

NE1720 Annual Meeting (Virtual) Hosted by Highland CC,
11/9/2020

Attendees:

Scott Kohl (Highland Community College, Kansas) (Chair)
Matthew Clark (U. Minnesota)
Dean Volenberg (U. Missouri)
Paul Read (U. Nebraska)
Tom Bewick (USDA NIFA)
Bruce Bordelon (Purdue University)
Gail Nonnecke (ISU)
Bruce Resich (Cornell University)
Horst Caspari (Colorado State)
Grant Cramer (U. Nevada Reno)
Tim Martinson (Cornell University)
Esmaeil Nasrollahiazar (Michigan State University) nasroll2@msu.edu
Candice Fitch-Deitz (Highland Community College)
Harlene Hatterman-Valenti (North Dakota State)
Elsa Petit (U. Massachusetts)
Aude Watrelot (Iowa State)
Terry Bradshaw (UVM)
Dan Ward (Rutgers)
Felipe Barrios Masias (U.Nevada-Reno)

Absent: Joe Fiola (Co-Chair)

Introductions

Tom Bewick: National Program Leader, USDA NIFA TBEWICK@USDA.GOV

NIFA Update: Reduction of NIFA employees to ~180 employees (down from 419) due to move to Kansas City

- RFA List: <https://nifa.usda.gov/rfa-list>
- Upcoming RFA calendar <https://nifa.usda.gov/upcoming-rfa-calendar>
- SCRI update (in 2018 Farm Bill):
 - Legislative focus areas (see upcoming RFA for pre applications)
 - No cost extensions allowed
 - Jan 19, Pre-apps due
 - Mar 15 Invites for full proposals
 - May 15 full apps due
 - July 30 funding recommendations finalized
 - Oct 15, 2021

2021 Meeting Plans

Joe Fiola U. Maryland (proposed)

2022 Meeting

Highland CC, Kansas (back up in 2021, if Maryland is not available)

Margaret Smith Associate Dean Ag. Experiment Station, Cornell University (Ithaca);
Administrative Advisor to NE1720

Timeline for project renewals (see word document given to Scott)

Y1: Request to write (winter); Drafting proposal (Summer); Fall (Peer Review and Revisions)

Y2: Review by MAS and NERA approval (winter); 2nd opportunity for NERA approval (summer); CSREES review and approval; Oct 1 start date

Integrated, collaborative projects (not just loosely connected projects)

Matt Clark and Horst, Esmail, Harlene, Elsa, Terry B.

Volunteers to help to do the project renewal (initiate with the request to write). Focus on multi-state (jointly planned and executed): what are the objectives and approach to meet objectives? Plan this for the 2021 Annual meeting.

Impact statements: work on this (was missing in the 2019 annual reports). Should focus on these for the 2020 report, and for project planning. What impact does NE1720 have on the grower community/with stakeholders?

Some ideas for project areas in renewal

Horst: cold acclimation (recent cold events of 14F in October as the first frost), 3x as many record cold events in recent years.

Jason Londo (USDA-ARS) has a lot of data in this area in Geneva, NY

Tim: Collecting and collating data from the last 7-8 years including 1020 & 1720 data (seconded by Dan Ward)

-standardized format for data submission

-submission of data at all :)

Grant: Cold acclimation; increase in GDD in Nevada. Cold less of an issue with climate change. What is the broad perspective if the group remains broad (in geography)?

Margaret: implementation of a database

Bruce Reisch: What is the focus of the group? Coordinated efforts of new variety testing (supporting breeders) in advancing breeding selections.

Esmail: Lots of room for new varieties for testing at new Michigan vineyard site

Bruce Bordelon: Testing new selections is important; helps to advance new varieties with stakeholders (because they may have seen the vines and tasted wines).

Horst: Interested in testing new varieties. (benefit "impact" clear with adoption of new varieties)

Tom Bewick: sentinel varieties will be useful/required for a project like this

Dan (added post discussion): Sentinel varieties by region from the past

| | | Dormant season | | |
|-----------------------|-------------|-----------------------|--------------------------------------|---------------------|
| Growing season | | mild | cold | very cold |
| Growing season | Cool | Pinot noir, Cab franc | Pinot noir, Cabernet franc | Frontenac, St Croix |
| | Warm | Cab Sauvignon Merlot | Cab Sauv, Merlot, Chambourcin, Vidal | Frontenac, St Croix |
| | Hot | Cab Sauvignon Merlot | Cab Sauv, Merlot, Chambourcin, Vidal | |

Gail: supports this idea; data collection and consolidation/sharing

Bruce B. Some type of output to share with stakeholders, publish the data (could be extension bulletin; Catalyst, etc.); a weakness is low record of coordinated publication

Grant: youtube channel, podcast, etc. as a format to disseminate information. YouTube channel cost nothing. Can earn revenue from YouTube for the commercials/ads that they add to the channel.

Scott: The NE1720 program doesn't have "funding" per se.

Matt: How can the NE1720 group be more effective at data collection and dissemination?

Tom B. NC140 (25 years history, gets papers out).
We should talk to Terry Bradshaw (UVM)?

Dan Ward: Strong project coordinator with a significant role in design, data collection, framing, etc. for each of the uniform plantings. Subset of multi-state members per planting (region, species, etc.). A coordinator is in charge of a planting and sees it through to publication; sets requirements on the collaborations.

Grant: people will need to donate their time for the efforts in doing this type of collaborations. No easy solution, will require an extra effort.

Tom: Multi-state project has yearly leadership rotation but could set up an "Objective" chair (volunteers) who lead the objective and contribute to the continuity. Make this part of service for tenure/promotion and recognized by Dept. Head/Deans

Margaret: consider this for the proposal writing process

Scott: More objectives in new proposal, with focus that would allow for an objective leader without too broad of responsibility.

Dan: Sub-objectives fit well for this idea leading to more academic outputs

Horst: Northern Grapes Project was developed as a subset of this group;
Can we make more use of winemaking that is being done?

Dan: wine making/training was useful (done at Geneva meeting); could be added to be more specific: "wine making" specifically listed in proposals

Margaret: Funding is at discretion of local Ag. Exp. Station director; getting approval nationally doesn't give you entitlement to any funding. Is any-one station director willing to fund more aspects of this project? Funding in particular or to the entire project

Tom: use of federal funds to make wine: the assessment of grape quality REQUIRES evaluation of wine products and thus wine making. What additional enologist can come onto this project? (new person at VT); SCRI should be a target for this group to get funding (systems approach, multi-state, transdisciplinary); Specialty Crop Block Grant Program (within states through State Dept of Ag; ~\$20 million for Multi-state) through Ag Marketing Service
<https://www.ams.usda.gov/services/grants/scmp>
<https://www.ams.usda.gov/services/grants/scmp/states-contacts> these seem to be the states that administer were set in 2015: <https://www.ams.usda.gov/press-release/usda-selects-18-states-participate-2015-specialty-crop-multi-state-program>

NE1720 Objectives (Current): <https://www.nimss.org/projects/view/mrp/outline/18405>

1. Screen the viticulture characteristics of clones, cultivars and elite germplasm with significant potential throughout the USA.
2. Evaluate the viticultural and wine attributes of promising emerging cultivars and genotypes based on regional needs.
3. Conduct explorations of new germplasm and lesser-known cultivars that may have economic potential for the US wine industry.

Proposals for 2023 Meeting Host (selection of secretary for 2021)

2023: Michigan (requested by Esmaeil)

2022: Kansas?

2021: Maryland

2020: Kansas

2019: Minnesota

2018: Missouri

2017: New Jersey

2016: Vermont

2015: South Dakota

2014: New York

2013: Nebraska

2012: Connecticut

2011: Idaho

2010: Michigan

State Reports (see written submitted reports: submit them here

https://drive.google.com/drive/folders/13tYh1tLzL_uO0scYVDhLpYD1L9YpGtO?usp=sharing)

Colorado: Horst Caspari: 2 year severe winter weather (in October); loss of St. Vincent w/no observable symptoms and not cold injury related, no suckers

New York (Cornell): Tim Martinson: Two Vignoles irradiated clonal selections for loose clusters significantly reduce cluster rots(USDA-ARS; MTA required). Two clones are available from Double A Vineyards. Tim would like the 2 clones plus the 'standard' Vignoles placed in plantings for evaluation. tem2@cornell.edu **please contact him with numbers of vines needed.**

Bruce Reisch: bruce.reisch@cornell.edu

3 selections for testing for quality white wine, standard disease resistance
1 Red wine grape selection with Run1/Rpv 1 resistance for Powdery and downy Mildew resistance
Riesling hybrid NY81.0315-17 rot resistant
Rose specific red wine variety NY01.609.01
Vines are being propagated at Double AA

Iowa: Gail: Aude Watrelot new faculty member in enology; potential new positions Fruit Crops (tenure track); field specialist (horticulture crops)

Ideas for new selections for planting? (with Itasca, Petite Pearl and Crimson Pearl)
Experienced 80-140 mph sustained winds that blew entire vineyards down, replaced posts and stood vines back up

Vermont: Terry Bradshaw: 8 varieties fruiting for the first time **may come back later
Survey of viruses in Vermont; little virus detected in vineyard (nursery site) and established vineyards (8 viruses included leaf roll).
Testing named varieties (not selections). GDD has increased in Vermont, varieties had very low acid comparatively in 2020; very high brix for some (Marquette 27.6) .Verona is high yielding.
Collected disease data on foliage and clusters in unsprayed vineyard for 2 years (2018/2019).
Reported that biodynamic/natural wines in the press.

VitiNord December 12-13 2022 <https://vitinord.org>

Kansas: Candice: space for 10 emerging varieties or selections: Includes 2 from North Dakota. Cold hardiness (spring frost) and issue in 2020 due to earl budbreak/late frost. Resulted in second crop on laterals.

Maryland: not present

Massachusetts: Elsa Petit: trunk diseases, fruit fly variety preferences. Unique death of Chambourcin (leaf purple, vein green: checked for red blotch and grapevine rupestris stem pitting associated virus but came back negative); shoot and cluster thinning on Frontenac and Chardonnell. Dean commented that Chambourcin (in Missouri) has leaf blotch and somewhat asymptomatic for crown gall (in vascular but no visible lesions)

Michigan: Esmaeil: Polar vortex (2019); crown gall; GDD is difficult to estimate, changes due to climate change, but can cause problems for ripening. ~20 Brix for some key varieties.

Minnesota: Matt: MN 1220 will be released. If interested in trialling any varieties contact Matt at clark776@umn.edu. Several other advanced selections are in process for eventual release.

Missouri: D.V. and collaborators are working on looking at virus combinations in Norton, Chambourcin, and (other ?). 'Cunningham' has been brought back to the U.S. by Lucie Morton and it is being quarantined and cleaned up here.

