IOWA STATE UNIVERSITY

MACHINERY ADOPTION DECISION EXAMPLE: A MECHANICAL HARVESTER

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How do you decide whether or not it makes sense to purchase a piece of equipment for your operation?

One approach is to calculate the "breakeven acres" – the number of acres for which the cost of completing the operation with the equipment is just equal to the cost of completing the operation without it (or by hand).

The formula to calculate the breakeven acres is:

$$\frac{\text{Total Ownership Costs (per year)}}{\text{Hand Operating Costs/acre} - \text{Machine Operating Costs/acre}}$$

Let's consider a pull-type harvester.

Hand Harvesting Costs

The worksheet below will help you calculate your hand harvesting costs. The example assumes 620 bushes planted per acre with an average yield of 20 pounds of berries per bush[1]. It uses a picking rate of 16.1 pounds per hour and an hourly wage of $7.25. You can adjust these numbers to fit your operation. The worksheet also allows you to calculate your hand harvest costs if you pay pickers on a per pound basis. With these assumptions, hand harvesting an acre of berries requires 770 hours of labor at a wage of $7.25/hour. **The operating cost of hand harvesting is (770 hours × $7.25/hour) $5,580/acre.**

Machine Harvesting Costs

Now, compare hand harvesting to the costs associated with owning and using a mechanical harvester. Machinery costs can be divided into two categories: ownership costs (or fixed costs) and operating costs (or variable costs). Ownership costs are costs that you will incur no matter how much (or how little) you use the machine. These include depreciation, interest, insurance, repairs and housing costs. Operating costs are the costs associated with using the machine and will change depending on how much you use it. Operating costs include the labor required for running the equipment, fuel, lubrication, and the costs of other required equipment.

1 Estimated plant density obtained from Hardy, C. "Aronia Berry Profile," Agricultural Marketing Resource Center, January, 2010. Available at www.agmrc.org/commodities__products/fruits/aronia_berries_profile.cfm.

This document is a work in progress. It grew out of the needs identified in December 2009 for the April-May 2010 Aronia Berry Annie's Project, and it builds on documents created for that program. It's intended to be the decision tool used for an Aronia Berry harvester sharing program. The ongoing assistance of Charlie and Jolene Caldwell in the shaping of the document is appreciated.

Please provide your comments regarding this document's units and assumptions to Georgeanne Artz at gartz@iastate.edu. If you could include a note regarding your willingness to participate in an Aronia Berry harvester sharing program and your mode of delivery preference (face-to-face or online) that would be most appreciated.

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Hand Picking Labor Worksheet (per pound payment basis)

			1/4 ACRE	1/2 ACRE	1 ACRE		YOUR NUMBERS
a	Aronia berry bushes		155	310	620[2]	bushes	
b	Yield per bush		20	20	20	lbs	
c	Picking rate		16.1[3]	16.1	16.1	lbs/hour	
d	Per pound labor rate		$ 0.45	$ 0.45	$ 0.45	$/lb	
	Total production	a × b	3,100[4]	6,200	12,400	lbs	
	Hours	(a × b) / c	193	385	770	hours	
	Total cost	(a × b) × d	$ 1,395	$ 2,790	$ 5,580	dollars	
	Cost per bush	(b × d)	$ 9.00	$ 9.00	$ 9.00	dollars	
	Hourly wage	(c × d)	$ 7.25	$ 7.25	$ 7.25	dollars	
	Number of pickers/week	((a × b) / c) / 40	5	10	19	pickers	

Hand Picking Labor Worksheet (per hour payment basis)

			1/4 ACRE	1/2 ACRE	1 ACRE		YOUR NUMBERS
a	Aronia berry bushes		155	310	620	bushes	
b	Yield per bush		20	20	20	lbs	
c	Picking rate		16.1	16.1	16.1	lbs/hour	
d	Labor rate		$ 7.25	$ 7.25	$ 7.25	$/hour	
	Total production	a × b	3,100	6,200	12,400	lbs	
	Hours	(a × b) / c	193	385	770	hours	
	Total cost	((a × b) / c) × d	$ 1,396	$ 2,792	$ 5,584	dollars	
	Cost per bush	(((a × b) / c) × d) / a	$ 9.01	$ 9.01	$ 9.01	dollars	
	Cost per pound	(d / c)	$ 0.45	$ 0.45	$ 0.45	dollars	
	Number of pickers/week	((a × b) / c) / 40	5	10	19	pickers	

2 In this example, we assume that the number of plants per acre is 620, based on the planting density for mechanical harvest, for both hand harvest and mechanical harvest. In practice, hand harvested plants could be planted more densely.

