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The Production of Organic Apples and Asian Pears To Promote the Sustainability of Existing Orchards and as Alternative Enterprises for New Growers

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EXECUTIVE SUMMARY

Orchard crops can provide significant returns to producers that allow farming to continue on high value land. Demand for organic foods has been growing rapidly since the late 1980s. Organic production simultaneously offers established fruit growers the opportunity to reduce complaints from nearby homeowners arising from their pesticide usage while potentially increasing farm receipts. We hypothesized that newly-set orchards that rely on advanced orchard technology could be planted and operated successfully and profitably as organic operations.

We established a two-acre apple and Asian pear orchard at the WyeREC in Spring, 2003. One plot in each of five blocks was managed conventionally using current integrated pest management (IPM) methods, and the other plot was managed using OMRI-approved organic inputs. Organic blocks were certified by the Maryland Department of Agriculture in 2006 after a three year transition period. Fruit trees chosen for this research were selected from three broad categories based on species and cultivar. These categories are: conventional apple cultivars, disease-resistant apple cultivars, and Asian pears. Conventional (IPM) blocks were fertilized as recommended using hand-placed calcium nitrate in April. The organic fertilizer was applied in a similar manner so that equivalent units of nitrogen were applied to all trees in the study. Trees survived under both organic and IPM production programs, but fruit yields were greater in the IPM plantings. We encountered three management hurdles in the organic blocks: reduced growth rate of young trees, difficulties in controlling grass and weed competition, and a greater difficulty controlling insect pests.

An economic analysis was conducted comparing organic and conventional apple management systems. This economic evaluation focused on farming practices and input materials that differed between organic and conventional plots. Specifically, we examined the costs of pest control, nutrients, field operations, and tree support. Organic production took more time than conventional production stemming from the difficulty of weed control under organic management. Techniques to grow apples organically are not fully documented especially in hot, humid climates such as Maryland. Good organic farmers would continually focus on reducing expenses. We found that the greater issue in the relative profitability of organic and conventional systems in this study was the differences in yields. In 2005 and 2006, organic yields were 57% and 70% of their conventional counterparts, respectively. In this experiment, low organic yields were a far greater barrier to profitability than the higher expenses for organic inputs.

BACKGROUND INFORMATION

Orchard crops can provide valuable returns to producers that allow farming to continue on high value land. But these same crops can pose particular difficulties for conventional fruit growers and transitional organic producers as they require a diverse set of management skills. Organic fruit and vegetable production is one of the fastest growing segments of global agriculture, and may provide growers an opportunity to remain profitable while simultaneously being better environmental stewards in the face of population and developmental pressures. To provide a 'roadmap' for local growers to produce tree fruit organically, we established a two acre apple and Asian pear block at the WyeREC in Queenstown, Maryland.

Demand for organic foods has been growing rapidly since the late 1980s, with annual rates of increase estimated at 20% or more (Greene, 2001). While organic production is still a very small part of total food consumption, organic agriculture represents a viable way for Maryland farmers to add value to their products and increase their profitability. In particular, organic production may prove valuable for Maryland fruit producers who have struggled in recent years to maintain their financial viability.

Unlike orchards of the past, fruit trees are now precocious and come into bearing rapidly. Growers typically expect to harvest their first crop in the third leaf, at about 27 months after planting. While it is expected that 'organic' production methods will reduce marketable fresh fruit yield (Caprile, 1994), our hypothesis is that this reduction could be offset by the premium for 'organic' fruit. Based on previous observations of Asian pears (Walsh, et al 2002), we also hypothesized that Asian pears can be an equally productive and profitable alternative crop when grown under either conventional/IPM or organic management.

Fruit production has historically been centered in the Appalachian region of Maryland. Orchards were located on less-fertile mountainside soils. This was done to avoid spring frost damage while simultaneously generating farm income on highly erodible soils. Many family farms still remain in these sites. Fruit are sold through a mix of outlets with varying profitability: fresh-market wholesale, direct-market retail and by delivery to processing plants.

