Final Grant Report

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Regarding the grant agreement between the Michigan Department of Agriculture and Rural Development and Michigan State University MSU Transmittal No. 28484

Grant title: Improving Northwest Michigan Horticulture Research Center for a Data Driven Wine Grape Extension Program

1. Project Goals and Objectives

The goal of this project was to improve Northwest Michigan Horticulture Research Center's (NWMHRC) capabilities to conduct applied research and address regional viticulture extension needs. Specific short-term objectives: 1.) Facilitate hands-on training of vineyard establishment, management, scouting, and use of fruit maturity equipment to research technician, 2.) Evaluate fruit maturity response of mature Riesling grapevines to various manual canopy management practices (vine spacing, pruning, leaf removal) at the NWMHRC research vineyard in 2018 and beyond, and 3.) Produce timely and consistent regional fruit maturity and insect activity reports to facilitate data driven viticultural and enological decisions. Specific long-term objectives: 1.) Generate and document fruit maturity curves with the aim to predict variety performance in NW Michigan, 2.) Develop vineyard or site-specific indices of optimal ripeness using Brix, pH, and TA parameters, and 3.) Generate publications of the vine performance at the new research vineyard to determine qualitative and quantitative protocols of principal varieties beginning in 2020-2021.

2. Project Results, Conclusions, and Outcomes

Project 1: 2018 *Vitis vinifera* Core Cultivar Planting

The grant funding supported the salary of a Viticulture Research Technician position (Figure 1) to assist in the core cultivar planting (Figure 2), and the purchase of grape fruit maturity laboratory equipment (grape press, Centrifuge, Digital refractometer, and Auto-titrator) housed at NWMHRC to collect and process wine grape data (Berry weight, Brix, Titratable acidity, and pH) in a timely manner (Figure 3). In reference to the specific short-term objective 1.) and to have plant material to address the specific long-term objectives 1.), 2.), and 3.), 600 grapevines, comprised of 5 core cultivars were planted at NWMHRC on 30 May, 2018 and managed by the Viticulture Research Technician (Figure 2). Cultivars (*Vitis vinifera*) in this vineyard planting included 'Cabernet franc', 'Chardonnay', 'Pinot blanc', 'Pinot gris', and 'Pinot noir' and important cultural practices for successful vineyard establishment in Northwest Michigan were outlined (Figure 3). These cultivars were planted in north-south orientation, a randomized complete block design with a vine spacing of 4x9ft (vine x row) (Figure 2). Drip irrigation was implemented at roughly 2 -2.5 gallons of water each day per vine (Figure 2). Foliar fertilizer (brand name: Mora-Leaf) formula (NPK: 20-20-20) was applied two times to the grapevines (60 and 90 days after planting) at a rate of 5lbs per acre (Figure 2). Photographs were taken to document grapevine growth progression (Figure 2).

Project 2: Impacts of vine spacing, pruning, and leaf removal timing on *V.vinifera* 'Riesling' yield, fruit maturity, and composition

In reference to the specific short-term objectives 1.) and 2.), ~300 established 9-year-old *V. vinifera* 'Riesling' grapevines grown at NWMRHC were rehabilitated and managed by me and the Viticulture Research Technician between the months of March and November, 2018. According to the Northwest industry standard training and canopy management for *V.vinifera*, 125 Riesling grapevines were cane-pruned and bilaterally cordon trained to the fruit wire (~3ft above soil surface), vertically shoot positioned, and were used to measure the impacts vine spacing, pruning, and leaf removal timing have on yield, fruit maturity and vine balance on Northwest Michigan's most prolific cultivar (Figure 4). Across three vine spacing variables expressed as vine x row spacing (3x9ft, 4x9ft, and 6x9ft), Riesling grapevines were cane-pruned to 2 or 4 canes. Within each pruning treatment, two types of leaf removal were conducted, early leaf removal [(ELR) at pre-bloom stage] and normal leaf removal [(NLR) Buck shot stage]. There was no cluster thinning conducted, and shoot hedging was conducted one time before veraison. 200 representative berries per treatment were collected 1x per week after veraison (4 Sep) until harvest (22 Oct). Weight, brix, pH and TA parameters were measured to track composition using new equipment. At harvest, 400 representative berries per treatment were collected to measure fruit composition. Yield components such as yield/vine (lbs), and damaged clusters/ vine, and type of damage were measured. Clusters were recorded as damaged if three adjacent berries presented the same type of damage. Standard farm management practices including weed, insect and disease control were conducted on a preventative and as-needed basis.

