018	43.7	47	130	218	2018	50	11	34	80
2019	46.9	61	196	216	2019	50	29	127	136	2019	43.7	74	182	276	2019	50	24	77	127
Full bloom																			
Year	Tb	DDmin	DDAve	DDmax	Year	Tb	DDmin	DDAve	DDmax	Year	Tb	DDmin	DDAve	DDmax	Year	Tb	DDmin	DDAve	DDmax
2016	50.7	566	701	815	2016	50	605	746	863	2016	46.8	666	803	1021	2016	50	514	616	809
2017	50.7	340	438	508	2017	50	369	472	546	2017	46.8	319	542	696	2017	50	194	381	509
2018	50.7	527	615	677	2018	50	560	652	719	2018	46.8	527	741	887	2018	50	390	569	689
2019	50.7	462	594	682	2019	50	497	634	727	2019	46.8	494	695	847	2019	50	353	519	645
Veraison																			
Year	Tb	DDmin	DDAve	DDmax	Year	Tb	DDmin	DDAve	DDmax	Year	Tb	DDmin	DDAve	DDmax	Year	Tb	DDmin	DDAve	DDmax
2016	54.5	1435	1557	2307	2016	50	1996	2145	1693	2016	49.5	1710	2042	2241	2016	50	1653	1978	2173
2017	54.5	1482	1594	2226	2017	50	1962	2101	1691	2017	49.5	1589	1990	2186	2017	50	1538	1932	2123
2018	54.5	1572	1681	2370	2018	50	2093	2229	1795	2018	49.5	1721	2117	2319	2018	50	1669	2058	2255
2019	54.5	1427	1532	2225	2019	50	1958	2090	1640	2019	49.5	1636	1998	2175	2019	50	1582	1936	2110

The variability of five weather stations was analyzed for the accumulation of Growing Degree Days during the growing season from April 1 to October 31 for several years (Figure 1) using Tb= 50.

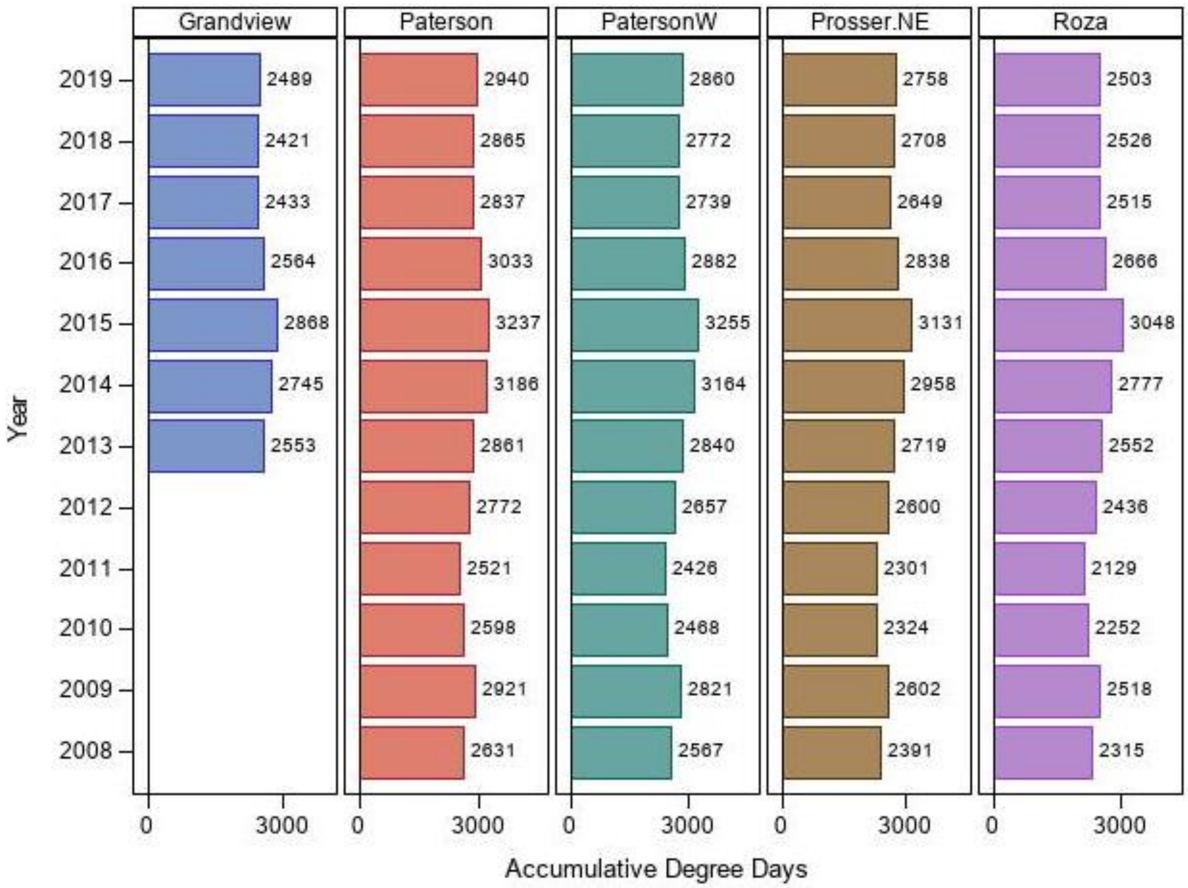

Figure 1. Accumulative Degree Days variability.

