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Economic Analysis of Organic Pest Management Strategies for Lowbush Blueberries Using Enterprise Budgeting

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SUMMARY

Enterprise budgets were developed for the 12 different pest management treatments of a large-plot organic blueberry transitions project covering each of two prune/harvest cycles (2004–2005 and 2006–2007) as well as for the aggregate of the two prune/harvest cycles combined. Regression analysis of the plot-level yield results for the aggregate of the two prune/harvest cycles indicated that burning fields (with a tractor-pulled flamer) as compared to mowing fields (with a tractor-pulled flail mower) significantly increased (95% confidence level) blueberry yields over the aggregate of two prune/harvest cycles (a four-year time period). Similarly, adding 1,000 lbs of sulfur before the first prune/harvest cycle significantly increased (95% confidence level) blueberry yields over the aggregate of two prune/harvest cycles (a four-year time period) as compared to no addition of sulfur. The addition of fertilizer had no significant impact (95% confidence level) on blueberry yields.

Since there was no difference in yield due to fertilizer input, the yields from the fertilizer treatments were aggregated into their respective burn/mow and sulfur/no sulfur treatment to reduce the analysis from 12 enterprise budgets to four enterprise budgets. An average amount of fertilizer (20 lbs N) was assumed for each.

INTRODUCTION

In the spring of 2004, a research team from the University of Maine received a USDA Organic Transitions Program grant for the project entitled, "Development and Implementation of Organic Pest Management Strategies for Lowbush Blueberries: A Multi-Year, Multi-Disciplinary Study."

This project was designed to examine all aspects of blueberry management to develop an integrated approach to organic pest management in lowbush blueberries. While numerous studies have helped to create general standards for blueberry pest management, few have looked at the interaction between organic pest management practices and organic soil fertility management. Investigators in the fields of entomology, plant pathology, weed science, and soil fertility conducted experiments to meet these goals.

There were four main objectives of this project: (1) to develop effective organic pest management tactics and optimize them under operational conditions, (2) to measure direct and indirect (pest interactions) effects of organic fertilizers on crop yield, (3) to conduct economic analyses of various organic strategies, and (4) to develop proactive educational programs to facilitate adoption of organic strategies.

The economic component of this project (i.e., main objective #3—"conduct economic analyses of various organic strategies") was expanded after the project began to include a survey of all organic lowbush blueberry growers in Maine, along with case stories of a select group of those growers. The original focus of this component, which is the focus of this report, makes use of the results of a large-plot study that employed a randomized complete block split-split-split design to develop enterprise budgets for the various treatments.

METHODOLOGY

The large-plot study of the organic transition project was conducted in a field entering its vegetative year located in the town of Amherst in Hancock County, Maine. There were eight large blocks with a total of 96 2×16-m plots arranged in a randomized complete block split-split-split design. Each of the eight blocks contained 12 treatments designed to determine the interaction between pruning method (mow or burn), application of sulfur (to lower soil pH to 4.0), and organic fertilizer on blueberry growth and development and pest populations. In the spring of 2004, each of the eight large blocks was divided into two subplots: one that was pruned using a mower and one that was pruned by burning. In each pruned subplot, half of the subplot was treated with sulfur to lower the soil pH to 4.0, and the other half was left untreated. Each sulfur- or non-sulfur-treated portion contained three 2×16-m plots, that received one of three application rates of organic (4-6-4) fertilizer: 0, 20, or 40 lbs/acre.

Enterprise budgeting was used as the means of comparing the economic performance of the 12 different pest management treatments. Enterprise budgeting assumes consistency in all aspects of the farm except the enterprises in question (in this case, the pest management treatments). As a result, expense for items such as equipment and land, since they are assumed the same for all enterprises, are disregarded. In terms of equipment, the only equipment that is different between these treatments is the equipment for burning and the equipment for mowing. It is assumed that the tractor and implement for burning has the same expense as the tractor and implement for mowing. In terms of labor expense, from the results of the 2006 Survey of Organic Blueberry Producers, most growers (85%–90%) only hired non-farm/non-family labor for harvesting and cleaning/packaging. As a result, it is assumed that all production activities—except harvesting and cleaning/packaging—are performed by farm-family labor, which is not quantified in this study. Thus, the net income results do not include farm-family labor.