Unfortunately, the elevation and scenic views of prime orchard sites in Appalachia also make them prime development sites (Eddy and Sparks, 2001). Some orchards have been sold for housing lots. This exacerbates pressures on remaining growers as the new homeowners become concerned with pesticide drift from these orchards. On-farm production of 'Certified Organic' apples and Asian pears would allow growers to have a locally-marketable high-value crop while simultaneously avoiding pesticide-related complaints from adjacent homeowners.

With a potential yield of 10 tons or 500 bushels per acre per year and an average wholesale price of 50 cents per pound, fresh-market apple and Asian pear growers can potentially gross about $10,000 per acre per year. In contrast, gross receipts for a processing apple orchard on a similar site would be $2,600 or less (estimated from the data of Perez and Pollack, 2001).

Based on recent studies, organic fruit could increase grower returns per pound (Henry Doubleday Research Association, 2005 and Granatstein and Kirby, 2007). Pome fruits (apples and pears) show the greatest promise for organic production in Maryland. First, there is considerable genetic resistance in both species. Ongoing breeding projects have added disease resistance to a number of apples during the past 40 years, which may reduce annual fungicide requirements by as much as 80% (Fischer, 2000). Asian pears (low-acid ‘juicy pears’) also show far greater insect and disease resistance than European (or ‘buttery’) pears. During the past decade we have tested more than thirty apple and Asian pear cultivars of pear and apple, and identified those appropriate for sustainable, commercial production in Maryland (Heflebower and Walsh, 1994, and Walsh, et al., 2002).

In 2001, the largest organic crop in Canada was apple production with 845 organically certified acres. Organic apple yields were 21% less than their conventional counterparts and organic apple prices were 73% higher than conventional prices (Parsons, 2002). In 2001 through 2003 in the United Kingdom, organic apple yields were 50% to 80% of their conventional counterparts (Henry Doubleday Research Association, 2005). Organic apple prices were approximately double those of conventional apple prices (100% higher). There are also great concerns about the long term stability of organic prices. Since organic fruit production is increasing around the globe, these price premiums may not be sustainable.

We hypothesized that newly-set orchards that rely on recent advances in orchard technology can be planted and operated successfully as certified organic farms. It is our belief that well-managed, young orchards are more readily managed than transitioning existing orchards (Henry Doubleday, 2005).

METHODOLOGY

Orchard Design and Establishment

We established a two-acre apple and pear block at WyeREC in Spring, 2003. Soil at this site is reasonably level and uniform, classified as a Mattapex silt loam. The planting was located in a field previously planted to corn and protected by an electric-charged high-tensile wire deer fence. Corn stubble was incorporated after harvest in fall, 2002 and a permanent K-31 fescue sod was established in late October.

Sod in the IPM plots was killed using glyphosate prior to planting. Sod was rototilled by hand prior to planting the organic plots. Trees were hand-planted using an auger, staked at planting and provided with trickle irrigation in their first growing season.

This orchard trial included ten replicated plots, which were further grouped into five complete blocks. One plot in each block was managed conventionally using current integrated pest management (IPM) methods, and the other plot was managed using OMRI-approved organic inputs.

Plots and blocks were separated by 50-foot (16 meter) wide sod buffer strips. This distance meets the Maryland Department of Agriculture's (MDA) minimum separation requirement required for organic certification.

