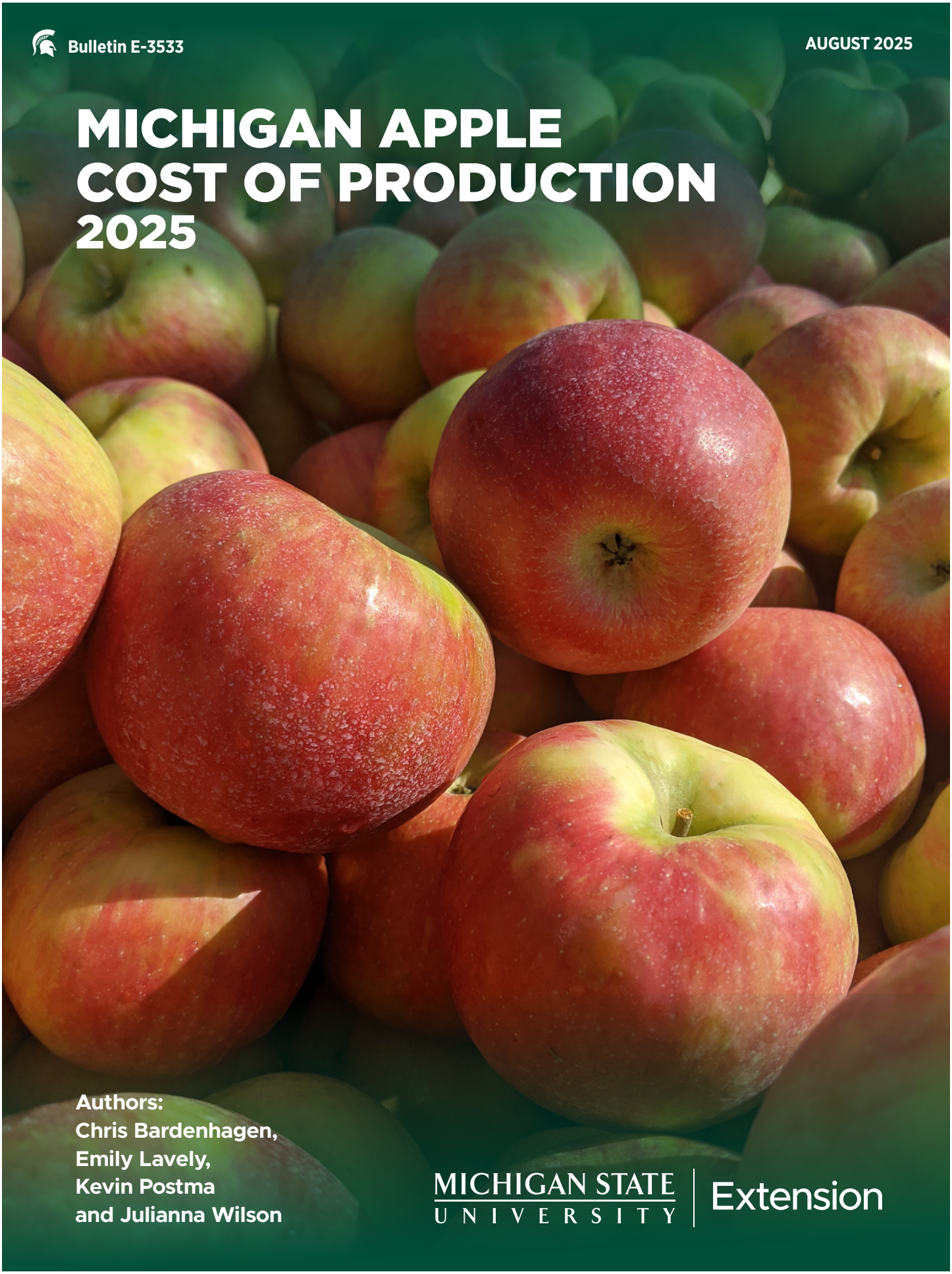
Bulletin E-3533

AUGUST 2025

MICHIGAN APPLE COST OF PRODUCTION 2025



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EXECUTIVE SUMMARY

Michigan's bearing apple acreage has increased substantially since 2017. Much of the acreage being planted or replanted today is in high density, trellised orchards, but a substantial amount of acreage continues to be planted into medium density, semidwarf orchards. This study focused on developing enterprise budgets for both high density and semidwarf systems. While we found all plantings to show some level of profitability in current conditions, caution is also warranted. Profitability is very price dependent, and gluts due to overproduction do not need to be large in order to depress prices below the cost of production.

We found that semidwarf systems produce apples at a lower cost per bushel – about 10% to 12% less than high density systems at a given yield. Semidwarf plantings have the advantage of lower tree cost and no trellis system. Less capital is therefore needed for their establishment.

High density systems, however, have the highest profitability overall. This is because their yield potential is substantially higher and production comes on much earlier, leading to more fruit over time. The higher up-front costs of high density establishment (planting costs of $26,578) versus semidwarf establishment (planting costs of $7,676) pay for themselves over time. We found similarly that the extra costs of planting at very high densities, (e.g. 1,800 or 2,000 trees per acre) should be easily covered with a slightly higher yield (2 bins/acre/year) or earlier onset of production.

Our climate analysis found that the high density systems are more carbon friendly than semidwarf systems, due to the higher volumes of fruit produced using similar amounts of carbon. However, both systems were found to be more carbon friendly than row cropping, an alternative land use.

We conducted analysis on three variety types: high-value (Honeycrisp, Tango), mid-value (Gala, Fuji, other fresh), and processing varieties. Operating costs for producing processing apples are about 19% less than fresh. We determined that variable harvest costs, not including trucking, are about $71 per bin for high-value, $45 per bin for mid-value and $35 per bin for processing apples.

For high density systems, the high-value (Honeycrisp) breakeven price, at a yield of 1,000 bu/acre, is $211/bin (price received from packer when dropped at packer's cooler or dock). At 1,200 bu/acre, the mid-value (Gala, Fuji) break-even dock price is $163/bin. For semidwarf systems, the high-value (Honeycrisp) breakeven price at 700 bu/acre is $235 per bin, and the mid-value (Gala, Fuji) breakeven price at 900 bushels per acre is $175 per bin. Note that these numbers include a $5 allocation for trucking from farm to packer. Note also that the stated yields are considered to be the amount sent to the packer (versus the field yield per acre). Tables showing breakeven numbers for different yields and prices are provided in the main report.

Cover photo by Anna Wallis, MSU Extension

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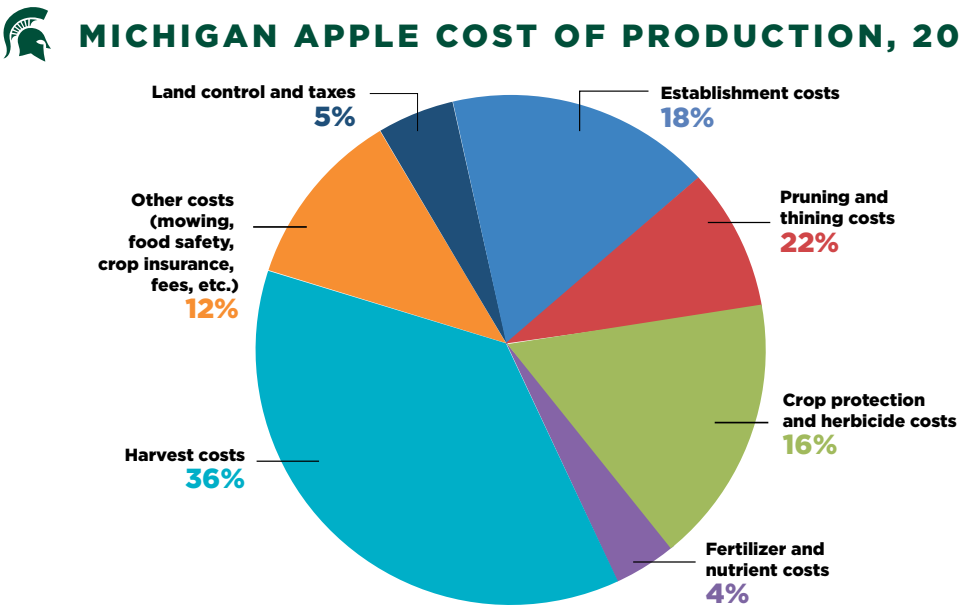

Figure 1. Costs of apple production in Michigan for an example/average farm, as a percentage by category.

INTRODUCTION

According to the 2022 Michigan Fruit Inventory, Michigan has about 850 apple farms (NASS 2024a). Michigan had just over 40,000 bearing acres in the 2022 Census of Agriculture, up 7,000 acres from just five years prior (NASS, 2024b). This represents a 21% increase in bearing acreage, a result of high planting levels in recent years, in some cases replacing cherries.

On average, the density of apple orchards, or the number of trees per acre, is rising. In some regions, new orchards are almost exclusively being planted to high density, while in others, medium density semidwarf plantings still predominate. There are costs and benefits to both types of orchard systems.

Apple farms vary dramatically in size. According to the 2022 Census of Agriculture, the majority of apple orchards are 5 acres or less, many of which are a fraction of an acre. Some of these smaller farms are engaged in local, direct sales to the consumer. Together, these farms make up only 2% of Michigan's bearing apple acreage. 91% of Michigan's bearing acreage is on farms with 25 acres or more of apples (NASS, 2024b). Most apples go to a packinghouse to be graded and packaged for sale, or to processors to make products such as sliced apples, juice or cider, and sauce.

Many varieties of apples exist, but growers generally plant varieties that are popular with fresh market consumers. For high density and semidwarf orchards, which make up a majority of current plantings, desired varieties are grafted onto dwarfing rootstocks at tree nurseries. One of the main growing challenges is to optimally match the rootstock, variety and training system with the soil type into which the trees will be planted. The choices will greatly affect quality and yield. For pollination, most growers arrange with beekeepers to bring honeybee hives to farms during bloom time. Wild pollinators can be abundant in some orchards but may not be sufficient to provide pollination for larger contiguous blocks during the short bloom time period.

Modern apple orchards generally require some manner of apple thinning. If all apples set that could, there would be fruit sizing issues, and the loads would be too heavy for the trees. In some varieties, biennial bearing would result – meaning big yields one year, followed by low yields the next. On the other hand, orchards that are overthinned can have too few and too large of fruit. Thinning, therefore, continues to be a critical factor in

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production quality. In addition, hand labor is involved in pruning and other horticultural practices required to maintain production in apple orchards.

Weed suppression under trees and mowing of row middles, disease prevention (e.g. apple scab, fire blight), and damage prevention from arthropod (insects and mites) and vertebrate (deer, rodents, birds) pests are all important crop protection practices in apple orchards. These practices require annual inputs in terms of materials and supplies, labors, and fuel usage in the application of preventative measures.

Apples in Michigan are harvested from August (early varieties) to November (late varieties). Different varieties and markets require different harvesting approaches, but all apples are hand-harvested. Some varieties need to be stem-clipped so that the stems do not damage other apples in the box (for example, Honeycrisp). Fresh varieties are "color-picked" – laborers go through the orchard and pick only the fruit that is ripe enough for market. This means that multiple pickings are required for most orchards. On the other hand, processing apples are often picked all at once.

This report summarizes our findings related to the costs of producing apples in Michigan. We studied different training systems (high density and semidwarf) and different variety types (high-value, mid-value and processing) to enable comparisons. Our analysis includes revenue data based on recent prices reported by growers. This study also includes an analysis of the carbon impact of different training methods compared to other land uses.

METHODS/ INFORMATION SOURCES

For this study, we first interviewed a sample of growers with good records. Growers were interviewed across apple regions in Michigan. Industry supporters, including MSU Extension educators, were also interviewed as key informants. A focus group with multiple growers was held in Sparta in mid-winter 2025 to gather information and develop consensus on the inclusion of certain cost categories. We used the 2022 Michigan Apple Cost of Production Update spreadsheet as a reference during that meeting and as a starting point for data collection.

For analysis, we developed budgets based on density (high density, semidwarf) and variety/market split (Honeycrisp/high-value, Gala/mid-value and processing). We also created an overall budget and revenue picture for an "Example Farm" to develop a sense of the overall costs of apple farming in Michigan. We included a calculation of the savings that occur within each system when growing apples for the processing market, entered into the budgets as negative cost numbers.

A climate impact analysis was also conducted for this study. Fuel usage was calculated from our final dataset, and upstream impacts were calculated in part using the 2022 Michigan Apple Cost of Production spreadsheet mentioned above. The carbon impact was analyzed using methods and conventions endorsed by the Intergovernmental Panel on Climate Change (IPPC).

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ASSUMPTIONS

The cost analysis for this study is based on several assumptions informed by the interviews, focus group and existing data about the Michigan apple industry, including National Agricultural Statistics Service (NASS) reports. Michigan apple regions are diverse in their spread of orchard types, making development of an average challenging. We concluded that our example Michigan farm would have 50% high density acreage and 50% lower density acreage (semidwarf and large trees). Further, we assume that orchards being planted are either high density training systems or semidwarf systems looking forward. Accordingly, we created two budgets – one for high density and one for semidwarf. For varieties and markets, we used three categories: high value fresh (Honeycrisp and other varieties), mid-value fresh (Gala, Fuji and other fresh varieties) and processing oriented.

Some of our main assumptions are summarized as follows:

Acreage, density, varieties for the average farm:

- 50% high density, at an average of 1,208 trees per acre. These acres consist of 50% Honeycrisp/high-value, 40% mid-value (Gala, Fuji, other fresh), and 10% processing (e.g. Jonagold).
- 50% semidwarf acreage, average 388 trees per acre. These acres consist of 40% Honeycrisp/high-value, 30% mid-value, and 30% processing varieties.

Yields at full production:

- High density – hits full production at Year 6. Honeycrisp –1,000 bushels per acre; mid-value/Gala – 1,200 bushels per acre; processing varieties – 1,100 bushels per acre.
- Semidwarf – hits full production at Year 9. Honeycrisp –700 bushels per acre; mid-value/Gala – 750 bushels per acre; processing varieties – 800 bushels per acre.

Prices:

- Processing price of 12 cents per pound, all products considered (juice, sauce, slices)
- $350 per bin for Honeycrisp, amount received from packer, after dropping off at dock.
- $200 per bin for Gala/mid-value to the grower – dock price.

Cooling costs: assumed to be on the packer side after delivery
Life of orchard: Average of a 24-year total life (high density and semidwarf, all varieties)

Figure 2. Average yields over the life of a *high density* Honeycrisp planting.