Labor

Pruning and tying required in this trial was a function of the number of vines per acre (vine spacing) and the number of fruitful canes per vine. In other words, labor and time required to cane-prune and tie vines was perceived as lowest at 6x9ft vine spacing followed by 4x9ft (industry standard for *V.vinifera* production) and then 3x9ft and pruning to and tying 4 canes per vine is a longer practice than pruning to and tying 2 canes per vine (anecdotal observation).

Fruit maturity

We measured fruit maturity from veraison through harvest (September 4 to October 22) and fruit quality and composition at harvest (October 22) of Riesling grapes grown at NWMRHC to determine the impact of vine spacing, pruning and leaf removal timing had on the rate of sugar accumulation, pH and TA (titratable acidity). We found vine spacing did not significantly impact the rate of sugar accumulation, pH, or TA in the berries (data not shown). In other words, 6x9ft, 4x9ft, and 3x9ft planting densities had similar rates of sugar accumulation, and pH and TA values through ripening. However, at 4x9ft vine spacing (industry standard) and among all pruning combinations tested, we found ELR vines had faster sugar accumulation than NLR (Figure 4A).

Yield components

As expected, we found vines with larger vine spacing (6x9ft) and 4 fruitful canes per vine produced larger yield (lbs) per vine than those with smaller vine spacing (3x9ft) and 2 fruitful canes per vine with general yields per vine ranging from 1.1 to 4.3 (lbs) (Figure 4B). In both ELR and NLR treatments, vines of 6x9ft spacing consistently had the largest yield (lbs) per vine (range: 4.0 to 6.6) and the vines of 3x9ft spacing which had the smallest yield per vine (range: 1.1 to 3.9) (Figure 4B). Vines planted at 4x9ft spacing produced intermediate to high yield per vine (range: 1.4 to 4.8) (Figure 4B). Across all vine spacing and pruning combinations, we found NLR to consistently have larger yield per vine (range: 1.8 to 6.6) than ELR (1.1 to 4.3) (Figure 4B). Across all vine spacing and leaf removal combinations, vines cane-pruned to 2 canes per vine consistently had lower yield (T/A) (range: 0.9 to 2.4) than vines cane-pruned to 4 canes per vine (range 2.5 to 6.6) (Figure 4B). Common among vine spacing and pruning combinations, we found ELR consistently decreased yield in (T/A), ranging from 0.5 to 1 ton, and the greatest decrease in yield (35%) was found in vines spaced 3x9ft. Conversely, across all vine spacing and leaf removal combinations, retaining 4 canes per vine consistently increased yield (T/A), ranging from 1 to 2 tons compared to its 2 cane counterpart, and the greatest increase in yield (107%) was found in vines planted 3x9ft. This indicates that as the number of vines per acre increase, leaf removal and pruning practices become more impactful on a per acre basis. In other words, at the 3x9ft vine spacing (highest density), ELR more significantly reduced yield (T/A), and retaining 4 canes more significantly increased yield (T/A) compared to 4x9ft (intermediate density) and 6x9ft (lowest density) vine spacing (Figure 4B).

