Washington State Wine Commission Research Grant Program
ANNUAL PROGRESS/FINAL REPORT FORMAT
2020-21 FUNDING CYCLE

PROJECT TITLE: Developing Economic and Financial Benchmarks for Mechanizing Northwest Vineyards

PI Name: Clark F. Seavert, Department of Applied Economics, Oregon State University

Summary of Research
The project estimated the profitability of four vineyard tasks that could be mechanized and determine the financial feasibility to purchase these machines by farm size. The four vineyard tasks chosen were spur pruning, shoot thinning and desuckering, leaf pulling, and harvest. Each investment was evaluated on two sizes of vineyard operations - a 100-acre and 500-acre vineyard operation. The 100-acre vineyard used existing tractors to pull the equipment. The 500-acre vineyard used existing tractors as well but only for the shoot thinning and desuckering, and leaf pulling. A Pellenc power-unit was purchased with the accompanying precision pruner and harvester built for that power-unit.

The expected returns and costs to establish a wine grape vineyard in Oregon provided the basis for several of the assumptions used in this study. Most assumptions, however, were modified to reflect differences between states, growing regions, and size of the operation. Industry interviews also provided valuable information for labor hours by size and location of the vineyard and current harvest rates. Enterprise budgets for Washington state wine grapes were developed, showing the expected yields, prices received, and out-of-pocket expenses paid to grow and harvest the crop. To adjust for future increases to prices received and input costs paid, inflation rates were applied to income and expense items each year.

There are significant returns to vineyard owners for mechanizing these four tasks. A 100-acre operation could increase net profits by $436, $52, $194, and $1,120 per acre per year by mechanizing spur pruning, shoot thinning and desuckering, leaf pulling, and harvest, respectively. A 500-acre operation could increase net returns by $403, $84, $216, and $1,230 per acre per year by mechanizing spur pruning, shoot thinning and desuckering, leaf pulling and harvest, respectively.

Custom hiring an entity to spur prune proved to be more profitable for both size of vineyard operations, $455 per acre per year compared to owning a pruning machine of $436 and $403 for a 100-acre and 500-acre respectively. Custom hiring the leaf pulling task was also more profitable but only for the 100-acre operation - $206 per acre per year compared to $194 of owning the machine. Owning the harvesting machine generated the highest net present value of returns with $1,120 and $1,230 per acre per year.

The results of the purchasing the leaf puller and harvester and financing it with a loan generated more liquidity without increasing long-term debt. The shoot thinner and desuckering machine is an exception in that it did not increase liquidity as the other machines due to a smaller reduction in labor hours. The decline in labor costs overtime was a toss-up when considering the up-front investment of mechanization. Although profitable, the advantage of purchasing this machine was negligible to improving the financial position of the business.

Washington State Wine Commission Research Grant Program
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PI Name: Clark F. Seavert, Department of Applied Economics, Oregon State University

Final Report: 2018-2019

Project Title: Developing Economic and Financial Benchmarks for Mechanizing Northwest Vineyards

Principal Investigator/Cooperator(s):

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Objectives:

1. Identify the vineyard tasks that would generate the highest return on investment by integrating mechanization.
2. Determine the financial requirements to purchase machines by farm size and the minimum acreage required to make the investment feasible.
3. Compare the economics of retrofitting existing or establishing new vineyards designed for mechanization.

Summary of Major Research Accomplishments and Results

When analyzing long-term investments, there are two principles to consider; the first is profitability (will the investment make money) and the other financial feasibility (does the owner have the ability to finance the investment either from equity dollars or loans). To measure the profitability of an investment, the net present value is used to account for any upfront investments and the stream of future cash inflows and outflows over time. These inflows and outflows generate a net return that is discounted to today's value. The further in the future money is received, the less value it has based on its potential risk. The sooner an investment can

generate positive cash flow, the less financial risk. A positive net present value indicates that the projected net returns generated by the investment exceed the anticipated costs and vice versa.

To measure the feasibility of an investment, the financial ratios of the current ratio, working capital to annual operating expenses, and debt-to-asset ratio show the impact of an investment on the liquidity and solvency of a business.

Funding of Project

It should be noted this project was jointly funded equally with the Erath Family Foundation in Oregon. A final report was submitted to the Foundation and included in Appendix A, page 8.