Nebraska: Paul: Current research with varieties from ND, MN, Cornell, and private breeders. Working on growing season extension via high tunnel and experiments in 2021 with V. vinifera. Crop reduction/yield to improve fruit quality requested by industry. Ground cover study is complete and published.

Nevada: Grant Cramer: NCD3: ABA biosynthesis; ABA regulation and drought tolerance. Field experiment (rootstocks (ramsey, riparia, and cab sauv) with cav sauv scion. Investigated ABA, NCD3 transcript abundance, protein abundance. Drought stress experiment on own roots (Ramsey and Riparia); rapid dehydration experiment. Confirmed that Ramsey is more drought tolerant than CS and Riparia. Rootstocks play a role in growth, water relations, and salinity. Improved growth under drought stress. ABA increases more rapidly in Ramsey>CS>Riparia. Increased NCD3 transcript abundance, but not the protein

New Jersey. Dan Ward: daniel.ward@rutgers.edu (change to email!) Happy to help data analysis. Early season had fruit quality issues, late season less of an impact. Windy and rainy. (89 mph winds knocked down high cordon plants). Italian varieties (at FPS)

Grapevine Pinot gris virus: limiting distribution of material out of FPS.

New selection: San Marco; loose clusters, black fruit, oval shape Teroldego x Lagrein
<https://www.morningagclips.com/ocpva-names-new-wine-grapes/>

North Dakota: Harlene: Injury response in 2018/2019. Retrained vines in 2019 died in 2019/2020 winter. Not clear why. New growth, grows longer in the season and doesn't acclimate as well. Even after mild winter! Late frost damage at some sites (5/11/20 28F and 5/12 26F). Variation within 20 miles for budbreak. 2 selections; ND054.27 and ND213 large cluster grapes. Being tested in Montana (Tongue River). Targeting TA under 10 g/l. Deacclimation is an issue, particularly in ND.

Indiana (Purdue): Bruce Bordelon: 2019 November was very cold (single digits). Mild winter overall. 2 frost events in spring. 8 varieties had crops (Petit Ami, Prairie Star, Petite Pearl, Crimson Pearl, Verona) and Frontenacs. Petite pearl has short rachis, Verona suffered sour rot (thin skin). Petite Pearl alternative to Marquette (avoids frost). Marquette is not being recommended. Thomcord performs well.

Recommendation for vineyard sensors: Low cost temperature sensors USB-501Pro (\$125 from Measurement Computing).

New Business and Announcements

Members discussed virtual meeting technology being used for future NE1720 meetings
Allowing the participation of individuals unable to join face-to-face meetings

Objectives

1. Evaluation of vine establishment and performance

Location:

Hot-Cold Climate Warm-Cold Climate

W. Col. Res. Ctr. – Orchard Mesa W. Col. Res. Ctr. – Rogers Mesa 3170 B ½ Rd,
Grand Junction, CO 81503 30624 Highway 92, Hotchkiss, CO 81419 39.02.35 N,
108.27.57 W 38.47.56 N, 107.47.16 W

Elevation: 1,433 m 1,718 m

Soil: Clay loam Clay loam

Average GDD (°C): 2,020 (15 Apr-31 Oct) 1,550 (1 May-31 Oct)

2020 GDD (°C): 2,267 (15 Apr-26 Oct) 1,825 (1 May-26 Oct)

Killing frost: 26 Oct 2020 (-10.0 °C) 26 October 2020 (-14.7

°C) Average frost-free period: 182 days 150 days

Design: RCB (6 blocks, 4-vine plots) RCB (6 blocks, 4-vine plots) Rootstock: 110R,
own rooted own-rooted, except NY 81.0315.17/101-14 Training system: VSP, High
Cordon VSP, High Cordon

Vine x row spacing: 1.52 m x 2.44 m 1.52 m x 2.69 m

Irrigation: Micro-sprinkler Micro-sprinkler

A series of record cold temperature events (Oct 1, 2008; Dec 9-11, 2009; May 1, 2011) are thought to have caused significant cold injury to most vines at the **Hot-Cold** site. Only 27.3 % of the vines planted in the spring of 2008 were still alive by the fall of 2011. Own-rooted replacement vines of 10 varieties were planted in the spring of 2011. Also, Aglianico and Carignane were replaced by Chambourcin and Marquette, respectively. In 2012, the few remaining vines of Aleatico, Furmint, and Trousseau were removed and replaced by three new varieties (Cabernet Dorsa/1103P, Durif, and Zweigelt). In the spring of 2016, 24 Itasca (MN 1285) were planted in open spaces previously planted to Tocai Friulano and Verdejo.

Overall, vine survival has been much better at the **Warm-Cold** site. However, there are pronounced differences in vine survival between cold-hardy varieties (average 92 %) and *Vitis vinifera* varieties (average 68 %).

2020 season

The determining factor for the 2020 season were record cold events at the start and end of the dormant season. The first event occurred on 30 and 31 October 2019. For the first time since record keeping began in 1895 a temperature below -10 °C was recorded in October in the Grand Valley – the previous minimum being -9.4 °C. At the Western Colorado Research Center – Orchard Mesa the temperature on 30 and 31 October 2019 dropped to -13.4 °C and -13.0 °C, respectively. In fact, these were the lowest temperatures recorded during the dormant season. Bud evaluation following this cold event showed a range of 0 % to 76 % for primary bud kill (Fig. 1).

There was a clear trend for higher bud damage on late-ripening *Vitis vinifera* varieties. Of note is the very high primary bud survival of two Blaufränkisch (aka Lemberger) crosses: Cabernet Dorsa (Blaufränkisch x Dornfelder) and Zweigelt (Blaufränkisch x Sankt Laurent).

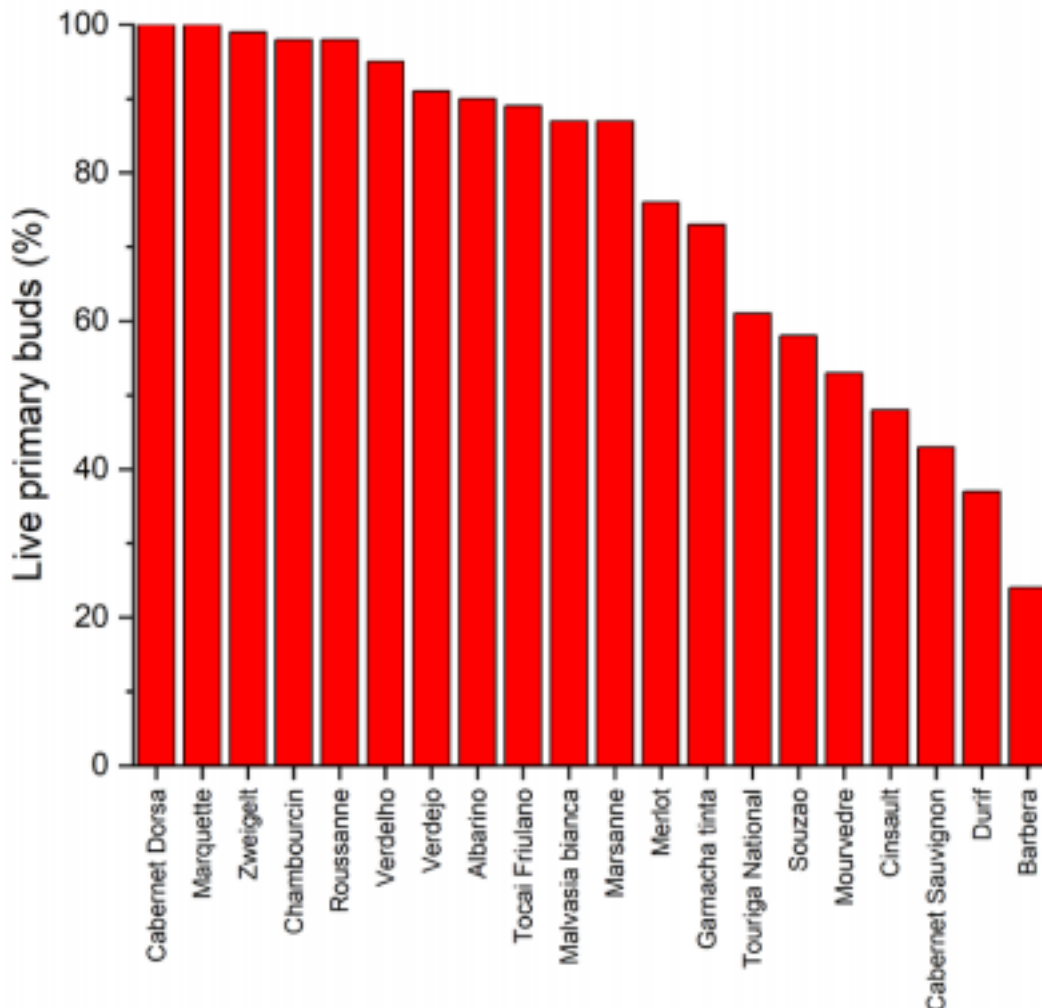


Fig. 1: Primary bud damage for 20 grape varieties growing at the Western Colorado Research Center – Orchard Mesa from extreme low temperature events in late October 2019.

Another record-breaking cold event (-7.8 °C) occurred on 14 April 2020, just prior to bud break for many varieties. Results from controlled freezing tests during the first week of April indicated that early breaking varieties had LT₅₀ values >-6.7 °C. That close to bud break we were unable to do a detailed survey to determine the impact of this severe spring freeze event on varieties that had sustained no or minimal bud damage during the severe fall freeze event. However, yield reductions of 50 % or more compared to the 2019 season were primarily due to lower cluster number and much reduced average cluster weights, indicating that many primary buds were killed and much of the crop came from secondary shoots.

At the Warm-Cold site the minimum temperatures on 30 and 31 October were -13.7 °C and -15.2 °C, respectively. The dormant-season minimum temperature was -16.7 °C on 31 Dec 2019. Bud

break at this site is 2-3 weeks later than at the Hot-Cold site so none of the varieties were affected by the 14 April freeze.

The 2020 growing season was once again hot and dry. Growing degree days (°C) at the Hot-Cold site from 15 April to killing frost on 26 October was 2,267, the fourth highest ever recorded. Timing of bud break was average but harvest as much as three weeks earlier than average. We had both the earliest start and end of harvest ever. On average the crop was reduced by >50 % compared to 2019.

2. Initiate winemaking and continue evaluation of vine establishment and performance. At the Hot-Cold site, yield and must data (Table 1) were obtained from all varieties but wines were made from 14 varieties only. Yields were insufficient to make wine from Barbera, Cinsault, Garnacha Tinta, Mourvedre, Tocai Friulano, and Verdejo.