Fruit quality, and composition

In 4x9ft spaced vines, we found average berry (grams) and cluster weights (lbs) did not differ between vines cane-pruned to 2 and 4 canes. Conversely, ELR treatments had lower average 100-berry weight (range: 113 to 133 g) and average cluster weight (range: 0.10 to 0.12 lbs) compared to the NLR treatments which had average 100-berry weight (range: 140 to 144 grams) and average cluster weight (range: 0.14 to 0.17 lbs) (data not shown). At harvest, rot damage (range 1.2 to 1.5%), shrivel (0.8 to 1.5%), and mechanical damage (range: 26 to 28%) did not differ between any vine spacing, pruning and leaf removal combinations (Figure 4C). At harvest, soluble solids (Brix) was highest in vines cane-pruned to 2 canes with ELR (21) with all other pruning and leaf removal combinations having lower Brix (range: 19.6 to 20.3) (Figure 4D). Across pruning treatments, we found vines with NLR had lower pH (range: 3.17 to 3.18) than ELR vines (range: 3.23 to 3.26) (Figure 4E). Also, vines cane-pruned to 4 canes resulted in fruit with higher T.A. (range: 11.51 to 11.63) than vine cane-pruned to 2 canes (range: 10.31 to 10.65) (Figure 4F).

<u>Provisional conclusions, and considerations</u>

Labor

When selecting the vine spacing, it is important to consider the different labor requirements. Although not directly measured in this study, a cane-pruned vineyard with more vines per unit area will have greater labor requirements during pruning and tying than vineyards with fewer vines per unit area. Also, cane-pruned systems that retain more canes per vine will require greater amount of time selecting canes and tying them to the fruit wire than those with fewer canes per vines. This principle may carry over to increased labor requirements during the growing season for canopy management practices like shoot positioning, leaf removal, and cluster thinning.

Yield

Yield (T/A) was relatively stable across vine spacing variables when pruning and leaf removal practices are controlled because yield per vine measurements do not translate exactly to yield in tons/acre (T/A) when comparing different vine x row spacing variables. This is because yield (T/A) is a function of yield per vine and number of bearing vines per acre, i.e., vine x row spacing. Interestingly, across all vine spacing variables we found that yield (T/A) were relatively similar and this is because the greater number of vines per acre at a vine x row spacing of 3x9ft (1,613 vines per acre) than at a 4x9ft (1,210) and 6x9ft (807) compensated for the lower yield per vine. Moreover, any increase or decrease in yield (T/A) of vines in different planting densities were not caused by the vine spacing but instead were the result of retaining 4 canes per vine, which increased yield, or conducting ELR, which decreased yield. Common among vine spacing and leaf removal combinations tested, vines cane-pruned to 4 canes per vine produced consistently larger yields than those cane-pruned to 2 canes per vine. Common among all vine spacing and pruning combinations tested, vines with NLR produced consistently larger yields than those with ELR. This means that low yielding Riesling vineyards could incorporate cane-pruning to 4 canes per vine with NLR to increase yield and avoid under cropping. Conversely, the results suggest that overly fruitful Riesling vineyards with relatively weak vegetative growth could implement cane pruning to 2 canes per vine with ELR to decrease yield and avoid over cropping.

Fruit maturity

From September 4th through October 22nd (harvest date), sugar accumulation was trending faster in ELR vines than in NLR vines, regardless of how many fruitful canes were present. In other words, although retaining 4 canes results in larger yield per vine than retaining 2 canes per vine, the ELR practice still increased the rate of sugar accumulation across all vine spacing and pruning combinations, and thus can perhaps be used as a tool to improve fruit ripening in in Northwest Michigan's short and variable growing season.

Fruit quality

Common among all vine spacing and pruning combinations, ELR was associated with higher Brix accumulation and higher pH while vines cane-pruned to 2 canes per vine were linked to lower TA. This suggests cane pruning to 2 canes per vine with ELR can be used as a tool to increase sugar accumulation and pH and decrease TA. However, this improvement on fruit quality of vines cane-pruned to 2 canes with ELR comes with lower yield (T/A) than its 4 cane with NLR counterpart.