Enterprise Budgets

Enterprise budgets for Washington state wine grapes were developed, showing the expected yields, prices received, and out-of-pocket expenses paid to grow and harvest the crop (Appendix B, page 12). To adjust for future increases to prices received and input costs paid, inflation rates were applied to income and expense items each year. To account for the increased maintenance costs of owning machines, a $50 per acre per year charge was applied to each budget.

Inflation and Discount Rates

Inflation is the rate at which the average price level of selected goods and services increases over a period of time. To account for inflation, wine prices paid to growers increased by 1.5% annually. Production inputs were increased between two and three percent (Table 1). It is important to note that the minimum wage rate established by the state in 2019 was $12 per hour and increases to $13 per hour in 2020. Based on this increase in wage rate and the assumption that compression would not be occur, (all workers receive the same increase in wages regardless of duties and current pay), the 2019 wage rates were increase 12.5% in 2020 and then 3% in subsequent years. A discount rate of 6% was applied to future net returns to account for the timing of benefits of mechanization over hand labor to generate a net present value for each vineyard task.

Table 1. Inflation Rates for Wine Prices and Expenses

Item	Annual Increase from Previous Year
Wine Prices Received	1.50%
2020 Labor Rates	12.50%
2021-28 Labor Rates	3.00%
Equipment Replacement	2.00%
Machine Repairs	2.00%
Fuel, Lube & Oil	2.00%
Fertilizer	2.00%
Chemicals	2.00%
Supplies	2.00%
Miscellaneous & Overhead	2.00%
Hiring Other Custom Operators	3.00%

Objective 1 was to identify the vineyard tasks that would generate the highest return on investment by integrating mechanization.

The steering committee decided to focus on four vineyard tasks that field data was readily available, and the technology had the highest near-term chance of success. The four tasks were 1) precision pruning, 2) shoot thinning and desuckering, 3) leaf pulling, and 4) mechanical harvesting. To account for the economy of size when investing in mechanization, each investment was evaluated on two sizes of vineyard operations - a 100-acre and 500-acre vineyard operation. The 100-acre operation used existing tractors to pull the pruners, shoot thinner, leaf puller, and harvester. The 500-acre operation used existing tractors as well but only for the shoot thinning and desuckering and leaf pulling tasks. However, a Pellenc power-unit was purchased for the accompanying precision pruner and harvester built for that power-unit. Current market values for power-units, purchased equipment, estimated acres per hour, annual hours of use and repairs, and expected salvage values are shown by farm size in Table 2.

Table 2. Machinery Cost Assumptions for Vineyard Operations in Washingon State

						-------- 100-Acres --------				-------- 500-Acres --------			
Machine	Size or description	Value ($)	Width, Feet	Speed, MPH	Acres/ Hour	Hours of annual use	Expected life (years)	Annual Repairs ($)	Salvage value ($)	Hours of annual use	Expected life (years)	Annual Repairs ($)	Salvage value ($)
Tractor	100 HP, 4WD	$75,000	NA	NA	NA	1,336	9	$3,612	$24,080				
Precision Pruners	2-sided, 1 row	$30,000	8.00	1.83	1.36	74	10	$240	$3,000				
Shoot Thinning and Desuckering	8 Width	$32,000	8.00	1.83	1.36	74	10	$192	$6,400	368	10	$960	$3,000
Leaf Pulling	1-sided, 1 row	$30,000	8.00	1.25	1.09	92	10	$240	$3,000	459	10	$1,200	$3,000
Harvester	2-sided, 1 row	$210,000	8.00	1.25	1.09	92	20	$630	$21,000				
Pellenc	175 HP, 4WD	$252,000	NA	NA	NA					459	12	$10,080	$37,800
Precision Pruners	1-sided, 1 row	$60,000	8.00	1.83	1.36					368	10	$2,400	$6,000
Harvester	2-sided, 1 row	$158,000	8.00	1.25	1.09					459	10	$6,320	$23,700

The expected returns and costs to establish a wine grape vineyard in Oregon provided the basis for several of the assumptions used in this study. Most assumptions, however, were modified to reflect differences between states, growing regions, and size of the operation. Industry interviews also provided valuable information for labor hours by size and location of the vineyard and current harvest rates. Table 3 shows the results of these discussions. Hand labor hours for pruning, shoot thinning and desuckering, and leaf pulling, before mechanizing, were estimated at 35, 8, and 15 hours per acre, respectively. It was assumed current harvest operations were custom hired at the cost of $945 per acre, based on $270 per ton at 3.5 tons per acre.