Table 1: Vine growth, yield and must data at the **Hot-Cold** site for 2020 season^a.

| Variety | Vine survival (%) | Harvest Date | Yield (Kg/m ²) | Cluster number/m | Berry Weight (g) | Must pH | Must Brix | Must TA (g/l) |
|--------------------|-------------------|--------------|----------------------------|------------------|------------------|---------|-----------|---------------|
| Albarino | 96 | 04-Sep-20 | 2.35 | 55.4 | 1.20 | 3.45 | 25.2 | 6.60 |
| Barbera | 54 | 22-Sep-20 | 0.86 | 10.0 | 1.49 | 3.47 | 30.5 | 6.57 |
| Cabernet Dorsa | 71 | 29-Aug-18 | 1.70 | 18.3 | 1.16 | 3.55 | 28.3 | 6.50 |
| Cabernet Sauvignon | 96 | 22-Sep-20 | 1.48 | 22.3 | 0.99 | 3.34 | 26.9 | 6.59 |
| Chambourcin | 100 | 14-Sep-20 | 1.87 | 18.8 | 1.50 | 3.16 | 25.8 | 8.68 |
| Cinsault | 63 | 22-Sep-20 | 1.10 | 9.2 | 2.73 | 3.54 | 26.9 | 5.61 |
| Durif | 79 | 22-Sep-20 | 1.72 | 15.8 | 1.33 | 3.27 | 28.2 | 6.74 |
| Garnacha Tinta | 33 | 22-Sep-20 | 2.15 | 16.6 | 1.51 | 3.47 | 27.1 | 5.07 |
| Malvasia bianca | 75 | 26-Aug-20 | 1.56 | 9.1 | 2.13 | 3.28 | 22.8 | 7.75 |

| | | | | | | | | |
|------------------|-----|-----------|------|------|------|------|------|------|
| Marquette | 100 | 10-Aug-20 | 1.72 | 42.4 | 0.85 | 3.07 | 29.9 | 9.79 |
| Marsanne | 54 | 15-Sep-20 | 1.90 | 18.8 | 1.13 | 3.65 | 25.2 | 5.32 |
| Merlot | 79 | 27-Aug-20 | 1.53 | 25.3 | 1.01 | 3.30 | 24.7 | 6.88 |
| Mourvedre | 83 | 22-Sep-20 | 0.86 | 9.0 | 1.77 | 3.39 | 24.5 | 6.55 |
| Roussanne | 54 | 14-Sep-20 | 1.81 | 25.5 | 0.94 | 3.12 | 27.6 | 9.75 |
| Souzao | 71 | 16-Sep-20 | 1.06 | 16.2 | 1.30 | 3.17 | 25.6 | 8.08 |
| Tocai Friulano | 8 | 18-Sep-20 | 2.00 | 19.6 | 1.22 | 3.75 | 28.7 | 4.14 |
| Touriga Nacional | 46 | 17-Sep-20 | 2.10 | 23.1 | 1.43 | 3.45 | 24.8 | 6.15 |
| Verdejo | 8 | 18-Sep-20 | 0.75 | 22.0 | 2.05 | 3.64 | 26.8 | 4.62 |
| Verdelho | 63 | 26-Aug-20 | 2.69 | 27.4 | 1.03 | 3.23 | 27.8 | 7.62 |
| Zweigelt | 96 | 26-Aug-20 | 1.38 | 15.9 | 1.18 | 3.17 | 25.9 | 7.47 |

*Based on live vines

Despite netting, wildlife damage from racoons and birds continues to be a major issue at the Warm-Cold site. There was no yield on Auxerrois, Bianchetta trevigiana, and Blauer Portugieser due to the extreme cold event in late October 2019 (Table 2).

Table 2: Vine growth, yield and must data at the **Warm-Cold** site for 2020 season.

| Variety | Vine survival (%) | Harvest Date | Yield (Kg/m ²) | Cluster number/m | Berry Weight (g) | Must pH | Must Brix | Must TA (g/l) |
|---------|-------------------|--------------|----------------------------|------------------|------------------|---------|-----------|---------------|
|---------|-------------------|--------------|----------------------------|------------------|------------------|---------|-----------|---------------|

| | | | | | | | | |
|--------------------------|-----|--------------|------|------|------|------|------|-------|
| Aromella | 83 | 24-Sep 20 | 0.52 | 11.6 | 1.28 | 3.29 | 26.3 | 8.75 |
| Auxerrois | 54 | | | | | | | |
| Bianchetta trevigiana | 75 | | | | | | | |
| Blauer Portugieser | 58 | | | | | | | |
| Chambourci n | 96 | 16-Oct 20 | 1.42 | 20.3 | 1.60 | 3.25 | 26.5 | 10.34 |
| Grüner Veltliner | 83 | 29-Sep 20 | 0.47 | 10.4 | 0.97 | 3.31 | 24.4 | 6.81 |
| Marquette | 100 | 02-Sep 20 | 0.64 | 18.4 | 0.91 | 3.52 | 30.4 | 7.99 |
| MN 1200 | 100 | 02-Sep 20 | 0.93 | 30.5 | 0.82 | 3.36 | 28.7 | 6.77 |
| NY 81.0315.17 | 79 | 29-Sep 20 | 1.37 | 22.1 | 1.31 | 3.35 | 24.9 | 6.09 |
| Vidal | 92 | 16-Oct 20 | 2.41 | 23.9 | 1.29 | 3.36 | 25.1 | 7.86 |

Useful findings (Hot-Cold site)

- Several extreme cold temperature events during the first six years of this study resulted in high vine mortalities and complete crop losses.
- A record-breaking extreme cold temperature event in late October 2019 resulted in big differences in bud damage. Late ripening *Vitis vinifera* varieties had much higher levels of bud damage than early or mid-season varieties.
- Long pruning in situations when there is high damage to fruitful buds followed by shoot thinning after bud break can be used to achieve moderate yields even when primary bud damage exceeds 50 % (example Cabernet Sauvignon: 6 t ha⁻¹ with 57 % primary bud kill).
- Since 2015, only three varieties have averaged more than 6.7 t ha⁻¹ (3.0 ton acre⁻¹): Albarino, Cabernet Sauvignon, and Cinsault.
- Bud cold hardiness evaluations over the past four to six years show that Albarino, Cabernet Dorsa, and Zweigelt are more cold hardy than Chardonnay and Cabernet Sauvignon throughout most of the dormant season. Albarino, Cabernet Dorsa, and Zweigelt also had very high primary bud survival following a severe freeze event very early in the dormant season.

- Bud break of Marquette is extremely early – up to four weeks ahead of Chardonnay. • Cabernet Dorsa and Zweigelt also break bud early, ahead of Chardonnay.
- Despite 100 % vine survival, yields of Chambourcin and Marquette have been disappointing. The low yields can be in part attributed to the wider vine spacing used for those two varieties (2.03 m versus 1.52 m for all other varieties) and insufficient vine vigor to fill the allocated space. Other contributing factors with Marquette are very low berry and cluster weights.

**NE1720: MULTI-STATE EVALUATION OF WINEGRAPE
CULTIVARS AND CLONES
2020 Report**

State: Iowa

Author(s): Iowa State University

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Timing of Activities: 2019-2020

Impact Nugget:

New Facilities and Equipment:

Announcements:

Faculty and Personnel:

New faculty member in enology.

[Dr. Aude Watrelot](#) was hired as Assistant Professor of Enology in the Department of Food Science and Human Nutrition in August 2019, with activities in the [Midwest Grape and Winery Industry Institute](#).

Unique Project-Related Findings:

In Iowa:

A derecho on August 10, 2020 damaged research vineyards at the Iowa State University Horticulture Station. Both single curtain and double curtain trellising systems were flattened and the crop was lost. Trellis line posts were replaced and the vineyards' trellises reestablished.

Accomplishments Related to each of the 3 Objectives:

1. Screen the viticulture characteristics of clones, cultivars and elite germplasm with significant potential throughout the USA.
 - It was determined that northern hybrids selected for cold climates rely on other factors in addition to heat accumulation for guiding annual development, and factors such

as photoperiod likely have a strong influence on phenological timing during seasons with unusual weather patterns.

2. Evaluate the viticultural and wine attributes of promising emerging cultivars and genotypes based on regional needs.

- Summary analysis of screening of cold-climate wine grape cultivars and advanced selections for their viticultural characteristics in Iowa were completed and include:

- Cultivars Frontenac, MN1258, MN1220, and MN 1200 have the lowest risk of issues related to cold temperature.

- Based on both yield and fruit composition variables, cultivars and selections of Marquette, MN 1235 and MN 1220 ranked as top performing in Iowa's climate, followed by Petit Ami and St. Croix. 'La Crescent' had midrange yields and high SSC, but the high total acidity of 'La Crescent' fruit resulted in a low sugar:acid ratio at harvest. Three cultivars, Corot Noir, MN 1189 and Arandell, had insufficient yield or undesirable fruit composition in Iowa's climatic conditions.

3. Conduct explorations of new germplasm and lesser-known cultivars that may have economic potential for the US wine industry.

- Grapevine cultivars in the current NE1720 trial showed that Itasca, Crimson Pearl, and Petite Pearl survived record low winter temperatures in January 2019, whereas NY06.0514.06 and NY81.0315.17 died and did not regrow from the ground level or had minimum growth from the ground level.

Impact Statements

Iowa grape growers seek adapted cultivars with economic yields and excellent fruit quality for local climatic and soil conditions. NE1020 and NE1720 trials provide timely and relevant information about cultivars and new selections adapted for Iowa's production environments.

Published Written Works (relative to NE-1720 activities)

Nonnecke G. R. and J. Schrader. 2020. Impact of minimum winter temperatures on the growth of winegrape cultivars and advanced selections. Iowa State University Research and Demonstration Farms Progress Reports 2019-36, p. 23-24. RFR-A1928:

Available online: <https://www.iastatedigitalpress.com/farmreports/article/id/11321/>

Schrader, J.A., P. A. Domoto, G.R. Nonnecke, and D.R. Cochran. 2020. Multifactor models for improved prediction of phenological timing in cold-climate wine grapes.