Vine balance

The established concept of vine balance refers to the ratio between reproductive (fruit) and vegetative (shoots and leaves) weight and is a critical parameter to consider for optimum and sustainable wine grape production systems. To determine which vine spacing, pruning, and leaf removal combination tested produced balanced vines, pruning weights need to be collected to calculate the ratio between fruit weight and pruning weight per vine. Because pruning is an invasive action in the vineyard, pruning weights have not yet been collected in this trial and will be conducted during spring pruning. This additional data will shed light on exactly which treatments produce balanced vines, and which lend themselves to over- or under cropping and allow stronger recommendations for optimum vine spacing, pruning and leaf removal combination for sustainable Riesling grape production in Northwest Michigan.

Key findings for practical application

Across all vine spacing variables, vines cane-pruned to 4 canes with ELR produced larger yields and fruit with more sugar accumulation, higher pH. Also, the reduced cluster weight may indirectly reduce cluster compactness and thus decrease disease incidence in tight clustered cultivars. Although pruning and tying 4 canes per vine and implementing ELR may be economically costly, the results indicate the pruning and leaf removal combination of cane-pruning to 4 canes per vine with ELR will result in maximum overall benefits with increased yield (T/A) and improved fruit quality compared to cane pruning to 2 canes with normal leaf removal (industry standard). However, the findings from this one-year study, which lack vine balance data, are not sufficient to confidently guide grower actions. Therefore, the potential value of this research warrants further investigation with a replicated study in 2019.

Communication activities

The findings in this report were included in a poster that was presented at the 2018 Great Lakes Fruit and Vegetable Expo in December, 2018. The findings of this report were shared with other viticulture extension personnel at the NE1720 Multi-state project meeting in Columbia Missouri in November, 2018. The accomplishments described in this report have been presented and recorded via recorded power point presentation with Michigan State University in November, 2018.

Results and activities were shared on multiple platforms to reach growers including MSUENEWS, the Grape/ FruitNet, and Morning Ag Clips. Here is a list of linked outputs:

1. Harvesting grapes after fall frost, October 29, 2018
http://www.canr.msu.edu/news/harvesting_grapes_after_fall_frost
2. Harvest is underway in northwest Michigan vineyards, October 4, 2018
http://www.canr.msu.edu/news/harvest-is-underway-in-northwest-michigan-vineyards
3. Research vineyard updates on recovering Riesling and core cultivar planting, September 7, 2018
http://www.canr.msu.edu/news/research-vineyard-update-recovering-riesling-and-core-cultivar-planting
4. Weather events lead to biotic pressures as grape harvest approaches, September 7, 2018
http://www.canr.msu.edu/news/weather-events-lead-to-biotic-pressures-as-grape-harvest-approaches
5. Research vineyard update on planting density and pruning impacts on potential yield, September 7, 2018
http://www.canr.msu.edu/news/research-vineyard-update-planting-density-and-pruning-impacts

Budget narrative

The project was conducted consistent with the budget proposed by the principal investigator and approved by the state of Michigan. There were no other sources of funding for this area of investigation under direction by the principal investigator. Legacy vineyard services assisted in the vineyard planting by volunteering roughly 12 man hours in auguring holes.

Improving Northwest Michigan Horticulture Research Center For a Data Driven Wine Grape Extension Program

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Figure 1. Jasmine Hart

Introduction

The Northwest region of Michigan straddles at the 45th parallel. Lake Michigan moderates the region's weather, and as a result, NW Michigan is well-suited for wine grape production. However, the region has a considerably shorter growing season compared with SW Michigan or other wine grape growing areas across the country. Despite the climate challenges, NW Michigan still has ~1,800 acres of wine grapes compared to ~1,100 in SW, and 80% of all Riesling grapevines in Michigan are located in the NW region. Typically, NW Michigan accumulates 30% fewer growing degree-days (GDD) than SW Michigan, which normally results in a growing season that is two weeks shorter than SW Michigan. This shorter season can challenge growers to properly ripen fruit in this narrower time frame. This project aims to conduct applied research trials and outreach programming to develop methods to help growers produce high-quality, fully ripened grapes on an annual basis.