For the study in question, there were two prune/harvest cycles involved (2004–2005 and 2006–2007). Enterprise budgets are presented for each cycle, individually, and for the aggregate of the two cycles

Descriptions of the line items that make up the revenues and variable expenses of the enterprise budgets are given below.

Revenues

- Acres—The plot results were converted into per acre values.
- Gross yield (lbs/acre)—Blueberry harvest yields were obtained from the specific plots for each pest management treatment in question. We converted each harvest yield of the eight replications to a per acre basis. We calculated an average value of the eight replications for each harvest year (2005 and 2007) for the individual cycles, and the sum of the two harvest years was calculated for the aggregate.
- Harvest-conversion factor—Since there is yield loss during the cleaning process, we used a conversion factor to convert "gross yield" into marketable yield. This "harvest-conversion factor" was the average value (i.e., 80%) reported by respondents to the 2006 Survey of Organic Blueberry Producers.
- Fresh-pack price ($/lb)—Given that most organic blueberry growers who market their product do so as fresh product, we used a general fresh-pack price for organic blueberries to calculate revenues, based on conversations with growers. We used the price of $3.00 per pound (or $4.50 per quart) for the 2005 harvest year and $3.50 per pound (or $5.25 per quart) for the 2007 harvest year. The price used for the aggregate of the two cycles is a weighted average for the two harvest years so may vary between treatments.

Variable Expenses

Labor

- Harvesting by hand—Since the vast majority of respondents to the 2006 Survey of Organic Blueberry Producers primarily hired outside labor for harvesting, labor expense was determined for harvesting. We estimated the pay rate for harvesting by hand at $0.20 per pound.
- Cleaning/packaging—Given that roughly two-thirds of respondents to the 2006 Survey of Organic Blueberry Producers market either at a farm stand or to retail outlets, we estimated cleaning/packaging costs based on conversations with a number of growers. We used average cleaning rates at 13 lbs of field berries per hour per person and assumed that two people were cleaning/packaging berries at a time—one of whom was a hired laborer paid at the rate of $8.00 per hour and the other was part of the farm family (and thus, unpaid).

Materials

- Diesel fuel—Diesel fuel was used for burning the fields (using a tractor-pulled flamer) and for mowing the fields (using a tractor-pulled flail mower). The amount of diesel required to burn one acre of blueberry field can vary considerably due to environmental factors. Based on input from employees at Blueberry Hill Farm, the University of Maine's blueberry research farm, we estimated the amount of diesel fuel used to burn an acre of field at 80 gallons. Based on input from those same sources, we estimated the amount of diesel fuel used to mow one acre at 14 gallons. The cost of diesel fuel was estimated as the highway price in the Northeast (based on data from the Energy Information Administration) less $0.83—the estimated amount of fuel tax that agricultural operators are not required to pay. The fields were burned in the spring of 2004, when the cost was estimated at $0.97 per gallon, and in the fall of 2005, when the cost was estimated at $1.90 per gallon.
- Insecticide, organic—Since there were no outbreaks of insect pests, no organic insecticide was purchased or applied.

- Insect traps—We estimated the cost of traps for monitoring levels of insect pests at $15 per acre and used only in the harvest year.
- Sulfur—Sulfur came in 50-lb bags; the mix was 90% sulfur and 1,000 lbs per acre of sulfur was the application goal. Therefore 22.22 bags per 1,000 lbs active ingredient were required. The sulfur cost $8.35 per 50-lb bag and was only applied in May of 2004.
- Fertilizer, organic—The fertilizer application was based on the desired pounds of nitrogen (i.e., 0 lbs, 20 lbs, or 40 lbs). Fertilizer (4-6-4, N-P-K) cost was $20.00 per 50-lb bag and was purchased before the 2004 application for both the 2004 and 2006 application. Fertilizer was applied in May 2004 and May 2006.
- Packaging—Since roughly two-thirds of respondents to the 2006 Survey of Organic Blueberry Producers market either at a farm stand or to retail outlets, packaging costs were estimated. We estimated average packaging costs at $0.04 per pound of cleaned berries.