General labor hours in the vineyard were eliminated when tasks were mechanized, except for pruning, which required 5 hours per acre following up after the machine. Tractor driver labor replaced the general labor at much lesser amounts, however, requiring 1.5 hours per acre for pruning and shoot thinning and desuckering, and 1 hour per acre for leaf pulling and during the harvest operation.

Table 3. Labor Assumptions of Mechanizing Tasks for Vineyard Operations in Washingon State.					
Vineyard Task	Hand Labor (Hours/Acre)	Hand Labor Required w/ Machine (Hours/Acre)	Tractor Driver (Hours/Acre)	Change in Labor Hours/Acre	Percent Change in Labor Hours
Spur Pruning	35.00	5.00	1.50	-28.50	81.43%
Shoot Thinning/Desuckering	8.00	0.00	1.50	-6.50	81.25%
Leaf Pulling	15.00	0.00	1.00	-14.00	93.33%
Harvesting, Custom[2]	$945/acre	NA	1.00	1.00	NA

[2]Based on $270/ton @ 3.5 tons per acre

Table 4 shows the net present value, discounted payback period, and hiring a custom operator to perform vineyard tasks with machines. It was assumed the life of each machine was 10-years, which was the premise for the 10-year analysis. The discounted payback period gives the number of years it takes to break even from undertaking the initial investment of a machine, by discounting future cash flows and recognizing the time value of money. A payback period less than one indicates the machine could be purchased and paid for from annual cash flows within a year. Periods greater than one would require financing, either from equity dollars or loans.

Hiring a custom operator with machines to perform vineyard tasks were projected over the ten years, including a 3% inflation rate, and discounted back to today's dollars. A rate higher than the net present value of owning the machine would indicate custom hiring the operation would be more profitable.

The net present value for each mechanized vineyard task, regardless of vineyard size, was profitable, indicating that the projected earnings generated from each investment exceeded the estimated costs, based on today's dollars.

There are significant returns to vineyard owners for mechanizing these four tasks. A 100-acre operation could increase net profits by $436, $52, $194, and $1,120 per acre per year by mechanizing spur pruning, shoot thinning and desuckering, leaf pulling, and harvest, respectively. A 500-acre operation could increase net returns by $403, $84, $216, and $1,230 per acre per year by mechanizing spur pruning, shoot thinning and desuckering, leaf pulling and harvest, respectively.

Hiring a custom operator with machines to spur prune proved to be more profitable for both size of vineyard operations, $455 per acre per year compared to owning a pruning machine of $436 and $403 for a 100-acre and 500-acre respectively. Custom hiring the leaf pulling task was also more profitable but only for the 100-acre operation - $206 per acre per year compared to $194 of owning the machine. Owning the harvesting machine generated the highest net present value of returns with $1,120 and $1,230 per acre per year.

Table 4. Profitability Results: Net Present Value (NPV) and Discounted Payback Period to Purchase Machines or Hire Custom Operators with Machines to Perform Vineyard Tasks, a 10-Year Analysis using a 6% Discount Rate, per acre basis.

	PURCHASE EQUIPMENT				HIRE CUSTOM OPERATOR W/ MACHINE[5]	
Vineyard Task	NPV 100-acre Vineyard[3] ($/acre/year)	Discounted Payback Period (Years)	NPV 500-acre Vineyard ($/acre/year)	Discounted Payback Period (Years)	Rate to Hire Operators w/ Machines ($/acre/year)	NPV 100 & 500-acre Vineyards ($/acre/year)
Spur Pruning	$436	0.7	$403[4]	1.5	$80	$455
Shoot Thinning/Desuckering	$52	6.2	$84[3]	0.8	NA	NA
Leaf Pulling	$194	1.5	$216[3]	0.3	$65	$206
Harvesting	$1,120	1.9	$1,230[4]	0.7	$400	$592
Accumulative Payback Period		1.5		0.6		NA

[3]Existing 100 Hp tractor(s) used to pull machines.
[4]1 Pellenc power-unit was purchased for the 500-acre operation to perform vineyard tasks of precision pruning and harvesting.
[5]Rate to hire custom operatiors with machines to perform vineyard tasks were increased 3% annually, labor hours removed as shown in Table 3, resulting in the NPV for each vineyard task as a comparison to the purchasing option.