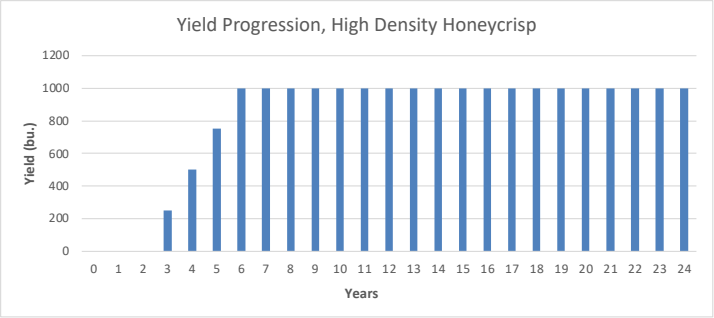
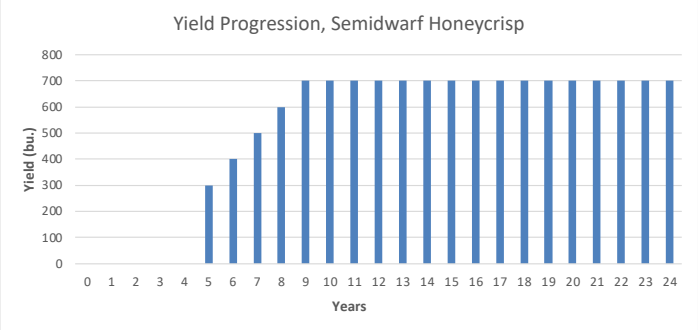


Figure 3. Average yields over the life of a *semidwarf* Honeycrisp planting.



Our analysis assumes that establishment is financed using the farm's cash flow. This is because we include an establishment allocation for each production year in the budgets. Our budgets do include an allocation for short-term credit line interest costs. However, the costs for financing orchard establishment, if incurred by the farmer, would need to be added to the budget (see the section "Application to the individual farm" later in this report).

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Relatedly, we assume that most apple farms have a spread of plantings, staggered from old to new, which arguably obviates the need for net present value (NPV) analysis. That said, we conducted NPV analysis and calculations for new plantings of the different types in order to determine the potential return on investment.

Equipment used: Equipment used in apple production is largely similar to that used in other tree fruit production in Michigan. We assume a certain amount of sharing among different crops when considering the total hours used for different pieces of equipment (see Table A25 in the Appendix). Pruning assist vehicles are often used in semidwarf apple production ("Brownies" being a popular type), and trailers which can hold multiple apple boxes for picking in the field are common.

Somewhat specific to apple production, many growers use platforms. These drive slowly down the rows and elevate workers to the treetops, in some cases reducing the need for ladders. High density orchard design invites the use of platforms. Because platforms can be used for many tasks, including pruning, tying new trees to trellis and hand thinning, it is not uncommon for growers to have multiple on hand. However, the number of platforms a farm would need to do all harvesting by platform is prohibitive, given their costs and short amount of use during the year.

Table 1. Equipment used in apple production in Michigan.

Equipment Type	Purchase Price
85 HP 4WD tractor w/cab	$85,000
60 HP 2WD tractor / forklift	$60,000
Tree planter	$ 8,500
Brownie pruner	$30,000
Platform (thinning, pruning, tying, picking)	$70,000
Apple trailer	$12,000
Forklift	$35,000
Flail chopper	$10,000
Rotary mower	$ 8,000
Airblast sprayer	$47,000
Weed sprayer	$15,000
Fertilizer spreader	$10,000

Young Gala orchard on G11 rootstock, planted in 2022. Photo by Chris Bardenhagen, MSU Extension

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Labor and housing: The prices stated in Table 2 for manual and skilled labor include housing costs and other benefits. Housing is a major benefit provided for many workers. Several growers are working with the H-2A Temporary Agricultural Worker Program. This program requires the funding of travel, transport and, in some cases, food for workers, in addition to their mandated minimum wage (currently $18.15). If growers work with farm labor contractor (FLCs), the FLC incurs these costs and passes them on to the grower. While some growers budget $30 an hour for all-in manual labor costs, averages from the different regions came to about $27, including housing, contractor and related costs. We considered housing costs to be about $2 per hour on average.

Table 2. Labor prices.

LABOR COST		
Skill Level	Notes	Total
Owner/Manager	All in wage placeholder	$40.00
Skilled, year-round	Includes benefits/housing	$29.00
Manual, hourly	Includes benefits, housing, & contractor costs	$27.00

ORCHARD ESTABLISHMENT

We found that growers are mainly planting into two types of training systems: high density and semidwarf. For our tables, we assume 1,208 trees per acre for high density and 388 trees per acre for semidwarf. Orchard tree spacing varies within these two systems, with some growers putting in very high density orchards (2,000 trees per acre).

Growers' costs of establishment vary, based how much they do themselves, the equipment that is owned by or available to them and the bulk discounts they can get on supplies or services. For example, some growers can put up their own trellis, while others hire that task to be done.

A big challenge for orchard establishment is matching the soil type, training system and appropriate rootstocks with the desired variety. Once planted, growers are basically locked into their choices for a long period (24 years). High expenses and lost profits are associated with taking out an orchard early or grafting over to a new variety, so these are avoided as much as possible.

Semidwarf block in July.
Photo by Chris Bardenhagen, MSU Extension

Land preparation: Orchards are usually planted on land that has previously had tree fruit, so in our budget we include the cost of orchard removal (land clearing). After removal, tillage is required to get the soil leveled out and ready for planting. Cover cropping is usually done for at least one season between orchards, if not more. Table 3 illustrates land preparation costs for both high density and semidwarf plantings.

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Table 3. Land preparation costs.

Land Preparation	Time	Labor Rate	Materials	Equipment Rate		Subtotal	TOTAL
	Hours/ acre	$/hour	or **Custom Cost** $/Acre	$/hour Variable (cash)	$/hour, Fixed (non-cash)	$/acre	$/acre
Pre-plant (Year 0)							
Land clearing			$1,000.00			$1,000.00	
Roots and rocks – all-in cost			$350.00			$350.00	
Tillage – various tasks, all-in			$100.00			$100.00	
Poultry manure – 1.5 tons/acre @ $75/ton			$112.50			$112.50	
Cover crop – all-in			$50.00			$50.00	
					Total Pre-plant costs		**$1,613**

Planting year: The planting process often includes a crew of six to eight people. One person will drive the tractor; two will sit on the planter machine; up to three people will clip strings, clean up trees and move them from the shipping package to a holding space on the planter; and two will go behind the planter and step in trees, adjusting the planting depth a bit as necessary. Most orchards are now planted with tractors using GPS systems to help create straight lines. This has the benefit of ensuring that orchards are platform-ready as well as straight and consistent enough to potentially support robotic harvesting if it becomes economically feasible.

To protect the small trees from damage, deer fencing was included in our budget. We assumed a fenced-in space of 20 to 40 acres. Growers who do not have fencing use a variety of techniques to deter deer, including bags with repellent, and shiny tape meant to scare the deer. To prevent rodent damage, tree guards are used on the base of the tree. While some growers are moving away from tree guards, we include them in the budget due to their current widespread use.

For high density orchards, a post and wire trellis system is needed along with poles for each tree. Growers generally use bamboo poles. In semidwarf orchards, where no trellis is used, we budgeted for metal conduit poles, which are a bit stronger and longer lasting when put into the soil to help support the tree.

Irrigation costs vary, depending on what infrastructure is available to that orchard already – some have a well recently installed, some have a well that needs a new motor/ wellhead and others don't have an accessible well at all. In our budgets we assumed an average of $700 for well costs, in addition to the trickle line and replacement main line.

The grass strip between rows is often planted with orchard grass or lower mowing mixes (such as fescues). Middles are planted soon after the trees and trellis are put up, when soil will be disturbed less.

Table 4 illustrates the basic costs associated with the establishment of a high density orchard.

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Table 4. Apple planting costs—*high density*.

Planting -- Spring of Year 1	Time	Labor Rate	Materials	Equipment Rate		Subtotal	TOTAL
	Hours/ acre	$/hour	or **Custom Cost** $/Acre	$/hour Variable (cash)	$/hour, Fixed (non-cash)	$/acre	**$/acre**
Tree costs							
$12 per tree x 1208 trees/acre			$14,496.00			$14,496.00	
Tree guards – $0.35 per tree			$422.80				
Bamboo poles – $1.25 per tree			$1,510.00				
Planting							
10 laborers for 1.5 hour per acre	15.0	$27.00				$405.00	
85 HP tractor/driver	1.5	$29.00		$15.51	$24.86	$104.05	
Planter	1.5			$2.13	$13.29	$23.12	
Seeding grass middles							
All-in cost, seed plus planting			$50.00			$50.00	
Trickle							
Labor (all-in or custom)			$500.00			$500.00	
Well cost			$700.00			$700.00	
Drip line and main line hookups			$1,300.00			$1,300.00	
Trellis							
Labor (all-in or custom)			$2,000.00			$2,000.00	
Materials			$6,500.00			$6,500.00	
Deer fence – custom or all-in			$500.00			$500.00	
					Total Planting costs		**$26,578**

Establishment of a semidwarf orchard varies from high density in two main ways. First, the number of trees needed is much lower. Second, we use the assumption that no trellis is needed. A third benefit of semidwarf plantings for some growers is they can use larger equipment from other farm production (e.g., cherries) and forgo buying compact tractors and equipment needed for high density production.

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Table 5. Apple planting costs—*semidwarf*.

Planting -- Spring of Year 1	Time	Labor Rate	Materials	Equipment Rate		Subtotal	TOTAL
	Hours/ acre	$/hour	or **Custom Cost** $/ Acre	$/hour Variable (cash)	$/hour, Fixed (non-cash)	$/acre	**$/acre**
Tree costs							
$12 per tree x 388 trees/ acre			$4,656.00			$4,656.00	
Tree guards – $0.35 per tree			$135.80				
Conduit poles – $5.00 per tree			$1,940.00				
Planting							
6 laborers for 1.5 hour per acre	9.0	$27.00				$243.00	
85 HP tractor/ driver	1.5	$29.00		$15.51	$24.86	$104.05	
Planter	1.5			$2.13	$13.29	$23.12	
Seeding grass middles							
All-in cost, seed plus planting			$50.00			$50.00	
Trickle							
Labor (all-in or custom)			$400.00			$400.00	
Well cost			$700.00			$700.00	
Drip line and main line hookups			$1,000.00			$1,000.00	
Deer fence – custom or all-in			$500.00			$500.00	
					Total Planting costs		**$7,676**

Early/non-bearing years: During the early growing years, crop protection spray costs are lower, partly due to less surface area to spray and partly from no need to manage pests that only attack fruits. The fertilizer program is quite different in the early years, when growers are working to pulse higher levels of nitrogen (often fertigated) in numerous applications over the year.

Herbicide costs are higher on average because orchards need special herbicides that minimize harm to young trees.

In the early years, pruning is relatively quick, but significant time is spent training the trees, including tying them to different wires on the trellis or conduit poles as the trees grow upward. Table 6 details early year production costs for high density orchards.

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Table 6. Early year annual costs for high density apples (years 1-4).

Growing Years 1 - 4	Time	Labor Rate	Materials	Equipment Rate		Subtotal	TOTAL
	Hours/ acre	$/hour	or **Custom Cost** $/Acre	$/hour Variable (cash)	$/hour, Fixed (non-cash)	$/acre	**$/acre**
Pruning and training – includes tying to trellis	36.0	$27.00				$972.00	
Brush chopping – Average 50% of full costs in early years							
85 HP tractor	0.5	$29.00		$15.51	$24.86	$34.68	
Flail mower	0.5			$1.00	$10.48	$5.74	
Fertilizer – 2 trips for granular							
60 HP tractor	0.4	$29.00		$9.78	$11.70	$20.19	
Spreader	0.4			$1.25	$9.56	$4.32	
Materials for early years (average)*			$175.00			$175.00	
Mowing – for 4 trips per year							
60 HP tractor	1.3	$29.00		$9.78	$11.70	$65.62	
Rotary mower	1.3			$0.62	$6.45	$9.18	
Crop protection – total for all trips							
85 HP tractor	2.1	$29.00		$15.51	$24.86	$145.66	
Airblast sprayer	2.1			$2.24	$17.11	$40.63	
Materials for early years (average)**			$780.00			$780.00	
Herbicide – total for 2 trips							
60 HP tractor	1.3	$29.00	$25	$9.78	$11.70	$90.62	
Weed sprayer	1.3			$1.15	$8.82	$12.97	
Porta-potties			$20.00			$20.00	
Food safety (average- incurred on years 3 and 4)			$50.00				
Land control costs			$400.00			$400.00	
Real estate tax			$45.00			$45.00	
Soil testing – $12 every 3 years			$4.00				
Pickup – 50 miles @ IRS rate $0.70			$35.00				
Management	5.0	$40.00				$200.00	
Credit line interest							
8% APR on costs, average 4 months			$80.58			$80.58	
					Total Annual Early Year Operating costs		**$3,102**

*Year 1 $150; Years 2 and 3 $100; Year 4 full program.

** Year 1 20% of full program; Year 2 60%; Year 3 and forward = full program.

Early year costs for semidwarf plantings are generally similar. The exceptions are lower average pruning and training costs and slightly higher herbicide costs. The higher herbicide costs are due to a larger weed-free strip designed for a larger canopy. Annual early year operating costs totaled $2,718 per acre (versus $3,102 for high density as shown in Table 6). See Table A28 in the Appendix for more details.

Very high density approach: Growers face some additional costs when planting into very high density systems, versus the average high density of 1,208 trees per acre. These are mostly due to extra tree and bamboo costs, but for very close spacing orchards, more trellis rows are needed per acre. See Table 7, which shows the extra costs for very high density plantings, and the estimated amount of extra yield needed per year to pay for that extra investment. Also consider the benefits that can accrue from an earlier start to production. Further, there is an argument that quality and therefore packout might also be higher, due to better light penetration throughout the orchard.

Table 7. Difference in costs for very high density orchards.

Partial Budget for 'Very High' Density Orchard Plantings					
Row spacing	12 feet		10 feet*		
Trees / acre	**1600**	**1800**	**1800**	**2000**	**2200**
Total extra establishment costs	$4,704	$7,104	$8,719	$11,119	$13,519
Extra establishment costs, per bearing year	$235	$355	$436	$556	$676
Extra bushels needed to breakeven/acre per year**	17	26	32	40	49

*Assumes 19% higher trellis costs based on having more rows per acre

**Assuming 50% Honeycrisp at $350/bin & 50% mid-value at $200/bin to grower

PRODUCTION

During the production years, pruning and thinning become higher costs, while training, particularly in high density orchards, slows down as trees reach the top wire. Fertilizer, crop protectant and herbicide programs have some nuances for the different varieties and markets, but they are largely the same across high density and semidwarf systems.