Fruit trees chosen for this research were selected from three broad categories based on species and cultivar. These categories are: conventional apple cultivars, disease-resistant apple cultivars, and Asian pears. One clonally-propagated tree of each of the following cultivar and rootstock combinations was planted into each plot:

Conventional apple cultivars
Autumn Gala / M.9 NAKB337
Royal Court / M.9 NIC 29
Sun Fuji / M.9 NAKB337

Disease-resistant apple cultivars
Enterprise / EMLA.7
GoldRush / M.9 NIC29
Liberty / M.9 NAKB337

Asian pear cultivars
Atago / Betulaefolia
Niitaka / OH x F 97
Olympic / Betulaefolia

Cultivars were chosen based on our previous observations of their performance in grower orchards and at prior cultivar trials at this and other research locations. Apple trees used had been budded onto size-controlling M9 (Malling) or EMLA.7 (East Malling Long Ashton) rootstocks in the nursery. Pear trees were budded onto 'Betch' rootstock (*Pyrus betulaefolia*) the commercial standard, or a fireblight-immune semi-dwarf rootstock hybrid from the Old Home x Farmingdale (OH x F) series developed at Oregon State University. Trees were propagated by ACN Nursery, located in Aspers, Pennsylvania and shipped directly to WyeREC.

All trees were staked at planting to provide trunk support and then trained to a slender-spindle system. Trees in the IPM blocks were staked with 2.5 inch lodge posts supplied by ACN, while trees in the organic plots were staked with 'permanent' galvanized fence posts. Tree spacing was 10 feet in row with 14 feet between rows (3.1 by 4.3 meters). This spacing yielded a moderate density orchard of 311 trees per acre.

Fertilization and Orchard Floor Management

Conventional (IPM) blocks were fertilized as recommended using hand-placed 12 ounces of calcium nitrate in April. The organic fertilizer (*McGeary's Production Prince 5-3-4*) was applied in a similar manner. About three times as much of this organic fertilizer was used per tree. Equivalent units of Nitrogen (N) were applied to all trees in the study.

To minimize cross-contamination between organic and conventional plots, mowing equipment was cleaned before being used in the organic plots. Pesticides were applied with separate sprayers, one of which was dedicated to organic pesticide application at the research center. Tractors were also cleaned between pesticide applications.

In the IPM plots, weeds were controlled using the standard recommended herbicides for apple and pear trees. In the organic plots many strategies were employed in an attempt to control weeds. These included hand work following mowing, application of contact materials such as acetic acid (vinegar) and mulching with nursery cloth. By the end of the study, nursery cloth was the preferred practice which was set annually each spring to the organic plots. Nursery cloth was removed in fall to minimize the likelihood of rodent damage during winter.

During August, 2006 leaf and soil samples were taken for nutrient analyses. Leaf samples were taken from each ‘Enterprise’ apple tree and each ‘Olympic’ pear tree in each plot of the study (ten samples per fruit species) for comparison. Leaf samples were air dried and submitted to Pennsylvania State University Laboratory for tissue analyses.

Soil samples were taken from underneath the dripline of ‘Enterprise’ apple trees in each plot. Samples were sent to the University of Illinois (for the Illinois sugar-nitrogen test) and to the University of Delaware (for standard soil analyses).

Pest Management and Pesticide Applications

Pesticides were applied using two sprayers; one for the IPM plots and a second sprayer for the organic plots. Pesticide timings were based on tree phenology, *MaryBlyt* predictions and standard pheromone trap counts.

In the non-bearing years (2003 and 2004) relatively few sprays were used. Beginning in 2005 trees began receiving a full-season pesticide schedule as they flowered and set fruit. Since one goal of this study was to raise fruit with similar yields and quality under both management regimes, more sprays were applied to the organic plots. Additional sprays were needed due to their lack of pesticide residual effects and the ease with which organic materials can be washed off the leaves and fruit.

Tree Growth and Productivity

Cultivars selected for this study are late-maturing. Consequently, harvest began in early September and was completed by the end of October in each year of the study. Trees were harvested when fruit was fully mature. After harvest, the WyeREC crew weighed the fruit picked from each tree in the study and recorded data for each tree separately.

A preliminary analysis of yields was conducted using apple and pear yield data taken in 2005 and 2006. Analyses were conducted using SAS version 8.0 (Triangle Park, North Carolina).

