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Organic farming research project report submitted to the Organic Farming Research Foundation:

Project Title:

Organic apple production in Washington State: A 1994 survey of growers

FINAL PROJECT REPORT

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Fourteen organic apple producers in Washington State were interviewed in a select survey study that sought to identify common successes and barriers in organic apple management. Historically, control of codling moth has been a primary barrier to organic apple production in the Northwest. In addition, organic production incurs significantly higher costs than conventional production for certain aspects such as fruit thinning and weed control. The following commonalities emerged from the interviews:

1. Mating disruption has become the dominant pest control method for codling moth.
2. Production practices are driven by both internal (i.e. pest populations, tree nutritional status) and external (i.e. market prices, spray material availability) factors.
3. Growers use several strategies simultaneously to achieve acceptable levels of pest control.
4. Growers perceive that enhancement of habitat for beneficials and ecological diversity is linked to reducing reliance on pesticides.
5. Growers attribute better fruit quality and fewer disease problems to an active organic fertility management program.
6. Labor is the largest factor in increased cost of organic production.
7. Though costs of production during the first few years of organic practices are generally higher than in conventional systems, net returns improve over he first few years of organic production and consistently exceed net returns from conventional orchards.

While there is no simple "recipe" for organic apple production, experienced growers share a core of strategies that include diversification of pest management techniques, proactive soil fertility management, and continued experimentation to develop cost-effective options for those aspects of organic production that are more expensive than conventional practice.

Introduction

Organic apple production in Washington State has been steadily increasing since 1991. Acreage took a dramatic jump in 1980 in response to the Alar crisis, but most of those farms only remained in organic production for one season. This was largely due to the difficulty of controlling codling moth *(Cydia pomenella),* the primary direct pest in the region, and also in response to the collapse of market prices for organic fruit due to the huge increase in supply. For organic farming to succeed, growers need to reduce risk, both on the production side (by having more options to deal with problems) and on the market side (minimizing the need for a price premium by cutting production costs). In order to increase the chances for growers to succeed at organic apple production, a survey of selected organic producers was undertaken in 1994 to draw on the experiential knowledge in the field at that time. Interest in this type of information was expressed by growers as well as by agricultural support personnel.

Grower experience in organic practices ranged from a couple of years to over two decades. Farm size ranged from one acre to 200 acre plantings of apples. We asked the growers to share the evolution of their cultural practices and identify both their triumphs and their tribulations. Questions included queries on farm history, fertility management, and any labor or economic considerations that altered pest control practices. Growers were also asked to identify where they obtained information about farming practices and what needs were left unfulfilled.

Methodology

Fourteen farms were chosen for the study using several criteria. These farms represented a broad range of conditions. Farms were selected from each of the four main fruit growing areas of thte state: north central, Yakima Valley, Columbia Basin, and upper Columbia Valley. Farming operations ranged in size from five total orchard acres with one acre of apples to farms with over 400 acres in a single management unit. Both all organic and mixed operations were represented. The length of time in organic production ranged from still in transition to over 20 years. Growers level of experience with organic practices on their farm varied. Some had worked on other organic farms prior to working thwir.'ow. As horticultural practices are changing rapidly with dwarfing rootstocks and high-density plantings the selected orchards represented a range from large old freestanding trees to semi dwarf, *trellised and* hedgerow planting styles. Proximity to other apple orchards varied from isolated orchard settings to complete enclosure by surrounding conventional farms. An initial pool of potential survey candidates was compiled by the investigators based on their knowledge of organic apple production in the state. The list was narrowed to 14 farms to fit the resources of the project while maintaining the diversity described above.