Pruning: Pruning in mature orchards was found to average about 18 labor hours per acre in high density and 17 hours per acre in semidwarf. The difference is for semi-dwarf, pruning towers (often "Brownies" or similar) are used to more easily reach tree tops. Some growers choose mechanical hedging to create more easily prune-able orchards, but most growers use loppers or other hand tools. These hand tools may be equipped with electrical assist.

Thinning: As mentioned in the introduction, apple thinning is a very tricky aspect of management. While good pruning helps to manage a balanced crop load, either chemical thinning or hand thinning must be done to reach desired fruit sizing and keep trees from biennial bearing. Growers often do some combination of chemical and hand thinning, but rising labor costs have changed decision points for when hand thinning is done. Growers may now be willing to take a higher risk of overthinning to avoid high hand thinning costs. For some varieties, hand thinning is no longer considered a viable option.

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Fertilizer: In the early years, higher nitrogen is needed, but growers slow the nitrogen down as the orchard comes into full production. Often potash and micronutrient application amounts increase as orchards enter full production. Many growers are using foliar feeds to help provide balanced nutrient support in their trees.

Table 8. Fertilizer costs, full production.

FERTILIZER MATERIAL COST	
Granular or fertigation mixes	$250
Micros added (Boron, Sulfur, etc)	$50
Foliar products	$50
TOTAL /Acre	**$350**

Pest and disease management: Table 9 shows the average herbicide and crop protectant costs incurred by the growers we interviewed. Plant growth regulators (PGRs) and thinning chemicals are included in the crop protection category because they are generally sprayed on the tree along with pest and disease management products.

Not all varieties are treated the same, however. For some of the higher-value varieties, such as Honeycrisp, some growers spend extra on materials that can help improve quality and storability. These may cost an extra $300 per acre or more, but they are not included in our budget because, presumably, they lead to higher packouts and revenues than our average.

For processor-oriented fruit, such as Ida Red or Jonagold, spray costs are $300 less per acre, due to a lower need to treat for russeting and other cosmetic issues.

Table 9. Grower spray cost averages.

GROWER SPRAY COST AVERAGES		
Spray Type	**Fresh Varieties**	**Processor-oriented varieties**
Crop Protection, PGRs, and thinning	**$1,200**	**$900.00**
Herbicide	**High Density**	**Semi Dwarf**
	$25	**$40**

Herbicides vary between systems, because for semidwarf production, a higher percentage of the orchard floor needs to be sprayed to create weed-free strip. High weeds can become vectors for pests that climb up into the tree and weeds can interfere with picking activities.

Other production tasks, overhead, and operating costs

A number of other operating expenses occur during apple production. Some of these are not fixed costs but are overhead costs that happen regardless of the orchard's output that year. These include soil testing, food safety related costs, portable bathrooms and crop insurance, among others.

Crop insurance: We included an allocation of $300 for crop insurance in the budget. Crop insurance costs can vary widely, depending on the options used, historical yields, varieties of apples covered and level of coverage selected. Growers will often need to adjust

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this study's budget based on their specific costs (see the section "Application to the individual farm" later in this publication).

For more details on operating costs generally, see Table 10, which illustrates the operating costs for high density orchards, and Table A29 in the Appendix, which provides the details for semidwarf orchard operating costs. Note that both tables include a cost savings allocation for processor production, based on the percentages assumed for each system (10% for high density and 30% for semidwarf).

Mature semidwarf orchard with deer fencing. Photo by Chris Bardenhagen, MSU Extension

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Table 10. Operating costs for high density apple orchards in Michigan.

Operating and harvest costs, and cost totals for Michigan HIGH DENSITY Apple production, 2025
Per acre, based on the full production years during the 24 year total orchard life

OPERATING COSTS	Time	Labor Rate[1]	Materials	Equipment Rate		Subtotal	TOTALS
	Hours/ acre	$/hour	or **Custom Cost** $/acre	$/hour variable (cash)	$/hour fixed (Deprec.)	$/acre	**$/acre**
Pruning and brush disposal							**$567**
-Labor hours for pruning	18.0	$27.00				$486.00	
-85 HP tractor for brush disposal	1.0	$29.00		$15.51	$24.86	$69.36	
-Flail chopper	1.0			$1.00	$10.48	$11.48	
Hand thinning							**$270**
-Labor hours for thinning, average per acre	10	$27.00				$270.00	
Mowing – Total for 4 trips per year							**$75**
-60 HP tractor	1.3	$29.00		$9.78	$11.70	$65.62	
-Rotary mower	1.3			$0.62	$6.45	$9.18	
Crop protection – Total, all trips included							**$1,386**
-85 HP tractor	2.1	$29.00		$15.51	$24.86	$145.66	
-Orchard sprayer	2.1			$2.24	$17.11	$40.63	
-Total material costs			$1,200.00			$1,200.00	
Herbicide – Total for 2 trips per year							**$104**
-60 HP tractor	1.3	$29.00		$9.78	$11.70	$65.62	
-Weed sprayer	1.3			$1.15	$8.82	$12.97	
-Total material costs			$25.00			$25.00	
Fertilizer							**$375**
-60 HP Tractor for dry applications 2x /year	0.4	$29.00		$9.78	$11.70	$20.19	
-Spreader	0.4			$1.25	$9.56	$4.32	
-Dry material costs			$250.00			$250.00	
-Added micros (boron, sulfur, etc.)			$50.00			$50.00	
-Foliar material costs[2]			$50.00			$50.00	
Other Operating							**$704**
Property taxes per acre			$45.00			$45.00	
Soil testing – every 3 years @ $12/acre			$4.00			$4.00	
Crop insurance			$300.00			$300.00	

(more)

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Table 10. Operating costs for high density apple orchards in Michigan. (Cont.)

OPERATING COSTS	Time	Labor Rate[1]	Materials	Equipment Rate		Subtotal	TOTALS
	Hours/ acre	$/hour	or **Custom Cost** $/acre	$/hour variable (cash)	$/hour fixed (Deprec.)	$/acre	**$/acre**
Food safety compliance			$100.00			$100.00	
Porta-potties			$20.00			$20.00	
Management and labor supervision	5.0	$40.00				$200.00	
Pickup use – 50 miles/acre x $.70 IRS rate			$35.00			$35.00	
Subtotal Operating Costs							**$3,480**
Difference (Savings) for Processor Apple Production (Jonagold, etc.)[3]							
Hand thinning – only use chemical thinning	10	$27.00				$270.00	
Spray material – 25% less material			$300.00			$300.00	
Summer pruning – don't need	4	$27.00				$108.00	
Lower Costs for Processor Apple Production, Per Acre						**$678.00**	
Savings Based on Processor Apple Production Level of						**10%**	**-$68**
TOTAL OPERATING COSTS							**$3,412**

HARVEST COSTS

Harvest costs vary substantially by variety and market.

Picking: High value varieties such as Honeycrisp must be stem clipped to avoid punctures. This takes extra time in the orchard and incurs higher labor costs. All high-value and mid-value fresh varieties must be color picked. Harvest crews go through the orchard multiple times (the number depends on varietal characteristics) and only pick the apples that are ripe. Processor-oriented varieties, on the other hand, are usually picked in one pass. In some cases, growers will color-pick a fresh market variety once or twice, then pick that block a final time for processing.

Table 11 illustrates the costs of harvest for high density systems. The different variety/ market categories are shown, and the "harvested bushels" for each are based on the assumed split for high density acreage (found in the Assumptions section earlier in this publication). Table 12 shows the costs for semidwarf systems, based on our assumed splits. Note that yields vary by variety.

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Table11. Apple harvest costs for high density orchards.

HARVEST COSTS	Rate/ bin	Yield/acre (in 40 lb. bushels)	Percent of High Density acreage	Harvested bushels	Harvested bins	Subtotal	TOTALS /acre
Honeycrisp/ other (stem clip + color pick)		**1,000**	**50%**	**500**	**25**		**$1,763**
-Picking and supervision labor PER BIN[1]	$64.00				25	$1,600.00	
-Field pickup (all-in, tractor + labor) PER BIN	$3.50				25	$87.50	
-Housing allocation PER BIN	$3.00				25	$75.00	
Gala/ other mid-value varieties (color pick)		**1,200**	**40%**	**480**	**24**		**$1,080**
-Picking and supervision labor PER BIN[1]	$40.00				24	$960.00	
-Field pickup (all-in, tractor + labor) PER BIN	$3.50				24	$84.00	
-Housing allocation PER BIN	$1.50				24	$36.00	
Processor apples (strip pick)		**1,100**	**10%**	**110**	**5.5**		**$193**
-Picking and supervision labor PER BIN[1]	$30.00				5.5	$165.00	
-Field pickup (all-in, tractor + labor) PER BIN	$3.50				5.5	$19.25	
-Housing allocation PER BIN	$1.50				5.5	$8.25	
Other Harvest costs							**$764**
-**Trucking** per bin (all in cost, all types, assumed average across MI)	$5.00				54.5	$272.50	
Replacement costs	#/Year				Cost/acre		
-Bin replacement cost – 4 average	4.0				$62.50	$250.00	
-Apron replacement for picking basket	0.5				$34.00	$17.00	
-Strap replacement for picking basket	2.0				$12.00	$24.00	
-Ladder replacement (1 per year)	1.0				$200.00	$200.00	
						TOTAL HARVEST COSTS	**$3,799**

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Table 12. Apple harvest costs for semidwarf orchards.

HARVEST COSTS	Rate/ bin	Yield/acre (in 40 lb. bushels)	Percent of Semidwarf acreage	Harvested bushels	Harvested bins	Subtotal	TOTALS /acre
Honeycrisp/ other (Stem clip + color pick)		**700**	**40%**	**280**	**14**		**$987**
-Picking and supervision labor PER BIN[1]	$64.00				14	$896.00	
-Field pickup (all-in, tractor + labor) PER BIN	$3.50				14	$49.00	
-Housing allocation PER BIN	$3.00				14	$42.00	
Gala/ other mid-value varieties (Color pick)		**900**	**30%**	**270**	**13.5**		**$608**
-Picking and supervision labor PER BIN[1]	$40.00				13.5	$540.00	
-Field pickup (all-in, tractor + labor) PER BIN	$3.50				13.5	$47.25	
-Housing allocation PER BIN	$1.50				13.5	$20.25	
Processor apples (Strip pick)		**800**	**30%**	**240**	**12**		**$420**
-Picking and supervision labor PER BIN[1]	$30.00				12	$360.00	
-Field pickup (all-in, tractor + labor) PER BIN	$3.50				12	$42.00	
-Housing allocation PER BIN	$1.50				12	$18.00	
Other Harvest costs							**$689**
-**Trucking** per bin (all-in cost, all types, assumed average across MI)	$5.00				39.5	$197.50	
Replacement costs	#/Year				Cost/acre		
-Bin replacement cost – 4 average	4.0				$62.50	$250.00	
-Apron replacement for picking basket	0.5				$34.00	$17.00	
-Strap replacement for picking basket	2.0				$12.00	$24.00	
-Ladder replacement (1 per year)	1.0				$200.00	$200.00	
						TOTAL HARVEST COSTS	**$2,703**

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REVENUE AND PROFITABILITY CALCULATIONS

Here we conduct analysis for several categories of apples. First, we apply our numbers to our Example Farm, which is based on the average acreages found in the Assumptions section, earlier in this publication. Then, we analyze by variety/value for both high density and semidwarf systems.

Example farm: Our example farm has 50% high density plantings and 50% semidwarf plantings. When using our assumptions for variety splits, the overall farm acreage consists of 45% Honeycrisp, 35% Gala/other mid-value varieties and 20% processor-oriented varieties. Table 13 shows the spreadsheet calculator used to determine cost, revenue and profitability numbers.

Table 13. Revenue and profit calculator, set to example farm acreage splits.

	Revenue Calculator/Table										
High Density Acreage: 50%				**Costs**							
Semidwarf Acreage: 50%	**Revenues**			Operating & Harvest costs			Overhead Costs			**Net Returns**	
	Price	Yield harvested (bu)	Totals	Cultural*	Harvest	Farm Credit Line Interest	Establishment	Land Control	Other Overhead**	Net Returns over **Operating & Harvest Costs**	Net Returns over **Total Costs** (Profits)
Honeycrisp	$350.00	390	$6,825	$2,459	$1,676	$170	$1,565	$445	$864	**$5,372**	**$2,498**
Gala	$200.00	375	$3,750		$1,133						
Processor (price in lbs.)	$0.12	175	$840		$441						
	TOTAL Revenue		**$11,415**		$163	**Total Fees**					

* "Cultural" costs include pruning, hand thinning, mowing, crop protection, herbicide and fertilizer.
** "Other Overhead" costs include equipment depreciation & other expenses such as food safety and crop insurance)

At today's prices, costs and yields, our example farm is profitable. Looking at Figure 4, we can see that the first year of positive cash flow – where revenues exceed costs – occurs at Year 5, and the breakeven year – when establishment costs have been covered fully – is year 12. See also Table A30 in the Appendix, which details the example farm's net cash flows. If we were planting this average Michigan farm today, we would see a 2.78% return on investment.

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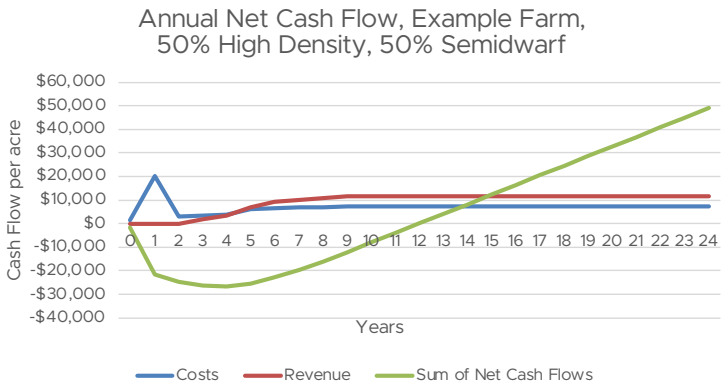
Figure 4. Annual net cash flow for an example Michigan apple farm.



To explore the profitability of this example farm further, see also Table A31 in the Appendix, which breaks down costs per bushel at different yields. Table A32 shows our analysis on the effects of a rise in input costs for the example farm, and Table A33 shows the effects of a rise in labor costs. Table A34 provides details on profits or losses that would occur for a range of different yields and prices.