Objective 2 was to determine the financial requirements to purchase machines by farm size and the minimum acreage required to make the investment feasible.
The discounted payback periods in Table 4 clearly shows most of the machines could be purchased and paid for within a year. The exception to that would be buying a shoot thinning and desuckering machine, leaf puller, and harvester for the 100-acre vineyard operation. Although purchasing the Pellenc power-unit and precision pruner for the 500-acre operation had a payback period higher than one year, there is the option of buying a pruner for the existing tractors with a payback period of less than a year as shown in the 100-acre operation. Therefore, the financial feasibility of machine ownership was estimated for the 100-acre operation and the three tasks with payback periods greater than a year.

Three financial measures provided the basis to analyze the financial position of purchasing the equipment. These measures included the current ratio, working capital to annual operating expenses, and debt-to-asset ratio. The first two ratios measure the liquidity of the operation and the latter solvency. Financial ratios for representative vineyard operations were developed with a current ratio of 1.86, working capital to annual operating expenses of 38%, and a debt-to-asset ratio of 25%.

Table 5 shows the results of financing a shoot thinning and desuckering machine, leaf puller, and harvester by the 100-acre vineyard operation. Financial benchmarks were established as if the operation continued to use hand labor, and any improvement to each measure was due to mechanization.

The first measuring the liquidity of the operation is the current ratio, the operation's ability to pay short-term obligations, or those due within one year. The higher the ratio, the more money is available within the next year to meet financial obligations. The beginning current ratio was set at 1.86.

The second liquidity measure is working capital to annual operating expenses. Annual operating capital includes all costs to produce the wine grapes, interest on the debt, principal payments on loans, and depreciation. The higher the ratio, the more dollar available for other expenditures and expansion.

The third ratio, debt-to-asset ratio, measures solvency, which is the percentage of an operation's assets are financed with long-term debt, including loans or other debt lasting more than one year.

Table 5. Evaluating the Financial Impacts of Purchasing Equipment using the Current, Working Capital to Operating Expense, and Debt-to-Asset Ratios, 2020 to 2024.

Current Ratio					
Vineyard Task	2020	2021	2022	2023	2024
Hand Labor	**1.86**	**1.80**	**1.84**	**1.86**	**1.86**
Shoot Thinner/Desuckering	1.86	1.78	1.80	1.81	1.79
Leaf Pulling	2.33	2.72	3.23	3.73	4.21
Harvester	2.59	2.91	3.53	4.14	4.73

Working Capital to Annual Operating Expenses					
Vineyard Task	2020	2021	2022	2023	2024
Hand Labor	**38%**	**32%**	**35%**	**36%**	**35%**
Shoot Thinner/Desuckering	38%	32%	34%	34%	33%
Leaf Pulling	75%	89%	120%	144%	167%
Harvester	104%	119%	168%	208%	245%

Debt to Asset Ratio (%)					
Vineyard Task	2020	2021	2022	2023	2024
Hand Labor	**25**	**25**	**24**	**24**	**23**
Shoot Thinner/Desuckering	25	25	25	24	23
Leaf Pulling	24	24	22	21	20
Harvester	23	26	24	22	20

The leaf puller and harvester generated more available cash without increasing long-term debt. The shoot thinner and desuckering machine is an exception in that it did not increase available cash as the other machines due to the amount of labor it reduced. Table 2 shows 8 hours of

general labor was eliminated from mechanization, but tractor driver hours increased 1.5 hours as well. The decline in labor costs overtime was a toss-up when considering the $32,000 up-front investment of automation. Although profitable by $52 per acre per year (Table 4), the advantage of purchasing the machine was negligible to improving the financial position of the business.

Objective 3 was to compare the economics of retrofitting existing or establishing new vineyards designed for mechanization.
The steering committee early on decided not to address Objective 3. The reason not to continue with this objective had to do with the difficulties of using existing machines in current systems. The committee felt time would be better spent addressing the efficiencies of current machines before addressing retrofitting existing or establishing new vineyards.

