

# PRELIMINARY ECONOMIC EVALUATION OF AUTONOMOUS PRUNERS

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## Autonomous grape vine pruner operating characteristics

- One-row machine for pruning grape vines
- Towed by sub-compact tractor
- Operates without operator assistance
- Pruning cuts are made by robotic arms
- Pruner operates over the row and makes cuts on both sides of trellis simultaneously
- Pruner would be in operation **16 weeks/year**
- Pruner would operate at around **8.2 feet/minute**



- One machinery operator could manage up to 5 machines
- Machine would operate 16 hours/day
- Field efficiency of 78%

## Economic Assumptions

- Tractor: 25 h.p. 4WD, \$20,000 list price
- Tractor life: 16,000 hours
- Tractor repairs and maintenance: 80% TAR
- Fuel and lubrication cost: \$3.80/hour (based on diesel fuel at \$3.00/gallon)
- Pruner cost: between **\$80,000 and \$160,000**
- Pruner repairs and maintenance: 60% TAR
- Labor: \$20/hour for pruner operation + \$30/acre for pre-pruning

## Economic Assumptions (cont.)

- Depreciation figured on straight-line basis with 10% salvage value
- Pruner has an expected life of 10 years
- Annual interest on investment is calculated at 6% of investment cost
- Annual housing and insurance expense is estimated at 1.5% of investment cost

## Number of acres pruned with autonomous grape vine pruner for a range of ground speeds and operating season lengths

Weeks used per year	Ground speed (feet/minute)				
	<u>7.4</u>	<u>7.8</u>	<u>8.2</u>	<u>8.6</u>	<u>9.0</u>
12	105.0	110.6	116.3	122.0	127.6
14	122.4	129.1	135.7	142.3	148.9
16	139.9	147.5	155.1	162.6	170.2

## Cost of pruning labor equivalent to capacity of an autonomous grape vine pruner (machine operating at 8.2 feet/minute)

Weeks used per year	Pruning labor cost (\$/A)				
	<u>\$200</u>	<u>\$250</u>	<u>\$300</u>	<u>\$350</u>	<u>\$400</u>
12	\$23,260	\$29,076	\$34,891	\$40,706	\$46,521
14	\$27,137	\$33,922	\$40,706	\$47,490	\$54,274
16	\$31,014	\$38,767	\$46,521	\$54,274	\$62,028

# Maximum price a grower would be willing to pay for an autonomous pruner to replace pruning labor (machine operating at 8.2 feet/minute)

Weeks used per year	Pruning labor cost (\$/A)				
	<u>\$200</u>	<u>\$250</u>	<u>\$300</u>	<u>\$350</u>	<u>\$400</u>
12	\$37,864	\$68,270	\$98,676	\$129,082	\$159,488
14	\$58,135	\$93,609	\$129,082	\$164,556	\$200,029
16	\$78,406	\$118,947	\$159,488	\$200,029	\$240,570

## Cost per acre for owning and operating the autonomous grape vine pruner

		Ground speed (ft/min)				
		<u>7.4</u>	<u>7.8</u>	<u>8.2</u>	<u>8.6</u>	<u>9.0</u>
<u>Machine price</u>						
<b>Operated 12 weeks/year</b>						
\$80,000		\$274	\$260	\$248	\$236	\$226
\$100,000		\$311	\$295	\$281	\$268	\$256
\$120,000		\$347	\$330	\$313	\$299	\$286
\$140,000		\$384	\$364	\$346	\$330	\$316
\$160,000		\$420	\$399	\$379	\$362	\$346
<b>Operated 14 weeks/year</b>						
\$80,000		\$246	\$233	\$222	\$211	\$202
\$100,000		\$277	\$263	\$250	\$238	\$228
\$120,000		\$308	\$292	\$278	\$265	\$253
\$140,000		\$339	\$322	\$306	\$292	\$279
\$160,000		\$370	\$351	\$334	\$319	\$305
<b>Operated 16 weeks/year</b>						
\$80,000		\$224	\$212	\$202	\$193	\$184
\$100,000		\$251	\$238	\$227	\$216	\$206
\$120,000		\$278	\$264	<b>\$251</b>	\$240	\$229
\$140,000		\$306	\$290	\$276	\$263	\$251
\$160,000		\$333	\$316	\$301	\$287	\$274



# Potential for high-density apple orchards?

Density <u>TPA</u>	<u>Spacing</u>	Pruning cost per tree				
		<u>\$0.30</u>	<u>\$0.40</u>	<u>\$0.50</u>	<u>\$0.60</u>	<u>\$0.70</u>
681	8' x 8'	\$204	\$272	<b>\$340</b>	\$408	\$476
908	6' x 8'	\$272	\$363	<b>\$454</b>	\$545	\$635
1,361	4' x 8'	\$408	\$545	<b>\$681</b>	\$817	\$953

## If the cost of an autonomous pruner for apples was similar to the grape vine pruner...

Break-even apple acreage needed to justify purchase of hypothetical autonomous apple pruner for a range of labor costs per tree

Density <u>TPA</u>	Spacing	Pruning cost per tree				
		<u>\$0.30</u>	<u>\$0.40</u>	<u>\$0.50</u>	<u>\$0.60</u>	<u>\$0.70</u>
681	8' x 8'	191	143	115	95	82
908	6' x 8'	143	107	86	72	61
1,361	4' x 8'	95	72	57	48	41

## If the cost of an autonomous pruner for apples was similar to the grape vine pruner...

Minimum ground speed (feet per minute) required to justify purchase of a hypothetical autonomous apple pruner for a range of labor costs per tree

Density <u>TPA</u>	<u>Spacing</u>	<u>Pruning cost per tree</u>				
		<u>\$0.30</u>	<u>\$0.40</u>	<u>\$0.50</u>	<u>\$0.60</u>	<u>\$0.70</u>
681	8' x 8'	12.6	9.5	7.6	6.3	5.4
908	6' x 8'	9.5	7.1	5.7	4.7	4.1
1,361	4' x 8'	6.3	4.7	3.8	3.2	2.7

# Conclusions

- For the grape vine pruner, cost per acre varies from \$184 to \$420 per acre, which compares very favorably with the estimated pruning costs from 9 cost estimates from 5 states.
- For the design targets of a ground speed of 8.2 feet per minute, operation for 16 weeks per year, and \$120,000 list price, the cost is \$251/acre (lower than 7 of 9 cost estimates).
- If such a machine could be developed for apples and operate at ground speeds of 4-6 feet per minute, it would have be economical for a wide range of high-density plantings.