Economic Evaluation

An economic analysis was conducted on the organic and conventional apple research study for the years 2003 through 2006. This economic evaluation focused on farming practices and input materials that were different for organic and conventional (IPM) production. Specifically, we examined pest control, nutrient requirements, related field operations, and support posts. We did not include operations that were judged to be similar, such as harvesting costs, marketing, installation of trees, or pruning and training.

Accurate records were kept for all sprays to control pests, nutrients added to encourage tree growth and fruit production, and the number of field operations that were performed in a season. These were all adjusted to an acre basis and current costs of these inputs were utilized. Prices of inputs were not changed through the study, and the current prices of inputs in 2007 were used. Machinery and labor costs for farm operations were taken from the *Pennsylvania Tree Fruit Production Guide* (Rytter and Travis, 2006).

ANALYSIS AND FINDINGS

Trees survived and grew well under both organic and IPM production programs. Tree growth and yields were greater in the IPM plantings. A very light crop was harvested in the second leaf (2004) on a few trees. This was about 27 months after planting. Commercial crops were harvested in 2005 and 2006 (third and fourth leaf, respectively). These two years' yields are presented in this report. Fruit from the organic blocks was classified as 'transitional organic' in 2005, and 'certified organic' in 2006. Some fireblight strikes were seen in trees in 2004 and a few trees were lost from the orchard that season. Little fireblight infection or damage was noted subsequently.

We encountered three general difficulties in managing the organic blocks:

1. Slow growth of young trees. This was due to a combination of factors. In the first season, trees did not respond well to the organic fertilizer application. This coupled with the rapid growth of trees treated with calcium nitrate in the IPM plots showed visible differences in vegetative growth and leaf color in the first and second leaf. This initial difference coupled with difficulties in reducing grass competition in the organic plots combined to reduce tree vigor and leaf nitrogen.

2. Difficulty in controlling grass and weed competition. Contact organic herbicides (citric and acetic acids) plus mowing were relatively ineffective in controlling grass and weed competition. Application of landscape fabric in spring, 2005 (third leaf) reduced competition, and trees subsequently appeared to regain some of their leaf color and vigor.

3. Direct pests affecting the fruit. Trees carried a light crop in the second leaf which gave us the opportunity to assess the effectiveness of our initial schedule on fruit quality. Despite 15 pesticide applications containing *Surround* (a particle clay insecticide) and/or *Pyganic* which were used in 2004, noticeable insect damage was seen on the limited number of organic fruits harvested that year.

To remedy pest problems, two major changes were made in the schedule in 2005 and continued in 2006. A neem-derived insecticide (*Neemix*) was added to the early-season sprays to control plum curculio. Intervals between organic sprays were also shortened to seven days from bloom until the fourth cover spray. The organic blocks received a total of 20 pesticide applications in 2005, while the Conventional (IPM) blocks received five fewer applications. Based on the changes made in 2005 and continued in 2006, fruit harvested from both apples and Asian pear trees were marketable.

Mineral Nutrition

Differences in macronutrients and micronutrients were found between organic and conventionally produced fruit. Major differences were seen in tissue levels of nitrogen (N), zinc (Zn), manganese (Mn), and aluminum (Al) (Tables 1 and 2). The differences in nitrogen appeared to be a direct effect of calcium nitrate in the conventional blocks coupled with greater grass competition in the organic plantings.

Analyses of soil samples showed no apparent difference in organic matter between treatments although the nitrate was slightly greater in soil samples at the end of the 2006 growing season (Table 3). Soil levels in manganese, zinc and aluminum did not differ between IPM and organic treatment although those micronutrients did differ in the leaf analyses. From these results we infer that the treatment differences seen in the leaf samples were likely caused by pesticide residue rather than differences in fertility *per se*. It also appears that the fifty foot separation between blocks reasonably isolated each pesticide management system, and little pesticide cross-contamination occurred between organic and IPM-treated plots.