Farm interviews were conducted primarily on-site during the winter (when farmers have time for such things). One or both investigators had previously visited all farms during the growing season, and crops had been viewed and discussed. Interviews generally lasted two hours. Some were taped for later transcription. Both investigators took notes for comparison of tone and content. Each interview was based around a series of eight questions (Table 1). These questions were given to the farmer, noting a number of specific-elements to identify under each topic. Insect pest management was generally the topic explored in most detail. Growers were asked to focus on ecological shifts that had occurred under organic management that impact pest control, and whether these changes could be adapted to conventional orchards.

The interview information was compiled by question/topic area. Under pest control management, a table was developed to identify the types of management strategies used and the relative importance of particular practices and strategies. Investigators scanned for patterns that repeated from one farn to another, especially in regard to the evolution of the farm ecosystem under organic management. Insightful remarks and analogies were noted for quotation. Permission was obtained from growers to use specific quotations for publication purposes.

Table 1. Interview questions

1. **What is the history of the operation and the producer?**
   --How long have you been orcharding? At this site?
   --How many years in organic production?
   --What was your motivation for organic production?
   --What have been the major barriers to using an organic system?
   --What are your goals for your operation? How are you planning to achieve them?

2. How do you control pests in your orchard?

--Insects, disease, weeds, vertebrates
--Practices, products and equipment used:
-Codling moth-mating disruption
-granulosis virus
-black lights
-Botanical pesticide use: Why or why not?
-Use of introduced insects
-Habitat modification for biocontrol
-Soaps, oils, diatomaceous earth, miracle products
-Tree varieties, orchard design and architecture
-Irrigation practices
-Sanitation
-Vegetation management; tillage
--Monitoring strategies
--Ecological shifts you have seen

3. How do you manage tree nutrition and soil health?

--Orchard floor management
--Nitrogen fertilization
--Foliar nutrients
--Links between fertility management, pest problems, crop quality
--Apple replant disease
--Soil compaction

4. How do you manage other horticultural aspects?

--Fruit thinning
--Irrigation
--Variety selection
--Orchard design and architecture

5. How do you handle labor issues in your operation?

--Worker safety
--Labor wages and needs (housing, benefits, etc.)
--Training
--Does organic production require more labor?

6. What are the economics of your operation relative to conventional orchards?

--Premiums received? Required for profitability?
--Relative costs of different management components
--Involvement in marketing
--Crop yields and pack-outs over time

7. What are your primary means of information support?

--Where do you learn about new practices?
--Do you conduct your own on-farm testing?
--Role of industry, groups, associations
--Role of university, USDA
--Major information, resource support gaps you would like to have filled