HortScience. Online publication date: October 26, 2020. Published online ahead of issue.
doi: <https://doi.org/10.21273/HORTSCI15367-20>

Schrader, J.A., D.R. Cochran, P.A. Domoto, and G.R. Nonnecke. 2020. Yield and berry composition of cold-climate grape cultivars and advanced selections in Iowa climate. HortTechnology. 30(2):193-203. doi: <https://doi.org/10.21273/HORTTECH04557-19>

Schrader, J.A. D.R. Cochran, P.A. Domoto, and G.R. Nonnecke. 2019 (Dec.). Phenology and Winter Hardiness of Cold-climate Grape Cultivars and Advanced Selections in Iowa Climate. HortTechnology. 29(6):906-922.
doi: <https://doi.org/10.21273/HORTTECH04475-19>

Watrelet A.A. and E. Norton. 2020. Chemistry and reactivity of tannins in *Vitis* spp.: A Review. Molecules. 25(9):2110. doi: [10.3390/molecules25092110](https://doi.org/10.3390/molecules25092110)

Scientific and Outreach Oral Presentations (relative to NE 1020 activities) Most

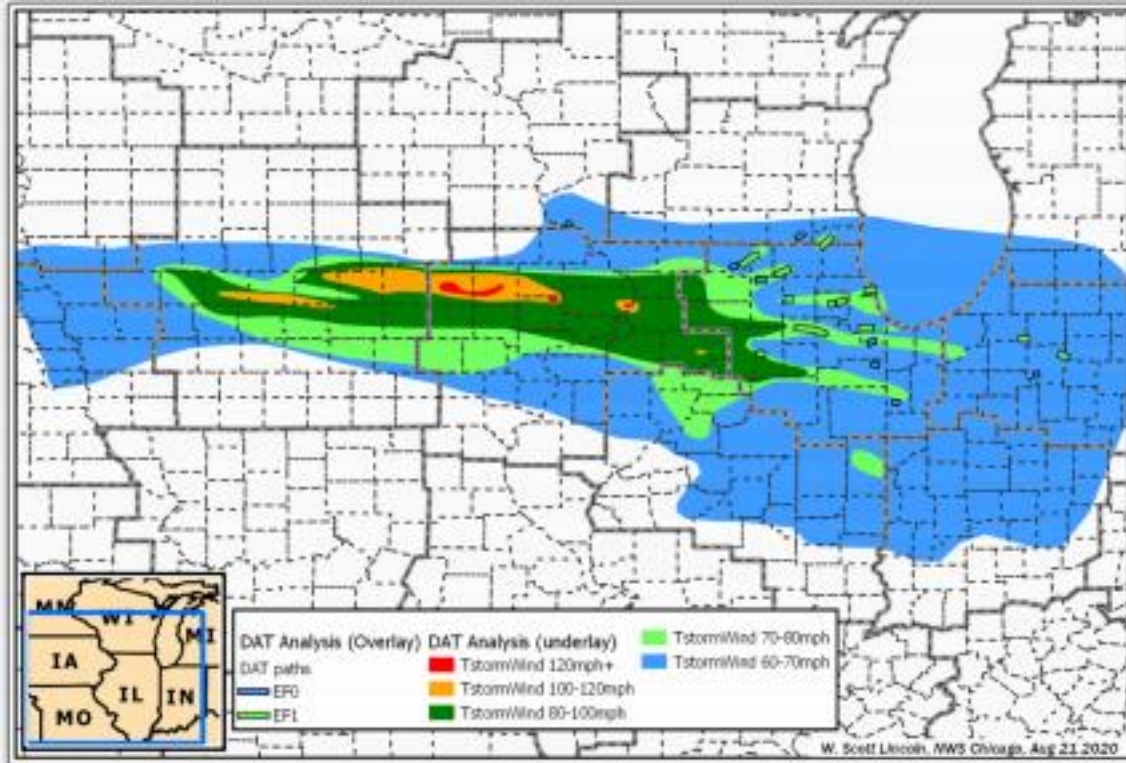
planned events cancelled or postponed.

Fund Leveraging (relative to NE 1020 activities)

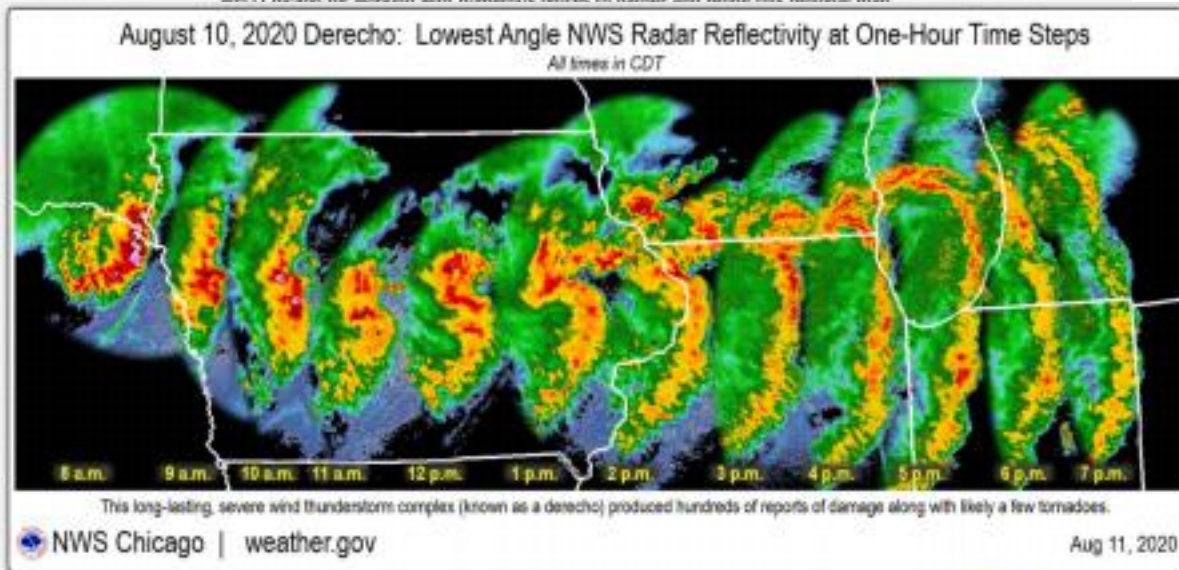
Appendix

A. Derecho images from the National Weather Service, August 10, 2020: <https://www.weather.gov/dmx/2020derecho>

B. Photographs of the ISU Horticulture Research Station's vineyards.
Appendix A: National Weather Service, August 10, 2020.



Preliminary map above shows the estimated wind speeds of the August 10, 2020 derecho across the region as of August 21, 2020. This is a collaborative effort between weather forecast offices Des Moines, IA Sioux Falls, SD Omaha, NE, Quad Cities, IA/IL, La Crosse, WI, Milwaukee, WI, Chicago, IL, central Illinois, IL, northern Indiana, IN, Indianapolis, IN, northern Indiana, IN, and Grand Rapids, MI. Thanks to Scott Lincoln, NWS Chicago for sharing with emergency offices in northern and central states.



Hourly radar images of the derecho's progression across the region. Image courtesy NWS Chicago (original).

Appendix B. Iowa State University, Horticulture Research Station's Vineyards.



August 12, 2020. Derecho damage to 'Marquette' and 'La Crescent' vineyard trellises.



October 12, 2020. Replacement of damaged posts and trellis system in 'Marquette' and 'La Crescent' vineyard

NE1720: MULTI-STATE EVALUATION OF WINEGRAPE CULTIVARS AND CLONES

2020 Report

State: Kansas

Author(s): Scott Kohl, Candice Fitch-Deitz

Timing of Activities: 10/1/2019 – 9/30/2020

1. Impact Nugget

The winery business incubator, 456 Wineries is managed by Highland Community College and currently has 3 incubator clients in the facility with a 4th client currently processing their licenses. That will make five wineries under one roof, representing nearly 10% of all wineries in Kansas.

2. New Facilities and Equipment

Highland Community College opened the new winery business incubator (www.456Wineries.com) just before harvest 2019 offering a better space for wine trials. The incubator has a commercial sales space / tasting room providing an outlet for direct consumer outreach.

3. Unique Project-Related Findings

Three consecutive nights of post bud-break freeze (April 24-26) killed primary buds in most varieties of the research blocks. Harvest yields were less than half of 2019 yields, canopy management became a nightmare due to plentiful lateral shoot growth, and over half of the cultivars set a secondary crop.

4. Accomplishments Related to Each of the 3 Objectives

1. Screen the viticulture characteristics of clones, cultivars and elite germplasm with significant potential throughout the USA.
 - a. Trial plot established in 2013, separate from NE1020 and NE1720. Annual wine evaluations started in 2017. Forty-four cultivars, 12 vines each. Growth data published online².
 - b. Second trial plot established in 2018. First crop expected in 2022. Crimson Cabernet and Zinthiana.
 - c. Third trial plot in development. Two varieties from North Dakota State University Grape Germplasm Enhancement Project established, ND054.27 and ND213. Buffer rows to include Frontenac Blanc, Crimson Pearl, Petite Pearl, Itasca, Chardonel, and Noiret with space for 10 additional germplasm trials within the Randomized Block Design.
2. Evaluate the viticultural and wine attributes of promising emerging cultivars and genotypes based on regional needs.
 - . Juice and must data from 2013 Trial Plot listed above: 2017³, 2018⁴, and 2019⁵.
3. Conduct explorations of new germplasm and lesser-known cultivars that may have economic potential for the US wine industry.
 - . N/A

5. Impact Statements

When Highland CC began offering degree programs in 2010, Kansas had approximately fifteen wineries. Today there are over fifty wineries, many of which have owners/operators that have taken

classes at HCC or attended workshops hosted by HCC. In 2010, Kansas had approximately 350 acres of vines. In 2020 that number is approaching 1000 acres.

6. Published Written Works (Relative to NE1720 Activities)

N/A

7. Scientific and Outreach Oral Presentations (Relative to NE1720 Activities)

- Fitch-Deitz, C. Something to Wine About. Brown County Women in Ag. Hiawatha, KS. 11/19/2019. 75 Attendees.
- Fitch-Deitz, C. Pruning Workshop. Dover, KS. 2/8/2020. 25 Attendees.
- Fitch-Deitz, C; Kohl, S. Viticultural Field Day. Wamego, KS. 7/28/2020. 30 Attendees.

8. Fund Leveraging (Relative to NE1720 Activities)

Viticulture and Enology Science and Technology Alliance (VESTA) 2015-2021 sub-award. NSF-ATE. Norgren, M. Co-PIs: Gump, B.; Fennell, A.; Smith, T.; Kohl, S. Aug 2015 – July 2021, \$271,196. Online Education Emphasis

9. Online resources:

1. [Research Vineyard Layout and replant notes \(Est. 2013\)](#)
2. [http://456wineries.com/wp-content/uploads/2020/01/Highland-Community-College-Viticulture-and-Enology-Program -Demonstation-and-Research-Vineyard-2017-2019-Harvest-Data.pdf](http://456wineries.com/wp-content/uploads/2020/01/Highland-Community-College-Viticulture-and-Enology-Program-Demonstation-and-Research-Vineyard-2017-2019-Harvest-Data.pdf)
3. <https://docs.google.com/spreadsheets/d/1tIvVAmFRrcP6ZscuFaxuA0jslmdbZKMcP5jbuxq1ANQ/edit?usp=sharing>
4. <https://docs.google.com/spreadsheets/d/1c09RmHEaPyozxNikGpvBJ8DBtGMWTOgTvUnyIigdEq0/edit?usp=sharing>
5. https://docs.google.com/spreadsheets/d/122XcsuN5QcN0CzGmcOfjNbp_LoU0Y9k5mwFqvz1EI18/edit?usp=sharing

NE1720: MULTI-STATE EVALUATION OF WINEGRAPE CULTIVARS AND CLONES

2020 Report

State: Northwest and Southwest Michigan

Author(s): Esmail Nasrollahiazar. Viticulture Extension Educator, Michigan State University Extension

Timing of Activities: 07/1/2020 – 11/31/2020

1. Northwest Michigan Horticulture Research Center (NWMHRC) research facilities

NWMHRC has two experiment vineyards including following varieties.

| Older vineyard | New vineyard (Disease resistance varieties) |
|--------------------|--|
| Pinot Noir | Soreli |
| Pinot gris | Fleurtaï |
| Cabernet franc | |
| Chardonnay | |
| Zweigelt | |
| Valvin Muscat | |
| Riesling | |
| Madeleine Angevine | |

NWMHRC has a viticulture and Enology lab, which is equipped with basic fruit quality analysis and color analysis (Spectroscopy) equipment.