Tree Growth and Productivity

In both years of the study, trees in the IPM plots yielded significantly greater amounts of fruit than did trees grown under the organic system (Table 4). Since these were early yields from young trees, we decided that it was too early to test for meaningful interactions between cultivar and management system. Consequently, our yield data in Table 4 and preliminary economic data evaluating each of these systems compares only the effect of management systems on the productivity across all six apple cultivars tested in this study.

Economic Evaluation

Table 5 summarizes pest control and nutrient management expenses for the organic apple production. In 2006 applications of 650 pounds of *Surround* in 13 sprays were made. With a cost of $0.67 per pound, the total annual material cost for *Surround* was $435.50 per acre. Similarly, there were 19 tank-mix sprays of organic pesticides. The labor and machinery costs per acre were $4.77 for a total annual cost of spraying organic pesticides of $90.63 per acre. Metal support poles were utilized in the organic orchard. In 2003 an investment of $3,054.02 was made to cover the cost of 311 poles at $9.82 each.

Table 6 summarizes pest control and nutrient management costs for conventional apple production. There was a greater variety of materials available to conventional production of apples; however, the total costs of these materials and their operations were uniformly less than those used in organic production. For example, the chemically treated support posts only cost $3.48 each for an investment of $1,082.28 per acre. These would not be allowed for organic production.

For the time period 2004 through 2006, the organic system averaged two more spray applications for pesticides (17.3 versus 15.3 sprays per year). The conventional system averaged 1.3 sprays per year for herbicides while the organic system did not spray herbicides for weed control. The organic system, however, averaged 15 hours per acre for weeding. In each system the orchard was mowed four times per year and had one application of fertilizer per year.

Table 7 summarizes net revenue over pest control and nutrient costs for the organic and conventional apple production systems. As mentioned previously, this analysis focuses on the differences between organic and conventional apple production. As a result, when costs associated with planting trees or harvesting fruit, which were assumed to be similar for both systems, are included, net revenue would be reduced for both types of operations.

The trees were planted in 2003. There were not any yields in 2003 and 2004, since in these years the trees were non-bearing. Total organic costs for 2003 and 2004 were $5,111. Total conventional costs were $2,378. The difference in costs between these two systems is $2,733. When this difference in investment is amortized over 20 years with 5% real interest, the additional investment cost to the organic system is $219 per acre. This investment cost is included as an annual cost in the organic orchard for the life of the orchard.

Organic production takes more time than conventional production. The differences stem from the difficulty of weed control under the organic production system. In particular, the organic farmer cannot use herbicides such as *Gramoxone* or *Round Up* and instead must use a hand-held weed trimmer. If finding labor is a problem for a farmer, this could limit the size of the organic fruit orchard. The cost of inputs for insect control and nutrients was less for conventional production. Insect control was very high in 2005 and 2006 for the organic system because of the use of the organic insecticides *Entrust* and *Neemix*, and the kaolin clay-based spray, *Surround*. By comparison, disease control costs were lower for the organic production system due to our heavy reliance on sulfur.

The analysis showed differences in net revenue when the price of apples was assumed to be $1.20 per pound for both the organic and conventional systems. As might be expected under equal prices, the net revenue for the conventional production system was greater. Since the price of organic apples is typically assumed to be higher, the question was then asked, "What price of organic apples would be required to equalize the net returns for the two production systems?" The organic breakeven price in 2005 would have to be 190% higher than the conventional price of $1.20 (or $2.28 per pound) for net revenue to be equalized. In 2006, the organic breakeven price to equalize net revenue dropped to $1.96 or 163% of the conventional price. While the organic yields were still lower than the conventional yields and the organic costs were still higher, there was less disparity in 2006.

Our breakeven organic price premiums were far greater than those reported in Washington State (Reganold, Glover, Andrews, and Hinman, 2001). In that 6-year study the premiums for organic apple production required to breakeven with conventional apple production were 12 to 14%. Washington State organic apple price premiums, from market surveys in 2006, ranged from +74% to +94% (174% and 194%) depending on the size of the apples (Granatstein and Kirby, 2007). These market-based organic premiums dramatically exceeded the breakeven premiums from that earlier Washington State study.