8. Future needs

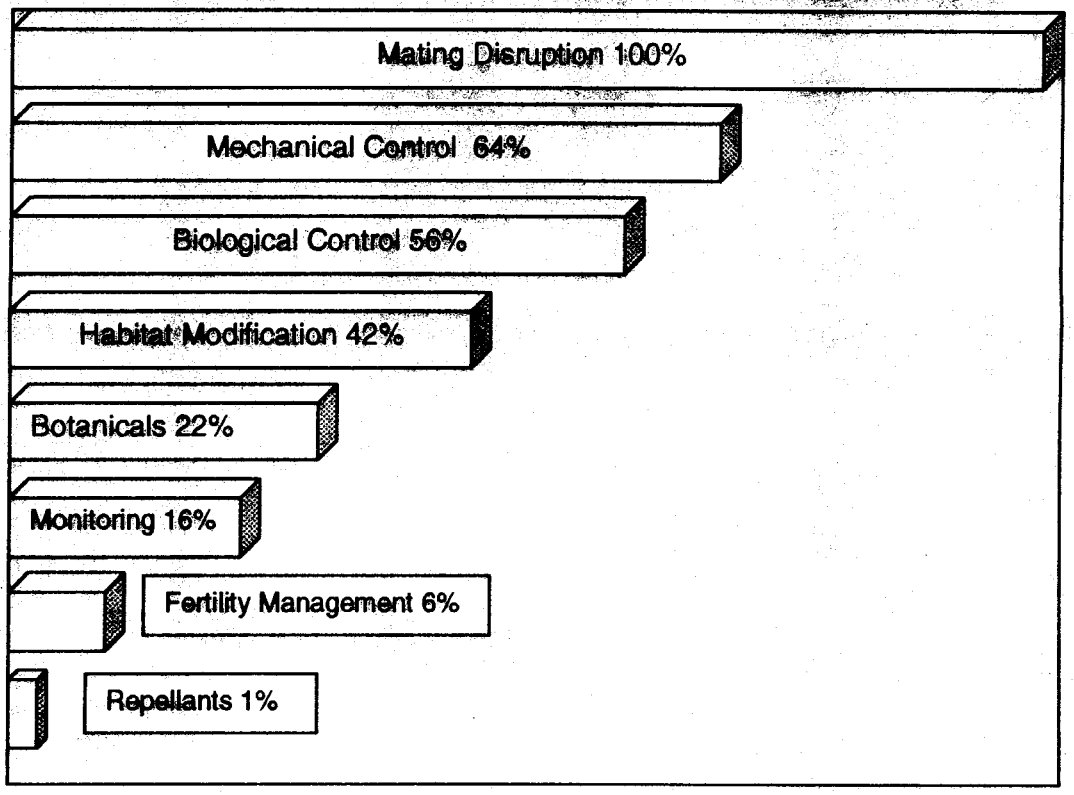
--Identify one or two priority issues you would like to address to help your operation; to help the entire apple industry
--What parts of your system have potential to be adopted by conventional growers?
--What will be the impact on you of the national organic production act?
--What is the future outlook for markets for organic apples and prices?

1. Pest Management

Insect Pest Control

Insect pest control strategies were categorized by their primary. mechanism of insecticidal action. Eight different categories were developed (Figure 1). Then the use of strategies was weighted as to its relative importance within the mix of strategies used on any particular farm. Farmers were asked if a mechanism was a major, contributing or minor component of their cultural practices to control codling moth. This was done to determine what the driving mechanisms of control were, if any, within the farm ecosystem. We also wanted to discover if the emphasis was similar from site to site.

Figure 1. Insect pest control: type and relative importance of strategies.



Percentage calculated from: [Number of growers using strategy / total number of growers] x [level of importance (3=major, 2=contributing, 1=minor)/ 3] x 100

Unilaterally, mating disruption has become the dominant type of pest control for codling moth in organic apple management. Though some sites are not well adapted to this methodology, all of the growers interviewed were using this as the primary means of control.

The second most common type of control was a category identified as mechanical control. This term included a group of practices or materials that had a physical mechanism of insecticidal action such as desiccation, smothering, etc. Dormant oils and lime-sulfur were most commonly used. Next was summer oils. Many growers used more than one strategy within this category; on average 2-3 out of the 6 identified.

Biological control included predators, parasitoids and pathogenic agents. Most growers used one of these forms at some point, but reported results were variable in terms of efficacy. It also was difficult for them to track the beneficial population levels and persistence from season to season. Consequently the use of these strategies was sporadic.

Habitat modification was designed to encourage biological control by beneficials and/or reduce hose environments for codling moth. This category contained the largest number of practices, and showed a creative diversity in ecosystem management. However growers used only 1 or 2 of these, and many were considered contributing rather than major factors in pest control.

Botanicals were viewed as materials to be used only when other strategies were failing, primarily due to the impact of the botanical insecticide ryania on beneficial populations and biodiversity in the farm ecosystem. Due to the weighted measure, though about half of the growers had used botanical insecticides, their place in the mix was contributory to minor.

Monitoring methods were used as only a minor, assisting role in the timing of other methods of control. With the development of models for insect life cycles by Cooperative Extension, much of the guesswork has been eliminated.