<u>Objective 2.</u> *To determine the critical temperatures of non-dormant reproductive tissue (during and after bud break) of grapevine cultivars under conditions of the Pacific Northwest.*

Critical temperatures of non-dormant reproductive tissue (during and after bud break) of Cabernet Sauvignon and Chardonnay during spring were determined under field and laboratory conditions for FS (First swell), BS(Bud swell), BB (Bud break), R(Rosete), FL (First leaf). A comparison of the variability for the data collected in the lab and field is presented only for Bud Break for Cabernet Sauvignon (Figure 2). A summary of the progression and change in temperatures by cultivar for all of the stages evaluated is presented in Figure 3. The values of the parameters and the temperatures estimated for each stage are presented in Table 4.

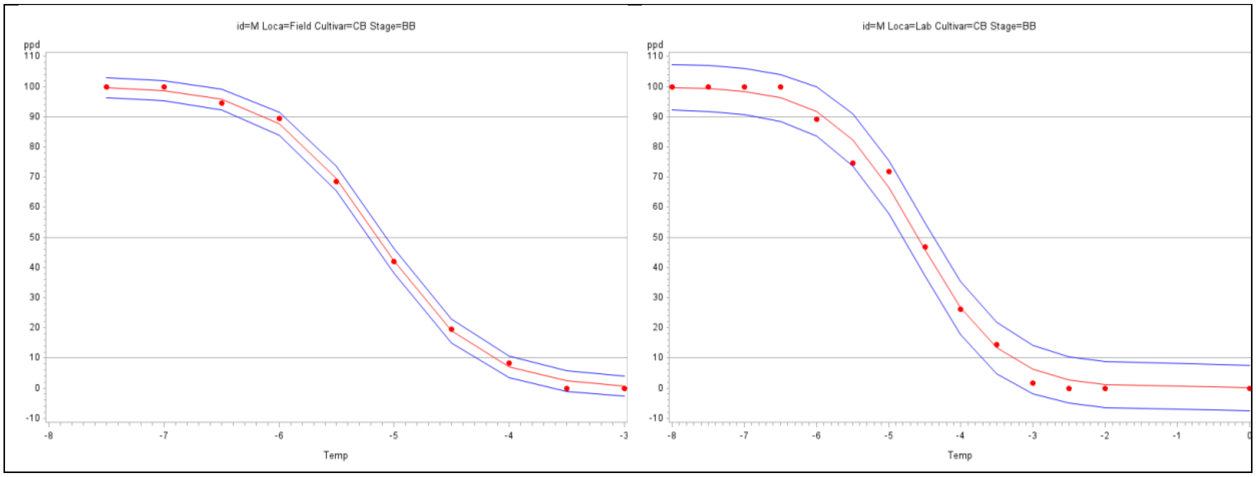

Figure 2. Comparison of the variability for BB example for Cabernet Sauvignon under field and laboratory.