In support of this apparent profitability of organic apple production, Washington State had the highest number of acres of certified organic apple production in the U.S.A. (6,721 acres). This was almost double the acreage of California, the next biggest producer. Over 90% of the certified acres for organic apple production are in the arid West (Granatstein and Kirby, 2007).

In the hot humid Mid-Atlantic region, techniques to grow apples organically are still not as well documented. One could argue that we utilized too many expensive organic inputs in growing organic apples in this research. If our expenses were lower, then the organic price needed to equalize the two systems would also be lower. When we reduced our organic expenses by 50% but kept the yields the same, the breakeven price of organic apples dropped to $2.14 and $1.80 per pound for 2005 and 2006, respectively. This drop in price was only a modest 14 to 16 cents per year.

The greater issue in the relative profitability of organic and conventional systems in this Mid-Atlantic study appeared to be the result of the great difference in yields. In 2005 and 2006, organic yields were only 57% and 70% of their conventional counterparts, respectively. Low organic yields were a far greater barrier to profitability than were the higher organic expenses. For example, if we could increase organic apple yields by 50%, then the breakeven price for organic production would fall to $1.52 and $1.31 in 2005 and 2006, respectively. Stated in terms of organic price premiums (+27% and +9% for those two years), they would then be reflective of the reported Washington State breakeven price premiums for organic production of 12 to 14%.

To fully investigate the economic potential of organic apple production in the mid-Atlantic Region, we believe it is necessary to identify barriers to full orchard productivity in organic systems. We plan to continue this research in the future to hopefully identify and then reduce these apparent barriers limiting organic apple yields.

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Table 1. Effects of orchard management system on the macronutrients measured in Enterprise apple and Olympic pear leaf tissue sampled in 2006. Data expressed as percent dry weight of leaf tissue.

Cultivar and Treatment	**N**	**P**	**K**	**Ca**	**Mg**
Enterprise apple IPM	2.25	0.17	1.26	1.30	0.39
Standard Deviation	(0.10)	(0.03)	(0.07)	(0.50)	(0.04)
Enterprise apple Organic	1.56	0.34	1.55	1.29	0.39
Standard Deviation	(0.09)	(0.11)	(0.26)	(0.07)	(0.04)
Olympic pear IPM	2.20	0.13	1.43	1.74	0.17
Standard Deviation	(0.10)	(0.01)	(0.16)	(0.28)	(0.05)
Olympic pear Organic	1.69	0.13	1.20	1.87	0.21
Standard Deviation	(0.15)	(0.02)	(0.21)	(0.34)	(0.04)

Table 2. Effects of orchard management system on the micronutrients measured in Enterprise apple and Olympic pear leaf tissue sampled in 2006. Data expressed as parts per million on a dry weight basis in leaves.

Cultivar and Treatment	**Mn**	**Fe**	**Cu**	**B**	**Al**	**Zn**
Enterprise apple IPM	57	57	6.2	29	--	103
Standard Deviation	(12.84)	(9.65)	(0.45)	(3.78)		(27.04)
Enterprise apple Organic	35	55	5.4	36	--	15
Standard Deviation	(5.50)	(5.52)	(0.55)	(1.52)		(1.30)
Olympic pear IPM	65	48	5.4	29	40	55
Standard Deviation	(18.45)	(2.39)	(0.55)	(2.51)	(7.54)	(7.29)
Olympic pear Organic	28	37	4.6	21	152	14
Standard Deviation	(11.33)	(1.14)	(0.55)	(0.89)	(16.65)	(4.12)

Table 3. Effects of orchard management system on the micronutrients measured in soil samples taken from underneath the canopy of Enterprise apple trees in November, 2006.