Honeycrisp/high-value plantings:
We conducted analysis for the high value varieties category in both high density and semidwarf plantings. The base assumption for the yield of high-value varieties is 1,000 bushels per acre for high density plantings and 700 bushel per acre for semidwarf plantings. Note that these are conservative estimates using averages over normal years versus top potential full production yields. We found that high density, high-value plantings are the most profitable at current prices and costs.

High density, high-value/Honeycrisp

Table 14 shows costs by various categories on a per-bushel basis for high density, high-value plantings. The table illustrates variations by yields; note that per bushel costs drop significantly as yields rise (see also Table A35 in the Appendix for a related breakdown).

Table 14. Costs per bushel at varying yields for high density, high-value plantings.

Cost/bu. at Varying Yield Levels, Honeycrisp/High-value High Density							
Yield (bu)	Total Operating and Harvest Costs	Operating/ Harvest Cost/ bu.	Establishment Cost ($2,067 per acre) per bu.	Land Cost ($445 per acre) per bu.	Other Overhead Cost ($841 per acre) per bu.	Total Costs / acre	Total Production Cost/ bu.
600	$5,546	**$9.24**	$3.45	$0.74	$1.40	$8,899	**$14.83**
700	$5,951	**$8.50**	$2.95	$0.64	$1.20	$9,304	**$13.29**
800	$6,358	**$7.95**	$2.58	$0.56	$1.05	$9,711	**$12.14**
900	$6,763	**$7.51**	$2.30	$0.49	$0.93	$10,116	**$11.24**
1,000	$7,168	**$7.17**	$2.07	$0.45	$0.84	$10,521	**$10.52**
1,100	$7,573	**$6.88**	$1.88	$0.40	$0.76	$10,926	**$9.93**
1,200	$7,979	**$6.65**	$1.72	$0.37	$0.70	$11,332	**$9.44**
1,300	$8,384	**$6.45**	$1.59	$0.34	$0.65	$11,737	**$9.03**

Table 15 shows profits for a Honeycrisp planting at different price levels and yields.

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Table 15. Profits by price and yield for high density, high-value variety orchards.

PROFITS BY PRICE AND YIELD - Honeycrisp/High-value High Density	Light red = break-even or better							
	YIELD- Bushels per acre							
PRICE	600	700	800	900	1000	1100	1200	1300
$200	($2,900)	($2,305)	($1,711)	($1,116)	($521)	$73	$668	$1,263
$250	($1,400)	($555)	$289	$1,134	$1,979	$2,823	$3,668	$4,513
$300	$100	$1,195	$2,289	$3,384	$4,479	$5,573	$6,668	$7,763
$350	$1,600	$2,945	$4,289	$5,634	$6,979	$8,323	$9,668	$11,013
$400	$3,100	$4,695	$6,289	$7,884	$9,479	$11,073	$12,668	$14,263
$450	$4,600	$6,445	$8,289	$10,134	$11,979	$13,823	$15,668	$17,513
$500	$6,100	$8,195	$10,829	$12,384	$14,479	$16,573	$18,668	$20,763
$550	$7,600	$9,945	$12,289	$14,634	$16,979	$19,323	$21,668	$24,013
$600	$9,100	$11,695	$14,289	$16,884	$19,479	$22,073	$24,668	$27,263

Using our budgets, a high density, high-value planting has a 16% return on investment at current prices ($350/bin to the grower, dock price) and assumed yields (1,000 bu per acre). For net cash flow information, see Table A36 and Figure A6 in the Appendix.

Semidwarf, high-value/Honeycrisp

Table 16 shows costs by various categories on a per-bushel basis for a semidwarf, high-value planting. Compared to the high density orchard, costs are actually significantly lower on a per-bushel basis with semidwarf production.

Table 16. Costs per bushel at varying yields for semidwarf, high-value varieties.

Cost/bu at Varying Yield Levels, High Value Semidwarf							
Yield (bu)	Total Operating and Harvest Costs	Operating/ Harvest Cost/bu.	Establishment Cost ($1062 per acre) per bu.	Land Cost ($445 per acre) per bu.	Other Overhead Cost ($887 per acre) per bu.	Total Costs / acre	Total Production Cost/ bu.
400	$4,604	**$11.51**	$2.66	$1.11	$2.22	$6,999	**$17.50**
500	$5,010	**$10.02**	$2.12	$0.89	$1.77	$7,405	**$14.81**
600	$5,416	**$9.03**	$1.77	$0.74	$1.48	$7,811	**$13.02**
700	$5,822	**$8.32**	$1.52	$0.64	$1.27	$8,217	**$11.74**
800	$6,229	**$7.79**	$1.33	$0.56	$1.11	$8,624	**$10.78**
900	$6,635	**$7.37**	$1.18	$0.49	$0.99	$9,030	**$10.03**
1,000	$7,041	**$7.04**	$1.06	$0.45	$0.89	$9,436	**$9.44**
1,100	$7,447	**$6.77**	$0.97	$0.40	$0.81	$9,842	**$8.95**

The semidwarf approach is also profitable at current prices and assumed yields (Table 17). According to our net present value analysis, an investment in a semidwarf, high value orchard would have a 12% return on investment. The lower yield potential and slower ramp up to production makes the semidwarf planting a bit less profitable overall than high density planting. On the other hand, the first year planting cost investment needed for a semidwarf planting is less than 1/3 of that of the high density. For more details, see Table A38 and Figure A7 regarding cash flows in the Appendix.

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Table 17. Profits by price and yield for semidwarf, high-value varieties.

PROFITS BY PRICE AND YIELD - Honeycrisp/High-value Semidwarf								
	Light green = break-even or better							
	YIELD- Bushels per acre							
PRICE	400	500	600	700	800	900	1000	1100
$200	($2,998)	($2,404)	($1,810)	($1,216)	($623)	($29)	$565	$1,158
$250	($1,998)	($1,154)	($310)	$534	$1,377	$2,221	$3,065	$3,908
$300	($998)	$96	$1,190	$2,284	$3,377	$4,471	$5,565	$6,658
$350	$2	$1,346	$3,690	$4,034	$5,377	$6,721	$8,065	$9,408
$400	$1,002	$2,596	$4,190	$5,784	$7,377	$8,971	$10,565	$12,158
$450	$2,002	$3,846	$5,690	$7,534	$9,377	$11,221	$13,065	$14,908
$500	$3,002	$5,096	$7,190	$9,284	$11,377	$13,471	$15,565	$17,658
$550	$4,002	$6,346	$8,690	$11,034	$13,377	$15,721	$18,065	$20,408
$600	$5,002	$7,596	$10,190	$12,784	$15,377	$17,971	$20,565	$23,158

Gala, Fuji and other mid-value plantings: We conducted analysis on mid-value varieties for both high density and semidwarf plantings. While Gala orchards can garner higher yields, we used the average of 1,200 bushels per acre for high density and 900 bushels per acre for semidwarf to incorporate other mid-value variety yields, and to estimate conservatively.

High density, mid-value/Gala/Fuji

Table 18 illustrates costs by various categories on a per-bushel basis for high density, mid-value plantings. Per-bushel costs drop with higher yields, but less dramatically than with Honeycrisps.

Very high density block coming into production years. Photo by Chris Bardenhagen, MSU Extension

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Table 18. Costs per bushel at varying yields for high density, mid-value varieties.

Cost/bu at Varying Yield Levels, Gala/Mid-value High Density							
Yield (bu)	**Total Operating and Harvest Costs**	**Operating/ Harvest Cost/bu.**	**Establishment Cost ($2067 per acre) per bu.**	**Land Cost ($445 per acre) per bu.**	**Other Overhead Cost ($841 per acre) per bu.**	**Total Costs / acre**	**Total Production Cost/ bu.**
800	$5,310	**$6.64**	$2.58	$0.56	$1.05	$8,663	**$10.83**
900	$5,584	**$6.20**	$2.30	$0.49	$0.93	$8,937	**$9.93**
1,000	$5,859	**$5.86**	$2.07	$0.45	$0.84	$9,212	**$9.21**
1,100	$6,133	**$5.58**	$1.88	$0.40	$0.76	$9,486	**$8.62**
1,200	$6,408	**$5.34**	$1.72	$0.37	$0.70	$9,761	**$8.13**
1,300	$6,682	**$5.14**	$1.59	$0.34	$0.65	$10,035	**$7.72**
1,400	$6,956	**$4.97**	$1.48	$0.32	$0.60	$10,309	**$7.36**
1,500	$7,231	**$4.82**	$1.38	$0.30	$0.56	$10,584	**$7.06**

Mid-value plantings are also profitable at current prices and yields, though less so than the high value varieties. We calculate a 7% return on investment at current prices ($200/bin to the grower, dock price) and a 1,200 bushel yield. Table 19 shows the profit potential of different yields and prices.

Table 19. Profits by price and yield for high density, mid-value varieties.

PROFITS BY PRICE AND YIELD - Gala/Mid-value High Density

Light red = break-even or better

	YIELD- Bushels per acre							
PRICE	800	900	1000	1100	1200	1300	1400	1500
$125	($3,664)	($3,313)	($2,962)	($2,612)	($2,261)	($1,910)	($1,560)	($1,209)
$150	($2,664)	($2,188)	($1,712)	($1,237)	($761)	($285)	$190	$666
$175	($1,664)	($1,063)	($462)	$138	$739	$1,340	$1,940	$2,541
$200	($664)	$62	$788	$1,513	$2,239	$2,965	$3,690	$4,416
$225	$336	$1,187	$2,038	$2,888	$3,739	$4,590	$5,540	$6,291
$250	$1,336	$2,312	$3,288	$4,263	$5,239	$6,215	$7,190	$8,166
$275	$2,336	$3,437	$4,538	$5,638	$6,739	$7,840	$8,940	$10,041
$300	$3,336	$4,562	$5,788	$7,013	$8,239	$9,465	$10,690	$11,916

Figure 5 illustrates net cash flows – we see positive cash flow starting at Year 4 and breakeven with establishment costs at Year 13.

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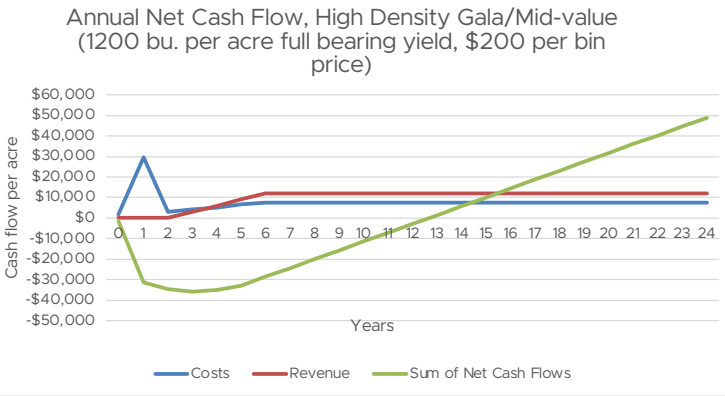
Figure 5. Annual net cash flow, high density planting of mid-value apples.



Semidwarf, mid-value/Gala/Fuji

A semidwarf planting for the mid-value category provides lower costs per bushel than high density at any given yield (compare Table 20 to Table 18).

Table 20. Costs per bushel at varying yields for semidwarf, mid-value varieties.

Cost/bu at Varying Yield Levels,Gala/Mid-value Semidwarf							
Yield (bu)	Total Operating and Harvest Costs	Operating/ Harvest Cost/bu.	Establishment Cost ($1062 per acre) per bu.	Land Cost ($445 per acre) per bu.	Other Overhead Cost ($887 per acre) per bu.	Total Costs / acre	Total Production Cost/ bu.
600	$4,630	**$7.72**	$1.77	$0.74	$1.48	$7,025	**$11.71**
700	$4,906	**$7.01**	$1.52	$0.64	$1.27	$7,301	**$10.43**
800	$5,182	**$6.48**	$1.33	$0.56	$1.11	$7,577	**$9.47**
900	$5,456	**$6.06**	$1.18	$0.49	$0.99	$7,851	**$8.72**
1,000	$5,732	**$5.73**	$1.06	$0.45	$0.89	$8,127	**$8.13**
1,100	$6,008	**$5.46**	$0.97	$0.40	$0.81	$8,403	**$7.64**
1,200	$6,282	**$5.24**	$0.89	$0.37	$0.74	$8,677	**$7.23**
1,300	$6,558	**$5.04**	$0.82	$0.34	$0.68	$8,953	**$6.89**

Table 21 shows positive profits at current prices and assumed yields.

Table 21. Profits by price and yield for semidwarf, mid-value variety plantings.

PROFITS BY PRICE AND YIELD - Gala/Mid-value Semidwarf								
	Light green = break-even or better							
	YIELD- Bushels per acre							
PRICE	600	700	800	900	1000	1100	1200	1300
$125	($3,275)	($2,925)	($2,576)	($2,226)	($1,876)	($1,527)	($1,177)	($827)
$150	($2,525)	($2,050)	($1,576)	($1,101)	($626)	($152)	$323	$798
$175	($1,775)	($1,175)	($576)	$24	$624	$1,223	$1,823	$2,423
$200	($1,025)	($300)	$424	$1,149	$1,874	$2,598	$3,323	$4,048
$225	($275)	$575	$1,424	$2,274	$3,124	$3,973	$4,823	$5,673
$250	$475	$1,450	$2,424	$3,399	$4,374	$5,348	$6,323	$7,298
$275	$1,225	$2,325	$3,424	$4,524	$5,624	$6,723	$7,823	$8,923
$300	$1,975	$3,200	$4,424	$5,649	$6,874	$8,098	$9,323	$10,548

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Investment value is also positive for semidwarf, mid-value plantings, showing a 3.3% rate of return. However, these plantings are less profitable on a per-acre basis than high density plantings due to their lower yield potential and slower onset of cropping. See Table A42 and Figure 8 in the Appendix for more details.

Application to the individual farm:
This study looked at averages across the apple industry and production regions in Michigan. Individual farms will have higher or lower costs based on each farm's unique circumstances. *Yield and price* are the most critical drivers of costs and profitability for apples. When applying these results to an individual farm, be sure to adjust total costs based on the farm's individual yield. To do this, simply divide the total cost of full-bearing acreage by the farm's average yield.

Additional adjustments that commonly need to be made:

- Trucking – currently has a $5 per bin allocation.
- Crop insurance – currently has a $300 per acre allocation.
- Financing – our budgets assume that cash flow is used to finance new plantings.
- Land costs – growers who have their farmland paid off can subtract out $400.
- Cooling costs – growers that do their own cooling, or pay custom cooling costs to a third party, need to add those costs.

Please contact corresponding author Chris Bardenhagen or another author to ask questions or make adjustments for your farm using the spreadsheet we developed. We hope to eventually create a user-friendly webpage where growers can input their information for different variables to calculate farm-specific costs.