We are going to the differential thermal analysis (DTA) equipment to the lab.

2. Research project:

Looking into the effectiveness of triggering the grape gene contributing to anthocyanin biosynthesis.

One of the main grape production challenges in cool climate viticulture with a short growing season is to consistently reach a uniform, optimal fruit technological maturity at harvest before the first autumn frost (Frioni et al, 2017). Low anthocyanin accumulation is a common grape production issue in cool climate viticulture areas. Indeed, viticulture practices partially can solve the issue, and enhancing the biosynthesis anthocyanin could be complementary.

Kereamy et al. in 2017 showed that spraying Cabernet Sauvignon grapes, with 5% ethanol at veraison enhances the anthocyanin accumulation. Ethanol in combination with an ethylene precursor enhanced anthocyanin content of cranberries. (Farag et al. 1992) The application of exogenous ethanol has been reported to inhibit or promote tomato fruit ripening in a dose-dependent manner, correlated to ethylene evolution (Beaulieu et al. 1997).

Ethanol at low levels can enhance anthocyanin accumulation in grape berries at veraison. Further research indicated that low-level ethanol can inhibit the expression of Cha, F3h, Dfr and Ans, while greatly enhancing the expression of Ufgt. These results highlight the significant role of UFGT in anthocyanin biosynthesis, and suggest that low-level ethanol can trigger grape expression leading to anthocyanin accumulation during ripening. (He st al. 2010).

This project aims to improve grape technological ripening in *Vitis Vinifera* cultivars and better understand the relationships between grape gene expression leading to anthocyanin, the application of exogenous ethanol and basic fruit quality in grapes. Our research questions are:

- 1) How does exogenous ethanol affect concentration of anthocyanin compound at harvest?
- 2) To what extent application of exogenous ethanol can improve grape basic quality, and farmer profitability?

Cold Hardiness Monitoring for Grapevines in Northwest Michigan (coming project)

Dormant buds will be collected from 5 to 15-year old vines growing at the NW Michigan grape growing areas. Buds will be taken from canes of moderate vigor that had no obvious sign of damage. Canes will cut so as to leave a 4-bud spur, and eight buds were used from each cane. The buds will be randomly assigned to 6 to 10 sets of 3 buds per variety and used for the differential thermal analysis (DTA). The samples will be placed on three trays; each tray included eleven thermoelectric modules (TEMs) that detect temperature gradients generated by the exotherms according to the methodology described by Mills et al. (2016). Buds will be covered in aluminum foil and placed directly on each TEM protected by foam insulation pads. A chamber lid was tightened to the tray and then will be loaded into a programmable freezer. The freezer will be programmed for a cooling rate of 4 °C /h decline. Initially, the temperature will be held at 4 °C for 1h and then dropped to -40 °C in 11h, then returned to 4 °C in 10 h, and then a DTA analysis will be performed. Thirty TEMs will be loaded per run (90 buds). The system will record for each TEM a voltage signal that corresponds to the temperature at which super cooled water presumably in the tissue freezes. The signals will be sent to an Excel spreadsheet. Exotherms were identified plotting the TEM signals (mV) against the temperature (°C). Bud exotherm output from the DTA system will previously be compared with tissue browning during the 2020/21 dormant season.

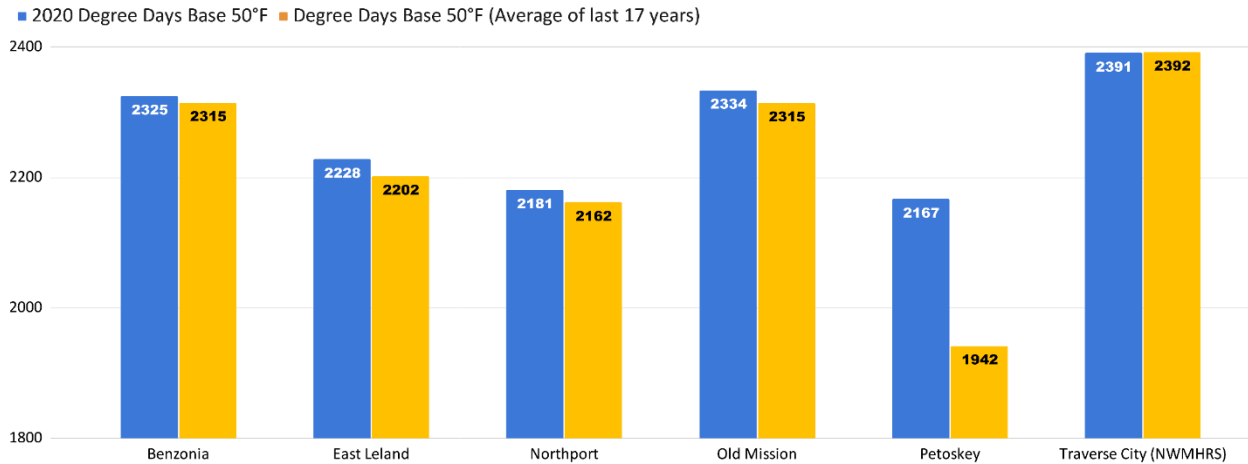
Objective 1 – Monitor and provide weekly bud cold hardiness updates of grape varieties after any cold events below 5°F in NW Michigan

5+ grape cultivars, ranging in baseline cold hardiness, will be evaluated each week in the dormant season (November to April) for their bud cold hardiness. Results will be published online, as in an MSU Extension update each week. Results will also be used to inform winter pruning decision-making, and disseminated through an MSU Extension article.

Objective 2 – Establish cold-hardiness limits of a range of grape varieties in Michigan to inform planting choices and site selection. Bud cold hardiness data collected in the winter of 2020-2021 will be compiled as a metric for site suitability and disseminated as an extension article, as well as in grower meetings.

Objective 3 – Provide cold damage evaluation service for the local growers at NWMHRC at the beginning of the growing season to help the grower to make the right decision of winter pruning.

2020 Growing Season Growing Degree Day & Ripening Summary



Average GDD Recorded in 10 weather station in Northwest Michigan 2003-2020

| Variety | Northwest Region (°Brix) | Southwest Region (°Brix) |
|--------------------|--------------------------|--------------------------|
| Pinot Noir | 21.8 | -- |
| Pinot Gris | 21 | 20.3 |
| Pinot Blanc | 21.6 | 21.3 |
| Cabernet Franc | 19.1 | 19.6 |
| Zweigelt | 20 | -- |
| Riesling | 19.5 | 19.6 |
| Madeleine Angevine | 22 | -- |
| Chardonnay | 21.5 | -- |
| Valvin Muscat | 18.1 | 20.6 |
| Traminette | -- | 21.4 |
| Gewurztraminer | -- | 21.2 |
| Cabernet Sauvignon | -- | 21.8 |
| Gruener Veltliner | -- | 20.6 |
| Concord | -- | 17.7 |
| Niagara | -- | 19.2 |

3. **Published Written Works (*relative to NE-1720 activities*)**
 1. [Viticultural practices in northwest Michigan at veraison](#)
 2. [Bird damage reduction strategies utilizing viticultural practices](#)
 3. [Critical practices to control late season grape diseases and the potential effects of fungicides on fermentation](#)
 4. [Post-harvest vineyard management: Preparing vines for winter](#)

4. New position:

Next year, a new Viticulture Specialist will be open for Southwest Michigan.

NE1720: MULTI-STATE EVALUATION OF WINEGRAPE CULTIVARS AND CLONES

2020 Report

State: Minnesota

Author(s): Matthew Clark, PhD. Assistant Professor, Grape Breeding and Enology, University of Minnesota-Twin Cities

Timing of Activities: 10/1/2019 – 9/30/2020

1. Impact Nugget: This project reaches over 80 wineries in the state, and the associated grape growers and suppliers in the state. The economic impact of grapes and wine, and associated tourism is over \$80M a year. The vineyards in Minnesota are primarily planted with U. Minnesota varieties that have been developed specifically for wine making, with the newest release 'Itasca' coming out in 2017 and first commercial wines now available.

2. New Facilities and Equipment: Purchase of new Stirling -80 ultra cold freezer for storage of samples for genetic and mass spectrometry evaluation.

3. Unique Project-Related Findings: Recent discoveries have uncovered the genetic regions associated with important traits in the breeding program. Jack Olson, MS identified a major QTL for the leaf variegation trait that is common, recessive trait in the program. Lu Yin, PhD, confirmed the QTL for leaf trichomes in a large mapping population. Also, she fine-mapped the QTL region for foliar phylloxera resistance to a single gene.

4. Accomplishments Related to each of the 3 Objectives:

Obj 1. The University of Minnesota does not have a dedicated (replicated) NE1720 or NE1020 vineyard for evaluation. However, the breeding program contributes germplasm for evaluation to the different sites. We report on key varieties and advanced breeding selections grown at the Horticultural Research Center during NE1720 meetings and state reports. The FY 2020 annual meeting was held at the University of Minnesota and participants were able to tour the research vineyards and trial table and wine grape selections. In 2020, we terminated some accessions that had been under evaluation for 10+ years which creates an opportunity to trial additional germplasm.

Obj 2. Our breeding program provided cuttings and whole plants of several selections of wine and table grape cultivars for evaluation with NE1720 test sites including U. Wisconsin, South Dakota State U., and non-university testers. Selections included MN1220, MN 1280, MN1369, and MN1296. We continued to make additional plants through cuttings and tissue culture (shoot culture) for further distribution in

testing in future years. One selection MN1220 is being advanced for variety release and has been distributed to nurseries.

Obj 3. We continued our efforts in sharing germplasm with collaborators (Primarily USDA-ARS) for the integration of fruit quality traits and diseases resistance into our cold-hardy back ground. In 2020, seedlings were evaluated for powdery mildew resistance in Geneva, NY. The targeted populations had multiple sources of resistance, called gene pyramiding. The objective is enter this disease resistant germplasm into the national repository so that private and public sector breeders have acces to the genetic materials and the DNA testing tools to trace the inheritance of these traits into regionally adapted germplasm.