Cultivar and Treatment	OM (%)	NO3-N (mg/kg)	Mn (lb/ac)	Zn (lb/ac)	Al (lb/ac)
Enterprise apple IPM	1.70	15.4	93	33	1708
Enterprise apple Organic	1.70	9.0	104	31	1867
Statistical Significance	NS	NS	NS	NS	NS

Table 4. Effects of orchard management system on fruit yields in two growing seasons at WyeREC (2005 and 2006).

Crop and Management System	Harvested yield (pounds / tree)		Estimated yield (bushels/acre)	
	2005	**2006**	**2005**	**2006**
Apple and pear, IPM	60.4	36.1	486.4	290.7
Apple and pear, organic	34.8	25.1	278.4	200.8
Statistical significance	0.001	0.01	0.001	0.01

Table 5. Pest control and nutrient costs for organic apple production on Maryland's Eastern Shore, 2003-2006 ($/acre).

Purpose	Material	$/Unit	Unit	2003	2004	2005	2006
Diseases	Copper	$3.01	pound	$0.00	$0.00	$0.00	$12.04
Diseases	Agri-Strep	$22.45	pound	$0.00	$0.00	$116.74	$107.76
Diseases	Lime-sulfur	$8.25	quart	$0.00	$0.00	$0.00	$82.48
Diseases	Sulfur	$1.55	pound	$37.20	$136.40	$148.80	$34.88
Diseases	Kocide	$4.25	pound	$0.00	$0.00	$17.00	$0.00
Insects	Surround	$0.67	pound	$50.25	$184.25	$217.75	$435.50
Insects	Pyganic	$11.15	pint	$55.75	$133.80	$178.40	$133.80
Insects	Entrust	$27.40	ounce	$0.00	$493.20	$753.50	$493.20
Insects	Neemix	$6.20	ounce	$0.00	$0.00	$793.60	$297.60
Weeds	Acetic acid	$2.62	gallon	$0.00	$0.00	$0.00	$0.00
Fertility	McGeary's	$0.43	pound	$331.22	$132.49	$397.46	$397.46
Fertility	Seaweed	$13.99	pound	$0.00	$22.38	$0.00	$0.00
Operations	Spray pesticides	$4.77	acre	$23.85	$62.01	$95.40	$90.63
Operations	Spray herbicides	$12.60	acre	$0.00	$0.00	$0.00	$0.00
Operations	Fertilize	$3.45	acre	$6.90	$3.45	$3.45	$3.45
Operations	Mow	$10.41	acre	$41.62	$41.62	$41.62	$41.62
Operations	Weed	$10.00	hour	$150.00	$150.00	$150.00	$150.00
Operations	Support posts	$9.82	post	$3,054.02	$0.00	$0.00	$0.00
	Total			$3,750.81	$1,359.60	$2,913.72	$2,280.41

Table 6. Pest control and nutrient costs for conventional (IPM) apple production Maryland's Eastern Shore, 2003-2006 ($/acre).