Outreach and Education Efforts - Presentations of Research:

- OWRI's Grape Day, April 3, 2019, Poster
- Western FarmPress, April 10, 2019, Startup States Push Precision Viticulture
- Good Fruit Grower, May 22, 2019, The Margins of Mechanization: Oregon State University economist assesses the costs and benefits of mechanizing vineyard tasks. The Margins of Mechanization
- OWRI and Washington Wine Commission sponsored webinar, June 11, 2019, titled "Can Mechanizing Vineyard Tasks Make you Money?" Webinar Recording
- National Grape Research Alliance Newsletter, June 2019: The True Cost of Mechanization
- Summer Vineyard Mechanization Workshop, July 11, 2019, Presentation titled: Economics of vineyard mechanization

Research Success Statements:
The results of this research show vineyard owners that mechanizing specific vineyard tasks can be more profitable than using hand-labor. The financial risk to purchase labor-saving technology is lessening when appropriately financed, considering their business' liquidity and solvency when purchasing the equipment. There are vineyard tasks that the owner should hire a custom operator to perform the work. Owners will have the financial benchmarks to determine if purchasing equipment from either borrowed or equity funds are more financially feasible, or to custom hire the work based on the size of their operation.

As the results of this study are known to the grape industries outside of the Northwest, there will be a lot of interest in mechanization, and I believe further research can be conducted on a national scale using this methodology and could lead to a technology roadmap for the U.S. wine grape industry.

APPENDIX A
Final Report to the Erath Family Foundation

ERATH FAMILIY FOUNDATION FINAL REPORT
FUNDING CYCLE 2018 – 2019

DATE: July 1, 2019
TITLE: Developing Economic and Financial Benchmarks for Mechanizing Northwest Vineyards
RESEARCH LEADER: Clark F. Seavert
COOPERATORS: Daniel Fay (OR), Joel Myers (OR), Richard Hoff (WA), Russ Smithyman (WA) and DR. Qin Zhang (WSU)
FUNDING FOR 2018-19: $15,000
EXECUTIVE SUMMARY: Growers must look beyond the price tag of expensive equipment when deciding whether they can afford to mechanize vineyard operations. They must evaluate profitability over time as much as financial feasibility. Rather than focusing only on how long it takes to pay equipment off, this study compared projected net returns of four vineyard tasks over 10 years on case-study vineyards of 20- and 40-acres in Oregon. The net present value of mechanizing each task as compared to hand labor was used to measure profitability (the difference between the timing of cash coming in and cash going out over time). Grower's purchasing machines to mechanize common tasks benefit economically compared to those who rely on hand labor. Not surprisingly, mechanized harvest for both the 20- and 40-acre vineyards was the most apparent winner with benefits over hand labor between $776 to $1,300 per acre per year. Cane pruning was the lone task not suited to mechanization, which is common in Oregon; it was the only example in which net present value was not higher than hand labor when mechanized.
OBJECTIVES: 1) Identify the vineyard tasks in Oregon and Washington that would generate the highest return on investment by integrating mechanization; 2) Determine the financial requirements to purchase machines by farm size and the minimum acreage required to make the investment feasible; and 3) Compare the economics of retrofitting existing or establishing new vineyards designed for mechanization.
PROCEDURES: a) Use Oregon State University and Washington industry costs of establishing and producing wine grapes as well as interviewing industry leaders to identify vineyard tasks that require significant labor inputs that can be reduced or eliminated by using mechanization, b) Determine representative information for equipment costs, speed of operations, repairs, fuel, lube, and operator labor, c) Develop enterprise budgets for existing labor-saving machines with data collected from growers who are mechanizing vineyard operations, d) Determine the economic value of using labor-saving machines based on the net present value of each orchard task identified above, e) Interview lenders to obtain liquidity, solvency, and repayment capacity information that is representative of growers in the industry, and f) Determine the financial requirements to purchase machines by farm size and the minimum acreage required to make the investment feasible.
COMPLICATIONS ENCOUNTERED: At a November 2018 meeting, the cooperator-advisory panel said completing Objective 3 may not be a prudent use of time considering the challenges of using current machines designed to accommodate more modern vineyards.
SIGNIFICANT FINDINGS TO DATE: When analyzing long-term investments there are two principles to consider; the first is profitability (can the investor make money) and the second financial feasibility, which addresses the investors ability to financial the investment. To measure profitability, labor rates in Oregon were increased by 6.68%, 6.20%, 5.88% and 3% for years 2020, 2021, 2022 and 2023 to 2028; to account for increases to the minimum wage rate. Production inputs were also increased between two and three percent annually to adjust for inflation. . Grape prices were also increase at one and a half

percent annually. Finally, a discount rate of six percent was applied to future net returns to account for the timing of benefits of mechanization over hand labor to generate a net present value for each vineyard task