At the time this grant was proposed, the NWMHRC did not have the personnel or equipment to collect and process wine grape information in a timely manner. Through this grant support, we hired the region's first viticulture technician in 2018 (Fig. 1) to assist in new research vineyard planting (Fig. 2), treatment application, data collection. We also purchased laboratory equipment (Fig. 3) to provide growers timely results of wine grape maturity parameters (Brix, pH, TA). This equipment measured the impact of cultural practices on the fruit maturity of mature Riesling grapevines currently grown at the NWMHRC research vineyard (Fig. 4) as well as improved grower collaboration on current and future wine grape research projects.

Objective 1. Successfully establish a newly planted research vineyard comprised of five core cultivars to generate publications of the vine performance to determine qualitative and quantitative protocols of principal varieties beginning in 2020-2021.
Objective 2. Evaluate fruit maturity and cropping responses of mature, recovering Riesling grapevines to various canopy management practices (planting density, pruning, and leaf removal) at the NWMHRC research vineyard in 2018 and beyond.

Methods

Across three spacing variables, Riesling grapevines were cane pruned to 2 or 4 canes. Within each pruning treatment, leaf removal was conducted at early or normal timing. There was no cluster thinning conducted, and shoot hedging was conducted one time before veraison.
200 representative berries per treatment were collected 1x per week after veraison (4 Sep) until harvest (22 Oct). Weight, brix, pH and TA parameters were measured to track composition using new equipment. At harvest, 400 representative Berries per treatment were collected to measure fruit composition. Yield components such as yield/vine (lbs), and damaged clusters/ vine, and type of damage were measured. Clusters were recorded as damaged if three adjacent berries presented the same type of damage. Standard farm management practices including weed, insect and disease control were conducted on a preventative and as-needed basis.