5. Impact Statements

6. Published Written Works (*relative to NE-1720 activities*)

Ebbenga, D. N.*, Burkness, E. C., Clark, M. D., & Hutchison, W. D. Risk of increased volatile acidity and Spotted wing drosophila injury in Minnesota wine grape varieties. American Journal for Enology and Viticulture.

Underhill, A. N. *, Clark, M. D., & Hirsch, C. D. Image-based phenotyping identifies QTL for cluster compactness in grape. J ASHS

Zou, C., Karn, A., Reisch, B., Nguyen, A., Sun, Y., Bao, Y., Cambell, M. S., Church, D., Williams, S., Xu, X., Ledbetter, C. A., Patel, S., Fennell, A., Glaubitz, J., Clark, M., Ware, D., Londo, J., Sun, Q., & Cadle, L. (2020).

Haplotyping the Vitis collinear core genome with rhAmpSeq improves marker transferability in a diverse genus. Nature Biotechnology.

Underhill, A. N. *, Clark, M. D., & Hirsch, C. D. (2020). Evaluating and mapping grape color using image-based phenotyping. Plant Phenomics: 8086309. <https://doi.org/10.34133/2020/8086309>

Yin, L. *, Clark, M., Burkness, E., & Hutchison, W. (2019). Grape Phylloxera, *Daktulosphaira vitifoliae* Fitch (Hemiptera: Phylloxeridae), on Cold-hardy Hybrid Wine Grapes (*Vitis* spp.): A Review of Pest Biology, Damage, and Management Practices. J. Integrated Pest Management. doi:<https://doi.org/10.1093/jipm/pmz011>

Yin. L., Burkness, E., Hutchison, W.D., & Clark, M.D. Effect of foliar phylloxera infestation on grapevine photosynthesis, yield, and fruit quality. [Submitted to J. of Entomological Science

7. Scientific and Outreach Oral Presentations (relative to NE 1020 activities)

Clark, M.D., Clark, A.M., Irish, L.E., & Smith, A.G. Bridging horticulture and art, using a drawing- to-learn framework to teach plant propagation concepts. American Society for Horticultural Science, Virtual Conference. (August 10-13, 2020)

Moreira, L., Wannemuehler, S.D., Treiber, E., Suresh, J., Brockman, S., Clark, M.D., & Hegeman, A. Sensory and metabolomic analyses link attributes of flavor and aroma in North American cold-hardy grapes. American Society for Horticultural Science, Virtual Conference. (August 10-13, 2020)

Syvantek, A., Stenger, J., Clark, M., Auwater, C., & Hatterman-Valenti, H., Exploratory observations on inheritance of lacinate leaves in hybrid grapevine populations derived from 'Chasselas Ciotat'. American Society for Enology and Viticulture. 2020, 3rd Place Video Presentation. (No conference held due to COVID-19).

Clark, M.D. Flavorful grapes aren't just for wine. You can eat them, too! CFANS Spotlight. <https://www.youtube.com/watch?v=tf0X6LdU1ho&feature=youtu.be> (2020).

Clark, M.D., Treiber, E., Karn, A., Zou, C., Cadle-Davidson, L., & Reisch, B. Seedling selection with AmpSeq Enriches Populations for Seedlessness, Muscat Aroma, and Powdery Mildew Resistance. 9th International Table Grape Symposium, Santiago, Chile. (February 17-21, 2020).

Moreira, L., & Clark, M.D. Characterization of flavor and aroma compounds in Minnesota cold-hardy grapes. 9th International Table Grape Symposium, Santiago, Chile. (February 17-21, 2020).

Treiber, E., Moreira, L., & Clark, M. D. Cold-hardy table grapes in Minnesota. 9th International Table Grape Symposium, Santiago, Chile. (February 17-21, 2020).

8. Fund Leveraging (*relative to NE 1020 activities*)

Award: Genetic Improvement of Hybrid Grape Fruit Quality Traits

Project Investigators: Clark, Matthew D (Principal)

Status: Pending federal approval

Sponsoring Organization: Minnesota Dept. of Agriculture Award Dates: 2020 - 2022

Funded Amount: \$99,929.00

Award: A Comprehensive Curriculum for Cold Climate Grapevine Production: Practical Skills for the Novice and Vineyard Manager

Project Investigators: Clark, Matthew D (Principal), Klodd, Annie (Co-PI) Status: Funded

Sponsoring Organization: North Central Regional Sustainable Agriculture Research and Education (SARE)

Award Dates: 2019 - 2021 Funded Amount: \$38,390.00

Award: Development and Evaluation of Cold Hardy Table Grapes

Project Investigators: Clark, Matthew D (Principal) Status: Funded

Sponsoring Organization: Minnesota Dept. of Agriculture Award Dates: 2019 - 2022

Funded Amount: \$239,819.00

NE1720: MULTI-STATE EVALUATION OF WINEGRAPE CULTIVARS AND CLONES

State: Missouri

Author(s): Dean S. Volenberg

Timing of Activities: January 2020 to November 2020

1. **Impact Nugget:** An extensive survey of Missouri vineyards determined that most all hybrid grape cultivars testing positive for Grapevine Red Blotch virus (GRBV) do not display typical Red Blotch symptomology except Crimson cabernet (Norton x Cabernet Sauvignon) which is 62.5% *Vitis vinifera*.

2. **New Facilities and Equipment:** Hanna autotitrator to quantify TA and pH in grape juice samples from grapevines infected or uninfected with GRBV.

3. **Unique Project-Related Findings:** Through an extensive sampling and testing procedure it was determined that Grapevine Red Blotch virus had an incidence of 54% within a two-acre block (1,200 vines) of Crimson Cabernet (Norton x Cabernet Sauvignon).

4. **Accomplishments Related to each of the 3 Objectives:**

1. A replicated cultivar trial was planned and grapevines ordered to be established in April 2021. The trial will consist of more than 40 cultivars and breeder selections.

2. The Missouri Grape and Wine Institute is currently in the process of hiring a Extension Enology Faculty position who will make and oversee small-batch wine production from the cultivar trial.

3. Bud wood is being sourced from Foundation Plant Services of grape cultivars from the Republic of Georgia and will be grafted to suitable rootstocks. These selections will be established in the replicated cultivar trial in April 2022.

5. **Impact Statements:** Grapevine viruses are one of the major issues resulting in reduced juice quality, grapevine vine health and grapevine longevity. Past research has focused often on the negative impact of a single grapevine virus in infected plants. With more than 70 grapevine viruses documented, often grapevines are infected with more than one virus. Little is known about the impact of more than one virus on grapevine juice quality, grapevine health and grapevine longevity. Research is underway to establish a replicated trial of grapevine cultivars infected with no viruses, GRBV, GLRaV-3 or the combination of GRBV with GLRaV-3. The results will have important implications for Missouri grape growers since a recent survey of commercial vineyards throughout Missouri determined that GLRaV 3 and GRBV were present in 53% and 35% of the samples, respectively. Yet, most all infected grape cultivars except Crimson Cabernet (Norton x Cabernet Sauvignon) do not display typical GRBV or GLRaV-3 symptomology as documented in *Vitis vinifera* cultivars.

6. **Published Written Works (relative to NE-1720 activities)**

Schoelz, J., D. Volenberg, M. Adhab, V. Klassen, C. Spinka, and M. Al Rwahnih. 2021. A Survey of Viruses Found in Grapevine Cultivars Grown in Missouri. AJEV (accepted in press).

7. **Scientific and Outreach Oral Presentations (relative to NE 1720 activities)** Grapevine survey for viruses of potential economic importance in Norton, Chambourcin, and Vignoles

Dr. James Schoelz and Dr. Dean Volenberg

Potential insect vectors of grapevine red blotch virus in Missouri vineyards

Harper Smith, Dr. Dean Volenberg, and Dr. Debbie Finke

8. Fund Leveraging (*relative to NE 1720 activities*)

The Missouri Wine and Grape Board provided \$10,000 for the establishment of a replicated cultivar trial to be established in April 2021.

NE1720: MULTI-STATE EVALUATION OF WINEGRAPE CULTIVARS AND CLONES

2020 Report

State: Nebraska

Author(s):

Paul E. Read, Professor of Horticulture/Viticulture

Stephen J. Gamet, Viticulture Technician

Benjamin A. Loseke, Laboratory Technician

Email contact: pread@unl.edu

University of Nebraska

Timing of Activities: 10/1/2019 – 9/30/2020

Impact Nugget: Over 100 grapevine cultivars and selections have been evaluated over a period of 20 years by the University of Nebraska Viticulture Program. New selections from private breeders, the University of Minnesota and Cornell University have been tested for cold hardiness, tolerance to abiotic and biotic stresses, response to vineyard floor and trellis management systems, yield and fruit and wine quality and characteristics. A new high tunnel project evaluating the ability to grow *vinifera* varieties in our cold climate has been initiated. In addition, the continuation of our crop load adjustment study continues in collaboration with UNL Food Science Department professionals (new faculty, Doctors Changmu Xu and Xiaoqing Xie).

2. **New Facilities and Equipment:** A new high tunnel is currently being constructed at Capitol View Winery to evaluate *vinifera* grape varieties.

3. **Unique Project-Related Findings:** New selections from Cornell University, the University of Minnesota, North Dakota State University and a private breeder (Ed Swanson, Cuthills Vineyards owner and Capitol View Winery winemaker) have been newly initiated.

4. **Accomplishments Related to each of the 3 Objectives:**

Obj 1. Screen the viticulture characteristics of clones, cultivars and elite germplasm with significant potential throughout the USA.

- As noted above, a large number of cultivars and selections have been evaluated for viticultural characteristics including timing of bud break, winter hardiness, resistance to stresses including grapevine trunk diseases, the number of growing degree days (GDD) required to reach specific phenological stages (e.g. flowering, veraison, harvest ripeness) and harvest parameters. Results have been presented at international, national and regional meetings and conferences (see list noted in #6), in our electronic newsletter (the Nebraska VineLines) and via our web site <https://viticulture.unl.edu>

Obj 2. Evaluate the viticultural and wine attributes of promising emerging cultivars and genotypes based on regional needs.

- Specific cultivars and selections – e.g. Marquette, Petite Pearl, La Crescent, Frontenac and Itasca – have been evaluated for both viticultural and wine attributes, the latter in collaboration with scientists in the UNL Department of Food Science and the Food Processing Center (Doctor Xu and Doctor Xie).

Obj 3. Conduct explorations of new germplasm and lesser-known cultivars that may have economic potential for the US wine industry.