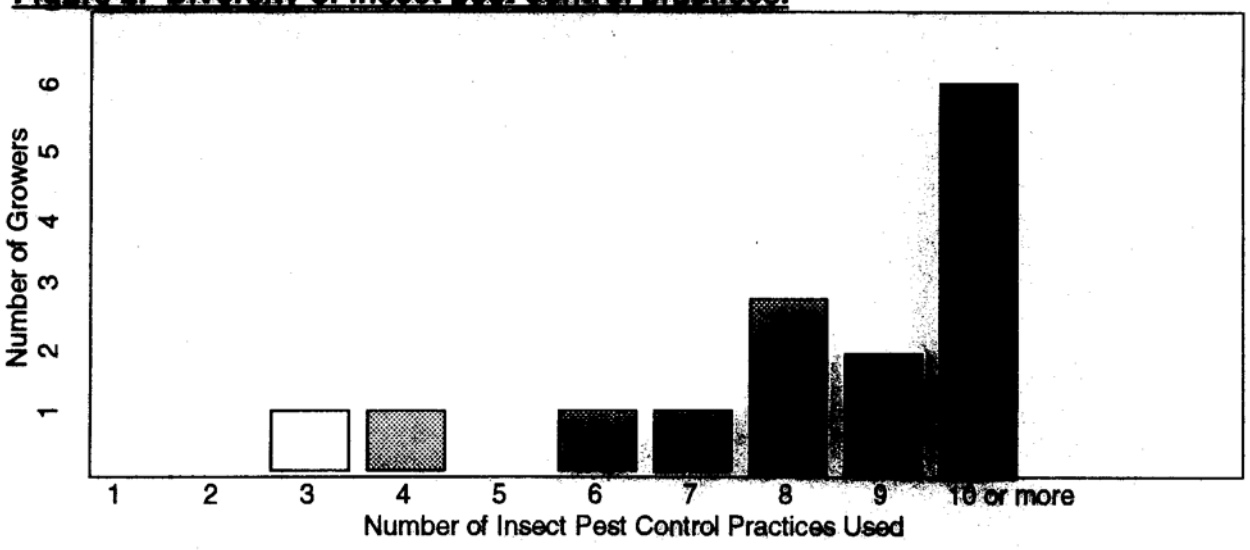
Fertility management was used by a few growers to improve overall health and vigor, fruit quality and crop set. Those that used this type of method felt that good fertility mangement assisted in minimizing damage from secondary pests and disease.

Only one grower used repellents regularly and felt they were a regular part of that orchard's pest control.

Every grower interviewed used a diversity of control strategies. Within each strategy category, a grower may have used one or more materials or cultural practices.Growers with a wider variety of control practices tended to also utilize a wider variety of control strategies. The range in diversity of insect pest management is illustrated in Figure 2.

There appeared to be some distinct differences between those growers who used the fewest pest control practices and those who used the most.

Figure 2. Diversity of insect pest control practices.



Characteristics of growers that used 5 or less practices:

They had small blocks surrounded by wild areas. It is likely that beneficial habitat and endemic populations were doing a significant amount of the pest control without the grower directly accounting for it or actively modifying it. One grower has a bird sanctuary between hom and orchard. At least two others knew that the sourrounding area provided a source of beneficials but didn't monitor for endemic species or purchase beneficials to release on the farm specifically for that reason.

They were new to organic production and still learning the options available. With fewer management strategies, more reliance was placed on botanical insecticide usage. Management practices used organic materials but appeared to be an "input substitution" system where materials were organic but management decision making styles were still similar to conventional practices (e.g. eradication instead of modification, zero pest pressure thresholds, etc.).

Characteristics of growers that use 10 or more methods:

Nearly half of those interviewed used the entire range of methods available to them. Within a particular type of strategy more than one management practice was often used.

The longer a grower used organic management, the more diverse the farm management practices. Innovation and experimentation became commonplace as knowledge of and confidence in organic methods grew.

Below is a list of specific insect pest management practices mentioned, by one or more growers.