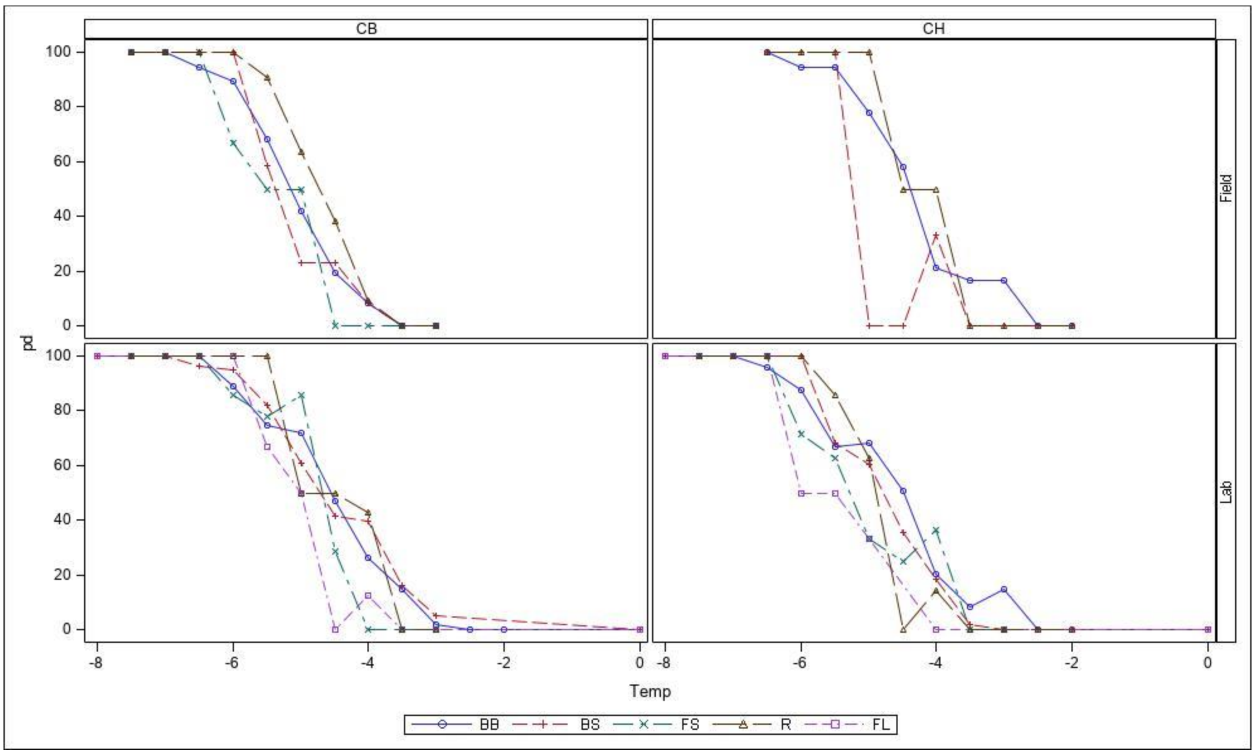

Figure 3. Progression and change in temperatures for Cabernet and Chardonnay under Field and Lab conditions for the different stages, FS (First swell), BS(Bud swell), BB (Bud break), R(Rosette), FL (First leaf).

Table 4. Parameters and temperatures estimated for each stage. LT10, LT50, LT90

Cultivar	Stage	Loca	d1	c	k	g	Stderr	LowLim	UppLim	LT10	LT50	LT90
	BS		100	0.000	-3.800	-5.4	0.077	-5.6	-5.2	-4.8	-5.4	-6.0
Cabernet	BB		100	0.000	-2.300	-5.1	0.017	-5.2	-5.1	-4.1	-5.1	-6.1
	R	Field	100	0.000	-2.800	-4.7	0.029	-4.8	-4.7	-3.9	-4.7	-5.5
	BS		100	0.000	-2.500	-4.5	0.060	-4.6	-4.3	-3.5	-4.5	-5.3
Chardonnay	BB		99	0.000	-2.400	-4.4	0.060	-4.6	-4.3	-3.5	-4.4	-5.3
	R		100	0.000	-2.800	-4.3	0.105	-4.5	-4	-3.4	-4.3	-5.0
	BS		100	0.000	-1.500	-4.6	0.101	-4.8	-4.3	-3.1	-4.6	-6.0
Cabernet	BB		100	0.000	-1.700	-4.6	0.046	-4.7	-4.5	-3.3	-4.6	-5.9
	R	Lab	100	0.000	-1.900	-4.5	0.147	-4.9	-4.2	-3.4	-4.5	-5.7
	BS		100	0.000	-2.000	-4.8	0.057	-5	-4.7	-3.7	-4.8	-5.9
Chardonnay	BB		100	0.000	-1.500	-4.7	0.063	-4.8	-4.5	-3.2	-4.7	-6.1
	R		100	0.000	-2.400	-4.7	0.051	-4.8	-4.5	-3.7	-4.7	-5.6

Objective 3. *To implement the results as a decision support tool on the AgWeatherNet portal to be used by local growers and vineyard managers.*

An information delivery system and media tool were planned and developed; a preliminary model was incorporated in the AWN page as a decision support tool. The new Director of AWN removed the model from the Webpage, AWN is in possession of the algorithm and parameters of the model.

Literature:

1. Ashenfelter, O, and Storchmann, K. 2016. Climate Change and Wine: A Review of the Economic Implications. Journal of Wine Economics, 11 (1):105-138.
2. Camargo, H., Salazar, M., and Hoogenboom, G. 2016. Predicting the dormancy and bud break dates for grapevines. *Hortimodel 2016* submitted paper. International Society for Horticultural Science, Brussels, Belgium.
3. Ferguson, J.C., J.M. Tarara, L.J. Mills, G.G. Grove, and M. Keller. 2011. Dynamic thermal time model of cold hardiness for dormant grapevine buds. Ann. Bot. 107:389-396.
4. Gu, S. 2016. Growing degree hours- a simple, accurate, and precise protocol to approximate growing heat summation for grapevines. *International Journal of Biometeorology* 60 (8): 1123–1134.
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7. Zapata D.M., Salazar M., Chaves B., Keller M., and Hoogenboom G. 2015. Estimation of the base temperature and growth phase duration in terms of thermal time for four grapevine cultivars. *International Journal of Biometeorology* 59 (12) 1771-1781.