CARBON/CLIMATE ANALYSIS

We found that as orchard density increases, the carbon footprint associated with producing one kilogram of apples decreases—from 0.04 to 0.03 kilograms of carbon dioxide equivalent (CO–e) emissions per kilogram of fruit. Table 22 illustrates that although high-density orchards require more herbicides and fertilizers, they use fewer crop protection inputs and produce more fruit per acre. Across all orchard systems, the use of nitrogen inhibitors reduces nitrous oxide (N–O) emissions by 37% when applied with ammonium-, urea- or excreta-based fertilizers.

Table 22. Effects of apple orchard density on greenhouse gas emissions.

Table 22. How orchard density and farming practices impact greenhouse gas emissions.

Orchard system	Semi-Dwarf	High Density
Trees/acre	388	1210
Bushels/acre	800	1100
Crop protection inputs		
Insecticides (lb/acre)	17.7	14.7
Fungicides (lb/acre)	23	19.1
Herbicides (lb/acre)	7.1	8.7
Fertilizer emissions depending on soil type and use of nitrogen inhibitors (kg CO2e/acre)		
Sandy soil without N-inhibitor	111	148
Sandy soil with N-inhibitor	86	133
Clay or silt without N-inhibitor	178	236
clay or silt with N-inhibitor	122	162
Emissions from farming practices		
Fuel use ($kgCO_2e$/acre)	355	355
Crop residues ($kgCO_2e$/acre)	91.4	91.4
Crop protection ($kgCO_2e$/acre)	135	123
Carbon Footprint (kg CO2e emissions per kg apples)*	**0.044 to 0.050**	**0.030 to 0.035**

Notes: CO_2e = carbon dioxide equivalent; includes nitrous oxide and methane, expressed as CO2 impact; positive values indicate emissions

Orchards sequester carbon dioxide through photosynthesis during their lifespans. However, this stored carbon is released back into the atmosphere when orchards are burned or chipped at the end of their

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productive life. In addition to CO–, the decomposition or combustion of orchard biomass also emits methane (CH–) and nitrous oxide—both potent greenhouse gases. Converting orchard biomass into biochar can conservatively retain about 30% of the biomass carbon. Applying biochar to soil has also been shown to improve future yields and fruit quality (Li et al., 2024). Importantly, this practice qualifies as "additionality" in the context of carbon market participation. See Table 23.

Table 23. Effects of apple orchard removal practices on greenhouse gas emissions.

Table 23. How end of life practices impact greenhouse gas emissions.

Orchard fate	traditonal burn pile	chipping trunks & roots	converting into biochar
Emissions (kg CO_2e per acre)[a]	2,190	821	805
kg CO_2 sequestered into soil[b]	nd	nd	-13,243

Notes: Positive values indicate emissions and negative values indicate sequestration. nd = no data available

[a]Assumes both orchard systems produce the same amount of woody biomass.

[b]An estimate based on 30% conversion of biomass carbon into biochar carbon (Amonette et al., 2021).

Planting orchards on land previously used for annual crops increases soil carbon for the first 20 years, until a new equilibrium is reached. In contrast, converting forests or set-aside land to orchards results in a net loss of soil carbon (Table 24).

Table 24. Impact of apple orchards on soil carbon relative to other uses.

Table 24. How orchards impact soil carbon compared to the land use that predated the orchard.

Soil Type	Past Land Use		
	Forest	Set-aside (CRP)	Annual Cultivation
Sandy soils	1.32	0.55	-0.32
High-activity clay soils	2.10	0.87	-0.51
Low-activity clay soils	1.97	0.82	-0.48

Note: Positive values a loss of carbon to the atmosphere and negative values indicate soil carbon sequestration.

Carbon neutrality on apple farms is achievable, especially when new orchards are planted into ground previously used for field crop production, when nitrogen inhibitors are applied with urea-based fertilizers and when wood and root biomass are converted to biochar at the end of an orchard's life. However, this analysis does not include emissions from transportation to cold storage or packing facilities, as well as the energy required to operate these facilities.

For a breakdown of fuel usage for our apple production budgets and for the related calculations to determine its carbon equivalent, see Tables A43 and A44 in the Appendix. Our calculations follow the IPCC (2019) Volume 4 Guidelines and the Cool Farm Tool's Technical Description. For a more detailed assessment of your farm, visit https://coolfarm.org.

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SUMMARY AND LIMITATIONS

Michigan apple plantings should remain profitable if current prices hold steady into the mid-term. High density orchards are more profitable due to higher output, but semidwarf plantings have lower per-bushel costs, and are much less expensive to install.

About 74% of production costs for our example farm are variable and therefore subject to potential cost swings. Labor makes up about 40% of the total costs, and a 10% labor price rise would therefore lead to a 4% increase in overall costs (see Table A33 in the Appendix). Fixed costs comprise 26% of the total budget (land, equipment depreciation and orchard establishment).

For the next Michigan apple cost of production update, there is a need to investigate how much of grower-stated yields for fresh varieties will go to the packer. In many cases, due to high labor costs, second or third color picking is being replaced with strip picking for processing, or not done at all. Also, prices received by the grower must be clarified to ensure, for example, that cooling and trucking costs are accounted for consistently to obtain clear, apples-to-apples comparisons.

ACKNOWLEDGEMENTS

The authors would like to acknowledge all the growers who participated in this study – thank you for providing your time and expertise. Thanks also to participating industry service providers and supporters who work tirelessly on growers' behalf, including Amy Irish-Brown, the Michigan Apple Committee, and the Michigan State Horticultural Society. Special thanks to Phil Schwallier, who helped support this study in many ways, not the least of which was compiling and holding very detailed information regarding Michigan apple production for many years. His dataset provided a baseline for this current project.

We would also like to acknowledge the funding that supported this work, MDARD Specialty Crop Block Grant #23-474 awarded to the Michigan State Horticultural Society. We are grateful for MDARD's continued support of apples and specialty crops.

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Young trellised orchard in the distance. Photo by Chris Bardenhagen, MSU Extension

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Table A25. Equipment list and cost per hour calculations.

EQUIPMENT															
Item	Cost	Salvage Value %	Rate Trade-in value	Years life	Annual depr.	Annual w Interest/ inflation @ 4.0%	fuel /hr.	Gal. $4.00 /gal.	Lubri-cation (10% of fuel)	Repair & Maint. Cost 1%	TOTAL annual cost	Total of use/yr	Variable Cost /hour	Fixed Cost /hour	Total Cost per hour
85 HP 4WD Spray w/cab	$85,000	15%	$12,750	12.5	$5,780	$7,457	2.88	$3,456	$346	$850	$12,109	300	$15.51	$24.86	$40.36
60 HP 2WD general/ forklift	$60,000	15%	$9,000	12.5	$4,080	$5,264	1.92	$3,456	$346	$600	$9,666	450	$9.78	$11.70	$21.48
Airblast	$47,000	15%	$7,050	15	$2,663	$3,593				$470	$4,063	210	$2.24	$17.11	$19.35
Weed Sprayer	$15,000	15%	$2,250	15	$850	$1,147				$150	$1,297	130	$1.15	$8.82	$9.97
Fertilizer Spreader	$10,000	15%	$1,500	15	$567	$764				$100	$864	80	$1.25	$9.56	$10.81
Rotary Mower	$8,000	15%	$1,200	10	$680	$838				$80	$918	130	$0.62	$6.45	$7.06
Flail Chopper	$10,000	15%	$1,500	10	$850	$1,048				$100	$1,148	100	$1.00	$10.48	$11.48
Brownie	$30,000	15%	$4,500	15	$1,700	$2,293				$300	$2,593	400	$0.75	$5.73	$6.48
Platform	$70,000	15%	$10,500	15	$3,967	$5,351				$700	$6,051	400	$1.75	$13.38	$15.13
Tree Planter	$8,500	15%	$1,275	20	$361	$532				$85	$617	40	$2.13	$13.29	$15.42
Trailer	$12,000	15%	$1,800	20	$510	$751				$120	$871	200	$0.60	$3.75	$4.35
Stake Truck - used	$40,000	15%	$6,000	20	$1,700	$2,502				$400	$2,902	200	$2.00	$12.51	$14.51
Forklift	$35,000	15%	$5,250	15	$1,983	$2,676	2.40	$3,360	$336	$350	$6,722	350	$11.56	$7.64	$19.20

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Table A26. Establishment costs for high density apple orchards.

ESTABLISHMENT COSTS per acre HIGH DENSITY Apples	Time	Labor Rate	Materials	Equipment Rate		Subtotal	TOTAL
	Hours/ acre	$/hour	or **Custom Cost** $/Acre	$/hour Variable (cash)	$/hour, Fixed (non-cash)	$/acre	**$/acre**
Pre-plant (Year 0)							
Land clearing			$1,000.00			$1,000.00	
Roots and rocks – all-in cost			$350.00			$350.00	
Tillage – various tasks, all-in			$100.00			$100.00	
Poultry manure – 1.5 tons/acre @ $75/ton			$112.50			$112.50	
Cover crop – all-in			$50.00			$50.00	
					Total Pre-plant costs		**$1,613**
Planting -- Spring of Year 1							
Tree costs							
$12 per tree x 1208 trees/acre			$14,496.00			$14,496.00	
Tree guards – $0.35 per tree			$422.80				
Bamboo poles – $1.25 per tree			$1,510.00				
Planting							
10 laborers for 1.5 hour per acre	15.0	$27.00				$405.00	
85 HP tractor/ driver	1.5	$29.00		$15.51	$24.86	$104.05	
Planter	1.5			$2.13	$13.29	$23.12	
Seeding grass middles							
All-in cost, seed plus planting			$50.00			$50.00	
Trickle							
Labor (all-in or custom)			$500.00			$500.00	
Well cost			$700.00			$700.00	
Drip line and main line hookups			$1,300.00			$1,300.00	
Trellis							
Labor (all-in or custom)			$2,000.00			$2,000.00	
Materials			$6,500.00			$6,500.00	
Deer fence – custom or all-in			$500.00			$500.00	
					Total Planting costs		**$26,578**
Growing Years 1 - 4							
Pruning and training – includes tying to trellis	36.0	$27.00				$972.00	
Brush chopping – Average 50% of full costs in early years							
85 HP tractor	0.5	$29.00		$15.51	$24.86	$34.68	
Flail mower	0.5			$1.00	$10.48	$5.74	

(more)

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Table A26. Establishment costs for high density apple orchards. (cont.)

ESTABLISHMENT COSTS per acre HIGH DENSITY Apples	Time	Labor Rate	Materials	Equipment Rate		Subtotal	TOTAL
	Hours/ acre	$/hour	or **Cost** $/Acre	$/hour Variable (cash)	$/hour, Fixed (non-cash)	$/acre	**$/acre**
Fertilizer – 2 trips for granular							
60 HP tractor	0.4	$29.00		$9.78	$11.70	$20.19	
Spreader	0.4			$1.25	$9.56	$4.32	
Materials for early years (average)*			$175.00			$175.00	
Mowing – for 4 trips per year							
60 HP tractor	1.3	$29.00		$9.78	$11.70	$65.62	
Rotary mower	1.3			$0.62	$6.45	$9.18	
Crop protection – total for all trips							
85 HP tractor	2.1	$29.00		$15.51	$24.86	$145.66	
Airblast sprayer	2.1			$2.24	$17.11	$40.63	
Materials for early years (average)**			$780.00			$780.00	
Herbicide – total for 2 trips							
60 HP tractor	1.3	$29.00	$25	$9.78	$11.70	$90.62	
Weed sprayer	1.3			$1.15	$8.82	$12.97	
Porta-potties			$20.00			$20.00	
Food safety (average- incurred on years 3 and 4)			$50.00				
Land control costs			$400.00			$400.00	
Real estate tax			$45.00			$45.00	
Soil testing – $12 every 3 years			$4.00				
Pickup – 50 miles @ IRS rate $0.70			$35.00				
Management	5.0	$40.00				$200.00	
Credit line interest							
8% APR on costs, average 4 months			$80.58			$80.58	

Total Year 1 Operating costs	**$3,102**
Total Year 2 Operating costs	**$3,102**
Total Year 3 Operating costs	**$3,102**
Total Year 4 Operating costs	**$3,102**
Growing Year 5 partial allocation* **	**$745**
TOTAL Establishment costs	**$41,344**
Allocation per year, for 20 production years	**$2,067**

*Year 1 $150; Years 2 and 3 $100; Year 4 full program.
** Year 1 20% of full program; Year 2 60%; Year 3 and forward = full program.
***Years 5 has 76% of full production, therefore 24% x base early year cost/year is attributed to establishment.

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Table A27. Full production costs for high density apple orchards.

Operating and harvest costs, and cost totals for Michigan HIGH DENSITY Apple production, 2025
Per acre, based on the full production years during the 24 year total orchard life

OPERATING COSTS	Time	Labor Rate[1]	Materials	Equipment Rate		Subtotal	TOTALS
	Hours/ acre	$/hour	or **Custom Cost** $/acre	$/hour variable (cash)	$/hour fixed (Deprec.)	$/acre	**$/acre**
Pruning and brush disposal							**$567**
-Labor hours for pruning	18.0	$27.00				$486.00	
-85 HP tractor for brush disposal	1.0	$29.00		$15.51	$24.86	$69.36	
-Flail chopper	1.0			$1.00	$10.48	$11.48	
Hand thinning							**$270**
-Labor hours for thinning, average per acre	10	$27.00				$270.00	
Mowing – Total for 4 trips per year							**$75**
-60 HP tractor	1.3	$29.00		$9.78	$11.70	$65.62	
-Rotary mower	1.3			$0.62	$6.45	$9.18	
Crop protection – Total, all trips included							**$1,386**
-85 HP tractor	2.1	$29.00		$15.51	$24.86	$145.66	
-Orchard sprayer	2.1			$2.24	$17.11	$40.63	
-Total material costs			$1,200.00			$1,200.00	
Herbicide – Total for 2 trips per year							**$104**
-60 HP tractor	1.3	$29.00		$9.78	$11.70	$65.62	
-Weed sprayer	1.3			$1.15	$8.82	$12.97	
-Total material costs			$25.00			$25.00	
Fertilizer							**$375**
-60 HP Tractor for dry applications 2x /year	0.4	$29.00		$9.78	$11.70	$20.19	
-Spreader	0.4			$1.25	$9.56	$4.32	
-Dry material costs			$250.00			$250.00	
-Added micros (boron, sulfur, etc.)			$50.00			$50.00	
-Foliar material costs[2]			$50.00			$50.00	
Other Operating							**$704**
Property taxes per acre			$45.00			$45.00	
Soil testing – every 3 years @ $12/acre			$4.00			$4.00	
Crop insurance			$300.00			$300.00	
Food safety compliance			$100.00			$100.00	

(more)

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Table A27. Full production costs for high density apple orchards. (cont.)