Double rate of pheromone dispensers on borders.

Poles beyond orchard border (especially upwind) with pheromone dispensers.

Tree trunk banding with cardboard or corrugated plastic (does not degrade) to trap codling moth larvae.

Thinning off infested fruit and removing from orchard.

Use of dormant oil.

Use of B.t. for leaf roller, cutworm; use on codling moth not effective.

Codling moth granulosis virus (generally not effective).

Hot pepper spray for codling moth.

Running overhead sprinklers at night to disrupt codling moth flight (not fully effective).

Delayed early season mowing to keep potential pests (lygus bug) in ground cover.

Black light traps and bug zappers on borders.

Fish oil as a summer oil control for codling moth.

Growers mentioned the importance of site topography and history in considering new sites for organic production. Of the six growers who had all of their arcreage in organic practices from the beginning, none were over 10 acres. Larger orchards either started with conversion of a portion of the existing acreage or converted additional acreage as new plantings were done.

Due to the predominance of mating disruption as a primary pest control strategy, new site choices were evaluated using criteria for that strategy's success such as:

-levelness
- low air flow
-mature even canopy
-degree of isolation from other orchards and their potential contribution to pest damage along the borders of the orchard.

All growers reported a change over time of the predominant secondary pest species. In many instances some pests regularly requiring treatment with conventional spray materials required no treatment or weren't present in organic blocks. These included campylloma, leafminer, aphid and mites. Most growers felt they tolerated more pest damage than a conventional grower might. However the degree of pest monitoring varied greatly among growers. In general, it appeared to be less than in conventional orchards. Some growers had a "don't worry, nature will take care of itself" attitude that dissuaded them from regular monitoring efforts.

Disease Control

Disease problems for apple growers in Washington State are relatively minor in most years due to the dry climate. However, some the newer varieties being planted are more susceptible to disease, particularly fireblight and powdery mildew. Fireblight is especially difficult to control in organic production, and the losses can be substantial.

The primary tools for disease control are sulfur materials and lime sulfur. These are effective against mildew and scab, but can require repeated applications if unfavorable weather conditions persist. No growers reported using scab resistant varieties. Most growers felt that a a balanced fertility program contributed to disease suppression in the orchard. The use of moderate nitrogen levels, fish and kelp foliar sprays, and calcium fertilizer were all reported as tactics to help prevent disease. One grower try to keep leaf N levels about 10% below the university recommendation to help prevent mildew. Some growers pruned the trees to specifically to increase air movement as a preventive control for scab and mildew. One grower reported that soap is more effective in controlling mildew than sulfur but is also more expensive. The soap is less disruptive of beneficial insects.

A few growers reported incidence of soil borne diseases, especially under mulched trees. Copper sulfate was reported as one control for crown rot. One grower felt that crown rot problems decreased as soil organic matter increased.

Weed Control

Weed control is a major challenge for organic growers, especially with new orchard plantings, where competition with the young trees can severely retard growth and fruit yield. Most growers relied on mechanical techniques to control vegetation. Mowing was the standard practice for the planted alleys. Some growers have avoided vigorous sod-forming grasses, as these tend to migrate into the tree rows and are difficult to control. Surface tillage was the most common technique for controlling weeds in the tree row. Tools such as the Weed Badger were used to mechanize the operation. However, their use is time consuming and thus expensive, and can damage tree trunks and roots if not carefully operated. In addition, continual tillage is destructive of soil organic matter and several growers cited the need for non-tillage weed control as a priority for improving their soil management.

A few growers still hand apply a mulch, such as hay or straw, in the tree row to control weeds. This can provide satisfactory control for several seasons. However, it can increase rodent problems and the susceptibility to crown rot. One grower has alfalfa growing in the alleys, which he mows and mechanically mulches onto the tree row.

Other techniques being tried include flame weeding (trees can-be damaged, need metal tree guards), low growing cover crops (especially white clover), and controlled watering to limit weed-growth.