3 This estimate is from a 2000-2001 study at the North Willamette Research and Extension Center in Aurora, Oregon, cited in C. Hardy, 2010.

4 These numbers reflect productivity levels of mature plants (year 3 and beyond).

Ownership Costs

First calculate the annual costs of owning the harvester. We assume you can buy a pull-type harvester for $30,000.

Depreciation

Since you are using the implement fairly infrequently and on a small amount of land, you estimate the useful life of the implement at 20 years (after which there is no salvage value, in other words, you cannot sell it for anything.) With these assumptions, you compute your depreciation cost at ($30,000/20 years) = $1500/year.

Interest

If you borrow money to purchase the harvester, you should include the cost of borrowing, the interest rate, in your cost calculation. Even if you use your own funds to purchase the implement, you should figure in the opportunity cost, or what you could earn from using that money elsewhere. Let's assume an interest rate of 6%. Since the value of the machine declines over time (due to depreciation) the standard method is to calculate interest costs using the average value over the life of the machine, in this case, $15,000. Another way to think about this is that if you borrowed to buy the machine, as you pay down your loan, the amount of interest you pay over time declines. Using these figures, your interest cost is $15,000 × 0.06 = $900 per year.

Insurance and Housing

You will need to insure and house your new harvester. An estimate for insurance cost is $10 per $1000 of valuation, or $300 per year. Similarly, an estimate of housing costs is 1% of the purchase price, or $300/year. Depending on the size and type of equipment you are purchasing, there may be no additional costs for insurance and housing. You may already have storage space and your blanket insurance policy may be sufficient to cover your new purchase.

Repairs:

You should also figure in an amount for maintenance and repairs. A suggested amount is 2% of the purchase price, or $600 per year[5].

Adding these up gives you the total costs of owning the machine per year (Table 1).

Operating Costs

Now compute the operating costs associated with using the harvester. You will need a tractor (minimum 35 HP) to pull the harvester and probably three people – one to drive the tractor, one on the harvester and one to handle the totes. Suppose that you can harvest an acre of berries using the harvester in 3 hours. Your labor cost is (3 hours × $12/hour × 3 people) = $108 an acre. The estimated cost of the tractor is $14/hour, or ($14/hour × 3 hours) = $42 per acre. This is an estimate based on the cost of renting a tractor ($8/hour) and includes fuel and lubrication costs ($6/hour). If you already own a tractor, only your operating costs of $6 per hour need to be considered. Adding these gives you the total variable costs for using the harvester to harvest an acre of berries (Table 2).

Table 1: Estimated Ownership Costs (per year)

Depreciation	$ 1,500.00	
Interest	$ 900.00	
Insurance	$ 300.00	
Housing	$ 300.00	
Repairs	$ 600.00	
Total Ownership Costs	**$ 3,600.00**	**per year**

Table 2: Estimated Operating Costs (per acre)

Tractor	$ 42.00	
Labor	$ 108.00	
Total Operating Costs	**$ 150.00**	**per acre**

5 Repair and maintenance costs are often thought of as operating costs since the frequency and amount of repairs increases with the use of the machine, and estimated on a per acre or per hour basis. In cases where the number of acres or hours of use is small, it may be more reasonable to figure a fixed amount for annual repairs and maintenance.

Calculating Breakeven Acres

Now that we have all the pieces, we can calculate the breakeven acres.

$$\text{Breakeven acres} = \frac{\text{Total Ownership Costs (per year)}}{\text{Hand Variable Costs/acre} - \text{Machine Variable Costs/acre}} = \frac{\$\ 3{,}600}{\$\ 5{,}584 - \$\ 150} = 0.66 \text{ acres}$$

In other words, if you harvest at least 0.66 acres of aronia berries each year, it may make sense for you to purchase the mechanical harvester.

You can adjust the numbers in this example to fit your operation. Changing assumptions will affect the calculation. For example including an addition $5,000 for an inventory of spare parts in the purchase price of the harvester raises the estimated breakeven acres to 0.77 acres.