RESULTS

2004–2005 Prune/Harvest Cycle

The average gross yield ranged from 449 to 1228 lbs per acre (Table 1). The average gross yield was greatest for the burn-sulfur treatments (990 to 1228 lbs per acre) with the treatment with 20 lbs of nitrogen yielding the largest (1,228 lbs per acre). The burn-no sulfur treatments also yielded relatively large amounts (856 to 1,089 lbs per acre). The average gross yield was lowest for the mow-sulfur treatments (449 to 565 lbs per acres) and was lowest among those in the treatment using 40 lbs of nitrogen within this group (449 lbs per acre).

Since the harvest-conversion factor and the fresh-pack price are assumed constant across treatments, the relationship of the gross yield between treatments is replicated in the gross revenues between treatments. Total revenue was highest in the burn-sulfur treatments, with total revenue ranging from $2,376 to $2,948 per acre, with the treatment using 20 lbs of nitrogen being the highest. The total revenue was lowest for the mow-sulfur treatments ($1,079 to $1,356 per acre) and was lowest for the treatment using 40 lbs of nitrogen in this group ($1,079 per acre). As with yield results, total revenue tended to decrease with increasing amounts of fertilizer applied for all treatment groups except the burn-sulfur treatments.

Table 1. Enterprise budgets for organic lowbush blueberry pest management treatments. Results for prune/harvest cycle of 2004–2005.

Pruning	Burn						Mow					
pH	Sulfur			No Sulfur			Sulfur			No Sulfur		
Fertilizer	0 lbs	20 lbs	40 lbs	0 lbs	20 lbs	40 lbs	0 lbs	20 lbs	40 lbs	0 lbs	20 lbs	40 lbs
Revenues												
Acres	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Gross yield (lbs/acre)	990	1228	1133	1089	993	856	516	565	449	813	704	614
Harvest-conversion factor	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Fresh pack price ($/lb)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Total revenue ($)	2,376	2,948	2,719	2,614	2,383	2,054	1,240	1,356	1,079	1,951	1,690	1,474
Variable costs												
Labor						$						
Harvesting (by hand)	198	246	227	218	199	171	103	113	90	163	141	123
Cleaning/packaging	305	378	349	335	305	263	159	174	138	250	217	189
Total labor costs	503	624	575	553	504	434	262	287	228	413	357	312
Materials												
Diesel fuel	78	78	78	78	78	78	14	14	14	14	14	14
Insect traps	15	15	15	15	15	15	15	15	15	15	15	15
Sulfur	185	185	185	-	-	-	185	185	185	-	-	-
Fertilizer, organic	-	200	400	-	200	400	-	200	400	-	200	400
Packaging	32	39	36	35	32	27	17	18	14	26	23	20
Total material costs	310	517	714	127	324	520	230	432	628	55	251	448
Total variable costs	812	1,141	1,289	680	828	954	493	719	856	467	609	760
Net income (loss)	1,563	1,807	1,430	1,934	1,554	1,099	747	637	222	1,484	1,081	714

Since we calculated variable labor costs (harvesting and cleaning/packaging) as a function of yield, the treatments with the largest yield recorded the highest variable labor costs. Thus, the burn-sulfur treatments had the highest variable labor costs, ranging from $503 to $624 per acre. The treatments with the lowest variable labor costs were the mow-sulfur plots ($228 to $262 per acre).