There are significant labor savings for mechanical pruning of spur canes, shoot thinning and desuckering, leaf pulling, and mechanical harvesting. However, due to the additional labor hours to cane prune after mechanical pruning, growers would lose $22 to $83 per acre per year, depending on the size of the vineyard operation. A 20-acre vineyard owner could increase net returns by $137, $64, $285, and $776 per acre per year by mechanizing cane pruning, shoot thinning and desuckering, leaf pulling and harvest, respectively. A 40-acre vineyard owner could increase net returns by $202, $129, $248, and $1,306 per acre per year by mechanizing cane pruning, shoot thinning and desuckering, leaf pulling and harvest, respectively. However, for both vineyard operations, hiring a custom operation to perform these tasks would be more profitable than owning the equipment, except for harvesting for the 40-acre operation. Tables 1 through 4 located here show the results of this data.

Five financial measures provided the results to analyze the financial feasibility of purchasing equipment for a 40-acre vineyard operation. These included the annual cash flows, annual net farm incomes, working capital to annual operating expenses, current ratio and debt-to-asset ratio. In addition, two levels of financial debt were analyzed; a typical operation with a 25 percent debt-to-asset ratio compared to a low-debt operation with a debt-to-asset ratio of 9.94 percent. These two operations provided a range of financial information to compare and contrast the financial implications when considering how to finance equipment.

In both situations regardless of the debt structure, continuing to use hand labor was not financially sustainable in the short- or long-term. Only financing the mechanical harvester provided a long-term option that was better than hand labor across all measures except the debt-to-asset ratio. Purchasing the other equipment with loans or from annual net returns had benefits but were not sufficient for long-term sustainability. The tables showing the results of the feasibility analysis can be found here.

POTENTIAL IMPACT OF FINDINGS: This project was useful for vineyard owners to understand better how labor-saving machines can be more profitable and the financial requirements to purchase based on a grower's equity, working capital or ability to borrow funds or hire a custom operator to conduct the vineyard task. They also have the fundamental financial guidelines to determine if purchasing equipment from borrowed or equity funds are more financially feasible or to custom hire the operation based on the size of their operation.

PUBLICATIONS, PRESENTATIONS OR OTHER SCHOLARSHIP RESULTING FROM WORK:

- OWRI's Grape Day, April 3, 2019, Poster
- Western FarmPress, April 10, 2019, Startup States Push Precision Viticulture
- Good Fruit Grower, May 22, 2019, The Margins of Mechanization: Oregon State University economist assesses the costs and benefits of mechanizing vineyard tasks. The Margins of Mechanization
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- Summer Vineyard Mechanization Workshop, July 11, 2019, Presentation titled: Economics of vineyard mechanization

OTHER FUNDING: A $15,000 grant from the Washington Wine Commission was also obtained to expand the study to Washington vineyards.

NEXT STEPS: As the results of this study are becoming known to the grape industries outside of the Northwest there is a lot of interest in mechanization and I believe further research will be conducted on a national scale using this methodology and could lead to a technology roadmap for the U.S. wine grape industry.

APPENDIX B
Returns and Cash Costs to Grow and Harvest Wine Grapes in Washington State, per acre, 2019.

Returns and Cash Costs to Grow and Harvest Wine Grapes in Washington State, dollars per acre, 2019.