OPERATING COSTS	Time	Labor Rate[1]	Materials	Equipment Rate		Subtotal	TOTALS
	Hours/ acre	$/hour	or **Custom Cost** $/acre	$/hour variable (cash)	$/hour fixed (Deprec.)	$/acre	**$/acre**
Porta-potties			$20.00			$20.00	
Management and labor supervision	5.0	$40.00				$200.00	
Pickup use – 50 miles/acre x $.70 IRS rate			$35.00			$35.00	
Subtotal Operating Costs							**$3,480**
Difference (Savings) for Processor Apple Production (Jonagold, etc.)[3]							
Hand thinning – only use chemical thinning	10	$27.00				$270.00	
Spray material – 25% less material			$300.00			$300.00	
Summer pruning – don't need	4	$27.00				$108.00	
Lower Costs for Processor Apple Production, Per Acre						**$678.00**	
Savings Based on Processor Apple Production Level of						**10%**	**-$68**
TOTAL OPERATING COSTS							**$3,412**

HARVEST COSTS	Rate/bin	Yield/acre (in 40 lb. bushels)	Percent of High Density acreage	Harvested bushels	Harvested bins	Subtotal	TOTALS / acre
Honeycrisp/ other (stem clip + color pick)		**1,000**	**50%**	**500**	**25**		**$1,763**
-Picking and supervision labor PER BIN[1]	$64.00				25	$1,600.00	
-Field pickup (all-in, tractor + labor) PER BIN	$3.50				25	$87.50	
-Housing allocation PER BIN	$3.00				25	$75.00	
Gala/ other mid-value varieties (color pick)		**1,200**	**40%**	**480**	**24**		**$1,080**
-Picking and supervision labor PER BIN[1]	$40.00				24	$960.00	
-Field pickup (all-in, tractor + labor) PER BIN	$3.50				24	$84.00	
-Housing allocation PER BIN	$1.50				24	$36.00	
Processor apples (strip pick)		**1,100**	**10%**	**110**	**5.5**		**$193**
-Picking and supervision labor PER BIN[1]	$30.00				5.5	$165.00	

(more)

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Table A27. Full production costs for high density apple orchards. (cont.)

OPERATING COSTS	Time	Labor Rate[1]	Materials	Equipment Rate		Subtotal	TOTALS
	Hours/ acre	$/hour	or **Custom Cost** $/acre	$/hour variable (cash)	$/hour fixed (Deprec.)	$/acre	**$/acre**
-Field pickup (all-in, tractor + labor) PER BIN	$3.50				5.5	$19.25	
-Housing allocation PER BIN	$1.50				5.5	$8.25	
Other Harvest costs							**$764**
-**Trucking** per bin (all in cost, all types, assumed average across MI)	$5.00				54.5	$272.50	
Replacement costs	#/Year				Cost/acre		
-Bin replacement cost – 4 average	4.0				$62.50	$250.00	
-Apron replacement for picking basket	0.5				$34.00	$17.00	
-Strap replacement for picking basket	2.0				$12.00	$24.00	
-Ladder replacement (1 per year)	1.0				$200.00	$200.00	
TOTAL HARVEST COSTS							**$3,799**
Farm credit line interest – on VARIABLE operating and harvest costs, 8% APR for an average of 4 months						$192	
Establishment costs – Per year, spread over 20 production years						$2,067	
Land control cost						$400	
Michigan Apple Committee and Michigan Tree Fruit Commission Fees[4]						$199	
TOTAL ESTABLISHMENT, LAND, FEE AND INTEREST COSTS							**$2,858**
GRAND TOTAL COSTS per acre							**$10,069**

[1] Pruning, picking, and packing labor are based on interview and focus group estimates, and are inclusive of domestic and/or H2A labor costs including farm labor contracting costs and benefits such as housing.

[2] Foliar materials are applied with crop protectants, so it is assumed there are no additional application costs.

[3] This number is the savings on operating costs from fresh production. It is therefore a negative number, calculated on a per acre basis, but then prorated to the % processor production in the mix.

[4] On a per pound basis, MAC fees are .45 cents for fresh, .24 cents for processing, and .1 cents for juice apples - we assume 25% of processing apples go to juice. MTFC fees are $0.001 per pound.

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Table A28. Establishment costs for semidwarf apple orchards.

ESTABLISHMENT COSTS per acre SEMIDWARF Apples	Time	Labor Rate	Materials	Equipment Rate		Subtotal	TOTAL
	Hours/ acre	$/hour	or Custom Cost $/acre	$/hour Variable (cash)	$/Hour, Fixed (non-cash)	$/acre	$/acre
Pre-plant (Year 0)							
Land clearing			$1,000.00			$1,000.00	
Roots and rocks – all-in cost			$350.00			$350.00	
Tillage – various tasks, all-in			$100.00			$100.00	
Poultry manure – 1.5 tons/ acre @ $75/ton			$112.50			$112.50	
Cover crop – all-in			$50.00			$50.00	
					Total Pre-plant costs		**$1,613**
Planting -- Spring of Year 1							
Tree costs							
$12 per tree x 388 trees/acre			$4,656.00			$4,656.00	
Tree guards – $0.35 per tree			$135.80				
Conduit poles – $5.00 per tree			$1,940.00				
Planting							
6 laborers for 1.5 hour per acre	9.0	$27.00				$243.00	
85 HP tractor/ driver	1.5	$29.00		$15.51	$24.86	$104.05	
Planter	1.5			$2.13	$13.29	$23.12	
Seeding grass middles							
All-in cost, seed plus planting			$50.00			$50.00	
Trickle							
Labor (all-in or custom)			$400.00			$400.00	
Well cost			$700.00			$700.00	
Drip line and main line hookups			$1,000.00			$1,000.00	
Deer fence – custom or all-in			$500.00			$500.00	
					Total Planting costs		**$7,676**
Growing Years 1 - 4							
Pruning and training – includes tying to pole	21.6	$27.00				$583.20	
Brush chopping – Average 50% of full costs for early years							
85 HP tractor	0.5	$29.00		$15.51	$24.86	$34.68	
Flail mower	0.5			$1.00	$10.48	$5.74	
Fertilizer – 2 trips for granular							

(more)

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Table A28. Establishment costs for semidwarf apple orchards. (cont.)

ESTABLISHMENT COSTS per acre SEMIDWARF Apples	Time	Labor Rate	Materials	Equipment Rate		Subtotal	TOTAL
	Hours/ acre	$/hour	or **Custom Cost** $/acre	$/hour Variable (cash)	$/Hour, Fixed (non-cash)	$/acre	**$/acre**
60 HP tractor	0.4	$29.00		$9.78	$11.70	$20.19	
Spreader	0.4			$1.25	$9.56	$4.32	
Materials for early years (average)*			$175.00			$175.00	
Mowing – for 4 trips per year							
60 HP tractor	1.3	$29.00		$9.78	$11.70	$65.62	
Rotary mower	1.3			$0.62	$6.45	$9.18	
Crop protection – total for all trips							
85 HP tractor	2.1	$29.00		$15.51	$24.86	$145.66	
Airblast sprayer	2.1			$2.24	$17.11	$40.63	
Materials for early years (average)**			$780.00			$780.00	
Herbicide – total for 2 trips							
60 HP tractor	1.3	$29.00	$40	$9.78	$11.70	$105.62	
Weed sprayer	1.3			$1.15	$8.82	$12.97	
Porta-potties			$20.00			$20.00	
Food safety (average-incurred on years 3 and 4)			$50.00				
Land control costs			$400.00			$400.00	
Real estate tax			$45.00			$45.00	
Soil testing – $12 every 3 years			$4.00				
Pickup – 50 miles @ IRS rate $0.70			$35.00				
Management	5.0	$40.00				$200.00	
Credit line interest							
8% APR on costs, average 4 months			$70.61			$70.61	

Total Year 1 Operating costs	**$2,718**
Total Year 2 Operating costs	**$2,718**
Total Year 3 Operating costs	**$2,718**
Total Year 4 Operating costs	**$2,718**
Growing Year 5 partial allocation* **	**$1,087**
TOTAL Establishment costs	**$21,250**
Allocation per year, for 20 production years	**$1,062**

*Year 1 $150; Years 2 and 3 $100; Year 4 full program.
** Year 1 20% of full program; Year 2 60%; Year 3 and forward = full program.
***Years 5 to 8 have an average of 60% of full production, therefore 40% x base early year cost/year is attributed to establishment.

Table A29. Full production costs for semidwarf apple orchards.

Operating and harvest costs, and cost totals for Michigan SEMIDWARF Apple production, 2025
Per acre, based on the full production years during the 24 year total orchard life

OPERATING COSTS	Time	Labor Rate[1]	Materials	Equipment Rate		Subtotal	TOTALS
	Hours/ acre	$/hour	or **Custom Cost** $/acre	$/hour variable (cash)	$/hour fixed (Deprec.)	$/acre	**$/acre**
Pruning and brush disposal							**$592**
-Labor hours for pruning	17.0	$27.00				$459.00	
-Brownie machine equipment time	8.0			$0.75	$5.73	$51.87	
-85 HP tractor for brush disposal	1.0	$29.00		$15.51	$24.86	$69.36	
-Flail chopper	1.0			$1.00	$10.48	$11.48	
Hand thinning							**$270**
-Labor hours for thinning, average per acre	10	$27.00				$270.00	
Mowing – Total for 4 trips per year							**$75**
-60 HP tractor	1.3	$29.00		$9.78	$11.70	$65.62	
-Rotary mower	1.3			$0.62	$6.45	$9.18	
Crop protection – Total, all trips included							**$1,386**
-85 HP tractor	2.1	$29.00		$15.51	$24.86	$145.66	
-Orchard sprayer	2.1			$2.24	$17.11	$40.63	
-Total material costs			$1,200.00			$1,200.00	
Herbicide – Total for 2 trips per year							**$119**
-60 HP tractor	1.3	$29.00		$9.78	$11.70	$65.62	
-Weed sprayer	1.3			$1.15	$8.82	$12.97	
-Total material costs			$40.00			$40.00	
Fertilizer							**$375**
-60 HP Tractor for dry applications 2x /year	0.4	$29.00		$9.78	$11.70	$20.19	
-Spreader	0.4			$1.25	$9.56	$4.32	
-Dry material costs			$250.00			$250.00	
-Added micros (boron, sulfur, etc.)			$50.00			$50.00	
-Foliar material costs[2]			$50.00			$50.00	
Other Operating							**$704**
Property taxes per acre			$45.00			$45.00	

(more)

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Table A29. Full production costs for semidwarf apple orchards. (cont.)

OPERATING COSTS	Time	Labor Rate[1]	Materials	Equipment Rate		Subtotal	TOTALS
	Hours/ acre	$/hour	or **Custom Cost** $/acre	$/hour variable (cash)	$/hour fixed (Deprec.)	$/acre	**$/acre**
Soil testing – every 3 years @ $12/acre			$4.00			$4.00	
Crop insurance			$300.00			$300.00	
Food safety compliance			$100.00			$100.00	
Porta-potties			$20.00			$20.00	
Management and labor supervision	5.0	$40.00				$200.00	
Pickup use – 50 miles/acre x $.70 IRS rate			$35.00			$35.00	
Subtotal Operating Costs							**$3,520**
Difference (Savings) for Processor Apple Production (Jonagold, etc.)[3]							
Hand thinning – only use chemical thinning	10	$27.00				$270.00	
Spray material – 25% less material			$300.00			$300.00	
Summer pruning – don't need	3	$27.00				$81.00	
Lower Costs for Processor Apple Production, Per Acre						**$651.00**	
Savings Based on Processor Apple Production Level of						**30%**	**-$195**
TOTAL OPERATING COSTS							**$3,325**

HARVEST COSTS	Rate/bin	Yield/ acre (in 40 lb. bushels)	Percent of Semidwarf acreage	Harvested bushels	Harvested bins	Subtotal	TOTALS / acre
Honeycrisp/ other (Stem clip + color pick)		**700**	**40%**	**280**	**14**		**$987**
-Picking and supervision labor PER BIN[1]	$64.00				14	$896.00	
-Field pickup (all-in, tractor + labor) PER BIN	$3.50				14	$49.00	
-Housing allocation PER BIN	$3.00				14	$42.00	
Gala/ other mid-value varieties (Color pick)		**900**	**30%**	**270**	**13.5**		**$608**

(more)

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Table A29. Full production costs for semidwarf apple orchards. (cont.)

HARVEST COSTS	Rate/bin	Yield/ acre (in 40 lb. bushels)	Percent of Semidwarf acreage	Harvested bushels	Harvested bins	Subtotal	TOTALS / acre
-Picking and supervision labor PER BIN[1]	$40.00				13.5	$540.00	
-Field pickup (all-in, tractor + labor) PER BIN	$3.50				13.5	$47.25	
-Housing allocation PER BIN	$1.50				13.5	$20.25	
Processor apples (Strip pick)		**800**	**30%**	**240**	**12**		**$420**
-Picking and supervision labor PER BIN[1]	$30.00				12	$360.00	
-Field pickup (all-in, tractor + labor) PER BIN	$3.50				12	$42.00	
-Housing allocation PER BIN	$1.50				12	$18.00	
Other Harvest costs							**$689**
-**Trucking** per bin (all-in cost, all types, assumed average across MI)	$5.00				39.5	$197.50	
Replacement costs	#/Year				Cost/acre		
-Bin replacement cost – 4 average	4.0				$62.50	$250.00	
-Apron replacement for picking basket	0.5				$34.00	$17.00	
-Strap replacement for picking basket	2.0				$12.00	$24.00	
-Ladder replacement (1 per year)	1.0				$200.00	$200.00	
						TOTAL HARVEST COSTS	**$2,703**
Farm credit line interest – on VARIABLE operating and harvest costs, 8% APR for average 4 months						$161	
Establishment costs – Per year, spread over 20 production years						$1,062	
Land control cost						$400	
Michigan Apple Committee and Michigan Tree Fruit Commission Fees[4]						$128	
						TOTAL ESTABLISHMENT, LAND AND INTEREST COSTS	**$1,751**
						GRAND TOTAL COSTS per acre	**$7,779**

[1] Pruning, picking, and packing labor are based on interview and focus group estimates, and are inclusive of domestic and/or H2A labor costs including farm labor contracting costs and benefits such as housing.

[2] Foliar materials are applied with crop protectants, so it is assumed there are no additional application costs.

[3] This number is the savings on operating costs from fresh production. It is therefore a negative number, calculated on a per acre basis, but then prorated to the % processor production in the mix.