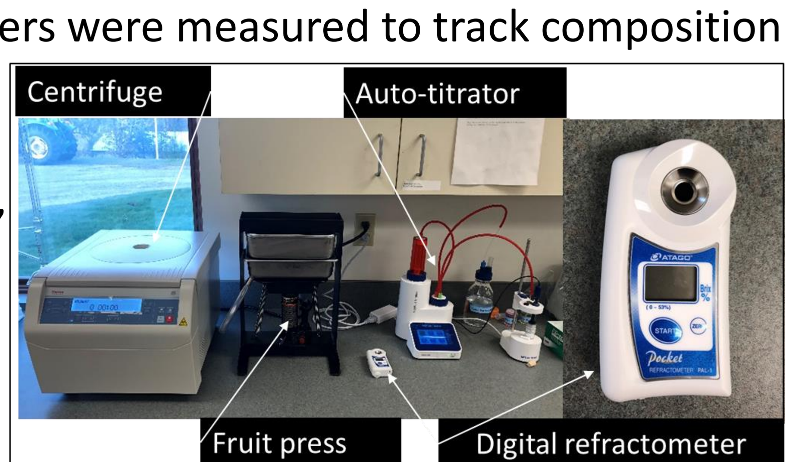
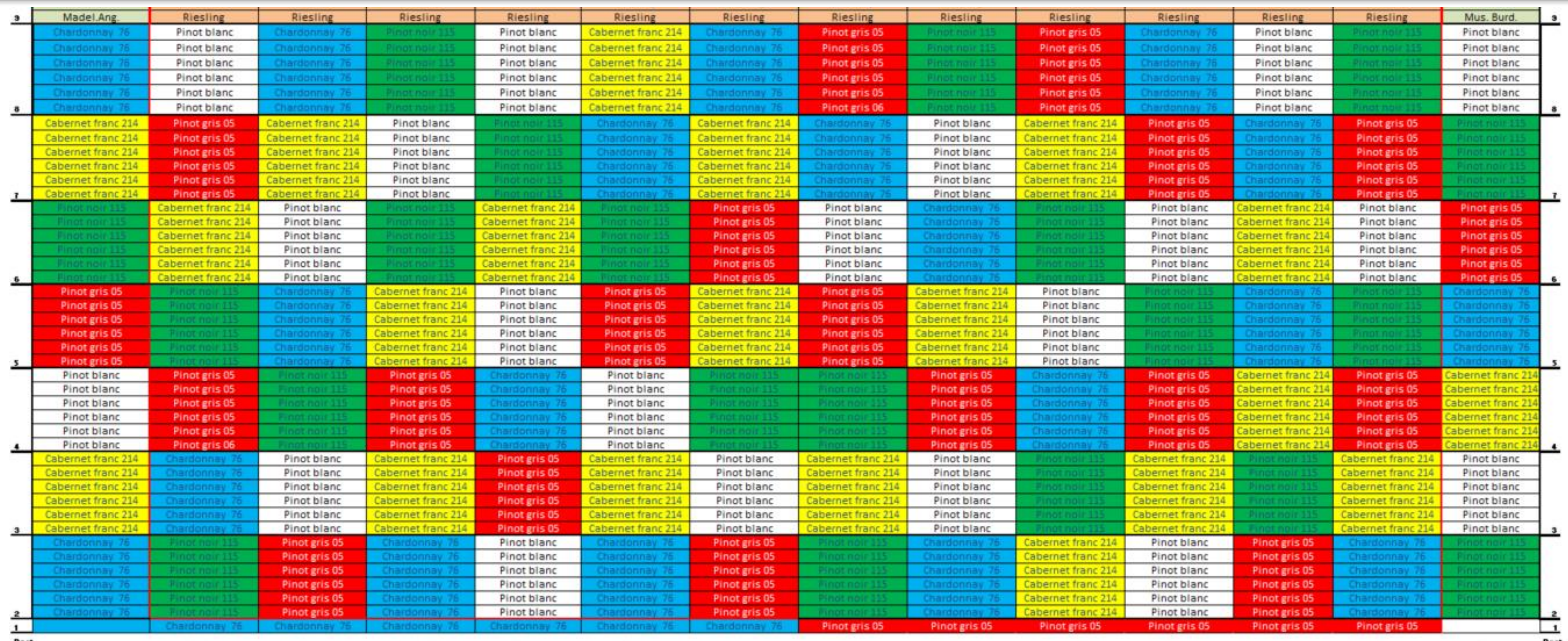


Figure 3. Fruit maturity equipment

2018 *Vitis vinifera* Core Cultivar Planting



Cultivars:
Cabernet franc
Chardonnay
Pinot blanc
Pinot gris
Pinot noir
Vine number:
600 total
(120/cultivar)

Planting:
Date: 30 May, 2018
Planting density:
4ftx9ft (vine x row)
Orientation:
North-South rows
Randomized Complete Block Design (RCBD)

Irrigation:
Type: drip irrigation
Timing and Rate:
6 hrs/ day at 0.42 gal/ hr
(~2.0-2.5gal /day per vine)
*weather dependent

Fertilization:
Type: Foliar fertilizer
Brand: *Mora-leaf*
Formula: 20-20-20 (NPK)
Timing and rate:
1st application 60 days after planting on July 16th and repeated on August 16th at 5lbs/ acre

Bud break
Early June

10 leaves unfolded
Mid July

3ft shoot length
Mid August

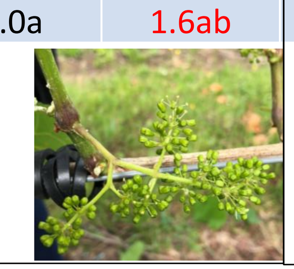
Figure 2. Vineyard map of core cultivar planting describing cultivars, planting, irrigation, fertilization, and growth progression