			Hand Labor		Precision Pruning		Shoot Thin & Desucker		Leaf Pulling		Harvester	
Returns												
Name	Unit	$/Unit	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Wine Grapes, $1,300 per ton	tons	$1,300.00	5.50	$7,150.00	5.50	$7,150.00	5.50	$7,150.00	5.50	$7,150.00	5.50	$7,150.00
Harvest Costs												
Name	Unit	$/Unit	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
4-Wheel tractor & harvester (1x)	acre										1.00	$13.55
4-Wheel tractor & harvester (1x) (Labor)	hours										0.92	$28.24
Harvesting, hand labor - custom	ton	$295.00	5.50	$1,622.50	5.50	$1,622.50	5.50	$1,622.50	5.50	$1,622.50		
Hauling to winery	ton	$60.00	5.50	$330.00	5.50	$330.00	5.50	$330.00	5.50	$330.00	5.50	$330.00
4-wheel drive tractor & forks w/loader	acre	$184.00	1.00	$184.00	1.00	$181.60	1.00	$181.60	1.00	$180.80	1.00	$44.75
4-wheel drive tractor & forks w/loader (Labor)	hours	$27.50	20.00	$550.00	20.00	$550.00	20.00	$550.00	20.00	$550.00	5.00	$137.50
Interest on Operating Capital		$2,686.50	2.00%	$40.30	2.00%	$40.26	2.00%	$40.26	2.00%	$40.25	2.00%	$8.31
Total Harvest Costs				$2,726.80		$2,724.36		$2,724.36		$2,723.55		$562.35
Non-Harvest Costs												
--- LABOR ---												
Machine Maintenance Labor	acre	$50.00	NA	$0.00	1.00	$50.00	1.00	$50.00	1.00	$50.00	1.00	$50.00
Dormant pruning - labor	hour	$19.75	35.00	$691.25	5.00	$98.75	35.00	$691.25	35.00	$691.25	35.00	$691.25
Leaf pulling - labor	hour	$19.75	15.00	$296.25	15.00	$296.25	15.00	$296.25	-	$0.00	15.00	$296.25
Tie canes - labor	hour	$19.75	5.00	$98.75	5.00	$98.75	5.00	$98.75	5.00	$98.75	5.00	$98.75
Sucker removal & disbudding - labor	hour	$19.75	8.00	$158.00	8.00	$158.00	-	$0.00	8.00	$158.00	8.00	$158.00
Irrigation - labor	hour	$19.75	5.00	$98.75	5.00	$98.75	5.00	$98.75	5.00	$98.75	5.00	$98.75
Trellis maintenance - labor	hour	$19.75	2.00	$39.50	2.00	$39.50	2.00	$39.50	2.00	$39.50	2.00	$39.50
Shoot position & raise wire- labor	hour	$19.75	6.00	$118.50	6.00	$118.50	6.00	$118.50	6.00	$118.50	6.00	$118.50
Cluster thinning - labor	hour	$19.75	15.00	$296.25	15.00	$296.25	15.00	$296.25	15.00	$296.25	15.00	$296.25
--- PRODUCTION INPUTS ---							-	$0.00	-	$0.00	-	$0.00
Fertilizer - foliar applied (Y2-F)	acre	$20.00	1.00	$20.00	1.00	$20.00	1.00	$20.00	1.00	$20.00	1.00	$20.00
Herbicide strip maintenance	acre	$50.00	1.00	$50.00	1.00	$50.00	1.00	$50.00	1.00	$50.00	1.00	$50.00
Fungicide materials - (Y2-F)	acre	$400.00	0.63	$252.00	0.63	$252.00	0.63	$252.00	0.63	$252.00	0.63	$252.00
Ties for Canes	acre	$10.00	1.00	$10.00	1.00	$10.00	1.00	$10.00	1.00	$10.00	1.00	$10.00
Irrigation repairs	acre	$40.00	1.00	$40.00	1.00	$40.00	1.00	$40.00	1.00	$40.00	1.00	$40.00
Trellis materials	acre	$40.00	1.00	$40.00	1.00	$40.00	1.00	$40.00	1.00	$40.00	1.00	$40.00

Returns and Cash Costs to Grow and Harvest Wine Grapes in Washington State, dollars per acre, 2019 (continued).