[4] On a per pound basis, MAC fees are .45 cents for fresh, .24 cents for processing, and .1 cents for juice apples - we assume 25% of processing apples go to juice. MTFC fees are $0.001 per pound.

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Table A30. Net cash flow table for example Michigan apple farm.

Year	0	1	2	3	4	5	6	7	8	9
Costs	$1,613	$20,037	$2,910	$3,421	$3,933	$5,971	$6,689	$6,896	$7,102	$7,351
Revenue	$0	$0	$0	$1,766	$3,532	$7,013	$9,402	$10,049	$10,696	$11,415
Cash flow	-$1,613	-$20,037	-$2,910	-$1,655	-$401	$1,042	$2,713	$3,153	$3,594	$4,064
Sum of NCFs	-$1,613	-$21,650	-$24,560	-$26,216	-$26,617	-$25,575	-$22,862	-$19,709	-$16,115	-$12,051

10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
$7,351	$7,351	$7,351	$7,351	$7,351	$7,351	$7,351	$7,351	$7,351	$7,351	$7,351	$7,351	$7,351	$7,351	$7,351
$11,415	$11,415	$11,415	$11,415	$11,415	$11,415	$11,415	$11,415	$11,415	$11,415	$11,415	$11,415	$11,415	$11,415	$11,415
$4,064	$4,064	$4,064	$4,064	$4,064	$4,064	$4,064	$4,064	$4,064	$4,064	$4,064	$4,064	$4,064	$4,064	$4,064
-$7,987	-$3,923	$141	$4,205	$8,269	$12,333	$16,397	$20,461	$24,525	$28,589	$32,653	$36,717	$40,781	$44,845	$48,909

Table A31. Costs per acre and bushel for different yields, example Michigan apple farm.

Example Apple Farm Costs by Category and Yield	**YIELD - Bushels/acre (average over varieties and training systems)**				
	700	**850**	**1000**	**1150**	**1300**
Operating & Harvest costs/acre:					
Cultural* -	$2,459	$2,459	$2,459	$2,459	$2,459
Harvest -	$2,667	$3,133	$3,599	$4,065	$4,531
Credit line interest -	$151	$163	$175	$186	$198
TOTAL Operating & Harvest costs/acre:	**$5,277**	**$5,755**	**$6,233**	**$6,710**	**$7,188**
TOTAL Operating & Harvest costs/bu:	**$7.54**	**$6.77**	**$6.23**	**$5.83**	**$5.53**
Total Overhead** costs/acre -	$2,874	$2,874	$2,874	$2,874	$2,874
TOTAL COSTS per acre:	**$8,151**	**$8,629**	**$9,107**	**$9,584**	**$10,062**
TOTAL COSTS per bu:	**$11.64**	**$10.15**	**$9.11**	**$8.33**	**$7.74**

* "Cultural" costs include pruning, hand thinning, mowing, crop protection, herbicide and fertilizer.

** Overhead costs include land control, establishment, equipment depreciation & other overhead expenses such as food safety and crop insurance.

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Table A32. Effects of a rise in the cost of inputs, example Michigan apple farm.

Effect of non-labor variable inputs on total costs on Example Farm budget.			
% Increase in input prices	Increase in cost per acre	Resulting total costs per acre	% increase in total costs
5%	$126	$8,812	1%
10%	$252	$8,938	3%
15%	$379	$9,064	4%
20%	$505	$9,190	6%
25%	$631	$9,316	7%

Table A33. Effects of a rise in the cost of labor, example Michigan apple farm.

Effect of labor prices on total per acre costs on Example Farm budget.			
% Increase in labor price	Increase in cost per acre	Resulting total costs per acre	% increase in total costs
5%	$180	$8,866	2%
10%	$361	$9,046	4%
15%	$541	$9,227	6%
20%	$722	$9,407	8%
25%	$902	$9,587	10%

Remnants of a semidwarf Gingergold orchard on M7 rootstock, overlooking a young Gala block.
Photo by Chris Bardenhagen, MSU Extension

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Table A34. Profits at different prices and yields, example Michigan apple farm.

PROFITS at DIFFERENT PRICES & YIELDS, EXAMPLE APPLE FARM (average across all the farm's varieties and training systems)					
Price: Honeycrisp per bin/ Gala per bin/ Processor price per lb.*	**700 bu Average Yield****	**850 bu Average Yield**	**1000 bu Average Yield**	**1150 bu Average Yield**	**1300 bu Average Yield**
$250 / $150 / $0.08	($2,009)	($1,171)	($333)	$505	$1,343
$250 / $175 / $0.08	($1,660)	($747)	$166	$1,079	$1,992
$250 / $200 / $0.08	($1,311)	($323)	$664	$1,652	$2,640
$250 / $225 / $0.08	($962)	$101	$1,163	$2,226	$3,288
$250 / $250 / $0.08	($613)	$524	$1,662	$2,799	$3,937
$300 / $150 / $0.10	($1,179)	($163)	$853	$1,869	$2,885
$300 / $175 / $0.10	($830)	$261	$1,352	$2,443	$3,534
$300 / $200 / $0.10	($481)	$685	$1,851	$3,016	$4,182
$300 / $225 / $0.10	($132)	$1,109	$2,349	$3,590	$4,830
$300 / $250 / $0.10	$217	$1,533	$2,848	$4,163	$5,478
$350 / $150 / $0.12	($349)	$845	$2,039	$3,233	$4,427
$350 / $175 / $0.12	$0	$1,269	$2,538	$3,807	$5,075
$350 / $200 / $0.12	$349	$1,693	$3,037	$4,380	$5,724
$350 / $225 / $0.12	$699	$2,117	$3,535	$4,954	$6,372
$350 / $250 / $0.12	$1,048	$2,541	$4,034	$5,527	$7,020
$400 / $150 / $0.13	$429	$1,790	$3,151	$4,512	$5,872
$400 / $175 / $0.13	$779	$2,214	$3,650	$5,085	$6,521
$400 / $200 / $0.13	$1,128	$2,638	$4,148	$5,659	$7,169
$400 / $225 / $0.13	$1,477	$3,062	$4,647	$6,232	$7,817
$400 / $250 / $0.13	$1,826	$3,486	$5,146	$6,806	$8,466
$450 / $150 / $0.14	$1,208	$2,735	$4,263	$5,790	$7,317
$450 / $175 / $0.14	$1,557	$3,159	$4,761	$6,363	$7,966
$450 / $200 / $0.14	$1,906	$3,583	$5,260	$6,937	$8,614
$450 / $225 / $0.14	$2,255	$4,007	$5,759	$7,511	$9,262
$450 / $250 / $0.14	$2,604	$4,431	$6,257	$8,084	$9,911

*Processor price is an average of fresh sliced, sauce, and juice.

**Average yield is based on average farm splits between varieties for both high density and semi-dwarf, at current assumed yields. As yields climb, and fall the percentage allocated to each rises and falls accordingly. Assumptions used in the study calculate to an overall average yield of 940 bu/acre (1090 average across high density variety spread and 790 across semidwarf varieties.

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Table A35. Costs by category for different yields in high density, high-value orchards.

Honeycrisp/ High Value High Density	YIELD - Bushels per acre							
	600	700	800	900	1000	1100	1200	1300
Operating & Harvest costs/acre:								
Cultural* -	$2,526	$2,526	$2,526	$2,526	$2,526	$2,526	$2,526	$2,526
Harvest -	$2,862	$3,257	$3,653	$4,048	$4,443	$4,838	$5,234	$5,629
Credit line interest -	$158	$168	$179	$189	$199	$209	$219	$229
TOTAL Operating & Harvest costs/acre:	**$5,546**	**$5,951**	**$6,358**	**$6,763**	**$7,168**	**$7,573**	**$7,979**	**$8,384**
TOTAL Operating & Harvest costs/bu:	**$9.24**	**$8.50**	**$7.95**	**$7.51**	**$7.17**	**$6.88**	**$6.65**	**$6.45**
Total Overhead** costs/ acre -	$3,353	$3,353	$3,353	$3,353	$3,353	$3,353	$3,353	$3,353
TOTAL COSTS per acre:	**$8,899**	**$9,304**	**$9,711**	**$10,116**	**$10,521**	**$10,926**	**$11,332**	**$11,737**
TOTAL COSTS per bu:	**$14.83**	**$13.29**	**$12.14**	**$11.24**	**$10.52**	**$9.93**	**$9.44**	**$9.03**

* "Cultural" costs include pruning, hand thinning, mowing, crop protection, herbicide and fertilizer.

** Overhead costs include land control, establishment, equipment depreciation & expenses such as food safety and crop insurance.

Table A36. Net cash flow for high density, high-value orchards.

Year	0	1	2	3	4	5	6	7	8
Costs	$1,613	$29,680	$3,102	$4,581	$5,569	$7,441	$8,454	$8,454	$8,454
Revenue	$0	$0	$0	$4,375	$8,750	$13,125	$17,500	$17,500	$17,500
Cash flow	-$1,613	-$29,680	-$3,102	-$206	$3,181	$5,684	$9,046	$9,046	$9,046
Sum of NCFs	-$1,613	-$31,293	-$34,395	-$34,601	-$31,420	-$25,736	-$16,690	-$7,644	$1,402

9	10	11	12	13	14	15	16	17	18
$8,454	$8,454	$8,454	$8,454	$8,454	$8,454	$8,454	$8,454	$8,454	$8,454
$17,500	$17,500	$17,500	$17,500	$17,500	$17,500	$17,500	$17,500	$17,500	$17,500
$9,046	$9,046	$9,046	$9,046	$9,046	$9,046	$9,046	$9,046	$9,046	$9,046
$10,448	$19,494	$28,540	$37,586	$46,632	$55,678	$64,724	$73,770	$82,816	$91,862

19	20	21	22	23	24
$8,454	$8,454	$8,454	$8,454	$8,454	$8,454
$17,500	$17,500	$17,500	$17,500	$17,500	$17,500
$9,046	$9,046	$9,046	$9,046	$9,046	$9,046
$100,908	$109,954	$119,000	$128,046	$137,092	$146,138

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Figure A6. Annual net cash flow for high density, high-value orchards.

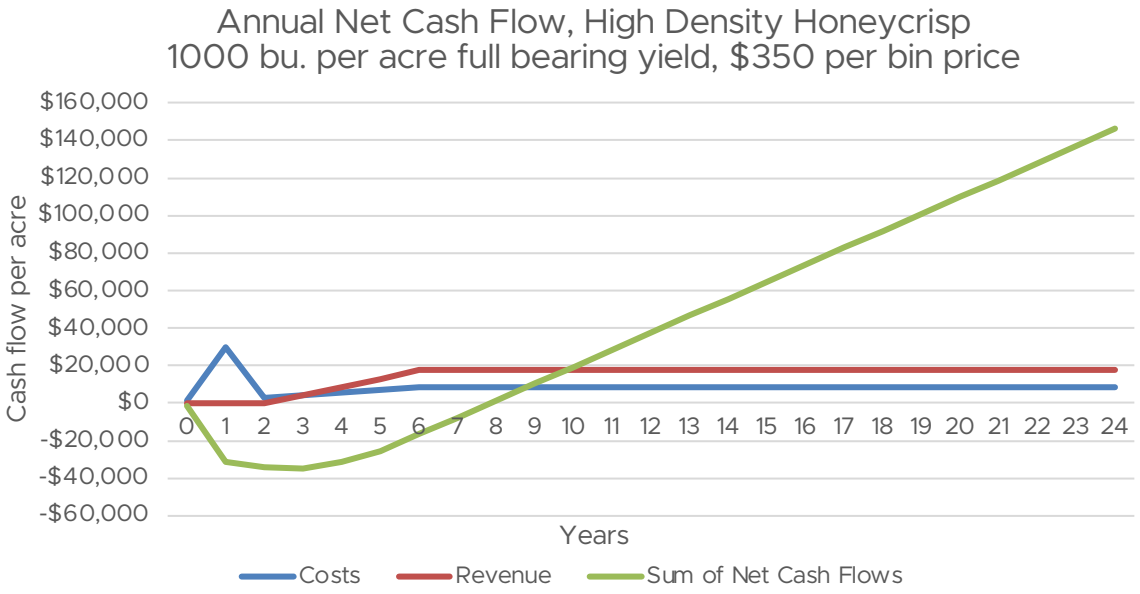

Table A37. Costs by category for different yields in semidwarf, high-value orchards.

Honeycrisp/ High Value Semidwarf	YIELD - Bushels per acre							
	400	500	600	700	800	900	1000	1100
Operating & Harvest costs/acre:								
Cultural* -	$2,393	$2,393	$2,393	$2,393	$2,393	$2,393	$2,393	$2,393
Harvest -	$2,076	$2,472	$2,868	$3,264	$3,661	$4,057	$4,453	$4,849
Credit line interest -	$135	$145	$155	$165	$175	$185	$195	$205
TOTAL Operating & Harvest costs/ acre:	**$4,604**	**$5,010**	**$5,416**	**$5,822**	**$6,229**	**$6,635**	**$7,041**	**$7,447**
TOTAL Operating & Harvest costs/ bu:	**$11.51**	**$10.02**	**$9.03**	**$8.32**	**$7.79**	**$7.37**	**$7.04**	**$6.77**
Total Overhead** costs/acre -	$2,395	$2,395	$2,395	$2,395	$2,395	$2,395	$2,395	$2,395
TOTAL COSTS per acre:	**$6,999**	**$7,405**	**$7,811**	**$8,217**	**$8,624**	**$9,030**	**$9,436**	**$9,842**
TOTAL COSTS per bu:	**$17.50**	**$14.81**	**$13.02**	**$11.74**	**$10.78**	**$10.03**	**$9.44**	**$8.95**

* "Cultural" costs include pruning, hand thinning, mowing, crop protection, herbicide and fertilizer.
** Overhead costs include land control, establishment, equipment depreciation & other expenses such as food safety and crop insurance.

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Table A38. Net cash flow for semidwarf, high-value orchards.