Impacts of planting density, pruning, and leaf removal timing on *V. vinifera* var. Riesling yield, fruit maturity, and quality

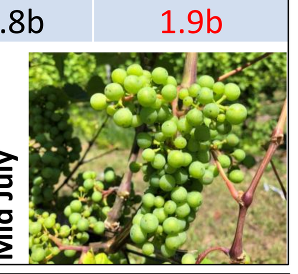
B		Early Leaf Removal		Normal Leaf Removal	
Spacing (Vine x row)	Cane-pruned (# Fruitful canes/vine)	Yield (Lbs/vine)	Yield (Tons/Acre)	Yield (Lbs/vine)	Yield (Tons/Acre)
3x9	4	2.5b	2.0a	3.9bc	3.1a
	2	1.1c	0.9b	1.8c	1.5b
4x9	4	3.7ab	2.2a	4.8b	2.9a
	2	2.4b	1.4b	3.9bc	2.4ab
6x9	4	4.3a	1.7ab	6.6a	2.7a
	2	4.0a	1.6ab	4.8b	1.9b

Jasmine Hart recording yield components

Trace-bloom
Mid June

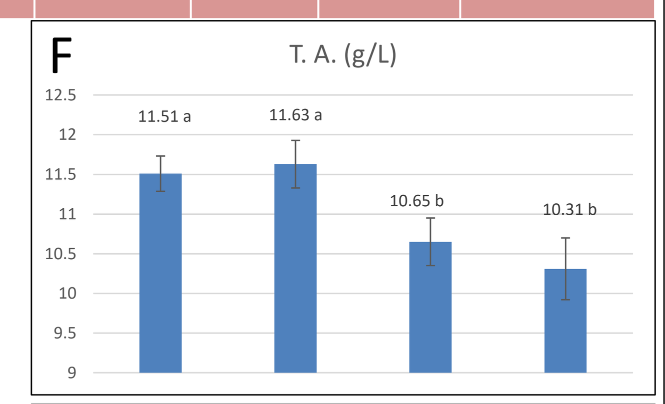


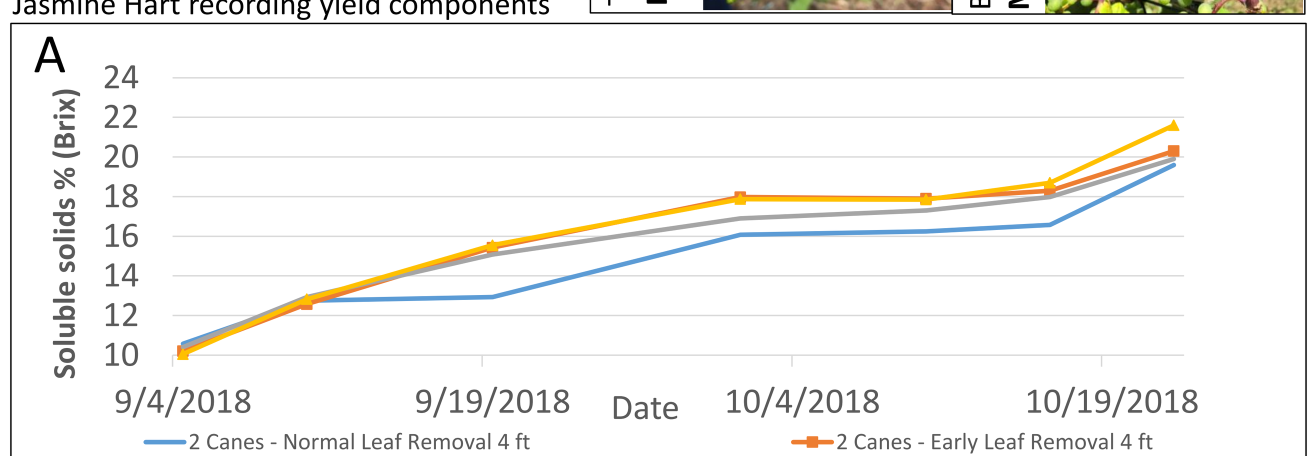
Buck shot
Mid July

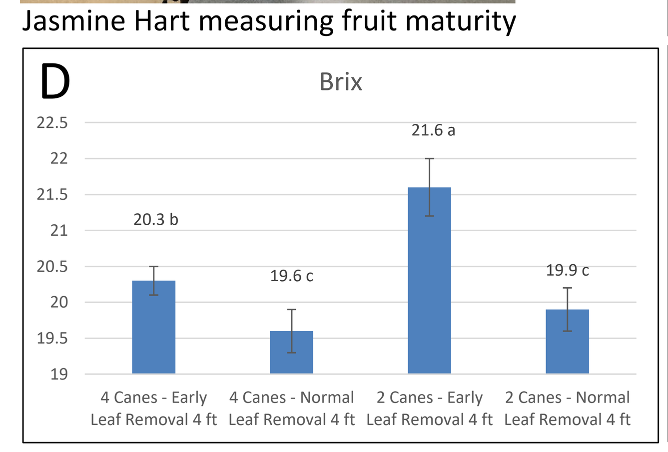


C Treatment	Total cluster (#)	Clean cluster (#)	Yield (lbs.)	Rot	Shrivel	Mechanical
2-Cane (n=65)	2380a	1709a	220.5a	34a	36a	671a
% of total clusters		71a		1.4a	1.5a	28a
4-cane (n=60)	3059a	2261a	270a	37a	26a	798a
% of total clusters		73a		1.2a	0.8a	26a
Total (n=125)	5439	3970	490.5	71	62	1469
% of total clusters		72a		1.3	1.1a	27a

Jasmine Hart measuring fruit maturity







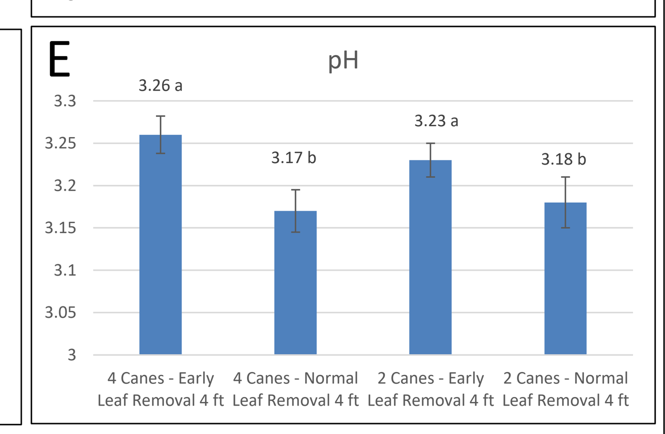


Figure 4. Brix accumulation [Sep 4 – Oct 22] (A), Yield components (B), cluster damage evaluation (C), and fruit composition [Brix (D), pH (E) and TA (F)] at harvest. Means followed by different letters in columns are significantly different by Fisher's least significant difference test at $P \leq 0.05$

Provisional Conclusions

Labor

- Pruning (P) and tying required in this trial was a function of # vines per acre and # fruitful canes per vine.

Yield

- Increasing fruitful canes per vine from 2 to 4 = yield increase of 1-2 ton/ acre
- Largest increase in yield was found in vines planted (3x9), i.e., 107% increase
- Early leaf removal (ELR), yield decrease of 0.5-1 ton/acre
- Largest decrease in yield was found in vines planted (3x9), i.e., 35% decrease

Fruit quality

- P did not impact average berry or cluster weights
- ELR reduced average berry and cluster weights
- P and LR strategies did not differ in their impact on CD
- Mechanical damage decreased yield by ~27%

Fruit composition

- Vine spacing did not impact fruit maturity
- P using 4 canes is linked to higher TA than 2 canes
- ELR appears to be link to higher brix and pH