In terms of variable material costs for this first two-year cycle, burn treatments were more costly than mow treatments. As one would expect, cost of fertilizer treatments increased with the amount of fertilizer applied, and sulfur treatments were more costly than no-sulfur treatments. The other variable material costs (packaging and insect traps) were small relative to diesel fuel, fertilizer, and sulfur. The burn-sulfur-40-lb treatment had the highest variable material cost ($714 per acre), whereas the mow-no sulfur-0-lb treatment had the lowest ($55 per acre).

Even though the variable expenses were relatively large for the burn treatments, the high total revenue values (which were proportional to the gross yield) by those same treatments offset the expenses such that the burn treatments yielded the highest net income values ($1,099 to $1,934 per acre). As a group, the burn-sulfur treatments recorded the larger net income values ($1,430 to $1,807), but the burn-no sulfur-0-lb treatment recorded the largest net income value ($1,934 per acre). The mow treatments recorded the lowest net income values, with the mow-sulfur-40-lb treatment yielding the lowest net income value at $222 per acre. It is important to note that these net income values do not include farm family labor expense, property costs, equipment costs, taxes, and debt expense.

2006–2007 Prune/Harvest Cycle

The average gross yield ranged from 824 to 2,388 lbs per acre (Table 2). The gross yield was greatest for the burn sulfur treatments (2,202 to 2,388 lbs per acre), with the burn-sulfur-40 treatment yielding the largest amount (2,388 lbs per acre).

Since the harvest-conversion factor and the fresh-pack price are assumed constant across treatments, the relationship of the gross yield between treatments is replicated in the gross revenues between treatments. Total revenue was greatest in the burn-sulfur treatments with total revenue ranging from $5,813 to $6,686 per acre, with the treatment using 40 lbs of nitrogen being the highest. The total revenue was lowest for the mow-no sulfur treatments ($2,307 to $2,584 per acre) and, in this group, was lowest for the treatment using 20 lbs of nitrogen treatment ($2,307 per acre).

Table 2. Enterprise budgets for organic lowbush blueberry pest management treatments. Results for prune/harvest cycle of 2006–2007.

Pruning	Burn						Mow					
pH	Sulfur			No Sulfur			Sulfur			No Sulfur		
Fertilizer	0 lbs	20 lbs	40 lbs	0 lbs	20 lbs	40 lbs	0 lbs	20 lbs	40 lbs	0 lbs	20 lbs	40 lbs
Revenues												
Acres	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Gross Yield (lbs/acre)	2076	2202	2388	1441	1147	1252	982	1507	1295	845	824	923
Harvest Conversion Factor	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Fresh Pack Price ($/lb)	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Total Revenue	5,813	6,166	6,686	4,035	3,213	3,506	2,750	4,219	3,626	2,366	2,307	2,584
Variable Costs						$						
Labor												
Harvesting (by hand)	415	440	478	288	229	250	196	301	259	169	165	185
Cleaning/Packaging	639	678	735	443	353	385	302	464	398	260	254	284
Total Labor Costs	1,054	1,118	1,212	732	583	636	499	765	657	429	418	468
Materials												
Diesel Fuel	152	152	152	152	152	152	27	27	27	27	27	27
Insect traps	15	15	15	15	15	15	15	15	15	15	15	15
Sulfur												
Fertilizer, organic	-	200	400	-	200	400	-	200	400	-	200	400
Packaging	66	70	76	46	37	40	31	48	41	27	26	30
Total Material Costs	233	437	643	213	404	607	73	290	483	69	268	471
Total Variable Costs	1,287	1,555	1,856	945	986	1,243	572	1,055	1,140	498	686	940
Net Income (Loss)	4,526	4,610	4,830	3,090	2,227	2,264	2,178	3,165	2,485	1,868	1,621	1,644

Since we calculated variable labor costs (harvesting and cleaning/packaging) as a function of yield, the treatments with the largest yield recorded the highest variable labor costs. Thus, the burn-sulfur treatments had the highest variable labor costs, ranging from $1,054 to $1,212 per acre. The treatments with the lowest variable labor costs were the mow-no sulfur plots ($418 to $468 per acre).