Vertebrate Pests

Most growers reported the potential for serious problems from rodents, especially voles and mice. The use of tree guards around the trunks is the most common control pactice. Some growers trap the rodents, while other use Qunitox, a vitamin-based rodenticide. Most growers encourage predation bycats, owls, hawks, snakes, and coyotes to the extent possible. A few growers do some early pruning in the late fall and leave the prunings on the ground to provide an alternative food source s for the rodents.

2. Fertility Management

Fertility management was a major endeavor for all the growers interviewed. They clearly felt it was essential to successful o rganic production, and invested more time and money than a conventional grower might. All but one grower used a combination of ground-applied amendments and foliar feeds. All felt that a proactive fertility management t program kept fruit quality high, and avoided damage from disease and pests. Coding moth damage,however, was not one of the pests whose damage could be avoided by fertility management.

All growers agreed that moderate vigor was better than high vigor. One specifically cited less aphid problems with moderate vigor. Others mentioned avoidance of the physiological disorder bitter pit (related to calcium deficiency, induced by a high nitrogen/calcium ratio). Another grower observed that lower vigor was correlated to greater leafhopper presence.

Growers have spent considerable time finding a nitrogen source that is effective and affordable. Seventy-nine percent of growers used a combination of nitrogen sources split between protein nitrogen and composted manures. Though protein nitrogen sources (feathermeal, bloodmeal, fishmeal) have higher percentages of nitrogen and are more readily available, composted manures build organic matter and cation exchange capacity, considered to be important parameters in long-term soil fertility. Chicken manure compost was a widely used fertilizer, as it provided one of the lowest cost sources of N, high levels of other nutrients, and a significant amount of available N.

Several growers had been testing their soil to monitor changes in soil organic matter. In two cases, the growers had seen organic matter levels double over the course of 10-15 years. On some soils, growers reported compaction problems and poor water infiltration. In addition to organic matter amendments, one grower used a soil aerator between tine tree rows twice a year. Several growers used gypsum periodically to try to improve soil structure.

One grower used analogies to describe the reason for building organic matter: "Soil is like a bank and I've got a lot of savings. It's like a ship steaming along that you can push with a tugboat, but don't have much influence except over a long period of time."

Other management techniques included the used of nitrogen producing cover crops or interplanted shrubs and trees. These were seen to have an additional advantage of harboring or feeding beneficial insects.

Foliar feeds were both broad spectrum and specific. Eighty-six percent of the growers used them annually. Hydrolyzed fish and kelp were utilized for their broad range of nutrients. Other sprays included specific micronutrients difficult to apply in small amounts to the ground, and often deficient in Northwest soils. Foliar feeds were also used to compensate for the slow breakdown of organic materials, especially during the transitional period from conventional to organic practices, where biological decomposition activity was generally low.

Growers reported testing or regularly using a number of "miracle products" for fertility. Many of these

were microbial inoculants and humic acid extracts. Leonardite, a mined humic acid product, was used by some growers both at initial planting and as a yearly topdress.

Growers reported bitterpit, a physiological disorder of the apple fruit due to improper balance of calcium and nitrogen, to be a common problem. Some were applying a foliar calcium spray to deal with it. This problem points to the challenge of precisely managing nitrogen coming exclusively from organic sources.

The level of soil and tissue testing by growers varied. Many had used soil and tissue testing in the past but found it to be of limited practical value in managing their fertility program. The LaMotte soil test and use of a refractometer were mentioned as monitoring tools. Overall, growers were still seeking economical sources of fertility for their trees and soils, but generally did not have problems supplying adequate levels of nutrition.

3. Labor Issues

All growers indicated that organic orcharding required significantly more labor than conventional systems. One grower stated that "it is a given that organic requires more labor." For those whose labor force is family members or themselves, this is an increased investment of time. For the rest, it is an increased expense.