Other Considerations:

Timeliness costs refer to the potential costs of not harvesting your crop in a timely manner. Timing of harvest (and planting) can affect the yield and quality of your crop. While it is hard to put a number on these costs, using machinery may help you reduce them. Another timeliness related issue is how quickly the harvester can be repaired in the event of a breakdown. The harvester considered in this example is manufactured in Poland and to date, there are no dealers in the midwestern U.S. You may want to consider maintaining an inventory of spare parts to insure against costly downtime during harvest.

At the same time, mechanical harvesting could reduce the quality of the harvested berries. The harvester may bruise the berries more than hand picking would. The machine might leave the stems on the berries, which could require the additional use of a de-stemmer. Mechanical harvesting will pick all the berries from the bush, picking some berries that are under-ripe. Hand harvesting might allow more discretion. Depending on the number of bushes you have, one strategy might be to hand harvest a portion of your berries for a higher-end market and mechanically harvest the remainder for a processing market.

Using a mechanical harvester will require certain field and planting conditions. For example, use of the harvester may require specific pruning practices to minimize damage to both the machine and the plants themselves. The plants will need to be spaced adequately to accommodate the harvesting equipment resulting in fewer plants per acre relative to what may be possible with hand harvesting. Obstacles in the fields and adequate turning radius for the equipment should be considered. Slope of the fields may also limit (or in some cases prevent) the suitability of using a mechanical harvester.

Using a mechanical harvester will likely require the use of totes, which may not be necessary for hand harvesting. The purchase or perhaps rental of these totes is an additional cost associated with mechanical harvesting not accounted for in the example above.

Finally, this example considers the machinery adoption decision for an individual operator. Alternatives include purchasing a harvester jointly with other growers or buying a harvester with the intent to operate a custom harvesting operation. In either of these cases, the efficiency of the machine will be improved as the fixed costs of owning the harvester are spread over additional acres. However, sharing or custom operating will entail added costs, including transportation costs of moving the harvester (and likely a tractor) between farms, coordination costs required to schedule timely use of the machine, additional liability insurance, and perhaps additional clean-out costs if harvesting for both conventional and certified organic growers.

For more information and decision tools please see the Machinery Management section of the Iowa State Extension Ag Decision Maker web site: www.extension.iastate.edu/agdm

Resources for Machinery and Labor Sharing

Farm Machinery & Labor Sharing Manual

Tools to help you evaluate sharing machinery and labor as an option in your farming operation, NCFMEC-21, by Georgeanne Artz, William Edwards, and Frayne Olson. Available through Midwest Plan Service, www.mwps.org. The North Central Farm Management Extension Committee has put together a manual to help farmers lower their machinery and labor costs through cooperation. The **Farm Machinery & Labor Sharing Manual** discusses both operational and organizational issues. It includes sample sharing agreements and worksheets for allocating costs fairly. This manual includes case studies that highlight the various types of arrangements, identify potential problems associated with sharing resources, and explains the strategies these groups used to resolve them.

Iowa State University Ag Decision Maker web site: www.extension.iastate.edu/agdm

Machinery Management information sheets and decision tools:
Joint Machinery Ownership – A3-34
Estimating Farm Machinery Costs – A3-29
Farm Machinery Joint Ventures – A3-37
Farm Machinery Joint Venture Worksheet – A3-38

Iowa Alliance for Cooperative Business Development: www.extension.iastate.edu/coops

Use this worksheet as a guide for estimating breakeven acres with numbers for your operation.

MECHANICAL HARVESTER	EXAMPLE		YOUR NUMBERS
Assumptions			
Purchase price	$ 30,000		
Salvage value	$ 0		
Estimated useful life	20	years	
Interest rate	6	%	
Insurance cost	$ 10	per $1,000 valuation	
Housing	1	% of purchase price	
Repairs	2	% of purchase price	
Tractor costs	$ 25	per hour	
Labor costs	$ 12	per hour	
Harvester time	3	hours per acre	
Hand picking time	770	hours per acre	
Ownership costs			
Depreciation	$ 1,500.00		
Interest	$ 900.00		
Insurance	$ 300.00		
Housing	$ 300.00		
Repairs	$ 600.00		
Total ownership cost	$ 3,600.00	per year	
Operating costs-harvester			
Tractor usage	$ 42.00		
Labor (3 people)	$ 108.00		
Total variable costs	$ 150.00	per acre	
Operating costs-hand harvest			
Labor	$ 5,582.00	per acre	
Breakeven acres	0.66	acres	