- For the Impact Statements (#5) – Nebraska growers have shifted cultivar focus based upon our results, including new plantings of Brianna, Petite Pearl, , Noiret, Itasca and Frontenac Blanc, for example, and have grafted over plantings (e.g. Brianna grafted over to Itasca). They also have adopted trellis systems and ground cover options based upon UNVP research associated with the NE 1720 project.

1. Impact Statements

- The success of the Nebraska wine and grape industry continues to improve with new cold hardy cultivars that also produce high quality wine.

1. Published Written Works (*relative to NE-1720 activities*)

| Title | Authors | Year | Type | Presented/Published | Status |
|--|---|------|-----------------|--|-----------|
| History of Viticulture and Wine Making in Midwest USA | Read, P.E. Loseke, B.A. Gamet, S.J. | 2019 | Journal Article | Acta Horticulturae | Accepted |
| Teaching Beverage Crop Science: Vines, Wines and You, a Case Study | Read, P.E. Loseke, B.A. Gamet, S.J. | 2019 | Journal Article | Acta Horticulturae | Accepted |
| Relating Harvest Timing to Growing Degree Day Accumulation | Read, P.E. Loseke, B.A. Gamet, S.J. | 2019 | Journal Article | c | Accepted |
| Biofortification with Selenium and Lithium Improves Nutraceutical Properties of Major Winery Grapes in the | Zhao, H. Xie, X. Xu, C. Read, P.E. Li, W. Loseke, B.A. | 2019 | Journal Article | Journal of Agricultural and Food Chemistry | In Review |

| | | | | | |
|---|---|------|------------------|--|-----------|
| Midwestern United States | Gamet, S.J. | | | | |
| Rootstock and Mounding Affect Growth and Cold Hardiness of Young 'Gewürztraminer' (<i>Vitis vinifera</i>) Vines | Gu, S. Read, P.E. Loseke, B.A. | 2019 | Journal Article | International Journal of Fruit Science | In Review |
| Impact of Alleyway and In-row Planted Groundcovers on 'Edelweiss' Grapevine Growth and Fruit Production | Read, P.E. Loseke, B.A. Gamet, S.J. | 2019 | Journal Article | International Journal of Fruit Science | Submitted |
| High Tunnel Table Grapes: An Alternative to Field Production in Nebraska? | Read, P.E. Loseke, B.A. Gamet, S.J. | 2019 | Poster | American Society for Horticultural Science | Presented |
| Chilling Requirements for 'Edelweiss', 'Frontenac' and 'Norton' Grapevines | Read, P.E. Loseke, B.A. Gamet, S.J. | 2019 | Poster | American Society for Horticultural Science | Presented |
| Hybrid Trunk Disease Evaluation: A Serendipitous Opportunity | Read, P.E. Loseke, B.A. Gamet, S.J. | 2019 | Oral Pres. | International Workshop on Trunk Diseases | Presented |
| Trunk Diseases and Winter Injury in NE America, How are They Related? | Smart, R. Barriault, E. Read, P. Volenberg, D. | 2019 | Magazine Article | Wine Business Monthly | Published |

I. Fund Leveraging (relative to NE 1020 activities)

USDA/Nebraska Department of Agriculture Block Grants

- Grafting to Delay Bud Break
- A Wine Industry Dilemma: Does Crop Size Reduction Make Better Wine?
- Table Grape Production in High Tunnels and Controlling Climate Variability

NE 1720 – Multi-State Evaluation of Winegrapes and Clones: ABA regulation and Drought Tolerance

2020 Report

State: Nevada

Author(s): Grant Cramer, Felipe Barrios Masias, ML Robinson, University of Nevada, Reno

Timing of Activities: 07/1/2020 – 11/31/2020

1. Itemized description of the research activities

- The vineyard experiment continued in Las Vegas with Ramsey and Riparia rootstock, and own-rooted vines of Colombard and Syrah as scions
- Soil samples were taken and analyzed from the Las Vegas vineyard and the natural site of SC2 in the Ashland Meadows Wildlife refuge
- Pruning weights of the vines, fruits yields, and Brix, titratable acidity and pH of the fruit at harvest were measured at the Las Vegas site.
- Two drought stress experiments were conducted in the summer with grafted grapevines in the greenhouse with Ramsey, Riparia and Cabernet Sauvignon rootstock and Cabernet Sauvignon scion.
 - Physiology (photosynthesis, stomatal conductance, growth and root hydraulics) measurements were made
 - Molecular measurements were made (ABA, NCED3 transcript and protein abundance)
- Molecular measurements (ABA, NCED3 transcript and protein abundance) were made for a previous drought stress experiment of grapevines grown on their own roots in the greenhouse
- A rapid dehydration experiment was conducted to support previous analyses
 - Both physiological and molecular measurements were made (ABA, NCED3 transcript and protein abundance in detached leaves)

Summary of preliminary results

- Ramsey is more drought tolerant than Cabernet Sauvignon (CS) and Riparia.
- Root stock influences growth, water relations and leaf chloride contents. CS root hydraulics are more sensitive to drought.
- Photosynthesis was not affected by rootstock in Colombard and Syrah at the Las Vegas site. Ramsey rootstock increased fruit yield and Riparia rootstock decreased fruit yield for Colombard, but both rootstocks decreased fruit yields for Syrah.
- Rootstock enhanced scion growth under drought stress in greenhouse experiments.
- Abscisic acid (ABA), a plant stress hormone, increased more rapidly due to water deficit in Ramsey, which was greater than Cabernet Sauvignon, which was much greater than Riparia.
- ABA concentrations were well correlated with transcript abundance but not protein abundance.
- Soil samples indicate mild salinity levels at Las Vegas site and high B levels at the Ashland Meadows site.
- A YouTube channel was created to make public previous data and information for Nevada Viticulture and Wines.

2. Impacts of this project, thus far:

Impacts in this project are:

Four graduate students have been trained in conducting experiments with grapevines. They have learned experimental design, statistics and data analysis. They have learned physiological measurements such as photosynthesis, water relations, hydraulic conductance, and ion analyses. They have also learned molecular analyses related to ABA analysis involving ABA concentrations, transcript and protein abundance of NCED3, the rate limiting enzymatic step in ABA biosynthesis.

Information was recently released to the public on a YouTube channel. It is too early to evaluate the impact but more than 60 people have viewed this site and there are currently 24 subscribers.

At least 3 publications are in preparation from the data already collected and are part of the graduate students PhD theses, two of whom are expected to finish this year.

No changes have been made to the goals or objectives of this project.

Quantitative Measurements for NIFA Reporting

Enter number of Adults and/or Youth you have had DIRECT contact with on this project:

Adults: 12

Youth: 0

Enter the number of Adults and/or Youth you have had INDIRECT contact with on this project:

Adults: 25

Youth: 0

List any external factors which may affect outcomes (bullet points, expand as needed).

- **None**

Peer-Reviewed Publications (provide title, authors, journal, page numbers and year):

- **None**

Brochures, Bulletins, Fact Sheets, Newsletters, and Surveys (list):

- **None**

Abstracts, Books, Book Chapter(s), Proceedings, Research Reports, and Technical Publications (list):

- None

Manuals and Other Printed Instructional Materials Produced (list):

- None

Presentations (list):

- NE1720 multi-state project annual meeting

Demonstrations and Workshops conducted (list):

- None

Number of Patents: None

Leveraged Research Funds (list):

- None

Digital Media and Websites created or updated (list):

- <https://www.youtube.com/user/grantcramer>

List number of people trained:

Grads: 4

Postdocs: 0

Undergrads: 6

Databases, Models, Protocols, and Research Materials (list):

- None

New Germplasm (list):

- None

NE1720: MULTI-STATE EVALUATION OF WINEGRAPE CULTIVARS AND CLONES

2020 Report

State: New York

Author(s): Bruce Reisch, Tim Martinson, and Alice Wise

Timing of Activities: 2020

1. Impact Nugget:

- Reisch Program: Six selections of interest have been offered to all members of NE1720
- Martinson: Two ‘Loose Clustered Vignoles’ selections have been grafted by Double A Vineyards and are ready for distribution in 2021
- Wise: 32 vinifera and 5 hybrid varieties are under evaluation at the Long Island Horticultural Research and Extension Center in Riverhead, Long Island

2. New Facilities and Equipment:

3. Unique Project-Related Findings:

4. Accomplishments Related to each of the 3 Objectives:

1. *Screen the viticulture characteristics of clones, cultivars and elite germplasm with significant potential throughout the USA.*

Martinson Program Accomplishments: For the fourth year, irradiated clones of the cultivar ‘vignoles’ have been evaluated for late season fruit rots (*Botrytis* bunch rot and sour rot). Eight clones have reduced rot incidence and severity by over 50%, and a subset have acceptable cluster size and weight. Two selections, R67V79 and R65V83, have been tested for leafroll and released to Double A vineyards for propagation. These selections are grafted to C3309 rootstock and available to NE1720 members for planting in 2021. We are making a list of interested sites for planting the two ‘loose-clustered’ clones along with standard Vignoles vines for further evaluations.

2. Evaluate the viticultural and wine attributes of promising emerging cultivars and genotypes based on regional needs.

Wise Program (Long Island): Data was generated from 37 varieties, 32 vinifera varieties and 5 hybrids. The vinifera varieties represent new and less common selections that could help growers diversify their vineyards and wine portfolios. It is essential to screen these as currently planting costs for one acre on Long Island is >\$20,000, not including the land. The disease resistance and fruit quality of the hybrids is being assessed in support of sustainable viticulture goals. These vines were treated with approximately half the fungicides of the vinifera. Also, hybrids are harvested earlier than vinifera, lessening the economic risk associated with letting fruit hang throughout the fall (avoiding losses to tropical storms, cluster rot, birds, raccoons, etc). Two vinifera selections were planted in 2019, Mencía, a versatile Spanish red, and Rkatsiteli, an aromatic white that has had some success in the Finger Lakes. In 2020, the vinifera Tannat (high tannin red) and two hybrids of Tocai Friulano were planted. TF is a high quality vinifera variety with economically unsustainable low yields. In terms of industry planting, based on our results, plantings of Albariño, Verdejo, Muscat Ottonel and

Auxerrois have been done recently. One grower has expressed strong interest in NY 81, the Cayuga White x Riesling hybrid. We have had great success with NY81 – consistently good yields with low wire VSP training and excellent fruit quality with no cluster rot.

3. Conduct explorations of new germplasm and lesser-known cultivars that may have economic potential for the US wine industry.