			Hand Labor		Precision Pruning		Shoot Thin & Desucker		Leaf Pulling		Harvester	
--- MACHINE OPERATIONS ---	Unit	$/Unit	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
4-wheel drive tractor & Precision Pruning (1x)	acre				1.00	$17.31						
4-wheel drive tractor & Precision Pruning (1x) (Labor)	hours				1.38	$30.33						
4-wheel drive tractor & Shoot Thin+Desucker (1x)	acre						1.00	$16.30				
4-wheel drive tractor & Shoot Thin+Desucker (1x) (Labor)	hours						1.38	$30.33				
4-wheel drive tractor & Leaf Pulling (1x)	acre								1.00	$10.37		
4-wheel drive tractor & Leaf Pulling (1x) (Labor)	hours								0.92	$20.22		
4-wheel drive tractor & blast sprayer (5x)	acre	$47.15	1.00	$47.15	1.00	$46.85	1.00	$46.85	1.00	$46.70	1.00	$45.70
4-wheel drive tractor & blast sprayer (5x) (Labor)	hours	$27.50	2.58	$70.90	2.58	$70.90	2.58	$70.90	2.58	$70.90	2.58	$70.90
4-wheel drive tractor & rotary mower (2x)	acre	$13.32	1.00	$13.32	1.00	$13.20	1.00	$13.20	1.00	$13.14	1.00	$12.74
4-wheel drive tractor & rotary mower (2x) (Labor)	hours	$27.50	1.03	$28.36	1.03	$28.36	1.03	$28.36	1.03	$28.36	1.03	$28.36
4-wheel drive tractor & weed sprayer (2x)	acre	$19.14	1.00	$19.14	1.00	$18.90	1.00	$18.90	1.00	$18.82	1.00	$18.00
4-wheel drive tractor & weed sprayer (2x) (Labor)	hours	$27.50	2.06	$56.72	2.06	$56.72	2.06	$56.72	2.06	$56.72	2.06	$56.72
Pickup 1/2 Ton 4x4	acre	$81.84	1.00	$81.84	1.00	$81.84	1.00	$81.84	1.00	$81.84	1.00	$81.84
ATV	acre	$33.60	1.00	$33.60	1.00	$33.60	1.00	$33.60	1.00	$33.60	1.00	$33.60
Miscellaneous and overhead	acre	$800.00	0.50	$400.00	0.50	$400.00	0.50	$400.00	0.50	$400.00	0.50	$400.00
Interest on Operating Capital		$2,960.28	2.00%	$44.40	2.00%	$36.97	2.00%	$43.47	2.00%	$41.16	2.00%	$45.11
Total Non-Harvest Costs				*$3,004.68*		*$2,501.73*		*$2,941.72*		*$2,784.83*		*$3,052.22*
Capital Investment												
4-wheel drive tractor & Precision Pruning (1x)	acre				1.00	$6.09						
4-wheel drive tractor & Shoot Thin+Desucker (1x)	acre						1.00	$6.09				
4-wheel drive tractor & Leaf Pulling (1x)	acre								1.00	$4.14		
4-Wheel tractor & harvester (1x)	acre										1.00	$16.84
4-wheel drive tractor & forks w/loader	acre	$99.00	1.00	$99.00	1.00	$102.80	1.00	$102.80	1.00	$104.40	1.00	$48.75
4-wheel drive tractor & blast sprayer (5x)	acre	$19.90	1.00	$19.90	1.00	$20.40	1.00	$20.40	1.00	$11.64	1.00	$25.30
4-wheel drive tractor & rotary mower (2x)	acre	$11.36	1.00	$11.36	1.00	$11.56	1.00	$11.56	1.00	$10.10	1.00	$13.52
4-wheel drive tractor & weed sprayer (2x)	acre	$9.54	1.00	$9.54	1.00	$9.94	1.00	$9.94	1.00	$20.60	1.00	$13.88
Pickup 1/2 Ton 4x4	acre	$41.04	1.00	$41.04	1.00	$41.04	1.00	$41.04	1.00	$41.04	1.00	$41.04
ATV	acre	$13.20	1.00	$13.20	1.00	$13.20	1.00	$13.20	1.00	$13.20	1.00	$13.20
Total Capital Investment Costs				*$194.04*		*$205.03*		*$205.03*		*$205.12*		*$172.53*
Total Annual Costs				*$5,925.52*		*$5,431.12*		*$5,871.12*		*$5,713.49*		*$3,787.10*
Returns minus Total Annual Costs				**$1,224.48**		**$1,718.88**		**$1,278.88**		**$1,436.51**		**$3,362.90**