One of the first reasons cited for higher labor requirements was increased training. Laborers often weren't familiar with the difference in organic practices. The effectiveness of certain practices can be reliant on careful execution, such as the proper placement of pheromone dispensers for effective mating disruption. Some jobs, like monitoring pest populations with pheromone traps, require both time and training expenses. Managers also find they spend more time on site and often need to stay with crews during training, taking time way from other duties.

Increased labor expenses were mostly for operations not mechanized, such as fruit thinning and hoeing. Other functions that were mechanized, such as foliar feeds applied by speed sprayer or weed control through tillage, simply included increased frequency, and therefore tractor time.

Fruit thinning was cited consistently as the major increase in labor need and cost in organic production. Though some growers use organic spray materials as thinning agents, none are labeled as such and none are as effective as conventional thinning materials. Timing is critical and it is very detailed work. Growers estimated that thinning costs can increase anymore from 10-100% over that in a conventional orchard. The grower with the lowest cost increase had a corresponding increase in pruning costs because he used spur pruning in winter to control crop set and thus reduced the need for hand thinning. For large organic orchard, it is possible that adequate labor might not be available for the critical 2-3 week post-bloom period when thinning needs to be done.

Weed control was the second most cited area with a significant labor increase since there are no organic herbicides comparable to conventional materials. Mechanical control and barrier methods (woven row cover or mulching) are primarily used. Hand hoeing is used even in orchards where tillage (by rotovator or Weed Badger) is used to detail around small trees and sprinkler risers.

Increased labor for fertility management was another operation cited by several growers. In addition to increased applications of foliar feed materials, ground applied amendments for building organic matter, such as composts or manures, are bulky and time consuming to apply. One grower tried a couple of different manure spar styles and went back to a low-slung trailer and four workers with shovels to obtain the tree row band he wanted. Another "grows" his fertility weed control by planting alfalfa in the tree rows, then cutting and windrowing against the trees.

4. Orchard Economics

All growers agreed that the premium price for organic fruit is necessary to maintain profitability. They also agreed that the premium had to be enough to cover the increase in costs of production. Most estimated that the increase in overall costs ranged from 10 to 30% over a conventional orchard. Part of this is the labor costs outlined above. The balance consisted primarily of the increased cost of fertilizer and spray materials.

Fruit yields were estimated by growers to be anywhere from 10-15% less to 10-15% more than comparable conventional orchards. Fruit quality was compared in several ways. Most growers commented on more cullage (one said 3-5% higher than his conventional fruit) from cosmetic defect, but they felt the fruit often had better firmness, flavor, color and grade. Long term, controlled atmosphere storage was used with less storage rots or scald (a common storage disorder in conventional fruit that requires the use of a compound called DPA). Several growers reported that the packout percentage of their organic fruit was equal to or better than that in their packing shed on average or on any conventional block they had. Most considered the price premium to be derived from consumer satisfaction with a quality product.

Prices for processor grade organic fruit have often been considerably higher than the conventional markets, and several growers felt this helped to compensate for any increased cullage that might occur.

Other economic considerations are related to supply and demand in a small niche market. All longer-term growers had experienced a major dip in price premium when the organic acreage jumped after the Alar scare. Most growers that were growing organic for a "fast buck" left organic practices after a year, and prices for most growers have returned to pre-alar levels. One grower planted high value varieties as a buffer against price fluctuations due to periodic oversupply by new organic acreage. One grower stated that his per-bin returns were double that of his conventional neighbor, but not double his costs. "What I did before, I was about to go down the river. Now I'm about to send my banker down the river." Another grower addressed this topic by saying "finding a niche market with higher value is a better marketing strategy than hoping your neighbor will have a disaster."

Growers were split on whether it is advantageous to do their own marketing or work with an organic broker. All felt that conventional fruit brokers don't know enough about the unique qualities of the organic marketplace to sell their crop.