In terms of variable material costs for the second two-year cycle, burn treatments were again more costly than mow treatments. And as one would expect, cost of fertilizer treatments increased with the amount of fertilizer applied. Also there was no sulfur applied to any of the treatments; sulfur was only applied prior to the first cycle. The other variable material costs (packaging and insect traps) were small relative to diesel fuel and fertilizer. The burn-sulfur-40-lb treatment had the highest variable material cost ($643 per acre), whereas the mow-no sulfur-0-lb treatment had the lowest ($69 per acre).

Even though the variable expenses were relatively high for the burn-sulfur treatments, the high total revenue values (which were proportional to the gross yield) for those same treatments offset the expenses such that the burn-sulfur treatments, again, yielded the highest net incomes ($4,526 to $4,830 per acre). Specifically, the burn-sulfur-40-lb treatment recorded the largest net income at $4,830 per acre. The mow-no sulfur treatments recorded the lowest net incomes, with the mow-no sulfur-20-lb treatment yielding the lowest net income at $1,621 per acre. It is important to note that these net income values do not include farm family labor expense, property costs, equipment costs, taxes, and debt expense.

Aggregated Prune/Harvest Cycles—2004–2005 and 2006–2007

We calculated the aggregate gross yield for each plot by adding the gross yields from each plot from the 2005 and 2007 harvest years (Table 3). These aggregated gross yields were then analyzed using regression analysis. Results of that analysis indicated that there were statistical differences (at the 95% level) for the sulfur/no-sulfur treatments and the burn/mow treatments. There were no statistical differences (at the 95% confidence level) between the yields of the fertilizer treatments within a given sulfur/no-sulfur and burn/mow matrix. As a result, the yields for the three fertilizer treatments within each sulfur/no-sulfur and burn/mow matrix (24 measurements) were averaged and reported as a single average gross yield. Since there was no statistical difference between fertilizer treatments with any given sulfur/no-sulfur and burn/mow matrix,

Table 3. Enterprise budgets for organic lowbush blueberry pest management treatments aggregated fertilizer treatment yields. Results for aggregate of prune/harvest cycles 2004–2005 and 2006–2007.

Pruning	Burn		Mow	
pH	Sulfur	No Sulfur	Sulfur	No Sulfur
Fertilizer	20 lbs	20 lbs	20 lbs	20 lbs
Revenues				
Acres	1.0	1.0	1.0	1.0
Gross Yield (lbs/acre)	3345	2264	1775	1642
Harvest Conversion Factor	0.8	0.8	0.8	0.8
Weighted Average Price ($/lb)	3.33	3.28	3.36	3.27
Total Revenue ($)	8,919	5,596	5,576	3,997
Variable Costs	$			
Labor				
Harvesting (by hand)	669	453	355	328
Cleaning/Packaging	1,029	697	546	505
Total Labor Costs	1,698	1,149	901	834
Materials				
Diesel Fuel	230	230	40	40
Insect traps	30	30	30	30
Sulfur	185	-	185	-
Fertilizer, organic	400	400	400	400
Packaging	107	72	57	53
Total Material Costs	952	732	712	523
Total Variable Costs	2,651	1,882	1,613	1,356
Net Income (Loss)	6,268	3,714	3,962	2,640

the treatment using 20 lbs of nitrogen was used for each of the four sulfur/no-sulfur and burn/mow treatments.

The average gross yield ranged from 1,642 to 3,345 lbs per acre, with the mow/no-sulfur treatment yielding the least amount and the burn/sulfur treatment yielding the greatest amount. As a result of the regression analysis noted above, these yield differences are significant at the 95% confidence level.

The range of the weighted average fresh-pack price for the four condensed treatments was from $3.27 to $3.36 per pound. The weighted price indicates the relative proportion of the 2007 harvest to the 2005 harvest. The greater the average gross yield in 2007 relative to 2005, the larger was the weighted average price. For those treatments where the weighted average price was $3.25, there was an equal amount of berries harvested at $3.00 per pound in 2005 as were harvested at $3.50 per pound in 2007. The weighted average fresh-pack price was greatest for the mow-sulfur treatment.