Purpose	Material	$/Unit	Unit	2003	2004	2005	2006
Diseases	Sulfur	$1.55	pound	$32.55	$0.00	$0.00	$0.00
Diseases	Copper	$3.01	pound	$0.00	$0.00	$0.00	$12.04
Diseases	Ziram	$3.00	pound	$0.00	$0.00	$33.00	$36.00
Diseases	Topsin-M	$18.50	pound	$0.00	$92.50	$203.50	$60.13
Diseases	Ag-Strep	$22.45	pound	$0.00	$0.00	$116.74	$80.82
Diseases	Lannate	$0.46	ounce	$0.00	$0.00	$4.60	$3.68
Diseases	Pristine	$33.50	pound	$0.00	$0.00	$0.00	$53.60
Diseases	Nova 40W	$4.50	ounces	$54.00	$43.88	$22.50	$0.00
Diseases	Kocide	$4.25	pound	$0.00	$0.00	$17.00	$0.00
Diseases	Mancozeb 75DF	$6.25	pound	$0.00	$50.00	$0.00	$0.00
Diseases	Rubigan	$2.60	ounce	$0.00	$7.81	$0.00	$0.00
Diseases	Captec	$7.49	quart	$37.44	$119.80	$0.00	$0.00
Insects	Imidan	$7.49	pound	$29.21	$157.29	$247.17	$116.84
Insects	Provado 1.6F	$4.07	ounce	$12.21	$24.42	$0.00	$12.21
Insects	Sevin 4L	$7.35	quart	$0.00	$7.35	$0.00	$5.51
Insects	Lorsban-4E	$4.35	pint	$0.00	$0.00	$4.35	$0.00
Insects	Oil	$19.40	gallon	$0.00	$0.00	$38.80	$0.00
Insects	Warrior 1CS	$2.20	ounce	$0.00	$6.61	$0.00	$0.00
Insects	Vydate 2L	$7.88	pint	$0.00	$63.00	$0.00	$0.00
Insects	Thiodan 50W	$9.40	pound	$0.00	$56.40	$0.00	$0.00
Weeds	Solicam DF	$20.29	pound	$0.00	$76.09	$0.00	$0.00
Weeds	Gramoxone	$5.46	pint	$10.93	$8.19	$10.93	$10.93
Weeds	Princep 90	$3.75	pound	$0.00	$0.00	$12.00	$12.00
Weeds	Devrinol	$8.45	pound	$0.00	$0.00	$67.60	$67.60
Weeds	Round Up	$10.50	quart	$37.80	$10.50	$0.00	$0.00
Fertility	Calcium nitrate	$0.21	pound	$83.60	$18.70	$0.00	$0.00
Fertility	NH4NO3	$0.16	pound	$0.00	$0.00	$39.82	$39.82
Operations	Spray pesticides	$4.77	acre	$23.85	$62.01	$71.55	$85.86
Operations	Spray herbicides	$12.60	acre	$50.40	$25.20	$12.60	$12.60
Operations	Fertilize	$3.45	acre	$6.90	$3.45	$3.45	$3.45
Operations	Mow	$10.41	acre	$41.62	$41.62	$41.62	$41.62
Operations	Weed	$10.00	hour	$0.00	$0.00	$0.00	$0.00
Operations	Support posts	$3.48	post	$1,082.28	$0.00	$0.00	$0.00
	Total			$1,502.78	$874.82	$947.22	$654.70

Table 7. Net revenue over pest control and nutrient costs for organic and conventional (IPM) apple production on Maryland's Eastern Shore, 2003 through 2006 ($/acre).

	2003		2004		2005		2006	
	Org	Conv	Org	Conv	Org	Conv	Org	Conv
Yield/acre (lbs)	0	0	0	0	10,823	18,784	7,837	11,258
Price ($/lb)	1.20	1.20	1.20	1.20	$1.20	$1.20	$1.20	$1.20
Revenue	0	0	0	0	$12,987	$22,541	$9,405	$13,510
Pest Control and Nutrient Management Costs								
Diseases	$37	$124	$136	$314	$283	$397	$237	$246
Insects	$106	$41	$811	$315	$1,943	$290	$1,360	$135
Weeds	$0	$49	$0	$95	$0	$91	$0	$91
Fertility	$331	$84	$155	$19	$397	$40	$397	$40
Operations	$3,276	$1,205	$257	$132	$290	$129	$286	$144
Investment[a]	$0	$0	$0	$0	$219	$0	$219	$0
Subtotal	$3,751	$1,503	$1,360	$875	$3,133	$947	$2,499	$655
		Net Revenue			$9,855	$21,594	$6,905	$12,855
		Organic premium necessary to equalize net revenue			190%		163%	
		Organic price necessary to equalize net revenue			$2.28		$1.96	

[a]Difference in costs between organic and conventional production for 2003 and 2004, amortized over 20 years at 5%, to capture the additional investment costs associated with organic production.