Growers also commented on the non-economic rewards of organic farming, including quality of life, reduced stress and regulation from handling fewer toxic materials, and positive feedback from consumers.

5. Information Sources

Growers' information sources were quite diverse. Some did their own on-farm research (65%). Trade magazines were used for horticultural information. Some organic industry publications were read for information specific to rganic fertility marnagement and pest or disease control. All attended workshops and conferences, both conventional (Washington State Hort Convention) and organic (Tilth Conference). All were avid readers and spoke regularly to knowledgeable people in the organic industry.

None relied on fieldmen's recommendations for farming practices, though some

fieldmen were asked for advice as part of the information mix. One grower said she liked to have "more than one pair of eyes" monitoring her orchard. Several had hired independent field consultants not connected to chemical sales or packinghouses, for a more objective opinion.

In general, the growers did not use Cooperative Extension as an information source. However, several growers felt that Washington State University had made major contributions to their operation through applied research programs, especially the work to operationalize pheromone mating disruption for codling moth. A few growers had participated in on-farm testing with University or USDA researchers.

6. Grower Needs

All growers expressed a concern for the lack of research by both public institutions and private entities for materials and practices relating to organic practices. Several felt that conventional chemical dollars skewed the research funding. Others felt that information was geared to furnish a "silver bullet" for growers. Since organic practices are multi-faceted, organic growers looked at these recommendations with skepticism.

Since there is much more biodiversity on organic farms, several growers indicated a need for more sophisticated insect identification. Some species are direct beneficials and others just compete for resources and habitat with pests. They also wanted more information on pest cycles and habitat to better target control measures

Growers also identified a need to have better marketing support from the Washington Apple Commission. (Growers who also had organic pears claimed better targeted marketing programs in that organization.) A number of growers indicated a need for consumer education on the meaning of organic, the value of organic practices and dispelling of old, negative stereotypes of organic food.

The following list of information and research needs were expressed by one or more of the growers

Organic systems studies - transition, ecological rebalancing
Relationship between plant nutrition and crop health
Soil biology and how to manage
Control of apple replant disease
Insect identification, especially beneficials
Enhancing biodiversity to increase natural pest control.
Rodent management options
Weed control, especially perennial grasses
Post-harvest residues of DPA
Information access - more on Internet, access to older research, more printed resources
Organic market information
Organic crop statistics

Conclusions

Though apple orchards and grower backgrounds varied considerably in this series of interviews, several common threads emerged during the compilation of results:

Mating disruption has changed the mix of pest control strategies dramatically in just two or three years. It removed the primary technical barrier for successful organic production and is largely responsible for the dramatic increase in organic apple acreage since this study was conducted.

With increasing length of time in organic production, growers tend to diversify their pest control strategies and find lower cost solutions.

The longer the time in organic production, the smaller the role of botanical insecticides and the larger the role of biological control and biodiversity.

Growers attribute better fruit quality (higher pressures, higher sugars, and better color) and fewer disease problems (less storage rot) to good organic fertility management.

The opening of markets and confidence in organic practices has encouraged mixed operations to convert some or all of their remaining acreage to organic production.

The labor cost for fruit thinning is the largest factor in the increased cost of organic production, though it can be reduced somewhat by varietal choices, fertility management and spur pruning.

Though costs of production during the first few years of organic practices are generally much higher than in conventional systems, net returns improve and exceed conventional orchards toward the end of that time frame.

In general, organic apple growers do, not experience yield loss or fruit quality decline once an orchard has been in organic production for several years..

There is no simple "recipe" for organic apple production. Based on the experiences of the growers interviewed during this study, successful orchards utilize the following core strategies:

A diversity of pest management; approaches

A pro-active soil fertility management program

Continual experimentation to develop cost-effective alternatives for those practices that are more expensive than in conventional systems.

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The investigators wish to express their appreciation to the growers who agreed to be interviewed and who generously shared both their time and knowledge.

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