Since the harvest-conversion factor was assumed equal for all treatments and the range of weighted average fresh-pack prices was narrow relative to the range of gross yields, fluctuations in total revenue were affected most by the average gross yield. Total revenue was highest for the burn-sulfur treatments ($8,919 per acre) and was lowest for the mow-no sulfur treatment ($3,997 per acre).

Since we calculated variable labor costs (harvesting and cleaning/packaging) as a function of gross yield, the treatments with the largest yield recorded the highest variable labor costs. Thus, the burn-sulfur treatment had the highest variable labor costs at $1,698 per acre, and the mow-no sulfur treatment had the lowest variable labor costs at $834.

In terms of variable material costs, burn treatments were more costly than mow treatments. The fertilizer cost was held equal (at 20 lbs nitrogen) for all treatments because of the lack of variability due to fertilizer input in the average gross yield. The other variable material costs (packaging and insect traps) were small relative to diesel fuel, fertilizer, and sulfur. The burn-sulfur treatment had the highest variable material cost ($952 per acre) while the mow-no sulfur had the lowest ($523 per acre).

Even though the variable expenses were relatively large for the burn-sulfur treatment, the high total revenue values by that same treatment offset the expenses such that the burn-sulfur treatment yielded the highest net income value ($6,268 per acre) for the two prune/harvest cycles of 2004–2005 and 2006–2007. The treatment with the second highest net income value was the mow-sulfur treatment ($3,962 per acre). The mow-no sulfur treatment had the lowest net income value ($2,640 per acre). It is important to note that these net income values are based on two prune/harvest cycles and do not include farm family labor expense, property costs, equipment costs, taxes, and debt expense.

In the above aggregated analysis, we considered the line items of each enterprise budget as a single known value with no variability. In reality, factors contributing to revenues (e.g., yield and price) and expenses (e.g., diesel cost and fertilizer cost) do vary across fields (i.e., yields) and across time (e.g., selling price of blueberries, and diesel cost). Thus, taking into consideration this variability will likely provide a more realistic representation of the net income figures provided above, in terms of variability within those figures. After using a statistical software package to reflect variability in revenue items and expense items, results indicate that there is no statistical difference in net income values between the four pest management treatments considered in Table 3.

DISCUSSION

We did not consider pollination in the enterprise budgeting because the cost of the bees would have been the same for every treatment in a given year. However, we believe that the difference in yields between the two harvest years is due in large part to a difference in pollination. For instance, bumble bees and honey bees (an amount equivalent to 15 honey bee colonies at a total cost of $930) were used during the first harvest year, but only honey bees (an amount equivalent to 16 honey bee hives at a total cost of $1,120) was used during the second harvest year. Although this difference in the number of pollinators could help to account for the difference in yields between the first and second harvest years, weather also likely played a part. Specifically, May and June in the first harvest year were cold and damp, and we believe that this contributed to less pollination of the blueberries than would have occurred in warmer and drier weather, as was the case during the second harvest year.

There is no clear answer to the question of which treatment is best for blueberry growers to use. Although there is statistical difference in gross yields between the burn/mow treatments and the sulfur/no-sulfur treatments, there is no statistical difference in the net incomes generated by these treatments when variability is induced into the enterprise budgets. This moves the grower away from decisions based on data and more toward decisions based on subjective factors.

The decision to apply or not to apply sulfur seems straightforward—assuming the pH is not already very low. The addition of sulfur improves yield, and there are no known downsides to applying a reasonable amount of it. The decision to burn or mow, however, is not always based solely on the economics of blueberry production. Some growers focus on safety to their home and property and the home and property of their neighbors. For those growers, it is a question of risk. For others, it is what is most convenient—that is, does not require too many people to help to manage the burn operation.

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