Year	0	1	2	3	4	5	6	7	8
Costs	$1,613	$10,395	$2,718	$2,718	$2,718	$5,529	$5,935	$6,341	$6,748
Revenue	$0	$0	$0	$0	$0	$5,250	$7,000	$8,750	$10,500
Cash flow	-$1,613	-$10,395	-$2,718	-$2,718	-$2,718	-$279	$1,065	$2,409	$3,752
Sum of NCFs	-$1,613	-$12,007	-$14,726	-$17,444	-$20,162	-$20,441	-$19,376	-$16,967	-$13,215

9	10	11	12	13	14	15	16	17
$7,154	$7,154	$7,154	$7,154	$7,154	$7,154	$7,154	$7,154	$7,154
$12,250	$12,250	$12,250	$12,250	$12,250	$12,250	$12,250	$12,250	$12,250
$5,096	$5,096	$5,096	$5,096	$5,096	$5,096	$5,096	$5,096	$5,096
-$8,119	-$3,023	$2,073	$7,169	$12,265	$17,361	$22,457	$27,553	$32,649

18	19	20	21	22	23	24
$7,154	$7,154	$7,154	$7,154	$7,154	$7,154	$7,154
$12,250	$12,250	$12,250	$12,250	$12,250	$12,250	$12,250
$5,096	$5,096	$5,096	$5,096	$5,096	$5,096	$5,096
$37,745	$42,841	$47,937	$53,033	$58,129	$63,225	$68,321

Figure A7. Annual net cash flow for semidwarf, high-value orchards.

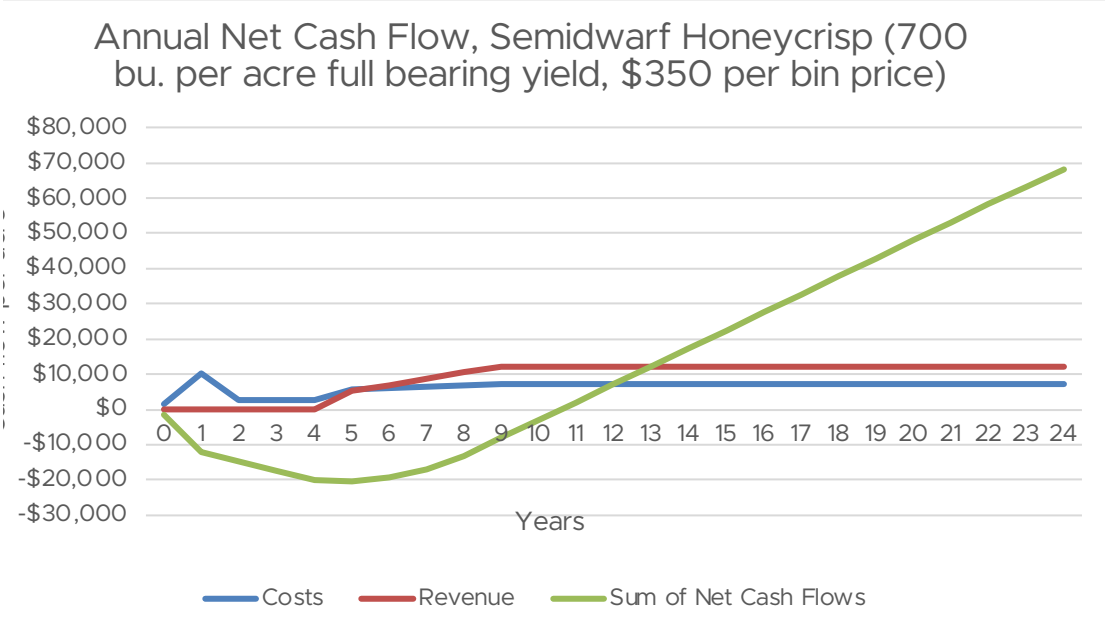

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Table A39. Costs by category for different yields in high density, mid-value orchards.

Gala/Mid-value High Density	YIELD - Bushels per acre							
	800	**900**	**1000**	**1100**	**1200**	**1300**	**1400**	**1500**
Operating & Harvest costs/acre:								
Cultural* -	$2,526	$2,526	$2,526	$2,526	$2,526	$2,526	$2,526	$2,526
Harvest -	$2,633	$2,900	$3,168	$3,436	$3,704	$3,971	$4,239	$4,507
Credit line interest -	$151	$158	$165	$171	$178	$185	$191	$198
TOTAL Operating & Harvest costs/acre:	**$5,310**	**$5,584**	**$5,859**	**$6,133**	**$6,408**	**$6,682**	**$6,956**	**$7,231**
TOTAL Operating & Harvest costs/bu:	**$6.64**	**$6.20**	**$5.86**	**$5.58**	**$5.34**	**$5.14**	**$4.97**	**$4.82**
Total Overhead** costs/ acre -	$3,353	$3,353	$3,353	$3,353	$3,353	$3,353	$3,353	$3,353
TOTAL COSTS per acre:	**$8,663**	**$8,937**	**$9,212**	**$9,486**	**$9,761**	**$10,035**	**$10,309**	**$10,584**
TOTAL COSTS per bu:	**$10.83**	**$9.93**	**$9.21**	**$8.62**	**$8.13**	**$7.72**	**$7.36**	**$7.06**

* "Cultural" costs include pruning, hand thinning, mowing, crop protection, herbicide and fertilizer.

** Overhead costs include land control, establishment, equipment depreciation & other expenses such as food safety and crop insurance.

Table A40. Net cash flow for high density, mid-value orchards.

Year	0	1	2	3	4	5	6	7	8
Costs	$1,613	$29,680	$3,102	$4,396	$5,199	$6,871	$7,694	$7,694	$7,694
Revenue	$0	$0	$0	$3,000	$6,000	$9,000	$12,000	$12,000	$12,000
Cash flow	-$1,613	-$29,680	-$3,102	-$1,396	$801	$2,129	$4,306	$4,306	$4,306
Sum of NCFs	-$1,613	-$31,293	-$34,395	-$35,791	-$34,990	-$32,861	-$28,555	-$24,249	-$19,943

9	10	11	12	13	14	15	16	17	18	19
$7,694	$7,694	$7,694	$7,694	$7,694	$7,694	$7,694	$7,694	$7,694	$7,694	$7,694
$12,000	$12,000	$12,000	$12,000	$12,000	$12,000	$12,000	$12,000	$12,000	$12,000	$12,000
$4,306	$4,306	$4,306	$4,306	$4,306	$4,306	$4,306	$4,306	$4,306	$4,306	$4,306
-$15,637	-$11,331	-$7,025	-$2,719	$1,587	$5,893	$10,199	$14,505	$18,811	$23,117	$27,423

20	21	22	23	24
$7,694	$7,694	$7,694	$7,694	$7,694
$12,000	$12,000	$12,000	$12,000	$12,000
$4,306	$4,306	$4,306	$4,306	$4,306
$31,729	$36,035	$40,341	$44,647	$48,953

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Table A41. Costs by category for different yields in semidwarf, mid-value orchards.

Gala/Mid-value Semidwarf	YIELD - Bushels per acre							
	600	700	800	900	1000	1100	1200	1300
Operating & Harvest costs/acre:								
Cultural* -	$2,393	$2,393	$2,393	$2,393	$2,393	$2,393	$2,393	$2,393
Harvest -	$2,103	$2,372	$2,641	$2,909	$3,178	$3,447	$3,715	$3,984
Credit line interest -	$134	$141	$148	$154	$161	$168	$174	$181
TOTAL Operating & Harvest costs/acre:	**$4,630**	**$4,906**	**$5,182**	**$5,456**	**$5,732**	**$6,008**	**$6,282**	**$6,558**
TOTAL Operating & Harvest costs/bu:	**$7.72**	**$7.01**	**$6.48**	**$6.06**	**$5.73**	**$5.46**	**$5.24**	**$5.04**
Total Overhead** cost/ acre -	$2,395	$2,395	$2,395	$2,395	$2,395	$2,395	$2,395	$2,395
TOTAL COSTS per acre:	**$7,025**	**$7,301**	**$7,577**	**$7,851**	**$8,127**	**$8,403**	**$8,677**	**$8,953**
TOTAL COSTS per bu:	**$11.71**	**$10.43**	**$9.47**	**$8.72**	**$8.13**	**$7.64**	**$7.23**	**$6.89**

* "Cultural" costs include pruning, hand thinning, mowing, crop protection, herbicide and fertilizer.

** Overhead costs include land control, establishment, equipment depreciation & other expenses such as food safety and crop insurance.

Table A42. Net cash flow for semidwarf, mid-value orchards.

Year	0	1	2	3	4	5	6	7
Costs	$1,613	$10,395	$2,718	$2,718	$2,718	$5,136	$5,549	$5,962
Revenue	$0	$0	$0	$0	$0	$3,000	$4,500	$6,000
Cash flow	-$1,613	-$10,395	-$2,718	-$2,718	-$2,718	-$2,136	-$1,049	$38
Sum of NCFs	-$1,613	-$12,007	-$14,726	-$17,444	-$20,162	-$22,298	-$23,347	-$23,309

8	9	10	11	12	13	14	15	16	17	18
$6,375	$6,788	$6,788	$6,788	$6,788	$6,788	$6,788	$6,788	$6,788	$6,788	$6,788
$7,500	$9,000	$9,000	$9,000	$9,000	$9,000	$9,000	$9,000	$9,000	$9,000	$9,000
$1,125	$2,212	$2,212	$2,212	$2,212	$2,212	$2,212	$2,212	$2,212	$2,212	$2,212
-$22,184	-$19,972	-$17,760	-$15,548	-$13,336	-$11,124	-$8,912	-$6,700	-$4,488	-$2,276	-$64

19	20	21	22	23	24
$6,788	$6,788	$6,788	$6,788	$6,788	$6,788
$9,000	$9,000	$9,000	$9,000	$9,000	$9,000
$2,212	$2,212	$2,212	$2,212	$2,212	$2,212
$2,148	$4,360	$6,572	$8,784	$10,996	$13,208

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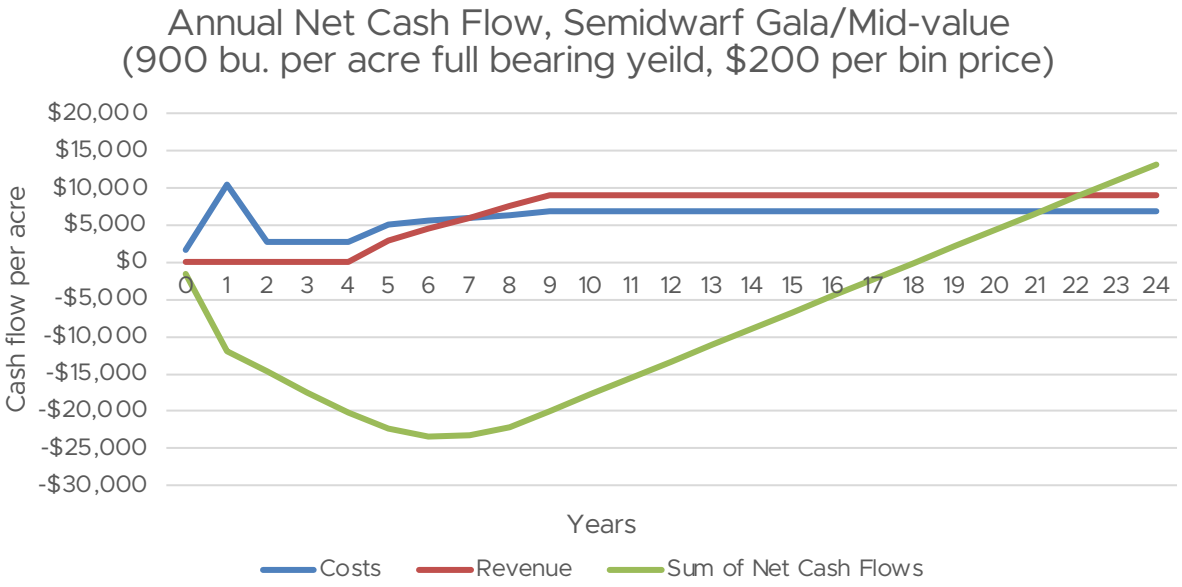
Figure A8. Annual net cash flow for semidwarf, mid-value orchards.



Honeycrisp planted on B9 in 2023, working towards that top wire. Photo by Chris Bardenhagen, MSU Extension

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Table A43. Fuel calculations for Michigan apple production.

Fuel Calculations for Michigan Apple Production[1,2,3,4]			
Task	**Total hours/ acre**	**Gallons for semidwarf system**	**Gallons per acre for high density system**
ESTABLISHMENT & PLANTING			
Land Clearing	12	96	96
Tillage during establishment, total	0.8	2.8	2.8
Spreading poultry manure	0.5	1.8	1.8
Cover crop	0.5	1.35	1.35
Planting- 85HP tractor	1.5	5.25	5.25
Total Establishment & Planting		**107.2**	**107.2**
GROWING YEARS 1 through 4			
Brush chopping - 85HP tractor	0.5	1.75	1.75
Fertilizer - 60HP tractor	0.4	1.1	1.1
Mowing - 60HP tractor	1.3	3.5	3.5
Crop protection - 85 HP tractor	2.1	7.35	7.35
Herbicide - 60HP tractor	1.3	3.5	3.5
Pickup usage, 50 miles @ 14mpg		3.6	3.6
Total per Year		20.8	20.8
TOTAL for Growing Years 1 through 4		**83.2**	**83.2**
FULL PRODUCTION YEARS			
Brush chopping - 85HP tractor	1.0	3.5	3.5
Mowing - 60HP tractor	1.3	3.5	3.5
Crop protection - 85 HP tractor	2.1	7.35	7.35
Herbicide - 60HP tractor	1.3	3.5	3.5
Fertilizer - 60HP tractor	0.4	1.1	1.1
Pickup usage, 50 miles @ 14mpg		3.6	3.6
Harvest- field pickup -- 2 hours 60HP tractor, 3 hours forklift	5.0	8.4	8.4
Total per Year		31.0	31.0
TOTAL for 20 Full Production Years		**619.0**	**619.0**
TOTAL Gallons over 24-Year ORCHARD LIFETIME (same for both semidwarf and high density)			**809**
Average Annual Gallons of Fuel Usage per acre			**33.7**

[1] 85 Horsepower Tractor assumed usage is 3.5 gallons/hour

[2] 60 Horsepower Tractor assumed usage is 2.7 gallons/hour

[3] 40 Horsepower Tractor assumed usage is 1.9 gallons/hour

[4] Other equipment fuel usage estimated/extrapolated from accepted usage values

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Table A44. Fuel emissions CO2 equivalent calculation for apple production.

Calculations to Determine Fuel Emissions*			
Emission Type	**kg/gallon**	**kg/acre**	**kg CO2 equivalent**
CO2	10.21	344.3	344.3
CH4	0.001	0.042	1.19
N2O	0.001	0.036	9.85
	Total kg CO2 equivalent per acre:		**355.4**
	grams CO2 equivalent/m^2:		87.8
	grams CARBON equivalent/m^2 per acre:		**23.9**

* Emissions for CO , CH , and N O from fuel combustion were calculated using the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Volume 2: Energy, Sheet 1 of 4 – Tier 1 source categories) using 2025 US-EPA Emission Factors.