Reisch Program Accomplishments: Our role in NE1720 is to develop promising selections with commercial potential, and offer them to NE1720 participants for testing in a variety of locations. We have identified six selections of interest (four white wine, one highly-disease resistant red wine, and one for rosé production), and have offered these selections to all members of NE1720. One offered in 2019 was eliminated due to sour rot issues. IN 2019, the program made 24 crosses resulting in >7,500 seeds and in 2020 the program made 15 crosses resulting in 5,006 seeds. Most crosses were intended to combine disease resistance genes into cold hardy, high wine quality backgrounds, and to introgress new sources of diversity from programs in Italy and Germany into the Cornell breeding program. Newly identified sources of downy mildew resistance from *Vitis amurensis* were incorporated into the program in 2020. We identified 47 and 44 selections of interest in 2019 and 2020, respectively, for propagation and further testing. This is more than twice the number of selections made in previous years, and reflects the high quality of recently planted seedlings due to marker-assisted selection procedures, which help us select disease resistant seedlings prior to field planting.

5. **Impact Statements**

6. **Published Written Works** (*relative to NE-1720 activities*)

7. **Scientific and Outreach Oral Presentations** (*relative to NE 1020 activities*)

8. **Fund Leveraging** (*relative to NE 1020 activities*)

NE1720: MULTI-STATE EVALUATION OF WINEGRAPE CULTIVARS AND CLONES

2020 Report

State: South Dakota

Author(s): Anne Fennell

Timing of Activities: 10/1/2019 – 9/30/2020

1. Impact Nugget

New vineyard established in highly visible University location, result in increased awareness of vineyards and wineries in SD.

2. New Facilities and Equipment

A 2-acre trickle irrigated vineyard with 8' deer fencing established in Brookings, SD.

3. Unique Project-Related Findings

Ethanol can be used to partially replace chilling in promotion of uniform bud break.

4. Accomplishments Related to Each of the 3 Objectives

1. Screen the viticulture characteristics of clones, cultivars and elite germplasm with significant potential throughout the USA.
 - a. Trial plot established in 2017 for NE1720. New trial established in 2019 in new vineyard location due to University land sale. First crop expected in 2022. Four sentinel cultivars (Marquette, Frontenac, Itasca, Frontenac Blanc) with five advance selections. Two from North Dakota State University (ND054.27 and ND213). Three from University of Minnesota (MN1280, 1369 and 1385) in randomized Block Design.
 - b. Vitisgen2: Mapping the way to the next generation of grapes (USDA51181-26829) Replicated planting of SD F2 population have been established in Brookings, SD and California. New materials are in development.
 - c. Graft transmissible effects of rootstocks on grapevine shoots (NSF154869). F1 rootstock population ungrafted and grafted with Marquette scion in three locations (SD, NY, MO).
2. Evaluate the viticultural and wine attributes of promising emerging cultivars and genotypes based on regional needs.
 - a. Juice data for Marquette, Frontenac, Brianna and LaCrescent from established NE1020 and Cooperative Garretson, SD vineyard monitored for 2017, 2018, and 2019 is being summarized for outreach publication.
 3. Conduct explorations of new germplasm and lesser-known cultivars that may have economic potential for the US wine industry.
 - . N/A

5. Impact Statements

The interaction of this multistate project and USDA and NSF projects provides early testing of advanced selections.

6. Published Written Works (Relative to NE1720 Activities)

- a. Rice, S, Maurer, DL, Fennell, A, Dharmadhikari, M, Koziel, JA. 2019. Evaluation of volatile metabolites emitted in-vivofrom cold-hardy grapes during ripening using SPME and GC-MS: A proof-of-concept. *Molecules*. 24:536.
- b. Rice, S., Maurer, D., Fennell, A. Y., Dharmadhikari, M., Koziel, J. 2019. Biogenic volatiles emitted from four cold-hardy grape cultivars during ripening. *Data*. 4:22.
- c. Rice, S, Tursumbayeva, M, Clark, M, Greenlee, D, Dharmadhikari, M, Fennell, A, Koziel, JA. 2019. Effects of harvest time on the aroma of white wines made from cold-hardy Brianna and Frontenac gris grapes using headspace solid-phase microextraction and gas chromatography-mass spectormetry-olfactometry. *Foods*. 8:29.
- d. Teh, S.L., Rostandy, B., Awale, M., Fennell, A., Luby, J., Hegeman, A. 2019. Genetic analysis of stilbenoid profiles in grapevine stems reveals a major mQTL hotspot on chromosome 18 associated with disease resistance motifs. *Nature Horticulture Research* 6:121.
- e. Chervin, C., Fennell, A. 2019. Ethanol sprays to release grapevine bud dormancy: a potential alternative to cyanamides. *OENO One* 4:661-666.

7. Scientific and Outreach Oral Presentations (Relative to NE1720 Activities)

- a. Fennell, A. 2020. Cold Genetics. North Dakota Grape and Wine Association Conference, February 29. Mandan, ND.

8. Fund Leveraging (Relative to NE1720 Activities)

- a. NSF 154869
- b. USDA/NIFA 51181-26829

9. Online resources: NA

NE1720: MULTI-STATE EVALUATION OF WINEGRAPE CULTIVARS AND CLONES

2020 Report

State: Vermont

Author(s): Terence Bradshaw, Sarah Kingsley-Richards, & Jessica Foster

Timing of Activities: 10/1/2019 – 9/30/2020

1. Impact Nugget:

The Vermont grape and wine industry has increased from essentially zero to 165 acres of grapes in 2020 with an estimated value in direct wine production of \$4-5 million. This growth is attributable to relatively new, cold-hardy cultivars with high potential for wine quality which did not exist until the 1990s. Expanded evaluation of new cultivars will improve wine quality and increase sales of locally-produced wine.

2. New Facilities and Equipment:

A new cultivar trial vineyard following NE-1720 protocols was established by the investigator in 2016, containing the following cultivars: Crimson Pearl, Petite Pearl, Verona, St Pepin, and MN 1285. Solid rows of Brianna, Louise Swenson, Marquette, and Marechal Foch were also installed to facilitate future research.

3. Unique Project-Related Findings:

In this new evaluation, five cultivars (Crimson Pearl, Petite Pearl, Verona, St Pepin, and MN 1285) were planted in a randomized, replicated trial, and four solid rows of Brianna, Louise Swenson, Marquette, and Marechal Foch were also planted to evaluate management practices on those cultivars. In 2018-2019, vines were managed without fungicide applications to evaluate natural susceptibility to disease. Results suggest that Marechal Foch, Itasca, and Louise Swenson were relatively resistant to powdery mildew on fruit clusters compared to the other cultivars. Black rot (BR) was relatively low in 2018, but in 2019 Brianna had greater BR on leaves and Foch, St. Pepin, and Verona on fruit than other cultivars. Little Phomopsis was observed, but Petite Pearl had greater incidence in 2019. St Pepin and Marechal Foch were affected by botrytis bunch rot in 2019. Separate from this dataset and only anecdotal in its

Crop yield remains relatively low. Marechal Foch, followed by Verona, had the greatest mean yield in 2020. Near the end of the season, birds found their way into the netting, which reduced yield on the latest-harvested cultivars, particularly Marquette. Cluster weight was relatively low, except Verona had an astounding 292 g mean cluster weight. Juice quality for winemaking was acceptable, with

chaptalization, for all cultivars. Of particular note is that all cultivars had juice titratable acidity < 1.1 g/100 ml.

4. Accomplishments Related to each of the 3 Objectives:

1. Screen the viticulture characteristics of clones, cultivars and elite germplasm with significant potential throughout the USA.

NA

2. Evaluate the viticultural and wine attributes of promising emerging cultivars and genotypes based on regional needs.

Grapevines were evaluated for vegetative growth (2018-2019) and fruit production and quality (2019-2020). All vines were evaluated for disease susceptibility under no-spray conditions in 2018-2019, and what fruit were produced were included in those evaluations. Crop yield and quality data to managed, productive vines will be collected 2020-2025.

Data on disease incidence are presently being written up for publication. Results from that work were incorporated, into the redesign of our fact sheet UVM FRT 003: Relative Disease Ratings for Wine Grape Varieties Grown in Vermont.

Vine growth, crop yield, and juice quality are preliminary at this point. They will be shared with NE-1720 Multistate Evaluation of Winegrape Cultivars and Clones committee in November 2020 and collated with others' data from similar projects. Written summaries of these data will be posted to UVM Fruit Program website in early 2021.

3. Conduct explorations of new germplasm and lesser-known cultivars that may have economic potential for the US wine industry.

N/A

4. (Separate from NE-1720) Screen Vermont vineyards and the primary regional nursery for the primary grape viruses: tomato ringspot virus (ToRSV); grapevine leafroll-associated virus 1 (GRLaV-1); grapevine leafroll-associated virus 2 (GLRaV-2); and grapevine leafroll-associated virus 3 (GLRaV-3).

Work in 2018 and 2019 was focused on evaluation virus status of vines at a local grapevine nursery (NVS) and UVM Horticulture Research and Extension Center exclusively, in order to develop a virus-free block for future propagation. Of 167 samples tested for inclusion in the mother block at NVS, only one virus (grapevine leafroll-associated virus 3) of the eight sampled for was detected, and only on 11 samples across all years. As those vines were eliminated from consideration for further propagation, virus incidence declined to zero tested vines in 2020.

5. Impact Statements

In the 1990s, there was no grape or wine industry in Vermont, but by 2016, winegrapes were grown on 165 acres and wine was valued at over \$5 million annually. Continued refinement of cultivar breeding and selection for unique cold-climate regions will increase the quality of wines made and the economic impact of wineries in the region.

6. Published Written Works (*relative to NE-1720 activities*)

Bradshaw, Terence and Lorraine P. Berkett, 2020. "Relative Disease Ratings for Wine Grape Varieties Grown in Vermont." UVFRT-003 fact sheet.

Bradshaw, T. UVM Fruit Website, <http://www.uvm.edu/~fruit>. Outreach website for tree fruit and viticulture-related horticultural and IPM information for commercial growers. Affiliated blog archives 12 email postings made to grape producer listserv (275 subscribers) during reporting period.

7. Scientific and Outreach Oral Presentations (*relative to NE 1020 activities*)

NA

8. Fund Leveraging (*relative to NE 1020 activities*)

Evaluating systems components for orchard and vineyard crops in Vermont. Vermont Agriculture Experiment Station Hatch Grants Program, Oct 2020 -Sep 2025. \$63,942. PI: T. Bradshaw

Winegrape cultivar evaluation and virus screening to support the Vermont grape industry. USDA/Vermont Agency of Agriculture Specialty Crops Block Grants Program. PI: T. Bradshaw. October 2017 – September 2020. \$34,849.

Vermont IPM Extension Implementation Program: 2017-2020. USDA CPPM EIP. PD: A. Hazelrigg. Co-PIs: S. Bosworth, T. Bradshaw, H. Darby, M. Skinner. September 2017 – August 2020. \$150,000 for Fruit emphasis area.

Responding to Need for On-Farm Technical Support for Vermont Apple and Grape Growers. USDA/Vermont Agency of Agriculture Specialty Crops Block Grants Program. PI: T. Bradshaw. January 2019 – June 2020. \$25,963.